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Application of a Macro-Economic Demographic Simulation Model to Planning in Paraguay

by

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"The accelerating rate of change has telescoped the available lead-time between problem-identification and the solution deadline.... However frustrating our study of the future may seem -- it is infinitely better to try to influence the future favourably than to just let it happen to us by default."[2]

Planning as a tool in development is usually associated with macro studies designed to provide a guide for the short run (less than one year) or the longer period of 5-10 years.[3] A target is usually fixed for GNP growth and, if an input-output study is available, effects of policy alternatives can be evaluated a priori but this is restricted by the model's essentially static nature.[4] In an effort to achieve relevency, simulation models have been developed for entire economies, but these have the drawback that considerable effort and financial resources are required and the descriptive information is often lacking. An additional problem which arises is the sophistication required by the planners in utilizing the model and in revalidating it periodically.[5]

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The problems mentioned above are especially acute in small developing countries where the probability of having adequate funds and/or the trained personnel available are notably lacking.[6] Nevertheless, planning must take place and, to have any substance, it should provide for solutions in the short run to mitigate long run problems. The suggestion then is that future "bottlenecks" must be considered in an effort to shunt the car of development from a railbed based on reaction to crisis situations to a smooth one resting on anticipation of future exigencies. In addition an attempt should be made to foresee ramifications of continuing present trends. Furthermore, and perhaps more important, the future bottlenecks should be recognized not only in the direct planning horizon, but also in the long run (10-20 years) and even in the very long run (greater than 20 years). This paper is especially oriented toward these latter situations.

One technique which fits within these delineated constraints is the macroeconomic demographic simulation model known as ECO-POP. Because models of this type have been discussed elsewhere, a recapitulation will not be given at this juncture.[7] What will be discussed is how the particular model can be applied to planning in the small, lesser-developed country of Paraguay. The consequences of various population growth rates will be evaluated in light of its effect on a principal foreign exchange source, beef exports. The model will also be used to evaluate an almost universal conception in small countries with a small man/land ratio, that, because the population pressure is low, the development strategy to follow is one of increasing the population base in an effort to enlarge the size of the market. The purported benefit, according to proponents, is a greater market for domestic industrial and agricultural producers. The economic concept which is, unfortunately, neglected by many planners in these countries is the role of effective demand. This term means that no matter what the psychological need may be, the consumer or the country is no better off if the means of buying the food, in other words purchasing power, is not available.

The dilemma of development -- Paraguay and elsewhere

Paraguay is a small, agriculturally-oriented country (55% of the work force was employed in agriculture in 1950 and 58% in 1965) located in the center of South America.[8] It has an area of 157,067 square miles, about 2.6 million people, and a GNP per capita of about $230. As could be expected, there is a persistent balance of payments problem. Most of the exports are meat and meat byproducts (about 30-35% of the value of all exports), crop commodities (25-30%),

and forest products (20-30%).[9] Nearly all meat products are beef and are exported in canned form. Trade is essential to the promotion of well-being in small countries, yet, unfortunately, little progress has been made in freeing it in Paraguay from heavy taxes and import restrictions.[10] One significant reason has been the failure of the Latin American Free Trade Association (LAFTA) to achieve its goals of acting as a common market.[11]

Paraguay's situation is similiar to that of many developing countries where present population pressure is not excessive, where one or two commodities are depended upon for foreign exchange and where the level of technology is fairly low. The problem confronting these countries is how to proceed in the development process so that a "large enough" internal market can be reached, yet undertaking that change in such a manner that the balance of payments (and other attendant factors such as inflation, long term debt, etc.) are not jeopardized and, concomitantly, achieving an acceptable rate of growth in real per capita GNP.[12] The dilemma is that population growth is obviously needed to achieve the "desirable" market size, yet the faster that population grows the slower per capita income grows and, of course, the greater the pressure on natural resources to accomodate this burgeoning population.

Simulation Projections for Paraguay

Economic relationships for the period 1960-68 were simulated for Paraguay using the macro-economic demographic simulation model known as ECO-POP. This deterministic, non-feedback model is based on a Cobb-Douglass production function and utilizes only highly aggregated data. This feature is both its advantage and its weakness. Because it is highly aggregated only a minimal amount of input data is required thus making the model a useful tool where there are fund and personnel limitations. The drawback is that a number of micro relationships are obscured.

The model is linear in logarithms and can be constructed to yield increasing, decreasing or constant returns to scale. In this form, GNP is a function of the level of employed labor and capital available at the beginning of the time period. The productivity of labor and capital is increased by a specified amount each year to represent technological change. Fertility control affects GNP through changes in the size of the labor force and capital resulting from reduced consumption due to prevented births. Coupled with this is a single parametered population growth function which simply allows population to grow at some rate from one year to the next.

Because only three parameters-- technological change, the marginal propensity to consume, and population--were found to affect the model to any degree, and because the latter two are known with a high degree of certainty, the problem was simply one of parametrically changing the rate of technological change until annual GNP s similiar to a recent historical period were established. A model with a technological change rate of 0.8 per cent annually was found to give the best fit, having a correlation coefficient of0.997.[13]

Projections for 50 years were made using the same parameter values as in the historical period but with 3 different assumptions about the rate of population growth. A rate of 3.2% annually was observed for the later 1960's.

If this rate remained constant, population (as shown in Table 1), would increase nearly 5 times in 50 years. Real per capita GNP would only increase in that period by about 1% annually. Overall growth in real GNP would be about 4.2% annually however.

If a declining population growth rate, reaching zero in year 50 were assumed, population would just double, and overall growth in the economy would remain about constant for the first 30 years when the rate of growth would decline rapidly. Per capita growth rate in income continues to increase each year however.

A very real possibility is the population growth rate declining to 1% in year 25 and constant thereafter. In this situation the overall growth rates would be about the same as in the previous example, but per capita GNP would grow slightly faster up to year 30.

Two important uses of a macro-economic demographic simulation model will now be discussed. The first is for purposes of evaluating different strategies which relate to the parameters, one of the most sensitive being the marginal propensity to consume. Changing it from the assumed .90 to .80 causes GNP to be 18% higher in year 15 and 36% higher in year 50. The question is, however, by what means can the government accomplish this in a free society. Further computer runs indicated that changing the rate of unemployment does not have much effect on the base projections nor does changing the capital/GNP ratio from the assumed value of 2.86.

Probably the best possibility with respect to the model for increasing the rate of growth is augmenting technological change. In addition this is the most sensitive parameter. A reasonable, potentially possible rate of technological change for Paraguay based on studies in other countries is 1.5% annually.[14] When this disturbance term is introduced in the base run with a constant growth rate of 3.2%, both overall and per capita growth rate increases, on the average about 1% annually more than with the base technological rate of 0.8. While these results are not summarized in the tables included in the paper, it is worthy of notice that both per capita and overall GNP are about 50% larger in year 50 and about 13% larger in year 15 than under the assumption of a 0.8% rate. One of the most dramatic results of this change in assumptions is when population growth rate is assumed to decline to zero in year 50. Annual per capita GNP growth rate now exceeds 6% for the years 30 to 50. When it is assumed that the population growth rate decreases to 1% in year 25 and remains constant to year 50, the results are not nearly as impressive as under the previous assumption.

Overall, of the three population growth rates which are assumed and summarized in the tables, the best policy, from a strictly economic viewpoint, seems to be a growth rate declining to zero in year 50.[15] This rests primarily on the rapid change in per capita GNP. It should be noted in passing that while the absolute numbers apply only to Paraguay, the relative changes probably fit a number of the LDC's and punctuate the benefits from a declining population rate. We would suggest that the rapid increases in per capita GNP from a declining population rate as opposed to a constant one are ample indication that effective demand will not increase unless population grows at a declining rate.[16]

The beef sector -- A "bottleneck" identified

A second use of macro-economic demographic simulation models is in evaluating the ramifications of target plans and, perhaps more importantly, as a tool for identifying future bottlenecks or problem areas. As an example, a discussion about the Paraguayan beef sector concentrating both on the supply and demand side will now be presented. For the period 1960-1970, production of beef and veal increased about 0.5% annually. Concomitantly, domestic consumption varied between 2/3 and 3/4 of production with per capita consumption fluctuating between 35 and 45 kilos

Table 2 shows the effect of various population growth rates on the availability of beef for export. Production has been assumed to continue increasing at 0.5% annually. It is recognized that the rate of production could increase to some degree if prices remained higher for an extended period or if there were a massive, sustained government program. Nevertheless, because the livestock industry is based on extensive rather than intense practice, and given the deeply ingrained traditionalism of ranchers, it is questionable if a substantial increase is possible in the foreseeable future.[17]

Assumptions about per capita consumption are particularly brave, resting on an estimation of future government policy. Given that neighboring Argentina has a fairly long record of beefless weeks (weeks when no beef can be sold in markets or resturants), that Uruguay is now in a long-term period when no beef can be sold for domestic consumption, plus other Latin American countries having a history of beefless days, it is most likely that restrictions of this nature would be expected in Paraguay in an effort to maintain present export levels as population growth exceeds production increase. Thus, the assumption about per capita consumption becomes a residual resting on the supposition about exports. As demonstrated in Table 2, a crisis situation can be seen to develop between year 20 and 30 if population grows at a constant 3.2% annually. By that time per capita consumption of beef will have fallen to what could be considered an unacceptable level and, at the same time, there is virtually no beef available for export. If, however, as also shown in the table, a declining population growth rate is assumed this crisis is either avoided or is mollified.

Earlier in this paper, it was noted that simulation is concerned with evaluating the effect of maintaining current trends. In Table 3, per capita consumption of beef is assumed to fall to the lowest level (35 kilos) experienced in the past 10 years and remain there. If this should happen and the population growth rate remains at 3.2% annually, a large deficit soon appears.

A planner would naturally like to know the effect of increasing beef production so that costs could be compared with benefits. If it is assumed that production increases at a rate of 1% annually rather than 0.5%, as shown in Table 3, exports can be maintained although per capita consumption must still fall to levels about equal to those where production was at 0.5%.[18] Additionally, if the population growth rate is assumed to decline to zero in year 50, by increasing production 1% annually current export levels can be maintained and per capita consumption declines moderately.

At first blush the copious quantity of "what if" assumptions appears to be a major drawback in the analysis about beef. Further reflection reveals,

however, that the more assumptions required, the greater number of policy alternatives available. In fact, simulation really should be looked upon as a "what if" model, as the purpose is not estimation or prediction but mechanical projections under various assumptions. Time constraints have prevented elaboration on other figures generated by the model such as return per worker, effect of per capita income, the stock of capital and demographic makeup of the population which would be included by the planner for greater realism in his evaluation of the future situation in the beef sector.

Overall, at least three important points have been brought out in this paper. First, a good measure of future effective demand is available by using this model. Second, a very bothersome parameter to calculate, the rate of technological change, may be estimated fairly well if only two other parameters, population growth rate and MPC, are known with some degree of certainty.[19] Third, one application to a specific problem, the beef sector, was discussed. Time limitations have not permitted discussions in the depth which these problems deserve. Nevertheless, in our estimation the flexibility, low cost, and remarkable simplicity in using macro-economic demographic simulation models of the type utilized in this paper do much to recommend them in the smaller developing countries where funds and trained technicians available for planning are limited.

FOOTNOTES

1. Special thanks go to Dr. Lonnie Jones and Mr. Vito Blomo, both of Texas A and M University for comments on earlier drafts. All responsibility for errors is , of course, our own.

2. Charles F. Jones, Dean College of Business Administration, University of Houston.

3. See: Hanson, Bent, (1967) Long and Short Term Planning in Underdeveloped Countries, (Amsterdam, North-Holland Publishing Company) p.41. It could be argued that the choice of terms "short run" (1 year) and "longer run" (5 to 10 years) as usually used in planning are, unfortunately, nebulous. For the rest of this paper, short run will refer to one year or less, intermediate run will be 2-10 years, long run for the period 11-20 years and the very long run as greater than 20 years.

4. Ibid., p.7.

5. Hayenga, M.L., et al (1968) "Computer Simulation as a Planning Tool in Developing Countries", Am. J. of Agr. Econ. 50:1755-1859, Dec. 1968.

6. Demas, William G., (1965) The Economics of Development in Small Countries (Montreal, McGill Univ. Press).

7. See Billingsley, Ray V. and James R. Simpson, (1973), "ECO-POP: A Macro-Economic Demographic Simulation Model to Evaluate Agricultural Development Policies for Developing Countries", unpublished paper, Texas A and M University, Jan. 1973).

8. For a more complete discussion on sociological and demographic factors see: Lederman, Esteban and Arnaldo Silvero, "La Planificacion de los Recursos Humanos en el Paraguay",(1968) Revista Paraguaya de Sociologia, 12:53-108, Aug. 1968.

9. Pincus, Joseph (1968), The Economy of Paraguay (New York, Praeger Publishers) p. 380 and 385.

10. Wiel, Thomas, A., et al (1972), Area Handbook for Paraguay,(Washington, U.S. Govt. Printing Office) p.226, gives a detailed description of the ramifications of these measures.

11. Sloan, John (1972), "LAFTA in the 1960's: Obstacles to Progress", International Development Review,14:16-25, 1972, No.1.

12. The term development and growth are often confused. A review of the literature does not indicate any consensus on definition. For purposes of this paper the term growth will refer to positive changes in GNP. Development will be defined a la Higgins (1968) (Economic Development, New York, Norton and Company) as a discernible rise in total and per capita income widely diffused among occupational groups and among regions and lasting for at least 2 generations. The process is accompanied by structural change, narrowing gaps in productivity among sectors and regions, and in improved education and health.

13. The population growth rate is known with accuracy. An MPC of .90 was used for verification of historical data and is consistent with estimates by Landau, Luis (1971), "Savings Functions for Latin America", in Studies in Development Planning ed. by Hollis B. Chenery, Cambridge, Harvard Univ. Press

p.308, for countries with an average per capita income of $300 in Latin America. (Actually he gives an MPS of .10, but 1-MPS=MPC). While he gives an MPS of .174 for countries with an average of $400 per capita, a constant MPC of .90 has nevertheless been used for projections. It is thus recognized that economic projections beyond 30 years may be biased downward.

The technological change rate of 0.8 is reasonable for Paraguay since it is, almost exclusively, an agricultural country highly imbued with traditional methods. See: Mitchell, Glenn H., and Eduardo Casati (1972) "Costs and returns of Selected Beef Cattle Ranches in Paraguay, 1971", unpublished report to the Agricultural Economics Research and Statistics Center, Facultad de Agronomia y Veterinaria, Universidad Nacional de Aguncion. This is especially true since most of the economy is based on livestock where annual technological change is very low, even in the developed countries. For a further discussion and comparison of technological change rates see Norvell, Douglass G. (1970), "A Comparison of the Effects of Constant Declining Rates of Population Growth on the Economy of the Dominican Republic", unpublished Ph.D. Thesis, College Station, Texas A and M University.

14. See for example, Billingsley, Ray V., and Douglass G. Norvell (1971), "A Macro-Economic Demographic Simulation Model for the Dominican Republic", International Programs Information Report, Texas A and M University.

15. If population growth rate stopped at 1% in year 35 and, rather than declining to zero, remained at 1%, the overall population would be 5.5 million rather than 3.0 million and per capita GNP would decline to $878 from $949. GNP would, however, remain about constant.

If population growth rate declines to zero in year 35 and remains there to year 50, GNP per capita reaches $324 in year 15 and $1,081 in year 50.

16. For a fine discussion of the benefits of a declining population growth rate see: Micklin, Michael (1970), "Demographic, Economic, and Social Change in Latin America: An Examination of Causes and Consequences", (Journal of Developing Areas,) 4:173-199, Jan. 1970.

17. See: Eastman, Clyde and Glen Mitchell, (1972) "Increasing Beef Production in Paraguay: Sociological Perspectives", unpublished report to the New Mexico State University Technical Assistance Team to Paraguay.

18. In Argentina, where production is on a much more intensive scale than in Paraguay, there has been an annual increase in production of about 2% annually for the last 20 years. See: Hutchison, John E., et. al (1972) "Argentina: Growth Potential of the Grain and Livestock Sectors Washington", FAER No.78, ERS/United States Dept. of Agriculture, 1972.

19. For a good discussion of methodological and data problems in estimating individual industry technological change rates see: Katz, Jorge M. (1969), Production Functions, Foreign Investment and Growth: A Study based on the Argentine Manufacturing Sector 1946-1961, (Amsterdam, North-Holland Publishing Company).

Table 1. Simulated Fifty Year Projections of Population, Gross National Product and Capital Stock for the Republic of Paraguay Based on the Most Likely Assumptions, Given Three Alternative Population Growth Rates.[a]

Year	Population (Thousands)	GNP (Million $)	Capital Stock (Million $)	Per Capita GNP ($)	Real Annual Rate of Growth of GNP in Last 5 Year Period (%)[b]	Real Per Capita Annual Rate of Growth of GNP In Last 5 Year Period (%)[c]
Constant Population Growth Rate (3.2%)						
Base	2,305	514	1,509	223	---	---
5	2,698	631	1,786	234	4.2	1.0
10	3,158	778	2,126	246	4.3	1.0
15	3,696	954	2,546	258	4.2	1.0
20	4,327	1,165	3,058	269	4.1	.9
30	5,929	1,750	4,455	295	4.2	.9
40	8,124	2,634	6,558	324	4.2	.9
50	11,132	3,959	9,723	356	4.2	.9
Population Growth Rate Declining to Zero in Year 50						
Base	2,305	514	1,509	223	---	---
5	2,673	631	1,786	236	4.2	1.1
10	3,054	778	2,126	255	4.3	1.6
15	3,436	954	2,546	278	4.2	1.7
20	3,806	1,164	3,059	306	4.1	1.9
30	4,461	1,702	4,443	382	3.9	2.2
40	4,914	2,371	6,426	482	3.3	2.4
50	5,083	3,117	9,118	613	2.8	2.4
Population Growth Rate Declining to 1 per cent in Year 25 and Then Constant to Year 50						
Base	2,305	514	1,509	223	---	---
5	2,665	631	1,786	237	4.2	1.2
10	3,018	778	2,126	258	4.3	1.7
15	3,349	954	2,546	285	4.2	2.0
20	3,639	1,164	3,059	320	4.1	2.4
30	4,067	1,685	4,439	414	3.8	2.6
40	4,493	2,285	6,381	509	3.1	2.0
50	4,963	2,888	8,925	582	2.4	1.4

a All figures are for end of year and in real terms to the base year, 1968. Rate of technological change assumed is 0.8% annually.

b The economy experienced a real growth rate of about 4.0% annually in GNP for the period 1960-1968. This was determined by fitting a linear function to deflated GNP. This is consistent with other studies, See for example Robinson, Sherman "Sources of Growth in Less Developed Countries: A Cross-Section Study," Quarterly J. of Econ. 85:391-408, Aug. 1971.

c The economy experienced a growth rate of 0.7% annually in per capita GNP for the period 1960-68.

Table 2. Beef Production, Consumption and Exports for the Republic of Paraguay Based on Three Alternative Simulated Fifty Year Projections and the Most Likely Beef Production and Consumption Patterns.

Year	Population (Thousands)	Assumed Per Capita Consumption (Kilos)	Total Domestic Consumption (1000 Metric Tons)	Estimated[a] Production (1000 Metric Tons)	Available for export (1000 Metric Tons)
			Constant Growth Rate (3.2%)		
Base[b]	2,231	41	91	118	27
5	2,698	36	97	121	24
10	3,158	32	101	124	23
15	3,696	27	100	127	27
20	4,327	25	108	130	22
30	5,929	23	136	136	0
40	8,124	18	146	142	- 4
50	11,132	14	156	148	- 8
			Growth Rate Declining to Zero in Year 50		
Base	2,231	41	91	118	27
5	2,673	36	96	121	25
10	3,054	32	98	124	28
15	3,436	29	100	127	27
20	3,806	27	103	130	27
30	4,461	27	120	136	16
40	4,914	27	133	142	11
50	5,083	27	137	148	11
			Growth Rate Declining to One Percent in Year 25 and then Constant in Year 50		
Base	2,231	41	91	118	27
5	2,665	36	96	121	25
10	3,018	34	103	124	21
15	3,349	32	107	127	20
20	3,639	29	106	130	24
30	4,067	27	110	136	26
40	4,493	27	121	142	21
50	4,063	27	134	148	14

a Computations from statistics in various Foreign Agriculture Circulars (U.S.D.A.) indicate that production (excluding Farm Slaughter) increased an average of 0.5% annually for the period 1960-1970. This is about 590 metric tons per year or about 3000 metric tons every 5 years. A linear projection out to year 50 has been made.

b Base year is 1968.

Table 3. Beef Production, Consumption and Exports for the Republic of Paraguay Based on Constant and Declining Fifty Year Simulated Population Projections Assuming Beef Production Increasing at 0.5% and 1.0% Annually.

Year	Population (Thousands)	Assumed Per Capita Consumption (Kilos)	Total Domestic Consumption (1000 Metric Tons)	Estimated Production (1000 Metric Tons)	Available for export (1000 Metric Tons)
Constant Population Growth Rate (3.2%) and Production Increasing at 0.5% Annually					
Base	2,231	41	91	118	27
5	2,698	35	94	121	27
10	3,158	35	111	124	13
15	3,696	35	129	127	- 2
20	4,327	35	151	130	- 21
30	5,929	35	208	136	- 72
40	8,124	35	284	142	-142
50	11,132	35	390	148	-242
Constant Population Growth Rate (3.2%) and Production Increasing at 1% Annually					
Base	2,231	41	91	118	27
5	2,698	36	97	124	27
10	3,158	33	104	130	26
15	3,696	30	111	136	25
20	4,327	27	117	142	25
30	5,929	22	130	154	24
40	8,124	18	146	166	20
50	11,132	14	156	178	22
Population Growth Rate Decreasing to Zero in Year 50 and Production Increasing at 1% Annually					
Base	2,231	41	91	118	27
5	2,673	37	99	124	25
10	3,054	34	104	130	26
15	3,436	32	110	136	26
20	3,806	30	114	142	28
30	4,461	29	129	154	25
40	4,914	28	138	166	28
50	5,083	30	152	178	26