

## AN ECONOMIC-DEMOGRAPHIC SIMULATION MODEL OF INTERREGIONAL GROWTH : THE TURKISH CASE

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### I. Introduction :

Interest in interregional growth has recently expanded as a result of an increased awareness of the differential spatial impacts of the development process. It is agreed that the system at work is one in which regional growth takes place within a framework of interdependent relationships characterized by trade flows. The question of whether or not interregional growth is an equilibrating process however, still remains unanswered. In other words, there is disagreement among regional economists as to whether interregional growth is convergent or divergent. This leads to conflicting policy recommendations ranging from no government intervention (Neo-classical Models) to direct government intervention (Cumulative Causation Models).

The purpose of this paper is to contribute to the understanding of both the process of interregional growth and how policy measures operate. Therefore, this study examines first, whether or not interregional growth is convergent; second the trade off between economic efficiency and equity; third, the role played by various public policies in affecting regional growth rate differences. This objective is carried out by elaborating on a two-region growth model constructed along Kaldorian lines (Kaldor, 1970; Ledent & Gordon, 1979). The model allows for the interaction and simultaneous determination of demographic and economic variables. As such if/when incomes in the two regions vary sufficiently, some labor migration from the low income to the high income region is allowed. The next section explains the methodology used, followed by the model of analysis. Section IV outlines estimation of the model's parameters. Sections V and VI report simulation results. The last section discusses briefly the results and their implications.

## II. Methodology :

The parameter values and initial conditions of the model are derived from the Turkish data using econometric and/or input-output techniques (Yavaş, 1983). After specifying the parameters, the model is simulated. The result is a base-case simulated scenario. Then, various changes in the initial conditions and/or parameters are made, and the paths obtained using these values are compared to the base-case paths. In this way, the effects of a change in certain variables on other variables can be determined.

## III. The Model of Analysis :

The model presented below is taken from Yavaş (1983), and it draws on Kaldor (1970) as well as Ledent & Gordon (1979). It consists of three blocks which describe a) The impact of demographic forces on regional income growth rates, b) the impact of economic forces on regional population growth rates, and c) the relationship linking the demographic and economic sides of the model.

First Block :

$$1. \quad (g_t) = \Gamma (x_t) + \Phi^1 (n_t) + \Phi^2 (n_t + l_t)$$

where  $(g_t)$  is the vector of regional income growth rates,  $(x_t)$  is the vector of export growth rates,  $(l_t)$  is the vector of labor force participation rate changes,  $(n_t)$  is the vector of population growth rates, and  $\Gamma$ ,  $\Phi^1$  and  $\Phi^2$  are diagonal matrices of coefficients. The coefficients are elasticities because all variables are expressed in their growth rates. Notice that the first equation is a basic equation of a class of models known as export-base models which relates a two element vector of regional income growth rates to the growth in regions exports. Population and labor force variables are added to bring about the impact of demographic factors on growth, stressing the role of households as consumers well as suppliers of labor.

$$2. \quad (x_t) = \eta(p_t) + z\varepsilon(i)$$

where  $(p_t)$  is the vector of regional price changes,  $z$  is the change in world demand,  $\eta$  is a matrix of demand elasticities with respect to price,  $\varepsilon$  is a diagonal matrix representing the elasticity of world demand change with respect to export growth, and  $(i)$  is a two-element vector of ones. Equation 2 is the export demand function which relates the growth of exports to changes in prices and world demand.

$$3. \quad (p_t) = (w_t) - (r_t) + (\tau_t)$$

where  $(w_t)$  is the vector of regional wage rate changes,  $(r_t)$  is the vector or regional rates of technological change, and  $(\tau_t)$  is the vector of regional rates of cost mark-up.

Changes in labor productivity,  $(r_t)$ , can be partially endogenized to the regional economy through the use of the Verdoorn law (Kaldor, 1970).

$$4. \quad (r_t) = (\bar{r}) + \lambda^1(g_t) + \lambda^2(I_t)$$

where the labor productivity growth is a function of both the rate of growth of income and investment, and  $(r)$  is the rate of autonomous productivity growth. Investment is determined by :

$$5. \quad (I_t) = sY_{t-1} \quad (i)$$

The assumption made here is that a constant proportion of income in the last period is invested.

The next equation shows how wage rates are determined :

$$6. \quad (w_t) = (\bar{w}) + \Psi_t(t_t)$$

where  $(\bar{w})$  is the exogenous element and  $(t_t)$  is the labor force participation rate change.  $\Psi_t$  is a diagonal matrix representing each region's wage elasticity with respect to labor force participation rates. The elements of  $\Psi_t$  are not taken as constants. It is assumed that the absolute value of each element of  $\Psi_t$  which has a negative sign, increases with the value of the beginning-of-the-period labor force participation rates (LFPR). Therefore, if the LFPR can take on values within a range of  $(\rho^l - \rho^r)$  where  $\rho^l$  is LFPR low enough to have no impact on the wage rate change, and  $\rho^r$  is high enough to have an infinite impact. Then,

$$7. \quad \Psi_t = D (\rho_t - \rho^l I) (\rho_t - \rho^r I)^{-1}$$

where  $D$  is a diagonal matrix of coefficients,  $I$  is the  $2 \times 2$  identity matrix, and  $\rho_t$  is the diagonal matrix representing the beginning-of-the-period LFPR.

The last equation of the first block posits a relationship between a region's rate of change of income growth and its rate of change in employment.

$$8. \quad (e_t) = \mu (g_t)$$

This equation is needed because one wants to be able to compare a



variable from the demographic side with an economic variable to ensure consistency (Ledent, 1981).

$$9. \quad N_{it+1} = N_{it} + b_i N_{it} - m_{it} N_{it} + m_{jt} N_{jt} \quad i = 1, 2.$$

where  $N_{it}$  is population in region  $i$  at time  $t$ ,  $b_i$  is the  $i^{\text{th}}$  region's exogenous rate of increase, and  $m_{it}$  is the migration rate from region  $i$  to the other region in period  $t, t + 1$ .

Translated into growth rates, equation 9 yields :

$$9^1 \quad (n_t) = (b) - N_t^{-1} P N_t (m_t)$$

where  $(n_t)$  is the vector of population growth rates and  $P$  is the matrix

$$\begin{vmatrix} 1 & -1 \\ -1 & 1 \end{vmatrix}$$

The next relationship specifies the way in which economic forces cause migration rates to change

$$10. \quad m_{it} = \alpha_i \frac{N_{it}}{N_{it} + N_{jt}} \left\{ \dot{I} + \beta_i \left( \frac{e_{jt}}{u_{jt}} - \frac{e_{it}}{u_{it}} \right) \right\} \quad i, j = 1, 2; i \neq j.$$

The migration rate out of each region is related to the difference in the economic opportunities offered by the two regions and is proportional to the attractiveness of the other region. The index of economic opportunities used here is a variation of Todaro's probability that a migrant finds a job (Todaro, 1976), represented by the ratio of employment growth rate to the beginning-of-the-period unemployment rate.

In matrix notation :

$$10^1. \quad (m_t) = \frac{1}{N_t} \alpha N_t \{ (i) - \beta P u_{it}^{-1} (e_t) \}$$

where  $N_t$  is the total population of the system at time  $t$ ,  $\alpha$  and  $\beta$  are diagonal matrices of coefficients, and  $u_t$  is the matrix of regional unemployment rates at time  $t$ .

Third Block :

The first equation of the third block explains the change in LFPR.

$$11. \quad (l_t) = \gamma_t (I - u_t)^{-1} (u_{t+1} - u_t)$$

where  $u_t$  is the matrix of regional unemployment rates at time  $t$ ,  $u_t$  and

$u_{t+1}$  are two by one vectors,  $\gamma_t$  is a diagonal matrix representing elasticity of the unemployment rate change with LFPR change. It is assumed that the value of each element of  $\gamma_t$  is smaller when the unemployment rate takes on extreme values, and larger for intermediate unemployment rate values.

$$12. \quad \gamma_t = A (u_t - u^l) (u_t - u^r)$$

where  $A$  is the diagonal matrix of coefficients, and  $u^l$  and  $u^r$  are the boundaries of the interval within which  $u_t$  falls.

A closer look at equation 11 reveals an important feature of the model. The determination of LFPR is dealt with explicitly since disequilibrium in the labor market is allowed. Whenever the employment levels falls short of the labor force level, the labor market is thrown out of equilibrium. If, on the other hand, all markets cleared continuously, equation 11 would have been unnecessary.

Finally, consider the identity which relates employment and population levels:

$$13. \quad E_t = \rho_t (I - u_t) N_t$$

If the above identity is differentiated, the last equation of this block results (in :).

$$13^1. \quad (e_t) = (u_t) - (I - u_t)^{-1} (u_{t+1} - u_t) + (n_t)$$

As shown in the appendix, various substitutions permit one to reduce each of the three blocks to a single equation in  $(e_t)$ ,  $(u_t)$  and  $(n_t)$ . This gives rise to simple model of three equations and three unknowns. The reduced-form equations are easily derived because the coefficients of the endogenous variables either depend on lagged variables or are constant. From the reduced-form equations a simulation of the time paths of  $(e_t)$ ,  $(u_t)$  and  $(n_t)$  as well as of all the other variables can be developed. It can be seen from these reduced-form equations that the model is much more dynamic than those that include only economic variables (Dixon & Thirwall, 1975). This is so because the equations describing demographic behavior have introduced nonlinearities.

#### IV. Estimation of the Model's Parameters :

Sixty-seven provinces of Turkey have been grouped in such a way so as to constitute the two regions in this study. Region A (Advanced

region) consists of fourteen provinces of the Ege and Marmara, and Region B (Developing region) has the rest of the provinces. For further information on the regionalization scheme used in the study and its justification, the reader is referred to Yavaş (1983).

Regional exports are estimated by incorporating a gravity-type approach in an Input-Output framework. The procedure first estimates regional Input-Output tables from a corresponding National table. Regional I-0 tables are then transformed into an interregional I-0 table via the use of a method due to Leontief and Strout (1963). Finally, trade coefficients are determined from a simultaneous linear equation system under the restriction that the sum of deliveries from each regional sector to other regions is equal to the total known deliveries from that regional sector to other regions. Similarly, the sum of deliveries into a region for a good is equal to total use in that region (Yavaş, 1985).

Table 1 in the appendix provides a summary of all parameter values and initial conditions used. It is important to distinguish between methods employed in parameter estimation. While most parameter values have been determined from the data available using conventional econometric methods, others, due to the lack of data, have been assigned "reasonable" values, determined on the basis of relevant existing literature, and that also replicate the time path of variables to which they are related. Therefore, it is the latter group which constitutes the most controversial parameter values. The question then becomes: how sensitive is the model to changes in the values of the "unconventional" parameters? In an attempt to investigate the stability properties of the model, a sensitivity analysis is conducted for many of the key parameters. The model appears to be fairly stable for small changes in most of the cases. However, the calculation of income growth rates ( $g$ ) is slightly more sensitive to changes in the coefficients in determination of the migration rates ( $\alpha$  and  $\beta$ ) and in the rate of natural increase ( $b$ ). Therefore, it can be concluded that the model is fairly stable in the vicinity of the parameter values used in this study. This enhances the generality of the results.

After specifying the parameter values and initial conditions, the equations of the model are solved in sequence. As already mentioned, three reduced-form equations are developed from the equations of the model. When the model is solved once, new values for the variables are obtained. These are used to update initial conditions for the next period. The base period (year) chosen was 1975.



## V. Results of the Base Run :

It can be seen from figure 1 that the model generates oscillations in income growth rates ( $g_i$ ), employment growth rates ( $e_i$ ), population growth rates ( $n_i$ ) and unemployment growth rates ( $u_i$ ). The emergence from the simulations of the non-static long term rates of change is in contrast both with Neoclassical models which predict automatic income convergence, and with Cumulative Causation Models which predict persistent growth rate differentials. Fluctuating growth rates over patterns of convergence and divergence is due primarily to the inclusion of a demographic sector which added migration response and nonlinearities. However, it is important to point out that since migration and population levels appear as independent as well as dependent variables in the solution of the model, it is difficult to single out those variables that effect net migration flow. It may be noted again that migration influences the economic submodel as well as being responsive to changes in economic conditions.

A closer look at Figure 1 indicates that the output growth rate peaks in region B in the fortieth year and reaches a minimum in region A around the same time period. Employment growth rates exhibit similar behavior, falling first, rising towards the end of the simulation in Region A; increasing initially and falling between the forty-second and forty-sixth years in region B. Population growth rate in region A initially falls slowly, then decreases at an increasing rate, and finally levels off at the end of the simulation. The time path of LFPR growth rate exhibits fluctuating behavior also. It decreases in both regions initially. Then it becomes positive in region B after the twenty-sixth year. It is important to note that even though the population, employment, and labor force levels increase regularly, the model does not generate implausible LFPR and/or unemployment rate values. As it is shown below, both rates are entirely consistent with empirical evidence. Turning to migration, a net flow of migrants from region B to region A is observed. Initially, net migratory flow increases rapidly. It levels off around the twenty-eighth year, and increases again toward the end of the simulation. This result is expected since region A, being more advanced, offers better economic opportunities, signalled by a lower unemployment rate and higher employment growth rate. Finally, per capita income growth is higher in region A until the thirty-seventh year. After the fortieth year however, regional per capita income levels start to converge.

Even though the model was not designed to deal with short run changes in economic demographic events, it does appear to replicate

history quite closely. For example, for 1975-1985, a period for which data on many variables exist, the model replicates population levels faithfully, resulting in less than .04 root mean square error (Yavaş, 1985).

Per capita income levels for the same period are also accurately predicted by the model for 1976-1978, the period for which such information is available (Özutun, 1980).

Year	Model			History		
	Reg. A	Reg. B	Nation	Re. A	Reg. B	Nation
1976	20.4	10.1	13.05	20.6	9.95	13.25
1977	20.9	10.3	13.30	20.9	10.12	13.50
1978	21.5	10.5	13.60	21.0	10.20	13.60

The downward trend in LFPR and the upward trend in unemployment rates are also captured in the model. Both rates are consistent with estimates of the State Planning Organization (SPO, 1973).

The model's predictions of net migratory flows from region B to region A are also consistent with the findings of internal migration studies in Turkey (Yener, 1977).

## VI. Policy Experiments :

1. The first experiment deals with the effects of differential inter-regional distribution of total investment. In this way, one can evaluate not only the effectiveness of investment policy in narrowing spatial differences, but gain considerable insight into the efficiency-equity trade-off. To resolve this issue, more investment is directed to the developing region, B, and less to region A. It is found that output growth rate in region A, while still exhibiting oscillatory behavior, is lower when compared to its value in the base run. The opposite is true for the output growth rate in region B. Moreover, if per capita income levels are compared, convergence tendencies dominate. Thus, redirecting investment does help the lagging region narrow the existing income gap. What may be more interesting is that national growth is virtually unaffected. Therefore, an efficiency-equity trade-off may be avoided.

It is also found that  $(e_t)$ ,  $(n_t)$  and  $(u_t)$  for both regions continue to fluctuate over the patterns of convergence and divergence. When compared with their base-run values, however,  $(e_t)$  and  $(n_t)$  are lower in magnitude



in region A and higher in region B. This is expected since there is more capital on hand in region B which creates more employment opportunities. The latter, on the other hand, would dampen outmigration from region B, giving rise to higher population growth there. As expected, a net flow of migrants from region B to region A is observed, but the migration response is not as pronounced as it was in the base run.

2. The second experiment involves the utilization of the United Nation's population projections to evaluate population control strategies. Therefore, instead of taking the rate of natural increase (b) constant, (b) is made a function of time and is estimated using regression analysis. The values obtained are then incorporated into the computer program and simulated. The results, summarized in figure 2, indicate that the oscillatory nature of the main variables ( $g_t$ ), ( $n_t$ ), ( $e_t$ ) and ( $m_t$ ) remains the same as in the base run, with migration response being larger. This can be explained on the basis of the higher employment growth rate and the lower unemployment rate in region A, both of which provide signals for higher economic opportunities on which prospective migrants base their decisions. A more basic difference can be observed in regional per capita income levels. While the national per capita income increases only slightly reflecting the fall in total population, its regional counterpart in region A increases dramatically. In region B, on the other hand, there is a small drop in per capita income. These results are consistent with expectations on theoretical grounds: falling population growth rates, *ceteris paribus*, imply increasing per capita income levels. Furthermore, since the fall in the population growth rate is larger for the advanced region, a higher per capita income level in region A is to be expected. In conclusion, policies aimed at lowering the rate of population growth tend to increase existing per capita income differences between regions (A (Advanced) and B (Developing)) provided that the reduction in the rate of population growth is higher in the advanced region than in the developing region. This is true despite the fact that migration from the developing to the advanced region accelerates. Migration alone is not sufficient in achieving interregional balance (convergence).

3. The final policy experiment deals with wage and tax subsidies which have been suggested as policy tools to make regions more competitive (Clark & Peters, 1964; Hutton & Hartley, 1968). With the establishment of free ports and zones in Turkey together with the use of tax/wage incentives offered to firms that locate in the zones, the effects of such subsidies have caused considerable interest.

When both wage and tax subsidies are incorporated into the model,

it is found that the differences between regions in per capita income levels narrowed, with per capita income in region A falling and its counterpart in region B rising. Second, employment in region B increased compared with its value in the base run. Other variables,  $(g_t)$ ,  $(e_t)$ ,  $(u_t)$  continued to show fluctuating behavior with consistent LFPR and unemployment rates.

## VII. Conclusions :

The main purpose of this paper has been to investigate policy options available within framework of an economic-demographic interregional growth model. The model is general in the sense that many key variables are determined endogenously. Furthermore, disequilibrium is allowed in the labor market due to long-term labor contracts (wage stickiness) and/or search behavior (imperfect information). Second, interactions between economic and demographic subsystems have been explicitly taken into account. Models that neglect such interactions are not satisfactory. For example, the possibility of steady-state growth by a pair of regions in the long run (Dixon & Thirwall, 1975) it is argued, is a result of a) the omission of migration which would put a brake on income divergence over the long run, and b) the linear structure of the model (Ledent & Gordon, 1979).

The model was estimated using data from Turkey. The initial conditions were taken from the national accounts and the population census reflecting the structure of the Turkish economy around 1975. The choice of 1975 as a base year was not arbitrary. Since data were available up to 1983 on most variables, it was thought that conducting historical (retrospective) simulations would throw light into the stability properties of the model as well as improving the reliability of the prospective simulations.

The main conclusion from the simulation studies was that the regions' growth rates fluctuate over pattern of divergence and convergence, thus ruling out the possibility of continuous income divergence in the long run. Also ruled out was the neoclassical position that there is a built-in mechanism which ensures income convergence in the long. Therefore, it appears that taking explicit account of the demographic and economic variables and their interplay has led to a more general result, capable of explaining both Cumulative Causation and Neoclassical predictions.

Different simulation studies have been helpful in providing answers to different policy questions examined. First, convergence in regional per

capita income levels may be achieved by directing a larger proportion of total investment to the lagging region. In addition, there may not be the need to sacrifice national growth objectives in order to narrow the interregional income gap. Efficiency-equity trade-offs may not exist. Such a result lends support to "generative" as opposed to "competitive" growth hypothesis (Richardson, 1978). Second, population policies aimed at reducing the population growth are effective in increasing the rate of growth of output in the long run while divergence (convergence) of per capita income levels depend on the magnitude of the reduction of population growth in one region vis a vis the other. Third, Wage/tax

## APPENDIX :

Table 1  
Summary of Parameter Values and Initial Conditions

Parameter	Region A		Region B	
$\tau$	0.85		0.75	
$\Phi$	0.65		0.70	
$\Phi$	0.10		0.10	
$\eta$	-1.5	1.5	1.5	1.5
$\varepsilon$	1.0		1.10	
$\lambda$	0.65		0.6	
$\lambda$	0.000000025		0.000000002	
s	0.12		0.825	
$\mu$	0.4		0.375	
d	3.0		2.0	
$\alpha$	0.07		0.078	
$\beta$	0.25		0.3	
a	6000		3000	
$\tau$	0.015		0.015	
r	0.025		0.025	
w	0.015		0.015	
b	0.017		0.022	
<b>Initial Conditions</b>				
N	11,425		28,922	
u	0.1		0.12	
$Y_{t-1}$	229,632		289,489	
$\rho$	0.4		0.38	
<b>Non-regionalized Parameters</b>				
$\rho^1$			0.35	
$\rho^r$			0.43	
$\mu^1$			0.05	
$\mu^r$			0.15	
z			0.04	
N.			40,347	



subsidies can be used to achieve interregional balance in the long run. Finally, the results indicate that for various policies to be effective, they have to be sustained. That is, a one-shot shock which raises a region's growth rate is not sufficient for its growth advantage to be maintained. In addition, it may be observed that even sustained shocks do not produce the expected results in the short run. Thus, one lesson to be learned is that regional growth is a long term process and that the policy maker should not expect immediate results.

### Derivation of the Solution of the Model :

If the equations of the first block are combined, we obtain the following equation :

$$A1. \quad E(e_t) = (h) + G_t(t_t) + (F)(n_t)$$

where

$$E = (I + \tau\eta\lambda^1) \mu^{-1}$$

$$F = \Phi^1 + \Phi^2$$

$$G_t = \tau\eta D(\rho_t - \rho^1 I) (\rho_t - \rho^1 I)^{-1} + \Phi^2$$

$$(h) = \tau \{ \eta ( (\omega) - (\bar{r}) + (\tau) - s \lambda^2 Y_{t-1} (i) ) + z\varepsilon (i) \}$$

E, G, and F are  $2 \times 2$  matrices. (h) is a  $2 \times 1$  vector.

A similar substitution procedure can be applied to the equations of the second block. The result is :

$$A2. \quad (n_t) = (k_t) + J_t(e_t)$$

where

$$J_t = \frac{1}{N_t} N_t^{-1} P N_t \alpha N_t \beta P u_t^{-1}$$

$$(k_t) = (b) - \frac{1}{N_t} N_t^{-1} P N_t \alpha N_t (i)$$

Finally, the third block equations give rise to :

$$A3. \quad (e_t) = (n_t) + M_t(t_t)$$

where

$$M_t = I - ( (u_t - u^1 I) (u_t - u^1 I) )^{-1} A^{-1}$$

J and M are  $2 \times 2$  matrices, (k) is a  $2 \times 1$  vector.

Therefore, the model reduces to a three-equation system in three unknowns. Furthermore, the coefficients of the endogenous variables are either constant or depend on lagged variables. Then, equations A1, A2, and A3 can be combined to obtain the three reduced-form equations of the model:

$$R1. \quad (e_t) = (E - FJ_t - G_t M_t^{-1} (I - J_t))^{-1} ( (F - G_t M_t^{-1}) (k_t) + (h) )$$

$$R2. \quad (n_t) = J_t \{ E - FJ_t - G_t M_t^{-1} (I - J_t) \}^{-1} \\ \{ (h) + (E - G_t M_t^{-1}) J_t^{-1} (k_t) \}$$

$$R3. \quad (t_t) = M_t^{-1} (I - J_t) \{ E - FJ_t - G_t M_t^{-1} (I - J_t) \}^{-1} \\ \{ (h) + (F - (E - FJ_t) (I - J_t)^{-1}) (k_t) \}$$

FIGURE 1

BASE - RUN RESULTS

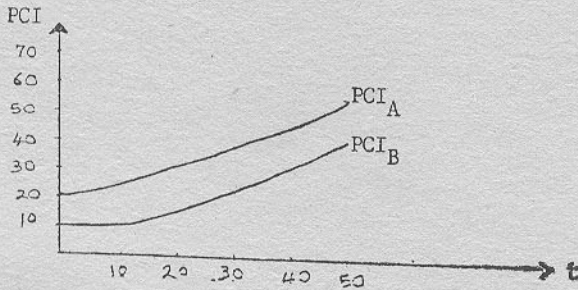
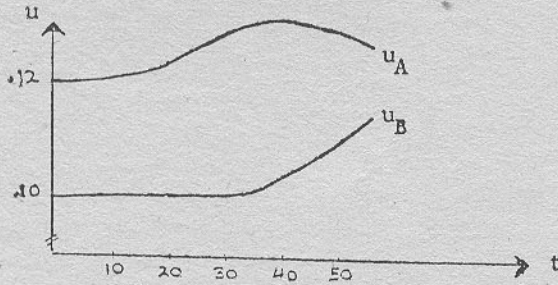
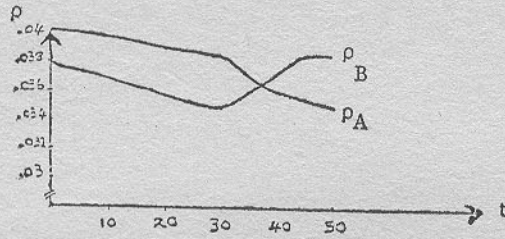
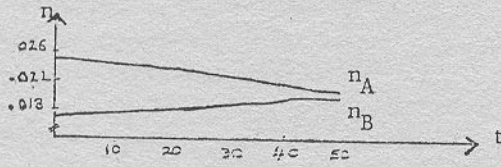
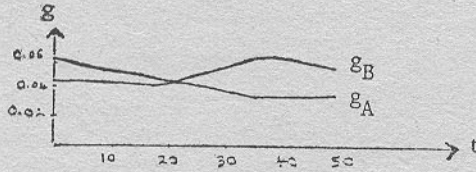
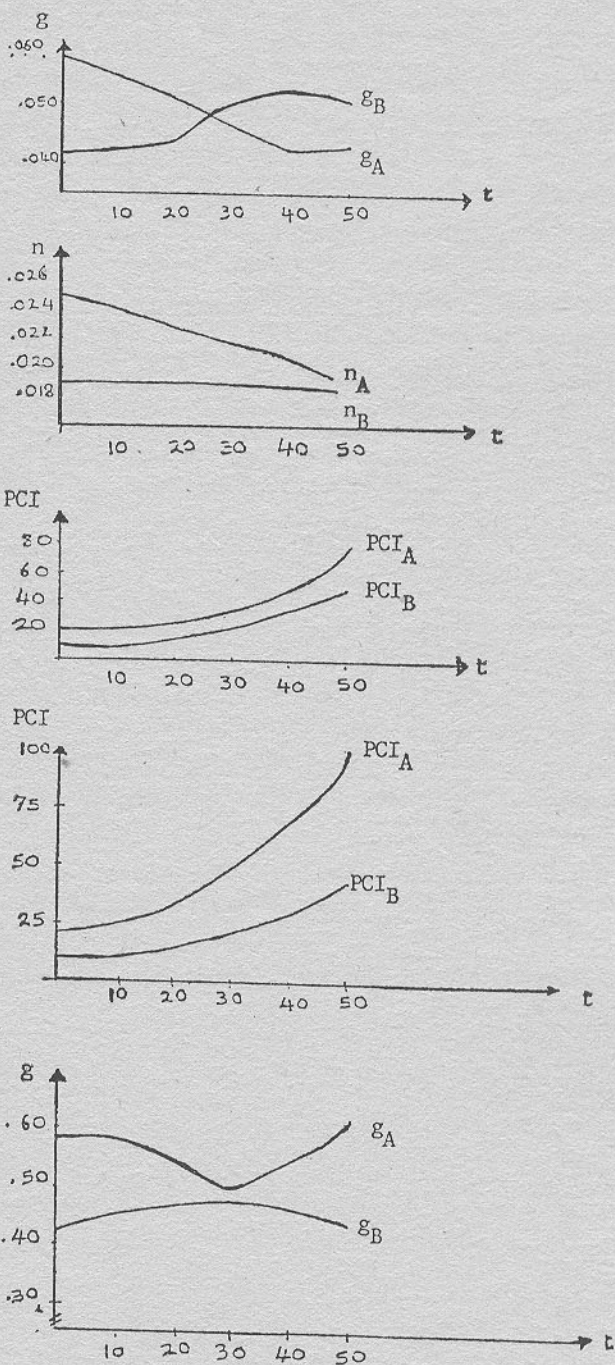




FIGURE 2  
POLICY SIMULATION RESULTS



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