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DIVERGENCE AND CONVERGENCE IN INTERREGIONAL INCOME DIFFERENTIAL

by
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I. INTRODUCTION

It has been observed that recent interregional per capita income differentials tend to converge in many developed countries possibly due to market mechanisms, such as labor and capital migration in response to their marginal productivity differentials. However, the speed of adjustment to the differentials is not necessarily instantaneous at the interregional level because of various kinds of transaction costs in labor and capital migration as identified by Williamson (1979). Since interregional price equilibrium is far from being attained in a short-term period, static analysis, such as theory of optimal city size, cannot be applied to the description of the interregional development stages, i.e., the growth and decline of regions. It would be more fruitful to investigate the slow adjustment mechanisms of labor and capital migration in a dynamic context.

It has also been observed that interregional income differential tends to diverge in developing countries and during the past in developed countries as well. At the initial stage of development, income inequality both at sectoral and regional levels is likely to widen presumably due to the Kaldor's cumulative causation effects by spatial concentration of economic activities. In view of this, Kuznets' U-hypothesis seems to have become an economic law which depicts such a transition in economic sectors and in the stages of interregional economic development.

This paper attempts to offer an explanation of the U-hypothesis with respect to interregional income differential, and to analyze the divergence and convergence phenomena together relating to interregional migration and urban agglomeration economies. Needless to say, rural and urban regions often overlap with agricultural and non-agricultural sectors respectively.

To begin with, in the next section, several interregional inequality indices are plotted against time using Japanese prefecture-based data of the postwar period. Just by comparing these plots of the crude indices, several hypotheses on U-curves are examined. Among others, Section III tests the contention of Dunlevy and Bellante (1983), who argue that not only migration is induced by interregional income differential though its adjustment speed is slow, but also migration operates to close the differential. Analyzed is a temporal relationship between income differential and net migration, and Sims' test of causality is utilized to detect this relationship. It will be revealed that income differential has been exogenous to migration in postwar Japan.

Section IV then focuses on the exogenous variable, i.e., interregional differential in per capita income, and attempts to explain its divergence and convergence trend in Japan by a simple growth model. The model incorporates urban agglomeration economies, interregional technological diffusion, and interregional movements of capital and labor. Conclusions are briefly summarized in Section V.

II. INTERREGIONAL INCOME DIFFERENTIAL, MIGRATION, AND ECONOMIC GROWTH IN JAPAN

Coefficients of variation are often used to measure the interregional differential in per capita income. An unweighted coefficient of variation is expressed by:

$$V(t) = \frac{\sqrt{\frac{1}{n} \sum_{i=1}^{n} [y_i(t) - \bar{y}(t)]^2}}{\bar{y}(t)}, \tag{1}$$

while a weighted coefficient of variation is written by:

$$V_w(t) = \frac{\sqrt{\sum_{i=1}^{n} [y_i(t) - \tilde{y}(t)]^2 \frac{L_i(t)}{L(t)}}}{\tilde{y}(t)}, \tag{1'}$$

where t is time; $y_i(t)$ is the per capita income in region i; $\bar{y}(t)$ is the simple average of per capita prefectural income $[= \frac{1}{n} \sum_{i=1}^{n} y_i(t)]$; $\tilde{y}(t)$ is the national per capita income $[= \sum_{i=1}^{n} y_i(t)L_i(t) / \sum_{i=1}^{n} L_i(t)]$; $L_i(t)$ is the population in region i; L(t) is the national population $[= \sum_{i=1}^{n} L_i(t)]$; and n is the number of regions.

Since our concern is urban-rural imbalances in per capita income, the ratio of urban per capita income to rural per capita income may also be used as an alternative measure of interregional income differential. That is,

$$D(t) = \frac{\sum_{i \in urban} y_i(t)L_i(t) / \sum_{i \in urban} L_i(t)}{\sum_{i \in rural} y_i(t)L_i(t) / \sum_{i \in rural} L_i(t)}. \tag{1"}$$

Needless to say, these indices (1), (1') and (1") are dimensionless, and hence free from a money inflation problem. Similarly, urban net migration is defined as:

$$M(t) = \sum_{i \in urban} M_i(t), \tag{2}$$

where $M_i(t)$ is the net migration to region i.

Using Prefectural Income Statistics (Economic Planning Agency, 1954-82), Population and Interprefectural Migration Statistics (Japanese Bureau of Statistics, 1954-82), data of nominal per capita distribution income $y_i(t)$, population $L_i(t)$, and net migration $M_i(t)$ are collected for 46 prefectures (excluding one prefecture, Okinawa) and from 1954 to 1982. Plotting of the time-series is done for V(t), $V_w(t)$ and D(t) in Figure 1, for M(t) in Figure 2, and for the growth rate of GNP in Figure 3. The urban region here is defined by the three largest metropolitan areas (Kanto, Tokai, and Kinki), which consist of 17 prefectures: Ibaraki, Tochigi, Gumma, Saitama, Chiba, Tokyo, Kanagawa, Gifu, Shizuoka, Aichi, Mie, Shiga, Kyoto, Osaka, Hyogo, Nara, and Wakayama. And, the rest of 29 prefectures excluding Okinawa prefecture constitutes the rural region.

All the figures exhibit bell-shaped curves. In particular, Figure 1 is consistent with Williamson's (1965) findings, and Figure 2 is in agreement with Zelinsky's (1971) hypothesis. On the other hand, Alonso (1980, p.11) argues the relationships between the bell-shaped curves, and claims that "the crest of geographic concentration occurs earlier than that of regional inequality, which is earlier than that of economic growth." Comparing those curves in Japan, however, the crest of regional inequality measured by V(t), $V_w(t)$, or D(t) occurred in 1961 (Figure 1), that of geographical concentration measured by M(t) was in 1962 (Figure 2), and that of economic growth rate took place in 1972-73 (Figure 3), which is against the Alonso's hypothesis.

In the United States, Vining, Pallone and Plane (1981, Figure 3) demonstrated that geographical concentration measured by net migration from the core regions ceased around 1970 whereas Williamson (1965, Table 4) found that the crest of regional inequality measured by $V_w(t)$ occurred in 1932. Comparing Vining et al. and Williamson's studies for other developed countries, it may not be hard to arrive at a conclusion that the crest of regional inequality is earlier than that of geographical concentration. In addition, if geographical concentration is measured by the share of urban population, then its crest is much later or no crest emerges yet, which reinforces our conclusion. We may thus say that interregional migration is determined by interregional income differential, but not vice versa, or income differential is exogenous to net migration, indicating a demand-oriented interregional labor market. We will conduct a causality analysis later to confirm this statement.

Contrary to the labor-demand-oriented result, Muth (1971), Olvey (1972), and Greenwood (1973) demonstrated by simultaneous-equations models using cross-sectional data in the United States that migration and employment growth are interrelated while Steinnes (1978) showed unidirectional causality running from migration to employment growth.

There may be two crucial flaws in the above empirical studies. Firstly, since net migration is absolutely equivalent to employment growth by definition aside from unemployment and change in labor force participation, their 'interrelationship' is taken for granted. In fact, it would be extremely difficult to distinguish whether people move because of job vacancy, or job vacancy induces people to move in. Since chain migration due to job transfer tends to be dominant in integrated societies [White (1970)], the causality between migration and employment growth may not be statistically detected especially from annual-based data. The literature suggest that it may be more important to investigate the temporal relationship between interregional differential and migration [viz. Bellante (1979), Dunlevy and Bellante (1983)].

Secondly, use of cross-sectional data does implicitly assume similarity in the structural equations across regions, and usually deals with only one period fixing a time lag a priori. Time-series analysis is, on the other hand, able to describe the dynamic relationship between variables without predetermining the time lag although it handles only one region. To test causality, time-series analysis is definitely preferable.

III. TEMPORAL RELATIONSHIP BETWEEN INCOME DIFFERENTIAL AND MIGRATION

Due to lack of consistent time-series data at the regional level, there appeared a limited number of time-series analyses dealing with interregional dynamics in the literature. Mera (1977) conducted time-series regressions of population concentration on the growth rate of GNP, income disparity, and so forth, and obtained positive relationships between them in postwar Japan. Clark and Gertler (1983) investigated time-series relationship between migration and capital investment in the United States by multiple time-series analysis.

Dendrinos and Mullally (1981) considered dynamic interactions between the ratio of urban per capita income to national per capita income ($y_i/\tilde{y}$) and the ratio of urban population to national population (L_i/L), and proposed a modified version of the Volterra-Lotka predator-prey system of simultaneous differential equations on the analogy of mathematical ecology.

In their studies, it is hypothesized that population is a predator, income is a prey, and there is a congestion effect of overpopulation. In the absence of population congestion, the trajectory oscillates indefinitely around a critical point in a two-dimensional phase diagram whereas the existence of congestion generates a stable focus, i.e., existence of an interurban labor market equilibrium. Although their dynamical system is autonomous and hence easy to analyze by the two-dimensional phase diagram, its economic and ecological interpretation and justification are less clear.

Their model explicitly incorporates feedback between the two variables, and thus high-income regions have a possibility to experience out-migration[1] owing to overcongestion whereas our finding in the preceding section did not show such migration for most of the study period in Japan. Needless to say, direct comparison is not possible because socio-economic conditions differ from one country to another.

In Japan, many socio-economic characteristics are systematic with respect to city size, and a hierarchical structure is conspicuous with respect to rank size. If the regional data were suitably disaggregated at the level of metropolitan areas such as SMSA, our system may be diagrammatically illustrated in a two-dimensional phase diagram as in Figure 4.[2] The heavy lines are the actual trajectories that are neither foci nor centers because migration from high- to low-income regions does not occur here. The share of labor L_i/L is always monotonic while the per capita income ratio $y_i/\tilde{y}$ always has a turning point in each region due to the divergence and convergence in per capita income differential. Note that these lines move in arcs around the fixed point F of the grand average of L_i/L and $y_i/\tilde{y}$ in each point of time. Consequently, the predator-prey analogy from mathematical ecology cannot be applied to the labor and income dynamics of the Japanese regional system.

Let us finally consider the spatial equilibrium of the labor and income dynamics. If it exists, then the income ratio in every region should converge to unity and the change in the labor share in each region should be nil at equilibrium. Otherwise, people have an incentive to migrate, and hence the labor share changes. Figure 2 in Section II shows that rural/urban net migration $\dot{M}(t)$ of (2) had decreased after 1970 and became close to zero after around 1975, which is qualitatively similar to the urban/rural income ratio D(t) of (1"). These figures may imply that after the long-term slow adjustment in the interregional labor market, equilibrium was attained around 1975.

However, it is a fact that there still exists quite a large difference in per capita income between urban and rural regions even after 1975 (the ratio D(t) in Figure 1 is more than 1.2) although the net migration flows have almost ceased. We may thus infer that there are persistent interregional differences in the cost of living and in the amenity between urban and rural regions: viz., land price, commuting, pollution and congestion costs, and so on. If so, we have to either deflate the urban income or inflate the rural income in accordance with the level of congestion costs which may be expressed as a function of city size. Provided that L_i, as a proxy for city size, is associated with the congestion level, we can superimpose the dotted lines in Figure 4 so that they all exhibit the converging trend to the horizontal line of $y_i/\bar{y} = 1$, which is the interregional equilibrium in the labor market. Implicit here is the hedonic price theory, which states that the marginal labor productivity and regional environment, such as congestion, pollution, and long-distance commuting are considered to be capitalized in the wage rates, and so there exists no real difference in the wage rate [Gerking and Weirick (1983)].

Of various econometric tests to detect causality, Sims' (1972) test of causality may be more suitable for our purposes, and easier to compute and to interpret for the two-variable case than the multiple time-series analysis. As inferred from Figure 1, results were shown to be similar for three income differential indices of V(t), $V_w(t)$, and D(t), and hence we report the results of the relationship between the unweighted coefficient of variation V(t) and the net migration M(t) only.[3]

Following Sims (1972), four kinds of time-series linear regressions are conducted, and are summarized in Table 1. We took three-year leads and six-year lags. It was found that the future coefficients in the regression of M(t) on V(t) are relatively small and insignificant whereas those in the regression of V(t) on M(t) are relatively large. Moreover, the regression result of M(t) on V(t) with future leads (column 1) is close to that without future leads (column 2).

In fact, under the null hypothesis that three future coefficients are zero, *F*-value in the regression of M(t) on V(t) is 1.31 (its significance level is 0.331), while that in the regression of V(t) on M(t) is 4.82 (its significance level is 0.028). Provided that those linear specifications are correct, we are able to conclude that interregional income differential causes (or is exogenous to) net migration, but that net migration does not cause income differential in postwar Japan at least in the short-run. This is just opposite to Steinnes' (1978) empirical finding presumably due to the difference in the variable selection as mentioned earlier.

It should be noticed that since accumulation of the net migration raises the population share in its region by definition, it may decrease the interregional income differential by market mechanisms in the long-run. However, this long-run effect of migration on income differential was not statistically detected in the above regression specifications.

Our finding is straightforward and common in the migration literature. It does deny the theory by Robinson (1976) and Braulke (1983), among others, who attempted to explain Kuznets' U-hypothesis of income inequality by the geographical concentration of the urban population share mainly caused by migration. The direction of the short-run causality is reverse!

As the rural/urban migration is found to be a function of the rural/urban differential in per capita income with a certain time lag, it may be inferred that per capita income in urban regions grew first, followed by the lagged growth in rural regions. We may thus conclude that urban growth necessarily precedes rural growth, rural/urban migration, and per capita GNP growth. The trigger of those bell-shaped curves would be the spontaneous growth in big cities, where business activities are concentrated and the new impressions and ideas that are the heart of technological progress are likely to occur [Sveikauskas (1975)]. Growth in rural regions may be considered to be due to spatial diffusion of urban technology which is usually accompanied with a certain time lag. The lags τ of regression of $M(t)$ on $V(t-\tau)$ may thus be attributable to the distance friction of technological diffusion as well as the delay in migration decision. Another source of rural growth may be capital migration from urban regions or labor migration to urban regions in response to marginal productivity differentials respectively.

IV. A MODEL OF TECHNOLOGICAL DIFFUSION AND MIGRATION OF CAPITAL AND LABOR

Since we have seen that the interregional differential in per capita income can not be explained by labor migration, this section explores the presence of other causes for the income differential, especially the bell-shaped trend in the income differential. Recently, Mera (1986) found that the labor force participation rates and the government transfer payments did not affect the interregional income differential, but that the growth rate of manufacturing employment is a key factor in the income differential in postwar Japan.

It may be therefore inferred that the urban manufacturing grew first, which was followed by the rural manufacturing with a few-year lag. As mentioned in Section II, the growth of the rural region is rather passive and may depend upon the spatial diffusion of urban technology and upon free migration of capital and labor in response to their marginal productivity differentials. The notion of the former is due to Vernon's (1966) product cycle hypothesis while the latter is based upon an interregional dynamics of the factors in the neoclassical framework. The growth of urban region, on the other hand, may be attributable to technological innovation in its own region possibly due to positive urban agglomeration economies.

Let us examine the contributions of these factors to the income differential by a simple model using a regional production function. Suppose that each region produces an identical commodity with the Hicks-neutral regional production function of homogeneous of degree one in K_i(capital in region i), and L_i(labor in region i):

$$Y_i = A_i F(K_i, L_i),$$

where technical progress is embedded solely in the term A_i. Differentiating per capita regional income $y_i (\equiv Y_i/L_i)$ with respect to time, we obtain

$$\frac{\dot{y}_i}{y_i} = \frac{\dot{A}_i}{A_i} + \pi \left(\frac{\dot{K}_i}{K_i} - \frac{\dot{L}_i}{L_i}\right) \tag{3}$$

where π $(\equiv \frac{K_i}{F} \frac{\partial F}{\partial K_i})$ is the distribution rate of capital which is assumed to be constant over time.

Suppose positive agglomeration economies exist at the regional production level, such as localization economies and urbanization economies, then a region experiences increasing returns to scale, or A_i is positively associated with output, labor, capital, or per capita income. One simple assumption would be that the growth rate of technical progress is endogenous and dependent upon per capita income level because high-income region has resources to spend on research and development which contribute to the technical progress. However, technical progress is induced by per capita income not only in its own region but also in other regions through spatial diffusion of technology (Krugman, 1979). The interregional technological diffusion hardly takes place in the early stages of development because of high communication costs, but it is gradually increasing in accordance with interregional socio-economic integration. Thus, the following may be one possible specification of agglomeration economies and technological diffusion:

$$\frac{\dot{A}_i}{A_i} = f(y_i) + \theta_1(t) \sum_{j \neq i}^{n} f(y_j), \tag{4}$$

where $f(y_i) > 0$ and $f'(y_i) > 0$ ensuring increasing returns to scale at each regional level, and the 'diffusion' parameter $\theta_1(t)$ is an increasing function of time t. We may safely assume that $\theta_1(0) = 0$ since no diffusion occurs in the initial period; and that $\theta_1(+\infty) = 1$ since technical progress is for common use in the mature stage.

The second term of the right hand side of (3) is the growth rate of capital minus that of labor. The former may be considered a function of the ratio of regional to national marginal productivity of capital, and the latter may be a function of regional to national marginal productivity of labor. If constant returns to scale prevail with respect to capital and labor, then these productivities become a function of capital/labor ratio and hence per capita income. The growth rate of capital minus that of labor is therefore expressed as:

$$\pi\left(\frac{\dot{K}_i}{K_i} - \frac{\dot{L}_i}{L_i}\right) = \theta_2(t)g(y_i/\bar{y}), \qquad (5)$$

where the 'mobility' parameter $\theta_2(t)$ is also an increasing function of time t, and $g'(y_i/\bar{y}) < 0$. Whereas $\theta_1(t)$ exhibits a degree of interregional technological diffusion, $\theta_2(t)$ shows interregional mobility of capital and labor which is inversely related to interregional migration costs of capital and labor. Negative $g'(y_i/\bar{y})$ means that capital movement from regions j to i and/or population growth due to net migration from regions i to j occur if per capita income in region j is greater than that in region i. Note that for mathematical tractability, the specification of (5) is slightly different from a conventional neoclassical specification, say Dendrinos (1982).

Consider the unweighted coefficient of variation (1) appeared in Section II. Use of the simple average is just for computational convenience. The direction of the change in the square of the coefficient of variation is the same as that in the coefficient of variation, since $\dot{V^2} = 2V\dot{V}$.

Since $\dot{\bar{y}} = \frac{1}{n}\sum_i \dot{y}_i$ by definition, and using equations (3), (4) and (5),

$$\dot{V^2} = \frac{1}{n}\sum_i 2\left(\frac{y_i}{\bar{y}} - 1\right)\frac{\bar{y}\,\dot{y}_i - y_i\dot{\bar{y}}}{\bar{y}^2}$$

$$= \frac{2}{n^2\bar{y}^3}\left[(1-\theta_1(t))\sum_j\sum_i (y_j - y_i)f(y_j)y_iy_j + \theta_2(t)\sum_j\sum_i (y_j - y_i)g(y_j/\bar{y})y_iy_j\right]. \tag{6}$$

Let us show that the first term of the right hand side of (6) is non-negative and that the second term is non-positive for any y_i. As $f'(y_i)$ is positive, the first summation term is:

$$\sum_j\sum_i (y_j - y_i)f(y_j)y_iy_j = \sum_{j>i}\sum (y_j - y_i)f(y_j)y_iy_j + \sum_{j<i}\sum (y_j - y_i)f(y_j)y_iy_j$$

$$= \sum_{j>i}\sum (y_j - y_i)f(y_j)y_iy_j + \sum_{i<j}\sum (y_i - y_j)f(y_i)y_jy_i$$

$$= -\sum_{j>i}\sum (y_i - y_j)(f(y_i) - f(y_j))y_iy_j$$

$$\leq 0,$$

with equality holding only if $y_i = \bar{y}$, $\forall$ i.

Similarly, as $g'(y_i/\bar{y})$ is negative, the second summation is shown to be non-negative. It should be mentioned that if both $f(y_i)$ and $g(y_i/\bar{y})$ are constants, then y_i grows exponentially and $V(t)$ becomes constant. In other words, when the unweighted coefficient of variation increases, each y_i must grow faster than the exponential due to the dominance of agglomeration economies. And, when the unweighted coefficient of variation decreases, each y_i must grow slower than the exponential.

Thus, the first term representing the agglomeration economies contributes to the divergence of the coefficient of variation in the initial period, but the second term showing interregional movements of capital and labor in response to their marginal productivity differentials operates to converge the coefficient of variation as in the recent period. The latter is consistent with the result obtained by Sakashita and Kamoike (1974) who proved convergence of the regional per capita income to a common value in the absence of increasing returns to scale in a general regional production function.

The relative magnitude is of course dependent upon the parameters of $\theta_1(t)$ and $\theta_2(t)$, whose values are exogenously determined by time. If t is small enough, then the second term would dominate the first term leading to the divergence of the coefficient of variation. If t is infinity, then the first term vanishes and hence the coefficient of variation must converge. This is consistent with Williamson's bell-shaped curve of the coefficient of variation and Figure 1 in Section II, i.e., the past widening trend and recent narrowing trend in interregional per capita income inequality.

An increase in $\theta_1(t)$ as a proxy for the technological diffusion and socio-economic integration may increase $\theta_2(t)$ by facilitating the interregional migration of capital and labor, or conversely the latter may increase the former. If the relationship is simply linear, then

$$\theta_2(t) = \gamma\theta_1(t) + \delta , \tag{7}$$

where γ and δ are non-negative parameters. It can be shown in general that if (7) holds, then depending upon initial conditions, (i) <u>the coefficient of variation diverges initially and converges afterwards</u>, or (ii) <u>the coefficient of variation always converges with the passage of time</u>.

Since $0 \leq \theta_1(t) \leq 1$, $\delta \leq \theta_2(t) \leq \delta + \gamma$. From (6), the following relationship should hold when $\dot{V}^2 = 0$.

$$\begin{aligned}\theta_1(t) = \frac{Z - \delta}{Z + \gamma} &\equiv F(y_1, y_2, \ldots, y_n) \\ &\equiv G(V, y_2, \ldots, y_n),\end{aligned} \tag{8}$$

where $Z = -\sum_j\sum_i(y_j - y_i)f(y_j/\bar{y})y_iy_j \;/\; \sum_j\sum_i(y_j - y_i)g(y_j)y_iy_j$ (≥ 0). Note that this explicit expression with respect to $\theta_1(t)$ is not obtained without the <u>linear</u> assumption of (7). While $0 \leq \theta_1(t) \leq 1$, $-\delta/\gamma \leq G(V, y_2, \ldots, y_n) \leq 1$ because Z ranges from zero to infinity.

Figure 5 illustrates the phase diagram of V(t) and $\theta_1(t)$. The heavy line shows equation (8), and the trajectories of V(t) and $\theta_1(t)$ are drawn by the arrows. Whereas $\theta_1(t)$ always increases over time, V(t) increases below the line and decreases above the line. By definition of $\theta_1(t)$, the initial point should lie on the horizontal axis of $\theta_1(0) = 0$, and the final point should lie on $\theta_1(+\infty) = 1$.

We now obtain the bell-shaped curve of V(t) (case (i) above) if an initial condition is right to A. It seems topologically obvious in this case that every trajectory intersects the heavy line of (8) at most once because G(•) is continuous and single-valued. However, if an initial point lies on the segment OA, then the coefficient of variation monotonically converges over time (case (ii) above).

We can assume the presence of the diffusion parameter $\theta_1(t)$ and the mobility parameter $\theta_2(t)$ to derive the bell-shaped curve of $V(t)$. It is clear that if $\theta_2(t)$ were permanently zero but $\theta_1(t)$ were not, i.e., no interregional factor movements is allowed, then $V(t)$ would always diverge. But, what if $\theta_1(t)$ should be permanently zero but $\theta_2(t)$ should not, i.e., no interregional technological diffusion should take place? Since both the first and second terms in (6) do not disappear for large t or for large y_i's, it may be useful to consider the exponent of y_i in each term so as to investigate the sign of $\dot{V}(t)$. While the exponent in the second term is 3 because $g(y_i/\bar{y})$ is dimensionless, that in the first term is greater than 3 because $f'(y_i) > 0$. This means that $V(t)$ diverges for large y_i's in the absence of the diffusion parameter $\theta_1(t)$. We can thus conclude that <u>both $\theta_1(t)$ and $\theta_2(t)$ are indispensable for the convergence of the unweighted coefficient of variation</u>.

V. CONCLUSION

The temporal relationship between per capita income and labor share in each region was investigated in Section III. Based upon the empirical findings in Section II, the income and labor dynamics may be briefly summarized in Figure 4 exhibiting an arc trajectory in each region of Japan. Interregional equilibrium in labor market is then expressed as a straight line on which per capita nominal income is balanced with the cost of living in every region.

Next, by use of Sims' test of causality, it was revealed that in postwar Japanese prefectures the interregional income differential is exogenous to the net migration rate, but not vice versa. However, since lags used in the Sims' test range from -3 to +6 years, and since the model specification is linear, it is quite within the bounds of possibility that the reverse temporal relationship (i.e., income differential follows migration) is not statistically detected. In theory, it is obvious that cumulation of the net migration contributes to the convergence of interregional income differential. We may therefore say that while migration is strongly affected by income differential in the short-run, income differential is weakly affected by migration in the long-run.

Thirdly, a simple growth model was developed to account for both the past divergence and the recent convergence trend in the coefficient of variation of regional per capita income. It was assumed that technological progress is positively related to per capita income due to agglomeration economies, that the level of spatial diffusion of technology is monotonically increasing over time, and that the marginal productivity differentials between regions determine the capital and labor migration whose speed is also monotonically increasing over time. It was shown that depending upon the initial conditions of y_i, the unweighted coefficient of variation diverges initially and converges afterwards, or it always converges with the passage of time.

Finally, it should be noticed that both technological diffusion and factor mobility are indispensable for the convergence of the coefficient of variation, and that the existence of positive agglomeration economies is essential to the divergence of the coefficient of variation. The latter would be relatively dominant in the early stages of development while the former would be dominant recently, which leads to the bell-shaped curve of the interregional differential in per capita income.

FOOTNOTES

1 Since the variables in their model are in relative terms, the population changes comprize not only migration but also natural growth. However, the latter is usually small in magnitude in most developed countries, and hence may be ignored.

2 In general, prefecture- or state-based data are so aggregated that changes in intraregional but intercity distribution of labor and income would be concealed, which prevents us from obtaining the systematic trajectories like Figure 4 in empirical studies.

3 It may be possible to consider the temporal relationships between interregional wage differential and migration. However, as Tabuchi (1983) demonstrated, the ratio of urban to rural wage rates increases over time for 1954-79, and the change in its coefficient of variation is relatively small at all times possibly due to the rigidity in the regional wage rates Johnson (1983). Hence, at least statistically, migration decision may be based not upon the average wage differential, but upon the utility differential which is a function of the income differential.

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Coefficient on lag of	M on V with future	M on V without future	V on M with future	V on M without future
-3	-5799 (-0.84)		-0.7104×10^{-5} (-1.08)	
-2	-3899 (-0.37)		0.7832×10^{-5} (0.67)	
-1	4147 (0.38)		1.5957×10^{-5} (1.38)	
0	16008 (1.53)	12133 (1.85)	0.6300×10^{-5} (0.54)	3.3420×10^{-5} (5.21)
+1	30432 (2.96)	28253 (2.82)	-0.7261×10^{-5} (-0.58)	-1.7328×10^{-5} (-1.32)
+2	20534 (2.02)	18873 (2.09)	0.4369×10^{-5} (0.43)	0.2991×10^{-5} (0.25)
+3	-6794 (-0.67)	-5021 (-0.64)	0.0883×10^{-5} (0.15)	0.0983×10^{-5} (0.13)
+4	-6093 (-0.61)	-5115 (-0.61)	0.7851×10^{-5} (1.55)	0.7432×10^{-5} (1.10)
+5	-10361 (-1.17)	-10358 (-1.19)	0.0808×10^{-5} (0.16)	0.1994×10^{-5} (0.31)
+6	-9867 (-1.50)	-7210 (-1.11)	-0.5544×10^{-5} (-1.48)	-0.4115×10^{-5} (-0.97)
constant	-2511 (-3.37)	-3168 (-4.69)	0.1359 (18.67)	0.1297 (15.54)
Degrees of freedom	9	12	9	12
$\bar{R}^2$	0.984	0.983	0.982	0.965
Durbin-Watson	1.43	1.44	2.60	2.52

(t-values are in parentheses.)

Table 1 Regressions of the Net Migration on the Coefficient of Variation, and Regressions of the Coefficient of Variation on the Net Migration

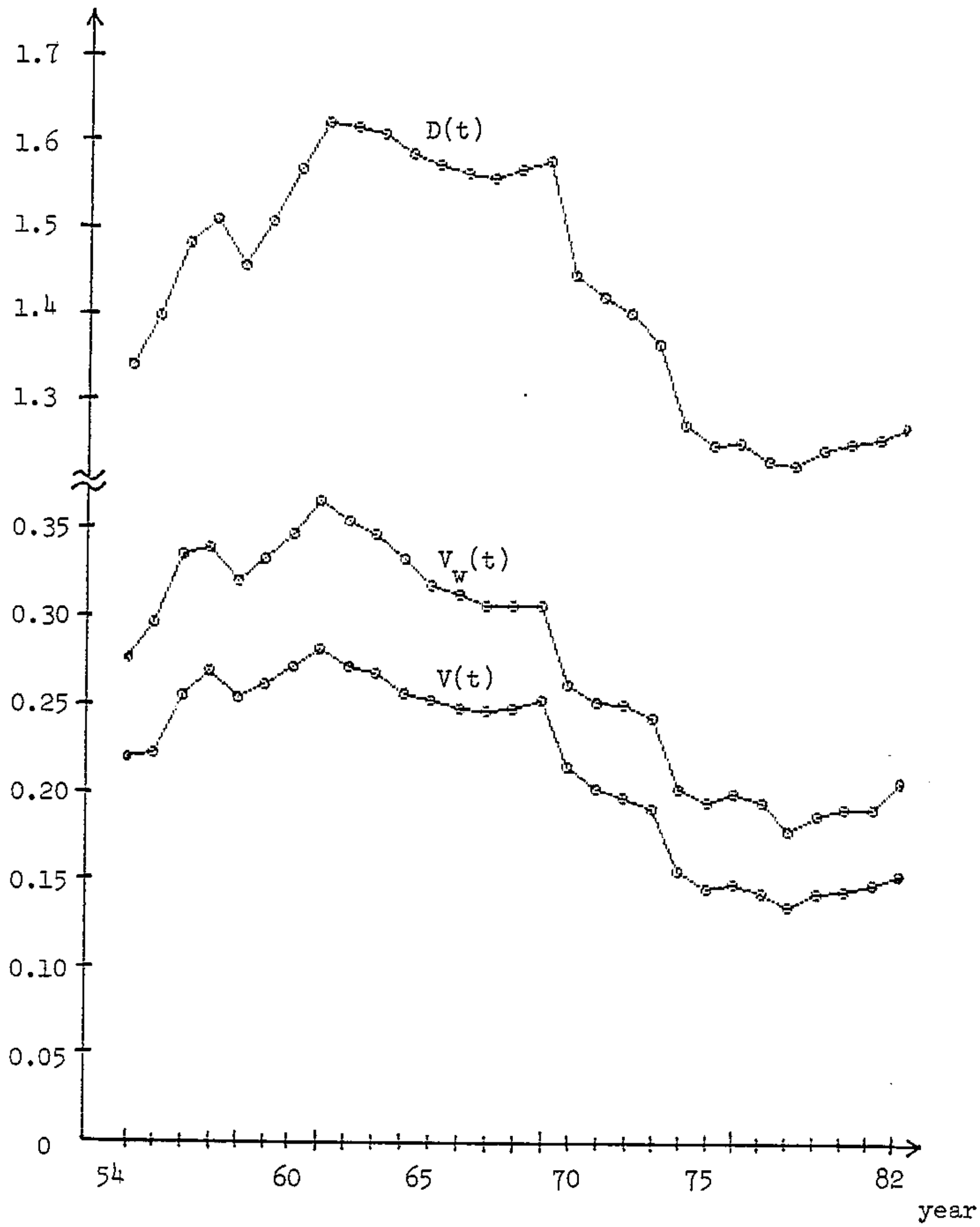

Figure 1 Weighted and unweighted coefficients of variation in per capita prefectural income, and urban/rural per capita income ratio

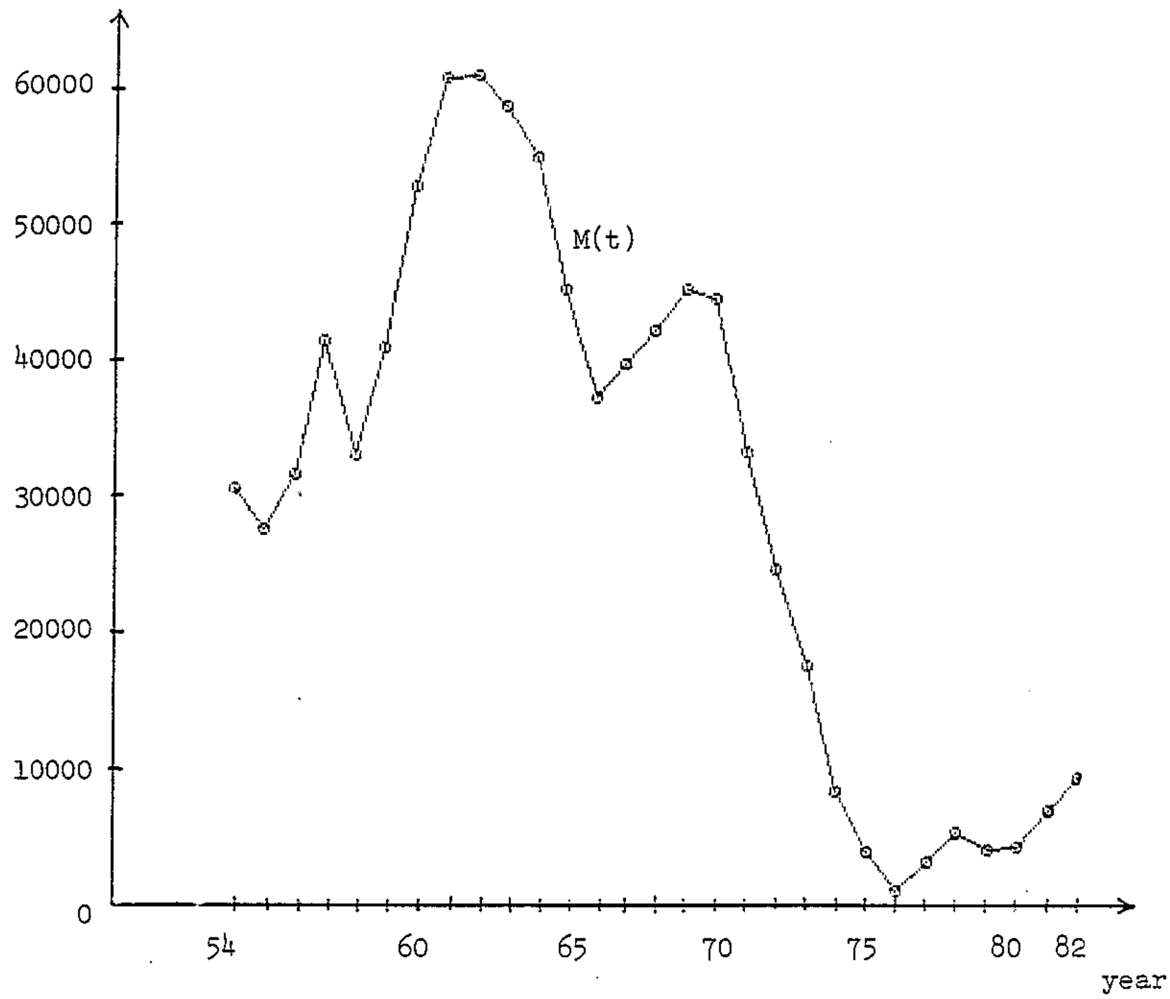

Figure 2 Net migration from urban regions to rural regions

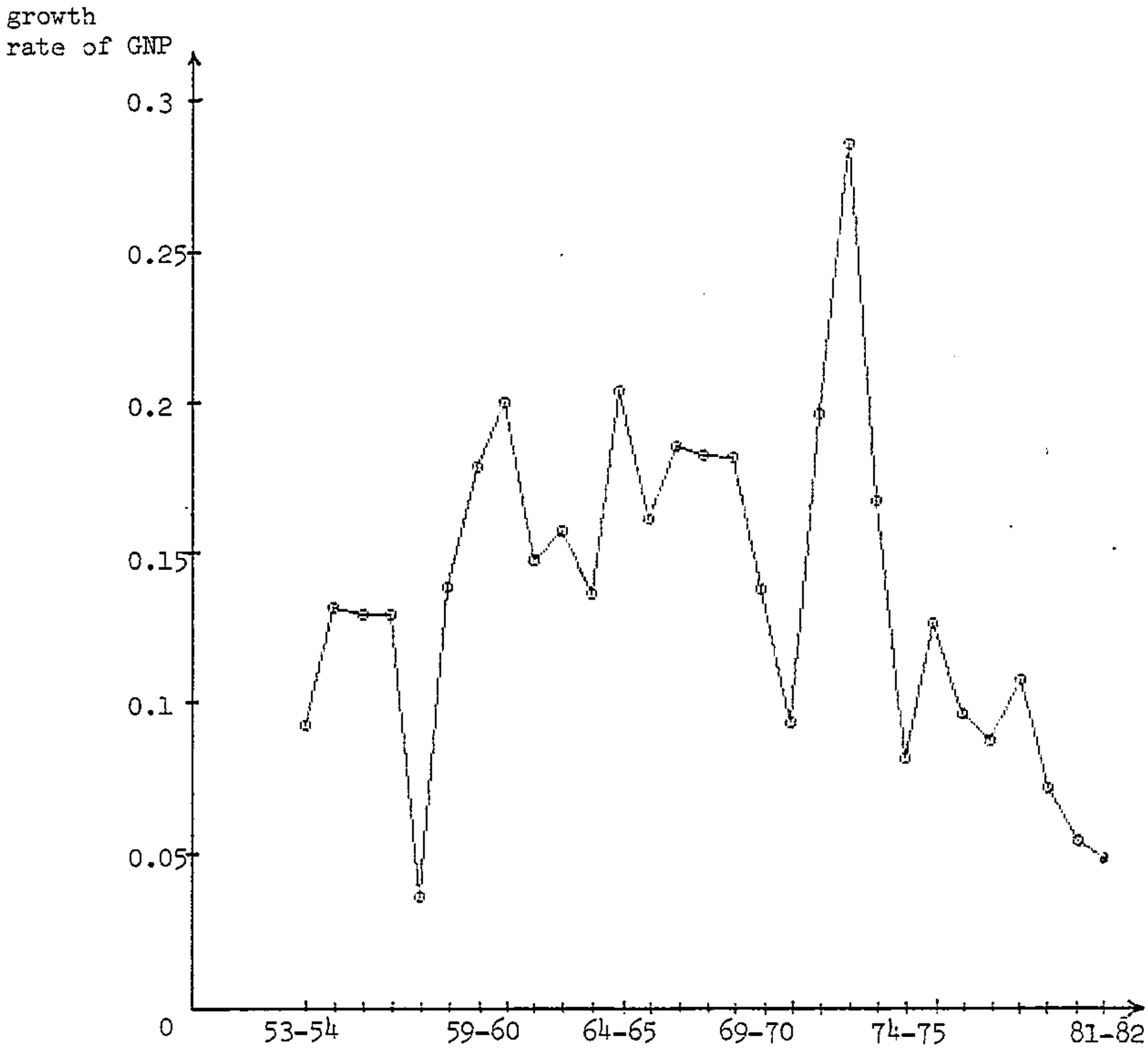

Figure 3 Growth rate of current gross national product

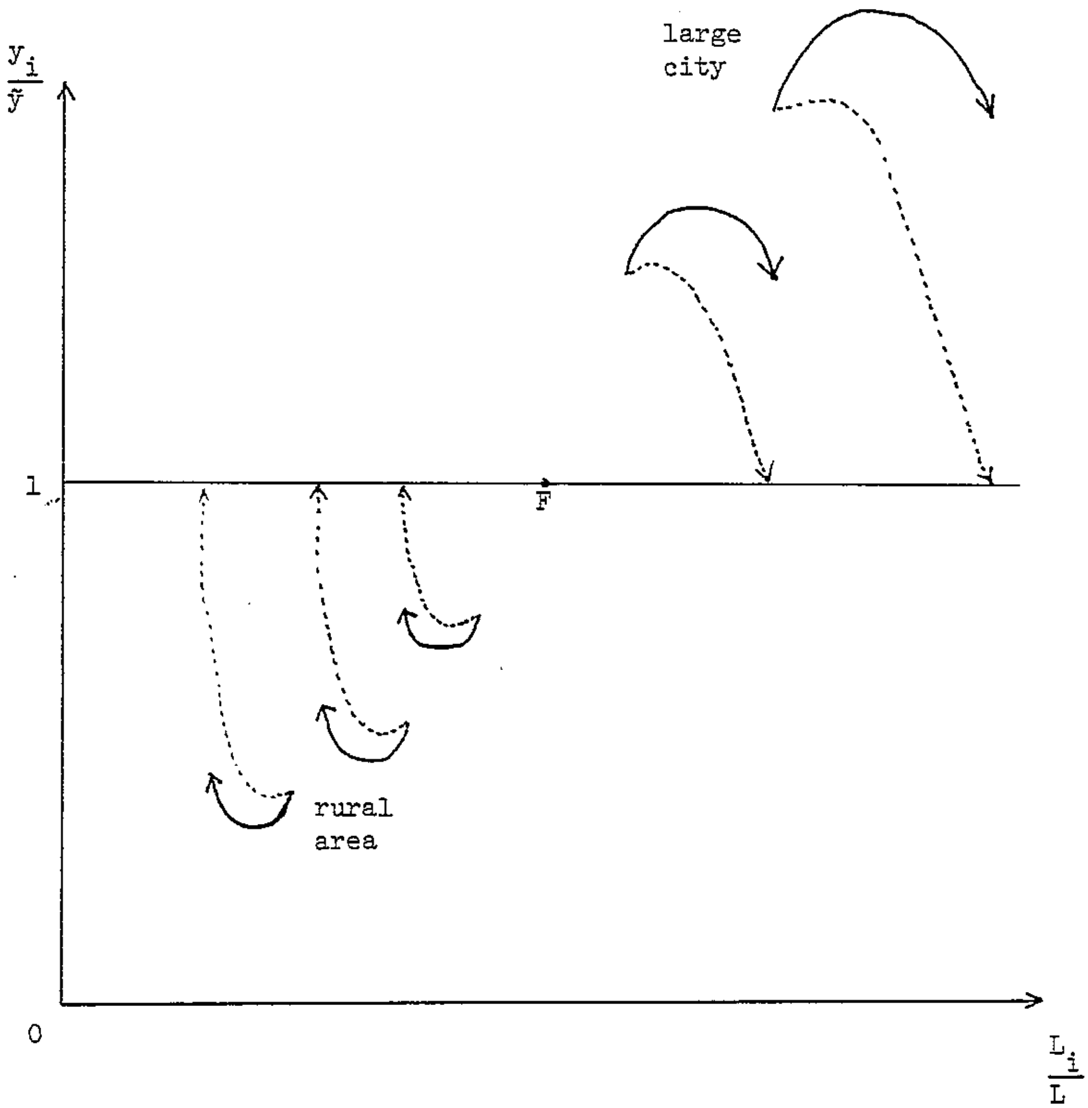

Figure 4   Dynamical relationship between the per capita income ratio and the labor share

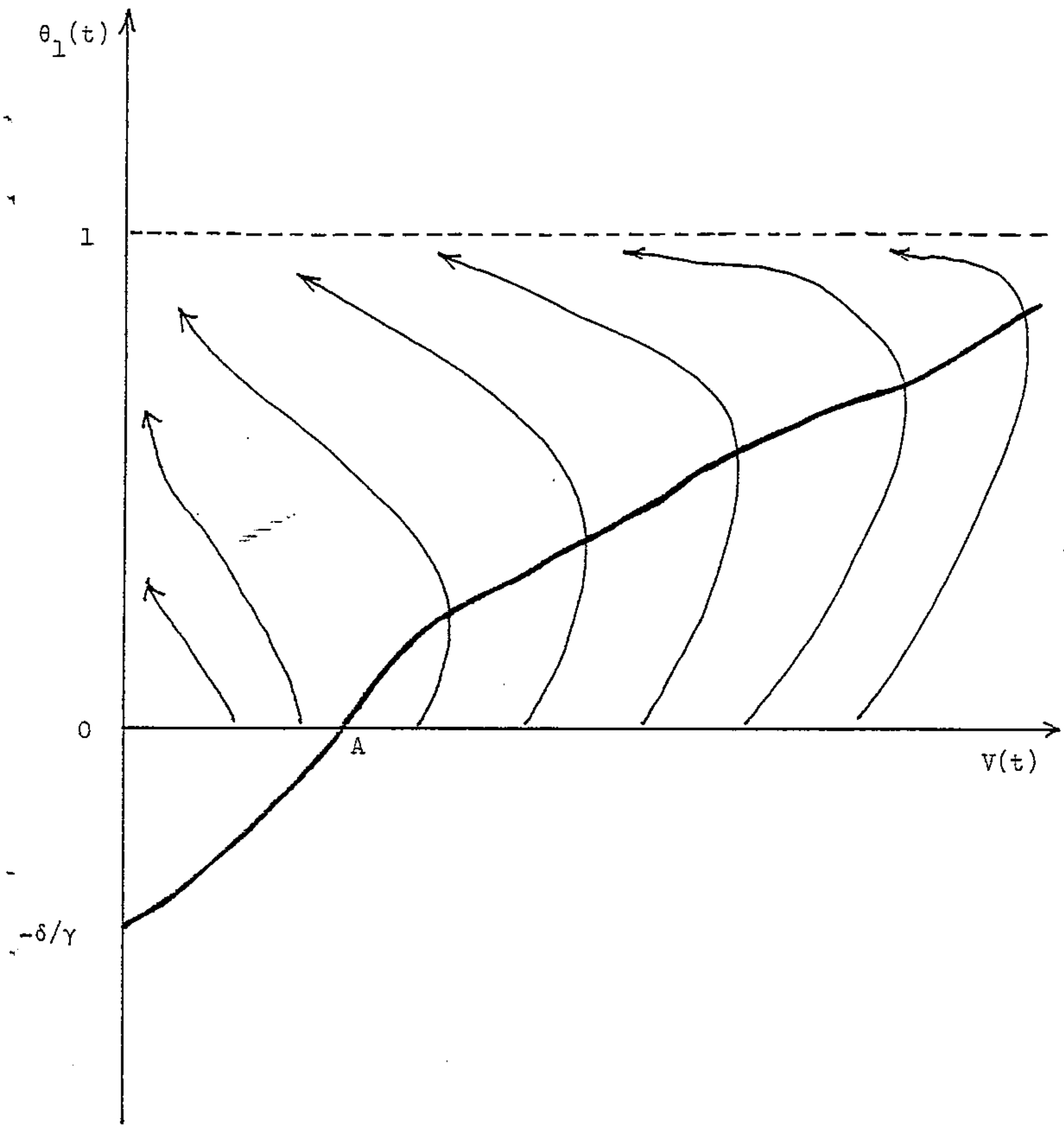

Figure 5 Phase diagram of V(t) and $\theta_1(t)$