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An Econometric Model for Nicaragua-Dusol*

1. INTRODUCTION

The purpose of this work is to present the progress made in a project undertaken by the Central Bank of Nicaragua aimed at developing a macroeconometric model of the Nicaraguan economy.

The growing need to quantify the effects of different policies on the economic welfare of our countries renders it increasingly necessary to have instruments of analysis and simulation, such as macroeconometric models, that incorporate the vast complexity and interrelations of the economic system. This need contrasts with the limitations in the availability of data and in our knowledge of economic behavior, particularly in the short term, with which our

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countries are particularly concerned, making it necessary to reach a compromise between needs and limitations.

The model presented here adopts this compromise approach and represents no more than a stage in the achievement of more ambitious objectives. Basically it stresses a series of interrelationships that we assume to be distinctive features of the Nicaraguan economy. In the development of the model a number of requirements for statistics have arisen that ultimately will improve our understanding of the behavior of the Nicaraguan economy.

This study contains five sections. Section 2 sketches some previous econometric research on the Nicaraguan economy. Section 3 contains the description of the model, its distinctive features and basic assumptions, and the specification of the equations in the different sectors of economic analysis. Section 4 is devoted to testing its predictive accuracy in the sample period of the model and includes a test of the stability of its coefficients. Finally, Section 5 summarizes the conclusions and prospects for future research in this field.

2. BACKGROUND

The construction of econometric models for Nicaragua was begun only recently. The isolated efforts of this kind were based on very different motivations, and this is reflected in the features of the studies in question. Three previous models—by INCAE, SIECA, and the World Bank—will be discussed; recently some others have also been estimated.[1]

The INCAE[2] model is a variant of the one used by M.B. Chenery and M. Bruno in Israel, a model that has three constraints, namely, the rate of capital formation, the balance of payments, and the supply of labor. These three constraints are basic features of the Israeli economy, and the INCAE authors assume that they are also features of the Nicaraguan economy.

The model consists of twelve equations; seven of them are structural, three specify constraints, and two are definitions. The estimates of the equations are given, but the significance tests are omitted, and therefore the reader does not know the probability level that determines whether the results of the model are accepted or rejected. In addition, the model is not tested to verify its convergence and the stability of the coefficients.

The production function is given in the following form:

$$Vn = \mathrm{Vo} + b(Kn - \mathrm{Ko})$$

where b represents the marginal output to capital ratio, which is assumed to be constant and equal to that observed in the period 1965/1971. V is the gross domestic product, and K is total installed capital. This specification follows Leontief; that is it assumes that during the period under consideration there is no substitution between labor and capital and that the proportions in which both factors are used remain constant. This assumption might be valid for some sectors but probably is incorrect at the aggregate level because there has been a strong absorption of capital and technology in the agricultural sector, which is basically the dynamic motor of the economy. It is precisely in the 1970s that the country made intensive use of land by replacing subsistence crops with highly commercial products, implying a consequent introduction of labor-saving technology.

By the production function

$$Vn - Vo = b(Kn - Ko) \text{ or } \Delta V = bI$$

investment becomes a fixed proportion, b, of the change in gross domestic product. The second equation for net capital formation

$$In = c(Vn - Vc)$$

is therefore redundant unless interpreted as a saving-equal-investment equilibrium, because it repeats what the production function has already described.

Apart from this redundancy, the rigidities and limitations involved in this naive conception of the accelerator are well known, especially bearing in mind the unutilized productive capacity at the aggregate level in the Nicaraguan economy and the lagged way in which the accelerator principle usually works.

The model also specifies labor supply and demand functions which in structural terms do not play a strategic role in the Nicaraguan economy. In this model the condition of equilibrium between the supply of and demand for labor would be expressed in the relationship $W/P = \delta X/\delta L$. In economies like that of Nicaragua, an expression $W/P = \delta X/\delta L \gtrless 0$ would reflect more reliably certain structural relationships observed in the conditions of production as well as the underlying model. Nevertheless, the virtues of specifying functions which are ex ante in disequilibrium are obscure and in general not recommended in econometric literature.

In sum, a production function from which a capital formation process cannot usefully be derived and a neoclassical labor market constitute an excessively restricted description of the economic

processes, though one that often has been forced upon econometric investigators.

In addition, the model lacks an explicit consumption function, thereby giving a somewhat partial view of the overall economic structure. On the other hand, this model does include a savings function. Although correctly defined as a function of changes in production, it probably does not possess the explanatory potential that would come from the inclusion of financial variables or foreign saving. Moreover, since the levels of significance of the functions are not given, there is no criterion to judge explanatory and predictive properties of the saving function.

An effort wholly separate from the INCAE study was made by the Permanent Secretariat of the Treaty for Central American Economic Integration (SIECA),[3] which developed econometric models for each country belonging to the Central American Common Market (MCCA) in order to estimate the impact of economic integration in the Central American area.

The model, which consists of seven behavioral equations, is aimed more at forecasting than explanation and has a Keynesian connotation for the purposes of comparative analysis. The specifications of the gross domestic product and aggregate demand equations were made following the principle of principal components. This is an effective way of retaining sufficient degrees of freedom in statistical analysis and of reducing the problem of multicollinearity.

The model disaggregates and formulates behavioral equations for the various components of effective demand both inside and outside the Central American area. A parallel line of analysis using sectoral production functions was abandoned because of statistical limitations.

The model has two other distinctive features—the lag structure and the introduction of an export function. The inclusion of lagged variables for consumption, investment, and imports in the system of equations is a step forward, giving it a dynamic character and permitting the corresponding short- and long-term marginal propensities to be calculated. Nevertheless, the use of mainly aggregate annual data and the difficulty of breaking down the statistics by quarters means that the functions with lagged variables probably do not reflect the structure of reactions to the changes in signals from the economy (data on prices, profits, resources, etc.). The formulation of one-year lags is the result more of a statistical limitation than a different formulation of behavioral reactions with regard to, for example, consumption and investment.[4]

If the introduction of lagged variables represents a step forward, the form in which the equations are finally specified, through the acceptance or rejection of included variables on the basis of their Student's t statistic, weakens the theoretical structure of the model. Thus in certain periods and for certain countries consumption is explained by the gross domestic product (and not disposable income), and in other periods for the same country it appears to be explained by consumption with a lag. The same type of criticism holds for the investment function. Obviously, these specifications are somewhat inconsistent, perhaps because the selection of independent variables may have been influenced by multicollinearity.

In addition to this problem, when the consumption function is estimated in two successive periods it often shows different marginal propensities to consume (MPC). In economic theory short-term marginal propensities to consume may differ not only from long-term propensities, but also among themselves when estimated over different periods. This has been attributed to the influence of the economic cycle through its redistributive effect on income. In the SIECA model the explanation of different short-term MPCs is attributed to both this Keynesian effect and a growth effect. When a MPC is lower than another similar short-term MPC, it means that the marginal propensity to save is higher, which translates itself into a higher demand for investment. This consumption behavior also should be reflected in the structure of the lags, which is not the case when consumption is formulated as a function of the gross domestic product (GDP) of the same period. In addition, the study lacks a statistical test of the proposition that the different short-term MPCs stem from a single long-term function.

A second novel feature of the SIECA model is its specification of an export function both to the Central American area and outside the area. Exports outside the area are treated as exogenous. Exports to the Central American region are a function of three explanatory variables: aggregate GDP of the other countries of the region; relative prices, that is, the ratio between the general price level of the other countries and that of the exporting country; and imports of the exporting country from the other countries of the area with a lag. The specification of the equation is linear in the logarithms of the explanatory variables. In all the countries the demand factor—aggregate GDP of the other countries of the area—was statistically significant for the period following integration. However, except for Nicaragua, the relative price variable before integration was insignificant. The significance of the export function for the Central American area is

an indicator of the growth of intrazonal trade, and its formulation was of considerable interest.

A third econometric modeling effort was made by the World Bank through the Minimum Standard Model, which is aimed at projecting external aid needs, although the same model also can be used from an availabilities standpoint. In general terms, the requirements model represents an ordinary two-gap model, which estimates the external assistance necessary to achieve a predetermined growth rate, given a minimum import elasticity, the marginal capital-product ratio, and a maximum marginal savings rate. The availabilities version estimates the GDP that can be achieved with specific foreign aid inputs, given a minimum import elasticity, a minimum marginal capital-product ratio, and a maximum marginal savings rate.

The limitations of this model stem from the fact that the three main structural parameters are given (although their value may change from year to year). These parameters are the marginal capital-product ratio, the minimum elasticity of imports, and the maximum marginal savings rate. Thus, rather than being a purely econometric model, the results of the Minimum Standard Model are a test of the consistency of the initial assumptions and a useful tool for the purposes of external assistance.

Pursuing this trend of econometric investigation, a new model is being developed by the Central Bank of Nicaragua and INCAE. The model attempts to cover both the supply and the demand side and to include the financial flows of the Nicaraguan economy. Nevertheless, the statistical requirements of the model are sophisticated, relative to the type of information available in Nicaragua. In addition, the model is still in the process of estimation, and therefore its results cannot be evaluated as yet.

The less ambitious model developed here, starting from certain basic assumptions about the experience and features of the Nicaraguan economy, attempts to quantify its behavior following the identification of functional relationships. As befits such an initial effort, the model basically explores the simplest relations—in most cases between GDP and/or credit variables and the dependent variables. Thus the model presented here should be viewed as the starting point for a more general effort to systematize, using an econometric approach, the structural properties and the process of economic growth of Nicaragua. Later efforts could use more complicated specification to eliminate the autocorrelation that occasionally appears and to investigate alternatives to some of the dummy variables. However, the model does have some interesting features that correct some of the questions raised in the above resumé of previous work.

In sum many of these features respond to the following questions and needs:

1. Integration of real and financial variables. The preceding summary indicates that earlier models concentrated primarily on real factors, and therefore in this type of research the explanatory or forecasting role of financial variables has not been included.
2. As a result of the above interrelationship, the model should permit simulations with monetary and fiscal policy variables and to establish short-term projections. This would constitute an additional empirical test of the basic assumptions that are set out below.
3. To test the consistency of the statistical series and determine further information needs. Hitherto the type of research done by the Central Bank of Nicaragua has been of a partial nature and thus the interdependence of the economic sectors has not been verified statistically. The DUSOL model enables us to observe the margins of measurement errors in our stock of information as well as to establish further needs.

The model contains 24 structural equations of which 10 are behavioral and 14 are identities. It presents 24 endogenous variables, 5 lagged variables, and 25 exogenous variables, including 6 economic policy variables and 3 dummy variables. The sample period runs from 1960 to 1974; structural changes and other qualitative variations within the sample period were corrected with dummy variables, and the dynamic simulation or test of convergence and stability of the coefficients covers the sample period.

3. DESCRIPTION OF THE MODEL

3.1 Distinctive Features and Basic Assumptions

The econometric model of Nicaragua presented here is a short-term model. Thus it does not include a series of features typical of growth models, such as technical restrictions on production, the dynamics of capital formation and population, and growth of the labor force. It is instead a demand-oriented model, in which the effective determination of the gross domestic product results from the basic identity of national accounts, and consists of the sum of domestic expenditure and the balance of payments surplus on current account.[5]

This formulation implicitly assumes that potential domestic pro-

duction in a specific year is determined by the availability of factors of production and their respective marginal productivities plus a residual factor that accounts for the effects of the environment and technological change. For Nicaragua the effective use of such productive factors is thought to be influenced by the behavior of demand, with external demand or demand for exports and the internal and external flow of credit occupying preponderant positions. The effect of external demand on the domestic product is unquestioned, but the impact of the financial flow is not, because it could chiefly affect total money expenditure, but not necessarily production. That is, to the extent that the supplies of the other factors of production do not respond with sufficient elasticity in the short term and production does not increase *pari passu*, the excess demand for goods and services resulting from flow of credit would be resolved either through the external sector or the price level.

In the model described here, while domestic credit and external resources may be viewed to a certain extent as inputs of the production process, beyond this limit they become transformed directly into a country's imports, given the level and structure of national production. This last point is a distinctive feature of the economic system described in this model. On the other hand, the rate of inflation, measured in Nicaragua as the percentage change in the wholesale price index, is an autonomous element of the model. The explanation for this assumption lies in the relative openness of the Nicaraguan economy, its relative insignificance in world markets, and the free movement of goods and capital that exists in the country. Thus the variation in the price level is closely linked to the behavior of the prices of the products and services that actually or potentially enter into the flow of external trade. As a result, the resolution referred to in the previous paragraph is assumed to lie in Nicaraguan case primarily in the external sector and only temporarily, if at all, in the price level.

These features of the Nicaraguan economy are reflected in the treatment of the domestic money and financial markets in the model by the omission of the explicit function explaining supply of money or liquid assets, which is used by many of the traditional models. In the specifications of the financial sector, only the demand for money or liquid assets is included. The implicit assumption in this formulation is that the duration of the process of adjustment of the disequilibria between domestic expenditure and production is less than a year and therefore the quantity of money or liquid assets existing in the country is the quantity demanded from period to period.

On the other hand, in the model domestic credit to the private

sector is not considered to be established by demand because it reflects to a large extent the explicit intentions of the monetary authorities or the financial system—the former to provide resources for economic activities, and the latter to place productively the resources tapped from other sources. Thus changes in domestic credit to the private sector may be interpreted as the main source of the variation that would occur in the nominal supply of money or liquid assets if there were no external sector; or, in the case of Nicaragua, the potential variation in the supply of money before the adjustment process through the external sector occurs. Consequently, the net international reserves of the banking system, or more precisely the changes in them, which are equivalent to the overall annual balance-of-payments, are determined in this model by the interaction between the demand for liquid assets and credit.

One of the objectives of the model is to detect the form and amount in which the financial variables affect the real aggregates of the economy. From the above it may be seen that the model uses the credit variable and not the money variable in the formulation of the equations determining private investment, consumption, and imports. That is, assuming that the process of adjustment is carried out in a one-year period and that the quantity of money is determined by demand, any effect on real aggregates occurs through the changes in credit and not through changes in the quantity of money.

Another feature of the model is the explicit assumption that external capital flows to the public sector occur in response to needs. To be specific, gross use of external resources results from the disequilibrium in the flow of its internal resources once the financing received by the domestic financial system and its capital expenditure have been fixed exogenously. This would seem to overlook the importance of the elasticity of supply of external credit for the country. However, it is felt that the impact of changes in the interest rate or in the schedule of debt payments, at least within reasonable limits, is small in the short run and therefore would not be captured by the model. In any case, for small changes the division between expenditure and financing is more exogenous than structural. However, this feature does suggest a limitation of the model that must be kept in mind if it is used for simulation of large changes in policy.

3.2 Specification of the Equations in the Different Sectors

The model contains three clearly differentiated markets (domestic goods, external goods, and financial). These are broken down and made compatible so as to show the gross domestic product expendi-

ture account and the flow of funds into and out of four basic sectors of the economy, namely, balance of payments, or foreign sector, public sector, financial system, and private sector. All these variables are expressed in constant (1958) prices.

The behavioral equations and identities of the model of the different economic sectors are described below. The figures that appear in brackets beneath the regression coefficients are the corresponding values of the Student's t. The coefficient of determination, adjusted by degrees of freedom, which measures the goodness of fit of the equation, the Durbin-Watson statistic, which measures the level of autocorrelation, the standard error for each equation, and the estimated value of *RHO*—the first-order autocorrelation—are also given.

The equations were run using ordinary least squares. Since the variables are expressed in levels, much of the goodness of fit reflects the trend and not explanatory power per se. In particular, it would seem that the model is not suitable to grasp abrupt changes in the dependent variables. Nonetheless, as will be shown below, the results of the dynamic simulation reveal acceptable predictive properties for the model.

3.2.1 Financial System: In the model the financial system is broken down into two subsectors—the banking system and the rest of the financial system. The latter differs from the former not only in the nature of its operations but also in its recent dynamic development and in the lower degree of control that the monetary authorities exercise over it.

A number of earlier studies[6] have accepted the hypothesis that in Nicaragua the nominal quantity of money or liquid assets existing in the economy is determined by the public's demand for them and therefore the Central Bank cannot permanently influence their level or rate of growth.

In accord with this theory, the resources obtained from the public, both by the banking system ($L2$) and by the rest of the financial system ($L3 - L2$), are expressed in the model as structural demand relationships. The explanatory variables are the gross domestic product (*PIB*) and a dummy variable (*DUMY*) for the years 1972, 1973, and 1974.

The estimated equation for $L2$ was as follows:

$$L2 = -147.26 + 0.179\,PIB + 237.81\,DUMY \qquad (3\text{-}1)$$
$$\qquad\quad (-2.37) \quad (11.24) \qquad (5.62)$$
$$\bar{R}^2 = 0.97; DW = 1.93; SE = 0.07; RHO = 0.0239$$

The coefficients both of *PIB* and *DUMY* are acceptable at a level of significance of 1 percent; the Durbin-Watson shows no problem of autocorrelation, and the $\bar{R}^2$ indicates that 97 percent of the variance in $L2$ is explained by *PIB* and *DUMY*.

Another alternative describing the demand for $L2$ would involve discrete and incomplete adjustment instead of an instantaneous process of adjustment as established in the basic assumptions; the proportion of adjustment would depend on the value of an adjustment coefficient. However, this alternative would introduce as an argument the lagged value of $L2$, a variable that is strongly correlated with the gross domestic product (*PIB*). Another alternative would be to include the rate of inflation as an indicator of the alternative cost of keeping liquid assets; this variable was not statistically significant. This is not surprising for the Nicaraguan economy shows great price stability for the sample period with the exception of 1973 and 1974. Perhaps the effect of this change in the behavior of prices or the lagged adjustment in this period is captured by the dummy variable. The dummy may also pick up some of the non-homogeneity of the linear form.

Credit to the private sector from the banking system (*FIB*) is an exogenous variable in the model. Such variables will be denoted by a bar. Although part of FIB could be considered fixed by demand, there is a high degree of implicit regulation by the Central Bank in determining its size. Likewise the net credit of the banking system to the government (*FIG*), basically related to Central Bank operations, was introduced as an exogenous variable. As a consequence, net international reserves (*RIN*) of the banking system are determined from the identity existing in the monetary accounts. The specifications are, therefore, as follows:

$$FIB = FIB_{-1} + \overline{\Delta\ FIB} \tag{3-2}$$

$$FIG = FIG_{-1} + \overline{\Delta\ FIG} \tag{3-3}$$

$$RIN = L_2 + \overline{OPNB} + \overline{FEB} - \overline{FIB} - \overline{FIG} \tag{3-4}$$

As may be seen in the identity of the net international reserves, the only source of error is the demand for liquid assets ($L2$), which is the variable that exhibits the lowest prediction error in the model within the sample period.[7]

The demand for liquid assets issued by the rest of the financial system is represented by the variable $L3 - L2$. The estimated equation was as follows:

$$L3 - L2 = -197.20 + 0.070\,PIB + 168.75\,DUMY \qquad (3\text{-}5)$$
$$(-4.83)\ (6.67)\qquad (6.05)$$
$$\bar{R}^2 = 0.95;\ DW = 0.88;\ SE = 0.23;\ RHO = 0.4896$$

The equation has a very low Durbin-Watson, indicating autocorrelation in the residuals. In order to obtain a better specification of the residuals the equation was corrected by means of a reestimation using the *RHO* coefficient.[8]

The equation thus corrected naturally has a much higher Durbin-Watson, and the variance is smaller. However, although this new equation was more acceptable, the predictive error (*MSE*) of *L*3 - *L*2 using it in the dynamic simulation of the model was higher than the predictive error with the uncorrected equation, and therefore the latter was retained in the model.

A number of alternative specifications were run for the variable *L*3 - *L*2. The formulation in logarithmic terms showed acceptable results at a reliability level of 1 percent. However, in the simultaneous results of the model the predictive error (*MSE*) of the logarithmic equation also was greater than that of the equation in absolute terms, and therefore the latter was retained.

The level of credit that the rest of the financial system grants to the private sector (*FIF*) is obtained through the identity:

$$FIF = (L3 - L2) + \overline{FEF} + \overline{OPNF} \qquad (3\text{-}6)$$

In this formulation the only one source of error is the result of the variable *L*3 - *L*2. The other two variables, defined as exogenous, are the medium- and long-term financing received from the external sector (*FEF*) and other net liabilities of the rest of the financial system (*OPNF*).

The remaining definitions for the financial sector are as follows:

$$\Delta FIF = FIF - FIF_{-1} \qquad (3\text{-}7)$$

$$\Delta FI = FIF + \Delta FIB \qquad (3\text{-}8)$$

3.2.2 Public Sector: The accounts of the public sector are broken down into two subsectors, the general government and the rest of the public sector. This difference is fundamental both for the purposes of making the figures compatible with the national accounts as well as for economic analysis and programming. Another reason for the breakdown is the different nature of both the income and the ex-

penditure of the autonomous entities and financial intermediaries relative to those of the general government.

Current income of the general government is broken down into three categories: direct taxes (*ID*), indirect taxes (*II*), and other net income (*OINCG*), which constitutes an exogenous variable.

Direct taxes (*ID*) are expressed as a function of national income (*Y*), that is, of payments to the factors of production, and of a dummy variable (*DNEW*) for the period 1969-1974, which reflects two fundamental changes:

1. A change in the system of payments of the mining sector from a progressive to a proportional system that considerably weakened revenue levels
2. The impact of the earthquake and of inflation. The estimated equation is as follows:

$$ID = -75.04 + 0.048\ Y + 29.11\ DNEW \qquad (3\text{-}9)$$
$$\qquad (-7.85)\ \ (18.32)\ \ \ (7.97)$$
$$\bar{R}^2 = 0.96; DW = 1.65; SE = 0.09; RHO = 0.055$$

The results are accepted at a confidence level of 1 percent, there is no problem of autocorrelation, and $\bar{R}^2$ is high.

Indirect taxes (*II*) are expressed as a function of total domestic expenditure (*GI*) and of a dummy variable (*DUMY*), which covers short-term economic pressures on the taxation system in the years 1972, 1973, and 1974. The estimated equation is the following:

$$II = 39.52 + 0.075\ GI + 71.80\ DUMY \qquad (3\text{-}10)$$
$$\qquad (1.43)\ (10.66)\ \ \ \ (4.00)$$
$$\bar{R}^2 = 0.96; DW = 1.72; SE = 0.06; RHO = 0.0878$$

The equation is highly acceptable with no problem of autocorrelation and a high goodness of fit.

General government consumption (*CG*), a concept equivalent to that of the national accounts, depends on the gross domestic product (*PIB*):

$$CG = 94.42 + 0.039\ PIB \qquad (3\text{-}11)$$
$$\qquad (5.47)\ (9.78)$$
$$\bar{R}^2 = 0.87; DW = 1.83; SE = 0.06; RHO = 0.0755$$

The equation is highly acceptable, the Durbin-Watson is high, and

the $\bar{R}^2$ indicates that 87 percent of the variance in *CG* is explained by *PIB*.

Interest on the external debt (*IDECG*) is defined as exogenous; current account savings are defined as the difference between current expenditure and income. As may be seen there are three sources of errors in the identity, direct and indirect taxes and current expenditure.

$$AG = ID + II + \overline{OINCG} - CG - \overline{IDECG} \tag{3-12}$$

General government capital expenditure consists of real investment (*ICG*) and capital transfers (*TK*), which are specified in the model as exogenous variables (the latter includes the movement of capital resources under the heading of Grants of Loans and Transfers proper, which flow from the central government to the rest of the public sector). Another exogenous concept in the capital account is amortization of the external debt (*ADECG*).

The financing of operations of the general government subsector is carried out by recourse to external borrowing (*RDECG*); savings on current account; financing received from the financial system (*FIG*); and the variation in the other net assets concerned. Since the latter two variables are determined exogenously in the model, the external borrowing amounts to defining a need for gross external financing to achieve the real and financing investment plans and the servicing of the external debt.

$$RDECG = \overline{ICG} + \overline{ADECG} + \overline{TK} - AG - \overline{\Delta\ FIG} - \overline{\Delta\ OANCG} \tag{3-13}$$

The rest of the public sector, made up of the public companies producing goods and services and the financial intermediaries, have as a source of income the revenue from tariffs and interest on placements (*INTRG*); the equation for *INTRG* is the following:

$$INTRG = -101.30 + 0.075\ PIB \tag{3-14}$$
$$(-3.79)\ (11.80)$$
$$\bar{R}^2 = 0.91; DW = 1.34; SE = 0.12; RHO = 0.3198$$

The result is highly acceptable with autocorrelation in the indeterminate range and an explanatory power of 91 percent of the variance of *INTRG*.

Current expenditure for the rest of the public sector (*CRG*) is

specified as a function of current income (*INTRG*). When *INTRG* was replaced by the gross domestic product (*PIB*) a rather low $\bar{R}^2$ was obtained. The result of the equation is the following:

$$CRG = 50.03 + 0.211\ INTRG \qquad (3\text{-}15)$$
$$(5.46)\ (5.17)$$
$$\bar{R}^2 = 0.65; DW = 0.68; SE = 0.14; RHO = 0.6925$$

This variable presents a similar problem to that of the variable (*L3 - L2*). The equation for *CRG* reveals problems of autocorrelation, and therefore one could respecify the residuals through a re-estimation of the *RHO* coefficient. The corrected equation improves the goodness of fit by three percentage points. However, since the fundamental purpose of the model is its forecasting power as a simultaneous system of equations, the corrected equation was not used because of the high margins of error (MSE) that it generated for this variable in the dynamic simulation.

To complete the current account of the rest of the public sector, interest on the external public debt is defined as exogenous as is the residual heading, Other Current Expenditure.

The capital account for this subsector includes real investment (*IRG*), which is formulated in exogenous terms, and the amortization of the external public debt (*ADERG*), which is also considered as exogenous. The financing headings are made up of the change in other net assets ($\Delta\ OANRG$), savings on current account ($INTRG - CRG - \overline{IDERG} - \overline{OCRG}$), capital transfers from the general government (*TK*), and external borrowing (*RDERG*), which is formulated as a requirement:

$$RDERG = \overline{IRG} + \overline{ADERG} - INTRG + CRG \qquad (3\text{-}16)$$
$$+ \overline{IDERG} + \overline{OCRG} - \overline{TK} - \overline{\Delta\ OANRG}$$

The sources of errors for *RDERG* stem from *INTRG* and *CRG*.

3.2.3 Balance of Payments: In the balance-of-payments accounts, the model treats exports of goods and services, excluding payments to factors abroad, as an exogenous variable.

Imports of goods and services (*M*), again excluding payments to factors abroad, are made to depend functionally on the gross domestic product (*PIB*) and the change in total credit to the private sector ($\Delta\ FI$).

It should be noted that this specification implies that imports are

one of the mechanisms through which the country adjusts to any disequilibrium in the financial market. The estimated equation was as follows:

$$M = 31.80 + 0.24\ PIB + 1.78\ \Delta\ FI \qquad (3\text{-}17)$$
$$(0.20)\ (5.17) \qquad (4.84)$$
$$\bar{R}^2 = 0.93; DW = 2.62; SE = 0.10; RHO = 0.3412$$

The equation yields a high $\bar{R}^2$, there is no problem of autocorrelation and the coefficients are acceptable at a level of significance of 1 percent.

Some of the remaining components of the balance of payments are determined in other sectors included in the model. Thus external borrowing (*RDECG* and *RDERG*) constitutes an additional need for resources in the public sector. Similarly, the behavior of net international reserves is determined in the accounts of the financial sector.

Other net income from external factors (*OINFE*), net gifts from the external sector (*DN*), and other net external borrowing (*ORNDE*), which round off the official capital account of the balance of payments, are also introduced as exogenous variables.

3.2.4 Private Sector (Enterprises and family units): In the private sector it is considered that private consumption (*CP*) is explained by disposable income (*YD*) and by the change in total credit to the private sector with a lag ($\Delta\ FI_{-1}$). The estimated equation is the following:

$$CP = 537.60 + 0.739\ YD + 1.30\ \Delta\ FI_{-1} \qquad (3\text{-}18)$$
$$(4.33)\ (4.99) \qquad (2.75)$$
$$\bar{R}^2 = 0.98; DW = 1.94; SE = 0.03; RHO = 0.0126$$

The results are highly acceptable, the Durbin-Watson is quite close to 2, the $\bar{R}^2$ is high, and the Student *t*s are statistically significant.

Private investment (*IP*) is specified as a function of the gross domestic product (*PIB*), the change in total credit ($\Delta\ FI$), and a dummy variable *DU* for the years 1970 and 1972. The dummy variable corrects the very high residuals registered in 1970 because the war between Honduras and El Salvador in 1969 caused trade to be diverted toward Nicaragua with a consequent effect on expectations and investment levels. In 1972 a fiscal reform of indirect taxes discouraged investment, and thus the estimated *IP* function overestimates the real value. The resulting equation was as follows:

$$IP = 68.56 + 0.072\,PIB + 1.75\,\Delta\,FI + 193.14\,DU \qquad (3\text{-}19)$$
$$(1.66)\ (5.90)\qquad (17.85)\qquad (7.88)$$
$$\bar{R}^2 = 0.99; DW = 1.78; SE = 0.05; RHO = 0.099$$

The equation is highly acceptable with no problem of autocorrelation.

Private sector savings (AP) are the difference between total domestic savings and general government savings.

$$AP = PIB - CP - CG - \overline{IDECG} - \overline{IDERG} + \overline{OINFE} \qquad (3\text{-}20)$$
$$+ \overline{DN} - AG$$

As may be seen, in the AP identity there are four sources of error, namely, PIB, CP, CG, and AG. Finally, the net external financing needed by the private sector (FEP) is specified as exogenous.

3.2.5 **National Accounts:** Domestic expenditure (GI) is defined as the sum of total consumption ($CP + CG$) and total investment ($IF + ICG + IRG$). The gross domestic product (PIB) is the result of domestic expenditure (GI) plus the surplus of imports over exports ($M - X$). National income (Y) is defined as the net domestic product ($0.96\ GDP$) minus indirect taxes (II) minus interest on the external public debt ($IDECG$ and $IDERG$) plus other net income from factors abroad ($\overline{OINFE}$). For disposable income (YD) the method of calculation used is explained in the appendix.

$$GI = CP + CG + IP + \overline{ICG} + \overline{IRG} \qquad (3\text{-}21)$$

$$PIB = GI + \overline{X} - M \qquad (3\text{-}22)$$

$$Y = 0.96\,PIB - II - \overline{IDECG} - \overline{IDERG} + \overline{OINFE} \qquad (3\text{-}23)$$

$$YD = 0.931105Y - ID \qquad (3\text{-}24)$$

3.3 SUMMARY OF THE MODEL AND DEFINITION OF VARIABLES

Banking System

$$L_2 = -147.26 + 0.179\,PIB + 237.81\,DUMY \qquad (3\text{-}1)$$
$$(-2.37)\ (11.24)\qquad (5.62)$$
$$\bar{R}^2 = 0.97; DW = 1.93; SE = 0.07; RHO = 0.0239$$

$$FIB = FIB_{-1} + \overline{\Delta\ FIB} \tag{3-2}$$

$$FIG = FIG_{-1} + \overline{\Delta\ FIG} \tag{3-3}$$

$$RIN = L2 + \overline{OPNG} + \overline{FEB} - \overline{FIB} - \overline{FIG} \tag{3-4}$$

Rest of the Financial System

$$L3 - L2 = -197.20 + 0.070\ PIB + 168.75\ DUMY \tag{3-5}$$
$$(-4.83)\ (6.67)\qquad (6.05)$$
$$\bar{R}^2 = 0.95;\ DW = 0.88;\ SE = 0.23;\ RHO = 0.4896$$

$$FIF = (L3 - L2) + \overline{FEF} + \overline{OPNF} \tag{3-6}$$

$$\Delta\ FIF = FIF - FIF_{-1} \tag{3-7}$$

$$\Delta\ FI = \Delta\ FIF + \Delta\ FIB \tag{3-8}$$

Central Government

$$ID = -75.08 + 0.048\ Y + 29.11\ DNEW \tag{3-9}$$
$$(-7.85)\ (18.32)\qquad (7.97)$$
$$\bar{R}^2 = 0.96;\ DW = 1.65;\ SE = 0.09;\ RHO = 0.55$$

$$II = 39.52 + 0.075\ GI + 71.80\ DUMY \tag{3-10}$$
$$(1.43)\ (10.66)\qquad (4.00)$$
$$\bar{R}^2 = 0.96;\ DW = 1.72;\ SE = 0.06;\ RHO = 0.0878$$

$$CG = 94.42 + 0.039\ PIB \tag{3-11}$$
$$(5.47)\ (9.78)$$
$$\bar{R}^2 = 0.87;\ DW = 1.83;\ SE = 0.06;\ RHO = 0.0755$$

$$AG = ID + II + \overline{OINCG} - CG - \overline{IDECG} \tag{3-12}$$

$$RDECG = \overline{ICG} + \overline{ADECG} + \overline{TK} - AG - \overline{\Delta\ FIG} - \overline{\Delta\ OANCG} \tag{3-13}$$

Rest of the Public Sector

$$INTRG = -101.30 + 0.075\ PIB \tag{3-14}$$
$$(-3.74)\ (11.80)$$
$$\bar{R}^2 = 0.91;\ DW = 1.34;\ SE = 0.12;\ RHO = 0.3198$$

$$CRG = \underset{(5.46)}{50.03} + \underset{(5.17)}{0.211}\ INTRG \qquad (3\text{-}15)$$

$$\bar{R}^2 = 0.65; DW = 0.68; SE = 0.14; RHO = 0.6925$$

$$RDERG = IRG + ADERG - INTRG + CRG + \overline{IDERG} + \overline{OCRG} - \overline{TK} - \overline{\Delta\ OANRG} \qquad (3\text{-}16)$$

Balance of Payments

$$M = \underset{(0.20)}{31.80} + \underset{(5.17)}{0.24}\ PIB + \underset{(4.84)}{1.78}\ \Delta\ FI \qquad (3\text{-}17)$$

$$\bar{R}^2 = 0.93; DW = 2.62; SE = 0.10; RHO = 0.3412$$

Private Sector

$$CP = \underset{(4.33)}{537.60} + \underset{(14.99)}{0.74}\ YD + \underset{(2.75)}{1.30}\ \Delta\ FI_{-1} \qquad (3\text{-}18)$$

$$\bar{R}^2 = 0.98; DW = 1.94; SE = 0.03; RHO = 0.0126$$

$$IP = \underset{(1.66)}{68.56} + \underset{(5.90)}{0.072}\ PIB + \underset{(17.84)}{1.75}\ \Delta\ FI + \underset{(7.88)}{193.14}\ DU \qquad (3\text{-}19)$$

$$\bar{R}^2 = 0.99; DW = 1.78; SE = 0.05; RHO = 0.099$$

$$AP = PIB - CP - CG - \overline{IDECG} - \overline{IDERG} + \overline{OINFE} + \overline{DN} - AG \qquad (3\text{-}20)$$

National Accounts

$$GI = CP + CG + IP + \overline{ICG} + \overline{IRG} \qquad (3\text{-}21)$$

$$PIB = GI + \overline{X} - M \qquad (3\text{-}22)$$

$$Y = 0.96\ PIB - II - \overline{IDECG} - \overline{IDERG} + \overline{OINFE} \qquad (3\text{-}23)$$

$$YD = 0.931105\ Y - ID \qquad (3\text{-}24)$$

DEFINITION OF VARIABLES

ENDOGENOUS VARIABLES RESULTING FROM THE STRUCTURAL EQUATIONS

1. *L2* — Real Demand for Money of the Private Sector. Includes: cash and demand, savings and time deposits in the banking system. Deflator: Implicit GDP index. Source: Monetary data.
2. *L3 - L2* — Real demand for liquid assets of the rest of the financial system by the private sector. Includes: savings and time deposits and outstanding securities. Deflator: Implicit GDP index.
3. *ID* — Real direct taxes of the general government on households and companies. Deflator: Implicit GDP index. Sources: National accounts, compatibilized with public sector data.
4. *II* — Real indirect taxes of the general government. Deflator: Implicit GDP index. Source: National accounts compatibilized with public sector data.
5. *INTRG* — Real nontax income of the rest of the public sector: Includes: Income from assets, sale of goods and services, other income and current transfers. Deflator: Implicit GDP index. Source: public sector data.
6. *CG* — Real consumption of the general government. Deflator: Implicit *CG* index. Source: National accounts compatibilized with public sector data.
7. *CRG* — Real consumption of the rest of the public sector. Includes: Payments and purchase of goods and services. Deflator: Implicit *CG* index. Source: Public sector data.
8. *M* — Real imports of goods and services, exluding payments to factors abroad. Deflator: Implicit *M* index. Source: National accounts compatibilized with balance-of-payments data.
9. *CP* — Real consumption of the private sector. Deflator: Implicit *CP* index. Source: National accounts.
10. *IP* — Real investment of the private sector. Deflator: Implicit *IP* index. Source: National accounts.

ENDOGENOUS VARIABLES FROM IDENTITIES AND EQUILIBRIUM CONDITIONS

11. *FIB* — Real credit of the banking system to the private sector. Deflator: Implicit GDP index. Source: Monetary data.
12. *FIG* — Real credit of the financial system to the public sector. Deflator: Implicit GDP index. Source: Monetary data.
13. *RIN* — Real net international reserves of the banking system. Deflator: Implicit *M* index. Source: Monetary data, compatibilized with balance-of-payments data.
14. *FIF* — Real credit of the rest of the financial system to the private sector. Deflator: Implicit GDP index. Source: Monetary data.
15. Δ *FI* — Change in total real credit of the financial system in the private sector.
16. *AG* — Real savings of the general government on current account. Deflator: Implicit GDP index. Source: National accounts compatibilized with public sector data.
17. *RDECG* — Real external debt drawings of the general government. Deflator: Implicit *M* index. Source: Public sector accounts, compatibilized with balance-of-payments data.
18. *RDERG* — Real external debt assets of the rest of the public sector. Deflator: Implicit *M* index. Source: Public sector data, compatibilized with balance-of-payments data.
19. *AP* — Real savings of the private sector (companies and family units).
20. *GI* — Real domestic expenditure. Source: National accounts.
21. *PIB* — Real gross domestic product. Deflator: Implicit GDP index. Source: National accounts.
22. *Y* — Real national income. Deflator: Implicit GDP index. Source: National accounts.

23. YD — Real disposable income.* Deflator: Implicit GDP index. Source: National accounts.
24. ΔFIF — Variation in real credit of the rest of the financial system to the private sector.

EXOGENOUS AND LAGGED VARIABLES

25. ΔFIB — Change in real credit of the banking system to the private sector. Deflator: Implicit GDP index. Source: Monetary data.
26. ΔFIG — Change in real credit of the financial system to the public sector. Deflator: Implicit GDP index. Source: Monetary data.
27. $\Delta OPNB$ — Change in other real net liabilities of the banking system. Deflator: Implicit GDP index. Source: Monetary data.
28. $\Delta OPNF$ — Change in other real net liabilities of the rest of the financial system. Deflator: Implicit GDP index. Source: Monetary data.
29. $\overline{OINCG}$ — Other real net income of the general government. Source: Public sector data.
30. $\overline{OCRG}$ — Other real consumption of the rest of the public sector. Source: Public sector data.
31. $\overline{ICG}$ — Real investment of the general government. Deflator: Implicit ICG index. Source: National accounts.
32. $\overline{TK}$ — Transfer of capital resources from the central government to the rest of the public sector. Includes: Loans and capital transfers.
33. $\overline{\Delta\ OANCG}$ — Change in other real net assets of the central government. Source: Public sector data.
34. $\overline{\Delta\ OANRG}$ — Change in other real assets of the rest of the public sector. Source: Public sector data.
35. $\overline{X}$ — Real exports of goods and services excluding payment of factors abroad. Deflator: Implicit X index. Source: National accounts with balance of payments.

*YD = Disposable Income equals National income less Companies' savings ($-0.075Y$) less Government income from property and companies ($-0.004Y$) less Direct taxes ID plus Interest on the public debt ($0.01Y$) plus Net current transfers of the general government ($0.000055Y$) plus Net current transfers from the rest of the world ($0.00005Y$) equals $0.931105Y - ID$.

36. $\overline{OINFE}$ Other real net income from factors abroad. Source: Balance of payments.
37. $\overline{DM}$ Real net gifts of the rest of the world. Deflator: Implicit *M* index. Source: Balance of payments.
38. $\overline{ORNDE}$ Other real net borrowings. Source: Balance of payments.
39. $\overline{IDECG}$ Real interest on the external debt of the general government. Deflator: Implicit *M* index. Source: Balance of payments compatibilized with public sector data.
40. $\overline{IDERG}$ Real interest on the external debt of the rest of the public sector. Deflator: Implicit *M* index. Source: Balance of payments compatibilized with public sector data.
41. $\overline{IDECG}$ Real amortization of the external debt of the general government. Deflator: Implicit *M* index. Source: Balance of payments compatibilized with public sector data.
42. $\overline{ADERG}$ Real amortization of the external debt of the rest of the public sector. Deflator: Implicit *M* index. Source: Balance of payments compatibilized with public sector data.
43. $\overline{IRG}$ Real investment of the rest of the public sector. Deflator: Implicit *IG* index. Source: National accounts compatibilized with public sector data.
44. $\overline{FEB}$ Medium- and long-term real external resources of the banking system. Deflator: Implicit GDP index. Source: Monetary data.
45. $\overline{FEF}$ Medium- and long-term real external resources of the rest of the financial system. Deflator: Implicit GDP index. Source: Monetary data.
46. $\overline{FEP}$ Net movement of external capital, including errors and omissions. Deflator: Implicit *M* index. Source: Balance of payments.
47. *DUMY* Binary variable for *L*2, *L*3 - *L*2, and *M*. 1972, 1973, and 1974 = 1; rest of the period = 0.
48. *DNEW* Binary variable for *ID*. 1969, 1970, 1971, and 1972 = -1; 1973, 1974 = 1; rest of the period = 0.
49. *DU* Binary variable for *IP*. 1970 = 1; 1971 = -1; rest of the period = 0.
50. FIB_{-1} Real credit of the banking system to the private sector with a lag.

51. FIG_{-1} Real credit of the banking system to the public sector with a lag.
52. FIF_{-1} Real credit of the rest of the financial system to the private sector with a lag.
53. ΔFI_{-1} Change in real total credit of the financial system in the private sector with a lag.
54. RIN_{-1} Real net international reserves of the banking system with a lag.

4. SIMULATION AND VALIDATION OF THE MODEL[9]

Dynamic simulation of the model involves grouping all the individual equations and identities into a simultaneous system whose interactions indicate whether or not the model is acceptable. Dynamic simulation is useful to determine the validity of the model as well as to identify the problem areas that could be improved to give better results. The validity of the model is tested through the following criteria: (1) a high degree of goodness of fit for the system of simultaneous equations, which ultimately is represented by the convergence of the model; (2) the conditions of stability of the model, which are tested by introducing an exogenous disturbance, for example, an increment of 20 percent in an economic policy variable, and observing whether the system returns to the initial value at the outset; (3) in order to quantify the goodness of fit of the system an analysis of errors is made through suitable indicators.

4.1 Goodness of fit of the Entire System: The percentage of the variance of the dependent variable that is explained by an individual equation may be measured by the coefficient of determination, R^2. However, this explained percentage of the variance may change when we insert the equation into a simultaneous system. In order to test what we have called, following convention, the goodness of fit, a dynamic simulation was carried out and then a graph was drawn of the estimated value of the simulation and the actual value for each endogenous variable. Some sample graphs are shown in Figure 3-1. Obviously the scale affects the degree of deviation in visual inspection, but the latter is combined with an analysis of the errors (Table 3-1) in which the deviation is quantified.

There are some functions, such as those of the demand for liquid assets of the banking system ($L2$) (shown), net international reserves (RIN) (shown), and credit from the rest of the financial system

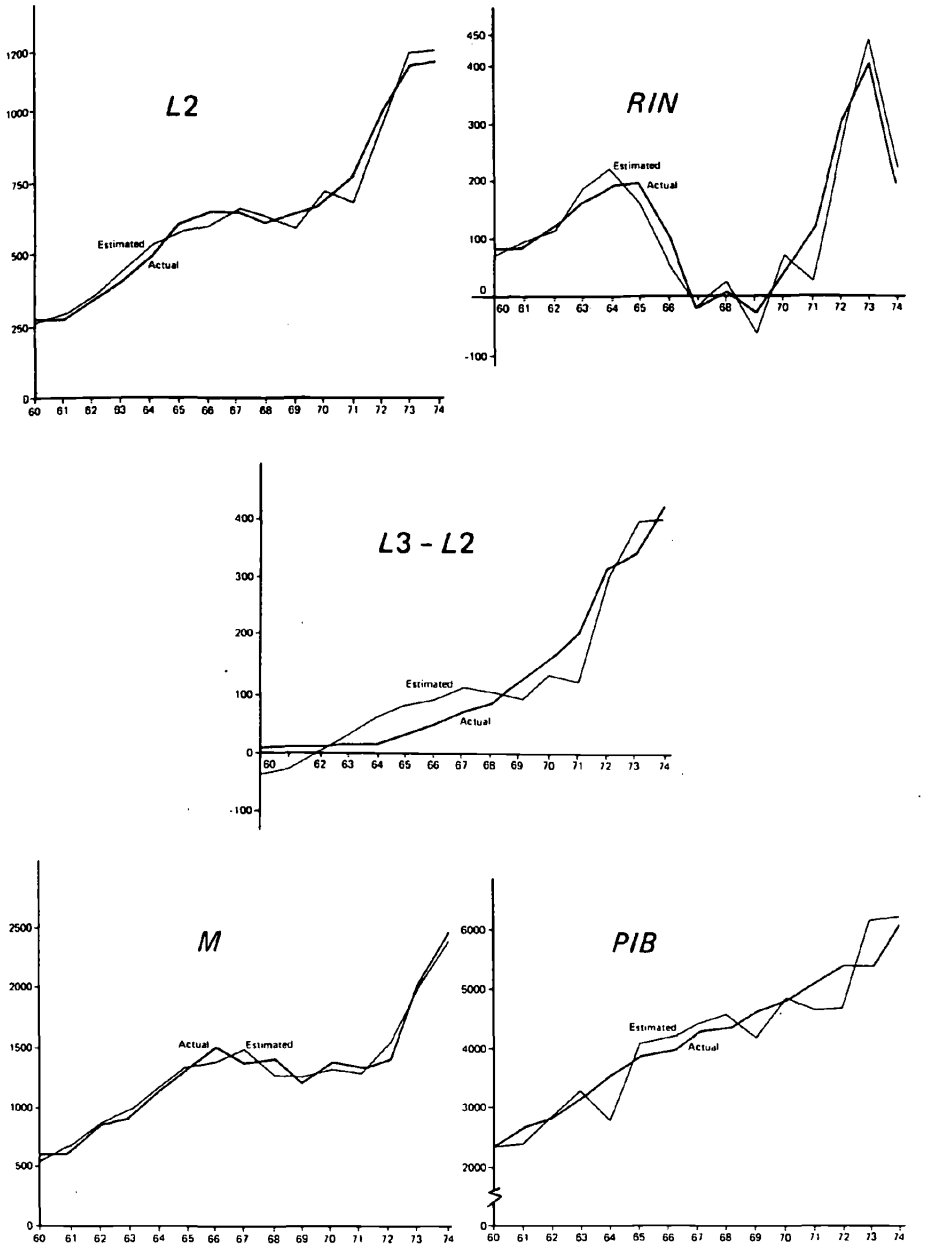

FIGURE 3-1. Comparison of Actual and Estimated Values, Selected Variables, Dusol—Nicaragua Model

(*FIF*), in which the estimated values identify the inflection points of the actual values, and both series show the same trend.

The model also simulates, although to a less satisfactory degree, indirect taxes (*II*), consumption of the general government (*CG*) and imports (*M*) (shown). Although the estimated values show a similar trend to that of actual values, certain inflection points are not well predicted by the model. Indirect taxes and imports are highly correlated; they both follow the same cyclical processes and reflect strong structural changes. It is therefore possible that the same variable is missing, which prevents us from capturing this behavior in full. For the consumption of the general government, the simulation accurately reflects the actual values until 1970, and from then on the trends diverge. The years 1971 and 1972 show a change in the composition of consumption between the public and private sectors, the former becoming more important; this break in the trend is not caught by the equation; likewise, the years 1973 and 1974 reflect the impact of the earthquake that affected public consumption; however, after being corrected by a binary variable this was not significant.

There are other variables such as private consumption (*CP*), total domestic expenditure (*GI*) and the gross domestic product (*PIB*) (shown) that in quantitative terms present errors below 10 percent; however, inspection of the graph shows that the estimated values simulate quite well until 1967 or 1968, after which the inflection points are not well captured by the model. As a consequence of the methodology used to calculate national income (*Y*) and disposable income (*YD*), both variables have the same behavior as the gross domestic product (*PIB*) with respect to the estimated values. The demand for liquid assets of the rest of the financial system (*L*3 - *L*2) (shown) and the consumption of the rest of the public sector (*CRG*) do not present acceptable results, graphically speaking, but this is partially due to the problem of specification of the errors in the two equations.

The direct taxes of the general government (*ID*) and the current income of the rest of the public sector (*INTRG*) are, of course, influenced by the behavior of the gross domestic product (*PIB*) and disposable income (*YD*). The simulations of the identities are less acceptable, perhaps due to the sources of errors in their definitions.

4.2 Stability: Once the model converges showing an acceptable goodness of fit as a whole, it is tested to verify its stability. Exoge-

nous variables were chosen that greatly affect the economic system or are of great importance from the point of view of monetary and fiscal policy. These variables were exports (X), real investment both of the general government and of the rest of the public sector (IRG and ICG), and the change in the real credit of the banking system to the private sector. Each of these variables was raised autonomously by 20 percent.

The reaction of certain macroeconomic and financial variables to this impact was then observed. The stability of the model is shown in Figure 3-2 by the fact that the exogenous disturbance creates a short-term (two or three years) divergence relative to the base run; however, asymptotically the variables thus disturbed converge on what could be viewed as an equilibrium point. If the system were unstable the trend would be divergent. Given that the information used in this simulation is annual, the reaction of the variables to an exogenous disturbance appears to be much slower and more insensitive than if the data were quarterly, for example. However, it may be seen that the changes stemming from exports have a greater effect on the gross domestic product (PIB) than those from the fiscal and monetary variables, and in turn the effect of fiscal variables is more noticeable than that of the monetary variables.

4.3 **Analysis of Errors:** This section describes quantitatively the predictive accuracy of the model. In particular the graphic analysis of the deviations is supplemented by three criteria concerning the calculation of these deviations shown in Table 3-1. Even excluding the variables expressed in first differences such as ΔFIF and ΔFI, the error in percentage terms ($RMSE$) is large. The variable $L3 - L2$ shows the greatest error. As mentioned above, the rapid changes in stocks in this subsector and its process of dynamic growth have not been accurately captured by the structural equation. While net international reserves captured the inflection points in the series, the relative predictive error is high. The other main macroeconomic variables show a somewhat lower relative predictive error as may be seen in the case of private consumption (CP), internal expenditure (GI), the gross domestic product (PIB), national income (Y), and disposable income (YD). The demand for liquid assets of the banking system shows the lowest predictive error. The deviation as well as the percentage difference between the arithmetic mean of the estimated values and the actual values are also shown. In general terms the deviation is rather low except in the case of the saving of the general government (AG).

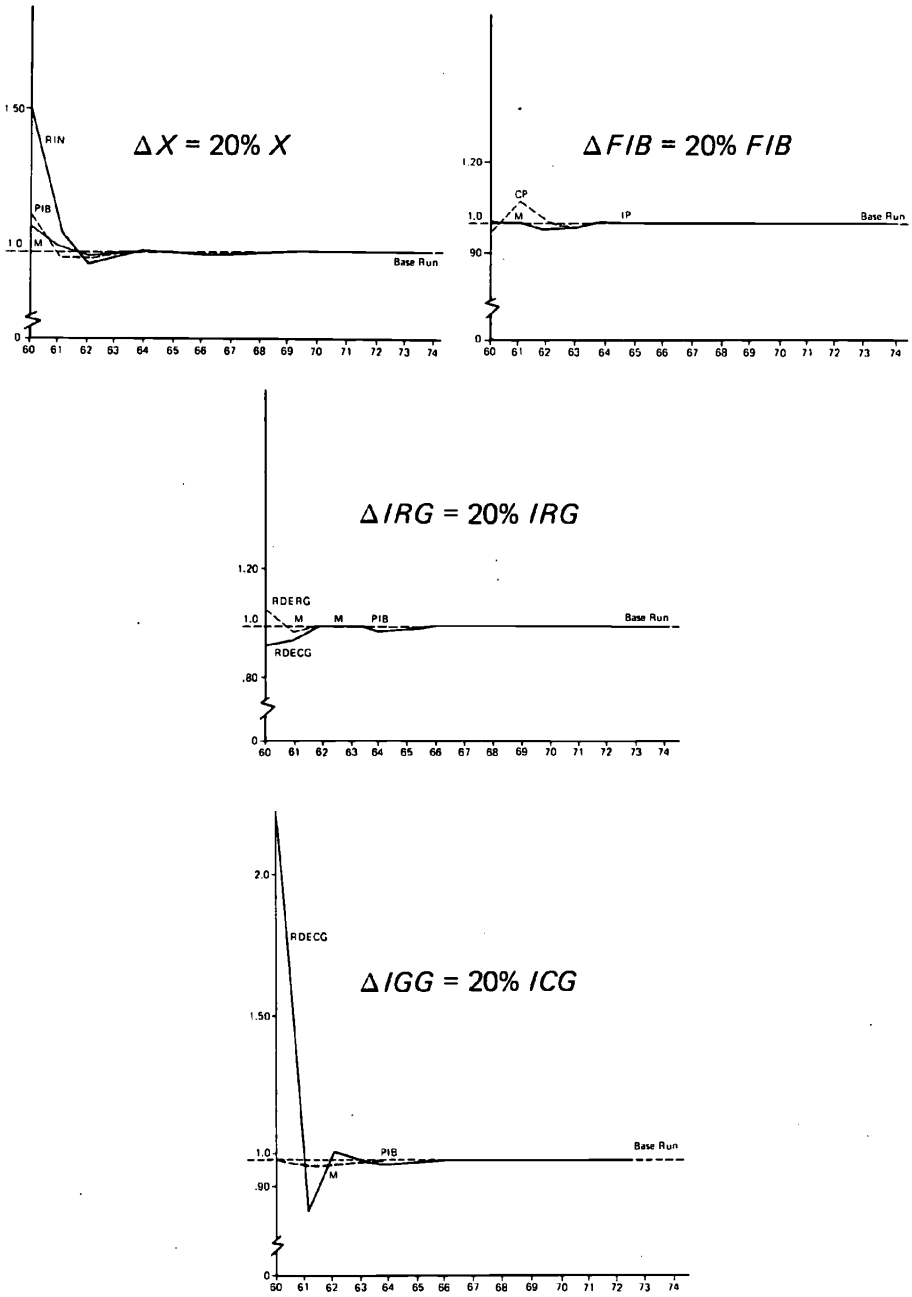

FIGURE 3-2. Simulations of Stability Properties, Dusol—Nicaragua Model

Table 3-1. Forecasting Errors in the Sample Period DUSOL Nicaragua Model

	MSE^1	$RMSE^2$ %	*Deviation*[3]
L2	34.6822	5.74	-0.0050
RIN	34.6822	28.72	0.0072
L3—L2	39.3311	32.91	0.0531
FIF	39.3311	8.02	-0.0024
ΔFIF	40.9364	51.24	-0.0468
ΔFI	40.9364	26.80	-0.0068
ID	15.7096	18.36	-0.0124
II	23.0996	6.75	-0.0052
CG	23.2780	9.62	-0.0027
AG	19.4091	15.74	-0.1555
RDECG	19.4091	23.80	0.0279
INTRG	27.2936	13.96	-0.0064
CRG	12.1008	13.72	-0.0030
RDERG	26.4989	19.14	0.0071
M	61.2476	5.02	-0.0055
CP	247.3117	8.64	-0.0066
IP	84.5449	13.85	-0.0065
AP	69.5052	11.50	0.0082
GI	305.7616	7.86	-0.0060
PIB	300.1831	7.72	-0.0058
Y	270.2719	8.20	-0.0066
YD	207.4770	6.93	-0.0105

[1] $MSE = \dfrac{\sqrt{\sum_{i=1} (Y - Y)^2}}{n}$

[2] $RMSE = MSE/\bar{Y} \times 100$

[3] Deviation $= \overset{\Delta}{Y} - \bar{Y}/\bar{Y}$

Where: $\overset{\Delta}{Y}$ = Arithmetic mean of estimated values.

$\bar{Y}$ = Arithmetic mean of real values.

5. CONCLUSIONS AND PROSPECTS

As a result of the experience described above, we wish to state once again that the model given here is part of a larger scale program that the Central Bank of Nicaragua intends to develop further. The results obtained, viewed in the light of their forecasting errors, should be accepted as a first attempt at simulation and in no way as a definitive test of the validity of the model. The testing of the convergence and stability of the model has illustrated problem areas that require further improvement and, obviously, raise fresh needs for statistical information. Until now the predictive effort has been limited to the sample period; a further test of validity is short-term projection for

the purposes of economic policy, by no means an easy task in an economic system subject to great dynamic changes that it is difficult to summarize in a mathematical formulation. This effort will be followed up by further econometric research in the country, an effort that we hope will result in a more thorough understanding of our economy and its problems and of the best solutions to them.

NOTES

1. J. Nugent, *Economic Integration in Central America: Empirical Applications* (Baltimore: Johns Hopkins, 1975).

2. Instituto Centroamericano de Administración de Empresas—Centro de Asesoramiento, "Modelo Macroeconómico de Nicaragua," Doc. N° NI/PL-002 (Marzo: 1973).

3. Secretaría Permanente del Tratado General de Integración Económica Centroamericana, "El Desarrollo Integrado de Centroamérica en la Presente Década," IDB-INTAL. Volume 2, Evolution 1960-1970 and Outlook 1970-1980.

4. Nonetheless an attempt has been made to rationalize the difference in length of the lags between the developed and the developing countries. Thus it has been said that there is greater impulsiveness or less planning on the consumption side in the developing countries, while on the investment side although the lag in decisionmaking may be shorter, the implementation lag is greater than in the developed countries.

5. Excluding net payments to factor abroad and net transfers.

6. *Capacidad y Posibilidad del Banco Central para manejar la Oferta de Dinero: El caso de Nicaragua*, document presented by Dr. Roberto Incer Barquero, at the XVIII Meeting of Governors of Latin American Central Banks, Caracas, Venezuela, April 24, 1974. *Dificultades Inherentes a la Programación Monetaria*, XII Meeting of Governors of Central Banks of the American continent and XX Meeting of Governors of Latin American Central Banks, May 1975, Panama, Republic of Panama.

7. By error we are referring to the following expression:

$$MSE = \sqrt{\frac{\sum_{i=1}^{n} (\hat{Y} - Y)^2}{n}}$$

This expression is an indicator of the goodness of fit of the variable not as an individual unit but including the interdependence of the system.

8. A process of first-order autoregression was assumed so that if the error term of an equation is U_t, it is assumed that:

$$U_t = RHO\ (U_{t-1}) + e_t$$

9. The organization of this section largely follows I. Otani, and Y.C. Park, "A Monetary Model of the Korean Economy," International Monetary Fund, 1975. (Unpublished.) Moshin S. Khan and Délano P. Villaneuva, "A Simultaneous Model of the Interest Rate and Money Supply in the United States," International Monetary Fund, 1975. (Unpublished).

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