MULTINATIONAL MODELLING OF FINANCIAL LINKAGES AND EXCHANGE RATES

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CONTENTS

The author is Head of General Economics Division. The system described is the result of a collective effort by a number of members of the OECD Secretariat. P. Richardson creatively impiemented the system on computer. Empirical work was executed by H. Kato. M. Rondoni and M. Ushida. Theoretical interpretation of the consistency conditions in the model evolved in discussions with P. Atkinson. V. Koromzay and P. Masson. Other members of the Secretariat contributed ideas. insights and encouragement. Surviving errors are those of the author.

INTRODUCTION

This paper describes the international financial linkages which are a subset of relations embedded in the OECD's world model, INTERLINK. For convenience this subset of relations is itself referred to as a model and is called Financial Interlink, but it is an integral part of the larger system. The paper consists of four parts: part one is introductory and sets out the purpose of the model and some operational considerations influencing its design; part two gives an overview of the system; part three gives the specification of international financial linkages in more detail, dealing with net international capital flows and exchange-rate expectations and determination; part four reports empirical estimation results for the relationships described in the previous section with some commentary.

The system is under continuous development. Simulation and tracking properties will be discussed in subsequent papers.

I. PURPOSE AND DESIGN CRITERIA OF "FINANCIAL INTERLINK"

International financial linkages were introduced into the INTERLINK system to permit simulation analysis of the transmission of financial impulses from one country to another. The primary function of INTERLINK is to help the OECD Secretariat better analyse the international transmission of fiscal and monetary policies. Other shocks and their international repercussions, such as oil price changes, are examined too. The other chief use of the model is in checking the international consistency of the Secretariat's twice-yearly forecasts.

The international financial linkages (hereafter Finlink) were conceived as a complete and consistent world system. International identities governing financial flows are binding and 16 exchange rates are determined simultaneously. This accords with the OECD's responsibilities towards over a score of Member countries involving economic forecasting for each of them. It also seemed the most promising way to exploit what comparative advantage the Organisation possesses in research. The more refined and institutionally rich the modelling of one sector or country, the less feasible it is to extend the approach to many countries. By the same token, a global approach is necessarily Procrustean in its treatment of many features of individual countries if it is to be manageable. Both approaches may yield insights despite their respective limitations, and the insights may be complementary. Many OECD countries have detailed macro-models and some institutions have developed international models covering a half-dozen or so countries in some detail[1], hence the choice of a broad summary approach covering the OECD countries and (in the current version of the model) three non-OECD zones.

At the same time, an operational requirement is that the model be solvable either in its entirety (linked mode) or by single-country portions (unlinked mode). And ideally the characteristics of important equations in a country model should be the same whether solving in linked or unlinked mode.

The model system has to be sufficiently "structural" to be applicable to a range of policy regimes, both for counter-factual simulations and to conform with OECD forecasting practice. This latter proceeds on the technical assumption of unchanged nominal exchange rates. The model's role in this context is to help check the consistency of national forecasts with each other and with the exchange-rate assumption. In particular, the model has to allow for whatever exchange-market intervention would implicitly be required to permit the assumed constancy of nominal exchange rates.

Those considerations conditioned the broad outline of the model, but certain operational factors were also influential. The resources devoted to the exercise were limited. Total input was about three man-years for specification, estimation, implementation and testing of the first operational version and no senior economist was engaged on it full-time. This enforced an economy of effort which was achieved by using the pre-existing INTERLINK structure and, in particular, the trade model which ensures a set of consistent trade balances. Another operational consideration was a computer constraint. During the forecasting period, same-day turnaround is often required from runs of the model in internationally linked mode. At the inception and development of Finlink this was on a relatively small Burroughs 6822 computer which was congested at peak periods. Model design, therefore, sought to prevent the introduction of financial linkages and floating exchange rates from greatly increasing the computational burden of model solution.

II. AN OVERVIEW OF THE MODEL

INTERLINK consists of 23 country models and sub-models of eight non-OECD zones grouped around a trade model. The trade model, which is described more fully elsewhere[2], has a five-commodity breakdown. The country models are generally income-expenditure systems with some parameters estimated econometrically and others imposed to reproduce national model properties. For six of the larger OECD countries, the models are relatively more developed with coherent factor-demand equations derived from a three-factor putty-clay aggregate technology and with all expenditure deflators determined in a behavioural wage/price system. A considerable drawback of the current model is that it does not incorporate fully-specified monetary sectors. The existing domestic monetary sectors are rudimentary but are currently under development.

A. Domestic financial relationships

Although the system is fully simultaneous, for exposition it is useful to decompose the financial relations into domestically endogenous and internationally determined components. The specification for a typical country model financial block is rather standard. The equations are reproduced here in simplified general form (see Table **1).**

The typical country financial block consists of five behavioural equations and five identities. The behavioural equations are those for: net private capital flows (in dollars), a short-term market interest rate, broad money supply, the expected bilateral dollar-exchange rate and the long-term interest rate. The identities define the "balance of official settlements" in dollars, the effective exchange rate, the expected effective exchange rate, foreign reserve changes valued in domestic currency and the net foreign asset position in dollars.

There is no equation as such for the bilateral exchange rate. In "fixed-rate" mode that is exogenous and the balance-of-payments identity (equation 6, Table **1)** may be interpreted as showing what official reserve changes would have to be to support a fixed exchange rate, given the other variables in the system. The exchange rate is endogenised when the model is run in "floating-rate" mode by pre-specifying values for *BOSD*. A control algorithm then inverts the relationship between reserve changes and exchange rates and solves, iteratively, for the domestic exchange rate required to achieve the prespecified reserve target or intervention limit. The iteration is carried out on the bilateral U.S. dollar exchange rate with corresponding effective exchange rates being calculated through a weighting matrix. The ***ex post*** balance-of-payments identity effectively becomes an ***ex ante*** equilibrium condition given the specified *BOSD.* This procedure is similar to that followed in several other international models[3].

The system thus has two polar policy regimes. In the first, the exchange rate is fixed and the consequent reserve changes, to the extent that they are unsterilised, affect the money supply. In the second, the exchange rate floats "cleanly", adjusting to levels that require no change in international reserves; the money supply is then determined by domestic credit expansion, treated as a policy variable.

In this context some comment on equation 3 determining the money supply is in order. It takes no account of the detailed money supply process and any constraints imposed by government borrowing requirements and interest rates. The equation may be seen as a reduced-form representation, to be replaced by a block of equations in due course. Its function is to transmit the effect of foreign exchange market intervention to a broad monetary aggregate. The parameter ***xster*** represents the combined effect of sterilisation and the domestic banking multiplier. It is non-zero for all countries except the United States where the operations of foreign

Table 1. Model variables

(1)	CAPFLO	=	c(IRS − IRFOR, EXCHEX/EXCHE, ΔCBD)
(2)	IRS	=	i(MONEYS, GNP)
(3)	MONEYS	=	MONEYS(−1) + xsterDFA + ADCE
(4)	EXCHX	=	f(EXCH, PGDPUS, PGDP, IRS − IRFOR, NFATS)
(5)	IRL	=	r(IRS, PCP, NLG)
(6)	BOSD	=	CBD + CAPFLO + CFD
(7)	EXCHE	=	EXCH/EXCHBASE(1/EXFOR)
(8)	EXCHEX	=	EXCHX/EXCHBASE(1/EXFRX)
(9)	DFA	=	BOSD/EXCH
(10)	NFATS	=	NFATS(−1) + CBD

Variables

(Fully exogenous variables indicated by *, variables exogenous to a country model but endogenous to the complete system by +)

	CAPFLO	:	net capital flows ($)
	IRS		short-term market interest rate
+	IRFOR	:	foreign short-term interest rate
	EXCHE	:	effective exchange rate
	EXCHEX	:	expected effective exchange rate ($EXCHEX_t$ is the value that agents at time t expect EXCHE will have at time t + 1)
	CBD		current balance ($)
	MONEYS	:	money stock
*	ADCE	:	autonomous component of domestic credit expansion
	DFA		change in foreign reserves (local currency)
	EXCHX	:	expected dollar exchange rate (defined analogously to EXCHEX)
	PCP		private consumption deflator
	PGDP		GDP deflator (local currency)
+	PGDPUS	:	GDP deflator for United States
	NFATS	:	residents' net foreign asset position (in current dollars)
	EXCH		dollar exchange rate (US $ per unit of local currency)
	IRL		long-term interest rate
	NLG		net lending of government
	BOSD	:	balance of official settlements ($)
*	CFD		compensatory finance ($), i.e. net official non-monetary capital flows
+	EXFOR	:	geometrically weighted index of foreign exchange rates against the dollar
+	EXFRX	:	geometrically weighted index of expected foreign exchange rates against dollar

central banks tend completely to sterilise the effects of foreign exchange market intervention on the United States' monetary aggregates.

The model is currently without explicit policy reaction functions, but may be used to simulate the effect of various intermediate policy regimes using the system's targeting facility. For example managed floating can be simulated by pre-specifying a path for reserve changes *(BOSD)* and varying the exchange rate to achieve it. It would be simple, in principle, to add a Central Bank exchange-market reaction function, thereby making managed floating the model's basic mode of operation. Another possibility arises if, for example, the government wishes to maintain a fixed exchange rate without use of reserves. It then has to adjust or affect short-term interest rates to ensure finance for the current deficit. This can be represented using the model's targeting (control) algorithm. The exchange rate remains fixed but *BOSD* is targeted at some limit using ADCE, the autonomous component of domestic credit expansion, as an instrument. Hence, money supply and interest rates adjust so as to achieve both reserves and exchange-rate targets. The expected exchange rate and net capital flows (equations **1** and **4)** are at the heart of the model and are discussed in detail in Part III.

B. International financial linkage

International linkage with financial consistency is primarily achieved through the use of "effective" exchange rates and analogously a multilaterally-weighted foreign interest rate as explanatory variables in the net capital flow equation. Common weighting procedures are used for exchange rates and interest rates. Suitably defined exchange-rate and short-term interest rate weights (w_{ij}) are held in a central routine of the model. In linked mode this routine automatically gathers individual domestic rates from each country-model solution file, carries out the appropriate weighting and then returns to each country file corresponding values for indices of foreign exchange rates, actual *(EXFOR)* and expected *(EXFRX),* and foreign short-term interest rates *(IRFOR).* For exchange rates, the effective-rate weighting procedures are geometric in form, consistent, for instance, with the practices of the IMF[4].

The foreign component of the actual effective exchange rate of country *i* (see equation 7) is defined as:

$$log(EXFOR_i) = \sum_j w_{ij}\ log(EXCH_j/EXCHB_j)$$

where $EXCH_j$ =exchange rate for country *j,* US$
$EXCHB_j$=base period value of $EXCH_j$.
Similarly, for expected exchange rates:

$$log(EXFRX_i) = \sum_j w_{ij}\ log(EXCHX_j/EXCHB_j)$$

where $EXCHX_j$=expected exchange rate for country *j*, US$. The use of this variable in equation 8 implies that there is one coherent market expectation for the course of each effective exchange rate in the model.

With interest rates in percentage form, an arithmetic weighting procedure is applied to give a weighted foreign rate for country *i* ($IRFOR_i$) as:

$$IRFOR_i = \sum_j w_{ij} IRS_j$$

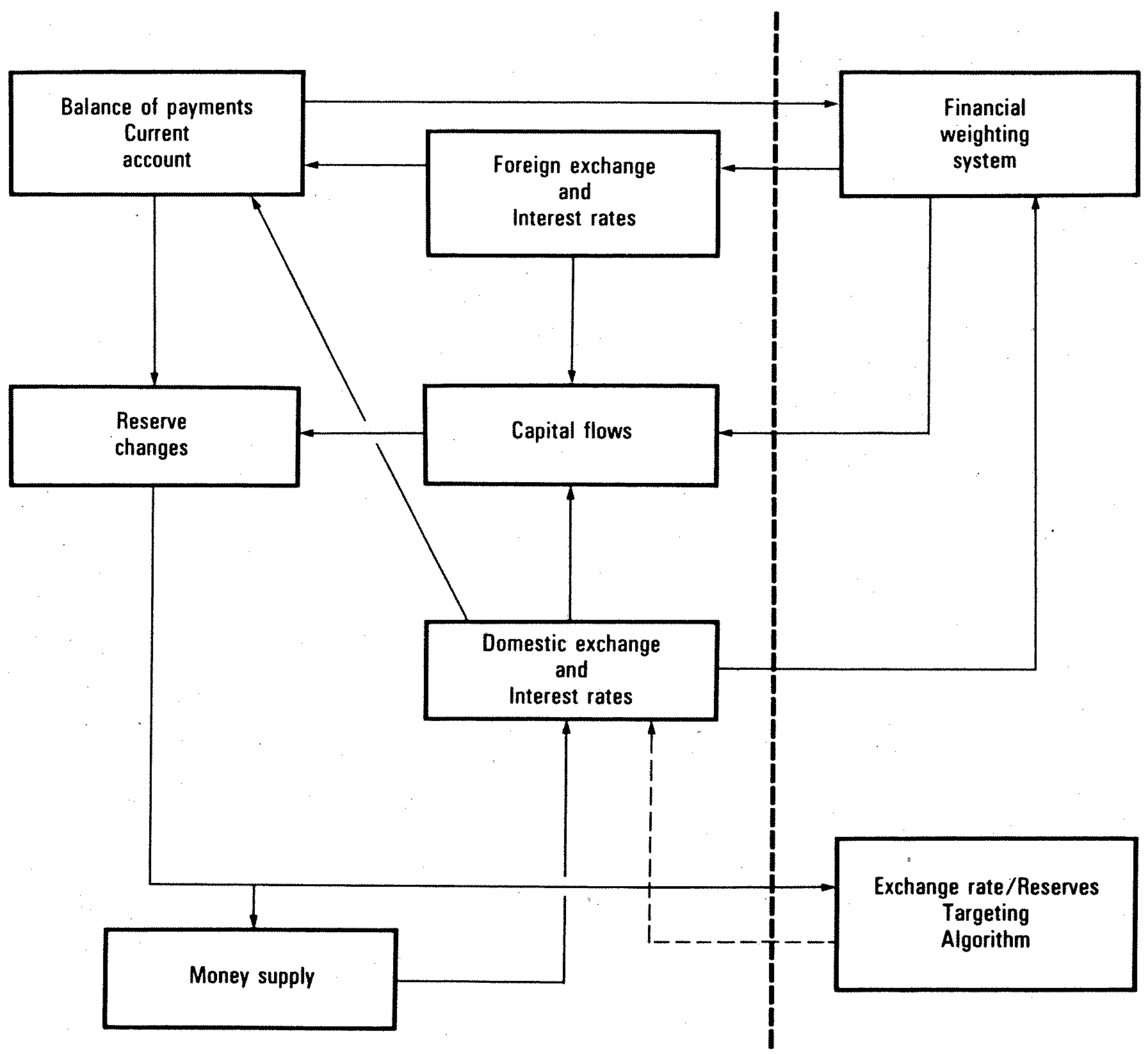
where IRS_j=short-term interest rates for country *j.* The empirical determination of the weights w_{ij} is dealt with in Part IV.

The international financial linkage routine, in addition, gathers current balance-of-payments information for individual countries and regions required, in semi-aggregated form, by the individual capital flow relationships. A further prerequisite for international consistency is a set of cross-country parameter restrictions on the set of net capital flow relationships, which are dealt with in the next part. These ensure that, for given changes in interest and expected exchange-rate differentials, the net capital flow resulting for any single country is exactly matched elsewhere in the system, by capital flows of the reverse sign.

Figure 1 illustrates the main information flows involved in the international financial linkages. In single-country mode, with foreign dollar exchange rates exogenous, a change in the domestic dollar exchange rate yields a corresponding change in the effective exchange rate and hence induces a capital flow. In linked mode, changes in exchange and interest rates for any single country feed through endogenously into other countries via the foreign rate weighting routine. In single-

Interlink financial linkages

Country models



country mode, the U.S. effective rate itself can be varied. In linked mode, changes in the effective U.S. rate are properly defined only in terms of the combined dollar rates of other countries.

III. NET CAPITAL FLOWS AND THE EXCHANGE RATE

Net capital flows were chosen as the key variable in international financial relations primarily on grounds of data availability. They are obtainable on an internationally consistent basis, valued in U.S. dollars, from balance-of-payments statistics. Apart from economy of data requirements, they also have the practical advantage over gross flows of not having to contend with various "round-tripping" problems that can affect the gross-flow data of some countries.

A feature of Finlink is the division of the world into two sets of countries. The first set consists of seventeen OECD countries. Capital flows between these are taken to be determined largely by the principles of portfolio allocation and are modelled accordingly. For analysing capital flows, the eight non-OECD zones of INTERLINK are aggregate into three: OPEC, less developed countries and a residual rest of the world[5]. These zones together with six of the smaller OECD countries[6] make up the second set of countries, in which the total capital flow is taken as determined *ex* ***post*** by the current account. In other words, for these areas, the current account is regarded as the result of prior decisions, which would of course take perceived credit availability into account. This procedure eliminates the modelling of domestic financial conditions in those areas. Exchange rates are not defined in the model for the non-OECD zones, and the effective exchange rates (trade-weighted) of the six OECD countries are assumed to remain constant in real terms; i.e. the nominal rate moves to match inflation differentials with trade competitors (except in Portugal where there is a "crawling peg" exchange regime). No domestic interest rates are defined for these countries or the non-OECD areas. The counterparts to these capital flows are distributed parametrically among the seventeen other OECD countries. This makes the model ill-equipped to deal with a situation of current concern, whereby the trade of many non-OECD countries is constrained by credit availability, influenced in turn by their debt position. The easiest way to incorporate such effects would be to make the imports of such countries explicitly a (decreasing) function of accumulated debt. The capital flow would remain determined by the current account which would include interest payments, themselves a function of accumulated debt. This is not done in the current version of the model, though in practice some approximation to these effects is possible by imposing adjustments via "add-factors".

OPEC is currently in the second set of countries in that its total net capital flow is determined by its current account and is supposed to flow entirely to the OECD area. A somewhat different approach was also tried in which the OPEC countries were assumed to allocate net increments to their portfolios (taken to be equal to the OPEC current balance) according to profitability criteria. This specification has so far not yielded usable results. It may be noted that the assumption that there is a counterpart capital flow from OPEC to the OECD exactly offsetting its current balance is not quite true, but appears to be a tolerable approximation. A regression of changes in total OECD official reserves (in dollars) on the OPEC current balance for the 1970s produced a significant coefficient equal to −0.23, with a standard error of −0.07, suggesting that a capital flow equal on average to 77 per cent of the OPEC surplus was received in the OECD. However, it is not clear whether the model is so appropriate to a period of OPEC deficits.

A. The capital-flow specification in detail

a) Flows between OECD countries and the non-OECD area

For the set II areas, private and official flows are not distinguished. For the set I countries, official compensatory finance as well as official reserve changes are differentiated from other capital flows. Compensatory Finance is defined as official foreign currency borrowing. (See Annex.) It is an exogenous variable in the model.

The capital flow equation for each of the seventeen OECD countries measures net flows in dollars. Following the scheme outlined above, the equation can be decomposed into two parts: net capital flows between country *i* and other OECD countries ($CAPFLO_{io}$), and net capital flows between i and non-OECD zones ($CAPFLO_{ino}$). The sum of the latter expression for all OECD countries must equal the net capital **flow** of the OECD area.

$$\sum_i CAPFLO_{ino} = CAPFLO_{oecd}$$

where subscript *i* indicates the OECD country concerned.

Assuming that compensatory finance nets out within the OECD, a balance-of-payments identity holds for the OECD area:

$$CAPFLO_{oecd} = BOSD_{oecd} - CBD_{oecd}$$

where *BOSD* is balance of official settlements (mainly reserve changes) and CBD is the current balance.

The following assumption is now made: $BOSD_{oecd}=0$, i.e. all reserve changes of OECD countries consist of changes in assets and liabilities with respect to other OECD countries, and for any OECD country there is a counterpart to its *BOSD* in the *BOSDs* or compensatory finance of other OECD countries. Again, this assumption is not quite true but its worst effects have been eliminated in empirical work by redefining the United States' capital flow to put official settlements flows with non-OECD countries "above the line". The assumption is being eliminated in later versions of the model.

Hence:

$$CAPFLO_{oecd} = -CBD_{oecd}$$

If k is an index with a range equal to the number of geographical zones in the model, then

$$\sum_k CBD_k = SD$$

i.e. the sum of the current balances of each world zone is the world current account statistical discrepancy. The OECD's current balance will equal the sum of the current balances of all other zones, with opposite sign, plus the world current account statistical discrepancy.

$$CBD_{oecd} = -\sum_{k \neq oecd} CBD_k + SD$$

Hence:

$$CAPFLO_{oecd} = \sum_{k \neq oecd} CBD_k - SD$$

The $CAPFLO_{ino}$ (net flow with non-OECD of any OECD country, i) is simply its share of this OECD capital flow.

$$CAPFLO_{ino} = \sum_{k \neq oecd} s_{ik} CBD_k - s_{isd} SD$$

where $\sum_i s_{ik} = 1$ for all k, and $\sum_i s_{isd} = 1$.

Note that this entails treating the statistical discrepancy as a shadow world zone with its own counterpart capital flow. This flow will be related to trade credit provision because part of the statistical discrepancy is owing to transport lags, exports being registered before imports. However, this relationship is not explored in the current version of the model.

For each of the world zones and the statistical discrepancy, the shares s_{ik} are treated as parameters and are not regarded as functions of interest or exchange rates. Initial values of these shares were estimated after a study of various data sources and these prior estimates were then modified by the technique of mixed regression. The estimation method is described in Part IV.

To recapitulate, the capital flow to a typical OECD country, i, is defined as:

$$CAPFLO_i = CAPFLO_{io} + CAPFLO_{ino}$$

This section has discussed the specification of capital flows between OECD countries and the non-OECD area. For a typical OECD country these are specified as:

$$CAPFLO_{ino} = s_{il} CBDLDC + s_{ir} CBDROW + s_{is} SD + s_{io} CBDOPEC \qquad (1)$$

where $\sum_i s_{il} = \sum_i s_{ir} = \sum_i s_{is} = \sum_i s_{io} = 1$.

b) *Intra-OECD* ***flows***

Intra-OECD capital flows are modelled as the result of portfolio adjustments by OECD wealth holders. It is in general possible to derive rigorously equations for the desired holdings of securities issued by a given country only if assumptions are made about the currency of issue of such securities. If countries issue securities only in their own currency, the expected yield on the securities issued by country *i* (Y_i) can, on this assumption, be defined as the interest rate payable plus expected currency appreciation in terms of some numeraire currency. For a half-yearly model, measuring yields in per cent at an annual rate, this gives:

$$Y_i = IRS_i + \left[(EXCHX_i/EXCH_i)^2 - 1\right]100 \qquad (2)$$

In the more general case where securities may be issued in foreign currencies, in the presence of "country risk" their yields and the size of inflows should still be related to domestic interest rates. Expected appreciation (depreciation) of the domestic currency would also tend to encourage (discourage) foreign borrowing by domestic residents in foreign currency, as they, not the foreign lenders, would bear the exchange risk. These arguments, though not rigorous, suggest yields defined as in (2) are relevant to capital flows in a world of multi-currency borrowing and lending.

A "foreign" yield rate for *j* can be defined:

$$YFOR_j = \sum_i w_{ij} Y_i$$

where w_{ij} is the weight of *i*'s yield in the foreign rate of *j*.

The private net foreign asset equation for country *j* is written as:

$$CAP_j = \left[a_j + b_j(Y_j - YFOR_j)\right] WWD \qquad (3)$$

where *WWD* is world wealth (strictly, OECD wealth) in dollars, and a_j and b_j are treated as parameters.

In Finlink this equation is written in terms of liabilities not assets; the signs of coefficients are the opposite of conventional values and this results in a capital inflow being defined as a positive quantity.

This equation can be derived as the reduced form of a system of gross-flow equations'. Assume the gross demand of residents of country *j* for the assets of country *i* is a function of all expected yields in the system; and assume *j*'s *ex ante* supply of debt to country *i* is just the negative of its demand for *i*-assets. Gross demands and supplies by *j* can then be consolidated and its net demand for *i*-assets written:

$$CAP_{ij} = (c_{ij} + \sum_k b_{ijk} Y_k) s_j WWD$$

where CAP_{ij} is *j*'s net *ex ante* assets/liabilities with respect to *i*

s_j is *j*'s share of world wealth in dollars

c_{ij} is *j*'s average propensity to hold *i*-assets

b_{ijk} is the marginal rate of substitution of asset *i* for asset *k* in the portfolios of *j* residents.

Then $b_{ijk} \leqslant 0$ for $i \neq k$

and, by country **j's** wealth constraint:

$$\sum_i b_{ijk}=0 \quad \text{for all } k.$$

The total ex ante net assets/liabilities of country j is its own net demand for foreign assets minus the net demand of the rest of the world for j-assets, i.e.:

$$\begin{aligned} CAP_j &= \sum_{i \neq j}(CAP_{ij}-CAP_{ji}) \\ &= \Big[\sum_i (c_{ij}s_j - c_{ji}s_i) + \sum_i \sum_k (b_{ijk}s_j - b_{jik}s_i)Y_k\Big] WWD \end{aligned} \tag{4}$$

And net liabilities in this sense sum to zero for the system as a whole

$$(\sum_I CAP_j=0)^{8}.$$

Equation **(4)** is equivalent to (3) if:

$$a_j = \sum_i (c_{ij}s_j - c_{ji}s_i)$$

$$b_j = -\sum_i b_{jij}s_i$$

$$w_{ij} = \frac{-\sum_k b_{jki}s_k}{\sum_k b_j k_j s_k}$$

A considerable simplification is achieved in current Finlink by treating the shares of different countries in world wealth as if they were fixed. That enables the a_j, b_j and w_{ij} to be treated as constants despite the fact that they are functions of the s_j[9]. Note that the s_j's do not enter (3) explicitly. The specification also implies the absence of valuation effects. Wealth holders are assumed to value portfolios at some constant set of accounting exchange rates.

Now, if $CAPFLO_j=dCAP_j/dt$, then, taking the total time derivative of (3):

$$\begin{aligned} CAPFLO_j &= (bjdY_j/dt - bjd\,YFOR_j/dt)WWD \\ &\quad + (a_j + b_jY_j - b_jYFOR_j)dWWD/dt \end{aligned} \tag{5}$$

These two terms can be interpreted as follows:

- The first term is the desired adjustment in the net stocks of assets held by j as a result of changes in relative yields;
- The second term is the flows resulting from allocations of increments to world wealth given existing yield differentials.

In equilibrium, this incremental net demand for foreign assets must equal j's current balance, representing increased net claims on foreigners. As the CAP_j must sum to zero over all j, *a fortiori* the $CAPFLO_j$ must do so. $CAPFLO_j$ must by definition equal the negative of the desired change in the net position of foreign residents vis-a-vis /-residents. For a change in j's yield, Y_j, the additional desired capital inflow to j is given by differentiating (5) with respect to Y_j:

$$dCAPFLO_j/dY_j = b_j\Big[d(dY_j/dt)/dY_jWWD + dWWD/dt\Big]$$

The incremental outflow for any other country, i, for the same change is:

$$-dCAPFLO_i/dY_j = b_i [d(dYFOR_i/dt)/dY_j WWD + (dYFOR_i/dY_j) dWWD/dt]$$
$$= b_i w_{ji} [d(dY_j/dt)/dY_j WWD + dWWD/dt]$$

as $YFOR_i = \sum_j w_{ji} Y_j$, then $dYFOR_i/dY_j = w_{ji}$.

In general, $dCAPFLO_j/dY_j$ must equal $-\sum_i dCAPFLO_i/dY_j$.

Hence the consistency condition implies: $b_j = \sum_i b_i w_{ji}$ (6)

i.e. j's coefficient equals the sum of each i's coefficient times the share of j in each i's "foreign" expected yield. If the weights w_{ji} are arranged into a matrix W and the coefficients b_j into a vector b, as (6) must hold for all j, the condition can be written in matrix form:

$$bW = b \text{ or } b(W-I) = 0. \qquad (7)$$

That is, the coefficients $\boldsymbol{b}$ must be the fixed-point vector of the matrix of weights $\boldsymbol{W}$.

Any weight matrix $\boldsymbol{W}$ will have certain characteristics, namely that columns will sum to unity (the shares of other countries in any country's "foreign" interest rate sum to one) and there will be zeros on the principal diagonal (no country's foreign interest rate includes its domestic rate). The first characteristic makes b unique up to a factor of proportionality[10]. This has the strong implication that once changes in shares of world wealth, s, are eliminated and if marginal rates of substitution between different assets are fixed (hence the W matrix is constant) then a joint cross-country restriction on the parameters of the capital flow equation and the weighting matrix $\boldsymbol{W}$ is implied. For a given weight matrix the restrictions imply a set of capital flow coefficients unique up to a factor of proportionality.

In Finlink these coefficient restrictions are applied. Doing so at the estimation stage has practical advantages (see Part IV). The chief one is that capital flows obey adding-up restrictions for the system as a whole without the need to leave one country residual. There are equations for each country with no over-determination and no need for a separate capital flows linkage block analogous to that of the trade model. This is economical in computer use and ensures that all countries have the same capital-flow characteristics whether they are simulated in linked or unlinked mode.

In addition to capital flows owing to portfolio allocation, some intra-OECD flows take the form of net trade credits which may be more responsive to trade flows than to interest differentials. Assume that a constant proportion 9 of a trade balance is financed by trade credit and that it is repaid at the rate $(1-r)$. Define TC_i, as net trade credit flows to country i and CBD_{io} as the current balance of country i with the rest of the OECD area. Then trade credit is given by:

$$\begin{aligned} TC_{it} &= -q\ CBD_{iot} + (1-r)q\ CBD_{iot-1} \\ &\quad + (1-r)rq\ CBD_{iot-2} + (1-r)r^2 q\ CBD_{iot-3} + \dots \\ &= -q(CBD_{iot} - CBD_{iot-1}) - rq\ CBD_{iot-1} \\ &\quad + (1-r)rq\ CBD_{iot-2} + \dots \end{aligned}$$

As the coefficients are diminishing with the order of the lag, terms after CBD_{iot-1} are ignored. In practice, the variable CBD_{io} is not readily available and is proxied by CBD_i, the current balance of the country in question.

The equation for capital flows to other OECD countries is obtained by substituting (2) into (5) and adding the trade credit terms. The discrete-time version is (i-subscripts omitted from explanatory variables):

$$
\begin{aligned}
CAPFLO_{iot} = \; & a_1(WWD_t - WWD_{t-1}) \\
& + a_2(IRS, - IRS_{t-1} - IFOR_t + IRFOR_{t-1})WWD_{t-1} \\
& + a_3\left[(EXCHEX_t/EXCHE_t)^2 - (EXCHEX_{t-1}/EXCHE_{t-1})^2\right]WWD_{t-1} \\
& + a_4(IRS_t - IRFOR_t)(WWD_t - WWD_{t-1}) \\
& + a_5\left[(EXCHEX_t/EXCHE_t)^2 - 1\right](WWD_t - WWD_{t-1}) \\
& + a_6(CBD_t - CBD_{t-1}) \\
& + a_7 CBD_{t-1}
\end{aligned}
\qquad (8)
$$

Total capital flows are obtained by combining (8) and (1).

To ensure that capital flows continue to sum to zero for the whole world, despite the addition of the current balance terms, the sum of these trade credit flows is taken and, if it is not zero, it is distributed among OECD countries according to their weight in trade. This entails adding another term to the capital flow equation, being each country's counterpart of total trade credit.

Countries can issue instruments in foreign currency and the currency composition of the assets and liabilities whose trade makes up capital flows can vary. The effect of such variation on equations like (8) is difficult to analyse. An expected appreciation of j-currency would be likely to increase the demand for *j*-denominated assets, wherever they were issued. Such *j*-assets are clearly most likely to be issued in country *j* but may also be issued in other countries which trade with *j* and require transaction balances of *j*-currency. This applies particularly where the currency is the dollar and, to a lesser extent, the Deutschmark and the Swiss franc. Foreign financial assets of the United States and Germany are denominated largely in dollars and Deutschemarks respectively and not in foreign currencies. An expected appreciation of the dollar, for example, might therefore induce relatively little desired repatriation of funds by U.S. residents. However, while an expected appreciation of *j*-currency will increase the demand for *j*-denominated assets, it will tend to reduce their supply. Borrowers can borrow more cheaply in other currencies, and j-residents in particular will be more inclined to borrow in foreign currency. Both on the demand and supply side, therefore, the expected appreciation will tend to generate an *ex ante* capital inflow into *j*. The net liabilities of *j*-residents will tend to increase but the currency of composition of the increase is indeterminate; lenders want to lend j-currency, borrowers want to borrow something else.

It is also a fact that in many smaller countries foreign borrowing is organised through state or public sector agencies which can frequently obtain better terms and longer maturities than private borrowers. The latter are left to borrow on the domestic market while the state borrows foreign currency to cover any expected current balance deficit, given an exchange-rate target. In principle, this would allow domestic interest rates to be disconnected from foreign borrowing. However, in practice the authorities in such countries tend to raise domestic interest rates the more they have to borrow abroad, for three reasons: it encourages some private foreign borrowing to restrain public foreign indebtedness; it affects domestic activity and hence the current balance that has to be financed; the terms obtainable even by sovereign borrowers in foreign currency are somewhat affected by their scale of current and past borrowing and the authorities usually relate domestic rates to their own cost of borrowing. Finlink does not model these institutional features and the coverage of the compensatory finance term in the model is doubtless inadequate because of data limitations. The practices described mean, however, that even capital flows with a public-sector component will be related to yields on domestic assets. However, as currency compositions shift over time, the parameters of such capital flow equations are likely to do so too.

B. Expected exchange rates

A key variable in the capital flow equation is the expected effective exchange rate which is an important determinant of the expected yield on any country's securities. In current Finlink, the expected effective exchange rate is a consistent weighting of the expected bilateral exchange rates in the system. The equation in each country model for the expected bilateral exchange rate therefore interacts crucially with the capital flow equation. This section deals with the specification of the expected exchange-rate equation; the next section deals with the actual determination of exchange rates.

Three approaches have been tried for modelling the expected exchange rate. Each consists of trying to model actual exchange rates in a reduced-form manner and then using the resultant equation, together with the information supposed available to agents at time t, to generate an expected exchange rate where the expectation is held at time t and applies to time $t+1$. The three approaches to modelling the exchange rate were: an ARIMA univariate model, a much simplified unrestricted reduced form of INTERLINK itself, and an *ad hoc* equation specifying a form of long-run purchasing power parity. The third approach, which is used in the current model, is described in detail below. There is, however, a general problem of modelling expected exchange rates in a model like Finlink which affects all methods.

The general problem is as follows. The exchange rate is determined by balance-of-payments equilibrium. Owing to J-curve effects, however (whereby changed terms of trade initially outweigh the effects of volume adjustments), a depreciation (appreciation) of the exchange rate makes the current balance more negative (positive) in the short run. If the model is to solve for the exchange rate therefore (abstracting from official intervention), a depreciation has to induce an *ex ante* capital inflow which exceeds the *ex ante* deterioration in the current account. A depreciation induced by an *ex ante* negative balance of payments (i.e. reserve losses) would then, and only then, be capable of restoring equilibrium. One mechanism whereby the exchange depreciation is supposed to induce this inflow is the so-called portfolio rebalancing effect. Changes in currency parities entail changes in the proportions of different currencies in total portfolios at current valuations. If portfolio holders wish to hold currencies in certain fixed proportions, then, in the absence of changes in relevant variables such as relative yields, their "rebalancing" of portfolios following a depreciation might result in a stabilizing capital flow[11]. Such effects do not exist in the current version of the model. Indeed, as noted in the description of the capital flow equation, changes in distribution of world wealth, which would follow parity changes if portfolios were valued at current prices, are abstracted from in the specification and agents are presumed to value their portfolios at a constant set of accounting exchange rates.

This means that in the current version of the model, stabilizing capital flows can occur only through regressive expectations in exchange rates. When the current spot rate changes, the expected future spot rate must change by less, so that an expected appreciation or depreciation is set up opposite in direction to the change that has occurred. Furthermore, given the J-curve, it is not enough that the elasticity of expectations for exchange rates be between zero and one; it has to be within that range but sufficiently below one for the induced capital flow to dominate the adverse movements in the current balance. In practice, this means a usable equation for the expected exchange rate cannot have too large a coefficient on the actual exchange rate. The estimated equation on which it is based cannot have too large a coefficient on the lagged dependent variable.

The approach to expected exchange rates currently in use assumes that, in the long run, exchange rates move so as to offset differential rates of inflation of tradeable goods prices. Tradeable goods prices were proxied by the deflator for gross domestic product which seems the least bad of available evils. The relationship is a long-run one and meanwhile the course of the exchange rate is allowed to be influenced by changes in relative monetary conditions, proxied by changes in short-term interest-differentials, and changes in the price of imported energy. The long-run real exchange rate, however, could be a function of relative rates of return to capital and hence the long-run capital flows in a country's "basic balance". This was represented in the equation by a long-run interest-rate differential.

To enforce long-run homogeneity of degree one between relative prices and nominal exchange rates, an error correction specification was adopted[12]:

$$\begin{aligned}\Delta exch_t = a_0 &+ a_1 \Delta(pgdpus_{t-1} - pgdp_{t-1}) \\ &+ a_2(pgdpus_{t-1} - pgdp_{t-1} - exch_{t-1}) \\ &+ a_3[NFATS_{t-1}/(PGDPUS_{t-1}/PGDP_{t-1})] \\ &+ a_4 \Delta(IRS_{t-1} - IRSUS_{t-1}) \\ &+ a_5 \Delta(pmed_{t-1}) \\ &+ a_6(IRL_{t-1} - IRLUS_{t-1}) + u_t\end{aligned} \tag{9}$$

implying in steady state equilibrium that $\boldsymbol{EXCH = kPGDPUS/PGDP}$ where $\boldsymbol{k}$ depends on the long-run interest differential. ***EXCH*** is the bilateral dollar exchange rate, and ***exch*** is its natural logarithm, ***PGDPUS*** and ***PGDP*** are United States' and domestic GDP deflators (local currency) respectively and ***pgdpus*** and ***pgdp*** are their logs, ***NFATS*** is the level of net foreign assets in dollars, ***IRS*** and ***IRSUS*** are domestic and United States' interest rates, ***pmed*** is the log of the index of imported energy in dollars and u_t is a stochastic error term. Lower-case mnemonics for a variable indicate it is in logs and the prefix A indicates a first difference. A feature of this specification is that, across steady states, proportionate changes in relative GDP deflators will be reflected by equi-proportionate changes in the exchange rate (for given interest rates). The term in a_2 might be termed the "proportionate correction mechanism" whereby any deviation of the exchange rate from its equilibrium relation to relative prices sets up a correction.

Some explanation of the term in a_3 is in order. It is intuitively reasonable that the exchange rate might be affected by the net debtor or creditor position of the country concerned, denoted in dollars and adjusted for the terms of trade. Indeed, as a period of current-balance disequilibrium leads to an accumulation of foreign assets or liabilities it implies continuing interest flows as debt is serviced. The real exchange rate may need to change to equilibrate the balance of payments, taking such flows into account. The term might also be seen as an "integral correction mechanism"[13]. If relative inflation rates continue to diverge, the proportional correction term might be inadequate to ensure that equilibrium is restored in a finite time. It is reasonable to suppose, however, that a continued divergence of the real exchange rate from its equilibrium value will have consequences for the current account. It could be hypothesised that:

$$CBD_t = f\left[\sum_{i=0}^{n} v_i (PGDPUS_{t-i}/PGDP_{t-i})\right]$$

In that case the integral over time of such disequilibria would be functionally related to the time integral of current balance positions, viz. the net foreign asset position in dollars[14]. The term in a_3 therefore helps to ensure homogenity between the logs of exchange rates and relative prices even when there is a trend in the latter.

The other variables enter the equation only in first-difference form, so that they affect the time path of the exchange rate but not its equilibrium value. Changes in relative monetary conditions, proxied by changes in short-term interest rates, or in the price of traded energy, given different degrees of dependence on imported energy, can affect the relationship because of short-term price stickiness.

All variables enter the equation with a lag. This means the equation can be used in the model for expected exchange rates, without supposing that agents at time t have information on variables at time t+1 as:

$$EXCHX_t^{t+1} = EXCH_{t+1} - u_{t+1},$$

If u is random, equation **(9)** becomes that for the expected exchange rate (because at time t the expected value of u_{t+1} is zero). The lagged terms in explanatory variables may be interpreted as reduced-form representations of the effects on expected exchange rates via their effect on their own expected future values.

C. Exchange rate determination

Various restrictions and procedures described in Part III A ensure that capital flows always add up correctly and that capital inflows into j from any country i

always equal outflows from *i* to *j*. As this equivalence holds identically, given the definition of net capital flows, it cannot be made the basis of exchange-rate determination in the model. Capital flows will balance at any exchange rate. Exchange rates are determined by the characterisation of equilibrium that desired capital flows must equal the current balance (plus any official intervention).

Using a balance-of-payments equilibrium condition to determine exchange rates has been criticised. One (erroneous) criticism is that it determines exchange rates via a flow equilibrium and ignores stocks. That is not necessarily so. In a general equilibrium system it is somewhat arbitrary to allocate the determination of a variable to any single relation. Nonetheless, capital flows can be seen as the result of the adjustment of world wealth holders to a full stock equilibrium. In that equilibrium the savings and expenditure decisions of agents result in a pattern of current balances and their portfolio preferences among financial assets determine consistent capital flows. And if *n* markets are identifiable it is possible to drop any one of them using Walras' law. It is then possible to regard the balance-of-payments identity as an equilibrium condition which determines the price in an omitted market? Nor is this practice at all inconsistent with modern asset-market theories of the exchange rate. It requires only that the instruments of different countries or instruments issued in different currencies are not perfect substitutes in the portfolios of wealth holders, so that a finite capital flow is determined by a given expected yield differential. If assets are perfect substitutes then yield differentials on financial assets alone determine exchange rates without any risk premium associated with the current balance or foreign indebtedness. Casual empiricism suggests that perfect substitutability can only hold, if at all, within a certain range of current balance positions and, therefore, asset supplies and demands. As a global proposition it is deeply implausible.

In Finlink, goods prices are proximately determined in domestic goods and labour markets; interest rates are proximately determined in domestic money markets and, in the absence of a foreign exchange market as such, the balance-of-payments equation determines the exchange rate. It should be noted that in a world model, such as this one where a vector of exchange rates is simultaneously determined, the balance-of-payments flows of any single country reflect the asset preferences of residents of all countries in the system. In the complete model, $n-1$ independent balance-of-payments conditions thus determine the $n-1$ exchange rates. The model, however, does not have a consistent flow-of-funds framework with bond supply being consistent with net lending positions of domestic sectors.

Other arguments against this method of determining exchange rates hinge on the fact that countries can and do incur debt in other than their own currencies[16]. This can mean that geographical flows cannot be identified with sales and purchases of assets denoted in a given currency and, it is argued, sources of ***ex ante*** pressure may be incorrectly specified. A comprehensive model would resolve this difficulty by distinguishing assets by currency of denomination as well as by holder and by identity of the issuer. However, this is impracticable for all but a handful of OECD countries because of data limitations. It would also make for an exceedingly intricate model. It seems possible in general to make substitutions so that the balance-of-payments equation can be used to determine the exchange rate irrespective of "internal" exchange transactions. To see this, assume for any country j that an equation analogous to (3) can be written—but representing the net demand for assets in foreign currency (A_j) irrespective of geographical location of the borrower. Then j's net demand for i currency assets/liabilities could be written:

$$A_{ij}=(c_{ij}+\sum_k b_{ijk}Y_k)s_jWWD$$

For each country j, the wealth constraint implies:

$$s_jWWD=\sum_i A_{ij} \qquad (10)$$

An equilibrium condition could be written for assets denominated in j currency:

$$B_j=\sum_i A_{ji} \qquad (11)$$

where B_j is the stock of "outside" assets in j-currency. Now following Stevens *et al. (op. cit.)*, (10) can be substituted into (11):

$$B_j=A_{jj}+\sum_{i\neq j} A_{ji}=s_jWWD-\sum_{i\neq j}(A_{ij}-A_{ji})$$

hence

$$s_jWWD-B_j=\sum_i A_{ij}-A, \qquad (12)$$

The left-hand side is j's net claim position against foreigners on the assumption that j is the only source of outside j-denominated assets. The time derivative of (12) asserts that net incremental demands for j of foreign assets minus foreigners' demands of j-currency assets should equal j's current account in equilibrium.

In practice, OECD governments do borrow in foreign currencies so that j need not be the only source of outside j-currency assets (B_j). In Finlink a beginning has been made to solving this problem by defining a separate variable, compensatory finance. However, the coverage of this variable is incomplete which means the Finlink capital flow equations are, for the moment, best interpreted as "geographical". The probable instability of "geographical" capital flow equations remains a drawback. More complete accounting for government foreign currency borrowing would allow capital flows in equilibrium to be interpreted more nearly in terms of currency preferences.

IV. EMPIRICAL WORK

A. Estimation of capital-flow parameters

Two different estimation methods were used for capital flow relations, though each had common elements. In both, a first step was to obtain extraneous information on the s_{ik} "share" parameters of the capital flows to non-OECD zones. This information was used to construct "prior" estimates of the share parameters which were subsequently modified in a Bayesian spirit by mixed regression.

Quite complete data are available on total resource flows from OECD countries to less-developed countries. Shares of each OECD country in the total flow from the OECD to the LDC zone can be calculated from the statistics maintained by the Development Co-operation Directorate of the OECD[17]. These shares are quite stable over time. Shares of flows to or from other non-OECD zones are less well documented. Shares of flows to the rest-of-the-world zone for each OECD country were estimated as an average of trade shares with this zone (as appearing in the trade matrix used in the model and constructed from bilateral balance-of-payments statistics) and shares of total gross capital flows of OECD countries. Gross flows of all OECD countries—the sum of absolute inflows and outflows—were calculated for five years 1975-1979, the share of each in the total was calculated for each year and the annual shares were then averaged. Shares of the statistical discrepancy counterpart flow were estimated by taking shares of total gross capital flows.

Data are available on the currency composition of OPEC reserves. These were used as prior estimators of s_{io} (the shares of the total flow between OPEC and the OECD). Obviously this imparts a bias to the estimate–OPEC holds dollar deposits elsewhere than in the United States, for example, so currency composition and geographical destination of the flow may be unrelated. This was compensated by specifying a diffuse prior variance for the share of OPEC flows. The prior estimators with their variances are shown in Table 2.

The next step was to use these priors in a mixed regression of the capital-flow equation. The regression was by two-stage least squares on quarterly data and resulted in ***a posteriori*** "mixed" estimates of the s_{ik}. There are shown in Table 3. Noteworthy is the lower posterior estimate of the share of OPEC flows going to the United States, consistent with the reasoning of the last paragraph. Estimation results are shown in Table **4.** The most important feature is the generally low value of the Theil χ^2 statistic, indicating that the "prior" and sample information is compatible and the "mixed" estimates are well determined. This is true everywhere except the United States (where the reason is known) and Italy.

In all other respects the estimation results are generally poor. The terms in interest differentials and changes in interest differentials are usually correctly signed, but the changes in expected appreciation are often wrong-signed and are never well-determined. **A** set of results is shown for a standard specification. Improved results can be obtained by marginal changes in specification for each country (and the best results were used to obtain the posterior estimates of Table 3). Among the variations tried were the inclusion of terms in the change in current balance and the lagged current balance, reflecting trade credit, the lagged dependent variable, and terms in which a yield differential was multiplied by the absolute OPEC balance–in an attempt to endogenise OPEC's placement of capital. The current balance terms were significant for only a few countries (the United Kingdom, Italy, Canada and Japan) and generally did not help the equation. The lagged capital flow term was also significantly different from zero in only three countries (Canada, Switzerland and Italy). The OPEC terms were almost always

Table 2. Initial ("prior") estimates of share of OECD countries in capital flow counterpart to current balances of non-OECD zones

	OPEC	Less developed countries	Rest of world	Statistical discrepancy
United States	0.60 (0.01)	0.32 (0.012)	0.20 (0.007)	-0.24 (0.007)
United Kingdom	0.03 (0.02)	0.15 (0.0027)	0.10 (0.001)	-0.09 (0.001)
France	0.03 (0.0005)	0.09 (0.0019)	0.09 (0.0010)	-0.11 (0.0030)
Germany	0.20 (0.0050)	0.08 (0.0014)	0.17 (0.0030)	-0.15 (0.0030)
Italy	0.00 (0.0010)	0.03 (0.0002)	0.07 (0.0010)	-0.05 (0.0020)
Belgium	0.00 (0.0010)	0.03 (0.0002)	0.03 (0.0040)	-0.06 (0.0040)
Netherlands	0.01 (0.0001)	0.03 (0.0003)	0.04 (0.0010)	-0.04 (0.0010)
Canada	0.00 (0.0001)	0.05 (0.0003)	0.03 (0.0001)	-0.05 (0.0002)
Japan	0.07 (00050)	0.16 (0.0081)	0.10 (0.0030)	-0.11 (0.0030)
Switzerland	0.06 (0.0025)	0.02 (0.0006)	0.04 (0.0040)	0.00 (0.0001)
Total	1.00	0.96	0.84	-0.90

Bracketed numbers are prior variances.

Table 3. Posterior estimates after mixed regression

	OPEC	Less developed countries	Rest of world	Statistical discrepancy
United States	0.35	0.39	0.20	-0.23
United Kingdom	0.030	0.12	0.087	-0.096
France	0.037	0.067	0.086	-0.11
Germany	0.081	0.087	0.17	-0.14
Italy	0.088	0.011	0.057	-0.051
Belgium	0.017	0.023	0.024	-0.049
Netherlands	0.016	0.025	0.046	-0.039
Canada	0.001	0.042	0.029	-0.051
Japan	0.11	0.13	0.10	-0.11
Switzerland	0.002	0.008	0.00	0.00
Total	0.73	0.90	0.80	-0.88

Table **4. Capital flow equation - Single equation, mixed regression**

Estimation period: Q2 1973 to Q3 1980

	ΔWWD	Δ(IRS — IRFOR)	Δ(EXCHE — EXCH)	(IRS — IRFOR)	(EXCHE — EXCH)	OPEC	LDCs	RW	SD	DUM
United States	−0.79	−0.011	−0.00050	0.30	0.0030	0.30	0.41	0.21	−0.23	
	(1.2)	(0.5)	(0.3)	(1.1)	(0.1)	(2.7)	(2.8)	(1.8)	(2.0)	
	$\bar{R}^2 = 0.41$		DW = 2.0		$X^2 = 26.5$					
United Kingdom	0.099	0.0019	0.00012	0.20	0.013	−0.041	0.14	0.098	−0.091	−0.013
	(0.5)	(0.9)	(0.4)	(4.0)	(1.6)	(1.2)	(2.8)	(3.1)	(2.8)	(1.1)
	$\bar{R}^2 = 0.55$		DW = 1.8		$X^2 = 4.8$					
France	−0.24	0.0051	−0.000047	0.042	0.00072	0.045	0.066	0.090	−0.11	
	(1.3)	(1.1)	(0.2)	(1.0)	(0.1)	(2.3)	(1.6)	(2.8)	(2.0)	
	$\bar{R}^2 = 0.40$		DW = 2.5		$X^2 = 5.0$					
Germany	−0.88	0.0080	0.00035	−0.09	0.058	0.13	0.086	0.18	−0.14	−0.58
	(3.0)	(1.3)	(0.9)	(1.7)	(4.1)	(2.6)	(2.2)	(3.2)	(2.5)	(1.3)
	$\bar{R}^2 = 0.55$		DW = 2.0		$X^2 = 5.9$					
Italy	−0.71	0.0026	−0.000071	0.078	−0.0046	0.074	0.017	0.060	−0.058	
	(6.0)	(1.0)	(0.3)	(6.1)	(0.6)	(3.1)	(0.9)	(1.4)	(0.9)	
	$\bar{R}^2 = 0.63$		DW = 1.3		$X^2 = 28.2$					
Belgium	0.015	0.0023	−0.00064	0.0028	−0.0070	0.0047	0.027	0.055	−0.051	
	(0.2)	(1.9)	(3.8)	(2.5)	(1.7)	(0.4)	(1.9)	(1.1)	(0.8)	
	$\bar{R}^2 = 0.38$		DW = 2.0		$X^2 = 4.6$					
Netherlands	0.087	0.0031	−0.00014	0.036	−0.00082	0.013	0.030	0.051	−0.037	
	(1.0)	(1.6)	(0.5)	(1.6)	(0.9)	(1.4)	(1.7)	(1.6)	(1.1)	
	$\bar{R}^2 = 0.22$		DW = 2.1		$X^2 = 6.3$					
Canada	0.16	0.0034	0.00072	0.11	0.027	0.0029	0.037	0.028	−0.052	
	(2.2)	(1.7)	(2.1)	(2.9)	(2.7)	(0.3)	(1.9)	(2.4)	(3.2)	
	$\bar{R}^2 = 0.37$		DW = 2.0		$X^2 = 12.2$					
Japan	−0.18	0.0044	0.00077	0.042	−0.0042	0.090	0.12	0.098	−0.11	
	(0.8)	(0.9)	(2.4)	(1.0)	(0.4)	(1.5)	(1.4)	(1.8)	(2.0)	
	$\bar{R}^2 = 0.44$		DW = 2.0		$X^2 = 3.1$					
Switzerland	−0.27	−0.00063	0.000023	−0.013	0.0057	0.011	0.011	0.00029	−0.0000098	
	(1.6)	(0.5)	(0.3)	(0.8)	(2.4)	(0.9)	(0.5)	(0.0)	(0.0)	
	$\bar{R}^2 = 0.05$		DW = 0.7		$X^2 = 2.8$					

Numbers in parentheses are "t" values.

Notes: 1. Specification $CAPFLO/WWD = a_1 \Delta WWD/WWD + a_2 \Delta(IRS - IRFOR) + a_3 \Delta(EXCHE - EXCH) + a_4 (IRS - IRFOR)\Delta WWD/WWD + a_5 (EXCHE - EXCH)\Delta WWD/WWD + a_6 \Delta CBD/WWD + a_7 OPEC/WWD + a_8 LDCs/WWD + a_9 RW/WWD + a_{10} SD/WWD$ (a, = a, = 0)

2. DUM UKM = Q4 1979 to Q3 1982 = 1, elsewhere = 0, representing abolition of exchange control.
DUM GER = Q2 1973 to Q1 1975 = ΔCBD, elsewhere = 0, eliminating atypical behaviour during the first oil-price shock.

3. X^2 is a statistic indicating compatibility of sample and extraneous information. See Johnston, "Econometric Methods", 2nd edition, pp. 221-227. The critical value in this regression, when the statistic is calculated with nine degrees of freedom, is about 21.

wrong-signed, suggesting that OPEC assiduously seeks investments with the lowest expected yield! They were not retained in the specification.

To further explore the trade credit issue, separate data were obtained for this component of net flows and regressions carried out relating trade credit to changes in the current balance. Results are shown in Table 5. They show that, although net trade credit is often a substantial proportion of total capital flows, its apparent responsiveness to changes in the current balance is rather small (except in Japan), so that probably the current balance terms may be dropped from the capital flow equation, particularly as compensatory finance, which is responsive to current balance developments, is accounted for separately.

Table 5. Estimated equations for trade credits (TC)

	Constant	ACBD	TC_{-1}	$\bar{R}^2$	DW
United States	—	−0.0198 (1.0)	0.841 (4.2)	0.60	2.2
United Kingdom	—	0.0261 (0.4)	0.952 (4.6)	0.69	2.7
France	—	−0.0334 (0.6)	1.1 (10.1)	0.90	1.2
Germany[1]	−1 910.0 (6.2)	−0.0520 (1.7)	−0.0961 (0.6)	0.19	2.9
Italy	−390.0 (0.7)	−0.0310 (0.2)	0.147 (0.2)	−0.24	1.9
Belgium	—	−0.0505 (1.1)	0.716 (0.2)	0.15	2.5
Netherlands[1]	—	0.00647 (0.8)	0.325 (0.2)	−0.05	1.2
Canada	−222.0 (1.9)	−0.0521 (1.5)	0.681 (3.0)	0.46	2.4
Japan	—	−0.159 (3.4)	0.0674 (0.3)	0.49	2.0

Numbers in parentheses are "t" statistics.
1. Estimation period is 1971 to 1981. But Germany is 1976 to 1981 and the Netherlands is 1972 to 1981.

An important step in all estimation was the selection of a weighting matrix to construct effective exchange rates and foreign interest rates. It is reasonable to suppose that the closer the trading links between two countries, the greater will be both desired asset balances and credit requirements of residents of one country in the currency of the other. In a global framework their assets are therefore more

Table 6. **Capital flows weighting matrix**

	USA	UKM	FRA	GER	ITA	BEL	NET	CAN	JAP	ASL	OST	DEN	IRE	NOR	SWE	SWI	SPA
USA	0.000	0.654	0.418	0.609	0.488	0.371	0.304	0.924	0.856	0.690	0.361	0.475	0.492	0.464	0.465	0.514	0.629
UKM	0.120	0.000	0.047	0.050	0.034	0.036	0.053	0.017	0.024	0.059	0.056	0.118	0.295	0.121	0.100	0.056	0.048
FRA	0.072	0.035	0.000	0.034	0.063	0.099	0.068	0.004	0.011	0.019	0.031	0.027	0.028	0.031	0.038	0.053	0.052
GER	0.316	0.136	0.325	0.000	0.291	0.348	0.448	0.024	0.060	0.077	0.314	0.211	0.101	0.227	0.209	0.242	0.164
ITA	0.048	0.019	0.054	0.047	0.000	0.029	0.033	0.004	0.007	0.013	0.045	0.022	0.012	0.021	0.021	0.040	0.023
BEL	0.013	0.008	0.020	0.018	0.008	0.000	0.023	0.001	0.002	0.003	0.005	0.005	0.006	0.006	0.008	0.006	0.006
NET	0.033	0.014	0.022	0.033	0.016	0.049	0.000	0.002	0.004	0.005	0.014	0.012	0.011	0.014	0.016	0.012	0.013
CAN	0.134	0.011	0.005	0.007	0.005	0.004	0.003	0.000	0.010	0.010	0.005	0.006	0.008	0.006	0.007	0.006	0.007
JAP	0.141	0.023	0.017	0.021	0.015	0.011	0.011	0.016	0.000	0.107	0.015	0.015	0.013	0.016	0.016	0.025	0.017
ASL	0.016	0.008	0.002	0.003	0.002	0.001	0.002	0.001	0.005	0.000	0.002	0.002	0.003	0.002	0.003	0.004	0.002
OST	0.003	0.003	0.003	0.012	0.004	0.002	0.003	0.000	0.001	0.001	0.000	0.004	0.001	0.003	0.005	0.012	0.002
DEN	0.007	0.007	0.004	0.008	0.003	0.004	0.006	0.001	0.001	0.001	0.007	0.000	0.003	0.023	0.028	0.006	0.003
IRE	0.003	0.014	0.001	0.002	0.001	0.001	0.002	0.000	0.000	0.001	0.001	0.003	0.000	0.002	0.003	0.001	0.002
NOR	0.006	0.006	0.003	0.006	0.002	0.003	0.004	0.001	0.002	0.001	0.005	0.022	0.003	0.000	0.030	0.005	0.003
SWE	0.009	0.010	0.005	0.010	0.004	0.005	0.006	0.001	0.002	0.002	0.010	0.033	0.005	0.035	0.000	0.008	0.004
SWI	0.057	0.044	0.063	0.081	0.049	0.030	0.029	0.003	0.011	0.008	0.122	0.039	0.014	0.023	0.042	0.000	0.025
SPA	0.022	0.008	0.011	0.010	0.009	0.007	0.006	0.001	0.002	0.002	0.005	0.006	0.006	0.006	0.009	0.010	0.000
Fixed point vector																	
	0.380	0.071	0.057	0.200	0.037	0.012	0.024	0.055	0.065	0.008	0.005	0.006	0.003	0.005	0.008	0.050	0.013

Note: For definition of countries see Annex.

likely to be close substitutes. However, some countries have currencies which are widely accepted in trade between other countries—reserve currencies. Such countries tend to lend in their own currencies. The substitutability of the instruments of such countries for the instruments of all others will be, so far as the residents of all other countries are concerned, higher than would be suggested by trade relations. This suggests that the appropriate matrix of w_{ij} should combine information about trade flows with information on the relative importance of reserve currencies. This was done in an iterative manner. The starting point was a MERM weight matrix based on trade shares and elasticities. Data on different countries' commercial banks' holdings of foreign currencies and the currency composition of official reserves were then used to construct a currency weighting matrix[18]. The geographical capital flows weighting matrix was assumed to be some weighted average of trade- and currency-weight matrices.

A number of matrices were generated with different weighted averages and estimation repeated with each. This was done both in capital-flow estimation and also in the estimation of interest-rate equations which used the foreign interest rate as an argument. The data did not readily discriminate between the different matrices and one was finally selected partly on the basis of results but also on grounds of *a priori* reasonableness. This matrix is shown in Table 6. The importance of the matrix is, of course, that its unique fixed-point vector determines the restrictions to be imposed on capital flow parameters. The fixed-point vector of the chosen matrix is also shown in Table 6. Its elements may be interpreted as indicating the overall importance of the corresponding country in the financial flows system. Importance is itself composed of two elements: the country's share of world wealth and the extent to which residents of other countries regard its assets as substitutable for their own.

In completing the estimation of capital flow equations there was a bifurcation in estimation procedure. In one case, presented in the following paragraphs, the dependent variable was adjusted by subtracting the non-OECD current balances multiplied by the *a posteriori* share coefficients to give an estimate of intra-OECD capital flows for each country. The equation for nine countries for this variable were then re-estimated simultaneously by three-stage least squares. In estimation, the cross-country parameter restrictions were imposed. Results are shown in Table 7. Estimation at this stage moved to use of semi-annual data to be consistent with the INTERLINK model. The cross-country restrictions have a very practical econometric function, namely preserving necessary degrees of freedom. On semi-annual data the sample consists of fewer than twenty observations per country, given that generalised floating did not begin before 1973. Estimating each country equation separately would result in unstable estimates arising from an excessively small sample. The actual procedure, in effect, pools the time series of a number of countries in order to estimate relatively few independent parameters. With a number of countries estimated simultaneously, the number of predetermined variables in the system usable as instruments becomes very large. To keep the number of instruments manageable, when instrumental variables were being constructed as the "fitted" values of endogenous variables, principal components

Table 7. Capital flow estimation

		Coefficients	"t" value
a_1	United States	−0.0077	3.0
	United Kingdom	0.0013	0.9
	France	−0.0021	2.8
	Germany	−0.00084	0.4
	Italy	−0.0043	4.5
	Belgium	0.00023	0.7
	Netherlands	−0.000075	0.2
	Canada	0.0021	3.7
	Japan	−0.00070	0.6
a_2		0.00019	2.2
a_3		0.000041	1.2
a_4		0.0018	3.1
a_5		0.000088	0.2

Weighted distance	0.0000224
Weiahted SEE	0.000446
Sum- of squared residuals	0.0000294
SE of estimate	0.000510
Log likelihood function	783.0
Correlated coefficient SQ.	0.241

	Sum of squared residuals	SE of estimate	Log likelihood function	Corr. coeff. SQ.
United States	0.0000107	0.00327	78.7	0.228
United Kingdom	0.00000363	0.00191	86.3	0.00658
France	0.000000931	0.000965	95.8	0.155
Germany	0.00000746	0.00273	81.3	0.0281
Italy	0.00000190	0.00138	90.8	0.341
Belgium	0.000000210	0.000458	106.0	0.0525
Netherlands	0.000000367	0.000606	102.0	0.000368
Canada	0.000000700	0.000837	97.8	0.109
Japan	0.00000352	0.00188	86.5	0.493

Specification: $CAPFLO_i = a_{1i}\Delta WWD + v_i[a_2\Delta(IRS_i - IRFOR_i) + a_3 200\Delta(\ln EXCHEX_i - \ln EXCHE_i)WWD + v_i[a_4(IRS_i - IRFOR_i) + a_5 200(\ln EXCHEX_i - \ln EXCHE_i)]\Delta WWD]$.

Cross-country restriction: vUSA = 1.0, vUKM = 0.19, vFRA = 0.15, vGER = 0.53, vITA = 0.097, vBLX = 0.032, vNET = 0.063, vCAN = 0.14, vJAP = 0.17

For notation see Table 1.

were taken of all the predetermined variables in the system and the most important of these were used as "first-stage" regressors.

A feature of the results is that the terms in interest rates and expected appreciation are now correctly signed. The coefficients on expected appreciation are smaller and worse-determined than those on interest differentials. And coefficients on changes in differentials are generally smaller than those on differentials themselves. These results no doubt reflect errors in variables; expected exchange rates are represented by an instrument obtained by regressing the actual exchange rate with a one-period lead on linear combinations of all the predetermined variables in the system. No doubt this inadequately captures expectations. Furthermore, expected appreciation is the difference between this variable and an instrument for the actual exchange rate (obtained by regressing current values of the exchange rate on linear combinations of predetermined variables). The change in expected appreciation is then the second difference. Quite obviously, this is likely to be a highly inefficient instrument and a well-determined parameter cannot be expected.

A consequence of taking these results at face value is that, contrary to much portfolio balance theorising, capital flows are bigger in response to expected yield differentials than to changes in such differentials. This means that there is a reasonably steady incipient flow of capital which goes on little diminished in response to an interest differential or expected appreciation, and not a flood of capital, as portfolios are adjusted, followed by a much smaller flow as subsequent growth in portfolios is allocated. That is rather counter to current conventional wisdom. Given the size of the estimated parameters, it also implies that capital flows in response to differentials are generally of a size that can be offset by official intervention for quite a long time.

Doubt about these features of the results led to the second estimation procedure. In this the stock demand function for net foreign assets (equation 3 Part III) was taken and renormalized as an equation for the exchange rate:

$$CAP_{oj} = \left[a_j + v_j b(IRS_j - IRFOR_j) + v_j c\,[LN(EXCHEX_j) - LN(EXCHE_j)] \right] WWD$$

where v_j is j's element of the fixed-point vector and the parameters thereby embody the fixed-point restriction. The o subscript indicates that these are net assets with respect to other **OECD** countries. Rearranging gives:

$$LN(EXCHE_j) = a_j/(v_j c) + b/c(IRS_j - IRFOR_j) + LN(EXCHEX_j) - 1/(v_j c)CAP_{oj}/WWD$$

which is the estimated equation. The estimation is by three-stage least squares and uses the minimum distance procedure of Amemiya; the iterative algorithm permits cross-equation coefficient restrictions. The v_j's cancel in the coefficient on interest rates which is therefore common to all countries. The vector cross-country restriction applies to the final, net foreign assets, term.

The results for a country sample are shown in Table ***8.*** Private net foreign assets series *(NFA)* were constructed by calculating for each country a base-year benchmark by capitalising interest payments in the balance-of-payments data, using current interest rates, and then cumulating capital flows, excluding compensatory finance, on this benchmark. The variable was adjusted to correspond to

Table 8. Net foreign asset equation, normalized on exchange rate, Seven countries

Semi-annual data, estimation period S1 1973 to S1 1981

		Coefficients	"t" value
a_1	United States	–0.012	0.9
	United Kingdom	–0.0085	0.6
	France	–0.0061	0.4
	Germany	–0.0020	0.2
	Italy	..	..
	Belgium		..
	Netherlands	–0.0099	1.0
	Canada	0.024	2.1
	Japan	–0.016	0.8
a_2/a_3		0.96	1.9
$1/a_3v_i$		127.9	2.0

$a_2 = 0.0075$
$a_3 = 0.0078$

Weighted distance	0.124
Weighted SEE	0.0359
Sum of squared residuals	0.250
SE of estimate	0.0510
Log likelihood function	168.0
Correlated coefficient SQ.	0.819

	Sum of squared residuals	SE of estimate	Log likelihood function	Corr. coeff. SQ.
United States	0.0331	0.0743	24.6	0.645
United Kingdom	0.0372	0.0787	23.7	0.825
France	0.0380	0.0795	23.6	0.265
Germany	0.0321	0.0732	24.8	0.845
Italy	..	..	..	..
Belgium	..		.	..
Netherlands	0.0136	0.0475	3i.3	0.674
Canada	0.00971	0.0402	33.8	0.901
Japan	0.0859	0.120	17.4	0.715

Specification: $\ln EXCHE_i = a_{1i} + \ln EXCHEX_i + a_2/a_3(IRS_i - IRFOR_i)/200 + 1/(a_3 v_i)(NFA_i + a_4\ NONOECD)/200.$

Notation: See Table 1; NFA_i private net foreign assets of OECD country i; NONOECD non-OECD zones net foreign assets,

Cross-country restriction: vUSA = 1.0 vUKM = 0.19 vFRA = 0.15 vGER = 0.53 vITA = 0.097
vBLX = 0.032 vNET = 0.063 vCAN = 0.14 vJAP = 0.17

NB. a_4 is an imposed coefficient equal to a weighted average of posterior estimates from mixed regression.

Table 9. **Net foreign asset equation, normalized on exchange rate, Nine countries**

Semi-annual data, estimation period S1 1973 to S1 1981

		Coefficients	"t" value
a_1	United States	−0.0056	0.5
	United Kingdom	0.0025	0.2
	France	0.0054	0.4
	Germany	−0.0073	0.6
	Italy	0.0331	2.5
	Belgium	−0.011	t.2
	Netherlands	−0.0086	1.1
	Canada	0.019	2.6
	Japan	−0.016	0.8
a_2/a_3		0.30	2.2
$1/a_3v_1$		63.8	2.6

$a_2 = 0.0047$
$a_3 = 0.016$

Weighted distance	0.142
Weighted SEE	0.0338
Sum of squared residuals	0.298
SE of estimate	0.0490
Log likelihood function	221.0
Correlated coefficient SQ.	0.863

	Sum of squared residuals	SE of estimate	Log likelihood function	Corr. coeff. SQ.
United States	0.0332	0.0911	24.6	0.655
United Kingdom	0.0402	0.100	23.1	0.811
France	0.0342	0.0924	24.4	0.303
Germany	0.0337	0.0918	24.5	0.838
Italy	0.0359	0.0947	24.0	0.924
Belgium	0.0173	0.0658	29.4	0.631
Netherlands	0.0121	0.0551	32.1	0.694
Canada	0.0100	0.0500	33.6	0.899
Japan	0.0815	0.143	17.8	0.740

For notation see Table 8.

assets held with respect to other OECD countries (excluding those with non-OECD zones and the six OECD countries in set II) by using the parameters for shares of capital flows to non-OECD zones, deriving from mixed regression. (See Annex.)

With parameters estimated via the re-normalized stock relation, the capital flow equation is derived analytically by differentiation of the stock relation. It was assumed that equilibrium is maintained from one half-year to another. The possibility that asset stocks adjust more slowly to changes in yield differentials was tested by including a lagged term in net foreign assets in the estimated equation. There was some variation but generally the coefficient was sufficiently small and ill-determined to be ignored.

The effect of this method is to impose the same coefficient on changes in yield differentials as on differentials themselves. That radically alters the characteristics of the capital flow equation. As changes in yield differentials are scaled by a variable proxying OECD wealth, while differentials are scaled by *changes* in the wealth variable, the scale factor is ten times higher on changes in yield differentials. If the coefficient is similar, therefore, the effect of a change in interest rate differentials is some ten times as great as the ongoing "flow" effect of the differential itself. As the "flow" coefficient is estimated to be roughly the same by this method as by estimation of the capital flow equation directly, this second estimation procedure results in a much larger initial capital flow in response to a new expected appreciation or interest differential.

The results nonetheless fall short of constituting successful research. One serious drawback of the estimation method is that coefficients are sensitive to the number of countries in the sample. When ten countries were estimated simultaneously, problems of convergence were encountered. This means some data "mining" was inevitable as a smaller sample had to be selected. A sample was selected where parameters were representative and conformed to priors such as requiring that coefficients on interest-rate differentials and expected appreciation should not be too different. Table 9 shows how results shift when two more countries are added to the sample of seven in Table 8. Generally the value of a_2, the parameter on interest rate differentials, varied between 0.0012 and 0.0075, a very large percentage variation but a small absolute one in the sense that the qualitative characteristics of the model are unaffected by the range of parameter values encountered. The variation in a_3, the parameter on expected appreciation, was somewhat greater.

For the remaining countries in the system no estimation of capital flows is carried out; their parameters are determined by the fixed-point restriction. The constants in their equations are obtained by taking the negative of the mean value of their current balance position over the past ten years and rescaling so that the constant terms of all seventeen countries sum to zero.

B. Expected exchange rates

The estimation of "expected" exchange rates was more straightforward than the procedure for capital flows. The specification was that set out in Part III, section B. An equation for the exchange rate was estimated and the expected exchange rate taken to be the expected value of this function one period later, i.e. $EXCHX_t = \varepsilon(EXCH_{t+1})$.

Estimation results for all countries are shown in Table 10. They are highly variable. For some countries the statistical properties of the equations are good and the parameter estimates proved robust in the face of changes in dynamic specification, despite the inordinately small sample. For a number of countries neither of these things are true—parameters are ill-determined and unstable with specification changes.

Where contemporaneous price-differential variables appear in the equation, the estimator was two-stage least squares. If possible, current prices were eliminated in favour of lagged prices and ordinary least squares were used. This method was preferred except where it led to a serious worsening of regression results, such as an increase in the influence of the lagged dependent variable (decline in coefficient a_2). Some attempt was made to estimate an equation for the exchange rate using "expected" current prices in the first term as this facilitates the conversion of the equation into one for the expected exchange rate. GDP deflator equations of autoregressive structure with the money supply as an explanatory variable were successfully estimated. The use of their fitted values as instruments in the exchange-rate equations, however, led to estimated parameters which implied dynamic instability, so the approach was abandoned. Where the estimated exchange-rate equation had current price terms in it, so:

$$EXCH_t = f(PGDPUS_t/PGDP_t, \ldots),$$

the expected exchange-rate equation was taken to be

$$EXCHX_t = f\left[\varepsilon(PGDPUS_{t+1}/PGDP_{t+1}), \ldots\right]$$

where $\varepsilon(\ )$ indicates expectation. Then, in coding the equation in the model, static expectations were assumed, i.e.:

$$\varepsilon(PGDPUS_{t+1}/PGDP_{t+1}) = PGDPUS_t/PGDP_t.$$

Unfortunately, the equations estimated led to instability in some simulations and for some countries imposed changes were necessary in implementation. Instability occurred because in the system as a whole the elasticity of expectations (the proportionate change in the expected exchange rate divided by the proportionate change in the actual rate) came to approach or exceed one. This occurred through the combined effect of movements in relative prices, the actual exchange rate and the net foreign asset (or debt) position of the country in question. When the actual exchange rate fell (for example) the expected one declined too, though not of course by so much. In a single-equation sense, expectations were regressive. However, in the system as a whole a depreciation also worsens domestic price inflation and raises prices relative to those abroad. This would further lower the expected exchange rate. And lastly, a depreciation via the J-curve worsens the current balance and hence, in the short run, the net foreign asset position, further

Table 10. Exchange rate equations1

	Constant	X1(-1)	x2	X3(-1)	x4	X5(-1)	X6(-1)	Dummy***	R^2/DW	SEE
United Kingdom	0.2265 (2.6095)	0.6603 (1.1303)	0.3063 (2.807)	—	—	0.6734** (3.0710)	—	—	0.4388 1.2514	0.0583
France	-0.7467 (-1.4964)	2.0116* (0.6609)	0.4949 (1.6559)	—	0.00454 (0.6116)	-0.1294 (-1.1141)	—	—	0.2934 1.1709	0.0772
Germany	-0.568 (-2.81)	—	0.580 (2.89)	—	0.00495 (2.28)	—	—	—	0.36 1.17	0.066
Italy	-1.9223 (-2.1782)	—	0.2936 (2.1601)	—	0.00871 (3.470)	—	-0.0259 (-3.0545)	—	0.5136 2.1847	0.0842
Belgium	-0.7586 (-0.9764)	1.2407 (0.6182)	0.1911 (0.9118)	—	0.0157 (2.2879)	—	-0.0207 (-0.4986)	—	0.4260 2.0082	0.0638
Netherlands	-0.3325 (-2.07)	—	0.316 (2.27)	—	0.00717 (1.48)	—	-0.019 (0.91)	-0.179 (-3.11)	0.63 1.87	0.051
Canada	0.0136 (1.0503)	—	0.3380 (3.2853)	0.0144 (3.9141)	0.00157 (2.5487)	—	0.0209 (-1.3039)	—	0.6531 1.6809	0.0155
Japan	-2.8564 (-2.6427)	—	0.5112 (2.6731)	—	0.0427 (1.5672)	-1.4608 (-2.4089)	—	0.1808 (3.1006)	0.6532 1.3668	0.0525
Australia	0.1596 (9.5139)	0.5078* (2.0445)	0.6464 (9.583)	—	—	0.0288 (1.5621)	—	-0.0672 (-3.4213)	0.9031 1.4528	0.0189
Austria	-0.6667 (-1.4291)	2.9698 (1.3873)	0.2392 (1.4779)	—	—	—	-0.0326 (-2.0454)	—	0.3669 1.6788	0.0651
Denmark	-0.7279 (-2.2592)	—	0.3380 (2.1635)	—	0.0869 (2.7767)	-0.1353 (-1.9703)	-0.0328 (-3.3670)	—	0.6371 1.9201	0.0498
Ireland	0.1783 (0.7267)	1.1187* (1.3263)	0.1986 (0.6876)	—	0.00244 (0.2103)	—	—	—	0.0607 1.8076	0.0547
Norway	-0.7904 (-5.6736)	0.7514 (1.2926)	0.4974 (6.0757)	—	—	0.2749* (3.0825)	-0.0321 (-1.7458)	—	0.7841 2.7468	0.0303
Sweden	-0.4024 (-1.1801)	—	0.2787 (1.1882)	—	0.00423 (1.0045)	—	-0.0145 (-0.7564)	—	0.3231 1.8623	0.0584
Switzerland	-1.9926 (-4.0465)	—	0.6271 (3.7863)	—	0.0508 (4.1333)	—	-0.0404 (-3.5050)	—	0.6410 2.1763	b.0560
Spain	-0.9819 (-2.9682)	0.4985 (0.6910)	0.1997 (1.9505)	—	—	—	0.0506 (-2.7294)	—	0.4327 1.5319	0.0664

Bracketed values are "t" statistics.

1. Specification: Dependent variable: $LN(EXCH) - LN(EXCH_{-1})$

Explanatory variables: $X1 = LN(PGDPUS/PGDP) - LN(PGDPUS_{-1}/PGDP_{-1})$ $X2 = LN(PGDPUS_{-1}/PGDP_{-1}/EXCH_{-1})$ $X3 = IRS - IRSUS - IRS_{-1} + IRSUS_{-1}$

$X4 = NFATS_{-1}/PGDPUS_{-1}/PGDP_{-1}$ $X5 = LN(PMED/PMED_{-1})$ $X6 = IRLUS - IRL$

* Parameters refers to the non-lagged variable.

** Parameters refers to X5(-1) times a dummy, where dummy is 0 to 1976, 1 thereafter representing the coming of North Sea oil.

*** Dummy for NET = 1 for S1, S2 1981, otherwise 0;
JAP = 1 for S2 1978, otherwise 0;
ASL = 1 for S1 1977, otherwise 0 (devaluation).

reducing the expected exchange rate. In such cases parameters were re-estimated with the net foreign asset and interest-rate terms suppressed.

The main weakness of the original specification was probably its implication that wealth-holders failed to "look through" the J-curve when assessing a country's net foreign asset position, and take into account the probable subsequent improvement. Research is now preceeding in several directions to amend the specification for this failing to give the system an expected exchange-rate equation combining reasonable tracking and simulation properties.

C. Conclusions and further projected empirical work

Research is continuing in developing the Finlink system. There are two encouraging features of the results reported in this paper. One is that the imposition of cross-country restrictions during estimation enabled a statistically significant "risk premium" term involving net foreign assets to be identified in the exchange rate equation. This is contrary to the finding of some researchers. Nonetheless, parameter estimates are not particularly robust to sample changes. Secondly, the size of estimated capital flow parameters also resulted in an exchange rate system which was generally stable without the need for central bank intervention. However, this stability also depends on the way that exchange-rate expectations are generated and here research has been less successful up to now. Simulation properties of the system, which will be reported in a subsequent paper, generally conform well to prior notions of plausibility. Initial indications on the system's tracking capabilities, however, are that, like other structural models, it performs no better than a random walk model, and in particular it is unable to account for the extent of the dollar's rise since 1980. The model is therefore currently more useful in simulation experiments—on the strong assumption that the unknown factors in exchange rate determination do not interact substantially with the factors known (or believed) to be at work—than it is as a forecasting device.

Developments of the existing model which are currently being studied are:

- Specification of consistent, "rational" expectations schemes bearing directly on effective rather than bilateral exchange rates;
- The removal of the assumption of fixed national shares in world wealth, currently embodied in the capital-flow system;
- The elaboration of domestic financial sectors, with more adequate treatment of money-supply and interest-rate determination;
- Refinement of methods for dealing with exchange-rate unions such as the European Monetary System and the practice of managed floating generally. The EMS is currently simulated by pegging relevant currencies to the DM assuming intervention is largely in dollars.

While some research has been undertaken in the following areas, results suggest that further work is particularly needed and is planned:

- Endogenisation of OPEC placements within the OECD;
- Non-trade components of OECD current accounts especially foreign debt service charges;
- Trade and debt interaction of less developed countries;
- Empirical investigation of the weighting matrix underlying the capital-flow system.

NOTES

1. These include the "World Economic Model" of the Economic Planning Agency of the Japanese Government which has nine countries and six regions; the "Multi-Country Model" of the Federal Reserve Board which has five countries and one rest-of-the-world region. Modelling of international financial linkages has also been carried out by R. Fair, P. Armington, and in the context of Project LINK. See Amano (1982), Amano et al. (1981), Haas and Symansky (1983), Hooper et al. (1982), Stevens et al. (1980), Armington (1979), and Fair (1981).
2. See OECD (1979, 1982) and Samuelson (1973).
3. Including, currently, both the EPA World Model and early versions of the FRB Multi-Country Model. The EPA models gross capital flows, while in its current version the Multi-Country Model drives the exchange rate via net flows, as does Finlink. While current Finlink is implemented with an equation for net private capital flows, in principle this equation could be inverted to give a direct exchange-rate equation. Indeed, the equation was estimated in that form. The equation will be renormalized as an exchange-rate equation in future versions of the model. Capital flows will then be determined by identity and the target algorithm will be needed to obtain "fixed-rate" solutions, using *BOSD* as an instrument. While this inverts the logic of solution the economic properties of the model are unchanged.
4. See Artus and Rhomberg (1973) and Rhomberg (1976).
5. For detail of the countries in each zone, see the Economic Outlook, e.g. E.0.32, December 1982, p. 149. OPEC comprises both high and low absorptive countries; LDCs comprise the following groups: oil-producing developing countries, newly industrializing countries, middle-income and low-income developing countries; Rest of the world comprises the USSR and Eastern European countries, China and setected Asian countries and the "Other" grouping.
6. Finland, Greece, Iceland, New Zealand, Portugal and Turkey. Yugoslavia is in the "Rest of the World" zone. Luxembourg is aggregated with Belgium.
7. The demonstration of this, here and in the next paragraph, is owed to Paul Masson.
8. Proof:

$$\sum_j \left[\sum_i (c_{ij}s_j - c_{ji}s_i) + \sum_i \sum_k (b_{ijk}s_j - b_{jik}s_i) Y_k\right] WWD$$
$$= \left[\sum s_j - \sum_i s_i \sum_j c_{ji} + \sum_j s_j \sum_k Y_k \sum_i b_{ijk} - \sum_i s_i \sum_k Y_k b_{jik}\right] WWD$$
$$= 0.$$

9. Another assumption which assures constancy of weights, however, is that for all countries assets of *i* and *j* are substitutes to the same degree. Hence

$$b_{ikj}=b_{ilj} \quad \text{for all } k, 1.$$

Then:

$$w_{ij}= - \frac{b_{jli}\sum_k s_k}{b_{jlj}\sum_k s_k} - \frac{b_{jli}}{b_{jlj}}$$

and the w_{ij} and b_j can be identified directly with asset substitutability parameters and wealth shares play no role. They continue to influence the *a,!,* however. Research is proceeding to develop a version of Finlink where the *a,* are functions of the international distribution of wealth.

10. Proof: if column sums of the square n x n matrix *W* are 1, then W^m $(m \rightarrow \infty)$ tends to a limit of the form *[b, b, ... b]* where ***b*** is an n-element vector, This is the fixed-point vector of *W* such that $Wb=b$. To show ***b*** **is** unique up to a factor of proportionality, consider any n-element vector a of positive elements, then:

$$W^m a=\sum_{l=1}^{n} a_j b=(\sum_{j=1}^{n} a_j)b. \text{ If } Wa=a, \text{ then } W^m a=a,$$

but

$$W^m a=(\sum_{j=1}^{n} a_j)b.$$

Hence ***a=b*** times a scalar equal to the sum of ***a's*** elements.

11. See Melitz (1982), Henderson and Rogoff (1982), Masson (1981) and Martin and Masson (1979).

12. See Davidson, Hendry, Srba and Yeo **(1978)**, Salmon (1982).

13. See Salmon *op. cif.* and Hendry and von Ungen-Sternberg (1979).

14. The net foreign asset position was calculated as:

$$NFATS_t=\sum_j CBD_{t-j}+NFAD_0.$$

For further details, see Annex.

15. This is proved in Stevens *et al.* (1980).

16. See Basevi (1973) and Hooper, Haas, Symansky and Stekler (1982) *op. cit.*

17. Statistics are published in "Geographical Distribution of Financial Flows to Developing Countries 1979/1982", OECD, Paris, 1984. "Unallocated" flows from individual OECD countries were assumed to be distributed in the same way as other flows; flows from multilateral agencies were allocated among OECD countries according to the weight of their flows to multilateral agencies. All loans classified as official development assistance were included in the flows but grants were excluded; in principle, these should appear as transfers in the current account.

18. The *MERM* matrix was used unadjusted in the first operational version of Finlink; it is shown in the OECD INTERLINK system manual, The currency matrix was compiled using confidential data from BIS and IMF sources.

ANNEX

DATA: SOURCES AND METHODS

CBD — Current Balance in U.S. dollars

— Source: Secretariat-compiled statistics; adjusted data from Central Bank and Governments' official publications.

For the bigger countries and some of the smaller ones (Austria, Denmark, Norway and Sweden) the adjustment made consists in multiplying the original quarterly data in local currency by the ratio between the yearly official figures and the sum **of** the quarterly figures, whenever there is a discrepancy. The series so obtained are then coverted into U.S. dollars. Since the quarterly average exchange rate is applied, it is possible that the sum of the quarterly series does not add up to the corresponding annual series. In these cases, the quarterly series are readjusted to make the two totals identical.

Some quarterly series have breaks; such gaps are filled in by interpolating yearly data using the method of minimizing first differences. For the other smaller countries (Ireland, Switzerland and Spain) only yearly series are available. Annual series are interpolated to generate quarterly figures.

In INTERLINK trade **flows,** and hence the foreign balance, are seasonally adjusted.

CBOPD — OPEC Current Balance in U.S. dollars

— Source: Secretariat-compiled statistics.

This series is an elaboration of data from the IMF International Financial Statistics, IMF World Economic Outlook, OECD Foreign Trade Inventory (FTI)—**Series A,** IMF estimates and OECD estimates.

CBDCD — Non-OPEC Less Developed Countries Current Balance in U.S. dollars

— Source: Secretariat-compiled statistics.

This series is an elaboration of data from the IMF World Economic Outlook and IMF estimates.

CBRND — Rest of the World Current Balance in U.S. dollars

— Source: Secretariat-compiled statistics

This series is an elaboration of data from IMF statistics, Central Banks' official publications and OECD estimates.

CBWDD — Current Balance Discrepancy

— Source: Secretariat-compiled statistics.

It **is** defined as the sum of the current balance in the four regions considered (OECD, OPEC, non-OPEC less developed countries, and the rest of the World).

Only annual data are available from the Secretariat for CBOPD, CBDCD, CBRND and CBWDD. Quarterly figures are obtained by interpolation.

BOSD — Balance of Official Settlements in U.S. dollars
— Source: Secretariat-compiled statistics; adjusted series from Central Banks and Government official publications.

Adjustments are made according to the same methods as described for CBD. Quarterly series are not available for OST, DEN, IRE, NOR, SWE, SWI and SPA. Annual data are therefore interpolated to generate quarterly series.

Note that for the United States the balance of official settlements is recalculated shifting the changes in liabilities to official institutions of non-OECD countries from "below" to "above the line"

CAPFLO — Capital Flows in U.S. dollars

These are secondary data generated according to the definition

$$CAPFLO = BOSD - CBD - COMP$$

where COMP is Compensatory Financing. Compensatory Financing is different from zero only for USA, CAN, GER, UKM, FRA and ITA. It is defined as follows:

USA: Non-marketable U.S. Treasury Notes publicly issued **to** Private Foreign Residents (source: official U.S. publications, BIS "Basle Tables");

CAN: Drawings under the Government's standby facility with Canadian chartered banks and drawings under standby facilities with U.S. and foreign banks (source: official Canadian publications and BIS, "Basle Tables"); plus Government's borrowing on foreign and international bond markets (source: OECD Financial Statistics):

UKM: Foreign currency borrowing by HM Government and by public bodies under exchange cover scheme (source: official U.K. publications);

GER: Direct and indirect official borrowing abroad (source: official German publications);

FRA: Emprunts exterieurs autorises a moyen et long terme des residents, nets des remboursements anticipes (source: official French publications);

ITA: Euro-credits borrowing and external bonds issued by central and local governments, financial and non-financial public enterprises (source: OECD Financial Statistics).

Note that for the United States CAPFLO is adjusted according to the definition given for US BOSD.

EXCH — Bilateral Exchange Rate
— U.S. dollars per local currency
— Quarterly and semi-annual averages of daily data
— Source: Secretariat-compiled statistics; from international financial publications.

EXCHE — Effective Exchange Rate
— Index Q1 1981 = 1

These series are generated by applying the weighting matrix W to the log of EXCH.

IRS — Short-term interest rates, annual percentage rates
— Quarterly and semi-annual averages of monthly data
— n.s.a.
— Source: OECD Main Economic Indicators (MEI), Financial and Fiscal Affairs Directorate (DAFFE), and official national statistics.

They are defined as follows:

USA: 6-month Prime Commercial Paper Rate, DAFFE
GER: 3-month Loans Rate, DAFFE
JAP: Call Money Rate, DAFFE

FRA: Rate of Day-to-Day Loans against Private Bills, DAFFE
UKM: 3-month Treasury Bill Rate, DAFFE
ITA: Interbank Deposit Rate, DAFFE
CAN: 90-day Finance Companies Paper Rate, MEI
ASL: 90-day Commercial Bill Rate, MEI
BLX: 3-month Treasury Bill Rate, MEI
NET: Rate of 3-month Loans to Local Authorities, DAFFE
DEN: Long-term Bond Yields, DAFFE
SWE: 3-month Treasury Bill Rate, DAFFE
NOR: Call Money Rate, DAFFE
IRE: 3-month Treasury Bill Rate, MEI
OST: Day-to-day money rate, Austrian Institute of Economic Research
SWI: Rate on 3-month Deposits with Major Banks, DAFFE
SPA: Rate on 1-month Money Market Certificates, DAFFE

IRFOR — Foreign Short-term Interest Rates

Secondary data obtained by applying the weighting matrix **W** to IRS series,

IRL
- Long-term Interest Rates
- Quarterly and semi-annual averages of monthly series
- n.s.a.
- *Source:* OECD Main Economic Indicators (MEI), and Financial and Fiscal Affairs Directorate (DAFFE).

They are defined as follows:

USA: Yield on Corporate Bond (ten years and over): MEI
GER: Public Sector Bond Yield (total); DAFFE
JAP: Telephone and Telegraph Bond Yields; DAFFE
FRA: Yield on Public and Semi-Public Sector Bonds: DAFFE
UKM: 20-year Government Bond Yield; DAFFE
ITA: Private Sector Bond Yield; DAFFE
CAN, ASL, BLX, NET, DEN, SWE, NOR, IRE: Long-term Government Bond Yield; MEI
OST: Yield on Industrial and Other Bonds; DAFF
SWI: Confederation Bond Yield; DAFF
SPA: Electricity Companies Bond Yield; DAFF

MONEYS
- Money Supply
- Local currency. Quarterly and serni-annual averages of monthly data
- s.a.
- Source: OECD Main Economic Indicators (MEI) and official national publications.

The monetary aggregates are defined as follows:

USA, JAP, FRA, ITA, CAN: M2 (MEI)
GER: M3 (Deutsche Bundesbank, “Monthly Report”)
UKM: Sterling M3 (Bank of England, “Banking Statistics”, Central Statistical Office, “Financial Statistics”)
BLX, NET, ASL, OST, DEN, IRE, NOR, SWE, SWI, SPA: M1 + quasi-money (MEI).

NFATS
- Total Net Foreign Assets
- Secondary data obtained from cumulated CBD

Benchmarks for these series are calculated for the end of Q2 1972 (base period). To do that, inflows and outflows of property and entrepreneurial income in local currencies are taken for 1971, 1972 and 1973. (Source: OECD, National Accounts, **Vol. II**, Table 15 “External Transactions”) and capitalized at the corresponding annual average long-term interest rates. IRLFOR is the rate applied to inflows (foreign long-term interest rate, a weighted average of IRL) and IRL the one applied to outflows. Net foreign assets are defined as the difference between the capitalized inflows and outflows; the yearly average, converted into dollars at 1972 average exchange rate, is then taken as the basis to cumulated net foreign assets,

NFAPS
- Net Foreign Assets in Private Sector
- Secondary data obtained from cumulating the negative of CAPFLO

Benchmarks for these series are the same as for NFATS.

NON-OECD
- Net Foreign Assets with non-OECD
- Estimated series

The benchmark for the calculation is defined as the sum of the NFATS benchmarks of all OECD countries, which corresponds to the liability of the whole non-OECD area at the end of Q2 1972. This is split among the four non-OECD zones in the proportion of the average current balance of each zone during the period 1970-1972.

The coefficients derived from mixed regressions are then applied to calculate the share of net foreign assets of each OECD country with each single non-OECD zone, and then the corresponding CBD are cumulated by the same proportion. Trade credit outstanding to the six OECD countries in set II is added using the same method.

PGDP
- GDP deflator
- Index 1975 = 1
- s.a
- ***Source:*** OECD National Accounts

Quarterly series are directly available only for USA, GER, JAP, FRA, UKM, ITA, CAN, ASL and OST. For the other countries quarterly figures were interpolated from annual series using the consumer prices index (source: MEI) as reference series.

PMED
- Oil Import Average Values in U.S. dollars
- Index 1975 = 1
- s.a.
- ***Source:*** Secretariat-compiled statistics.

Original series in local currency are converted into dollars by applying an exchange-rate index extracted from FTI, Series A. For some countries (CAN, ASL, JAP, UKM, GER, FRA, NOR, SWE, OST) data from the Secretariat are also derived from FTI, Series A, and are subsequently seasonally adjusted. For the USA data are derived from national publications, and for the other countries (ITA, BLX, NET, IRE, DEN, SWI and SPA) a "world price" index is calculated which is a weighted average of the prices in a certain number of countries.

TC
- Trade Credits
- ***Source:*** Secretariat-compiled statistics, from national balance-of-payments publications.

Series available only for USA, GER, JAP, FRA, UKM, ITA, CAN, NET and BLX.

USA: data cover only government export credits under the Export-Import Bank Act and, from 1979, non-banking concerns' commercial claims and liabilities. Trade credits extended by commercial banks are not shown.

CAN: data include only the export credits financed by the Government of Canada.

JAP, GER, ITA, BLX and ***NET:*** data are limited to trade credits extended and received by enterprises.

FRA and ***UKM:*** data on trade credits cover all claims and liabilities relating to enterprises' and commercial banks' transactions. They are the only major OECD countries whose data have a comprehensive coverage.

WWD — World Wealth in U.S. dollars

— Constructed series

This series is generated as:

$$WWD = WWD(-1) + sGDP + WWD(-1)PGDP/PGDP(-1)$$

where s is a saving rate (assumed 0.15), *GDP* and *PGDP* are GDP-weighted nominal GDP and GDP deflator of the OECD area. A benchmark $RWWD_0$ was taken as $3 \times$GDP in Q1 1970 (base period).

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