Eastern Economic Journal, Volume XVII, No. 4, October-December 1991

Building Infrastructure To Accommodate Growth

Leon Taylor*

INTRODUCTION

For more than a decade, U.S. infrastructure policy has turned upon this question: Do governments spend too little on physical infrastructure, such as roads, bridges, sewers, transit and water systems?

Many policy analysts, engineers and political scientists answer yes (Kaplan, 1990). Some point out that, in the United States, the share of all governments' spending that is devoted to public works peaked in the late 1960s. Since then, it has declined (McDowell, 1988). Hinds (1991) provides anecdotal evidence that, in recessions such as the current one, some cities cut back their public works spending first.

This paper contributes an analytical framework for assessing the underspending hypothesis. First, the paper distinguishes between building infrastructure to accommodate growth and building it to compete for growth. It argues that if governments spend too little on infrastructure, then they are more likely to do so when they are accommodating growth than when they are competing for growth.

For that reason, the analysis focuses on public works that accommodate growth. Through an optimal control model, it describes a construction path that maximizes the value of the works.

The model provides the analytical foundations for a later empirical study of whether governments spend too little on infrastructure. The model suggests how the empirical study can distinguish between accommodative and competitive spending. It also provides a normative benchmark for accommodative spending. Once the empirical study has isolated the actual path for accommodative spending, it can compare it to the "ideal" path. This is generated by some specification of the optimal control model.

The concepts of competitive spending and accommodative spending are widely accepted. Regional scientists refer to "infrastructure that leads private investment" and "infrastructure that follows private investment" (Rietveld, 1989). The idea of competitive spending is a variation on Hirschman's (1958) classic theme of unbalanced growth: Public investment precedes private investment, the road precedes the factory, much as the left foot precedes the right.

To this theoretical literature, the paper tries to make two contributions. First, it contrasts how the two types of spending respond to certain changes in the environment. Second, it explores their implications for the underspending hypothesis.

There is also an empirical literature that measures the relationship between infrastructure and private investment. The results are intriguing. Rietveld's (1989) survey cites evidence in the Netherlands that public investment leads to private investment, but not the reverse.[1] This suggests that competitive spending is more effective than accommodative spending.

---

* Tulane University, 103 Tilton Hall, New Orleans, La. 70118-5698. For valuable criticism, I thank Wallace Oates, Alison Rose, Robert Schwab and other scholars at the University of Maryland, as well as two excellent referees of this journal. The economics department at Tulane University provided some financial support. For all errors, I am the culprit.

FRAMEWORK OF THE THEORY

Jurisdictions build infrastructure to stimulate or facilitate growth. A good way, then, to begin thinking about infrastructure is to think about growth. In particular, consider two ways in which urban areas grow by attracting industry:

Through location. Some urban areas are close to natural resources, to pools of specialized labor, or to affluent markets. These assets attract firms. The urban areas grow.

Through competition. Some urban areas are poorly located. But they try to overcome this disadvantage through public policies that appeal to firms. For instance, they might lower corporate taxes or relax regulations. They might also build infrastructure that firms can use. Indeed, U.S. industry accounts for more than 56 percent of the increase in infrastructural services used between 1977 and 1984 (McDowell, 1988).

Often, the aim of these policies is to attract one key firm. In time, this firm might draw other firms through agglomeration economies. It might also generate spinoffs. Some empirical evidence associates large infrastructure investments with significant spinoffs (Rietveld 1989).

Nevertheless, it is risky for jurisdictions to compete by building infrastructure that firms *might* use. This can embody "creative destruction" (Schumpeter 1947). An infrastructure innovation occurs -- for instance, in the macadamizing of roads. Jurisdictions rush to be the first to offer that innovation to firms. The rush is understandable, since the innovation might entice firms more powerfully than low taxes.[2] But the competition wastes resources in two ways. First, the haste to adopt the new technology leads to mistakes. Second, losers in the competition are stuck with a costly infrastructure.

In sum, two determinants of urban growth are location and jurisdictional competition. In the first instance, firms compete for a location. In the second, locations compete for a firm.

This hypothesis has its roots in the famous German debate: Which is the main determinant of urban economic growth -- location or economies of agglomeration?[3] The debate is more than a century old, but it is still relevant for policymakers. If location dominates, then urban growth is path-independent and preordained (Arthur 1988). Policymakers can do little to control it. If agglomeration economies dominate, then urban growth is path-dependent. Which areas grow depends on where the first few firms locate. If policymakers can influence the decisions of these firms, then they can also influence growth.

Our inference is that areas with poorly endowed locations will try to exploit agglomeration economies. They will do so by competing for the first few firms. Thus policymakers concerned with regional growth will have the most leverage in areas with poorly endowed locations.

We might apply these ideas to decentralization. In many metropolitan areas, firms have moved from the central city to the outer ring, where large tracts of land are cheaper. To counter this locational pull, the central city competes for a few large firms, particularly corporate headquarters. It offers them tax breaks, help with the regulatory red tape, and cultural and recreational facilities.

Suppose that national policymakers want to reverse decentralization. The analysis implies that they should first determine whether the central city's instruments of competition slow the outflow of firms. If the instruments don't work, then one must examine more carefully the pursuit of a national urban policy. djusting to new growth patterns. The analysis suggests that jurisdictions are more likely to underspend on accommodative infrastructure than on competitive infrastructure. So let us build an accommodative model. Optimal control seems a reasonable technique: Building roads, utilities and schools takes a lot of planning, capital and time. Early decisions set the course.

Perhaps the least realistic feature of an optimal control model is its assumption that the public official estimates precisely the benefits and costs of a long-range construction plan. In fact, few jurisdictions draw upon benefit-cost or rate of return analyses for their infrastructural decisions (Kaplan 1990). One might expect an optimal control model to predict spending patterns poorly. However, in testing a dynamic programming model, Holtz-Eakin and Rosen (1989) find evidence that is consistent with the idea that bureaucrats spend on municipal capital in a way that maximizes an intertemporal utility function in the presence of uncertainty.

RUDIMENTS OF THE MODEL

An elected official must decide how much money to spend over time on infrastructure. The level of infrastructure is $Z(t)$, a stock. The rate of infrastructural investment is $Q(t) \equiv dZ/dt$, a flow. $Z(t)$ might be the total number of miles in Maryland's highway system at time t; $Q(t)$ might be the number of miles built at time t. The cost of investment is $C[Q(t)]$. Assume that $dC/dQ > 0$ and $dC^2/dQ^2 > 0$ over the relevant domain Q. The intuition behind the latter signing is that, at the margin, it costs more to build quickly rather than slowly. Assume that the jurisdiction pays the full cost of the infrastructural project.

Consider an official who wants to find the construction plan that will maximize the net return to his constituents of the infrastructure project. Two purposes drive this assumption:

The first purpose is positive: To derive refutable hypotheses about spending on infrastructure. It is not claimed that public officials actually maximize net return. Rather, it is claimed that, over the long haul, they tend to increase net return. After all, any elected official who consistently decreases a city's net return faces a growing likelihood of defeat at the polls. This argument will enable us to predict the sign of the response of infrastructural spending to changes in parameters.

The second purpose is normative: To provide a benchmark for evaluating actual behavior. In reality, officials might increase the return and yet fall short of the maximum return. How short? We need a benchmark to find out.

The gross return at time t is given by the function $P[Z(t),B(t)]$. Here, B is the value of the economic base of the jurisdiction. It includes the value of residences as well as of commercial and industrial activities.

For a given $Z(t)$, $dP/dB > 0$: The larger the local economic base, the more valuable the underlying infrastructure. The hundredth highway mile is more productive, and hence more valuable, in a prospering city than in a dying one.

We will treat B as a parameter. Indeed, sometimes we will suppress it as an argument in the function P. Denote dP/dZ as simply P'. Assume that *Pprime*> 0 and $P'' < 0$: For a fixed economic base, the hundredth highway mile is not as effective as the first mile. Finally, assume that the infrastructure depreciates at the constant rate b.

The official will solve the problem

$$\max \int_0^{\infty} e^{-rt}\{P[Z(t)] - C[Q(t)]\}\, dt \qquad (1)$$

$$\text{subject to } Z'(t) = Q(t) - bZ(t)$$

$$Z(0) = Z_0 \geq 0 \quad , \quad Q(t) \geq 0$$

The model yields several results:[7]

(1) At each moment, the optimizing official will invest in infrastructure until the marginal cost of investment equals the marginal value of the stock of infrastructure. Those who feel that the condition is reasonable might find it useful in estimating empirically the social rate of return.

(2) The official will treat the infrastructure as a jurisdictional asset, investing in it until its net rate of return equals the one available on competing assets. A competing asset might be a bond. It might also be police protection or public health protection, considered as stocks.

What is the net rate of return to the infrastructure? It is the sum of the rates of change in its stock and flow values, minus the rate of depreciation. Consider the rate of return to a newly constructed mile of residential street. It might reflect the value of the time that residents save by driving that mile rather than walking -- not only for this year but also for the expected life of the pavement (about 20 years). From this value, one might subtract the value of the health benefits of walking.

(3) In the steady state, investment just replaces wear and tear.

Some commentators fault the states for permitting their road systems to deteriorate. From the perspective of the model, the commentators seem to decry steady-state adjustments that permit net investment to fall below 0. The model tells us that the marginal value of the infrastructural stock will stabilize when the marginal value of the flow just covers the opportunity cost of investment.

(4) Suppose that infrastructure has a low marginal valuation. Then the official will let it decay until its marginal valuation rises enough to make it competitive with other assets.

This suggests that a big-city mayor is not necessarily myopic when he permits his public works to decay in the wake of exiting industries. However, suppose that the share of his city's spending shifts from maintenance to construction as industries exit. That might suggest competitive spending and myopia. The concluding section returns to this point.

Figure 1 depicts the equilibrium, which is a saddlepoint. One trajectory (AA) shows the path that leads to the equilibrium E. All other trajectories eventually veer away from E.

Begin at a point G that is toward the northwest extremity of the equilibrium path. Here infrastructure is scarce and hence highly valued. Its value motivates jurisdictions to produce more of it: Its level rises and its marginal value falls until the jurisdiction enters the steady-state. Here the amount of infrastructure that is created just offsets the amount that depreciates. Its marginal valuation is $P'/(b+r)$, or the stream of benefits from a new unit of infrastructure, discounted from the moment that we enter the steady state.

The scenario suggests that, in its early years, a jurisdiction might spend a relatively large share of its budget on building such scarce and urgently needed facilities as roads. In its later years, it will concentrate on maintaining the infrastructure or reallocate money to other uses.

COMPARATIVE STATICS AND RESULTS

Discount rate. The model might shed light on several issues. First, consider a permanent increase in the rate of return on competing assets. In response, the future value of infrastructure will fall, and so will the steady-state level of infrastructure. That result is plausible. The high interest rates of the early 1980s spurred many U.S. jurisdictions to exit the bond market and to curtail infrastructural spending (Vaughan, 1983). The sale of pollution control bonds and industrial revenue bonds seemed to have the same effect (Choate and Walter, 1981).

The rising value of competing uses of resources, signaled by a rise in interest rates, partly accounted for the decline in the public works share of public budgets. For all governments, the relative share of public works spending fell from nearly 20 percent of total spending in 1950 to 7 percent in 1984. Over the same period, spending for welfare and education rose from 10 percent to more than 40 percent of total spending (National Council on Public Works Improvement, 1988). Some scholars regard the decline in the infrastructural share of public budgets as evidence of the inadequacy of infrastructural financing (Kaplan, 1990). However, as local economies shift toward skill-intensive activities, the rate of return to education will rise. The ideal official will invest more in education and less in public works.

The welfare story is similar. If social tensions surge, the rate of return to welfare will rise -- particularly in the areas most prone to tension, the central cities under fiscal stress (Hulten and Peterson, 1984). The mayor is not myopic to invest more in welfare and less in public works.

Rewards. Consider a fall in the flow of rewards to building the infrastructure. The new steady state entails a lower level of infrastructure and a lower valuation of it. For instance, as a Northern state hemorrhages industrial activity to Southern states, its elected official is rational to permit part of its infrastructure to deteriorate. The roads and bridges are worth less than before.

Depreciation. A rise in the depreciation rate leads to a fall in the steady-state level of infrastructure. The change in the valuation of infrastructure is ambiguous.

COMPARING THE ACCOMMODATIVE AND COMPETITIVE MODELS

This section contrasts the accommodative model with the competitive model developed in Taylor (1990). In the competitive model, **n** jurisdictions vie for an industry by developing their infrastructures. The first jurisdiction to develop its infrastructure to a given level will win the industry. No jurisdiction knows precisely where it stands in the race. But each jurisdiction knows this: The faster that it spends money, the faster that it develops its infrastructure, boosting its chances of winning the industry. Each jurisdiction seeks the rate of spending that will maximize its expected gain from competing.

The statics of the two models contrast in several ways:

Discount rate. In the accommodative model, an increase in the discount rate reduces the steady-state level of infrastructure. In the competitive model, an increase in the discount rate has ambiguous results:

Suppose that the jurisdiction is far behind its potential rivals. Then a higher discount rate increases the opportunity cost of competing hard, since the jurisdiction must start spending now, rather than later, if it hopes to win. In this case, the jurisdiction will spend less.

Alternatively, suppose that the jurisdiction anticipates a large reward at the end of a successful infrastructural race. Then a higher discount rate increases the opportunity cost of not competing hard. If the jurisdiction competes in a leisurely manner, it will have to wait a long time to win its reward, which by then will be greatly discounted in value. In this case, the jurisdiction will spend more.

epreciation. In the accommodative model, an increase in the rate of depreciation leads to a fall in the steady-state level of infrastructure. In the competitive model, depreciation plays no role. The idea is to attract the industry. If it moves in, it will do so immediately after the infrastructure is completed. It will not wait for the infrastructure to depreciate.

Which is more important -- accommodative or competitive spending? For a sense of the answer, let us see which model better explains the rise and decline in local infrastructural spending in the United States since World War II. The analysis is casual but suggestive.

First, apply the accommodative model. In the 1940s, the demands of war forced American states and localities to postpone capital projects. After the war, the jurisdictions were at a northwestern point on the equilibrium path, where infrastructure was scarce and highly valued. The jurisdictions embarked on "catch-up" programs. In the same era, the baby boom raised the demand for schools. The population shifted from the North and East to the South and West; from areas that were densely populated to areas that were not (Hulten and Peterson, 1984; Peterson, 1984). All three factors induced a rise in the valuation of capital and in the investment rate. The jurisdictions moved down the adjustment path to the steady-state, where they simply replaced depreciating infrastructure.

Hulten and Peterson (1984) present evidence that suggests an accommodative response to an increase in demand, followed by an adjustment to a steady state. They estimate the average annual growth rate of the stock of structures for state and local governments. In percent, the estimates are 2.32 for 1959-62; 3.15 for 1963-67; 2.22 for 1968-72; 1.01 for 1973-77; and .26 for 1978-82.

Now consider the postwar story told by the competitive model. The release of pent-up demand for private production increased the rewards to jurisdictions of attracting firms. The baby boom also increased rewards. Infrastructural spending surged as jurisdictions competed to catch up. So far the competitive story is hard to tell apart empirically from the accommodative one.

However, the stories differ critically in the impact of three factors:

Depreciation. Three conflicting forces have affected the depreciation rate for old and new public works:

First, technological improvements in construction have lowered the depreciation rate for new works. Zero-maintenance pavements can provide virtually maintenance-free service for 20 years when combined with subgrade and enhanced drainage. Construction firms use steels twice as strong as those of 20 years ago. They also use concrete mixes three times the 20-year-old standard of 3,000 pounds per square inch (Ibbs and Echeverry, 1988).

Second, technological improvements in monitoring have lowered the depreciation rate for old public works. Television cameras monitor sewers internally. New radar devices penetrate the ground to locate objects. Ultrasonic waves measure the strength of concrete (Ibbs and Echeverry, 1988).

Third, new performance standards have raised the depreciation rate for old works. Water quality standards might require some jurisdictions to replace old treatment plants (Hulten and Peterson, 1984).

What is the net effect on depreciation? Peterson et al. (1983) concluded that most types of infrastructure deteriorated over the 1970s. In the accommodative model, a rise in the depreciation rate lowers the level of steady-state infrastructure. This is consistent with the decline in net investment that Hulten and Peterson noted. In the competitive model, the depreciation rate does not affect infrastructural building.

Discount rate. The credit crunch of the late 1970s increased the discount rate and decreased infrastructural spending. This is consistent with the accommodative model. It is consistent with the competitive model only for jurisdictions that have poorly developed infrastructures and that pursue not-the-most-lucrative industries.

Differences among jurisdictions in their levels of infrastructure. In the accommodative model, the fact that some jurisdictions have more highly developed infrastructures than others need not affect the aggregate rate of investment or the aggregate level of infrastructure. Each jurisdiction responds to the needs of its own economic base. It takes no account of what its neighbors do.

In the competitive model, under reasonable assumptions, aggregate infrastructural spending varies inversely with the variance across jurisdictions in levels of infrastructure. If one jurisdiction lags far behind its neighbors, it is less likely to undertake an infrastructural race. At a regional level, the model suggests that the South would devote a smaller share of its GNP to public works than the Northeast. In this respect, the competitive model seems to perform better than the accommodative model.

In sum, we are led to two hypotheses: Of the two models, the accommodative one does better at explaining nationwide trends in subfederal spending; the competitive one does better at explaining regional variations in subfederal spending. Because we would like firmer estimates of how much infrastructural spending actually occurs for competitive reasons, and how much for accommodative reasons (particularly if we are worried about the impact of federal subsidies), an econometric test will be useful.

Consider a locality's capital expenditures on mass transit. Model accommodative spending as $T_1 = f(dP, dE, dY)$. Here, dP is the locality's growth in population; dE is its growth in employment, a proxy variable for business growth; and dY is its growth in income. An increase in income raises the opportunity cost of commuting time. This stimulates demand for mass transit that eases congestion.

Model competitive spending as $T_2 = g(R/P)$, where R/P represents transit miles per capita. One testable prediction of the competitive model is that spending varies directly with the jurisdiction's existing level of infrastructure. A jurisdiction that already has good mass transit is more likely to upgrade it for competitive reasons than a jurisdiction with bad mass transit.

The jurisdiction's total capital expenditure on mass transit is $T = T_1 + T_2$. In a cross-sectional study of jurisdictions, estimate $T=j(dP,dE,dY,R/P)$. A positive derivative on the fourth variable is consistent with the hypothesis that competitive spending occurs. Positive derivatives on the first three variables are consistent with the hypothesis that accommodative spending occurs.

There is another way to find out whether officials build public works mainly to accommodate growth or to compete for growth: Ask them. They will have little reason to lie. And they will think carefully about the question, for it will interest them.

CONCLUSIONS

Scholars and analysts debate whether subfederal governments spend too little on public works. To assess the debate, this paper outlines a simple theory of infrastructural decisions by jurisdictions. Initially, jurisdictions build infrastructure to compete for new growth. Then the winners of these contests build infrastructure to accommodate overflow growth. If governments spend too little on infrastructure, they are most likely to do so on the accommodative type, not the competitive type.

Building infrastructure for accommodation takes planning, capital and time. These characteristics suggest the optimal control model that the paper develops.

The paper characterizes a construction path for accommodative infrastructure that maximizes its social value. Suppose that, on the equilibrium path, jurisdictions start at a point where infrastructure is scarce and highly valued. Then they will build more of it until they reach a steady-state. Here, they simply replace the infrastructure that deteriorates.

The steady-state level of infrastructure will rise if the rate of return to infrastructural spending rises, if the discount rate falls, or if the depreciation rate falls.

The models of accommodative and competitive spending respond differently to the discount and depreciation rates. The models also respond differently to the variation among jurisdictions in their initial levels of infrastructure. One can base an empirical test on these differences.

The purpose of the paper is to provide the analytical basis for an empirical study of whether governments spend too little on infrastructure. The purpose is not to undertake the empirical study itself. However -- at this stage, and at this level of casual empiricism -- there is not compelling evidence that the model's path varies wildly from the actual path of infrastructural spending in the United States since World War II.

The most significant result is that the path that maximizes utility is also the only path that leads to an equilibrium. If you think that the model's assumptions are reasonable, and if you think that infrastructural spending actually tends toward an equilibrium, then you will reject the underspending hypothesis.

Several empirical studies detect a pattern in infrastructural spending that looks like a movement toward equilibrium. The best way, then, to defend the underspending hypothesis is to attack the model's assumptions.

My sense is that the best line of attack is to argue that officials act myopically. The model assumes that the subfederal official acts in his constituents' interest as he builds infrastructure to accommodate growth. However, Inman (1983) and Barker (1984) argue that, in reality, the official might spend too much to build and too little to maintain, because he believes that very visible works will attract more votes than barely visible upkeep. Testing this myopia hypothesis might be a good way of testing the underspending hypothesis.

In the United States, Holtz-Eakin and Rosen (1989) test the hypothesis that local bureaucrats rationally adjust infrastructural plans to changes in key economic and demographic variables. Their careful study uses data from 433 communities in New Jersey. Holtz-Eakin and Rosen judge the rationality of capital spending by the length of the lags of explanatory variables. Short lags indicate that the spenders exploit most of the information available, so they are rational. Holtz-Eakin and Rosen found long lags for big communities and short lags for small communities. They suggested that the officials of large communities did not spend rationally. The officials were prone to myopia, liquidity constraints or backward-looking behavior.

The analysis here suggests another perspective. One might associate short lags with accommodative spending and long lags with competitive spending. In accommodating growth, the official might update spending each year or two as he receives current information about economic and demographic changes. In competing for growth, the official must act on information that is hard to update. He is playing a hunch (e.g., Can Cleveland beat Pasadena in the race for medical technological firms?) He might not obtain better information about that hunch for a long time. In this framework, the results of Holtz-Eakin and Rosen suggest that big communities are more prone to competitive spending, relative to accommodative spending, than small communities.

Serious deterioration of public works seems confined mainly to large cities in fiscal crisis (Peterson et al., 1983). This deferral of maintenance is not necessarily due to myopia. The leaders of big communities that lose contests are rational to permit their infrastructures to decay.

However, the deferral of maintenance might be due to myopia. In other words, one can reconcile the competition hypothesis to the myopia hypothesis. Public officials are most likely to act myopically when they build to compete for growth. The drama of such a project draws publicity and (presumably) votes. Consider the official who launches the project -- who snips the tape, or digs the first shovelful of dirt, for the TV cameras. He looks like a visionary. Next, consider the official who maintains an accommodative, steady-state infrastructure -- who patches the potholes and mends the water mains. He looks like a plodder. For the mayor who needs media, the choice is clear.

We are brought to these questions: Do the mayors of large, crippled cities permit deterioration because they are the rational losers of infrastructural contests? Do they permit it because they are myopic in deferring maintenance? Or do they permit it because they were myopic in building to compete and now are rational to let past mistakes decay?

Another test of myopia might be possible. Myopia implies that officials will defer too much maintenance. One test is to determine how much spending on maintenance is "too little" and whether actual spending exceeds this level. To do so, construct an optimal control model in which the official allocates a constrained budget between maintenance and construction. In effect, he picks an optimal path for the depreciation rate. A test of myopia might generate the optimal maintenance path (with suitable parameters) and compare it against the actual path.

The theory of public capital encompasses a large, rich literature. This paper adds but a grace note or two: There is value in asking why jurisdictions build. And there is value in viewing their decisions through the telescopic lens of optimal control.

NOTES

1. Rietveld's key reference here is den Hartog et al. (1986).
2. Schumpeter (1947) identified an analogue in private markets: Quality competition is more powerful than price competition.
3. Von hunen (1826), Christaller (1933) and Losch (1941) argued that location determined urban growth. Englander (1926) argued that agglomeration economies determined growth.
4. To enhance efficiency, the federal government could exploit informational economies of scale -- coordinating research, as well as disseminating data and analytical techniques, among state governments.
5. Assume away spillover effects. This assumption is strong indeed. But we have to start somewhere.
6. For instance, Hulten and Peterson (1984) assume an average depreciation rate of 3 percent. Note that the model concerns construction, not maintenance.
7. The derivations are available from the author.
8. How would we measure the health benefits of walking? In Grossman's (1980) model, the monetary rate of return to an investment in health is the product of the wage rate and the marginal product of health investment, divided by the marginal cost of health investment. Suppose that it takes 20 minutes to walk a mile. Suppose that we value an hour at the wage rate. Then the monetary rate of return to walking a mile is three times the marginal product of walking. To Grossman, the marginal product is the increase in the number of healthy days. How to estimate this? I might suggest this approach. For a sample of the adult population, regress the cumulative number of sick days upon such variables as age, weight, number of cigarette packs smoked per day, amount of non-walking exercise per day -- and the number of miles walked per day. Hope that the derivative with respect to miles walked is negative. If so, interpret its absolute value as the number of healthy days gained by a mile of walking.
9. In Figure 1, the locus for $(m' = 0)$ shifts left.
10. In Figure 1, a fall in P shifts the $(m' = 0)$ locus left.
11. In Figure 1, a rise in b shifts both locii left.
12. I assume that use causes depreciation.
13. In Figure 1, these factors caused P(Z) to shift up and $Z' = 0$ to shift left.
14. John Petersen (1988) also presents estimates that suggest a steady-state adjustment. He finds that the net stock per capita of state and local governments rose from 1950 to about 1978, when it leveled off at $2,500 in 1972 dollars.
15. Blinder (1990) discusses, with pith and wit, the craft of economic interviewing.

REFERENCES

Arthur, W. Brian. 1988. "Urban Systems and Historical Path Dependence." *In Ausubel and Herman*, 85-97.

Ausubel, Jesse H. and Robert Herman. 1988. "*Cities and Their Vital Systems: Infrastructure Past, Present and Future.*" Washington, D.C.: National Academy Press.

Barker, Michael, ed. 1984. "*Rebuilding America's Infrastructure: An Agenda for the 1980s.*" Durham, N.C.: Duke University Press.

Blinder, Alan S. 1990. "Learning By Asking Those Who Are Doing." *Eastern Economic Journal*. 16: 297-306.

Choate, Pat and Susan Walter. 1981. "*America in Ruins*. Reprinted in Barker.

Christaller, Walter. 1933. "*Central Places in Southern Germany*. English translation by Carlisle W. Baskin, 1966. Englewood Cliffs, N.J.: Prentice-Hall.

Englander, O. 1926. Kritisches and Positives zu einer allgemeinen reinen Lehre vom Standort. *Zeitschrift fur Volkswirtschaft und Sozialpolitik*. Neue Folge 5.

Gould, John P. 1970. "Diffusion Processes and Optimal Advertising Policy." *In Phelps*, 338-368.

Grossman, Michael. 1980. "On the Concept of Health Capital and the Demand for Health." *Journal of Political Economy*. 80: 223-255.

Hanson, Royce, ed. 1984. *Perspectives on Urban Infrastructure*. Washington, D.C.: National Academy Press.

Hartog, H. den, K. Heineken, B. Minne, R. Roemers and H. Roodenburg. 1986. "Investeren in Nederland." *Onderzoeksmemorandum* 17, Centrall Planbureau, The Hague.

Hinds, Michael deCourcy. 1991. "Strapped, Big Cities Take Painful Steps." *New York Times*, January 6, 14.

Hirschman, Albert O. 1958. *The Strategy of Economic Development*. New Haven, Conn.: Yale University Press.

Holtz-Eakin, Douglas and Harvey S. Rosen. 1989. "The 'Rationality' of Municipal Capital Spending: Evidence From New Jersey." *Regional Science and Urban Economics*. 19: 517-536.

Hulten, Charles R. and George E. Peterson. 1984. "The Public Capital Stock: Needs, Trends and Performance." *American Economic Review*. 74: 166-173.

Ibbs, C. William and Echeverry, Diego. 1988. "New Construction Technologies for Rebuilding the Nation's Infrastructure." *In Ausubel and Herman*, 294-311.

Inman, Robert P. 1983. "Anatomy of a Fiscal Crisis." *Business Review*. Federal Reserve Bank of Philadelphia. Sept.-Oct., 15-22.

Kamien, Morton I. and Nancy L. Schwartz. 1981. *Dynamic Optimization: The Calculus of Variations and Optimal Control in Economics and Management*. New York: North-Holland.

Kaplan, Marshall. 1990. "Infrastructure Policy: Repetitive Studies, Uneven Response, Next Steps." *Urban Affairs Quarterly*, 25: 371-388.

Losch, August. 1941. *The Economics of Location*. English translation by W.G. Woglom and W.F. Stolper from the second revised edition, 1954. New Haven, Conn.: Yale University Press.

McDowell, Bruce D. 1988. "Federalism and America's Public Works." Publius: *The Journal of Federalism*, 18: 97-112.

National Council on Public Works Improvement. 1988. Fragile Foundations: A Report on America's Public Works. Washington, D.C.: Government Printing Office.

Peterson, George E. 1984. "Financing the Nation's Infrastructure Requirements." *In Hanson*, 11-142.

Petersen, John E. 1988. "Infrastructure Financing: Examining the Record and Considering the Options." *In Stein*, 94-116.

Phelps, Edmund S. et al. 1970. *Microeconomic Foundations of Employment and Inflation Theory*, New York: Norton.

President's Commission for a National Agenda for the Eighties. 1980. *A National Agenda for the Eighties*. Washington, D.C.: U.S. Government Printing Office.

Rietveld, Piet. 1989. "Infrastructure and Regional Development: A Survey of Multiregional Economic Models." *Annals of Regional Science*. 23: 255-74.

Schumpeter, Joseph. 1947. *Capitalism, Socialism and Democracy*. New York: Harper.

Stein, Jay M., ed. 1988. *Public Infrastructure and Planning Management*. Newbury Park, Calif.: SAGE Publications.

Taylor, Leon. 1990. "Infrastructural Competition Among Jurisdictions." Forthcoming, *Journal of Public Economics*.

Thunen, J.H. von. 1826. *Der Isolierte Staat in Beziehung auf Landwirtschaft und Nationalokonomie. Hamburg*.

Vaughan, Roger J. 1983. *Financing Public Works in the 1980s*. Reprinted in Barker.