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DYNAMIC INVESTMENT PLANNING WITH OPTIMAL END CONDITIONS:

THE CASE OF CHILE

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This paper is to be presented to the Annual Meeting of the European Econometric Society in Budapest, Hungary, 5 September 1972. The authors are respectively, Chief, Development Planning Division of the Development Research Center of the World Bank and Associate Professor of Economics at Harvard University. The models described here were developed when both were working at ODEPLAN (Chile's National Planning Agency) as part of a cooperative research agreement between MIT and ODEPLAN. The authors are grateful for the collaboration of Alejandro Foxley and Paul Ide in early versions of this study and for the assistance of Lucy Cardwell, John Katzen and Ruth Sheshinsky during the computation phase. The error and interpretations expressed are the responsibility of the authors above.

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[illegible]

1. Introduction

Multisectoral models have been used frequently in developing countries to check on the consistency of targets embodied in national development plans, but only occasionally have they been used to set them. In retrospect, this represents a waste of resources, since in principle programming models can take into account a wide range of alternative policy goals and illustrate the trade-offs among them. There are a number of technical problems in doing this successfully [discussed at length in Taylor (20)], but, nonetheless, the possibility remains. To date, it has been little exploited.

One exception to this generalization is provided by planning exercises carried out in the Chilean National Planning Office (ODEPLAN) in the late 1960's. In 1969, a Leontief system was used to predict feasible production, investment, and import levels for 1970. These projections served as a base year for studies designed to set development targets for 1975 and 1980. Initial sets of targets were calculated in optimizing linear programming (LP) models of the type described in section 2 below.[1/] After consultation with sector specialists and further evaluation of trade-offs in the programming models, revised alternative medium term projections for the next decade finally appeared in an official perspective policy study, ODEPLAN (18).

1/ The use of the models to consider alternative strategies for developing the Chilean economy during the 1970's is described in Clark and Foxley (8,9) and Foxley (12).

At the [illegible] were static, [illegible] it was thought [illegible] without [illegible] by ODEPLAN [illegible] to solve and very difficult to debug [illegible].[2/]

[illegible] to this problem in two ways. The first was to disaggregate the static LP models to take into account [illegible], initial capacity restrictions, the government [illegible], the differential impact of import tariffs, etc. This [illegible] the number of policy instruments and resource restrictions included in the model and increased substantially the dimension of the transformation surface representing the production possibility set for Chile. This [illegible] feasible corner solutions and made the models as representative as possible of the economy within their two-year horizon. The other response was to develop a multi-period simulation model of the type originally used in India by Ferberman and Manne (3), to try to give a partial dynamic check on the planning targets set for 1975. This paper is devoted to the history of the marriage between the revised LP planning model for Chile and the dynamic simulation model.

The key problem with all static models is their lack of a convincing investment theory. Typically, their investment demands are determined

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2/ The static model did include an interplan marginal savings constraint, labor force [illegible] constraint, and a capacity augmentation constraint which limited the target year net investment by means of a lagged stock-flow conversion factor. [illegible] more complex than the standard Leontief system but [illegible], as explained below, to assure intertemporal consistency.

3/ A description of the [illegible] model appears in ODEPLAN (19). A similar specification is still being [illegible] by the authors and will be discussed fully in Behrman, Clark and Taylor (2).

by specifying rates of sectoral output growth beyond the plan year, or by using sectoral "stock-flow conversion factor" coefficients [illegible] the share of plan year investment to total investment required in each sector between the base and plan year.[1/] The stock-flow conversion factor for sector i is calculated by assuming some rate of growth of output between the base and plan years. The model solution gives another forecast of this growth rate, which will usually differ from the assumed one. Iteration could presumably close the gap between these two sets of sectoral growth rates, although we know of no proof of convergence of such a process. In the model for Chile, iteration on growth rates to close the gap was sometimes successful, sometimes not. Moreover, we could find no way to forecast when the iteration procedure would work because of the dynamic behavior of the marginal savings constraint.

The simulation model can overcome these difficulties since it embodies a consistent, accelerator-based theory of investment similar to the dynamic LP model. It also provides a means for testing the dynamic effects of different anticipated investment programs which can be derived exogenously from project analyses or sectoral expansion plans. On the other

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1/ In formal terms, the growth rate specification in a model with one-year investment gestation lags amounts to saying that sector j net investment by destination in the plan year t_f, $N_j(t_f)$, is determined by the relationship

$$N_j(t_f) = b_j r_j X_j(t_f) \qquad j = 1, 2, \ldots, n \quad (1.1)$$

where b_j is the sector's capital-output ratio, r_j is its assumed rate of growth between years t_f and t_f+1, $X_j(t_f)$ is its output level, and n is the number of sectors. The stock-flow method, [due in its most commonly used form to Manne (17)], sets

$$N_j(t_f) = k_j b_j [X_j(t_f) - X_j(0)] \qquad j = 1, 2, \ldots, n \quad (1.2)$$

where $X_j(0)$ is sector i output in the base year, and k_j is the stock-flow conversion factor.

hand, because we use the [illegible] models [illegible] targets ([illegible] conditions) for the [illegible] broad [illegible] for static consistency and efficiency [illegible] to help [illegible] population [illegible] criterion [illegible]

[illegible] documents are formed of three [illegible] (a) the definition of social goals through time, (b) the [illegible] patterns of output, [illegible] consistent with the attainment of [illegible], and (c) [illegible] of policy prescriptions designed to induce the [illegible] to realize these paths planned through time. Few planning [illegible] considered as models of a plan since [illegible] to be attached to the social goals nor simulate the set of policy changes required to assure the [illegible] attainment of predicted values.[1/] In this study we utilize static LP models to set targets since LP models are well suited to include large numbers of overlapping and alternative policy functions. However, to extend the static LP enriched by detailed policy configurations into the dynamic world of intertemporal planning using constrained multi-period LP systems, raises serious computational, stability, control and interpretational problems. We shall argue in this paper that the benefits of substituting a simulation model for a dynamic LP model greatly exceed the sacrifice of intertemporal optimization.

1/ Notable [illegible] development of planning technique is the work of the [illegible] [illegible] out the [illegible] and [illegible] the [illegible] with [illegible]

The simulation model does not constrain primary factor supplies. Nevertheless, projections of [illegible] change require [illegible] ODEPLAN's [illegible] projections of the expected availability for these resources. Some of these results are discussed in [illegible] following descriptions of each model's specifications. [illegible] experimental. We report them as an illustration of how we think a [illegible] should make use of the model to [illegible] various tests of the [illegible] consistency of the plans for the economy. We want to stress, though, that it is the overall quality of the interplan projections which justifies our description of the marriage of a simulation model and a static LP model as a computationally improved substitute for a dynamic LP model in the first place.

2. The Static Linear Programming Model

The central consistency requirement of any multisector system is that total supply, domestic production (X_i) plus CIF imports (M_i) valued in domestic currency and prices (d_i), must exceed or equal total demand. The latter is comprised of intermediate demand ($\sum_j a_{ij}X_j$), personal consumption (C_i), government consumption ($\bar{G}_i$), net investment by origin (N_i), replacement investment (R_i), inventory change (ΔS_i), exports (E_i), and the commercialization and distribution of imports charged as a demand for services and commerce (Sector 15). 1/

$$X_i + d_i M_i \geq \sum_j a_{ij}X_j + C_i + \bar{G}_i + N_i + R_i + \Delta S_i + E_i + \sum_j d^M_{15,j} M_j \quad (2.1)$$

$$i = 15 \text{ only}$$

1/ To simplify the presentation of the static model, all notation of the [illegible] period has been omitted. All variables refer in this model to the [illegible] year, 1975.

Table 1 gives the values of the [illegible] which satisfy the demand and supply consistency constraint for the optimal solution.

The major resource constraints of the system ration foreign exchange, domestic savings, and labor divided into eight skill groups by educational attainment. Production for export is determined endogenously by the export activities, which permit marginal exports ($\Delta \ddot{E}_i$) and subsidized exports ($\ddot{Es}_i$) to expand above sectoral minimum levels ($\bar{E}_i$) up to their predetermined upper limit (upper bounds noted by " over variable).

$$E_i = \bar{E}_i + \Delta \ddot{E}_i + \ddot{Es}_i \qquad (2.2)$$

Imports CIF are divided into competitive ($\hat{M}_i$) and non-competitive ($\tilde{M}_i$) categories which are each rationed by separate sectoral commercialization and tariff rates according to use as supply activities for intermediate goods ($d_i^A Ma_i$), personal consumption ($d_i^C Mc_i$), government consumption ($d_i^G Mg_i$), and capital goods imports ($d_i^B Mb_i$). Non-competitive imports are specified in fixed proportion with each category of demand.

$$\tilde{M}_i = \sum_j \tilde{M}_{ij}^A X_j + \tilde{M}_i^C C_i + \tilde{M}_i^C \bar{G}_i + \tilde{M}_i^B (X_i + R_i) \qquad (2.3)$$

Total competitive imports ($\sum_i \hat{M}_i = V$) are limited by the balance of payments constraint which restricts the use of foreign exchange for competitive and non-competitive imports and net factor payments paid abroad ($\bar{Ie}$). Foreign exchange supply is limited by the supply of foreign exchange derived from exports plus exogenous foreign capital inflow ($\bar{F}$).

$$V + \sum_j \tilde{M}_j \quad \bar{Ie} \geq \sum_j \bar{E}_j + \sum_j \bar{G}_j + \sum_j f_j \Delta \ddot{E}_j + \sum_j d_j^E \ddot{Es}_j + \bar{F} \qquad (2.4)$$

TABLE 1: [illegible] AND [illegible] BALANCES

(Millions of 1965 Rupees)

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Note that marginal exports are linear functions which cause foreign exchange earnings to [illegible] less than proportionally with [illegible] production. This was found to be especially important in the case of copper expansion, Clark and Lindley (7). Conservative subsidized export promotion schemes have increasingly subsidized special export categories ($\hat{e}_j^E$ 1.0) to compensate for the long-term over-valuation of the Escudo.

The model is free within bounds ($\hat{m}_j^A$, $\hat{m}_j^B$, $\hat{m}_j^C$) to select the competitive import [illegible] depending on the domestic efficiency of import substitution. The foreign exchange available for total competitive imports (V) is shifted by the model away from historical proportions (v^A, v^B, v^C) and then distributed by use among different sectors. For example, in the case of capital goods, the amount of foreign exchange assigned by the model for competitive imports of investment goods is:

$$Vb \leq v^B V \tag{2.5}$$

where: $Va + Vb + Vc \leq V$

The capital imports account is then distributed among sectors according to a set of "quota" constraints.

$$\hat{\hat{m}}_j^B Vb \leq \hat{Mb}_j \leq \hat{m}_j^B Vb \tag{2.6}$$

$$\sum_j \hat{Mb}_j \leq Vb \tag{2.7}$$

As $\hat{m}_j^B \rightarrow 1.0$ and $\hat{\hat{m}}_j^B \rightarrow 0.0$, diverging from historical patterns or trends, the model is given freedom to abandon traditional patterns ("quotas") imposed by institutional non-price factors to select new competitive import patterns consistent with Chile's potential comparative advantage of the plan year 1[illegible].

We have described the international trade specification in some detail in order to illustrate the advantage of incorporating target choice in a consistency model. The linear programming system was utilized to examine the dynamic comparative cost international trade criteria where import tariffs, commercialization rates, export subsidies, and institutional quotas could all be varied parametrically to explore alternative export and import programs under different degrees of foreign exchange scarcity (i.e. $\overline{F}$, $\overline{E}_j$, f_j and $\overline{FE}$ were altered).

The model is also designed to include other choice and policy variables which will not be described in detail here. Domestic savings for the plan year are estimated by the model, being composed of household, business and government savings. Each type of saving is derived from endogenous income sources constrained by different marginal saving rates. The interplay of domestic and foreign savings is an important behavioral nexus to which we have paid considerable attention. The constraint system rations foreign exchange and domestic savings under different behavioral assumptions than the simulation model which computes the resource utilization ex ante. Similarly, the eight labor types are partially substitutable within each production activity over a range restricted by the initial disposition of these labor types together with their past and predicted relative productivities.

The specification of capital accumulation is the most problematic aspect of a static programming model. In order to avoid the crude stock-flow conversion factor specification, we have utilized the accelerator investment theory and investment gestation structure developed for our

dynamic models. This requires an interative procedure for solving the target model using the investment program derived by the simulation model. The linking of the two models is discussed following the description of the simulation model in the next section.

3. The Simulation Model

In broad outline, the simulation model's functioning can be broken down into two parts -- (a) determination of investment and other final demand levels over time, and (b) determination of sectoral supply and demand balances subject to the capacity constraints on sectoral output levels implicit in the cumulated investment levels.

Final demands are determined in two ways -- "by hand" (without reference to terminal conditions) and by interpolation between base year values and consistent plan year forecasts from the linear programming (LP) target model. Sectoral levels of exports and government expenditures are set by the first method, and consumption and investment levels by the second. The sectoral consumption demand forecasts are calculated on the assumption of constant geometric growth between the boundary years -- 1965 and 1975 in our Chile model. The initial investment forecasts which can be modified for some sectors to enhance their realism [1/] are based on geometrical interpolation of sectoral outputs between 1968 (the last year for which we have data) and the predicted 1975 target levels. These forecasts, which we inter-

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[1/] This flexibility in specifying investment plans was particularly useful in the copper sector (characterized by lumpy investments over time) for which investment expenditure schedules were already drawn up.

pret as equivalent to capacity growth, imply demands for investment goods according to the standard accelerator formula, modified to take into account gestation lags. In formal terms, net investment $N_i(t)$ originating from sector i in year t is given by:

$$N_i(t) = \sum_j B_{ij} \sum_{q=1}^{3} P_{ij}(q) k_j [X_j(t+q) - X_j(t)] \qquad i = 1,2\ldots,n \qquad (3.1)$$

where n = the number of sectors in the model;

B_{ij} = share of investment demand in sector j which is produced by sector i;

$P_{ij}(q)$ = share of sector j investment in year t + q which must come from sector i in year t; i.e. there are matrices P(1), P(2), P(3) giving breakdowns by sector and year of the origins of investment by destination in each sector--for a fuller description of such matrices see Bokaris and Parikh (11).

k_j = capital-output ratio in sector j;

$X_j(t + q)$ = capacity on stream in sector j in year t + q.

The increments in capacity $[X_j(t + q) - X_j(t)]$, cumulated over time, give absolute capacity levels $\bar{X}_j(t)$. Imposing these capacity restrictions in addition to the usual interindustry balances results in the following inequalities, which must be solved for sectoral outputs in each year:

$$X_i(t) + \hat{M}_i(t) + \check{M}_i(t) \geq \sum_j a_{ij} X_j(t) + D_i(t), \quad i = 1,2,\ldots,n \quad (3.2)$$

$$X_i(t) \leq \bar{X}_i(t) \qquad i = 1,2,\ldots,n \qquad (3.3)$$

$$\check{M}_i(t)[\bar{X}_i(t) - X_i(t)] = 0 \qquad i = 1,2,\ldots,n \qquad (3.4)$$

The notation is as before, with the additional variables where:

$M_i(t)$ = total competitive imports into sector i in year t (exogenously specified in domestic users' prices);

$\check{M}_i(t)$ = "equilibrating" imports (in domestic prices) into sector i in year t;

$D_i(t)$ = total final demand for sector i in year t.

The interpretation of this system is that sector demands (on the right side of (3.2) are met either by domestic supply $X_i(t)$ or "ordinary" competitive imports $\hat{M}_i(t)$ up to the point where capacity limits as imposed by 3.3 are binding. Thereafter, "equilibrating" imports $\check{M}_i(t)$ are allowed into the system (filling the supply short falls) until (3.2) is satisfied. The equality (3.4) is a complementary slackness condition, which has the effect of setting balancing imports to zero in an excess capacity situation.

Bergsman and Manne (3) call this type of model "almost consistent" because it does not deal adequately with capacity shortfalls in non-traded sectors. Quantities such as $\check{M}_i(t)$ can be calculated for non-traded sectors whose demands exceed potential supply, but it is evidently incorrect to call them "imports" -- they must be viewed as estimates of the amount of rationing, queing, etc., necessary to balance demand and supply for non-traded goods. This inconsistency could be a serious problem in modeling, although fortunately it was of small magnitude in our exercises.

We solve the system (3.2) - (3.4) by a simple iterative procedure, starting from the assumption that all sectors are producing at full capacity. These supposed output levels give sectoral total demand predictions from the right side of (3.2), which can be checked against potential supply--competitive imports plus capacity. Outputs for the sectors with excess potential supply are then calculated explicitly by solving an appropriate subset of equations (3.2). These new output predictions (together with capacity levels from the capacity shortfall sectors) then are used to generate new, lower total demand predictions from the right side of (3.2). If additional sectors have excess potential supply, an enlarged subset of equations (3.2) is solved for new output predictions. This procedure is repeated until all sectors with

potential excess supply are discovered and their outputs computed. The equilibrating imports $\check{M}_i(t)$ are set equal to zero for these sectors, and equal to the difference between total demands and capacity-plus-exogenous-competitive-imports for the other sectors.

In this fashion, accurate predictions of both sectoral outputs and balancing imports are achieved. Similar precision is lacking in the Bergsman-Manne model, since they only use equations like (3.2) to calculate imports, setting the output levels $X_i(t)$ on the right hand sides equal to $\bar{X}_i(t)$. This produces an obvious overestimate of the intermediate demands, and thus of equilibrating imports.[1/]

4. Joining the Two Models

Our procedure for linking the two models is as follows:

(i) First, solve the linear programming model for 1975 repeatedly to test the sensitivity of different targets, each time determining investment endogenously by stock-flow conversion factors. After selecting a consistent set of target projections for outputs, consumption, etc., we put the outputs (equals capacity) levels into the simulation model. These enter together with desired (hypothesized) post-plan growth rates of outputs in order to compute new estimates of sectoral net investment by origin $N_i(t_f)$ in 1975 using the accelerator specification. These estimates are close to, but not identical with, the $N_i(t_f)$ determined endogenously in the programming model.[2/]

1/ Although we devised our algorithm independently, it should be noted that a similar one was used about twenty years ago by Chenery, Clark, and Cao-Pinna (5) in a model to determine Italian trade patterns. Arrow (1) gave a formal description and proof of convergence of their algorithm. Both these efforts, however, had faded into oblivion by the time we started to design our [illegible] model.

2/ The discrepancy illustrates some of the difficulties in making congruent a consistent, dynamic investment theory like that of the simulation model and the ad hoc theories which must be imposed in a static programming exercise.

(ii) Since these new $K_i(t_f)$ are consistent with the investment theory of the simulation model, we must impose them as lower bound constraints on investment in a new solution of the LP target setting model. This solution also uses the previous simulation model's solution to impose output levels for the target year as upper bounds on "capacity" by sector.[1/] This solution then gives consistent, "optimal" trade and consumption patterns for the target year subject to the pre-specified investment and capacity levels.

(iii) The consumption and capacity levels projected for 1975 by the foregoing two-step procedure are used as the basis for the interpolations, described in section 2, used to calculate the simulation model's consumption and capacity levels in the inter-plan years. The proportion of competitive imports in each sector's supply in 1975 are also calculated and used to derive the $M_i(t)$ of (3.2) in the inter-plan years. In practice, we reduce these coefficients more or less brusquely (as described below) from their 1975 levels to allow the simulation model to compute minimal import bills.

(iv) Several variant simulation runs have been made, based on the data set whose calculation was just described. These are discussed in the following sections.

5. How the Simulation Model May Be Used

The strength of the simulation model is that it is cheap to run and flexible. The model permits detailed investigation of its results and various

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1/ Recall that these target year capacities are already consistent in both models but that the investment levels is below brought into consistency using the more realistic lagged accelerator specification to improve the credibility of the static LP model's solution. The adjustment must be made by altering the time pattern of inter-plan capacity creation and equilibrating imports which, if reasonable, is equivalent to adding some dynamic constraints to the static optimizing model.

forms of modification "by hand" to make consistent, but more "acceptable", plans. Before the analysis of any solution was undertaken, these capabilities were used to:

a. specify sectoral output growth patterns for the years 1965 to 1968, in line with pre-existing information, and

b. build in completely exogenously the growth of capacity in the copper sector (and, therefore, generate exogenously via the capital matrices the investment capacity required to support the growth of copper exports).

c. After an initial run of the model, investment programs in sectors 3 (mining other than copper) and 7 (basic metals) were also built in "by hand" because of what appeared to be excessively high capacity levels in these sectors in 1968.

Initial comparisons of the model's results with the national accounts (for those years overlapping the model, 1966 to 1970) revealed that the gross aggregates produced by the model and those found in the national accounts were relatively consistent, except for imports. Table 2 shows this comparison.

The low levels of imports called for by the model cast some doubt on the appropriateness of the import coefficients. The run of the simulation model does not have competitive import requirements similar to the specification explained above because we were attempting to give the model the maximum amount of freedom to determine supply. Hence, equilibrating imports fill the gap between total demand and non-competitive imports. The result is that non-competitive imports are almost exactly those found historically and in the target year. However, the model which is unconstrained by a saving constraint undertakes an ambitious investment program, as compared to historical values, which does not require the traditional amount of imports. The consequence is a higher growth rate of GDP in early years. We are currently

[illegible] National Accounts
([illegible])

		[illegible]	1967	[illegible]	1969	1970	1971	1972	1973	1974	1975
C	Actual	[illegible]	[illegible]	[illegible]	15232.0	16181.0					
	Model	[illegible]	[illegible]	[illegible]	[illegible]	16620.1	17606.3	18662.0	19792.7	21004.7	22304.6
C	Actual	[illegible]	[illegible]	[illegible]	2431.0	2606.0					
	Model	[illegible]	[illegible]	2110.7	2193.4	2378.2	2486.4	2556.5	2652.1	2749.6	3098.0
I	Actual	[illegible]	[illegible]	[illegible]	3313.0	3561.0					
	Model	3214.7	3114.6	3261.1	3715.9	4159.1	4169.8	4036.7	4134.3	4201.7	[illegible]
ΔS	Actual	[illegible]	191.0	204.0	417.0	143.0					
	Model	476.5	[illegible]	163.7	211.2	270.1	304.2	283.1	261.8	266.1	345.6
[illegible]	Actual	[illegible]	[illegible]	2875.0	3055.0	2905.0					
	Model	[illegible]	[illegible]	[illegible]	3093.0	3416.5	3587.6	4363.5	4625.0	4795.4	4865.2
-M	Actual	[illegible]	2912.0	3159.0	3533.0	3824.0					
	Model	[illegible]	[illegible]	[illegible]	[illegible]	3223.0	3420.0	3613.0	3925.4	4219.3	4967.0
GDP[2]	Actual	[illegible]	[illegible]	20241.0	[illegible]	21572.0					
	Model	[illegible]	[illegible]	21034.5	22220.2	23621.0	24734.4	26288.9	27540.6	28797.9	29979.0
ET[3]	Actual	548.0	332.0	452.0	909.0	984.0					
	Model	[illegible]	[illegible]	451.2	914.0	1443.0	1025.2	968.8	657.1	647.8	642.9
GDP[4]	Actual	[illegible]	[illegible]	[illegible]	21824.0	22556.0					
	Model	[illegible]	[illegible]	21485.6	23134.2	25063.7	25759.6	27257.7	28197.7	29445.7	30621.9

1. Exports in constant prices of 1965.
2. GDP in fixed prices.
3. The terms of trade effect due to rising world prices for copper exports.
4. GDP in variable prices.

checking in detail the implications of the import pattern given by the model's solution. If valid, the low imports and correspondingly high levels of national savings (which are defined as in the [illegible] of gross investment less the current account deficit of the balance of payments) suggest that the development plan implied by one solution of the model is insufficiently ambitious.

The two most appealing ways to alter the inter-plan behavior of the model could be (a) to raise investment levels during the plan period and (b) to permit consumption levels higher than those resulting from the interpolation between sectoral levels in 1965 and those in the terminal year targets. We have decided against raising the target for 1975 even though the simulation model results might imply that these targets do not stress the economy between 1965 and 1975[1/]. Although the simulation model makes rigid growth look feasible during the 10-year period [2/], we feel that the targets may not be overly ambitious for the Chilean economy today.

The path of the sectoral consumption variables was modified by adding a vector of incremental sectoral consumption increases to the original smoothed consumption vector. The sectoral consumption increments were kept in the same sectoral proportions as found in the base year 1965.[3/] The total increments of consumption which were added were calculated in

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1/ Later versions of the simulation model will be compared by the authors with the results of a 10-period dynamic LP model to see just how efficient are the programs which can be produced by simulation techniques.

2/ One author feels the high growth potential results from the excessively [illegible] specification of equilibrating imports as the only balancing item of supply. [illegible] omitting some form of competitive import functions or limits we simulate [illegible] trade world (i.e. omit all tariffs and non-price trade restrictions), [illegible] unlikely in Chile. See Clark (6) for further discussion of this point.

3/ Note that the consumption elasticities used in the specification of the target-setting LP model caused the sectoral proportions of the simulation to change over time. Of course, non-price [illegible] introduced to simulate policy changes such as adjustments in the distribution of consumable income.

such a way as to make the savings behavior roughly consistent with the national accounts for 1965 to 1970 and to give a marginal savings rate of approximately .15 in the remaining years up to 1975. The macro-economic aggregates for this revised simulation are shown in Table 3. The effects of this revision have reduced consumption, imports and GDP, while lowering savings somewhat and the marginal rate considerably.

We do not feel we have used the simulation model long enough to know all of the ways we might introduce modifications into the system. At this point we would suggest that the planner control the simulations by looking at the ex post marginal savings rates, the gap given by the current account of the balance of payments, and the excess capacities appearing in different sectors in each year. A special iterative algorithm has been built into the model which attempts to eliminate excess capacities by changing the timing of the investments which create sectoral capacity. In the results used here to illustrate the gross workings of the model, competitive import coefficients were set to zero in order to keep excess capacities at a minimum. Since capacity shortfalls are less when competitive imports are required, later runs may be forced to use the intertemporal shifting of excess capacities to keep them at a reasonable level.

An aspect of the simulation model which has not been discussed here is the richness of the sectoral results produced for each year. The story told by tracing these variables through time is exceedingly detailed and complex. This allows the planner to examine inexpensively the workings of a consistency model at a meaningful level of detail in order to analyze and define appropriate alternatives. Since any run of the model requires

but a few minutes of computer time, an enormous number of simulations can be produced at a very reasonable cost compared with the typical dynamic LP model. The system's flexibility permits rapid turn-around and turns the dydactic tool such as a dynamic LP into a learning tool for the planner. The Fortran program of the solution of systems and the easily processed data storage and retrieval system designed by Ide and Taylor (16) furnishes the planner with a very adaptable computation system.

6. Conclusion

This report describes the marriage of a static LP model, used to set the end conditions for the dynamic system, and a dynamic input-output planning model. The system simulates the production capacity and import requirements needed through time to attain the consistent and efficient goals set by the target LP model. The modeling system is recommended because of its computational advantages whenever a planner wishes to trace the sectoral effects of consistency conditions through time. The approach is also recommended because of its flexibility, which permits easy manipulation of parameters and multiple solutions at low cost.

The marriage of an optimizing model to set terminal year targets with the dynamic input-output system is mutually advantageous. A static LP model normally suffers from an unrealistic investment specification where sectoral capital stock requirements are converted into average investment flows by means of a stock-flow conversion factor. This paper explains how the more realistic accelerator specification including the gestational lags

of the simulation model has been used to estimate sectoral net investment demands for the target year. The simulation model gives an inexpensive tool to test the dynamic consistency of terminal year capital stocks with the endogenously determined program of capital accumulation programmed during the plan period which has previously been found only in dynamic LP models.

Moreover, the surface below a simulation model aim at some optimal targets. The usual criticism of simulation is that without a specified criterion function, it is impossible to evaluate the merits of one program over another. For example, how can one say that the intertemporal phasing of capital investments at one end of the planning period is preferred over another sequence? If excess capacities are to occur, when and in what sectors is it most efficient to permit them? The fact that this simulation model does not test out the dynamic implications of a set of randomly, and perhaps inconsistently, determined targets is uniquely important. Only efficient and dynamically consistent targets have been set by the static LP model.

We conclude by asserting (the paper does not include sufficient numbers on details of quantitative demonstrations to be convincing at this point) that the dynamic input-output framework with optimally chosen end conditions is as good a planning tool as will be found among multi-sectoral models. It simulates most of the dynamic aspects which can be found in intertemporal optimizing models without the tremendous expense and major difficulties which are associated with dynamic LP models. A few planners can put together the parameters of a static LP swiftly. The tests of the simulation model, coupled with reasoning based on general equilibrium principles, allow the planner to rapidly validate the system. The planning lessons to be learned by use of a dynamically consistent multi-

sectoral model can be learned with greater ease and no loss of accuracy using the dynamic input-output model.

No model produces a development plan. The model is a tool to simulate the consequences of alternative targets and alternative inter-temporal resource allocations. There is no assurance that a dynamic IO model will produce an optimal intertemporal investment plan. Therefore, it is better that the model be used as a flexible learning device permitting the planner to test out the full consequences of all the [illegible] investment programs he is likely to put forward to the policy [illegible] of his country. The simulation model easily absorbs non-linearities and [illegible] information. It has become a computationally efficient aid to the planner.

Table 3

Revised Results of Simulation Model Compared to Chilean National Accounts

(Millions of 1965 Escudos)

		1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
C	Actual	13935.0	14413.0	14[illegible]9.0	15[illegible].0	16181.0					
	Model	13659.1	14417.5	15197.0	1[illegible]25.4	1[illegible].4	17[illegible]0.3	18[illegible]5.6	[illegible]	21[illegible].1	2[illegible]4.6
G	Actual	2187.0	2186.0	2[illegible]6.0	2431.0	2[illegible]6.0					
	Model	2010.5	2[illegible]09.5	2110.7	2193.4	2378.2	2[illegible].4	2[illegible].5	[illegible].1	27[illegible].6	3[illegible].0
I	Actual	2[illegible]00.0	2[illegible]41.0	31[illegible].0	3313.0	3[illegible]1.0					
	Model	3214.7	3114.6	3[illegible]1.1	3715.9	4159.1	41[illegible].8	40[illegible].7	41[illegible].3	4[illegible]1.7	4[illegible].5
ΔS	Actual	542.0	191.0	204.0	417.0	143.0					
	Model	477.4	128.6	163.6	211.1	270.0	304.1	283.0	261.7	2[illegible].0	3[illegible].6
E[1]	Actual	2[illegible]2.0	2851.0	2[illegible].0	3055.0	2[illegible]5.0					
	Model	2786.4	2857.9	2926.9	3093.0	3416.5	3597.6	4363.5	46[illegible].0	47[illegible].4	4[illegible].2
-M	Actual	3005.0	2912.0	3159.0	3533.0	3824.0					
	Model	2377.6	2185.8	2449.0	2844.0	3344.3	3522.8	3695.2	3[illegible]2.1	4[illegible]3.4	5104.8
GEP[2]	Actual	19[illegible]21.0	19670.0	20[illegible]41.0	20[illegible]15.0	21572.0					
	Model	1[illegible]800.5	20344.3	21210.3	22394.4	23[illegible]07.7	24875.4	26400.2	27620.5	28[illegible].1	29[illegible]41.1

1 Exports in constant prices of 1965.

2 GEP in constant prices.

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