Working Paper 8703

ESTIMATING THE RELATIONSHIP BETWEEN LOCAL PUBLIC AND PRIVATE INVESTMENT

by Randall W. Eberts and Michael S. Fogarty

Randall W. Eberts is an assistant vice president and economist at the Federal Reserve Bank of Cleveland. Michael S. Fogarty is director of the Center for Regional Economic Issues at Case Western Reserve University in Cleveland, Ohio. The authors gratefully acknowledge the assistance of Douglas Dalenberg and Chul Soo Park in compiling the investment series. Patricia E. Beeson and Robert Schwab provided helpful comments and suggestions.

May 1987

I. introduction

Economic development has become a major concern of many local policymakers. The most recent recession, by cutting deep into many urban economies, has left local officials scrambling to claim what they consider to be their share of the national economic expansion. Although competition for economic activity has considerable historical precedent, at present regional rivalry appears to be particularly keen as snowbelt states fight to slow the loss of manufacturing facilities to the southern and western regions of the country. One of the primary instruments available to local policymakers to retain, nurture and attract firms is the formation of public infrastructure. Maintenance and expansion of public infrastructure such as highways, water distribution and treatment facilities, airports, and waterways are important factors in the decision of firms to expand and locate.

The recent interest in the use of public infrastructure to promote economic development differs to some extent from the regional and federal development projects of the late 1950s and 1960s. These programs, such as the Appalachian development effort, involved massive infusions of money from higher levels of government in an attempt to provide these regions with a critical mass of infrastructure that would presumably stimulate economic growth. In contrast, infrastructure development at the individual local level is much less ambitious. Although federal grants are an important financing source of some local projects, to a large extent, local public investment is financed out of local and state revenues, which are under the control of area taxpayers. These funds are spent on local roads, water distribution and treatment facilities,.

schools, and other buildings and structures. State and local governments spent over 238.5 billion dollars on equipment and structures in 1978 alone, which is nearly 73 percent of total government expenditures on capital (Musgrave, 1981).

Despite the importance of these factors to businesses and local government officials, very little work has been done to explore the relationship between private and public investment. Investigation into this relationship has been plagued primarily by the lack of adequate data. Even with recent interest in the deterioration of the nation's public infrastructure, estimates of public capital stock for local areas, which provide consistent measures across standard metropolitan statistical areas (SMSAs), have not been made. In addition, information on plant location and estimates of local private capital stock is not readily available. In response to the lack of data to explore these issues concerning local economic development, we have undertaken a project to measure private and public capital stocks for 52 SMSAs from 1958-1978.

The fundamental issue raised in this paper concerns the use and effectiveness of public infrastructure as a local policy instrument. A necessary condition for local public investment to influence economic development is for the formation of public investment to precede the formation of private investment. Obviously, the timing of investment is not sufficient for public investment to be an effective policy instrument, since many other locational and market factors are important in business decisions. Nonetheless, such a sequence of events would indicate that local areas, through either deliberate local policy or the desire of local voters, actively use public outlays as an instrument to try to direct local development. On the other hand, if the sequence of events occurs in the opposite direction, it would appear that local officials merely respond to the location of private economic activity by putting in place infrastructure after private investment has been made. One could argue that the installation of roads and sewer and water lines, for example, may be prearranged before a business decides to locate in an area, even though the actual construction does not occur until after the private facility has been built. Considering, however, the amount of time necessary to build structures and the fact that we are looking at the aggregate behavior of many individuals, one would expect that over a sufficiently long period of time the likelihood of perfect timing and/or foresight would be very small.

To answer the question of whether local public investment "influences" private investment, we perform the Sims test of "Granger causality" for a sample of 40 SMSAs using investment data from 1904 to 1978. Granger's definition of causality is based upon the predictive ability of one series to explain another. Granger states that X "causes" Y if the past history of X can be used to predict Y more accurately than by simply using the past history of Y. While this definition is not in complete accord with the notion of causality held by philosophers of science, it has considerable appeal for examining statistical relationships since, under certain a priori restrictions, it is equivalent to econometric exogeneity. Sargent (1976), for example, used the Sims procedure to test for exogeneity of policy variables in his macro model. We perform the Sims test on public and private investment series to test if public investment is exogenous or if there are strong feedbacks from private to public investment.

The issue of exogeneity addresses a secondary area of concern: can public investment be considered exogenous in econometric models? One of our goals in investigating the relationship between public and private investment is to determine the effect of public infrastructure on the productivity of urban economies. Thus, the issue of exogeneity is important when entering public capital stock into production functions, private investment equations, regional economic growth models, and firm location equations.

For now, however, we perform the Sims test on investment series of each of 40 SMSAs. We then examine whether the patterns of significant directional relationships can be explained by various characteristics of these local economies. Finally, we consider the sign and magnitude of the correlation between the two time series for a subsample of the 40 SMSAs.

II. Econometric Specification

Urban Economic Model A simple model of the urban economy demonstrates the relationship between private and public capital and the possibility that the direction of influence between the two investment series may go in either direction.

Public infrastructure can be viewed as both an intermediate and a final good. Local residents consume services from public capital stock as a final good; local firms use public capital stock as a factor of production. In both cases, public capital is not purchased directly but is financed by tax dollars, the amount determined within the political process. The process by which local public investment influences private investment and vice versa can be illustrated by constructing a simple, export base model of a local economy. Similar models are found in Pestieau (1976) and Kanemoto (1980).

Assume that manufacturing firms within the local area purchase local inputs (private capital, K, and labor, L) that, when combined with local public capital (G) produces Q, an output that is sold to a national market. The issue of how public capital enters the production function has been discussed theoretically by Negishi (1973). He shows that public capital, viewed as an unpaid factor of production, renders the production function homogeneous of degree one with respect to all inputs, including public capital. Furthermore, he argues that if public and private capital stock are not substitutes, the higher rents accruing to firms due to the level of public capital will attract additional firms into the area. Thus, private capital investment is a function of public infrastructure investment. These relationships can be shown by positing a general production function:

$$(1) \qquad Q = Q(K,L,G).$$

Since G is determined exogenously, it is considered a quasi-fixed input.

Also, since G is not a pure public good in the Samuelsonian sense, congestion may occur depending upon the number of firms that use the good. A congestion factor could be entered into the model as

$$g_i = Q^{\beta}i\ G,$$

where g_i is the amount of services from G received by the ith firm, which is a function of the level of total output and a congestion parameter $(0<\beta<1)$. Since this additional characteristic will not change the general relationship between private and public investment, it is not included in the model. The publicness of the services from public capital stock, however, may be one of several reasons why public and private investment may not be strongly correlated for some SMSAs, if indeed this turns out to be the case.

Under certain regularity conditions, the demand for private capital and labor can be described as a function of public capital:

(2) $K = K(w,r,Q,G)$ and

(3) $L = L(w,r,Q,G)$,

where w is the wage rate and r is the price of capital.

Local income is generated through the payroll of manufacturing firms in the area. Dollars spent by manufacturing workers on local services create additional local income according to the multiplier 8. Thus,

(4) $Y = \theta wL.$

Public goods are provided through the political process in which the preferences of the median voter determine the level of public expenditures. Businesses do not have direct input into the political process. Their preferences may be conveyed through lobbying efforts directed at voters or government officials. Furthermore, communities with large industrial complexes may simply have more money to spend on public outlays.

At this stage, we keep the model simple and adopt a median voter model to determine the level of public outlays. The utility of the median voter is a function of a composite private good, X; and public capital stock, G. Of course, the median voter consumes other public serivces, but it serves our purpose to consider only G. The median voter maximizes utility, subject to a budget constraint:

$$(5) \qquad \max \ U(X,G) \ \ s.t. \ p_x X + p_G \gamma G = Y,$$

where p_x is the price of the private good, p_G is the unit cost of the public capital good, and γ is the median voter's share of the cost of the public capital good. We assume that local public goods are produced efficiently. First order conditions yield a demand function for G:

$$(6) \qquad G = G(p_x, p_G, \gamma, Y).$$

Again, a congestion function could be specified as described for the production function. Since the income of the median voter is a function of the wage rate and the demand for labor by firms in the community, the demand for public infrastructure is also a function of the level of private capital investment.

Within this simple framework, the relationship between public and private capital may be in either direction: public capital may actively influence private capital, or private capital may actively influence public capital. That is, G influences K directly through the production function; or K influences G indirectly by influencing L and thus Y.

Although firms and taxpayers benefit from the services they receive from capital stock, policy decisions are usually made with regard to investment. Capital stock is the result of past investment decisions. With constant depreciation patterns over time, the formation of capital stock follows the timing of investment decisions. Thus, public and private investment series are used to examine the issue of directional relationships.

Sims Test The Sims test is basically a test of predictiveness. At best, it can test Granger's statistical definition of causality. At the least, it can test whether an optimal prediction of one series depends upon another. The ability to test a specific hypothesis depends upon a priori restrictions placed on the structural equations. This problem with "causality" testing was first reported by Jacobs, Leamer, and Ward (1979). To illustrate their point, they consider a simple structural model that serves our purpose of modeling the relationship between private and public investment. Consider the possibility that public outlays (g) explain private investment (k):

(7) $$k_t = \theta g_t + \beta_{11} g_{t-1} + \beta_{12} k_{t-1} + \varepsilon_{1t},$$

and the possibility that private investment (k) explains public investment (g):

$$g_t = \tau k_t + \beta_{21} k_{t-i} + \beta_{22} g_{t-i} + \varepsilon_{2t}, \quad (8)$$

where (t-i) is a generalized delay of i periods and ε_{1t} and ε_{2t} are independent, serially uncorrelated random variables with zero means and variances σ_1^2 σ_2^2, respectively.

The reduced form of this structural system is

$$\begin{aligned} k_t &= \pi_{11} k_{t-i} + \pi_{12} g_{t-i} + u_1 \\ g_t &= \pi_{21} k_{t-i} + \pi_{22} g_{t-i} + u_2. \end{aligned} \quad (9)$$

Since we are concerned about feedback from private to public investment, we focus on three hypotheses that describe the extent k influences g:

H_1: $\tau=\beta_{22}=0$. JLW refer to this hypothesis as "k does not cause g," or that a policy that controlled k by selecting the error ε_{1t} could not have any impact on the g variable.

H_2: $\tau=0$. JLW refer to this as "g is contemporaneously exogenous."

H_3: $\tau\beta_{11}+\beta_{21}=0=\pi_{21}$. This is the hypothesis that an optimal prediction of g does not depend on k. JLW refer to this as "k is not informative about future g."

As they note, H_3 is often mistaken for the causality hypothesis (H_1). Since the structural model is not identified and none of the parameters can be estimated, it is not possible to estimate τ and β and thus not possible to test H_1. What can be estimated is π_{21}. If it is discovered that π_{21} is zero, then k is not informative about future. g. If, furthermore, one could restrict τ to be zero, then the finding that $\pi_{21}=0$ would infer that β_{21} is also equal to zero--thus g is exogenous to the model.

JLW further show that the informativeness hypothesis (H_3: $\pi_{21}=0$) is not a useful indicator of simultaneous equation bias. All that is required for consistent estimates is that $\tau=0$. In our particular circumstance, it is reasonable to assume that private and public investment are not contemporaneously correlated. The formation of public capital stock, in particular, requires a considerable amount of time. Roads, highways, airports, ports, water treatment and sewer facilities, for example, take a number of years to build. Add to this an equally long period of time required for private capital formation, it is highly unlikely that over a long period of time, public and private investment are consistently contemporaneous.

Therefore, with the a priori restriction that $\tau=0$, it is possible to interpret the results of the Sims test as a test of exogeneity. Even without this restriction, the Sims test indicates the ability of g to explain k and vice versa.

The Sims test regresses current g on past, current, and future values of k. The null hypothesis that g is not informative about k is equivalent to all the coefficients on the future values of k being equal. to zero. Thus, the two-sided regression model is estimated:

$$(10) \qquad g_t = \sum \pi_i k_{t-i} + w_t.$$

An analogous regression of k on past and future g is then estimated to test if k is informative about g. Since the error term (w) will generally be serially correlated, use of OLS will yield consistent but inefficient parameter estimates. A generalized least squares approach or some other method of prefiltering the time series is used. Sims suggests a specific filter $(1-.75L)^2$ where it is applied to the natural logs of the time series. Sims reports that this is successful in flattening the spectral density of most economic time series. Sims does report, however, that his filter does not completely prewhiten the series. Feige and Pearce (1979) show that the choice of prefiltering does affect the F-statistics. We, therefore, estimate equation (10) using the iterative Cochran-Orcutt estimation technique to correct for first-order serial correlation.

Four combinations of results from the Sims test are possible, and it is instructive to examine the various policies these results may imply. First, private Investment may influence public investment. In this case, public capital formation is passively responding to the needs of private investment. According to the model, as private investment increases, demand for labor and thus payrolls also increase, expanding the income of the local economy. With a higher income, the median voter demands a greater amount of public services, including public investment. Consequently, public investment does not appear to be used as a growth-stimulating policy instrument.

Second, public investment influences private investment. This case provides the strongest evidence possible from the Sims test that public investment stimulates private investment. Although other factors are undoubtedly important in explaining private investment, the model indicates that public investment, by yielding higher profits to local firms, attracts additional investment into the area.

Third, the direction of influence may go both ways. This would indicate either that the direction of influence switches from one time period to the next, possibly due to various external events, or that there are strong feedback effects present throughout the entire time period.

Fourth, there is no statistical relationship between public and private investment. This statement should be qualified by the possibility that the model is misspecified. Nonetheless, it may be the case that decisions to invest in the private sector and in the public sector are totally independent. Possible examples of this are cities dominated by a dingle industry, such as Detroit, Rochester, or Seattle. Another possibility is that public investment is used as a policy instrument, but is ineffective.

III. Data

Annual total public outlays for central cities within 40 SMSAs were collected for the period 1904-78 from City Finances. Public capital outlay is defined as direct expenditure for contract or force account construction of buildings, roads, and other improvements, and for purchases of equipment, land, and existing structures. Included as total outlays are expenditures on

a) sanitary and storm sewers and sewage disposal facilities,
b) roadways, sidewalks, and all structures and improvements necessary for their use, such as to11 highways, bridges and tunnels,

c) hospitals,
d) public service enterprises, which includes airports and ports.

Annual total private investment for manufactures was collected over the same time period from the <u>Census of Manufactures</u> and the <u>Annual Survey of Manufactures.</u> Investment was estimated for SMSAs using 1977 boundary definitions. Both series are converted to constant 1967 dollars by using the Engineering News-Record indexes.

One obvious difficulty with relating the two time series is that public outlays are available only for central cities over the entire time period, while private investment is for the entire SMSA. The severity of this problem varies across cities and time periods. For instance, prior to World War II, central cities comprised most of the SMSA and definitely dominated fiscal expenditures. Even after World War II, central cities provided much of the major water treatment facilities and contained much of the highway complexes. In recent years in which SMSA-level expenditures are available, we find that the percentage of total outlays in an SMSA by central cities varies from an average of 30 percent to over 90 percent. The city of Cleveland, for example, accounted for approximately 28 percent of total SMSA expenditures on public capital during 1965-81, although it contributed close to 90 percent of water treatment expenditures. New York City, on the other hand, contributed nearly 80 percent of the total SMSA expenditures on public infrastructure during the same time period. Thus, one would expect services provided by central cities to spill over into the rest of the SMSA. Therefore, the public investment series is useful in exploring lead and lag relationships between local public and private investment.

IV. Results

Recognizing that private and public expenditures over three-quarters of a century have been influenced by significant events and overall structural changes in behavior, we estimate the Sims test for pre- and post-World War II periods as well as for the entire 75-year period. The analysis examines 40 SMSAs. The plots contained in figures 1-6 are representative of the sample of SMSAs. Investment in public infrastructure is characterized by cyclical upturns and downturns, which in some cases follow the major business cycles during this century. With few exceptions, the older, pre-WWII cities exhibited tremendous increases in public capital formation during the new era prosperity of the 1920s. This boom was followed by a severe drop in public investment during the Great Depression. Very little activity occurred during the austere years of World War II, and it was not until the capital goods boom of the mid-1950s that we also see a significant increase in public capital stock formation. Due partly to increased suburbanization and the increased role of the federal government in financing public infrastructure, public investment in the latter quarter of the century is not as large and not as cyclical as found in the earlier period.

Even though these generalizations are applicable to most of the SMSAs, each SMSA exhibits some unique characteristics. Cleveland and Akron (figures 1 and 2), for example, show strong cyclical patterns throughout the entire time period with private investment apparently leading public investment before WWII and public leading private after the war. Seattle and Portland (figures 3 and 4) reveal somewhat different patterns. Public investment in the early part of the century exceeds private investment at several points in time. Seattle demonstrates a fairly haphazard lead-lag pattern whereas Portland's is somewhat more regular. Atlanta (figure 5) is illustrative of several of the "growth" areas in which private leads public investment, particulary during the postwar period. Houston (figure 6) is definitely a post-WWII city. Very little public or private investment was made during the first half of the century, but the second half shows tremendous private investment that dwarfs public investment.

Sims Test Results Results of the Sims test are meant to be suggestive of the relationships that may exist between private and public investment. As discussed earlier, this is a test of predictive power and not of structural causation. Interpretation of the results, therefore, must be made with considerable discretion. The results are shown in table 1 with asterisks indicating that the null hypothesis that public does not influence private investment (or private does not influence public) is rejected at the .05 percent significance level. When the test is applied to the entire time series (actually from 1916 to 1966, since we used 12 future and past lags), neither null hypothesis could be rejected for 29 of the 40 SMSAs. The null hypothesis that public investment does not influence private investment was rejected for 21 of the 40 SMSAs. The null hypothesis that private investment does not influence public investment was rejected for only eight SMSAs. Stated differently, neither hypothesis could be rejected for 16 of the 40 SMSAs. In addition, these results show a dominance of public investment influencing private investment, an important result for the use of public investment as a policy instrument.

When the sample was divided into pre- and post-WHII periods using four leads and lags, the results change. In this case, the null hypotheses could not be rejected for only seven SMSAs. In the pre-war period, private investment influenced public investment for six SMSAs, whereas public influenced private for 10 SMSAs. During the postwar period, private investment influenced public for 10 SMSAs, and public influenced private investment for nine SMSAs.

The dominance of public influencing private investment is reduced when shorter periods of time are considered: public investment influenced private investment for 19 SMSAs while private influenced public for 16 SMSAs. One reason for this difference may be that the four future and past lags may not be long enough to pick up the effect of public on private for some cities. When the entire period was used, coefficients of the eleventh and twelfth leads were statistically significant in some cases. Thus, nine SMSAs that rejected the null hypothesis that public does not influence private investment when the 12-year lag was used in the longer period could not reject it when shorter lags were necessary. This problem was offset to some extent by the ability to control for different structural relationships before and after the war. For example, seven SMSAs that did not reject the null hypothesis when the period spanned both pre-war and postwar periods rejected it when the time period was divided.

Directional Relationships across SMSAs In order to explore whether the direction of influence between public and private investment (or no relationship at all) differs systematically across SMSAs, we use logit analysis to explain the significant F-statistics in which the dependent variable equals one if significant at the .05 percent level and zero otherwise. The results are shown in table 2. The regional location of SMSAs were indicated by the WEST and SOUTH dummy variables, with the rest of the country included in the intercept. The variable EARLY is a measure of the relative timing of the placement of public infrastructure and the needs of the population. It is computed as the difference between the year in which maximum population (MAXPOPY) was reached in the central city and the year in which maximum public capital stock was obtained in the central city. Thus, if public capital stock peaks before population (EARLY greater than zero), then the SMSA may be considered to have more foresight in establishing an infrastructure base for future economic activity.

The results show that private investment is more likely to influence public investment for SMSAs located in the South than in the rest of the country. In addition, the sooner public infrastructure is put in place vis-a-vis the size of the population (EARLY is positive), the more likely public investment will influence private investment.

Sign and Magnitude of the Correlation between Investment Series The Sims test reveals significant relationships between private and public investment for a number of SMSAs in the sample, but it is unable to reveal the magnitude and sign of the correlation between public and private investment. We estimate this effect for the pre-war and postwar periods for a subsample of SMSAs using a slightly different approach.

Because of the strong possibility that other factors affect investment decisions in both the private and public sectors, each time series was regressed on past values of itself (Haynes and Stone, 1985). The residuals, thus purged of most of this extraneous influence, are used as innovations of each time series. The innovations of private investment are subsequently regressed on present and past values of innovations of public investment and vice versa. The sum of the coefficients of lags 1–6 are shown in table 3. If one considers six years to be sufficiently long to capture most of the influence of one investment on the other, then the sum can be interpreted as the long-run effect.

The first result to notice in table 3 is that all statistically significant coefficients are positive. Thus, an increase in one type of investment brings about an increase in investment of the other type. Second, with only a few exceptions, the relationships that were found to be significant using the Sims test, were also statistically significant in these regressions.

Results show that the long-run effect of private investment on public investment is always less than one. Furthermore, the effect appears to be much larger in the prewar period than in the postwar period. The relative magnitudes between the two periods are reversed for the long-run effect of public investment on private investment. However, estimates of $11 of private investment for every $1 of public investment, as was estimated for Cleveland, seems somewhat large. These magnitudes are not surprising when one considers the ratio of private investment to public investment. During the prewar period, the ratio for Cleveland averaged about 3 whereas in the postwar period it was closer to 8. As discussed earlier, these high figures may result from the fact that only central city expenditures on public outlays were available. The percentage of total outlays by the city of Cleveland compared to the entire SMSA, for example, is much lower during the latter period than the former. Thus, given the fact that the population in the city of Cleveland peaked in 1952, while the SMSA population continued to grow, one would expect the percentage of public outlays by the city with respect to total SMSA outlays to fall over this period. When it is possible to find SMSA-level data, we find that the ratio of city outlays to SMSA outlays is .25 during the 1960s and 1970s. Akron's ratio is higher at around .45 and thus its estimated long-run effect is lower than Cleveland's. It is interesting to compare our results with estimates obtained using cross-sectional data for the late 1960s and the 1970s when public outlays by SMSAs are available. Deno (1986), using the same private investment estimates and the same sample of SMSAs as we used, estimated the long-run effect to be 0.28.

V. Concluding Remarks

The basic question addressed in this paper Is whether public outlays influence private investment. A precondition for public outlays to be considered a policy instrument is that public outlays must precede private investment. This sequence of events does not ensure, however, that public outlays will be effective in stimulating local economic activity. A more complete identification of the causal links between public outlays and private investment would require estimating a full structural model. We have posited a simple model of the urban economy that relates public infrastructure and private economic activity. Unfortunately, sufficient time-series data are not available to estimate the structural model.

The reduced-form equations from the structural model offers another approach to estimating this relationship. The Sims test is used to estimate the direction of influence between the two investment series. In only seven out of the 40 cases, do we find no statistically significant relationship between public outlays and private investment. For half of the cities, public outlays influenced private investment; for a smaller number of cities private investment preceded public investment.

We have explored a number of factors to explain differences in the dominant direction of influence, but we have found only two significant characteristics. Private investment is more likely to influence public outlays in cities located in the South. One interpretation of this finding is that local governments in the South are less apt to use public funds for development purposes, especially before World War II. We also found that public outlays were more likely to precede private investment in cities in which the level of public capital stock peaked prior to the population peak of each city.

Based on our estimated public capital stock series derived from these public outlay data, investments by central city and special district governments have not been sufficient to maintain the public capital stock of many cities included in the sample since the 1950s. While this is consistent with the declining population of these cities during this period, it still leaves open the question of how much should cities invest in infrastructure. Although this question obviously cannot be answered with the present analysis, the findings in this paper do suggest a more active role for infrastructure in regional growth than existing research has identified.

Bibliography

Deno, Kevin T. "The Short Run Relationship Between Investment in Public Infrastructure and the Formation of Private Capital," Unpublished Dissertation, University of Oregon, Department of Economics, Eugene, Oregon, June 1986

Feige, Edgar L., and Douglas K. Pearce (1979). "The Casual Causal Relationship between Money and Income: Some Caveats for Time Series Analysis," The Review of Economics and Statistics vol. LXI, no. 4 (November 1979) pp. 521-33.

Granger, Clive W. J. "Investigating Causal Relations by Econometric Models and Cross Spectral Methods," Econometrica vol. 37, no. 3, July 1969 pp. 424-38.

Haynes, Stephen E., and Joe A. Stone (1985). "A Neglected Method of Separating Demand and Supply in Time Series Regression," Journal of Business and Economic Statistics vol. 3, no. 3, July 1985 pp. 238-43.

Jacobs, Rodney L., Edward E. Leamer, and Michael P. Ward (1979). "Difficulties with Testing for causation," Economic Inquiry vol. XVII, no. 3, July 1979, pp. 401-13.

Kanemoto, Yoshitsugu. "A Note on the Measurement of Benefits of Public Inputs," Canadian Journal of Economics, vol. XIII, no. 1, February 1980, pp. 135-42.

Musgrave, John C. "Fixed Capital Stock Estimates in the United States: Revised Estimates," Survey of Current Business, vol. 61, no. 2, February 1981, pp. 57-68.

Negishi, Takashi. "The Excess of Public Expenditures on Industries," Journal of Public Economics, vol. 2, no. 3, July 1973, pp. 231-40.

Pestieau, Pierre. "Public Intermediate Goods and Majority Voting," Public Finance, vol. XXI, no. 2, 1976, pp. 209-17.

Sargent, Thomas J. "A Classical Econometric Model of the United States," Journal of Political Etonomy, vol. 84, no. 2, April 1976, pp. 207-37.

Sims, Christopher A. "Money, Income and Causality," American Economic Review, vol. LXII, no. 4 September 1972, pp. 540-52.

U.S. Bureau of Census, City Finances, 1940-1964.

__________, City Government Finances, 1964-65 through 1980-81.

__________, Financial Statistics of Cities, 1909-1913, 1915-1919, 1921-1939.

__________, General Statistics of Cities, 1909, 1915, 1916.

Table 1: F-Statistic of the Sims Test for "Granger" Causation between Public and Private Investment in Selected SMSAs, 1904-1978.

SMSA	PreWWII A	PreWWII B	PostWWI A	PostWWI B	1904-1978 A	1904-1978 B
Akron	2.49	.67	.45	7.56*	3.51*	2.57*
Atlanta	1.40	3.72*	2.23	1.87	4.27*	1.12
Baltimore	.73	.80	1.08	2.04	.88	1.56
Birmingham	1.88	2.37	2.43	2.02	4.22*	2.27*
Buffalo	1.78	2.24	1.79	2.87*	.72	2.76*
Canton	.49	5.17*	1.85	1.67	1.07	.81
Chicago	.77	2.47	.87	2.32	.58	2.19*
Cincinnati	3.73*	1.89	.43	1.27	1.64	1.41
Cleveland	3.94*	2.18	.80	19.25*	2.28*	4.03*
Columbus	1.48	1.59	2.86*	1.10	1.86	1.96
Dallas	2.24	1.74	.53	1.23	1.60	2.56*
Dayton	1.30	10.16*	.67	.64	1.30	1.40
Denver	.34	.25	.89	2.65	2.09	.79
Detroit	1.00	1.59	.51	1.21	1.86	1.77
Erie	6.29*	.49	7.00*	.94	1.73	2.35*
Grand Rapids	1.86	6.36*	1.30	1.44	1.84	4.51*
Houston	1.58	1.07	4.04*	1.50	1.99	.60
Indianapolis	.21	2.61*	.40	1.40	2.11	1.03
Jersey City	1.62	1.16	19.38*	1.32	2.28*	1.12
Kansas City	.91	.52	2.90*	4.28*	1.16	3.62*

Table 1 (continued)

Los Angeles	1.02	1.53	.51	.37	.73	.86
Louisville	.89	5.19*	8.48*	.81	1.49	1.79
Memphis	.68	3.30*	2.00	.31	4.84*	.69
Milwaukee	2.91*	5.95*	.36	5.72*	1.30	16.08*
Minneapolis	3.54*	.83	.52	1.60	.95	18.18*
Newark	2.09	.92	1.11	.85	.97	6.77*
New Orleans	.40	2.79	1.13	4.97*	1.62	1.57
New York	2.39	6.00*	1.95	2.19	1.03	2.52*
Philadelphia	.95	2.14	6.89*	2.78	1.26	1.66
Pittsburgh	4.10*	1.25	1.86	.12	1.90	6.91*
Portland	.47	2.42	4.35*	2.86*	3.20*	17.09*
Reading	1.36	1.60	3.09*	.38	.93	5.52*
Richmond	.61	1.55	.23	1.55	1.83	.96
Rochester	1.04	.19	.49	1.35	1.88	1.65
San Diego	.36	1.59	.81	.40	6.74*	2.79*
Seattle	.97	.28	1.68	.12	.45	2.32*
San Francisco	1.94	1.90	6.55*	.48	.66	2.46*
St. Louis	.89	.74	1.40	3.42*	1.07	3.73*
Toledo	2.16	1.18	1.99	5.95*	1.74	2.93*
Youngstown	1.59	1.37	1.67	2.28	1.42	1.22
Total significant at .05 percent	6	10	10	9	8	21

Note: A: Private investment "Granger" causes public investment;
B: Public investment "Granger" causes private investment.
The pre-WWII period begins in 1904 and ends in 1945; the post-WWII period begins in 1946 and ends in 1978. The Sims Test was performed with four period leads and lags for these two subperiods. Public investment is total public outlays by central cities in each SMSA obtained from City Finances, 1904-1978. Private investment is investment by manufacturers within the SMSA obtained from Annual Survey of Manufactures and other sources. The combined period estimation of the Sims Test was performed with 12 period leads and lags.
The asterisk (*) denotes .05 significance level.

Source: Author's calculations.

Table 2: Factors related to the significance of the Sims Test for selected SMSAs, 1904-1978

Variable	Direction of Hypothesized "Granger" Causation							
	Private to Public				Public to Private			
	A	B	C	D	A	B	C	D
Constant	1.95 (6.32)	-43.44 (1.37)	-52.78 (1.65)	1.62 (5.21)	3.79 (4.76)	-16.10 (.14)	-36.30 (.31)	4.47 (4.33)
West	.82 (1.47)	.44 (.74)	.36 (.61)	.82 (1.45)	.02 (.01)	.36 (.17)	.19 (.09)	.07 (.04)
South	1.19 (2.32)	.87 (1.60)	.73 (1.33)	1.07 (1.99)	-1.55 (.91)	-2.58 (1.32)	-2.89 (1.46)	-1.30 (.73)
Early	-.004 (.26)	--	--	-.005 (.37)	.09 (1.93)	--	--	.09 (1.92)
Maxpopy	--	.02 (1.42)	.03 (1.70)	--	--	.01 (.17)	.02 (.35)	--
Maxpop	--	--	-.0002 (1.41)	.0002 (.21)	--	--	-.0004 (.83)	-.003 (.95)
Capn	--	--	--	-.0001 (.42)	--	--	--	.0007 (.83)

Note: Dependent variable equals one (zero) if F-statistic derived from the Sims test is statistically significant (insignificant) at the 5 percent level. T-statistics are in parentheses. The variable WEST denotes SMSAs in the western U.S.; SOUTH denotes SMSAs in the southern U.S.; with the northeast and the midwest included in the intercept. The variable EARLY is the difference between the year in which maximum population (MAXPOPY) was reached and the year in which maximum public capital stock was obtained. MAXPOP is the maximum population of the central city in the SMSA. CAPN is the maximum public capital stock of the central city in the SMSA.

Source: Author's calculations.

Table 3: Sum of the Estimated Lag Distributions of the Influence of Private Investment on Public Investment and Public Investment on Private Investment for Selected SMSAs

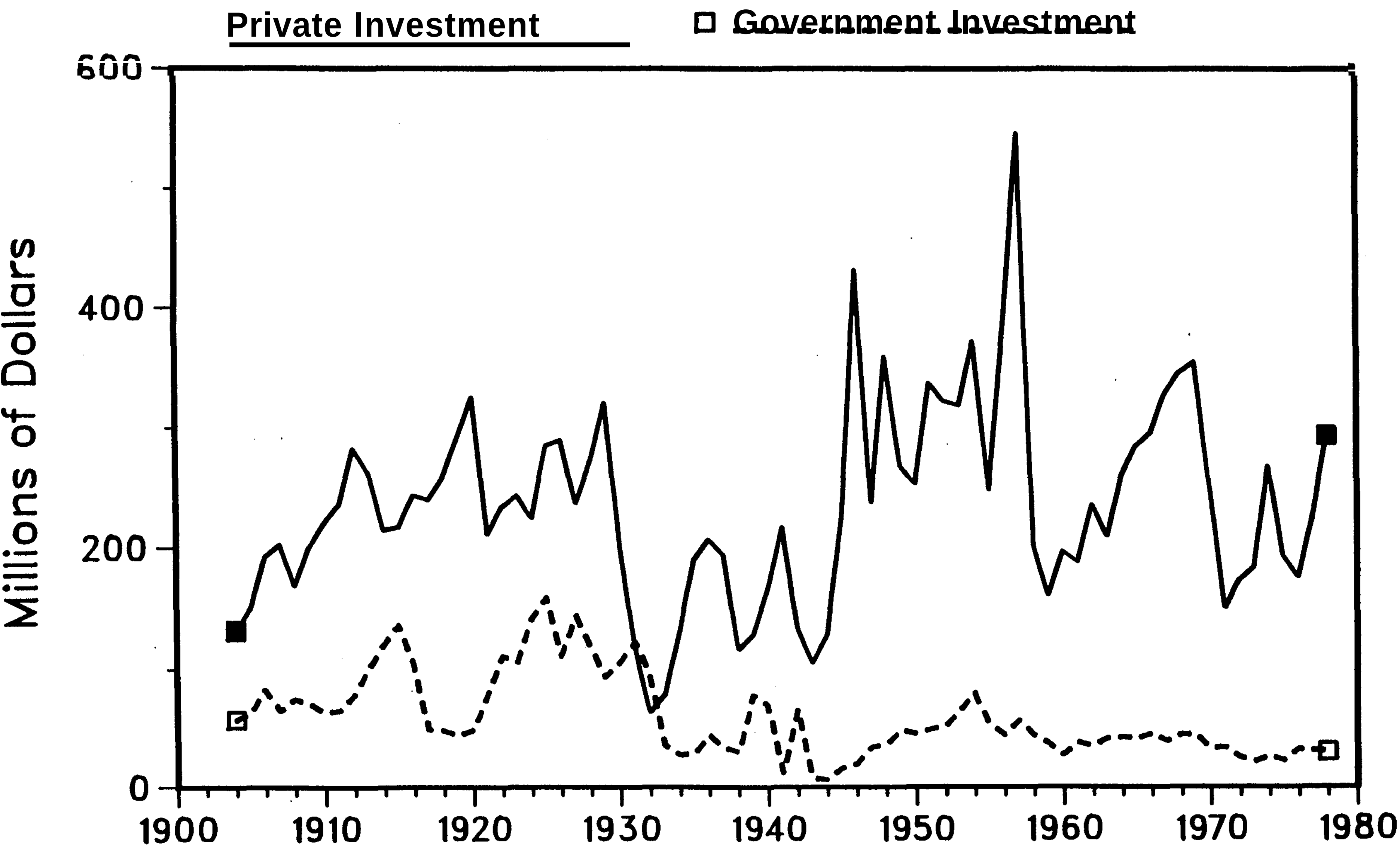
SMSA	1914-1940 A	1914-1940 B	1949-1978 A	1949-1978 B
Cleveland	.42	.38	.014	10.71
	(1.71)	(.37)	(.38)	(2.15)
Houston.	.83	.64	.29	2.69
	(.97)	(1.31)	(1.05)	(.44)
Portland	.94	-.04	.03	-3.67
	(.64)	(.14)	(.16)	(1.02)
Indianapolis	.70	.83	.10	-4.44
	(1.19)	(1.63)	(.92)	(1.15)
Pittsburgh	.21	-1.66	.83	.74
	(.94)	(1.41)	(1.56)	(.12)
Minneapolis	.52	.77	.41	3.96
	(2.14)	(.70)	(1.18)	(.56)
Dayton	1.46	-.20	-.22	-1.31
	(1.24)	(1.19)	(.96)	(1.16)
Akron	.36	.43	-.05	6.12
	(1.85)	(.26)	(.48)	(2.18)
Rochester	.29	.43	.15	.27
	(2.25)	(.57)	(1.04)	(.10)
Atlanta	.56	.92	.18	-1.37
	(1.18)	(2.43)	(.73)	(.71)
Philadelphia	.77	.26	.09	2.18
	(1.93)	(.45)	(.80)	(.70)

Note: Model A (B) regresses the innovations of current public (private) investment on innovations of private (public) investment with lags 0-6. The estimate reported in the table is the sum of the coefficients of lags 1-6. For each time series, innovations are the residuals from a regression of the series on a distributed lag of past values out four years.

Source: Author's calculations.

Figure 1

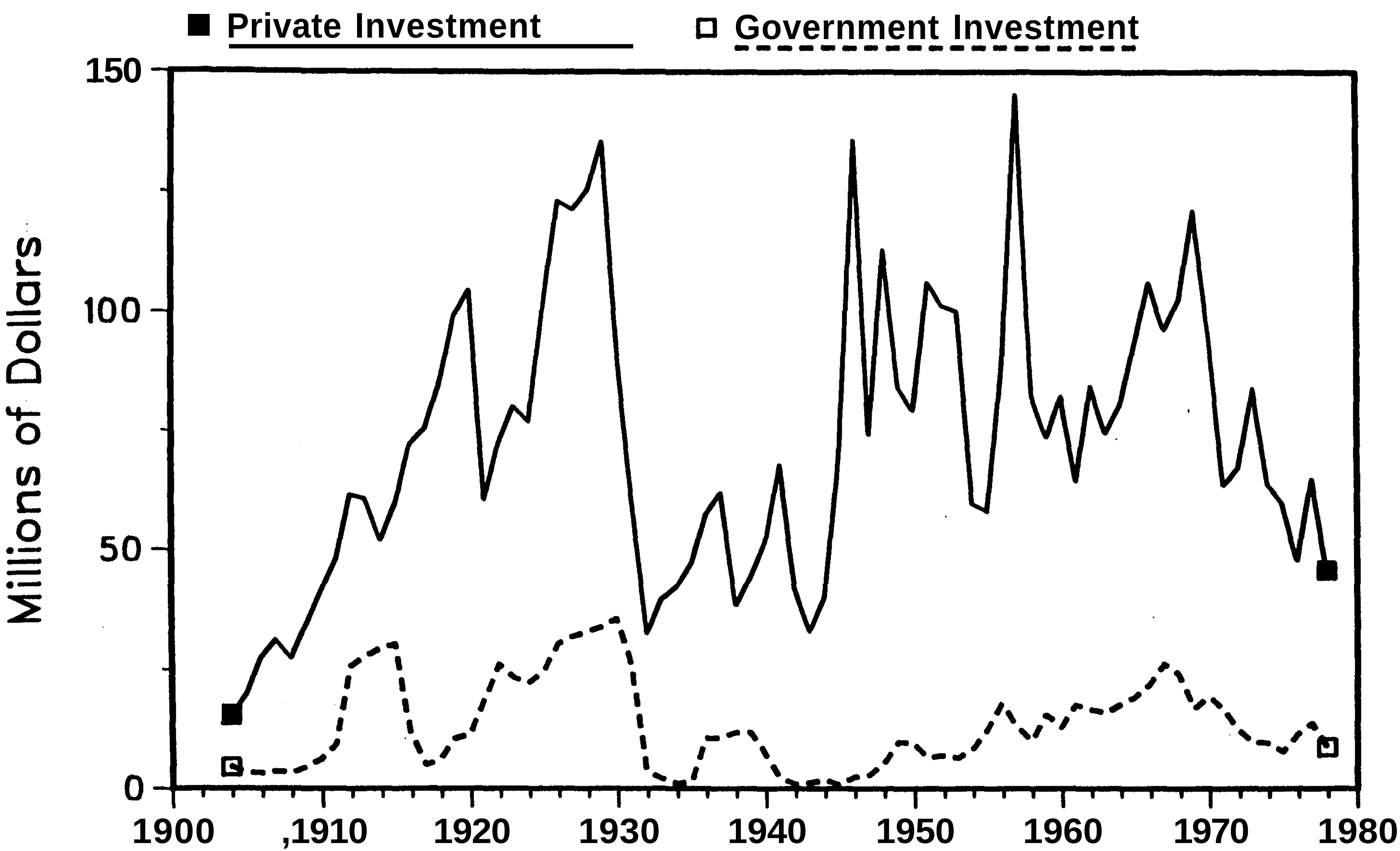
Cleveland Public and Private Outlays 1904–1978



SOURCE: Author's analysis.

Figure 2

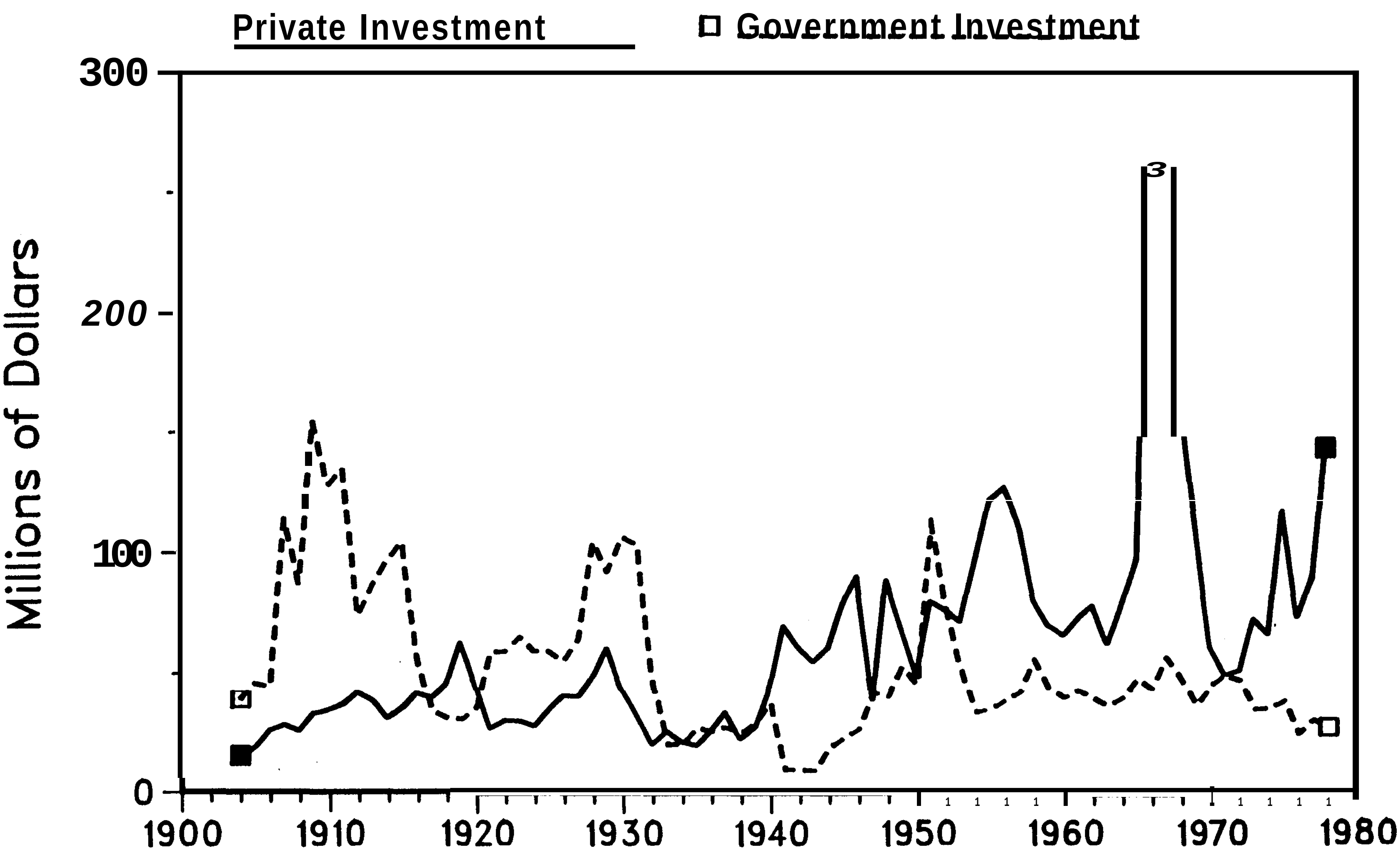
Akron Public and Private Outlays 1904–1978



SOURCE: Author's analysis.

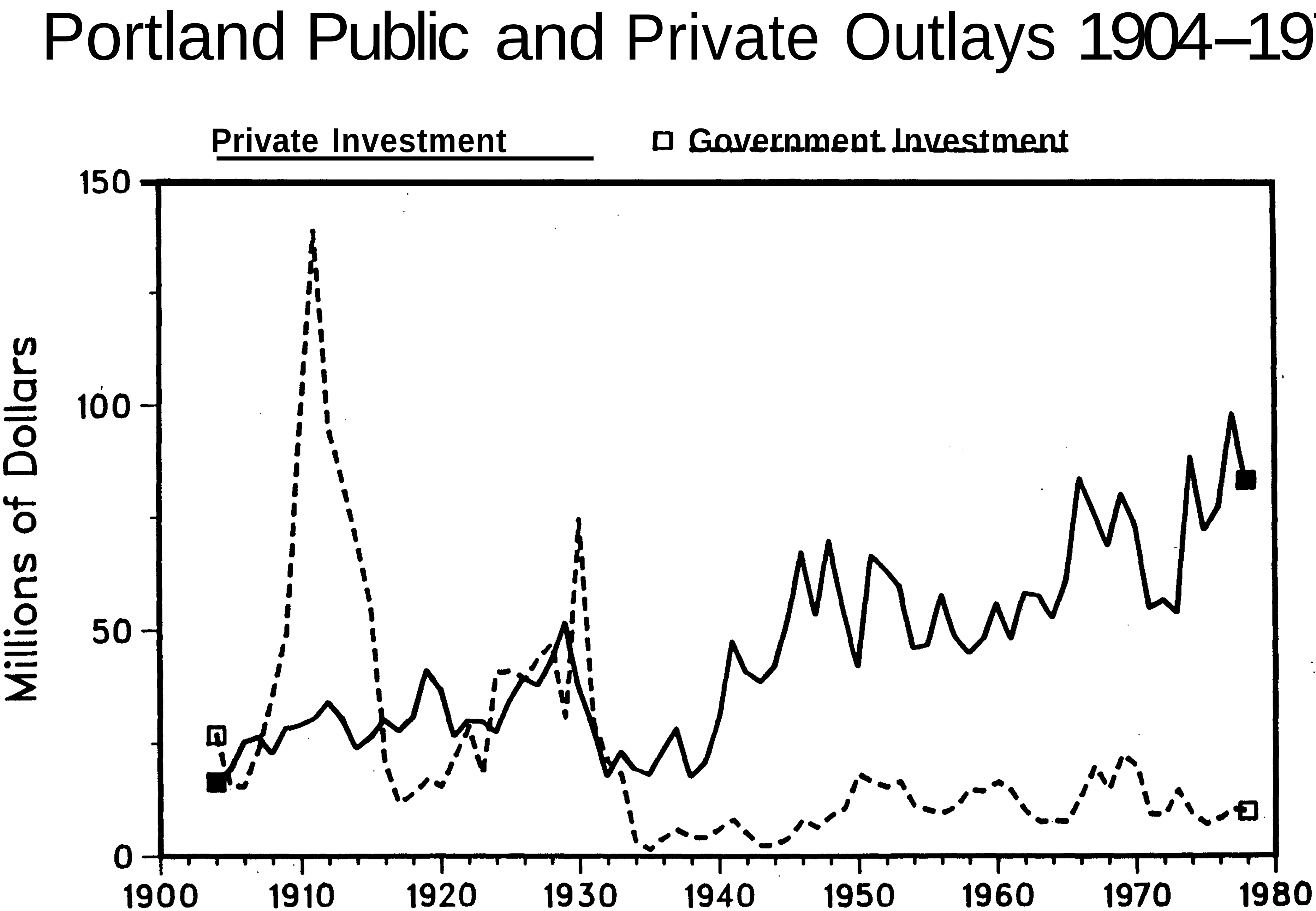
Figure 3

Seattle Public and Private Outlays 1904–1978



SOURCE: Author's analysis.

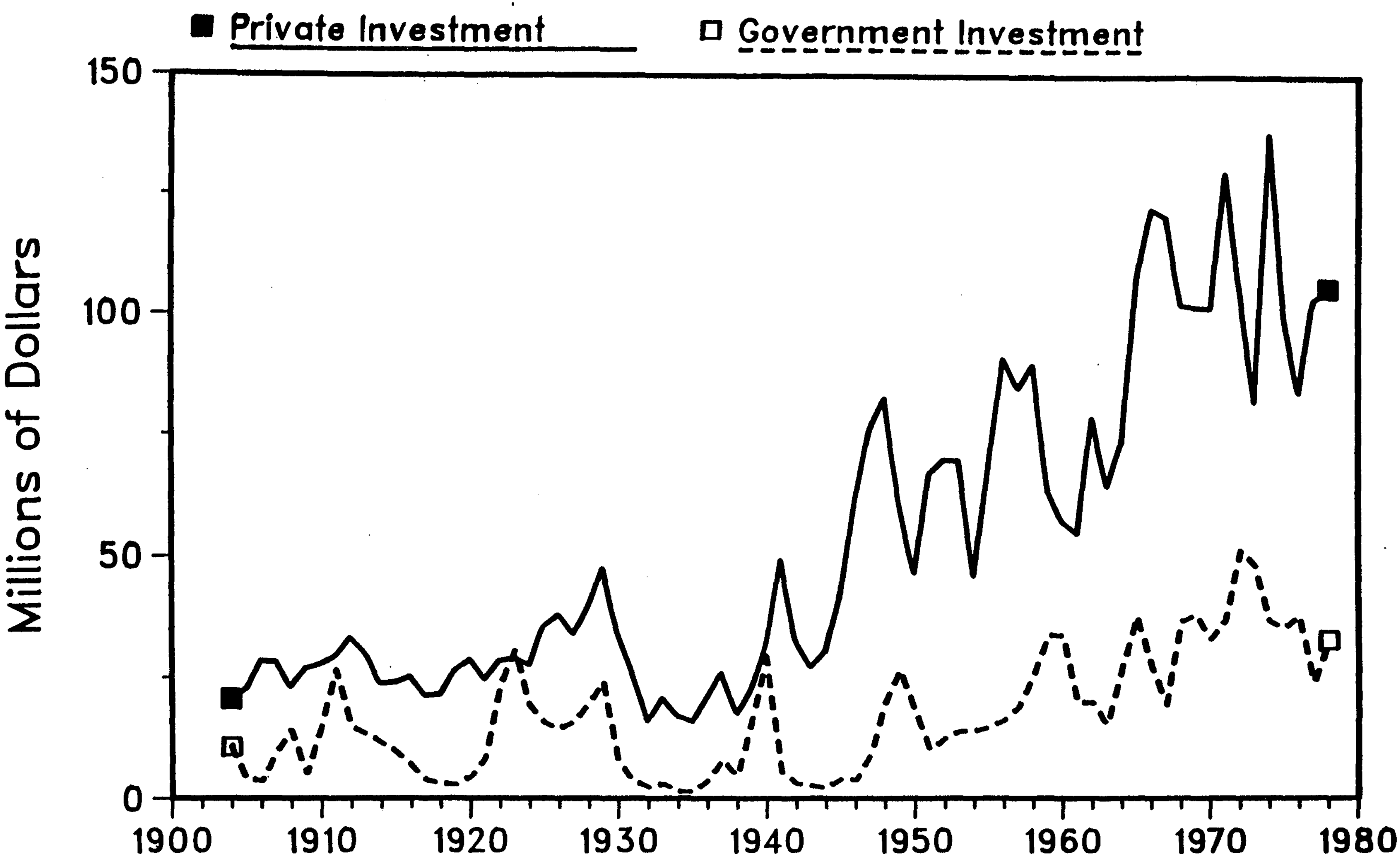
Figure 4



SOURCE: Author's analysis.

Figure 5

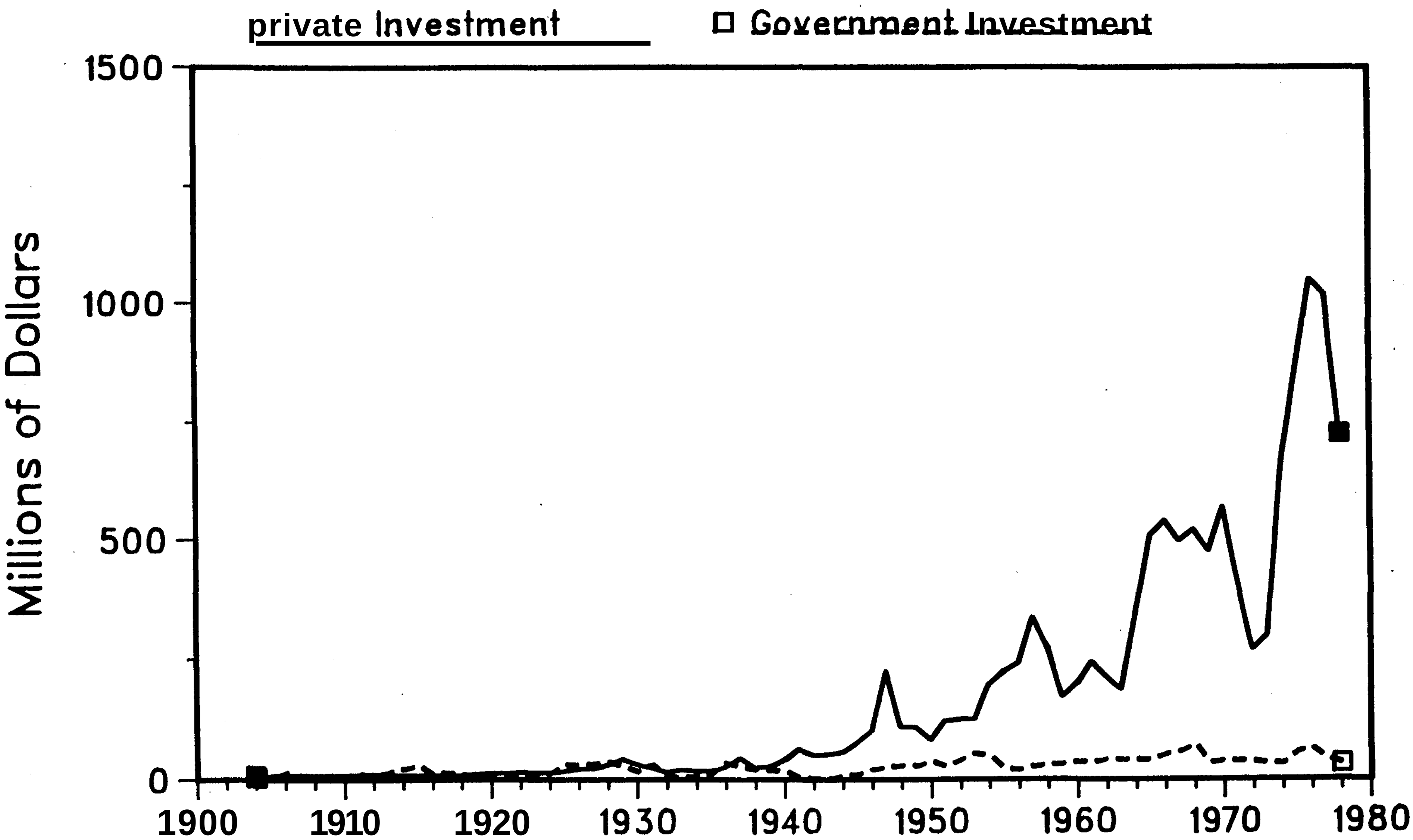
Atlanta Public and Private Outlays 1904–1978



SOURCE: Author's analysis.

Figure 6

Houston Public and Private Outlays 1904–1978



SOURCE: Author's analysis.