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# ALTERNATIVES FOR MODELING THE WORLD OUTSIDE THE UNITED STATES

by

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# Alternatives for Modeling the World Outside the United States

Guy V. G. Stevens*

Econometric models of the United States are notoriously deficient in their ability to measure the impact of internationally generated factors on the domestic economy. The situation has only worsened since the advent of flexible exchange rates. The project of which this paper is a part proposes a strategy for remedying the situation.

## I. Goals and Key Questions

More precisely, the goal of this project is to build a quantitative model, for the purposes of forecasting and policy-simulation, which has the following properties:

1. The international transactions and exchange rates important for the United States are endogenously determined.

2. The effects of these international variables on the U.S. economy, particularly trade and capital flows and exchange rates, can be specified and measured.

3. It is possible to analyze the effects of U.S. monetary policy on exchange rates, trade and capital flows, and the effects of these variables on the domestic U.S. economy.

4. It is possible to analyze the effects of exchange market intervention, both by the United States and foreign countries.

5. The most important effects of economic developments in the United States on foreign countries are measurable, and the feedbacks of these effects on the United States are specified.

To the greatest extent possible, consistent with consideration of cost and time to completion, the model should be constructed so that:

6. The impact of changes in foreign monetary policies on the U.S. economy can be analyzed.

7. The model can use as inputs the detailed information on individual countries provided by the Division's World Payments Section and produce as outputs forecasts of important foreign variables that aid in analyzing these countries.

The present paper is one of a set of six in which we attempt to describe a strategy for achieving the first five of the above goals, and to the greatest degree possible given the constraints on time and manpower, the final two.[1] In so doing this paper builds on our previous, related, paper, "Simultaneous Determination of the U.S. Balance of Payments and Exchange Rate" (IFDP#59)[2] and discussions and seminars based on it that we have had with members of the Division of International Finance and outside economists.[3]

This paper and its companion papers attempt to complete the task started in IFDP#59. As dubbed by one of our waggish readers, the earlier paper could be termed our "how not to" paper; there our major emphasis was on the drawbacks of certain approaches to modeling the foreign sector under flexible exchange rates; by a process of elimination, we arrived at a preferred alternative, but did not develop that alternative very far. The present series is meant to be our "how to" paper.

The present paper focuses in detail on the alternative approaches for modeling the world outside the United States. Most researchers

agree that modeling the foreign sector of the United States economy is particularly difficult because of what might be called the multi-country problem. Not only do the economies of many countries have a significant effect on the international transactions of the United States, but also no single country or exchange rate is of such overwhelming importance as to merit exclusive attention. Therefore the modeling of U.S. trade and capital flows involves, potentially, taking into account an enormous number of variables emanating from many countries.

In developing our own approach to the multi-country aspects of U.S. international transactions, we have had to arrive at answers to five key questions:

1. Should the world outside the United States be modeled as a single undifferentiated region or should certain individual countries or areas be broken out?

2. Assuming that a few countries are broken out separately, what should be the treatment of those many other countries that cannot be so separated (the rest of the world, ROW)?

3. Whatever the degree of country disaggregation in the world outside the United States, should the separate entities be modeled with structural models, with reduced form equations for important variables, or with the important foreign variables treated exogenously?

4. If it is decided to use either structural models or reduced form models for important countries, how should these be constructed?

5. Assuming that the U.S. economy will be modeled with a structural model, should the U.S. model be the same as, or different from the models for the individual foreign countries? What should be the strategy for linking the present project with the FRB econometric model of the United States?

This paper, as well as the others making up this project, attempt to answer all these questions in considerable detail. The most detail is devoted to the answer to questions 4 and 5, the development of structural models for selected foreign countries and the United States; our description of this structure and the alternatives to it are taken up in the companion papers by Berner, Clark and Kwack, Howe and Stevens.[4] In this paper we deal in detail with the answers to questions 1-3.

## II. The Treatment of the World Outside the United States (Question 1)

In discussing our previous paper (IFDP#59) inside and outside the Division of International Finance, we found overwhelming agreement that <u>eventually</u> the Division should attempt to model important exchange rates bilaterally; as we showed in IFDP#59 this goal implies some sort of individual modeling of those countries whose exchange rates are treated bilaterally. However, there has been considerable disagreement over whether country disaggregation should be the next step or only the last step in a sequence of modeling efforts. In particular, this sequence could start with a world outside the United States modeled as a single undifferentiated region, whose exchange rate with the United States is represented by a weighted-average exchange rate.[5] Some readers of

IFDP#59 have recommended that course, even though no one has objected to the analysis of that paper that attacked the use of weighted-average exchange rate as theoretically deficient. We will consider this in detail in the next section and then go on to consider alternative methods and degrees of disaggregation.

A. Arguments For and Against a Two-Country World

If the proponents of a two-region world did not quarrel with our attack on it, what makes them continue to support this strategy? As we see it, their argument is largely a question of research strategy under conditions of uncertainty; and their proposal is a plausible one--although we shall argue that we have a better one. The basic argument for a single, aggregative region outside the United States is that a two-region model can be completed more quickly than a disaggregated alternative and, just as important, with a much smaller risk of absolute failure. Two-region flexible exchange rate models do exist for countries such as Canada and the United Kingdom,[6] while no complete multi-region model exists for any country.

All agree, we think, that neither approach can be established or refuted solely on the basis of theoretical or a <u>priori</u> reasoning. All feasible alternatives are compromises with reality: no one could seriously suggest disaggregating <u>all</u> countries in the world, or even all countries in the world that are significantly related to the trade and capital flows of the United States. Table II, below, demonstrates that even the latter course would be beyond the resources of the Federal Reserve Board. Further, even if the required resources were available, insurmountable problems might arise in solving the resulting large non-linear model on the computer.

Our arguments against a two-region world are fivefold:

1) Neither the theoretical nor the empirical conditions for the use of a weighted-average exchange rate are present.

2) It is doubtful that the two-region alternative would be completed in less than a year; therefore we estimate that it would save only about four months over our preferred alternative.[7]

3) Assuming that a number of variables in the world outside the United States would be endogenized, the process of fitting equations for data aggregated over many countries would involve so many ad hoc decisions that we would expect the product to be very difficult to defend.

4) Much of the information that can be gleaned from a two-region model will be forthcoming from a separate project in the Division that soon will be completed, the linking of Sung Kwack's BOP model with the FRB domestic model.[8]

5) The Division has a strong interest in obtaining the kind of country detail that would be unavailable in a two-region model.

Concerning the first element in our argument, we assume that our theoretical case against a weighted-average exchange rate is accepted: in general there is no way to justify such an expedient. That leaves the empirical case: if all relevant exchange rates are perfectly correlated or nearly so, then a weighted-average or, in fact, any bilateral rate can stand as a proxy for each endogenous exchange rate.

The same empirical argument holds for any other endogenous variable related to the activities in a foreign country.

The question then becomes to what degree this condition has been fulfilled in the past and will be fulfilled in the future. The evidence in Table I indicates that in recent years important bilateral rates have not been highly correlated. Thus in the most recent period, 1974-75, the correlations among the exchange rates of Canada, Japan, the U.K. and West Germany ranged from a high of +.76 to a low of -.33. The average correlation was only .37. The same picture appears for the first half of the period of flexible exchange rates, 1971-73. The table also shows that the correlations changed substantially between our (arbitrarily) chosen sub-periods. To us this simple table demonstrates that it would be extremely dangerous to rely on the assumption that bilateral exchange rates move together or that the correlations remain constant over time.

Adding this negative empirical conclusion to the theoretical arguments against weighted average exchange rates, there seems every reason to believe that some degree of disaggregation is desirable in explaining and forecasting exchange rates and the endogenous variables that depend on them.

Table 1: Correlations Between Major U.S. Bilateral Exchange Rates, 1971-75 (Quarterly)*

1971 (2nd Quarter) to End of 1973

| | Can. | U.K. | W.G. | Jap. | W.ave. |
|---|---|---|---|---|---|
| Canada | 1.0 | -0.75 | .078 | .38 | .27 |
| U.K. | | 1.0 | -.067 | .022 | .034 |
| W. Germany | | | 1.0 | .91 | .97 |
| Japan | | | | 1.0 | .98 |
| Weighted Average** | | | | | 1.0 |

1974 - 75

| | Can. | U.K. | W.G. | Jap. | W.ave. |
|---|---|---|---|---|---|
| Canada | 1.0 | .76 | -.33 | .54 | .10 |
| U.K. | | 1.0 | .29 | .60 | .66 |
| W. Germany | | | 1.0 | .16 | .89 |
| Japan | | | | 1.0 | .43 |
| Weighted Average** | | | | | 1.0 |

*The quarterly observation for each exchange rate is measured by the quarterly average for Canada and the average of the end of month figures for W. Germany, Japan, the U.K., France, Italy, the Netherlands, Belgium, Sweden, and Switzerland.

**The average of the exchange rates of Canada (0.251), W. Germany (0.160), Japan (0.160), the U.K. (0.104), France (0.085), Italy (0.068), the Netherlands (0.061), Belgium (0.055), Sweden (0.028), and Switzerland (0.028) weighted by the average of each country's multilateral and bilateral trade weights in 1972 (computed by Bob Bradshaw in January 16, 1975 memo).

The major ostensible virtue of two-country approach is speed of completion. Our estimates indicate, however, that this approach would save only about four months in time to completion.[9] This estimate is calculated in the following way. There are three major stages to the completion of a project of this kind: (1) the estimation of the equations for a given country model; (2) the testing of the simulation capabilities and stability properties of each model separately; (3) the linking of the country models and the perfecting of the solution of the overall system. Assuming that a considerable number of variables are to be endogenized in the rest of the world, then we estimate that it would take at least as long and probably longer for the initial building of the ROW sector as it would take for one individual country model--approximately 6 person-months for one economist (working with considerable research assistance). It would take another 3 to 4 months to complete the second stage: to get the equations to simulate satisfactorly. Having more than one man working on this model should speed things up somewhat, but not very much; in estimation and in testing simulation capabilities, much of the time is spent on a few recalcitrant equations; added manpower cannot do much to speed things during the first two stages. Assuming the full section would be working on the aggregate ROW model and the U.S. sub-model, our estimated time-to-completion would be 7 months for these two stages, instead of 10 months. Thus even though it will take many more person-months to estimate a disaggregated version of the world outside the United States, the time to completion for the first two stages of both projects would be somewhat similar.

The final step is to get the particular representation of the world outside the United States simulating with the U.S. model, thereby determining the exchange rate(s) and other endogenous variables. For either version of the model this will be a step into the unknown; we estimate that there will be some saving of time in working with an aggregated world outside the United States rather than four or five country models, but probably not much, since the problems of getting multiple models simulating together are similar no matter how many models might be involved; for this stage we estimate a saving of one month for the aggregated ROW--four months compared to five or six. In total, then, we estimate a total of 11-12 months from beginning to end for the two-country model, and a total of 14-16 for the multi-country version.

Our final argument against constructing an aggregate world outside the United States in this project, is that another project now underway in the Division will gain us much of the information that such a project would yield. Sung Kwack is now in the process of linking his balance of payments model with the FRB domestic model; the former model has an aggregated world outside the United States and its exchange rate is represented by a weighted-average rate, which will be made endogenous. Thus much of the information that we would hope to get from building a two-country world for the present project will already be obtained from the other project. That effort will tell us whether there are insuperable difficulties in endogenizing the exchange rate and it will give us a

standard for forecasting accuracy by which to test future efforts. It is true that the model we propose now will not be identical to the linked Kwack-FRB model, so it will be impossible to attribute all differences in the behavior to the two models to the degree of aggregation of the world outside the United States; however, if this latter becomes a crucial issue, it will be much easier to construct another aggregated world outside the United States, identical in structure to the disaggregated country models, after these latter have been finished.

All of the above estimates of time to completion have assumed that there would be many variables endogenized in the rest of the world, whatever its degree of country disaggregation. Naturally it would be much easier and shorter to construct an aggregate world outside the United States that was nearly, or entirely, exogenous. To complete this part, with the exchange rate the only endogenous variable, the time to completion would be only three or four months; however, little overall time would be saved, since the previously estimated 10 person-months would be required to construct the U.S. part of the model and since it would still take three or four extra months to get the two parts working together to determine the exchange rate. If one opted to dispense with the U.S. model and use, say, the existing FRB model, then the result would be essentially the same as the soon-to-be-finished linkage project discussed above. Although this project will be very useful, we have discussed above a number of reasons why the Division should go on from there.

B. General Criteria for Determining the Degree of Country Disaggregation in the World Outside the United States

If one rejects a wholly aggregated world outside the United States, it is necessary to come up with a defensible rule for determining which countries are to be modeled individually. This is a most difficult question because all of the theoretical rules that can be applied lead to solutions that are empirically infeasible. It is also one of the most important questions, because its answer will affect crucially our ability to realize the seven goals set out above.

The major consideration determining the number of foreign countries to be modeled separately is how many bilateral exchange rates, levels of income in foreign countries, foreign interest rates, and other foreign variables should be made endogenous. An important part of the answer to this question is the disaggregation necessary to achieve good forecasts and policy simulations under goals 1-4, above. Another is the degree of detail required in modeling individual countries or regions. Once one decides to make a given country variable endogenous--particularly the bilateral exchange rate between a country and the United States--a large number of equations will likely be added to the overall model, equivalent in all probability to the construction of a small econometric model of that country.

How then, given some idea of the list of variables that it is desirable to make endogenous, does one go about deciding the number of countries or regions that should be present in the treatment of the world outside the United States? From a theoretical, a priori point of view, there are few reasons to support any aggregation; as discussed in IFDP#59,[10]

for exchange rates alone (not to mention the many other country variables), the condition for aggregation is that for a given set of equations--say trade equations--the impact of the different exchange rates in question must be proportional to each other. The stringency of the requirement is heightened when we realize that, to avoid modeling a given country separately, the proportionality requirement must hold for all the foreign variables (GNP, interest rates, prices, etc.) that affect U.S. transactions.

Since aggregation over countries really cannot be justified on a priori grounds, we have been forced to consider alternative, more empirically-based criteria. Along these lines, two major criteria for country disaggregation have suggested themselves to us and readers of our earlier paper (IFDP#59):

> (1) the degree to which the important variables of a country (exchange rates, etc.) are not highly correlated with those from other countries;
>
> (2) the importance of the country, based on the relative importance of its trade and capital flows with the United States, and/or special reasons for wanting to model that country's monetary and intervention policy.

Each of the number of specific recommendations discussed below is based on one or a combination of both of these criteria. Both criteria can lead to cases where aggregation over countries does not introduce significant error. However, let us not forget that the above criteria are not to be valued for their own sake, but only as they promote the basic seven goals of the project discussed above. And even if aggregation need not introduce error, the way it is done can affect our ability to

achieve certain of the basic goals. Concerning these goals, criterion (1) emphasizes statistical explanation, forecasting, and/or the avoidance of errors of aggregation; as long as variables are perfectly correlated, any one of them can stand for the whole set. A person emphasizing this approach would probably be willing to sacrifice goals 6 and 7 above--the modeling of the impact of foreign monetary policies on the United States and the provision of country detail for its own sake. For one thing, substantial variation in the paths of monetary and fiscal policy are likely to break the high correlations on which the approach is based. A proponent of criterion (1) might also be willing to downplay the fourth goal, concerned with modeling intervention.

Principle (2) can also be motivated by the goal of minimizing aggregation error; rather than relying on a specific statistical test, one can assume that the exchange rates, incomes, etc. of important countries will not as a rule move together--even if special circumstances may have produced high correlations in the past. Moreover, if one can model enough countries, so that trade and capital flows with the remaining countries are very small, one can be reasonably sure on a priori grounds that he has captured all the country variables which significantly affect the U.S. economy; unfortunately, as we discuss below, no feasible country breakdown satisfies this last consideration. Finally, principle (2), by focusing on the country as a fundamental modeling unit, allows the achievement of goals 4-7. However, it must be admitted, that insofar as it replaces a criterion based explicitly on maximizing the $R^2$ or some other statistical test, principle (2) may lead to poorer explanatory equations for U.S. endogenous variables during that sample period.

C. The QSS Approach to Modeling Individual Countries

In IFDP#59 we developed a method of disaggregation based primarily on the second principle; although mindful of the criticisms of this method and the numerous alternatives suggested by others, we continue to believe it is the best choice. We will elaborate on our approach first, and then discuss the alternatives.

We recommend that the following countries be disaggregated: Canada, Japan, the United Kingdom, and West Germany. This list was originally chosen primarily according to principle (2), above, and considerations of the manpower available in the QSS section; however, as Table I shows, the exchange rates of these countries also show a considerable lack of intercorrelation.

In terms of importance, Table II shows that the four countries hold the first three places for U.S. imports, exports, the stock of direct investment and the stock of portfolio claims on foreigners. A similar, though not quite so predominant a picture, can be observed for the stock of U.S. liabilities to foreigners and for all flows except the flow of total liabilities to foreigners; in this latter case, Switzerland and the Middle East oil exporters take the first two places.[11] Thus in terms of totals, these four countries account for a large percentage of all trade and capital flows with the United States--and a larger total than any other four country breakdown. However, to underline the importance of many countries for the U.S. balance of payments, the rest of the world still accounts for more than 50% of each of the flows and stocks broken out in Table II. This fact illustrates that it is impossible to suggest a feasible disaggregation by country that leaves a rest of the world (ROW) small enough to be ignored as de minimus.

TRADE AND INVESTMENT BY MAJOR COUNTRIES

(Millions of U.S. Dollars)

| | U.S. Trade (1974) | | U.S. Direct Investment (1974) | | U.S. Total Claims (Non-Direct) on Foreigners (1974) | | U.S. Total Liabilities (Non-Direct) to Foreigners (1974) | |
|---|---|---|---|---|---|---|---|---|
| | Imports | Exports | Stock | Flow (1974-1973) | Stock | Flow (1974-1973) | Stock | Flow (1974-1973) |
| W. GERMANY | 6428(3) | 4986(3) | 7998(3) | 348(12) | 1045(8) | 307(7) | 10429(4) | -3557(3) |
| JAPAN | 12455(2) | 10679(2) | 3337(8) | 666(6) | 14102(1) | 6438(1) | 14802(1) | 1406(5) |
| FRANCE | 2305(9) | 2942(9) | 4886(4) | 591(7) | 1347(6) | 199(11) | 4807(5) | 485(9) |
| UNITED KINGDOM | 4021(6) | 4574(5) | 12461(2) | 1421(2) | 5116(3) | 1676(2) | 10455(3) | 736(7) |
| CANADA | 22282(1) | 19932(1) | 28378(1) | 2837(1) | 5864(2) | 1330(3) | 4700(7) | -270(11) |
| ITALY | 2593(8) | 2752(10) | 2769(11) | 557(8) | 878(9) | 206(10) | 2869(11) | 1097(6) |
| NETHERLANDS | 1453(18) | 3976(6) | 3209(9) | 857(3) | 868(10) | 463(6) | 4086(8) | 535(8) |
| SWITZERLAND | 900(24) | 1150(19) | 4538(6) | 724(5) | 531 | 222(9) | 10862(2) | 5774(1) |
| MIDDLE EAST OIL EXPORTERS* | 4346(5) | 3215(7) | 2129(12) | -459(9) | 714(12) | NA | 4727(6) | 3981(2) |
| MEXICO | 3386(6) | 4855(4) | 2825(10) | 446(11) | 3112(4) | 961(5) | 1864(12) | 483(10) |
| VENEZUELA | 4676(4) | 1768(15) | 1772(13) | -279(13) | 1291(7) | 303(8) | 3494(9) | 1985(4) |
| BRAZIL | 1705(13) | 3089(8) | 3658(7) | 773(4) | 2503(5) | 966(4) | 1160(13) | 233(12) |
| 4 Country Total** | 45186 | 40171 | 52174 | 5272 | 26127 | 9751 | 40386 | -1685 |
| World Total | 100965 | 98524 | 118613 | 14938 | 61548 | 22577 | 112884 | 23504 |
| 4 Country % of World Total | 44.8% | 40.8% | 44% | 35.3% | 42.4% | 43.2% | 35.8% | 7.2% |

Source: U.S. Trade, Direction of Trade, Oct. 1975, p.2-4.
U.S. Direct Investment, Survey of Current Business, "U.S. Direct Investment Abroad", Oct. 1975, Tables 12, 13.
Total U.S. Claims on Foreigners, FRB Bulletin, Feb. 1975, A69, T.12, A75, T.23, A68, T.13, and Feb. 1976, A74, T.24, A73, T.23, A67, T.12 also Treasury Bulletin, May 1976, p.97, p.106, p.108.
Total U.S. Liabilities to Foreigners, FRB Bulletin, Feb. 1975, A66, T.8, A68, T.10, A75, T.23, and Feb. 1975, A64-A66, T.8-T.10, A69, T.15-T.16, A73, T.23 also Treasury Bulletin, May 1976, p.92, p.100, p.102, p.111-113.
*Middle East Oil Exporters are defined as in FRB Bulletin; Bahrain, Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia, Syria, United Arab Emirates
**Four Country Total comprises W. Germany, Japan, U.K., and Canada.

Concerning the latter point, we will show in the next section that fortunately the modeling of the rest of the world can be considered independently of the choice of countries; that is, for virtually any choice of goals and country breakdown, we can specify a theoretically appropriate rest of the world. For convenience of exposition, then, we shall defer consideration of the rest of the world until the next section.

If one assumes that certain countries should be broken out, and the number should be four or more, it is hard to argue against any of the four suggested; no one in fact has. However, in view of the large percentage of international transactions unaccounted for by these four, one might ask why more countries are not disaggregated. The first reason is manpower: we calculate in more detail below that each country model will take approximately 10 months to estimate, assuming that the job is undertaken by one economist working on it 2/3 time or more; the QSS section has available at most six economists (one of whom will not arrive until September 1976); the estimation of five country models will pretty well exhaust the available manpower for the next 10 months. The second is that although there are significant countries left out by this proposed disaggregation, the addition of just a few more countries would not overcome the problem of a sizable residual ROW. For example, the top 12 countries listed in Table II account for only between 2/3 and 3/4 of the important international transactions of the United States; thus whatever our country breakdown a sizable ROW remains.

Certain other countries have been suggested as particularly important and deserving of consideration for disaggregation. Switzerland is a possibility because of the importance of its capital flows with the United States. France is only slightly behind our group of four countries in its importance for all categories of U.S. international transactions. Mexico is the same, especially with regard to trade. Finally, at some point it would seem important to account explicitly for the extraordinary increase in the stocks of assets held by OPEC countries.

None of these suggestions seems to us to be out of order. It would be hard, however, to argue for the substitution of one of these alternatives in place of the four countries mentioned above. In our view, the question becomes, rather, whether in following the principle of disaggregating important countries or regions, one should model any of the above in addition to Canada, Japan, the U.K., and W. Germany. We think further disaggregation should wait until preliminary results are available on the proposed disaggregation. As we mentioned, four countries plus the United States is considerably more than has been previously attempted; more than these five countries would severely strain available resources, and none of the proposed additions would drastically reduce the significance of the rest of the world.

D. Alternative Proposals for Modeling Individual Countries

A number of readers of IFDP#59 have suggested alternative methods of disaggregation based more directly on criterion (1) above, the degree to which important foreign variables are not correlated; this of course is related to the concept of maximizing explanatory or forecasting ability.

The first and simplest suggestion is to determine the country or regional breakdown on the basis of the historial correlations for the exchange rates of important countries (and possibly other variables). Naturally, to the extent that a given exchange rate or other variable is a linear combination of other exchange rates, it would add no explanatory power to any U.S. international transaction. Short of this it would be hard to say anything definite about the importance of a given country's variable as compared to others. Further, a general argument against all statistical criteria for disaggregation is that one never knows whether the high correlations observed in a sample period will persist into the future. In any case, the evidence in Table I indicates that most, if not all, of our countries would be prime candidates for disaggregation according to this criterion.

An alternative criterion, but related to the above, would be to let the results of fitting the United States model to determine which countries should be broken out.[12] One would proceed by first estimating the U.S. model; in so doing, exchange rate, foreign GNP's, etc. would be allowed to appear in appropriate equations both in bilateral form and in plausible weighted averages; when disaggregated variables for a given country were shown to significantly improve the explanation of an endogenous variable, the country would be a prime candidate for individual modeling. This approach seems to us to be a significant improvement on the preceding one, in marrying the statistical approach to our primary goal; i.e., to pick that set of disaggregated foreign variables that adds the most to the explanatory ability of U.S. equations. We see two reasons for

preferring the method proposed in the last section to this one, although we find this one quite defensible.

First, despite the possibility that this procedure might come up with a shorter list of countries to disaggregate, it is virtually certain that it would take longer to complete the whole project. Work on the foreign country models could not begin until the U.S. model was essentially complete; even if all hands worked on the U.S. model, it is hard to expect it to be finished in less than six months; assuming the expected time for the completion of foreign country models--ten months--it is probably safe to say that one would not be in a position even to begin simulating the models together in less than sixteen months; thus in our estimation, this procedure would be likely to add six months to the length of the project.

The second reason is that this approach and the criterion which it is designed to achieve totally exclude interest in a foreign country for any reason independent of the explanation of U.S. transactions; i.e., it neglects goals 4, 6 and 7, the desire to model the impact of foreign intervention and monetary policy.

## III. Modeling the Rest of the World (ROW) (Question 2)

Table II establishes that any feasible model of the foreign sector of the United States must contain a significant set of countries that are either aggregated into a single residual "country" or are ignored. We just do not have the resources to disaggregate enough countries such that the rest of the world (ROW) would account for

a small share of U.S. transactions. Nevertheless, two types of questions seem to us to be important. First, given a proposed country breakdown, how best should ROW be modeled? Second, does a particular choice of country breakdown in any way limit or constrain the way ROW can be modeled?

Addressing the second question first, it would be of particular concern if the degree of country breakdown were constrained by the manner in which one chose to model ROW or vice versa. Fortunately we think the answer to this question is no; however, there were a number of points that concerned us, dealing with possible losses of information, costs of collecting data for different options, and possible effects on our ability to endogenize certain variables. In all these cases, upon closer examination we found that with care in constructing ROW, none of these considerations seemed to prevent the achieving of desired ends in either country disaggregation or modeling ROW.

With regard to possible losses of information, one apparent virtue of a totally aggregate treatment of the world outside the United States, is that this ROW in some sense includes <u>all</u> that is going on outside the United States; can we be sure of doing as well if we start disaggregating countries out of this ROW? In terms of preserving at least as much information in our new country breakdown as the two-country version, the answer must be yes. As long as we make sure to keep in ROW <u>all</u> the countries that have not been disaggregated, we have preserved as much information for any given variable as we had in the original wholly

aggregated treatment of the world outside the United States. And a greater degree of country disaggregation should, in principle at least, provide more information for any given variable such as U.S. trade and capital flows.

Consider, for example, the case of (net) short term capital flows. With an aggregated world outside the United States, the only possible dependent variables that can be used are total measures--either total gross or total net capital flows. With a new model containing, say, one foreign country and a ROW constructed appropriately, we can either (1) explain the same total net capital outflows (which now is the sum of the outflow to the country and to ROW) or (2) explain, separately, the net capital outflow to each area. Presumably, considerations of the explanatory ability or the importance for simulation purposes of the alternative equations will determine which alternative is followed. The main point of the preceding discussion is that by properly constructing ROW one always has the choice.

Similar arguments rule in the case of endogenization. If one has a variable endogenized in an aggregate world outside the United States--for example GNP--he can in principle do just as well in a more disaggregated world. For the example of GNP, we just must be sure to endogenize GNP in each of the countries disaggregated and also in ROW; naturally the data for a given variable in ROW would have to be equal to the former value for the aggregate world outside the United States minus the sum of the values for the countries that have been disaggregated.

This brings us to the question of the data requirements for a

disaggregated model and its effect on the modeling of ROW. If we have the data for an aggregate ROW and the data for the set of countries that one desires to disaggregate, there should be little trouble constructing the data for a new ROW by a process of subtraction. In fact, however, on examining the country coverage of the existing ROW's that we know of, we find that for most variables the data from very few countries are used in their construction. For example, for Kwack's existing BOP model, the GNP variable for the world outside the United States is the sum of the GNP's for four countries--in fact the four countries that we propose to disaggregate. Thus for this case, after disaggregating our proposed four countries, there would be nothing left in ROW;[13] similarly, the foreign activity and price variables used in most U.S. export and import equations, are a weighted average of a fairly limited number of countries. Thus a particular disaggregation of countries adds nothing to the costs of constructing a particular ROW--it may definitely add data costs to constructing the disaggregated country models, but in the case of the countries proposed these costs are small because we already have existing data banks for each country.

In summary, our conclusion concerning the possibility that constraints might be put on our ability to disaggregate individual countries by our desired structure for ROW is that this is not a serious problem.

A. Alternative Forms for ROW

Given the almost total independence between ROW and the degree of country disaggregation, we can combine our proposed country models with

any number of specifications for ROW. Our proposal is for a fairly limited ROW, at least at first. However, it might be useful to go over some of the alternatives.

First let us consider the constraints on ROW imposed by data collection. Virtually no world aggregates exist; the only exception is for trade. Thus, any ROW variables must be constructed by adding up the data for individual foreign countries. For most configurations of ROW this would involve considerable costs of data collection. Some help can come by using the individual country data banks for project LINK--which we will use for some of our proposed country models; but much of the LINK country data outside of the four we have chosen for individual modeling is not quarterly and/or does not contain all the variables that we want. Thus any ROW that does not include the four countries already disaggregated involves some degree of data collection; this indicates why ROW variables in the past, for example in Kwack's balance-of-payments model, have been aggregates of a very limited number of countries. In Kwack's model most ROW variables are aggregates of data for only four countries, those we have decided to treat separately.

Second is the question of the degree of endogenization of ROW variables and the type of model to be used for a given degree of endogenization. One option is to build a ROW that has exactly the same structure as our country sub-models; if one had already aggregated ROW data, this at least would be a feasible alternative. A somewhat similar strategy would be to endogenize the ROW variables, but to use reduced forms for the variables rather than structural equations. Finally, to the extent that ROW is insignificant, uninteresting, and/or has little feedback onto U.S. variables, one can contemplate letting most or all ROW variables be exogenous.

The interplay of the considerations of data availability and the size of the rest of the world for already existing models of the U.S. foreign sector, has pushed us toward a minimal size for ROW, at least as a first cut at the problem. As noted above, in our proposed disaggregation we have already captured most of the country detail present in other models --so even if a four-country breakdown does not look very impressive relative to the actual size of the world outside the United States, it compares favorably to what other models have done. Further, when we get beyond our four countries, we rapidly get to the point where it becomes difficult and costly to collect quarterly data; in fact most of the remaining countries in the world do not have readily available data on a quarterly basis for such variables as GNP, prices, money supply and so on. One could go to an annual ROW and do better in terms of data availability; this would be feasible, but would involve both considerable data collection and programming complications, the latter in order to work the annual ROW into our quarterly framework.

In view of the above considerations, we feel justified in starting with a very limited ROW. Our view is that two variables in ROW should be endogenized and at least one enter the model exogenously. The latter will be the price of primary products; this variable, we feel, will be important in the determination of import prices.

The variables we think should be endogenized are the Eurodollar rate and ROW exports. We discuss in Part II of our summary paper, why we feel it is a necessity to endogenize the Eurodollar rate. In fact, although the Eurodollar market will be outside all of our five country models, the rate really will not be a ROW variable, since it will be determined almost entirely by variables emanating from our five countries.

As we discuss in detail in explaining our framework for the determination of exports and imports, either ROW's exports or imports must be determined endogenously.[14] The specification of either of these permits the endogenous determination of exports and imports for each of our six regions. Normally we would prefer on theoretical grounds to determine ROW imports, as we do for all the other country sub-models. However, a ROW import function would require a good ROW activity or GNP variable to work well, and that may be hard to specify--and harder to endogenize. Hence we will attempt to work with a ROW export function, which will be driven primarily by a GNP variable for our five disaggregated countries; this variable has the added desirable characteristic of being endogenous.

As a final point, let us reiterate that the choice of ROW is not fundamentally limited by the degree of country disaggregation. Should the Division desire to start with a different formulation for ROW, this can be done without changing the other parts of the project.

## IV. Structural Models vs. Reduced Forms (Question 3)

In IFDP#59 a major topic for investigation was the possibility of using small reduced-form models for the important dependent variables of those countries that are to be modeled individually. If feasible, this alternative would promise significant savings of time and effort.

Unfortunately for this alternative, our conclusion of IFDP#59 still stands. We find the use of reduced forms infeasible for two major reasons. First, because of the non-linearities inherent in all systems of equations containing endogenous exchange rates, it is impossible to obtain an explicit reduced-form equation for a given exchange rate and,

consequently, for the other dependent variables of the system. Second, when one attempts to linearize the non-linear system of equations to get an approximate reduced form, so many independent variables appear in the reduced-form that it is impossible to estimate. The number of independent variables, which includes many product and cross-product terms, can vary anywhere from 200 to 1,000.[15,16]

Finally let us not forget the limitations of reduced forms as compared to structural models. First, because a single change in one structural equation will, in general, change all the coefficients of the reduced form, such coefficients are generally regarded as being less stable over time than structural parameters. Second, the use of reduced form models makes it impossible to model government policies that take the form of reaction functions; a reaction function makes policy action a function of one or more endogenous variables in the model, e.g., intervention may be a function of the deviation in the exchange rate from some target level. To change a reaction function for, say, the purposes of simulating alternative government policies implies, like the changing of any structural equation, the changing of <u>every</u> coefficient in the reduced form. Third, unless we make the dependent variables of a given foreign country a function of <u>all</u> exogenous variables throughout the world, we lose the feedback effects on the U.S. economy that are caused by changes in exogenous variables being transmitted through foreign countries--e.g., the effect on U.S. output caused by the fall-off of U.S. exports, which in turn is originally caused by a U.S. recession. But, of course, we do not have enough observations to make the dependent variables a function of all exogenous variables.

In IFDP#59 we established the above negative conclusion concerning reduced forms. We accepted the natural implication of that argument that the only alternative was to model the world outside the United States structurally; however, we did not have a structural model to offer at that time. In the Summary Paper and the companion papers by Berner, Clark and Kwack, and Howe we fill that void. We present in these papers a prototype structural model that we argue can be used for the United States and for the foreign countries that are to be modeled individually.

## V. A Summary of Time Estimates for Alternative Projects

In this section we summarize and elaborate the estimates given in the text for completing the alternative projects we have discussed.

### A. Five Country Models (including the United States) plus a minimal ROW

Assuming intensive work by all members of the Quantitative Studies Section, we estimate that it will take 14-16 months between now and the completion of this preferred alternative; the latter figure, 16 months, is the best guess, in that it allows for unforeseen difficulties--almost certain to occur in the latter stages of the project where a totally new problem will be encountered, getting the five country models with endogenous exchange rates to simulate together.

This overall time estimate breaks down as follows. Each country model, five in all, can be estimated in approximately 6 months. This assumes one economist devoting approximately 2/3 of his time to this project. (The section has five economists, with a sixth arriving in

September; however, some economists have other duties that will require more than 1/3 of their time; thus the above estimate implies that the section's resources will be quite fully committed.)

After the estimation of each country model, three or four months will be necessary to get it working properly: running successful dynamic simulation inside and outside the sample period; calculating and checking for the reasonableness of the multipliers of the model, etc.

Finally, a considerable period will be required to attempt to get the five country models to simulate together in order to solve for the four endogenous exchange rates in the model. This is an uncharted area as far as research is concerned; anticipating problems, we rather arbitrarily estimate that it will take five to six months to complete this stage and finish the project.

B. Time Estimates for a Two Region World, Both of Which Are Modeled Structurally

We have opposed this alternative strongly on theoretical and empirical grounds. Also, it does not seem that this scaled-down alternative would save a dramatic amount of time. The total person-months necessary to estimate the two, essentially similar, structural models would be considerably less than our recommended alternative: about 6 months required for the U.S. model (as above) and 9 person-months for the composite ROW structural model (considerable additional data collection will be required); this is a total of 15 months compared to 30 for the project above. However, this smaller total of person months would not be fully reflected in the time it takes to complete this stage of the project; we feel it would be

impossible to expect that one could complete the estimation stage in (15/5 = 3) three months; at least four and possible five months would be necessary. Approximately three months would be necessary to complete reasonable dynamic simulations for the models above. To get the models simulating together, still expecting considerable problems, we would estimate 4 months (as compared to 6 for the project above). The total would then be 11 to 12 months elasped time for this project (as compared to 14 to 16 for the recommended alternative).

C. Time Estimates for a Two-Region Model with a Minimal World Outside the United States

If the world outside the United States were modeled as largely exogenous, then the time to completion would be considerably shortened as compared to the desired alternative. However, we have noted above that this sort of strategy would improve little on the project now underway to link the Kwack model to the existing FRB model and to endogenize the exchange rate there. The time estimates would be: four months to construct and estimate the basic models, largely devoted to the estimation of the prototype U.S. model; two months to get the models simulating individually; and another four months to get the models working in tandem to solve for the endogenous exchange rate. This total would thus be 10 months.

Footnotes

*Chief Quantitative Studies, International Finance Division, Board of Governors etc. The views expressed herein are soley those of the author and should not be interpreted as reflecting the views of the Board of Governors.

[1]The model and the arugments supporting it are summarized in Berner, Clark, Howe, Kwack and Stevens, "Modeling the International Influences on the U.S. Economy: A Multi-Country Approach," (reference [3], below). Companion papers, besides the present one, that go into much more detail on specific subjects are the following: R. Berner, "The Goods Market and the Labor Market of the Multi-Country Model" ([1] below); P. Clark and S. Kwack, "Asset Markets and Interest Rates Determination in the Multi-Country Model," ([4] below); H. Howe, "Price Determination in the Multi-Country Model," ([6] below); G. Stevens, "Balance of Payments Equations and Exchange Rate Determination" ([8] below).

[2]R. Berner P. Clark, H. Howe, S. Kwack and G. Stevens, "Simultaneous Determination of the U.S. Balance of Payments and Exchange Rates--An Exploratory Report," International Finance Discussion Paper No. 59, Feb. 3, ]975. (The reference to this paper is abbreviated in the text as IFDP#59 and is [2] in the list of references).

[3]We have been greatly aided by discussions with and detailed comments from the following economists: William Branson, Ralph Bryant, Dale Henderson, George Henry, Lawrence Lau, Patrick Minford, J. David Richardson, Jeffery Shafer, Jerome Stein, Edwin Truman and Janet Yeller.

[4]See Berner on the goods and labor markets; Clark and Kwack on the assets market; Howe on prices; Stevens on balance-of-payments equations.

[5]By "weighted average" exchange rate we mean a weighted average of bilateral exchange rates with the U.S. dollar; in most cases the weights would be exogenous and unchanging, e.g., trade shares in some base period.

[6]See Helliwell, et. al. [5] and Minford [7].

[7]In Section V, below we go over these time estimates in detail.

[8]This project, now underway, will be completed sometime this year.

[9]See Section V, below, for more details.

[10]Berner, Clark, Howe, Kwack and Stevens [2], Section II.

[11]These data are for 1974, but a similar picture emerges for 1973.

[12]This suggestion was made by Heywood Fleisig of the Division of International Finance.

[13] In the present version of his balance-of-payments sector, Kwack uses eight bilateral exchange rates in constructing his weighted average exchange rate; of course, for a few variables like exchange rates, ample data exist for any sized ROW. But there are very few variables in this class.

[14] See Berner, "The Goods Market and the Labor Market of the Multi-Country Model," section II.C.

[15] See IFDP#59, p. 28 ff.

[16] Lawrence Lau, a reader of IFDP#59, has demonstrated that the specification of a linear-logarithmic demand function for imports would considerably reduce the extent of nonlinearity in exchange rates. Here, all terms including prices expressed in common currency would become the sum of the log of price and the log of the respective exchange rate. However, Lau's system still requires the conversion of consumption in local currency to the common currency by multiplication by the exchange rate. Thus the combined system of balance-of-payments equations is still not linear in exchange rates. A closed-form solution of the system to obtain reduced form equations in exchange rates is still not possible.

## References

[1] Berner, Richard, "The Goods Market and Labor Market of the Multi-Country Model," International Finance Discussion Paper No. 97, Board of Governors of the Federal Reserve System, 1976.

[2] Berner, R., P. Clark, H. Howe, S. Kwack and G. Stevens, "Simultaneous Determination of the U.S. Balance of Payments and Exchange Rates--An Exploratory Report," International Finance Discussion Paper No. 59, Board of Governors of the Federal Reserve System, 1975.

[3] Berner, R., P. Clark, H. Howe, S. Kwack and G. Stevens, "Modeling the International Influences on the U.S. Economy: A Multi-Country Approach," International Finance Discussion Paper No. 93, Board of Governors of the Federal Reserve System, 1976

[4] Clark, Peter and S. Kwack, "Asset Markets and Interest Rate Determination in the Multi-Country Model," International Finance Discussion Paper No. 94, Board of Governors of the Federal Reserve System, 1976.

[5] Helliwell, John, et. al, The Structure of RDX2, Bank of Canada, Staff Research Study No. 7, 1971.

[6] Howe, Howard, "Price Determination in the Multi-Country Model," International Finance Discussion Paper No. 98, Board of Governors of the Federal Reserve System, 1976.

[7] Minford, Patrick, "A Quarterly Model of the UK Balance of Payments and Exchange Rate," unpublished manuscript, 1974.

[8] Stevens, Guy, "Balance of Payments Equations and Exchange Rate Determination," International Finance Discussion Paper No. 95, Board of Governors of the Federal Reserve System, 1976.