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Forecasting and Policy Analysis with Econometric Models

In the previous chapters we have discussed in detail the estimation of the individual economic relationships that directly determine the balance of payments. The next step is the integration of these relationships into a comprehensive quantitative model designed to provide understanding and, ultimately, control of the economic environment. We shall see in this chapter that the problems of constructing a multi-equation econometric model are very much more difficult than the problems inherent in estimating individual relationships. In practice, these difficult problems have been largely ignored and consequently only meager evidence exists concerning what should or should not be done when a model is constructed. For this reason this chapter should be taken to be tentative and suggestive.

Historically, the quantitative analysis of the balance of payments began with the estimation of individual import and export demand equations. Considerable effort was expended in the 1940's and early 1950's in the measurement of income and price elasticities. There was a preoccupation during this time with the importance of the price variable, and it was common for researchers to subject their price variables to tests of significance in an effort to credit or discredit the hypothesis that price changes had little or no effect on the flow of goods and services.

In the 1950's, quantitative inquiry concerning the determinants of the balance of payments turned to multi-equation models. This shift in emphasis required, of course, the concurrent evolution of large-scale electronic computing facilities. It is now possible to build upon the many studies that have been made of particular relationships and to construct relatively large and complex econometric models. Our concern in the present chapter will be with the structure of such models, using as building blocks the relationships developed in the preceding chapters that dealt with the flow of goods and services, and of capital.

ECONOMIC FORECASTING

We may begin our discussion of forecasting with a justification for allocating resources to such efforts. It may be noted first that an econometric model of economic phenomena is designed to enhance our understanding of the interplay of forces behind the phenomena being studied. It is safe to say that no amount of *a priori* theorizing will disclose the quantitative impact of one variable on another. Moreover, the very preciseness of specification required in econometric model building should necessitate very careful and logical thought on the part of the analyst. Such thinking may often greatly enhance the analyst's theoretical view of the phenomena being studied, even before any empirical fits are obtained.

Nonetheless, greater understanding of economic events should not be viewed necessarily as a goal unto itself. Rather, understanding should be looked upon as a tool for optimal decision making designed to attain the economic objectives of the society. The making of both public and private economic decisions is measurably improved when there is a fundamental understanding of the consequences of such decisions. Thus, for example, government policymakers will be interested in the impact of various monetary and fiscal policies on the domestic economy and balance of payments, while private investors will want to know something about future profit rates in the industries of immediate concern to them.

This suggests that an econometric model and an associated forecast should be deemed successful insofar as decisions are made more effectively. The discussion to follow will therefore be cast in a decision-making context. Let us for the moment concern ourselves with some general considerations of model building.

General Concepts of Econometric Model Building An econometric model is a set of equations, including statistically estimated relations, that seeks to explain in quantitative terms some observed economic phenomena. Besides the econometric relations, the model may also include both identities and noneconometric behavioral relations (e.g., a tax relationship specifying some legally determined percentage of income).

In order to focus on concepts and problems pertaining to econometric models in general, let us consider a model of the following form

$$\begin{aligned} Y_1 &= f_1(Y_2, Y_3, \ldots, Y_n, \quad X_1, X_2, \ldots, X_m) \\ Y_2 &= f_2(Y_1, Y_3, \ldots, Y_n, \quad X_1, X_2, \ldots, X_m) \\ &\ldots \\ Y_n &= f_n(Y_1, Y_2, \ldots, Y_{n-1}, \quad X_1, X_2, \ldots, X_m) \end{aligned} \tag{5.1}$$

This model includes n equations, econometric or otherwise, each of which describes a particular variable Y_k as a function of the $(n - 1)$ remaining Y_i and m other variables, X_j, $(j = 1, \ldots, m)$. The Y_i variables are called *endogenous variables* since these variables are explained by or, equivalently, are endogenous to the model. Correspondingly, the X_i variables are called *exogenous variables* to indicate that no attempt is made to explain or forecast their values, or perhaps more accurately, that none of the endogenous variables influences the exogenous variables.

Before proceeding, we should perhaps caution the reader that this general representation of an econometric model does not imply that all the explanatory variables noted need be used in each equation. Rather, the explanatory variables in each equation are potential choices, not necessary ones. Consequently, we should take the functions f_i to be general enough to exclude any of the potential explanatory variables. Thus, for example, the case when Y_1 depends on X_3 and X_7 alone is implicitly considered by the very general function f_1. In addition, one or more of the equations may be identities or behavioral relationships that are arrived at by other than statistical methods.

Ordinarily the functions f_i used in economic research will permit the "solution" of the equation system (5.1). That is, we may express the endogenous variables as functions of the exogenous variables alone, as follows

$$\begin{aligned} Y_1 &= g_1(X_1, X_2, \ldots, X_m) \\ Y_2 &= g_2(X_1, X_2, \ldots, X_m) \\ &\cdots \\ Y_n &= g_n(X_1, X_2, \ldots, X_m) \end{aligned} \tag{5.2}$$

This of course requires that all of the relationships hold simultaneously, which implies rapid adjustment to disequilibria. This assumption is not so strong when adjustment lags are included in individual relations.

When the model is expressed in the form of the first system (5.1), we will call it a *structural model*. That is to say, System (5.1) represents the structure of the economic phenomena. It is meant to indicate how any particular variable directly influences any endogenous variable. System (5.2), on the other hand, is referred to as the *reduced form*. We may think of it as being an equilibrium system. To illustrate this point, we might consider the first equation of the structural model (5.1). A change in X_1 will induce a change in Y_1, but this change in Y_1 will induce changes in $Y_2, \ldots, Y_n$, which in turn alter Y_1 once more. Eventually, assuming stability, the system will settle down to an equilibrium again. This equilibrium influence of X_1 on Y_1 is expressed by the first equation of the reduced form system (5.2). Hence to repeat, the structural model indicates the initial impact of one variable on another, while the reduced form indicates the final equilibrium.[1]

The reduced form system (5.2) will play the central role in both forecasting and policy analysis. *Forecasting* will require the selection of a particular set of values for the exogenous variables X_j, which will be inserted into the reduced form equations to calculate forecast values for the endogenous variables Y_i. *Policy analysis* will involve such a question as: "If the value of a policy instrument X_i is altered, what will be the effect on variable Y_k?" The answer to such a question may be read directly from the kth reduced form equation.

Conditional and Unconditional Forecasts We have just described forecasting as requiring the selection of a particular set of values for the exogenous variables, which together with the reduced form system will imply values of the endogenous variables. This suggests that a forecaster may make either a conditional or an unconditional forecast. A *conditional forecast* will be of the form: "If the values of the exogenous variables turn out to be this, then the values of the endogenous variables will be that." In other words, the forecast is conditioned on the future values of the exogenous variables. An *unconditional forecast* may be represented as: "The values of the endogenous variables will be this." That is, the forecast is not conditioned on any future events. The difference between a conditional and an unconditional forecast should be clear. In the case of the conditional forecast, the forecaster in effect is admitting that he is unable or unwilling to project the values of the exogenous variables X_i. With an unconditional forecast, however, the forecaster will in effect provide the projected values of the exogenous variables.

[1] We can illustrate these points with a simple demand and supply model

$$Q = \alpha + \beta P + \gamma D \tag{i}$$
$$P = a + bQ + cS \tag{ii}$$

Equation (i) is the demand equation indicating quantity demanded Q as a linear function of the price P and some demand factor D. Equation (ii) is the supply equation indicating the supply price P as a linear function of the quantity sold Q and a supply factor S. This is a structural model with endogenous variables Q and P, and exogenous variables D and S. The corresponding reduced form is

$$Q = (1 - \beta b)^{-1}(\alpha + \gamma D + \beta a + \beta c S) \tag{i'}$$
$$P = (1 - \beta b)^{-1}(b\alpha + b\gamma D + a + cS) \tag{ii'}$$

We see from Equation (i) that a one-unit increase in D will have an impact on the quantity demanded equal to γ units. This "shift" in the demand curve will tend to induce a rise in the price due to the upward sloping supply function. Such a price increase will dampen the impact of the change in D on the market-clearing quantity. The equilibrium result can be read from the reduced form equation (i'), which indicates that the initial impact of size γ will be damped by the factor $(1 - \beta b)^{-1}$.

A pure conditional forecast is represented by the reduced form system alone. This implicitly contains all of the conditional statements that can be made. A pure unconditional forecast will report only the forecast values of endogenous variables. The reduced form would not be required here inasmuch as the values for the exogenous variables will have been specified. Most econometric forecasts fall between the pure conditional and unconditional cases. The reduced form or the structural model is therefore ordinarily reported. In addition, most likely values of the X_i are used to calculate the forecast Y_j. The user of the forecast is thus provided with both the most likely forecast as the forecaster sees it, and a means to alter that forecast in the event that the user disagrees with the forecaster's opinions about the future values of X_i. Thus, this hybrid forecast is preferred, since it provides the maximum of information.

Informative and Decision Forecasts A forecast will ultimately lead to decisions on the part of the forecast user. The forecaster may play one of two roles in this process. He may provide information about future events which will be analyzed by some decision maker, or he may use the information to make decisions himself. In the first instance, a forecast will provide probability statements about future events, while in the second the forecaster provides his view of what will occur without appending any probability statements. In the latter event, the forecast user is implicitly denied those decision making powers that relate to the weighing of the likelihood of various outcomes.

A concrete example of the difference between these two types of forecasts may be useful. If a forecaster predicts sales of one million units, production will be geared to that level of sales. If, however, the forecast specifies the probability of other levels of sales, management may decide on a production level best suited to its goals. For example, there may be a reasonably good chance of sales of two million units, and management may decide to have the excess capacity available in that event.

Let us consider first the *informative forecast*, which involves the forecaster as information provider but not as decision maker. An informative forecast seeks to provide useful information about the future. This information takes on the form of a probability distribution, indicating the forecaster's opinions regarding the likelihood of the possible values of the forecast variable. A useful way of summarizing this distribution is in terms of the most likely value and a 95 percent confidence interval. A *point forecast* (without the confidence interval) cannot be an informative forecast since it does not provide the required probability distribution.

It is of considerable importance to be able to evaluate the quality of a forecast after the event has occurred. A forecast may not be judged alone, but must be compared with other competing forecasts. Figure 5.1 depicts two

probability distributions, A and B, which represent competing informative forecasts. Forecast A reflects relatively weak opinions about the event. If y_1 occurs, we will tend to favor forecast A, since y_1 is more likely under that forecast; conversely, if y_2 occurs, forecast B would be preferred.

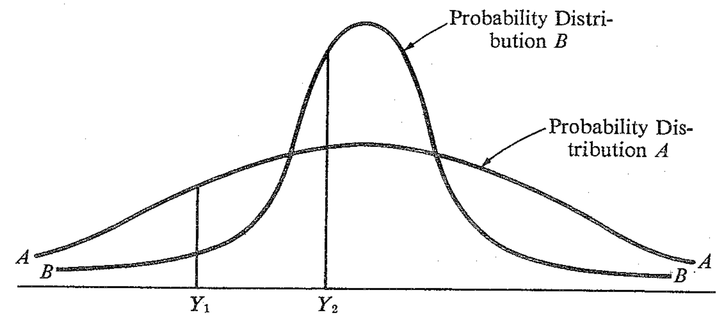

FIGURE 5.1

Probability Forecasts

This concludes our discussion of informative forecasts. Let us now turn to *decision forecasts*. We will view the process of decision making as deciding upon an act a that depends upon the future value of an endogeneous variable Y. Since Y is unknown, there is the possibility of making a nonoptimal decision. The penalty for such a decision will be described by a loss function $L(a, y)$, which describes the penalty for choosing act a, when y turns out to be the true value of Y. A reasonable decision rule is to select a that minimizes the expected loss

$$E(L) = \sum_y L(a, y)\, P(Y = y) \tag{5.3}$$

where $P(Y = y)$ is the probability that the future value of Y will be y. This probability distribution is implicitly provided by the informative forecast.

For any act a that is chosen, there will be a value of Y for which $L(a, y)$ is minimal. A decision forecast will provide only this value of Y. This will lead the forecast user necessarily to one particular act a. The forecaster will decide on the value of the point estimate of Y in the same way that any other decision maker would select an act given the probability distribution of Y, $P(Y)$, that is, on the basis of some loss function, explicit or otherwise. He therefore usurps the forecast user's decision-making powers.

The evaluation of decision forecasts will necessarily be different from the evaluation of informative forecasts. Since a decision forecast purports to minimize the loss we will incur from incorrect decision making, we will quite naturally give the best grades to those forecasts that truly minimize the loss. This will necessitate a comparison of two or more alternative forecasts. In the event that only one model is available, we may generate a dummy forecast for purposes of comparison. Suitable dummy forecasts may, for example, be the naive "no change" forecast or the projection of past trends.

This discussion of the difference between informative and decision forecasts is meant to emphasize that the form a forecast assumes will depend on the forecaster's role in the decision process. In our judgment, the proper form of the forecast will most often be *informative* and *unconditional*, with the reduced form system included to allow the forecast user some adjustment of the forecast according to his own judgment about the future values of the exogenous variables. However, most forecasts have in fact been of the decision variety.[2]

Forecast Error There are three sources of forecast error. In the first place, there are natural disturbances to the true relationships. Secondly, we are using estimates to represent the true relationships. The discrepancy between the estimates and the true relationships will result in forecast error. Finally, the discrepancy between the true levels of the exogenous variables and their estimated levels will induce additional forecast error. A conditional forecast will involve only the first two sources of error. An unconditional forecast will involve all three, although the last may swamp the other two. For this reason, practicing forecasters tend to neglect the first two sources of error.

This concludes the essentially mechanistic aspects of forecasting. As yet, the two most fundamental questions remain unanswered: What variables should be endogenous and what variables should be exogenous? Which explanatory variables should be used in each structural equation? Answers to these questions are about one part mechanical and nine parts intuitive, as we shall see. This is an area in which experience weighs very heavily.

Exogenous and Endogenous Variables Let us consider the first question: which variables to have exogenous. Suits [22] provides in this regard a useful catalog of exogenous variables. The first type consists of those that are historically given. These variables measure events that have occurred before the forecast period. A problem can arise, however, when a forecast for a particular period has to be made in the course of a period still in progress and/or when the relevant data may not be fully collected. In such an event, some method of extrapolating the data already collected or some projection scheme

[2] In some cases it may prove difficult to classify results as being informative or decision forecasts. For instance, when the reduced form is reported, we will somewhat arbitrarily classify the forecast as informative since confidence intervals may be generated on the basis of the forecast user's opinions about the future values of the exogenous variables.

must be used to arrive at particular values for the historically given variables. Experience suggests that reasonably good accuracy can be obtained in such circumstances.

Slowly changing variables make up a second set of exogenous influences. The appropriate values to assign to these variables will presumably be easily calculated by projecting the historical paths. Examples would be population and the labor force.

The third class of exogenous variables involves the set of government policy instruments, such as tariff levels and taxes. From the point of view of the government forecaster, the levels of these variables can be forecast with great accuracy. Although there may be considerable difficulty in projecting these policy instruments when one is not privy to such information, it is not possible to include them endogenously in an econometric model since the government policymakers are unlikely to display a consistent pattern that could be well approximated by an econometric equation. Accordingly, the projection of government policy will play a principal role in introducing error into an unconditional forecast.

The three sets of variables just mentioned are exogenous both from the point of view of the particular model and from the point of view of the economic system generally. That is to say, they are inputs into the economic system and do not to any significant degree respond to events that occur within that system. For this reason they are necessarily exogenous variables in any econometric model.

The fourth set of exogenous variables is composed of variables that are in fact endogenous to the economic system in general, but that for some particular econometric model are selected to be exogenous. For example, a one-equation model of imports might express imports as a function of GNP and prices. In such a model both GNP and prices are exogenous. To our mind, the decision of what to include in this fourth set of exogenous variables and what to include endogenously is the most troublesome problem that faces an econometric model builder. A model builder must ask himself if moving a variable from the fourth class of exogenous variables to the set of endogenous variables will improve the forecast. There is unfortunately often little information he can bring to bear on this question. A related problem is the optimal level of disaggregation. It is safe to say that a disaggregated model will yield more detail than an aggregated model, but it does not follow that the aggregates will be better forecast.

The development of econometric models quite naturally began with relatively small models with relatively few variables and equations. These gradually evolved into larger and more complex models, predicated on the assumption that the more variables endogenously determined, the better the model. In recent years, however, the pendulum has tended to swing the other way in response to arguments that the very large models are so complex that no one can fully grasp their fundamentals and that their relationship to the actual phenomena under study becomes more and more coincidental as they increase in size. According to this line of argument, a small manageable model may thus be preferable.

The fifth and final set of exogenous influences in an econometric model will consist of variables that represent rare events expected to influence the phenomena under study. For example, a commercial trade agreement soon to be ratified may be expected to increase the flow of trade. Since the effect of such an agreement could not be estimated from historical data, we may want to adjust our historically estimated relationships to allow for increased trade. This may be effected by putting exogenous variables that will reflect the likely magnitude of the event into one or more of the structural equations. The choice of the values of these variables will rest entirely on good judgment.

Explanatory Variables Let us now turn to the other question raised earlier concerning the choice of explanatory variables for each structural equation. In the preceding chapters we have discussed the estimation of individual equations and have argued that the appropriate explanatory variables should be suggested by theoretical considerations. This is not necessarily a preferred procedure for multi-equation systems, since when we combine these individual relationships, we will want to avoid the possibility of relatively small estimation errors being transmitted and amplified from equation to equation in such a way that the estimation error of the system as a whole far exceeds the sum of its parts. To put the problem precisely, ordinary least squares applied individually to the structural equations of a large model is not the optimal estimating procedure when the goal is an accurate reduced form.

Although multi-equation estimation methods are available, they are difficult to apply and have not been used to any great extent. In practice, most econometric model builders have used single-equation least squares methods of estimation with an experimental approach designed to reduce the danger of an inaccurately estimated model. For instance, several regressions may be fitted and the "best" one selected. It is important here to emphasize that the summary statistics that indicate good fits, for the individual structural equations, do not insure that the reduced form system is in itself very reliable. These summary statistics are calculated on the assumption that the explanatory variables are given. In fact, many of the equations will include endogenous variables whose values are not given to the forecaster, but rather are calculated from the reduced form.

To express this differently, we observe that when the reduced form is calculated from the structural form, we will have to divide by the structural coefficients on any of the endogenous variables that are also used as explanatory variables. If such a structural coefficient is small and unreliable, this division will greatly amplify the inaccuracy of the reduced form. Accordingly, we should put a premium on large reliable structural coefficients for any endogenous explanatory variables. Whereas experimentation is to be avoided when inference on parameter values of structural equations is desired, such experimentation may be an absolute must in order to arrive at a reasonably reliable reduced form.

The accuracy of the equation system as a whole may be assessed by using the historical values of the exogenous variables together with the reduced form to calculate estimates of the endogenous variables that may be compared with the actual historical values. Unfortunately, a discrepancy between the estimated and the historical values may not lead directly to the particular equation that is the source of that error, since errors will be transmitted in a very complex fashion from equation to equation.

POLICY ANALYSIS

Some separate comments may be in order on the subject of policy analysis. We have already indicated that policy analysis is no more than seeking an answer to a question of the form: "If the government does this, what will be the result?" The answer to such a question can be read directly from the reduced form system (5.2) when the other exogenous variables are given their fixed forecast levels. We should observe that policy analysis and conditional forecasts are essentially the same thing and may be distinguished only by the emphasis placed on a particular set of the exogenous variables by policy analysis.

Another form of policy analysis is *impact analysis*, which deals with the question: "If the government alters this policy instrument by this amount, by how much will that endogenous variable change?" Again the answer is contained in the reduced form system, but this time may be expressed in terms of a *policy multiplier*

$$\frac{dY_j}{dX_k} = \frac{\partial g_j}{\partial X_k} \tag{5.4}$$

where g_j is the jth reduced form equation. Such a multiplier indicates the marginal response of the jth endogenous variable to a variation in the policy instrument X_k. A model designed for impact analysis alone will be significantly easier to construct than other models, since the choice of endogenous variables will be more or less straightforward. That is, an impact model may have many exogenous variables and only a few endogenous ones. This will be undesirable in a forecasting model since in order to construct a forecast, the levels of all the exogenous variables would have to be selected. The model itself would play a minor role in the forecast and might be better discarded altogether.

However, the impact analysis will be useful only when the policymakers are able to react rapidly to economic events. Ordinarily the policy will be selected at some time before the actual event, in which case the policymaker must know both the policy multiplier and by how much the endogenous variable will differ from its optimal level. A forecast would therefore be required.

ECONOMETRIC MODELS OF THE BALANCE OF PAYMENTS

Having reviewed in general the main issues in the use of econometric models for forecasting and policy analysis, let us turn next to consider specifically the question of the structure of econometric models that are designed to investigate the balance of payments and its components. That is, we will examine in more detail the selection of endogenous and exogenous variables. As we have already implied, this question has not been and perhaps never will be satisfactorily answered. Indeed, the issues involved are at the very heart of economic science insofar as they relate to one's view of the world in general and economic phenomena in particular and to the choice of simplifying assumptions that will help to order these phenomena in ways that will improve our comprehension of and ultimately our control over them.

In earlier chapters, we have seen that there is considerable choice for competing selections of explanatory variables in individual equations. When we wish to combine equations into a comprehensive structural model, the problems of choice become manifold. Ultimately, competing models will have to be judged by performance. When a particular model performs poorly, it may be appropriately modified to improve performance. We nevertheless need some basis for departure in constructing a model. What should it be? What, in other words, is the appropriate structure for the model? We cannot hope to give a definitive and unambiguous answer to this question. But we can at least propose a framework that will help the researcher in making his own decisions and serve also as a means by which we can analyze certain specific models that have in fact been used for forecasting and policy analysis.

The process of model building should be attuned essentially to the tasks which the model is expected to perform. Our discussion here is meant to illustrate how a model may be constructed to perform a particular task, namely forecasting the balance of payments. A more relevant model would include domestic effects as well; but the process of model construction is essentially the same in both cases.

A Model of the World Economy The basis of our discussion will be a ten-market model of the world economy. More complex models as well as simpler ones could of course be constructed by disaggregating or aggregating the various markets we shall identify. Given the fact that most models that have been constructed to date are much simpler than the one we shall describe, we shall lean in our discussion more towards simplicity than complexity.

We will view the universe of economic events as the set of all economic exchanges, each exchange involving one supplier and one demander. Exchanges that may be considered to be essentially the same are classed together and called a market. The world economy is then a huge and complex set of interrelated markets. The number of markets we might discuss is limited only by the total number of exchanges, each exchange being at least in some respect different from all others. What we wish to accomplish in terms of theory is to combine, condense, or drop most of these markets in order to simplify and to bring order to the seemingly chaotic events, and yet at the same time to maintain the essential features of the exchange phenomenon. Many of the issues that arise in the process of simplification are essentially empirical. It is therefore important that the model we use at the initial stages of empirical analysis be general enough to include many of the competing views of the world economy. We may then allow the data to suggest the appropriate simplifications that are empirically relevant.

However, generality in specification combined with the usual data limitations will ordinarily leave the researcher with little results of any use. Accordingly, he will be forced to impose his own theoretical views upon the data. The point where theory should end and the data should take over in the process is by its nature difficult to determine. The theoretical view we will present is a comparatively weak one, and we shall discuss at some length a number of additional assumptions that will make the theoretical base stronger, but less general, as well.

The construction of our model of the world economy will require, first, a classification of exchanges into a set of markets. Each market is meant to include all of but only those exchanges that for our purposes may be considered to be essentially the same. Furthermore, every exchange may be easily classified into one of the markets. We shall abstract in particular, however, from imported capital goods.

Let us then divide the world into two hypothetical countries, domestic and foreign, to be denoted by America and England. The balance of payments between these two countries will result from the complex interaction of ten markets. These are the markets for: (1) American importables (English exportables); (2) American exportables (English importables); (3) American securities; (4) English securities; (5) American home goods (not tradeable);

(6) English home goods; (7) American capital goods; (8) English capital goods; (9) American labor; and (10) English labor.

It is not difficult to see how events in each of these markets may influence the balance of payments. The first four markets will determine directly the international flows of goods and services and securities. The next four markets for home goods and capital goods will compete with the exportables and importables markets for the existing resources. For example, price increases for American home goods or American capital goods will tend to lower the American supplies of importables and exportables as real resources are shifted from those industries to the home or capital goods industries in response to the price increase. Similarly, American demand will shift from the home or capital good onto the importables and exportables. All of these consequences of price increases in the home or capital goods markets will tend to increase American imports and decrease American exports.

The capital goods markets will also play the highly important role of determining the level of investment in each of the industries. Of course, events in the goods markets will have an important impact on this decision also. In addition, the securities markets will play a role in determining the interest rate and hence the demand for capital goods. Finally the labor markets will determine the wage rates, which will in turn influence supply functions in all the goods markets and the demand function in the capital goods market.

This description is not meant to include all possible interactions, but rather is meant to indicate that each of the markets may play an important role in influencing the balance of payments. Nor is this model meant to be the only possible model of an open economy. As we have mentioned, more complicated models as well as simpler ones could surely be constructed by varying the level of commodity or regional disaggregation or aggregation. The present model is meant to be a sort of middle ground from which to view all balance-of-payments models. It will provide a foundation for the construction of both simpler and more complex models as well as serve as a useful reference from which to evaluate other models.

For example, let us consider a simple two-country Keynesian model

$$Y_i^D = C_i + I_i + X_i - M_i \qquad i = 1, 2 \tag{5.5}$$

$$C_i = a_i + b_i Y_i \qquad i = 1, 2 \tag{5.6}$$

$$M_i = X_j = e_i + m_i Y_i \qquad i \neq j = 1, 2 \tag{5.7}$$

$$Y_i^S = Y_i^D \qquad i = 1, 2 \tag{5.8}$$

where Y_i^D, Y_i^S, C_i, M_i, X_i, and I_i are aggregate demand, aggregate supply, consumption, imports, exports, and (autonomous) investment. The model has only two markets—the markets for Country 1's and Country 2's goods. Home goods, capital goods, and exports are considered to be essentially the same in each country. Events in the securities market and the labor market are assumed to have an insignificant impact on the goods markets and are thus neglected. Although this Keynesian model represents a much simpler view of the world economy than our ten-market model, it may nevertheless capture the essential features of the important phenomena, such as the international transmission of the business cycle. As we shall see, most of the models which have in fact been constructed have this simple Keynesian structure.

Let us now explore in more detail for our broader model possible arguments for its simplification that are analogous to those arguments implicit in the Keynesian model above. We will want to consider each market's impact on the balance of payments to try to make some judgment as to whether that market may be excluded from the model or aggregated with another market. The decision to exclude a market may be based on one of two propositions. We may feel that the impact of a market on the balance of payments is relatively slight. Alternatively we may observe the complexity of a market and conclude that only very great research efforts could make any quantitative sense out of the observed events. Accordingly, an educated guess as to the future values of the variables controlled by this market will be as accurate as any model forecast. In other words, the cost of an improved forecast in terms of research effort may not be worth the amount of improvement so afforded. In what follows we will argue only on the basis of the first proposition: remoteness.

Considering our model from the United States' point of view, the first step of simplification may be to discard the foreign markets: English home goods, English capital goods, and English labor. The impact of these markets on the U.S. balance of payments may be very remote. Nonetheless, they will influence the English supplies and demands of American importables and American exportables. We may want to decide how these functions will enter our model before we make a decision about discarding any of the three foreign markets. For instance, if we should decide that the price of imports (English exports) is to be forecast exogenously, then the link between this price and the events in the three English markets may be neglected, and these three markets may be discarded.

If the international flow of capital forms a small stable entry in the balance of payments, the securities markets may also be neglected. However, if investment demand (capital goods demand) is responsive to interest rates or other events in the securities markets, we may need to include the securities markets endogenously in order to predict investment.

The first two markets—importables and exportables—are certainly required in any balance-of-payments model. Each of these markets includes two demand functions and two supply functions. The American importables market is made up of American demand and supply and British demand and supply. If we like, we may think of the American demand for British exports as being the difference between the American demand for importables and the American supply, that is, an excess demand function. Nonetheless, we will have to realize that the American demand for British exports will be influenced by American supply factors, in particular the capital stock employed by the American suppliers of import-competing goods. Of course, in the short run the capital stock is fixed and we may ignore its impact on the flow of goods. We have, therefore, justified the severing of one link between the consumable goods markets and the capital goods markets, at least in short-run models. However, in models designed to forecast several years into the future, it may be quite important to maintain this link between investment and the supply capacity of the various industries.

This discussion could in principle be pursued at much greater length. We will nevertheless terminate it here since there is no end of variation in the models that might be constructed to fit particular empirical circumstances. The construction of an econometric model is an exceedingly difficult task if done in a reasonable fashion. Since our discussion has been centered not on "what to do" but rather on "how one might decide what to do," we will have succeeded in our goal if the reader has a flavor of the complexity of the issues and a feeling about how one might seek solutions.

EVALUATION OF ECONOMETRIC MODELS OF THE U.S. BALANCE OF PAYMENTS

We have already stressed the point that the only norm with which to judge a model is performance. Let us consider then for illustrative purposes some models that have been used for prediction or policy analysis with regard to the United States. Using our ten-market model as a guide, we will first explore these models to deduce the implicit answers to the questions we have posed. We will then ask how well the model performs. In the event that the model performs well, we will have a reason to favor the kind of structure employed. If the model performs poorly, we may wish to avoid such a structure in the future.

The Brookings Report The first model we will examine was constructed by the staff and associates of the Brookings Institution in 1962 under contract with the Council of Economic Advisors [21]. At that time there was growing concern over large balance-of-payments deficits and the resulting gold outflow from the United States. Government policymakers accordingly sought answers to two important questions: was the situation likely to continue, and, if so, what policy measures would be appropriate to remedy it?

An econometric model was used to forecast the level of the components of the U.S. current account in 1968. The capital account was projected exogenously on the basis of several assumptions about such things as growth, profit, and depreciation rates. The econometric model of the current account divided the world into three regions: the U.S., Western Europe, and the Rest of the World. For our purposes, we need consider only the U.S. and Western European regions of the model. In this case the structure of the model may be represented by two equations: U.S. demand for Western European goods and Western Europe's demand for U.S. goods.

It should be clear that this model is extremely simple. If we use our ten-market model as a guide, we will be able to find only the markets for international goods. In addition, these markets consist of a demand side only. The real problem of forecasting is left to the selection of the exogenous variables, and the projection of the many balance-of-payment items that are excluded from the model. The bulk of the Brookings Report in fact discusses these problems and the econometric model is hidden in an appendix. One cannot help wondering if the model had a significant impact on the projection or whether it was merely window-dressing for a basically noneconometric forecast.

The Rhomberg and Boissonneault Model A model which provides an interesting contrast to the Brookings model has been presented by Rhomberg and Boissonneault (R & B) [19]. The R & B model is essentially an expanded version of the Brookings model. The R & B forecast is more heavily dependent on the nature of their model. As in the Brookings work, the world is divided into three regions. The features of the model that interest us are best illustrated by examining only the equations for the U.S. and Western Europe. The structure may then be reduced to six equations, three for each region: a consumption function, an import-demand function, and an export-supply price equation. This contrasts with the Brookings model, which contains only the import functions. Thus, the R & B model includes the supply side in the importables and exportables markets and also the demand side of the two home-goods markets (U.S. and Western Europe). Four of our ten markets are included, but with only the demand side for two of them. There are no interest rates; no concept of capacity; no mechanism for generating domestic prices; and so forth.

As it has been repeatedly emphasized, the absence of certain relationships from a model does not constitute grounds for criticism. Performance is what counts. Since both the Brookings and R & B models were used to generate a forecast for 1968 under two sets of similar assumptions, we will be able to assess their accuracy. The forecast changes are given in Table 5.1 together with the actual values for 1968. It is evident that the two models substantially underestimated the changes that occurred on both the export and import sides. The initial assumptions for the increases in real GNP turned out, interestingly enough, to be almost exact. While the increase in GNP prices was in fact greater than that which had been projected for both regions, it is noteworthy that inflation proceeded substantially faster in Western Europe, as had been hypothesized. The projected increase in U.S. export prices was in fact too low, whereas the increase in Western Europe's export prices was between the initial and alternative assumptions.

TABLE 5.1

Changes from 1961 to 1968 in U.S. Current Account
(In Billions of Current U.S. Dollars) †

	Initial Assumptions [a]		Alternative Assumptions [b]		
	Brookings	R & B	Brookings	R & B	Actual [c]
Exports of goods and services					
Merchandise	+11.2	+ 9.3	+ 7.6	+ 7.5	+13.5
Service	+ 3.0	+ 3.8	+ 3.0	+ 3.3	+ 8.3
TOTAL [d]	+14.3	+13.1	+10.6	+10.8	+21.8
Imports of goods and services					
Merchandise	+ 8.9	+ 8.1	+ 7.9	+ 7.1	+18.5
Service	+ 1.6	+ 3.1	+ 1.5	+ 2.7	+ 6.5
TOTAL [d]	+10.5	+11.2	+ 9.4	+ 9.7	+25.0
Current account balance	+ 3.8	+ 1.8	+ 1.2	+ 1.0	− 3.2
Allowance for E.E.C. discrimination	− 0.6	—	− 0.6	—	
Current account with E.E.C. allowance	+ 4.4	+ 1.8	+ 1.8	+ 1.0	

[a] Based on the following assumed percentage increases for the U.S. and Western Europe, respectively: real GNP, 43 and 33; GNP prices, 11 and 20; and export prices, 4 and 11.

[b] Based on the following assumed percentage increases for the U.S. and Western Europe, respectively: real GNP, 36 and 29; GNP prices, 11 and 11; and export prices, 4 and 7.

[c] The actual percentage increases from 1961 to 1968 for the U.S. and Western Europe, respectively, were: real GNP, 42.3 and 31.9 (partly estimated); GNP prices, 16.9 and 27.2 (partly estimated); and export prices, 9.8 and 9.8.

[d] May not be precise due to rounding.

† Adapted from R. R. Rhomberg and L. Boissonneault, "Effects of Income and Price Changes on the U.S. Balance of Payments," International Monetary Fund, *Staff Papers*, XI (March 1964), 82; U.S. Department of Commerce [29, p. 27]; and Organization for Economic Co-operation and Development [14].

The actual deterioration in the current account balance from 1961 to 1968 was $3.2 billion. This was in sharp contrast to the current account surplus that had been projected on the two assumptions noted. It is of course too much to expect that all the events that occurred between these years could have been foreseen. This is particularly true with regard to the impact of defense expenditures for Vietnam and the sharp rise in U.S. income and prices in 1967–68 that resulted in large increases in imports. It is nevertheless the case that the models did not yield very accurate projections. The moral is thus twofold: we need better models for forecasting purposes; and medium-term forecasting is a risky business indeed.

The Prachowny Model A substantially more disaggregated model of the U.S. foreign sector than either of the foregoing has been constructed by Prachowny [18] on a quarterly basis for the period 1953–64. As noted in Table 5.2, his foreign sector contained 23 equations, including identities. Some flavor of the degree of complexity or lack thereof in the various foreign sector equations is evident from the variables that are listed. The domestic sector of the model is relatively small and highly simplified, yet it permitted Prachowny to build in some of the domestic and foreign sector interrelationships.

A very important point to recognize with regard to this model is the fact that although a great number of equations have been added, the structure of the goods markets remains the same as in the simple Keynesian model. That is to say, the various demand components are added together into a single demand term, "aggregate demand," and supply is assumed to be forthcoming to meet any demand that arises. In other words, there is a single domestic goods market with the simple Keynesian supply response of providing all that is demanded. The problem of capacity limitations on production is ignored, as is the related problem of price determination. Such a Keynesian model should thus be applied only to short-run periods with ample excess capacity. When demand begins to impinge on productive capacity the Keynesian supply response is quite unlikely to be an adequate description of reality. Longer-run models will of course need to deal with both the determinants of prices and the determinants of domestic capacity. These considerations are dealt with to some extent in the other models of the U.S. economy to be examined below.

After estimating the various equations,[3] Prachowny was able to calculate impact multipliers to analyze the effects of changes in various exogenous variables on the balance of payments and GNP. In particular he considered the impact on the balance of payments of the imposition of the Interest

[3] In general, his statistical fits were distinctly better for the current account than for the capital account equations.

TABLE 5.2

Prachowny's Quarterly Model of the Foreign Sector of the U.S. Economy, 1953–64 †

Equation	Dependent Variable	Major Explanatory Variables
Foreign Sector		
1	Imports of consumer goods	Real disposable personal income; relative prices; lagged imports.
2	Imports of investment goods	Real expenditures on producers' durable equipment; relative prices; lagged imports.
3	Imports of raw materials	Manufacturing production; real change in nonfarm business inventories; relative prices; lagged imports.
4	Merchandise exports	Real world exports (minus U.S. exports); relative prices; U.S. direct investment; trade credit; lagged exports.
5	U.S. payments for foreign travel	Current disposable personal income.
6	U.S. receipts for foreign travel from Canada	Canadian disposable personal income; Canada–U.S. exchange rate.
7	U.S. receipts for foreign travel from rest of world	Sum of consumer expenditures in France, Germany, Italy, and the U.K.
8	Transportation, private remittances, and other services	Imports; travel expenditures abroad.
9	Transportation receipts	Exports; travel receipts.
10	Private remittances	Lagged remittances.
11	Miscellaneous service payments	Lagged payments.
12	Private miscellaneous service receipts	Canadian GNP; GNP in the European OECD countries.
13	U.S. direct investment abroad [a]	Differential between U.S. long-term interest rate on government bonds and average of Canadian and U.K. rates; lagged investment.
14	Foreign direct investment in the U.S.	Same interest differential as Equation 13.
15	U.S. purchases of foreign long-term securities	Same interest differential as Equation 13; dummy variable for Interest Equalization Tax; lagged purchases.
16	Foreign purchases of U.S. private long-term securities [c]	Same interest differential as Equation 13; lagged purchases.
17	Repatriation of dividends and interest earned in the U.S.	Sum of foreign direct investment and other private assets owned by foreigners times U.S. long-term interest rate; differential growth rate of GNP in other OECD countries and U.S.
18	Repatriation of dividends earned abroad [b]	Same interest differential as Equation 13; lagged investment times average of Canadian and U.K. long-term interest rates.
19	Repatriation of interest earned abroad [b]	Same interest differential as Equation 13; lagged private assets times average Canadian and U.K. long-term rates.
20	U.S. short-term capital movements [c]	Covered interest differential between U.K. and U.S. Treasury bill rates; exports; dummy variable for Voluntary Restraint Program.
21	U.S. long-term claims against foreigners [d]	U.S. Treasury bill rate; exports; dummy variables for Interest Equalization Tax.
22	Import identity	
23	Balance-of-payments identity	
Domestic Sector		
24	Consumption expenditures	Real disposable personal income; lagged consumption.
25	Nonresidential construction	Based on Liu [11].
26	Producers' durable equipment	Based on Liu [11].
27	Residential construction	Based on Liu [11].
28	Investment in nonfarm business inventories	Real GNP; lagged stock.
29	Disposable personal income	Real GNP.
30	Industrial production	Real GNP.
31	U.S. long-term interest rate	Average quarterly yield on U.S. Treasury bills; lagged rate.
32	GNP identity	

† Adapted from M. F. J. Prachowny, *A Structural Model of the U.S. Balance of Payments.* Amsterdam: North-Holland Publishing Company, 1969.

TABLE 5.2 (Cont.)

[a] Excludes second and third quarters of 1957.
[b] Beginning first quarter of 1959.
[c] Beginning first quarter of 1959 through 1965.
[d] Through 1965.

Equalization Tax and the Voluntary Restraint Program during 1963–65. He presented in addition the results of some simple simulation experiments on the balance-of-payments and GNP impacts of a 1 percent increase in the Treasury bill rate coupled with some continuing changes in government expenditures.

While Prachowny's results are of considerable interest, they cannot of course be taken literally in view of the comparative simplicity of the model. That is, while the model is explicit in its treatment of the demand side for international transactions in goods, services, and financial instruments, it abstracts almost completely as we have noted from supply considerations in the relevant markets. Moreover, the absence of a mechanism generating domestic prices and interest rates in the model is an important limitation. If the model is to prove useful for purposes of forecasting and policy analysis, the measurement of the capital account relationships especially must be improved and a linkage accomplished with a comprehensive model of the real and financial relationships of the domestic economy. Despite these reservations, Prachowny's work represents an important step in the construction of a fairly detailed model of the U.S. balance of payments.

Other Models There are a number of models of the U.S. economy now in existence that deal almost exclusively with the domestic sector. This reflects in part the orientation of the Keynesian system towards relationships involved in a closed economy, an assumption which until recent years at least has been plausible for the U.S. in view of the relatively small size of its foreign sector. There is some question now, however, about the appropriateness of these models in view of the increased importance of the balance-of-payments constraint and the consequent increased sensitivity of U.S. economic policy to international economic influences. It may be instructive to look briefly at how the foreign sector is handled in a number of these models in order to obtain some impression of the work yet to be done.

Let us consider first the Michigan econometric model of the U.S. economy [30], which is an annual model in which equations are estimated for components of aggregate demand; productive capacity and employment; income, labor costs, and prices; taxes and social insurance; and the financial sector. The change in imports, which is included as a part of aggregate demand, is held to be dependent mainly on a composite relation between the change in nonfarm GNP and capacity utilization and on the change in relative prices. Exports are taken to be exogenously determined and to change at some specified rate. A forecast is thus made of net exports as one of the components of aggregate demand.[4] No forecast is made of any of the financial items in the capital account.

[4] For example, in November 1966 according to [30, p. 4], it was forecast that the 1967 increase over 1966 (in 1958 prices) would amount to $3.8 billion for exports and

The Wharton quarterly model [7] of the U.S. economy consists of 47 equations with unknown parameters and 29 identities. It covers in its published version an estimation period from 1948 to 1964. Like the Michigan model, it is Keynesian in nature with respect to the determination of aggregate output and employment but includes equations for the determination of prices, wage rates, aggregate supply, and factor shares. It contains in addition a small monetary subsector dealing with the determination of interest rates. Imports are divided into three categories in the model: crude and processed food, crude materials and semimanufactured products, and all other imports (including services). There is a single equation for exports.

The import equation for crude and processed food is estimated in per capita form with real per capita personal disposable income and relative prices as the explanatory variables. Imports of crude materials and semimanufactured products are assumed to depend on sales originating in the manufacturing sector, the change in manufacturing inventories, and relative prices. All other imports are assumed to depend on real personal disposable income, relative prices, and lagged imports. Exports are assumed to depend upon an index of world trade (proxy for world income), relative prices, and lagged exports. U.S. export prices are endogenously determined in the model while the world trade and price variables are exogenous. In the use of the model to generate *ex ante* forecasts and for purposes of policy simulation, values for imports and exports can be obtained as a component of aggregate demand [7, pp. 50–69].

The quarterly model of the U.S. economy developed by the Office of Business Economics [29] consists of 36 equations and 13 identities covering components of GNP, prices and wage rates, labor force and employment-related magnitudes, income components, monetary variables, and miscellaneous variables introduced to close the model. The model contains two equations for imports. Imports other than crude materials and foodstuffs are dependent on real disposable income and the ratio of nonwage to wage income. Imports of crude materials and foodstuffs are dependent on the real value of lagged private GNP. Neither equation contains a relative price term, it is interesting to note. Exports are treated exogenously in the model. None of the financial items in the balance of payments is included. The model is thus able to make a forecast of net exports as a component of aggregate demand.[5]

$3.4 billion for imports. The observed preliminary changes were $1.9 billion for exports and $2.1 billion for imports. The change in the balance of trade thus turned out to be −$0.2 billion rather than the $0.4 billion that had been forecast.

A separate quarterly model is now being developed at Michigan and forecasts based on it were first presented at the Annual Conference on the Economic Outlook in November 1968. Net exports were treated in this version of the model as completely exogenous.

[5] The forecast for 1965 in billions of current dollars seasonally adjusted at annual rates was as follows [29, pp. 26–27]:

(*Footnote continued on next page*)

The Federal Reserve–MIT econometric model [2] is a quarterly model of the U.S. economy that focuses mainly on the financial sector and on the links between this sector and those for goods and services. Its primary purpose is to quantify monetary policy and the effects this policy has on the economy. The model consists of three principal blocks of equations: a financial block; a fixed investment block; and a consumption-inventory block, which includes as well income shares, imports, and federal personal taxes. There is a single equation for imports that are assumed to depend on real GNP and a measure of capacity utilization. Dummy variables are included to capture the effects of the 1959 steel strike and the 1965 dock strike. Relative prices were omitted because they were found to be unimportant statistically. Exports are treated exogenously. None of the financial items in the balance of payments are considered. Thus, we again can obtain a model forecast of net exports as a part of aggregate demand.[6] The model was also used to analyze by means of simulation the effects of a $1 billion increase in unborrowed reserves, a $5 billion increase in defense spending, and a 10 percent increase in the personal tax rate.

The Brookings econometric model of the U.S. economy [9] is a gigantic affair compared with the other models we have mentioned. It contains more than 300 equations and has involved data collection for over 2000 variables.

	1Q		2Q		3Q		4Q		Year	
	P	*A*	*P*	*A*	*P*	*A*	*P*	*A*	*P*	*A*
Exports (exogenous)	34.7	34.7	40.4	40.4	40.1	40.1	40.8	40.8	39.0	39.0
Imports	28.2	28.6	30.3	32.4	30.7	32.7	32.0	33.9	30.3	31.9
Net Exports	6.5	6.1	10.1	8.0	9.4	7.4	8.8	6.9	8.7	7.1

Predicted (*P*) imports apparently fell short of actual (*A*) imports in each quarter. This was due mainly to the underestimation of imports other than crude materials and foodstuffs. Predicted net exports were thus $1.6 billion below actual net exports.

[6] In the published version of the model [2, p. 22] predictions were given only for total imports (in billions of dollars at annual rates) in the context of the complete consumption-inventory block:

	1965		1966			
	3Q	4Q	1Q	2Q	3Q	4Q
Predicted imports	33.6	35.1	36.5	37.3	38.0	38.6
Actual imports	32.9	34.4	36.0	37.1	39.0	39.7
Difference	0.7	0.7	0.5	0.2	−1.0	−1.1

Allowing for data adjustments in the actual value of imports, predicted imports for the last two quarters of 1965 were closer to actual imports in the FED–MIT model than in the OBE model noted in the preceding footnote.

It consists of the following principal sectors: consumption; residential construction; inventories; orders; investment realizations; investment intentions; foreign sector; government revenues and expenditures; production functions and factor income payments; wages and prices; agriculture; labor force; monetary sector; and the automotive industry. The purpose of having such a large model is to capture the workings of the economy as an interrelated system and to be able to make forecasts and analyze the effects of policy in great detail.

Despite the size of the Brookings model, it contains a relatively simple foreign sector. There are two equations for imports and one for exports. The imports of finished goods and services are assumed to depend on real disposable personal income, relative prices, and lagged imports. Imports of crude materials, crude foodstuffs, and semimanufactures are assumed to depend on the change in real nonfarm business inventories, real gross product originating, relative prices, and lagged imports. Exports of goods and services are assumed to depend on real world exports excluding U.S. exports, relative prices, and lagged exports. Import prices are apparently taken to be exogenous in the model, whereas export prices are generated in a rather complex manner from the price deflators for five producing sectors. The model was estimated for 1948–60 and furnished the basis for some forecasts for 1961–62 as well as a number of different simulation experiments involving changes in government expenditures, government employment, personal income taxes with and without changes in monetary policy, and changes in monetary policy. The detailed results of the forecast as well as the policy simulations thus include estimated values of net exports in constant dollars [9, pp. 20 and 41].

Although the equation specifications differ somewhat, it should be clear from our discussion that the foreign sector is treated on a relatively very simple basis in the most noteworthy of the econometric models of the U.S. economy. This is in part a holdover from the period in which the foreign sector played only a minor role in the economy. It also reflects the fact that the construction of a comprehensive model of the foreign sector that includes international capital transactions is a very difficult task. It is obvious that the foreign sector has to be treated comprehensively in countries that are much more dependent on international trade and foreign capital markets than may be the case for the U.S.[7] But given the increased importance of balance-of-payments policy considerations in the U.S. especially since the early 1960's, much remains to be done to integrate the foreign and domestic sectors in econometric models of the U.S. economy.

[7] See [10] for a quarterly econometric model of Canada, in which relationships describing foreign trade and international capital movements are of central importance. Work is now in progress at the Bank of Canada to link the foregoing model with the FED-MIT model of the U.S. economy.

CONCLUSION

Econometric model building is properly viewed as a tool for optimal decision making. A model builder may assume one of two roles in the decision-making process. He may provide information about future events in the form of probability statements, in which case a forecast consumer can make his own choice of actions by weighing the likelihood of the various outcomes. Alternatively, the forecaster may usurp these decision-making powers and provide only a point estimate, in which case the forecast consumer is driven necessarily to a particular action. We have argued that the former (information-provider) role is the appropriate one.

The construction of an econometric model is much more an art than a science. The choice of variables and model structure is exceedingly difficult and has often been made more by chance than by design. While the only norm with which to assess a model is performance, this unfortunately provides little or no insight into the problem of model building. But what this norm does suggest is that a model ought to evolve by annual adjustments, rather than be created at a single point in time. However, any model must begin sometime, and its initial form may greatly influence its evolutionary path. How, then, should the model begin?

We have tried to provide a thought-structure within which the decisions involved in model building could be made. We first divided the universe of economic exchanges into a set of mutually exclusive markets, in such a way that all exchanges within a market are essentially the same and that any two exchanges from different markets are fundamentally different. Keeping in mind just what our model is meant to do, we examined each of the markets to determine whether it could be discarded with little or no impact on the performance of the model. Through this process an appropriate structure may be selected.

Finally, we have considered some examples of econometric models that have actually been used in balance-of-payments forecasting and policy analysis in the case of the United States. Except for Prachowny's model, these models have employed a fairly simple structure for the foreign sector. We have been afforded therefore relatively little experience that would suggest the most appropriate structure for balance-of-payments models. Hopefully, important advances in this area may be realized in the near future.

APPENDIX TO CHAPTER 5

"TWO-GAP" MODELS

A separate species of model worth considering is the so-called two-gap model, which has been used to forecast the foreign aid requirements of developing countries. The genesis of two-gap models stems from the supposed rigidities and lack of resources in less developed countries (LDC's) that may hamper the effectiveness of traditional policy instruments in these countries in achieving their stated economic goals. In such circumstances, foreign resources in the form of grants and loans will help in the achievement of their goals.

The goals typically involve high levels of employment, balance in foreign payments, and rapid economic growth. We know from the theory of economic policy that at least the same number of policy instruments is required if the aforementioned goals are to be achieved. Thus, the policy instruments in question will commonly involve fiscal, exchange-rate, and monetary policies. In effect then if these policies do not work well in the LDC's, by making foreign aid available, we are providing these countries with an additional instrument of policy. What we shall be concerned with in our discussion therefore is estimating the foreign resources required to meet a reasonable set of goals established by an individual LDC subject to the help and cooperation of a high-income, industrialized donor country.

The issues involved in forecasting foreign resource requirements are especially complex because it is impossible to know what is required from foreign sources over a period of five or ten years unless we have a fairly accurate idea of what determines economic growth. Since our knowledge of the determinants of growth is unfortunately still rather limited, researchers interested in constructing economic models for forecasting foreign needs have had to make numerous simplifying assumptions. While the range of possible assumptions combined with the diversity of intellectual temperament of individual researchers might have resulted in a fairly wide variety of models, the two-gap models to be discussed presently are all quite similar. There may accordingly be considerable room for alternative specifications of these models.

The models in question are highly aggregative and look upon economic growth as stemming exclusively from gross capital formation. Output capacity is most typically given by the Harrod–Domar function, the product of the constant output-capital ratio and the total capital stock

$$Q = \frac{1}{k} K \tag{5.A.1}$$

where Q is the quantity of aggregate output, k is the capital-output ratio, and K is the capital stock.

In these models there are two limits to the amount of capital formation. The first is simply the lack of adequate resources. The economy in question may not have the capacity both to supply the consumption needs of its population and to produce or trade for the capital goods required for growth. To estimate the resource needs, it is necessary to calculate full employment output and subtract from that the level of required real consumption. The figure obtained represents the supply of savings, or the real output available for capital formation, after consumption needs are satisfied. In the event that the desired level of investment exceeds this figure, foreign resources will be required to fulfill the investment objective. This inadequacy of domestic productive capacity is usually referred to as the savings-investment gap, reflecting the fact that the gap is the difference between full employment real savings and the desired level of investment.

The second constraint on capital formation is the foreign exchange or export-import gap. Accelerated growth is supposed typically to be associated with rapidly expanding imports of goods and services. Exports, on the other hand, will tend to grow as the product of the developed countries' growth rate and their income elasticity of demand for LDC exports. Growth in exports may be relatively low due to the preponderance of primary products in total LDC exports. The consequence of this disparity in the rates of growth of imports and exports is that many LDC's will experience chronic balance-of-payments deficits. Foreign resources will thus be required to finance these deficits if the growth of GNP is to be sustained.

Although there is no *ex ante* relationship between the two gaps, they are observed to be the same due to the following *ex post* identity

$$Q - (C + I) = S - I = X - M = I_F \qquad (5.A.2)$$

Thus, according to this identity, if the domestic purchases of goods $(C + I)$ exceed aggregate output Q, this will be equivalent to the excess of investment I over savings S, which will in turn be equivalent to the excess of imports M over exports X, which finally is equal to foreign investment or the quantity of foreign resources made available for domestic use I_F.

If we consider these relationships in an *ex ante* or *desired* sense, the gaps need not be the same. In the event that the *ex ante* full employment levels do not conform to the equilibrium relationship (5.A.2), either government policy must adjust the *ex ante* values or the amount of income/expenditure will diverge from the full employment level to induce a change in the actual values of expenditure to conform with the equilibrium equation (5.A.2).[1]

[1] This can be illuminated with the aid of an example. Suppose that savings and imports are given by

$$Q - C = S = -10 + 0.2Q \qquad (a)$$

and

$$M = 10 + 0.3Q \qquad (b)$$

where Q is the real value of GNP. If full employment Q [calculated from the capital stock by relationship (5.A.1)] is at the level of 100, then savings and imports can be calculated as $S = 10$ and $M = 40$. Consider now the following cases with investment I and exports X given in the parentheses.

Case I: ($I = 10$, $X = 40$). The desired level of investment and the exogenous level of exports are such that neither gap is operative. The equilibrium relationship (5.A.2) is satisfied.

Case II: ($I = 20$, $X = 40$). Investment exceeds the available savings, but the export-import gap is not operative. An inflow of 10 from foreign sources is required to support this investment. The country uses the inflow to increase its imports from 40 to 50, thereby creating a balance-of-payments deficit of 10. The *ex post* identity (5.A.2) is thus seen to hold.

Case III: ($I = 10$, $X = 30$). Savings supply is sufficient, but there is a balance-of-payments deficit of 10. An inflow of 10 to finance the deficit can be used either to increase investment or to reduce savings (increase consumption). This change is such that the *ex post* relationship (5.A.2) holds.

In the event that the inflow from abroad is not forthcoming, the country's growth objectives will not be fulfilled. But whatever occurs, the *ex post* relationship (5.A.2) must hold. Thus, in Case II, the actual level of investment may be reduced to 10 or an additional 10 in real savings may be forced upon the economy. Case III will require the restriction of imports, perhaps through slower growth of GNP.

The foregoing examples should indicate clearly the difference between the *ex ante* gaps and also the necessary equality of the *ex post* gaps. The examples also imply that when both gaps are operative, foreign resources will be needed to fill the larger of the two gaps.

In the *ex ante* sense, one gap will ordinarily be larger than the other. If the investment plan is to be realized, foreign resources will be required to fill the larger of these two gaps. The smaller gap can then be widened to conform with the *ex post* identity (5.A.2). For instance, if the export-import gap is the *ex ante* constraint and if foreign resources are available to fill that gap, then either savings may be decreased or investment increased in order to bring about the *ex post* equality of the gaps.

It should be noted that the foregoing considerations are applicable to developed as well as developing countries. The very important distinction, however, is that the developed countries typically have greater mobility of resources, which will make their policies aimed at eliminating trade imbalances more effective. Many LDC's, in contrast, are forced to rely heavily on imports especially of capital goods for investment purposes. Once a level of investment is selected, the level of imports may be more or less fixed. Given the level of exports, a trade imbalance may thus be a necessary consequence of the investment program.

It will be evident from our discussion that there are three fundamental relationships used in two-gap models: the production function, savings function, and import function. Exports are typically thought to grow exogenously, and investment is calculated from the production function once a target growth rate is selected. This is of course an exceedingly simple description.

It may be useful in any event to evaluate the model's relationships in more detail.

The Production Function As indicated earlier, the production function is typically of the Harrod–Domar type

$$Q = \frac{1}{k} K$$

This involves the assumption that the available labor is not a significant constraint on output, and that even if substitution between capital and labor is possible in production, no substitution in fact occurs. Furthermore, the constant k rules out any possibility of shifting investment from less productive to more productive activities.

The constant k may be estimated in a number of ways, the most straightforward of which is a regression of ΔQ_t on I_{t-1}

$$\Delta Q_t = \frac{1}{k} I_{t-1} \tag{5.A.3}$$

where I_{t-1} is the gross domestic capital formation in the previous period. A similar approach, suggested by the United Nations group [27], specifies

$$Q_t = \alpha + \frac{1}{k} \sum_{T=0}^{t} I_T \tag{5.A.4}$$

where I_T refers to gross capital formation.[2]

These various estimates of the capital-output ratio are based on historical data, and it is taken for granted in this regard that the productivity of investment is immutably fixed. This is a rather restrictive assumption, for it may well be that historical performance is of limited relevance in the development context. In fact, a most significant aspect of a development plan may

[2] A slightly different formulation by Chenery and Eckstein [4] is based on the proposition that a part of the gross investment which occurs is allocated to replacement and social overhead capital. The amount thus allocated is a constant share z of current production. The capacity-creating investment is reduced to that extent

$$\Delta Q_t = \frac{1}{k} [I_{t-1} - zQ_{t-1}] \tag{c}$$

or

$$\frac{I_{t-1}}{\Delta Q_t} = k - z \left(\frac{\Delta Q_t}{Q_{t-1}}\right)^{-1} \tag{d}$$

The constant term k in a regression of the form in Equation (d), which relates the ratio of investment to the change in output to the inverse of the rate of growth of output, is seen to be the incremental capital-output ratio.

It may be noted further that Chenery and Bruno [3] in the case of Israel estimated k from input–output tables.

be an improvement in the capital-output ratio. That the capital-output ratio varies substantially in fact among countries at different levels of development attests to the significance of this point.

The Savings Function Savings are typically related to output as

$$S = \alpha + \beta Q \tag{5.A.5}$$

This is of course an extreme simplification. Furthermore, the use of historical data to determine the marginal savings rate is questionable. Offhand, there would seem to be a presumption that a developing economy would experience rather wide shifts in the marginal savings rate over the time period for which a projection is being made. This would be particularly true when the government made a conscious effort to increase the savings rate. In addition, the data observations which are available may not accurately describe the savings function. When domestic investment opportunities are absent, full employment will be sustainable only at low or zero savings. Government policy aimed at maintaining demand for full employment would accordingly reduce savings below the theoretically possible savings rate, which is to be estimated.[3]

The Import Function As before, by means of historical data, a simple regression of imports on GNP is often used to explain imports

$$M = a + bQ \tag{5.A.6}$$

The objections to such a procedure made with regard to the savings function could be repeated here almost verbatim. An import function such as Equation (5.A.6) is excessively simple and is doubtfully stable. The use of historical data ignores the very significant performance aspects of imports. That is, to the extent that relatively poor performance in the past is reflected in historically high levels of imports, should such performance be rewarded by larger inflows of foreign assistance? Also, to what extent should we expect a lowering of the import propensity due to import substitution? Are historically low levels of imports the result of excessive government interference causing various inefficiencies? If so, development objectives should allow for somewhat higher levels of imports to promote efficiency. These various considerations suggest that the historical data on imports in the form of Equation (5.A.6) are of doubtful relevance to a development projection.

[3] On this point Chenery and Eckstein [4] argue that investment opportunities are directly related to exports. They argue further that foreign capital inflow can substitute for domestic savings, and that savings will be depressed by such capital flows. Their arguments are supported by a regression of savings on GNP, inflow of foreign capital, and the export/GNP ratio. As one would expect, they find the marginal propensity to save to be higher than that calculated by simple regressions of savings on output.

TABLE 5.A.1

Estimates of the Trade and Savings Gaps (Annual Basis) †

I. Estimates Based on LDC Foreign Exchange Requirements

Source	Period Covered	Growth Target (percent)	Import Requirements	Export Earnings	Trade Gap	Service Gap	Foreign Exchange Gap
					($ billions)		
GATT	1956/60–1975	5	28–32	17	11	—	11
UN	1959–1970	5	41	29	12	8	20
FAO	1959–1970	5	42	31	10	8	18
Balassa 1.	1960–1970	4.5	38	33	5	6	11
Balassa 2.	1960–1975	4.7	49	42	7	7	14
Chenery/Strout 1.	1962–1970	5.2	58	45	13		13
Chenery/Strout 2.	1962–1975	5.2	76	57	19		19

II. Estimates of Savings Gap

Source	Period Covered	Per Capita Growth Target (percent)	Capital-Output Ratio	Capital Requirement (annual) ($ billions)
Millikan/Rostow	1953	2.0	3.0	$6.5
Hoffman	1960–1969	2.0	3.0	7.0
Tinbergen	1959	2.0	3.0	7.5
Rosenstein-Rodan	1962–1966	1.8	2.8	6.4
	1967–1971	2.2	2.8	6.4
	1971–1976	2.5	2.8	5.0

† J. Pincus, *Trade, Aid and Development*. New York: McGraw-Hill Book Company for the Council on Foreign Relations, 1967, pp. 298–99.

A somewhat more reasonable description of imports is to disaggregate into imports of consumption goods M_c and capital goods M_I

$$M_c = a_c + b_c Q \tag{5.A.7}$$

$$M_I = a_I + b_I I \tag{5.A.8}$$

indicating that imports for consumption are a function of gross output while capital goods imports depend on investment alone. The use of historical data to describe the import content of investment is more justifiable than its use in describing the required consumption-goods imports. In addition to these variables, Chenery and Eckstein [4] use reserves and export earnings to reflect the scarcity of foreign exchange.

Exports Exports X are typically assumed to grow exogenously through time t

$$X_t = X_0(1 + \lambda)^t \tag{5.A.9}$$

where λ refers to the rate of growth. An alternative approach is to make exports to developed countries a function of demand conditions there, usually with output as the explanatory variable. Unfortunately, such a procedure cannot insure improved forecasting unless the value of output in the developed economies can be reasonably well forecast.

Some Estimates of the Two Gaps Some indications of the orders of magnitude of the two gaps are given in Table 5.A.1. Estimates of the savings gap are about $6 billion to $7 billion annually for 1970, while estimates of the foreign exchange gap, including both goods and services, run on the order of $12 billion to $20 billion. These estimates are subject of course to all the problems we have mentioned. That is, the projections assume that there are fixed and stable relationships involving the capital-output ratio, the behavior of savings, and changes in foreign trade, and that despite their simplicity these relationships capture the essence of economic growth in the LDC's.

Conclusion The two-gap model is evidently subject to many criticisms.[4] Nonetheless, the model will prove or fail to prove itself only in performance. Unfortunately, however, there is almost no way to assess its performance. The implied forecasts are based on the assumption that the foreign aid required to fill the two gaps is in fact forthcoming. Inasmuch as none of the

[4] Many of the same considerations we have discussed are relevant also to projections of debt servicing in which estimates are made, under various assumptions concerning the volume and terms of aid and the growth of current account receipts, of the net financial flows from the industrialized countries to the LDC's and the proportions of current account receipts that may be preempted by debt servicing.

forecasts was actually accompanied by the "required" aid, the model cannot be said to have been tested. But even in the absence of such tests, all of the objections we have outlined will properly make us skeptical of the results based upon two-gap models.[5]

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[5] Indeed, some writers on foreign aid question the whole exercise of calculating the two gaps. For example, Pincus [17, pp. 301 and 304] has stated:

> The underlying issue is ethical, not technical. There is no way to estimate the appropriate aid total except in light of agreed standards. But the agreement about aid levels implies an agreement about goals and methods of reaching them. . . .
>
> All econometric or impressionistic estimates of trade and savings gaps are in effect techniques of quantifying discontent according to a certain set of standards. They put the seal of rationality on [LDC] aspirations. Because it is a safe bet that many LDC's could grow faster if they could get more aid, the inaccuracy of such measures does no great harm. In the eyes of those who support increases in foreign aid, some gap is better than none.

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