

Accounting For Subnational Economic Growth: The Hawaiian Experience, 1900-1976

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Renewed interest in growth accounting as a means of analyzing the long-term performance of an economy has recently coincided with a noticeable slowdown in the U.S. productivity growth rate.¹ Although these studies have focused mainly on national rates or averages, they have noted significant regional or subnational variations. For example, Denison found regional growth rates ranging from 2.0 percent in New England to 4.4 percent in the Far West against a national growth rate of 2.9 percent for total product from 1929 to 1957 (1962).²

However, there does not appear to have been any systematic attempt to analyze long-term trends and sources of growth at the subnational level. As in other regional economic studies, this may be attributed to lack of necessary statistical information and the feeling that regional or subnational developments may be dominated by overall national trends and policies. Nevertheless, it is our feeling that growth analyses, with adequate recognition of data limitations, can provide useful insights for state and local social and economic policy.

This paper represents a first attempt to apply growth accounting methodology to a state or subnational jurisdiction. Hawaii, as an insular economy only recently attached to the United States, has had a comparative advantage over other regional entities in the production and availability of statistical data and economic accounts and seemed a natural starting point for subnational growth analysis.³ The rest of this paper will present brief highlights of the Hawaiian growth record, estimates and analysis of rates and sources of growth, and some concluding observations on the state growth process. For convenience of perusal, the analytical framework, underlying assumptions, and algorithm for the growth estimates are placed in an appendix.⁴

HIGHLIGHTS OF HAWAIIAN ECONOMIC GROWTH, 1900-1976

The Hawaiian growth record is summarized in Table 1. Basically, it reflects the combined impact of modernization, urbanization, and educa-

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tional improvement—factors considered by development economists to be essential for economic growth (Oshima and Ono).⁵ It is customary in growth studies to identify shorter intervals within the overall time span of the investigation so as to analyze special relationships which may have influenced the longer-term results. The convention followed in this paper is to use decennial periods, commencing with census years, mainly for data availability. However, the periods are roughly coincidental with distinctive stages of Hawaiian economic development. Thus, the period from 1900-1940 was one of agricultural expansion and Hawaii's emergence as a mid-Pacific military base; the average growth rate of real income is estimated at 3 percent per annum. The period from 1940-1950 saw accelerated military expansion, with an estimated growth rate of 5.5 percent. From 1950-1960, the islands went through a postwar adjustment stage, with a continued decline in agricultural activities, increasing economic diversification, and a political union with the other 49 states; the average growth rate is estimated at 4.5 percent. The decade of the sixties saw overall expansion based on the post-Statehood growth in tourism, construction, and related service and manufacturing activities, with an estimated growth rate of 5.2 percent. The most recent period indicated in Table 1 saw a decline in the growth rate to 3.4 percent, which may be attributed to national economic fluctuations and international uncertainties (e.g., energy shortages).

However, since the purpose of this article is to account for basic sources of growth, rather than analyze fluctuations in growth rates, we will focus on the longer-term trends. Thus, between 1900 and 1976, State Income (SI) increased from \$38 million to \$6,230 million (current dollars). In the

TABLE 1
State Income (Current and 1967 dollars),
Per Worker and Per Capita Income, 1900-1976

Year	State Income (SI) Mil. \$	Deflator 1967=100	State Income (SI) 1967 \$ (1) / (2)	Index	Per Worker Income	Per Capita Income
1900 (1901)	38.1 (est.)	17.4	219.0	1.000	2,429	1,420
1910	44.5	20.0	222.5	1.016	2,205	1,151
1920	152.2	27.3	557.5	2,546	4,995	2,138
1930	168.9	34.6	488.2	2,229	3,168	1,327
1940	280.3	39.4	711.4	3.248	3,935	1,663
1950	796.1	65.1	1,222.9	5.584	6,422	2,456
1960	1,595.3	84.0	1,899.2	8.672	7,400	2,960
1970	3,613.9	115.0	3,142.5	14.349	9,307	4,059
1976	6,229.5	161.7	3,852.5	17.591	9,858	4,345

Sources: Hawaii Dept. of Planning and Economic Development, Income and Expenditure Accounts; Robert Schmitt, *Historical Statistics of Hawaii*.

same period, the Gross State Product (GSP) deflator increased from 17.4 to 161.7 (1967 = 100). Adjusting the State Income by these deflators resulted in SI values of \$219.0 million and \$3,852.5 million (in 1967 \$) in 1900 and 1976, respectively. These SI values showed an 18-fold increase, averaging about a 3.8 percent annual increase over the 76 years. This 3.8 percent annual average growth rate is the capacity benchmark used for subsequent computations.

In addition, the population increase averaged 2.3 percent during this period. Therefore, per capita real income increased 1.4 percent per annum from 1900-1976. At the same time, employment grew at 1.9 percent and per worker income also increased at a 1.9 percent average annual rate.

ESTIMATION AND ANALYSIS OF SOURCES OF HAWAIIAN ECONOMIC GROWTH, WITH U.S. COMPARISONS

As indicated, the basic analytical framework, underlying assumptions, and algorithm for computation of the contributions of various sources of growth to the overall growth rate are described in the appendix. Essentially, the estimation procedure follows the format devised by Denison for his U.S. growth accounting studies and his comparative analyses of growth rates of other countries. The results of our first-step investigation of sources of Hawaiian economic growth are summarized in Table 2.

The average growth rate of real state income in Hawaii from 1900-1976 has been estimated at 3.8 percent per annum. In comparison, real U.S.

TABLE 2

Sources of Growth, Hawaii State Income, 1900-1976

Source of growth	Average annual growth rate (percentage points)	Contribution to growth rate (percent)
State income	3.8	100
Total factor input	2.31	62
Labor	1.71	46
Employment adjusted for hours	.95	25
Education	.80	21
Capital	.60	16
Construction	.30	8
Equipment	.30	8
Land	.00	0
Productivity factors	1.44	38
Advances in knowledge	.83	22
Economies of scale	.38	10
Residual	.23	6

Sources: Sources and procedures used in calculating the above data have been summarized in this paper and are more fully described in the unpublished "Growth Accounting Analysis of the Hawaiian Economy—Selected Years from 1900-1976."

Gross National Product (GNP) increased from 1909 to 1959 at 2.9 percent per annum.⁶ From 1929 to 1969, real U.S. National Income increased at a 3.3 percent annual rate. For Hawaii, real State Income increased 4.3 percent annually between 1910-1960, 4.8 percent per annum between 1930-1970, and 3.4 percent per annum from 1970-1976. Denison's U.S. calculations show a negative growth rate (-0.54 percent per annum) from 1973-1976 (1979).

Thus, starting from its much smaller base, the Hawaiian growth rate has remained above the U.S. rate, with changes roughly paralleling national changes. This illustrates a "catching-up" process for the less-developed economy, as well as the growing interdependence between the two.

Following the estimating algorithm, we proceed to calculation of the contribution of the different sources of Hawaiian economic growth.

Factor input shares of total output. The average unweighted labor return (including self-employed) share of state income was estimated to be 73 percent, while the capital return share was assumed to be 27 percent (residual). Denison shows for U.S. from 1909-1958 a 71 percent labor share of national income, 22.8 percent for reproducible capital and a 5.8 percent land share. From 1900-1976, the labor share of Hawaii State Income grew from about 64 percent to about 81 percent, primarily because of increasing supplementary payments to employees, including the self-employed. A similar trend is indicated for the United States: from 1909 to 1957, the labor share rate increased from 60 percent to about 83 percent, declining to 80 percent by 1968.

Returning to the assumptions underlying the analytical model, the implications of these findings are that a gain of one percent in labor quantity input should result in a .73 percent increase in State Income—labor price, production methods, and other things remaining constant. The further assumptions here are that sufficient effective demand is available to absorb all new factor input supply into employment and that contributions of factor inputs relate to improvement in long-term productive capacity.

Contribution of labor input. The relatively greater availability of information enabled a closer analysis of factors affecting the contribution of labor input to Hawaiian economic growth. Between 1900 and 1976, persons employed increased from 90,172 to 390,303 a fourfold increase (about 1.9 percent per annum). The population increased at a 2.3 percent annual rate. Thus, the worker-resident population elasticity rate was .83 during this period. A one percent resident (not counting visitors) population increase was related to about a 0.8 percent increase in employment.

For the United States, both employment and population increased 92 percent between 1909 and 1958, for an average annual growth rate of 1.3 percent. The average worker/population elasticity rate was about 1.0.

To obtain the labor input contribution to overall growth, employment increases must be adjusted for changes in working hours. The number of hours worked per employed person in Hawaii declined 40 percent from 3,182 to 1,920 hours per annum. This may be attributed to mechanization of agricultural activities, unionization and improved labor conditions, and

the increase in industrial, service, and government employment, where paid vacations and 40-hour weeks have become standard contract items. In 1900, it was estimated that the average worker spent 61.2 hours per week working; but in 1976, the comparable rate was 40.0. The estimated number of weeks worked decreased from 52 to 49 weeks per annum. For the U.S., Denison estimated that average hours worked dropped 25 percent from 2,704 in 1909 to 2,057 in 1958.

If annual hours worked per person in Hawaii had remained constant from 1900-1976, the labor input contribution would have been 1.39 percentage points per annum. The reduction in working hours decreased the labor input contribution to an average annual growth rate of 1.3 percent. This labor input growth rate (1.3 percent) was next multiplied by the labor share rate (73 percent) to obtain a labor contribution of 0.95 percent per annum toward the overall growth rate. Dividing .95 percent by 3.8 percent gives the contribution of labor inputs (employment adjusted by hours) toward long-term Hawaiian productive capacity. This labor input contribution "explains" about 25 percent of the growth rate, with a possible over-estimation since it was assumed that employment covered only full-time workers.

There are many growth policy implications for researchers in other subnational areas, relating to this summary measure. Thus, working hours and employment data can be divided into various demographic, social, and economic groups. As noted by Denison, employment changes are related to changes in working age population, labor force participation rates, voluntary vs. involuntary unemployment (1962, Chapter 6). Working hour changes are related to the ratio between potential and actual average working hours per week, average weeks worked per year, and so on. In turn, these are affected by work stoppages, nutrition, and health status of the population, propensity for leisure, use of leisure time, family/household work patterns, lost labor due to crime and other activities and public policies on maintenance of employment. Simulation techniques can be applied to formulate different "what if" scenarios (under limiting assumptions) regarding how different socio-economic activities impact long-term productive capacity, e.g., what would be the gain in retrieving lost labor from those unemployed or underemployed or from the prevention of institutional commitment through education and social rehabilitation. Research along these lines can be useful in evaluation of state and local program priorities and funding commitments in view of proposed federal cutbacks.

Improvement in labor quality (education). The major proxy for measurement of the contribution of improvement in labor quality to long-term growth in this and other studies has been through the educational component. Between 1900 and 1976, the median school years completed per person increased from 3.5 to 12.7 years, an average annual growth rate of 1.7 percent. Average income of employed persons increased from \$1,621 to \$4,123 (in 1967 \$) over this period (a 2.2 percent rate). Not all of this income improvement is due to educational attainment alone; other factors

such as native ability, household environment, and availability of mass communication techniques must be considered. Following Denison, we have calculated roughly one-half of the real income gain or 1.1 percent per annum to be attributed to "pure" educational attainment.⁷ Thus, the education input of 1.1 percent is multiplied by 73 percent (labor share of income) to obtain the growth rate attributable to education (0.8 percent). Dividing 0.8 percent by 3.8 percent gives 21 percent, the contribution of formal educational attainment toward the long-term Hawaii state income-generating capacity. This finding confirms the general proclivity of largely immigrant populations to place greater emphasis in their spending and savings patterns on educational attainment for their subsequent generations.

Denison finds initially that educational attainment contributed 20 percent toward improvement in the U.S. growth rate during the 1909-57 period. For 1920-57, he found originally that education contributed 23 percent of the growth rate, but in a later study he revised the figures downward to 13 percent, noting reductions in the number of days attended per school year and changes in the bias estimates of Census data.

Implications of these findings for national and subnational growth policy are obvious. Unquestionably, adequate educational attainment is a prerequisite for expansion and improvement in long-term productive capacity. In Hawaii, for each one percent increase in school year completed, there appears to be a 1.4 percent gain in worker's income. However, for education to be fully cost-effective, there must be available jobs (through effective demand creation and investment) to absorb the growing supply of graduates. This analysis has related primarily to long-term productive capacity analysis; the demand side of the production function has not been examined. Further investigation will be required to avert potential and costly mismatches between the supply and demand of educational output in various subnational areas. Another area of research is the analysis of potential gains to be made by "permanent" labor commitment, which is operational here in Hawaii and may be a factor in other areas, because of barriers to full labor mobility. For example, the overall labor quality of Hawaii's working population may be higher than that of many mainland states because of possible tradeoffs between Hawaiian "amenities" and better compensation on the Mainland for the same type of work.

Between 1900 and 1976, then, the quantity and quality contribution of labor amounted to 46 percent or 1.71 percentage points of the average annual growth rate. Denison's comparable figures for the U.S. from 1909-1957 were about 34 percent for employment and hours, 20 percent for education, and 3 percent for better labor utilization, sex-age composition changes, and so on.

Contribution of capital. Estimates for the capital contribution and productivity improvement categories of this study are most tentative because of limitations in data availability and continuing methodological refinement (Denison, 1979; Kendrick, 1980; Stone). To arrive at our capital estimates,

we have used the same methodology as for the labor input calculations with additional assumptions as detailed in the 1979 report.

Between 1900 and 1976, the average annual growth rates of equipment and construction inputs into the economy were estimated to be 5.0 percent and 4.8 percent, respectively. The capital share of state income, after depreciation was calculated conservatively at about 6 percent. Weighting the two growth rates by 6 percent resulted in a contribution of about .3 percent each per annum for producer durable equipment and net construction investment expenditures. These rates were then divided by 3.8 percent, resulting in contribution to the average annual growth rate of 8 percent each for equipment and construction, or a total contribution of 16 percent for the capital component. The net impact of changes in inventories and Hawaii-owned assets abroad on the Hawaiian growth rate were assumed to be small, but will require further analysis.

Overall, the relative capital contribution appears to be underestimated.⁸ Denison shows contribution of private structures and equipment to growth of 15 percent for the period 1909 to 1957. His coverage also includes inventories and net foreign assets abroad, which we excluded from our analysis. However, he excluded the sizable public capital input, which we included in our analysis because of the relatively large public economic activity base of the Hawaiian economy, for the military complex and to meet infrastructural requirements of modernization. Needless to say, the Hawaiian-computed data must be regarded as initial (tentative) estimates.

Residual productivity factors. Thus, between 1900 and 1976, labor input changes accounted for 46 percent, while capital input changes accounted for 16 percent of the long-term (76 years) improvement in Hawaiian production capacity. This leaves a residual of 38 percent to be explained by factor productivity increases due to advances of knowledge, economies of scale, shift from agriculture to nonagricultural employment, reduced labor utilization waste, and other reasons. As indicated, the state of the art for deriving such estimates is extremely rudimentary.

Here, a simplified approach is used, primarily to obtain first estimates. This essentially involves calculating output elasticities and relating them to explanations of factor productivity. This requires computing percentage change of output and dividing by the percentage change of the productivity factor analyzed.

For example, to assess the impact of advances in knowledge, elasticity measures were derived by relating increases in number of firms engaged in research and development activities, professional and scientific employment, membership in professional societies, and transpacific telephone communications to the growth of state income over specific periods for which such information is available.⁹ Similarly, the impact of economies of scale due to widening markets was approximated by relating increases in the number of telephones in service, adjusted by reductions in long distance rates, to the growth in real state income. Other relationships come readily to mind, but results must be considered highly tentative until

interrelationships are more thoroughly analyzed and more comprehensive measures are tested.

Applying output/factor elasticity rates resulted in the following:

- (1) Of the residual (factor productivity), advance of knowledge contributed 22 percent to total economic growth. This rate is consistent with past technological progress in Hawaiian agricultural activities, the growth in research and development activities associated with the defense establishment, and general improvement in scientific capacity of higher education institutions (e.g., the University of Hawaii has ranked among the leading 50 institutions in receipt of federal research grants over the past 10 years).
- (2) Economies of scale contributed about 10 percent toward raising the long-term economic growth rate.
- (3) The residual, including reallocation of resources (farm to nonfarm employment) and other variables, was reduced to 6 percent for further analysis.

For other subnational areas, research on the growth effects of policies and programs designed to increase factor productivity will be both fruitful and necessary. This is particularly so for areas facing declining population growth or outward movement of capital and/or labor (e.g., New England and some of the mid-East and mid-West States). The key questions involve interrelationships between technological progress and economic growth. The role of academic institutions, research facilities, technological innovation and adaptation has been stressed in regional studies. However, the reverse relationship—the effects of economic growth and economic scale on technological progress and thus long-term growth rates—merits detailed investigation.

CONCLUSIONS

This paper has attempted to apply concepts and principles of growth accounting analysis and derive quantitative measures of rates and sources of growth in a subnational economy over a given time period—in this case, the State of Hawaii since the turn of the century. Summary results of the study, which highlights a more detailed report for the state government, are contained in Table 2.

The gist of this assuredly and admittedly preliminary investigation is that of the calculated 3.8 percent average annual growth rate for Hawaii from 1900-1976, increases in labor quantity contributed 25 percent, improvements in labor quality 21 percent, advances in knowledge 22 percent, and capital inputs (probably underestimated) another 16 percent. The close interrelationships among these key variables in the Hawaiian growth process should be noted further.

Before the second World War, assured and protected markets for sugar, and to a lesser extent pineapple, together with a disciplined, largely immigrant, and relatively low cost labor force, resulted in high profits and reinvestment in research and development and advances in knowledge generally. With continued increases in agricultural productivity, producer

profits augmented by external capital sources were invested in other economic activities, thus increasing economies of scale. In the meantime, immigrant families exhibiting low time preference rates were able to accumulate savings and invest in education, housing, and business activities. Thus, a unique combination of labor and capital inputs, augmented by investment in education, advances in technical and managerial knowledge, and increasing economies of scale, assured continuing growth at above the national averages.

World War II, with its sharp acceleration of military expenditures and curtailment of much civilian activity, proved a major turning point in Hawaiian economic development. Following the wartime boom, market growth of the dominant prewar agricultural activities slackened with increased external competition, while technological changes led to displacement of additional workers. Combined government and private research, development, and promotional efforts were undertaken to discover new income and employment sources and investment outlets. Expanded public investment in education, research, and physical and social infrastructure laid the ground-work for much of the economic growth and diversification which was to follow attainment of statehood by Hawaii. For the future, the major growth potentials appears to lie with continued investment in human capital and creation of opportunity and environment for its fuller and more effective utilization.

The Hawaiian model of economic growth is not likely to be replicated in other subnational areas. However, closer examination of their rates and principal sources of growth should provide clues as to their ability to meet continuing social needs or deal with changing economic requirements. To meet these new challenges, growth analysts generally will need to augment their examination of quantitative data with qualitative information on legal and institutional changes, government vs. market efficiency, and changes in social attitudes.

APPENDIX

Framework, Assumptions, and Algorithm for Growth Analysis

Alternative approaches to identifying and evaluating sources of growth of national or subnational economies are suggested by the basic identities of income/product flows.

The traditional approach among development economists has been to examine growth from the demand side: i.e., growth occurs with expansion of export industries, which in turn generate higher income levels to the domestic population, resulting in higher savings to be reinvested into creation of other income-generating activities. An alternative approach is to focus on the supply side: i.e., increases in quantity and quality of factors of production (labor, capital and land) interact in a cumulative fashion for accelerated or sustained growth. This approach places heavy emphasis on

investment in human resources, research and development, and technological applications. A more comprehensive approach would consider both demand and supply factors, plus analysis of underlying legal-institutional conditions, individual and social work attitudes, geo-political influences, etc.

The analytical framework used here focuses on the supply side and seeks to transform basic production functions into growth equations. We begin with the familiar

$$(1) Y = \delta(K, L), \text{ where } K = \text{Capital Input} \\ L = \text{Labor Input}$$

Since we are investigating rates of change, L and K can be in either physical or value terms. We assume here that L is in physical terms and obtain

$$(2) \frac{dY}{dt} = \frac{dK}{dt} \cdot \frac{dY}{dK} + \frac{dL}{dt} \cdot \frac{dY}{dL}$$

To focus on the concept of the average annual rate of growth, we rewrite (2)

$$(3) \frac{1}{Y} \cdot \frac{dY}{dt} = \frac{1}{Y} \cdot \frac{dK}{dt} \cdot \frac{dY}{dK} + \frac{1}{Y} \cdot \frac{dL}{dt} \cdot \frac{dY}{dL} = \frac{dK}{Y} \cdot \frac{dY}{dK} + \frac{dL}{Y} \cdot \frac{dY}{dL} \cdot \frac{L}{L}$$

Assuming wage (W) $\div \frac{dY}{dL}$, marginal productivity of labor, a simple transformation results in:

$$(4) \frac{1}{Y} \cdot \frac{dY}{dt} = \frac{dK}{Y} \cdot \frac{dY}{dK} + \frac{dL}{L} \cdot \frac{(W)(L)}{Y}$$

Thus the labor contribution to the average annual rate of growth is the product of the growth rate of labor supply and the labor share of total income.

The Capital component can be estimated similarly. Assuming K in physical terms, we have

$$\frac{dK}{Y} \cdot \frac{dY}{dK} \cdot \frac{K}{K} \div \left(\frac{dK}{K} \right) \cdot \left(\frac{K \cdot P_K}{Y} \right)$$

where marginal productivity of capital is equal to average return on investment (P_K). Also:

$$\frac{dK}{Y} \cdot \frac{dY}{dK} \cdot \frac{K}{K} = \left(\frac{dK}{K} \right) \cdot \left(\frac{dY/Y}{dK/K} \right), \text{ where } \frac{dY/Y}{dK/K} = (\text{Capital-income elasticity})$$

Thus the capital contribution to the average annual rate of growth is the product of the growth rate of capital and the capital share of total income (investment). Alternatively, capital-income elasticity may be substituted for the capital share of total income.

The estimating form of the growth equations may now be written

$$(5) \ g_Y = g_L s_L + g_K s_K + r, \text{ where}$$

g_Y = Average annual growth rate of aggregate state income

g_L = Average annual growth rate of labor contribution category

s_L = Average share of labor income to state income

g_K = Average annual growth rate of Capital stock

s_K = Average share of Capital income to state income

r = Productivity index

In other words, the overall growth rate is the sum of the growth rate of each factor weighted by its average share of output value plus a residual. The assumptions underlying this conclusion and providing the basis for the estimating algorithm are:

- (1) Constant returns to scale, with no interaction among variables; differential factor returns are wholly identified with the targeted source; hence each component is additive.
- (2) Marginal products of factors are equal to factor returns, which implies perfectly competitive market conditions.
- (3) No major economic structural changes distort the above assumptions (this assumption is maintained by averaging results of shorter analytical periods).

From the growth estimation equation (5), the following basic algorithm is derived:

- (1) Compute the real growth rate of State Income between 1900 and 1976 (and also other intervening periods as required).
- (2) Compute the average share of the factor input (labor, capital) to total output (at factor costs) during the period analyzed.
- (3) Compute the average annual growth rate of the factor input in real terms over the period to be analyzed.
- (4) Multiply the rates found in steps (2) and (3) above and divide the result by the rate computed in step (1).
- (5) For the productivity analysis, estimate output elasticities and ascertain the opportunity cost/gain that would have occurred due to the particular activity, e.g., economies of scale, utilization of research and development findings, and so on. Attribute these losses/gains to the growth rate and derive activity contributions to the growth rate.

FOOTNOTES

¹In fact, E. F. Denison, widely recognized as a pioneer and foremost practitioner of growth accounting analysis, titled his recent work, *Accounting for Slower Economic Growth: the United States in the 1970s* (1979), as a sequel to his earlier classic, *Accounting for United States Economic Growth, 1929-1969* (1974). Also John Kendrick indicates the growth of real gross product per labor hour in the U.S., which reached a peak average annual rate of 3.5 percent in the period 1948-66, declined to about one percent during 1973-78, and then fell absolutely in 1979-80 (1980, p. 1).

²His comparative study of national income growth from 1950-1962 in eight Western European countries, in a sense a regional analysis, showed rates ranging from 2.4 percent for the United Kingdom to 6.3 percent for West Germany (1967).

³The principal sources for our Hawaiian growth analysis were income and expenditure accounts developed in a project initiated at the University of Hawaii by one of the co-authors and historical information compiled by Robert Schmitt in his comprehensive *Historical Statistics of Hawaii*. The income-expenditure project has since become the basis for the system of economic accounts maintained by the State government (Hawaii Department of Planning and Economic Development, 1972 and 1976).

⁴A detailed description of the estimation methods used to derive the summary results reported in this paper is contained in memoranda submitted to the Hawaii Department of Planning and Economic Development and is available upon request from the authors. We hope this information can be utilized by other researchers not only to advance the state of knowledge in their respective areas, but also to improve our own Hawaii growth estimates. As Phyllis Deane notes in her review of Denison's *Why Growth Rates Differ*: "these are not the kind of statistics that effectively prove or disprove anything at all, except the immense complexity of the task of defining or interpreting national growth rates. They raise more interesting questions than they answer and Denison is always explicit. Only the most naive reader could suppose that these numbers are intended to be taken at their face value."

⁵The elements mentioned in the cited work were "industrialization, urbanization and education." We have substituted "modernization" for industrialization in this paper to emphasize the special nature of Hawaiian economic development in the form of large-scale, highly mechanized process in the production and marketing of its basic agricultural commodities—sugar and pineapple, as well as the use of modern technology and methods in other areas. This avoids the connotation of heavy manufacturing which has not been part of the Hawaiian development process.

⁶Unless otherwise cited, U.S. growth rate comparisons for periods before 1960 have been taken from Denison (1962); for periods after 1960, we have utilized Denison (1974). For conciseness of presentation here, we drop the usual convention of citing pages or table numbers. These are contained in the 1979 unpublished report.

⁷Denison makes some cross-sectional calculations to isolate the contribution of increased years of schooling to real income improvement and arrives at a 60 percent adjustment factor (1962). In our Hawaii calculation, we have considered the more recent advances in radio programming and educational television in arriving at the 50 percent rate.

⁸Psacharopoulos estimated a 35 percent contribution of capital investment to the Hawaiian growth rate from 1950-1960. Mollett shows real capital per worker in the Hawaiian sugar industry increasing from a 1.1 percent average annual growth rate (1900-1930) to 5.3 percent (1930-1961). However, the growth in the latter period may be due as much to the decline in agricultural employment as to increases in Capital utilization.

⁹The assumption was then made that the identified trends would apply over the longer period under study, subject of course to future refinement. Thus, the calculations showed output elasticities of .15 for changes in number of R and D firms, .16 for changes in professional and scientific employment, .32 for changes in professional society membership, and .24 for transpacific phone calls. Averaging the four items resulted in an elasticity rate of .22, which was used to estimate the contribution of "advance of knowledge" to output capacity.

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