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Chapter 2

An Annual Macroeconometric Model for Chile, 1945–65

Changes in the international economic regime have substantial effects throughout the Chilean economy. Foreign-sector policies interact in complex ways with fiscal, monetary, and income policies. Prices are the most important transmittal mechanism, but the magnitudes of available physical quantities also have direct impact on other real variables in the system; the underlying structure is not linear; responses are not homogeneous across sectors;[1] since feedbacks often are quite important, partial-equilibrium analysis may be misleading.

Given these conditions, a general-equilibrium macroeconometric model is the most appropriate tool for analyzing their aggregate effects.[2] I have prepared an annual econometric model containing 172 endogenous variables estimated for the 1945–65 period. Because it is referred to frequently in the subsequent text—in particular, it is used extensively in parts III and IV to explore the implications of foreign-sector changes for factors that are of major concern to macroeconomic policymakers—a brief description of the model is provided in section 2.1, below. Some of the components of the model are presented and discussed below in Part III; a complete presentation and examination of the model is contained in Behrman [1974].

For the purposes of the present study, the model includes a number of desirable features: (i) nonlinear technological and behavioral responses of real quantitative variables to prices and policies;[3] (ii) lags in adjustments and in the formation of expectations; (iii) a wide range of government policy instruments and the interactions among them; (iv) emphasis on the direct and indirect consequences of changes in the foreign sector;[4] (v) adding-up constraints on fiscal and monetary behavior; (vi) disaggregation to the nine-sector

level[5] to reflect sectoral heterogeneities; and (vii) inclusion of intermediate demands and intermediate prices, based on input-output tables, to link the sectors; and (viii) simultaneous and lagged feedbacks.

2.1 STRUCTURE OF THE MODEL

The model has its roots in the Keynes-Tinbergen-Klein tradition. However, it is distinguished from that tradition by the following modifications in order better to reflect the structure and goals of the Chilean economy:

i. Sectoral production capacities are determined within the model by physical investment and labor allocation decisions and by secular technological trends.[6] The implications of a set of policies for long-run growth thus can be investigated by examining changes in these capacities.

ii. Short-run output is *not* determined by final demand. Instead, sectoral capacity utilization decisions determine real production in response to prices of products relative to inputs (adjusted for the impact of fiscal policies), import and credit availabilities, and total demands. The difference between total production and (noninventory) final demand determines the change in inventories, which feeds back on short-run capacity utilization and balance-of-payments functions and on long-run decisions on capacity creation.

iii. The agricultural and services sectors absorb residual labor.

iv. The foreign sector is pervasive in its effects—not only through current prices and quantities, but also through expectations.

v. The impact of inflation and of inflationary expectations also is very widespread because of the experience of very rapid price changes (e.g., an average annual increase of over 30 per cent in the GDP deflator for the sample period).

vi. Substitution between domestic and foreign savings is incorporated.[7] Increases in the command over foreign resources, therefore, go in part to increased current consumption.

vii. The specification of policies reflects the specific institutional constraints under which the government operates. Money supply basically responds passively to government deficits and changes in international reserves because of legal requirements to accept government debt and the lack of a developed open market. The effective internal monetary instruments are limited to average and marginal reserve rates, rediscount rates, bank interest rates, restrictions in the use of dollar bonds and deposits, credit ceilings, and institutional changes such as the creation of the State Bank (Banco de Estado) in 1953. Tax revenues from a given activity depend not only on the level of that activity and legal tax rates, but also on the degree of inflation and expectations thereof. Government consumption is primarily endogenous because the short-

run latitude of the government is limited given the annual legal determination of its wage structure. Government expenditure policy, therefore, operates primarily through changes in public direct and indirect investment. Foreign-sector policies include a multitude of both price-related and quantity-based tools.

These seven features and the previous comments give much of the flavor of the model. However, some further detail is useful.

2.1.1 Policy Variables.

The model includes the primary macroeconomic policy tools which the Chilean government used with a substantial degree of discretion in the sample period. In the long run, of course, not all of these instruments are independent.[8]

FISCAL POLICIES.

Revenue instruments include legal tax rates or their proxies for eleven tax categories,[9] import prior-deposit rates, and the legal cost of production for large-scale mining. The last of these determines how many dollars the large-scale mining companies have to convert into escudos for local expenditures at a generally disadvantageous NER. The profits from the resale of those dollars at a higher rate go to the government.

Expenditure instruments include domestic or export subsidies, current government consumption (but see the discussion of the seventh point above), and direct and indirect public financial investment.

INTERNAL MONETARY POLICIES.

The monetary base changes mainly because of internally financed government deficits and changes in international reserves. The Central Bank shapes the impact of changes in the monetary base on the monetary supply by its determination of the marginal and average reserve requirements for time and demand deposits, the rediscount rate, the bank interest rate, quantitative restrictions on total credit, and the requirements for dollar deposits. The nominal money supply is determined by these factors, together with behavioral relationships for the net free reserves held by the commercial banks and for the composition of assets held by the private sector. These behavioral relations depend upon expectations concerning inflation and devaluation, interest rates, and the relevant activity variables, i.e., the level of deposits for bank reserves and the level of product for privately held assets.

INCOME POLICIES.

The minimum wage (*sueldo vital*) is the major direct tool in this area, but obviously, many other policies, such as those on taxes, also affect income distribution.

FOREIGN-SECTOR POLICIES.

The price-related tools included in the model are the average ad-valorem-equivalent nominal tariff rate, which incorporates all the taxes and exemptions discussed in section 4.1, the import prior-deposit cost rate, a subsidy rate for nontraditional exports, three legal NERs (one for large-scale mining, another for services, and a third for other transactions),[10] and copper price and surtax policies. Among the last are included the establishment of the Chilean sales monopoly in 1952–54; the introduction of the Chilean producers' price in 1964; and the imposition of surtaxes in 1951 (see section 4.2.1).

Quantitative policies in the foreign sector are represented by the Ffrench-Davis quantitative restrictions index (line 1.2.6.2 in Table A.1), ratios of aggregate internal prices to EERs,[11] variables which relate to the short-run availability of foreign exchange (such as the export capacity to import and the net foreign-exchange reserves of the banking system), the legal cost of production in large-scale mining, and dummy variables for a number of particular policy changes which are discussed in Part II below.

In Chapter 1, I suggested that major changes in foreign-sector policy instruments generally have been implemented only as part of an over-all economic program with an internal focus. Between initiations of such programs, large numbers of smaller often ad hoc adjustments have been made in order to offset some of the negative effects explored in Part III below. Although there is some latitude for independent choice about international economic policies in the short run, therefore, the ranges of alternatives are narrow. On the whole, such policies have had more of a passive than an active nature.

2.1.2 Model Relationships.

For the most part, the model consists of a set of relationships for each of the nine sectors indicated above. In some cases, however, the lack of necessary data precludes estimation on the same level of disaggregation in all cases.[12]

The *sectoral capacity for real GDP production*[13] is determined by a CES production function of the secular sectoral labor force and of the sectoral capital stock. The function incorporates constant returns to scale and Hicks's neutral technological change. The use of the secular sectoral labor force and of total capital stock makes possible the representation of production capacity instead of production. The estimated sectoral elasticities of substitution between capital and labor are significantly nonzero and substantial in some important sectors, namely, agriculture, 0.31; mining, 0.51; industry, 0.76; utilities, 0.32; and government, 0.89 (see Behrman [1972a] for a detailed discussion).

The *sectoral secular labor allocation*[14] is based on long-run adjustment, assuming competitive conditions, in the expected ratio of the price of labor,

including employers' social security taxes, to the product price. Agriculture and services absorb any excess labor, given the exogenous total supply.[15]

Sectoral real physical capital investment consists of responses to replacement needs, changes in the desired stock of capital, availability of government financial investment, and availability of imported machinery and equipment. The desired stock of capital, in turn, depends on a neoclassical term, expected utilization rates, and price uncertainty (for detailed discussion of these determinants, see subsection 12.2.3.1).

Sectoral capacity utilization rates determine real sectoral GDP for a given sectoral capacity. Domestic determinants of utilization rates include ratios of product prices to input prices after adjustments for taxes, indices of the change in current economic activity, the relative availability of credit, natural conditions (e.g., the level of rainfall and the impact of earthquakes), the state of infrastructure development, the average indirect tax and subsidy rates, the rate of inflation, the real value of monetary balances, and a number of sector-specific factors. Foreign determinants include the ratios of intermediate goods imports to total domestic product and of competing imports to product; quantitative restrictions indices; and sector-specific factors. Section 9.2 contains further discussion of these relations. Because sector-specific data on unemployment fluctuations for the sample period are lacking, sectoral capacity utilization rates are used instead.

The *sectoral product price* reflects general and sector-specific factors both of domestic and of international origin. General domestic factors include the monetary supply, real GDP, indices of economic activity, indices of sectoral and factoral distribution, and dummy variables for the initiation of stabilization programs. Sector-specific domestic factors include several measures of sectoral capacity utilization, sectoral intermediate input prices, sectoral unit labor costs (including the employers' social security tax contribution), and average real sectoral labor productivity. General foreign-sector determinants include the NER, the deflator for imports, indices of quantitative restrictions, and prior-deposit requirements on imports (which, when increased, absorb banking system credit and reduce inflationary pressures). Sector-specific international factors include the ratio of the premium-inclusive EERs for sectoral intermediate inputs to the general NER, EERs for sectoral imports or exports, and the level of sectoral imports relative to domestic absorption. For estimates and comment, see subsection 9.1.3.

The *sectoral intermediate input price* is the price the sector must pay for domestic and imported intermediate inputs. This price is a weighted average of all sectoral product prices and of imported intermediate goods prices. The weights are based on aggregation from the 1962 input-output table in ODEPLAN [1970].[16]

The *sectoral wage* primarily reflects domestic considerations: sectoral

nominal and real average labor productivities, sectoral capacity per laborer, sectoral unionization, indices of sector-specific or general economic activity, employers' social security contribution rate, the institution and timing of minimum wages, and expectations for leading prices (and the Harberger [1963] "accelerator" variant). The international economic regime directly enters only through the expectational impact of legal and black-market NERs.

The *price for sectoral investment* is a weighted average of sectoral product prices and of imported machinery and equipment prices. The weights are the average of the 1960–66 estimates of the sectoral origin of sectoral investments by Meza [1967].

The *deflators for final demand components* are weighted averages of sectoral product prices and of relevant EERs, with an adjustment in the latter for the effects of quantitative restrictions.

Sectoral real exports are determined for the following breakdown (the relative percentage share in exports over the sample period is given in parentheses): agriculture (8), large-scale mining (62), small- and medium-scale mining (11), industry (7), and services (11). Export determinants can be divided into three groups: (i) Levels and standard deviations of relative prices (i.e., EERs relative to factor input costs or PLD-EERs); (ii) quantitative supply factors, including the effects of quantitative restrictions; and (iii) quantitative demand considerations reflecting the level of activity in the destination countries. See section 7.2 for the estimates and their interpretation.

Real imports are included for the following categories (the relative percentage share in imports over the sample period is given in parentheses): services (12), staple consumption goods (19), durable consumption goods (6), secondary consumption goods (3), machinery and equipment investment goods (18), transportation equipment investment goods (10), and intermediate goods (32). In the model, real imports depend on relative price characteristics, other demand characteristics, and the degree of policy restrictiveness. The relative prices are the levels and standard deviations (as a proxy for uncertainty) of PLD-EER(PI)s, PLD-EERs, and PLD-NERs. The other demand characteristics include a relevant activity index (e.g., real consumption in the consumption goods import relations), total real credit, and direct and proxy measures of domestic inventories and income distribution. The degree of policy restrictiveness is represented by the Ffrench-Davis quantitative restrictions index, the export capacity to import, the net foreign exchange reserves held by the banking system relative to the unit value of imports, and dummy variables to represent such events as the operation of the Public Law 480 food program. Section 6.2 contains a discussion of the underlying estimates.

Real domestic savings relationships are included for the government, business, and households and nonprofit institutions. Real savings depend on the relevant real net revenue variable (e.g., real disposable income for households)

and real foreign savings. In addition, private real savings respond to the level of real monetary balances, the means and standard deviations for expected inflation and exchange rate movements, and the sectoral and factoral distributions of income. (See subsection 12.2.3.2 for further discussion.)

Factoral income distribution depends on the relationships, mentioned above, for production (or capacity utilization), labor allocation, product price, and wages. Given the values calculated from these relationships and given government policies, especially on taxation, nonwage income can be calculated as a residual.

2.2 SIMULATION PROCEDURE

In parts III and IV extensive use is made of the Chilean macroeconometric model to simulate the general-equilibrium impact of changes in the foreign sector. Eight characteristics of the simulation procedure are especially important:

i. The structure of the model outlined in the previous subsection is assumed to be the true structure of the Chilean economy in the periods to which these simulations are applied. If biases exist in the estimated coefficients, such biases have an impact on the simulation results. Sensitivity analysis, of course, can be utilized to explore the effect of any such expected biases in specific parameter values or in particular relations in the model. Nevertheless, some possibly very important phenomena—such as changes in psychological and political attitudes or the effects of Krueger [1974] competitive rent-seeking—are not well incorporated into the model.[17]

ii. The simulations presented in this study are all nonstochastic.[18]

iii. All the simulations are dynamic in that in the nth simulation period, simulated lagged endogenous values from the first $n-1$ simulation periods are used instead of actual lagged endogenous values. This procedure permits the tracing out of the time path of the responses to a given change.

iv. For each simulation only an explicitly indicated alteration in foreign-sector policies or foreign-sector conditions is explored. All other variables and parameters, including internal policy instruments, are fixed at their base simulation values in order not to confuse the impact of the foreign-sector changes with that of other changes.[19]

v. Because the model is nonlinear, it cannot be solved by simple matrix inversion. Instead, a two-step Gauss-Seidel iterative procedure is utilized (with the two steps referring to iterations back and forth between the real and the monetary sectors, both of which also are solved iteratively).

vi. In each simulation, unless otherwise noted, the indicated foreign-sector changes are maintained not for a number of years, but for the initial year

only. The results therefore give the time pattern of response to such once-and-for-all shocks.

vii. In most cases the important consequences of a particular foreign-sector change occur within three or four years. Therefore, Table A.11 includes the results for the first and the third year after the designated change. These two years are presented in order to include the short- and medium-term effects of the indicated change without the voluminous presentations which would be required if the year-by-year effects for a longer period were included. In the few cases in which two-year cycles or effects after the third year are important, such features are noted explicitly in Part III, below.

viii. In Part III, a chapter each is devoted to examining the effects of foreign-sector changes on each of five major macro policy areas. However, the reader should realize that for each foreign-sector change real trade-offs exist. The consequences are positive in at least one area and also are negative in at least one other area. No particular change is uniformly beneficial.[20]

The results of a number of simulations of the impact of foreign-sector changes are presented in Table A.11. To summarize the simulations, ex-post general-equilibrium elasticities are given for responses to the change indicated in the column headings for the first and third years.[21] Elasticities are presented in order to have a measure of the responses independent of the particular units in which the underlying data are reported. For variables which are defined to be differences between flows (e.g., savings, net reserves, and deficits), however, the implied elasticities may be very high because of the small absolute value of the base difference relative to the magnitudes of the two underlying flows.[22]

Elasticities are included for variables associated with each of the five major policy areas to be discussed in Part III: (i) balance-of-payments factors, i.e., exports and their major components, imports and their major components, and other related variables; (ii) real and nominal cyclical fluctuations in capacity utilization, price levels, monetary supply, monetary base, government deficit, and net foreign reserves; (iii) resource allocation among the major goods-producing sectors and measures of goods sectors versus service sectors, i.e., product prices relative to intermediate prices, the secular labor force, and capital distributions, and distributions of capacity and of real product; (iv) distribution of income and of control over resources (factoral, international, intertemporal, and public versus private); and (v) economic growth in product, capacity, savings, and investment.

The elasticities are calculated from deviations from a base simulation which is identical to the other simulations except as is indicated in the column headings. The first two columns of Table A.11 contain proportional deviations from the actual values for 1962 and 1964, the first and third year of this base

simulation. The proportional deviations are fairly large for some of the variables that are defined as differences between two flows and for some of the disaggregated variables.[23] In general, however, these deviations are small enough so that one can proceed to use the model with considerable confidence. For a dynamic simulation covering 1962–68, root mean square errors computed for some of the major aggregate variables indicate that the model seems to duplicate the Chilean experience of the 1960s rather well. For a thorough exploration of the properties of the model, see Behrman [1974].

NOTES

1. For econometric evidence of the sectoral heterogeneity in responses, see Behrman [1972c].

2. Several other quite competent general-equilibrium analyses of impacts of changes in Chilean international economic policies are available. Linear programming models are used by Cabezón [1969], Clark [1970], and Foxley [1971]. Black [1971] and Taylor and Black [1973] use a log-linear, Johansen-type model. For the purposes of the present investigation, however, these models have definite inadequacies. The linear programming studies assume zero elasticities of factor substitution and proceed with the maximization of a global objective function which leads to the exploration of the question "what *could* happen if socially optimal readjustment of the economy occurred in response to policy changes," rather than "what *would* happen if independent economic units which make up the economy followed their traditional behavioral patterns in response to such changes." The Taylor-Black approach includes only one primary factor (labor), does not require consistency in the final demand and factor payments sides of the national accounts (i.e., relations linking factor payments, savings, and consumption are not included), and assumes short-run perfectly competitive behavior on the production side. More important, the usefulness of both types of approach in exploring the short- and medium-term impact of policy changes is very limited because immediate adjustments are assumed, the government policy tools incorporated in the analysis are few, and the entire fiscal-monetary-incomes-international policy-inflation nexus is ignored. Given the dominance of adjustment and cyclical problems in the Chilean economy, the intimate relations between major changes in domestic and foreign-sector policies, and the repeated failure of reforms of the international economic regime because of internal cyclical problems (see Chapter 13, below), such deficiencies are very important.

3. Table 5.3 and the tables in Appendix A provide the basis for analyzing the effects of the foreign-sector regime on prices, costs, and value added. What is of fundamental interest, however, is the response of real quantities (e.g., capacity, capacity utilization, imports, exports, and other final-demand components) to those price-related variables.

4. The indirect effects, especially those transmitted through the monetary and price system, are very large in some cases. See Part III, below for examples.

5. The sectors and their respective mean percentage shares in GDP and in the labor force in the sample period are agriculture, 13, 31; mining, 7, 5; construction, 2, 6; industry, 20, 19; transportation, 7, 5; utilities, 1, 1; housing, 7, 0; government, 8, 8; and other services, 35, 35.

6. Attempts to incorporate the effects of changing human capital on the basis of estimates by Harberger and Selowsky [1966] were not fruitful.

7. Rahman [1967], Griffin and Enos [1970], and Weisskopf [1972], among others, have emphasized the importance of such substitution. For a counterview, see Papanek [1972, 1973].

8. For example, long-run exchange rate and exchange control policies must be coordinated with internal fiscal and monetary policies because of effective limits on foreign debt accumulation. In the short run, however, there is a greater degree of independence among such policies.

9. The tax categories are employer social security contributions, with a mean percentage share in total taxes of 19 for the sample period; employee social security contributions, 17; direct personal income taxes, 6; direct taxes on large-scale mining, 9; direct taxes on other businesses, 6; sales taxes, 7; import taxes, 12; production taxes, 8; legal taxes, 3; service taxes, 6; and other taxes, 6.

10. The black-market NER also is included in the model, in part to represent the impact of quantitative restrictions (see the equation in note c to Table A.7).

11. This ratio differs from 1.0 whenever the import premium rate is nonzero, but this may occur because of adjustment lags rather than effective quantitative restrictions (see note to line 1.1.6 in Table A.1).

12. The estimation technique primarily used for these relationships is ordinary least squares, although in some cases nonlinear maximum likelihood procedures are utilized for autocorrelated structures or nonlinear functions. The expected returns on the use of more sophisticated methods are less than the expected costs of doing so given the nature of the data, some questions about the robustness of alternative estimators, and the opportunity costs of sophistication in estimation procedure in terms of exploring various model structures. Annual data are utilized for the following reasons: much of the data, especially the national accounts data, are available only on an annual basis; the relevant responses are those of more than very transitory impact such as might dominate with shorter observation periods; and strong seasonal patterns exist owing to the timing of agricultural production and of annual wage (and related price) readjustments. The 1945–65 period is used because a consistent set of national accounts is lacking before 1940 and after 1965. In addition, the existence both of lagged responses and of a possibly altered structure for the Second World War years suggests the necessity or wisdom, or both, of dropping the 1940–44 observations. Finally, the switch to the Brussels nomenclature associated with the adoption of the new tariff law at the start of 1967 also was associated with a widespread reclassification of all international trade data; as a result series consistent with earlier definitions are in many cases not available after 1966. Of course, some of the estimated functions can be utilized to comment on the implications of the policies adopted in the postsample period (such as the sliding-peg NER and the export subsidies under the Frei administration discussed in Chapters 3, 4, and 7). All the estimates and more detailed comment are given in Behrman [1974].

13. Capacity is defined by the trend-through-the-peaks method. For discussions of the strengths and weaknesses of this approach, see Behrman [1973b] and the references given there.

14. Data on the allocation of the secular labor force are based on interpolations between observations in census years. Such series are useful for determining long-run capacity trends, but do not reflect short-run employment fluctuations.

15. Lewis [1954] is the seminal article about the implications of such a role for traditional sectors in many developing economies. In this connection, the Instituto de Economía [1963:6] places particular emphasis on the role of the services sector in the Chilean experience.

16. The lower the elasticities of substitution among intermediate inputs and between

intermediate and primary inputs, the more satisfactory are these weights. Theil and Tilanus [1966] and Balassa, Guisinger, and Schydlowsky [1970] claim that the available empirical evidence reveals very low substitutibility on an aggregate level between intermediate and primary factors.

17. For example the psychological and political impact of the nationalization of copper or of participating in a possibly unique experiment in the democratic transformation to socialism are very difficult to incorporate. However, the model can be used to give some insights about such effects. To the extent that psychological and political attitudes are related to collective consumption which should enter into the social maximand, the model can be used to explore the trade-offs (if any) between such collective consumption variables and other variables in the objective function. To the extent that these attitudes affect parameters such as those related to labor productivities, moreover, those parameters can be changed appropriately, although the direction of change is not obvious since the increased real income resulting from the collective consumption good may be associated with reduced labor productivity but the increased pride of the workers may result in an increase in productivity.

18. Young [1972] presents an interesting exploration of the impact on policy choices of including or excluding the stochastic aspects of a macroeconomic model.

19. Behrman [1974] uses the same basic model to explore the consequences of changes in internal policies.

20. Taylor [1973b] presents an interesting analysis, based in large part on the Chilean experience, of the difficulties in certain developing economies of pursuing stabilization, balance-of-payments, growth, and distributional objectives even when all of the available major policy instruments are manipulated simultaneously.

21. The elasticities are based on deviations of 0.01 in the relevant exogenous variable(s). Because of the nonlinearities in the model, the magnitudes of the elasticities might change with considerably different proportional deviations. The simulations in columns 2.1.1–2.1.3 of Table A.11 provide an example.

For some simulations, proportional deviations are given because elasticities cannot be defined. Such cases are indicated explicitly in the table.

22. The sign of the elasticity indicates whether the particular variable changes in the same (positive) or opposite (negative) *algebraic* direction as the exogenous variable(s) the value(s) of which is (are) altered for that simulation. If the level of the variable is negative (as is the case for some of the variables which are defined to be the difference between two flows), a positive elasticity implies that this variable increases algebraically (and decreases absolutely) in response to an increase in the exogenous variable(s) with which it is being compared.

23. For example, the deviation for the government deficit financed abroad (line 1.3.3) is large in the first year because the actual value of this variable for the base year was almost zero. As a result, small deviations for the underlying flows result in very large deviations relative to this small base.

Some of the deviations, moreover, reflect the particular time period selected for this base simulation. For example, the proportional deviation in industrial exports (line 1.1.3) is much larger in the 1962–64 period used for this base run than for earlier or subsequent periods because the underlying single-equation estimate for these exports has large residuals in these years. The simulations in Table A.11 can still indicate the responses in industrial exports within the context of the general-equilibrium model under the assumption that those residuals are not causally related to the changes under exploration.