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Physical Infrastructure and Economic Growth in El Paso: 1976-2009

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The University of Texas at El Paso
UTEP Border Region
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Abstract

Prior research on the impacts of public capital stocks on economic growth has generally employed either national macroeconomic or multi-jurisdictional regional data. This study attempts to contribute to this area of the discipline by utilizing time series data for a single metropolitan economy. To allow for both short-run and long-run effects, an error correction modeling framework is used for the empirical analysis. Because comprehensive public infrastructure stocks are not published for El Paso, Texas, estimates for those variables are calculated using information regarding annual public capital investment data. Estimation results indicate that physical infrastructure investment may disrupt short-run economic growth, but does improve long-run metropolitan economic performance.

Keywords: Public capital stocks, metropolitan economic expansion, applied econometrics

JEL Categories: R15, Regional Econometrics; H76 Local Government Expenditures

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Introduction

Public infrastructure is an important component of national, regional, and local economies. Well-maintained physical infrastructure is generally regarded as a key element in providing a foundation for growth and productivity. Regional infrastructure tends to reinforce the development of commerce and can reduce costs for households and firms. For example, surface highways enable smoother transactions from suppliers to distributors to consumers for nearly all goods and services. If infrastructure is allowed to deteriorate or does not keep pace with regional growth, it can potentially lead to costly bottlenecks and impair private sector productivity (English & Cunningham, 2008; Munnell, 1990).

Some studies indicate that physical infrastructure enhances regional economic performance (Eberts, 1990; García-Mila & McGuire, 1992). Other efforts, however, indicate that the relationship between public capital stocks and growth

is not so clear cut (Albala-Bertrand & Mamatzakis, 2007; Garcia-Mila, McGuire & Porter, 1996; Tatom, 1993). Nearly all of these studies rely on either national or multi-jurisdictional regional data. Given the numerous regional economic differences that exist across most countries, analyses based on data from multiple regions may fail to uncover significant relationships that exist within individual economies. This study differs from previous work on this topic by focusing on the impacts of private and public capital stock investment in only one urban economy, that of El Paso, Texas.

An important factor that distinguishes El Paso from other metropolitan economies in the United States is its location on an international border. The local economy benefits from the presence of industries related to the export-oriented manufacturing sector of neighboring Ciudad Juárez, Mexico (Hanson, 2001). The North American Free Trade Agreement (NAFTA), which went into effect in 1994, reinforced economic ties with Mexico and, at the same time, required large-scale investment in border region transportation infrastructure to facilitate the increased trans-boundary flow of goods (Bradbury, 2002). Investment in public infrastructure, and especially transportation networks, accelerated substantially in El Paso after 1994. El Paso's role as a conduit for international trade may condition the impact of public infrastructure, and other factors of production, on local economic growth.

The literature review situates the approach of this analysis within the context of previous research. The data and conceptual framework section then describes the sources of data used in this study as well as the econometric approach that is employed. The section on empirical results includes the estimated model along with a discussion of alternative specifications. It is followed by a conclusion and suggestions for future research.

Literature Review

The efforts of local governments to promote economic development are constrained by the changing characteristics of the national economy. While globalization reduces the efficacy of economic development strategies based on recruiting manufacturing firms, the rising importance of the service sector and information technology further suggests that remaining competitive may require greater investment in regional innovation capacity (Hall, 2007a). Inadequate investment in physical infrastructure capacity can work in the opposite direction by creating bottlenecks that increase inefficiency and retard growth.

Public infrastructure provides a number of services to an economy. Those services may improve productivity either directly or indirectly (Tatom, 1991; 1993). Because it is difficult to optimize the levels of investments for these government provided goods, carrying capacities can often be surpassed, producing negative externalities such as congestion and impeding growth (Meade, 1952). Per unit cost assignments cannot always be charged to those individuals or firms that utilize public goods, adding to the unappealing nature of infrastructure provision. Consequently, most public goods are provided by government entities employing a variety of funding mechanisms.

Most of the efforts to quantify the economic impact of public infrastructure involve estimating a production function in which output is a function of labor, public capital, and private capital. Several studies report that public capital stocks have a positive effect on output in the United States (Aschauer, 1989; Costa, Ellson & Martin, 1987; Eberts, 1990; Garcia-Mila & McGuire, 1992). The impact of public capital is also found to be positive in studies conducted for Australia (Bosca, Cutanda & Escriba, 2004; Otto & Voss, 1998), Italy (DeStefanis & Vena, 2005; Marrocu & Paci, 2010), and Japan (Okubo, 2008). Albala-Bertrand and Mamatzakis (2004) find that public infrastructure investment in Chile lowers costs of production and raises productivity. Duffy-Deno and Eberts (1991) estimate simultaneous equations indicating that both the stock of public capital and the flow of public investment positively affect personal income while personal income contemporaneously affects public investment expenditures.

Public capital may influence regional economic development by serving as a complement to private capital and thus affecting the return to private investment. Costa et al. (1987) report that public and private capital stocks have complementary productivity effects, though the relationship is not found to be statistically significant at conventional levels. While Eberts (1990) acknowledges that public capital and private capital are typically complements, the magnitude of the impact of private capital on output is usually greater than for public capital. Deno (1986) finds that private net investment has a greater

impact on public capital outlays than public capital outlays on private industry.

Though numerous studies document positive links between public infrastructure stocks and output, others attribute these results to econometric estimation errors. Tatom (1991) finds that including non-stationary variables, excluding a time trend, or ignoring the relative price of energy may result in a spurious correlation between output and public capital. Using panel data, Holtz-Eakin (1994) finds that the positive and significant relationship between the public capital stock and output results from excluding state-specific fixed effects. These analyses suggest that efforts to estimate the impact of public capital on output should take into account the potential pitfalls of using non-stationary variables and using aggregated multi-region data. Accordingly, this study examines a single metropolitan economy and conducts co-integration tests as a means to ensure that the regression residuals are stationary.

It is important for policy-makers to know which components of the public capital stock generate the largest productivity impacts. Feltenstein and Ha (1995) find that communications and electricity infrastructure improve productivity in Mexico, but investment in highways is found to hurt private sector output. Noriega and Fontenla (2007) obtain estimates that point to favorable economic impacts associated with investment in highways and electrical power, but not telecommunications infrastructure. Albala-Bertrand and Mamatzakis (2007) report that electricity infrastructure lowers the cost of production, while the results are less clear with respect to transportation infrastructure. Using differenced data, Garcia-Mila et al. (1996) find that highways as well as water and sewer infrastructure have statistically insignificant impacts on output. When feasible, such studies sometimes allow for a more fine-tuned analysis of the impacts of infrastructure variables on output.

Data on the stock of public infrastructure are very limited, especially at the local level (Eberts, 1990). In many cases, the capital stock variables that are needed to estimate a production function must themselves be estimated. Duffy-Deno and Eberts (1991) and Costa et al. (1987) use the perpetual inventory method (PIM) to obtain estimates of the public capital stock. In this method, the capital stock is calculated by summing investment flows over time and subtracting depreciation, which requires a complete set of historical data. Because such data are often unavailable or unreliable, Albala-Bertrand (2010) proposes an alternative procedure called the optimal consistency method. This method, like the PIM, is based on an equation in which investment and depreciation determine the capital stock. Its principal innovation is the incorporation of output data and capital-output ratio parameters into the capital stock equation. The parameters of this modified equation can be estimated using linear programming and those estimates can be used to calculate the benchmark level of the capital stock.

Although much of the existing research is concerned with the long-term relationship between public capital and overall economic activity, some of the analyses mentioned above use first-differenced data to capture the effect on output of short-term variations in public infrastructure investment (Garcia et al., 1996; Tatom, 1991). Scant attention is typically paid to the question of whether public infrastructure has the same impact on output in the short run as it does in the long run. This analysis addresses that issue by estimating both a long-run cointegrating equation as well as a short-run error correction equation and by quantifying the length of time required to achieve equilibrium in the metropolitan output market.

The rising importance of information technology and the service sector has generated disparate effects on economic outcomes across different regions of the United States (Hall, 2007b). Similarly, the increase in North American trade after 1994 may affect El Paso differently than other regions of the country due to proximity and close economic ties to Mexico. This analysis investigates the impact of infrastructure investment on output in this uniquely situated border economy. The disaggregated investment series for 1976 through 2009 are transformed into an aggregate capital stock estimate using the optimal consistency method proposed by Albala-Betrand (2010). Disaggregated infrastructure stocks are calculated for highways, water and sewer systems, streets and the international airport (Cain, 1997). An advantage of conducting the analysis for data over 34 years for El Paso is that it permits examining both short-term and long-term impacts of infrastructure investment on growth in this metropolitan economy.

Data and Conceptual Framework

This effort examines the impact of public infrastructure on gross metropolitan product (GMP) in El Paso County,

Texas. Towards that end, a traditional production function is developed including labor and capital, with the latter divided into physical infrastructure and the private capital stock. Physical infrastructure data collected include the following capital asset categories: (a) water and sewer mains, (b) highways, (c) streets, and (d) the airport. Private sector capital stock data are collected for commercial and industrial structures. El Paso Water Utilities is the only entity that has a nominal capital stock series available, but the Texas Department of Transportation, City of El Paso, and the Central Appraisal District record nominal gross investment flow series. In order to deal with that data gap, steps are taken to transform the flow variables into stock variables using an optimal consistency approach (Albala-Bertrand, 2010). Those steps are discussed below.

Real GMP, measured in 2001 constant dollars and total employment for El Paso, are collected from the University of Texas at El Paso Border Region Modeling Project (BRMP 2010). The U.S. Bureau of Economic Analysis (BEA 2003, 2010, 2011a, 2011b) is the source of the real capital asset depreciation rates, service life, and deflator information utilized to calculate the public capital stock estimates. Selection of the appropriate variables for the calculation of each infrastructure stock series is important (Costa et al., 1987). Inaccurate information can affect the reliability of any subsequent econometric results obtained (Jorgenson, 1996). The time series utilized are annual frequency data, starting in 1975 and ending in 2009.

From BEA (2011a), the Current-Cost Net Stock of Government Fixed Assets and the Chain-Type Quantity Indexes for Net Stock of Government Fixed Assets are obtained, and these are used to create the three public asset deflators. Using the current cost value for reference year 2005, these deflators convert the chain-type quantity index into a pseudo chain-type dollar value through multiplication. A ratio of the current-cost net stock and the created chain-type constant dollar value is taken in order to obtain the implicit price deflator for public assets with reference year 2005. The deflator for private capital assets is calculated in the same manner, using the Current Cost Net Capital Stock of Private Nonresidential Fixed Assets and the Chain-Type Quantity Indexes for Net Capital Stock of Private Nonresidential Fixed Assets; both are obtained from BEA (2011b). The appropriate capital asset deflator is used to create each of the 2005 constant dollar capital stock series.

In order to calculate capital stock estimates, initial year benchmark estimates are required. The optimal consistency method proposed by Albala-Bertrand (2010) outlines a useful benchmark estimation method that has relatively minimal data requirements. The benchmark capital stock estimates for 1976 are calculated using a linear programming procedure by finding the optimal productivity of accumulated investment flows over the 34-year sample period. The procedure requires data on gross metropolitan product, gross investment flows for each asset category, and physical infrastructure depreciation rates based on capital asset service lives. BEA (2003) estimates for the service lives of the capital asset inputs in this study are: (a) highways and streets, 45 years; (b) sewer and water systems, 60 years; (c) airports, 25 years; and (d) commercial and industrial assets average around 38 years. Once benchmark capital stock levels for 1976 have been estimated, investment flows and depreciation rates are used to develop the capital stock series according to the perpetual inventory method. The four individual public infrastructure series are then added together to obtain the aggregate public capital variable.

As in Aschauer (1989), the production function in Albala-Bertrand and Mamatzakis (2001) is a log transformed Cobb-Douglas specification, which assesses the long-run relationship between public infrastructure and output. This is shown in Equation (1):

$$\ln GMP_t = \ln A_t + a_1 \ln EMP_t + a_2 \ln KPUB_t + a_3 \ln KPVT_t + U_t \quad (1)$$

where A is the technology index, EMP is total employment, KPUB is public infrastructure capital, KPVT is private capital, U is a stochastic error term, and t is time index. Estimates of the respective elasticities of output with respect to each input are provided by a_1, a_2, and a_3.

To capture short-run dynamics, an error correction representation can be utilized as shown in Equation (2):

$$d(\ln GMP_t) = b_0 + b_1 d(\ln EMP_t) + b_2 d(\ln KPUB_t) + b_3 d(\ln KPVT_t) + b_4 U_{t-1} + V_t \quad (2)$$

The b_4 coefficient measures the short-term response of the economy to any prior period disequilibria. The physical infrastructure variable $KPUB_t$ can be total public capital

or any of the four components noted above: (a) streets, (b) highways, (c) airport, and/or (d) water and sewer.

Empirical Results

Graphs of the key variables in the sample are shown at the end of the report. Figure 1 shows four of the variables collected for El Paso. Characteristic of a growing metropolitan economy, all four of the variables are upward trending. It is easy to observe from Figure 1 that these variables tend to grow at different rates. Figure 2 shows the growth over time of the four component parts of the aggregate public infrastructure. Because the annual investment amounts for each infrastructure category can differ substantially, the expansion patterns for each series tends to vary discernibly from those of the other variables.

Because all of the variables included in Figure 1 are upward-trending it is likely that these series are non-stationary. A battery of chi-square autocorrelation function, augmented Dickey-Fuller t-tests, and Phillips-Perron t-tests indicate that, not surprisingly, the series are non-stationary in level form. Residuals from linear regressions of GMP on the explanatory variables, in levels, are found to be stationary using augmented Dickey-Fuller t-tests and Phillips-Perron t-tests. Those results indicate that the variables in the sample are co-integrated (Pindyck & Rubinfeld, 1998; Stock & Watson, 2007). Given these outcomes, two sets of error-correction results are presented below.

Results for the long-run equation where GMP is specified as a function of labor, aggregate public capital stocks, and aggregate private capital stock are shown in Table 1. Given the parsimonious nature of the specification, it is not very surprising that serial correlation is present in the initial estimation results. Accordingly, the results in Table 1 are corrected for autocorrelation using a nonlinear autoregressive moving average exogenous (ARMAX) estimator (Pagan, 1974). A one-period lag of the prediction error, MA(1), is included in the specification. All of the coefficients, including that for the moving average term, satisfy the 5% significance criterion. The coefficient of determination is calculated for the data in both level form and first-differences to facilitate comparison with the output in Table 2. The elasticities for these inputs indicate that increasing returns to scale are observed in El Paso over the course of the sample period in question. Yet this finding should be interpreted with caution since the results of an F-test also indicate that the hypothesis of constant returns is only rejected by a razor-thin margin at the 5% level of significance. The results in Table 1 indicate that, in the long-run, a 10% increase in the stock of public capital leads to a 2.6% increase in GMP. That outcome is similar to recent evidence regarding this topic reported in studies such as Albala-Betrand and Mamatzakis (2004) and Marrocu and Paci (2010).

Short-run error correction estimation results are shown for this specification in Table 2. Most notably, the parameter for physical infrastructure is statistically indistinguishable from zero. The coefficients for employment and private capital do satisfy the 5% criterion. Although the sign of the error correction term parameter is negative as expected, it is not significant at conventional levels. However, its magnitude of -0.153 is plausible. It represents the speed of adjustment back to equilibrium and implies that approximately 15.3% of any deviation away from it will be corrected during the first year following the shock. It further indicates that it will take approximately 6.5 years for any GMP disequilibria, which might be caused by a surge in public investment among other things, to completely dissipate.

Taken together with the long-run estimation results, the information in Table 2 has interesting implications. The long-term results clearly indicate that public capital and private capital both contribute to metropolitan economic expansion in El Paso. In the short-term, however, the picture is much less clear. Increases in employment and private capital stocks exercise favorable impacts, but increases in public infrastructure stocks engender insignificant, at best, effects on growth. In fact, the negative parameter estimate is reminiscent of results reported in prior studies that raise questions about the contributions, or lack thereof, of public capital stocks to regional economic performance (Garcia-Mila et al., 1996; Holtz-Eakin, 1994).

The apparently contradictory results shown in Tables 1 and 2 may have a logical explanation. Over the long-run, physical infrastructure may indeed provide the so-called backbone of regional economic performance. As anyone who has suffered through new large-scale construction or infrastructure upgrade projects can attest, however, public projects can also be very disruptive, at least in the short-run (Iimi, 2011). In El Paso, for example, such concerns are frequently voiced by members of the business community (Burge, 2011; Gray, 2011). Whereas additions to the private capital stock result from businesses' internal decision-making processes, firms do not directly plan and implement additions to public infrastructure and the benefit of such

projects may only materialize after a lengthy adjustment phase. From that perspective, ambiguous, or even short-term negative outcomes may plausibly be associated with investment in public capital stocks. Once those projects are completed, the new, or upgraded, infrastructure may then raise business productivity, in which case a positive impact would result for GMP.

As noted in the introduction, El Paso's economy is closely linked with that of Ciudad Juárez, Mexico. The importance of international trade for the local economy raises the question of whether any of the regression parameters changed as a result of the implementation of NAFTA in 1994. Table 4 suggests that the marginal contribution of labor to metropolitan output did increase after 1994, although the interaction coefficient is only statistically significant at the 10% level. NAFTA may have contributed to labor productivity by spurring cross-border trade and, in particular, by encouraging export-processing in Ciudad Juárez, which complements economic activity in El Paso (Hanson, 2001). At the national level, information technology increasingly contributed to growth in labor productivity and output in the 1990s (Jorgenson, Ho & Stiroh, 2008), and this trend may also have impacted El Paso's economy. A separate regression, not shown, indicates that the marginal effect of public infrastructure on output also increased after NAFTA was implemented, although the magnitude of this effect is smaller than that reported for labor. The economic impact of investment in border region public infrastructure, especially transportation networks, may be augmented by the increased trade under NAFTA (Bradbury, 2002).

Some studies note that it may be necessary to control for changes in population when estimating the impact of public infrastructure on output (Garcia-Mila & McGuire, 1992; Noriega & Fontenla, 2007). Since a larger population ordinarily necessitates a larger infrastructure stock, it is possible that the positive impact of public capital on output actually reflects a correlation between population and gross metropolitan product. To control for this possibility, all variables are divided by population before being logarithmically transformed and the equations are re-estimated. The regression output, shown in the Appendix (Tables 5 and 6), is very similar to the results obtained without controlling for population. The impact of public capital is estimated to be somewhat larger in the long run and is still negative and insignificant in the short run.

A model specification that employs the four individual infrastructure stock categories assembled for El Paso was also attempted. Estimation results for that approach yielded similar elasticity magnitudes to those discussed above for employment (LEMP) and private capital (LKPVT). However, none of the coefficient estimates for the four individual infrastructure categories satisfied conventional significance criteria. Similar to one of the problems highlighted in Ai and Cassou (1997), the culprit is multicollinearity.

Individual, often lumpy, funding and expenditure patterns cause the various infrastructure growth paths to vary (Hansen, 1965). While that is directly discernible in Figure 2, the series still remain highly correlated with each other over the course of the sample period. Those estimates are shown in Table 3. LAIR is the real airport capital stock; LHWY is real highway infrastructure; LSTR is the value of the stock of real streets capital; and LWNS is the real water and sewer capital of El Paso Water Utilities. Consistent with what typically results when multicollinearity is problematic, experimentation with subsets of the infrastructure variables yielded parameter estimates that are both greater than zero and statistically significant.

Because the growth patterns of the four components of public capital vary over time, there is less multicollinearity between the first differences of these series. But when the equation is re-estimated using first differences, the marginal effects of the four components of public capital stock are still statistically indistinguishable from zero. It may be that the relatively small size of the sample inhibits precise estimation of these marginal effects, especially if the true parameters are themselves relatively small. The individual impacts of each of the four components of the infrastructure stock are likely to be smaller than the aggregate impact of public capital. This problem may eventually be overcome as more sample observations become available. Accurate estimation of the overall stock of public capital in El Paso still requires calculating each category individually due to variant annual investment rates.

Conclusion

Debates frequently take place over the contributions, or lack thereof, of public capital stocks to economic performance. Because of the absence of metropolitan data on these variables, empirical analyses generally utilize state or national level information. This study attempts to at

least partially address that gap in the regional economics literature by examining evidence assembled using data for the El Paso, Texas metropolitan economy. Focusing on El Paso also allows some assessment of how increased international trade and other changes during the NAFTA era impact the relationship between output and the factors of production in a border-region economy.

Physical infrastructure stock estimates are developed for four separate categories: an international airport, highways, streets, and the municipal water and sewer system. A dynamic error correction framework is utilized for the empirical analysis with real GMP as the dependent variable. Other variables employed include labor and an aggregate private capital stock measure for El Paso. The sample period, determined by capital stock investment records availability, is 1976-2009.

Long-term cointegrating equation results indicate that labor, public capital, and private capital all contribute to real GMP. Short-run error correction estimation results indicate that although labor and private capital exert positive influences on GMP, investment in public infrastructure is potentially negative. The latter result may be due to the disruptive nature of public works projects. The limited number of observations currently prevents estimating a model specification with the disaggregated infrastructure categories deployed as individual regressors.

In the case of El Paso, it appears that infrastructure investment helps foster long-run economic growth. Whether these results are unique to this metropolitan economy or can be generalized to other regions is not clear. The development of similar public capital stock estimates for other regions may prove helpful. Given the presence of multicollinearity in this sample, utilization of a longer sample period is recommended for cases in which municipal investment records permit doing so.

References

Ai, C., & Cassou, S.P. (1997). On public capital analysis with state data. *Economics Letters, 57*, 209-212.

Albala-Bertrand, J.M. (2010). A contribution to estimate a benchmark capital stock: An optimal consistency method. *International Review of Applied Economics, 24*, 715-729.

Albala-Bertrand, J.M., & Mamatzakis, E.C. (2001). Is public infrastructure productive? Evidence from Chile. *Applied Economics Letters, 8*, 195-198.

Albala-Bertrand, J.M., & Mamatzakis, E.C. (2004). The impact of infrastructure on the productivity of the Chilean economy. *Review of Development Economics, 8*, 266-278.

Albala-Bertrand, J.M., & Mamatzakis, E.C. (2007). The impact of disaggregated infrastructure capital on the productivity of the Chilean economy. *Manchester School, 75*, 258-273.

Aschauer, D.A. (1989). Is public expenditure productive? *Journal of Monetary Economics, 23*, 177-200.

BEA (2003). BEA depreciation estimates, U.S. Bureau of Economic Analysis. Accessed 23 July 2009. http://www.bea.gov/national/FA2004/Tablecandtext.pdf

BEA (2010). BEA depreciation estimates, U.S. Bureau of Economic Analysis. Accessed 12 October 2010. http://www.bea.gov/national/FA2004/Tablecandtext.pdf

BEA (2011a). Standard fixed assets: Section 7 – government fixed assets, U.S. Bureau of Economic Analysis. Accessed 6 January 2011. http://www.bea.gov/national/FA2004/SelectTable.asp#S7

BEA (2011b). Detailed fixed assets table: Section 2 – nonresidential detailed estimates, U.S. Bureau of Economic Analysis. Accessed 6 January 2011. http://www.bea.gov/national/FA2004/Details/Index.html

BRMP (2010). Border Region Modeling Project data. University of Texas at El Paso Border Region Modeling Project. Accessed 9 September 2010. http://academics.utep.edu/Default.aspx?alias=academics.utep.edu/border

Bosca, J.E., Cutanda, A., & Escriba, J. (2004). Rates of return to public and private capital: New estimates using nonlinear Euler equations. *Applied Economics, 36*, 1225-1232.

Bradbury, S.L. (2002). Planning transportation corridors in post-NAFTA North America. *Journal of the American Planning Association, 68*, 137-150.

Burge, D. (2011, March 28). Oregon Street is to be done in November. *El Paso Times*, p. B1.

Cain, L.P. (1997). Historical perspective on infrastructure and U.S. economic development. *Regional Science and Urban Economics, 27*, 117-138.

Costa, J.S., Ellson, R.W., & Martin, R.C. (1987). Public capital, regional output, and development: Some empirical evidence. *Journal of Regional Science, 27*, 419-437.

Deno, K.T. (1986). *The short run relationship between investment in public infrastructure and the formation of private capital*. Unpublished doctoral dissertation, University of Oregon: Eugene, OR.

DeStefanis, S., & Vena, S. (2005). Public capital and total factor productivity: New evidence from the Italian regions. *Regional Studies, 39*, 603-617.

Duffy-Deno, K.T., & Eberts, R.W. (1991). Public infrastructure and regional economic development: A simultaneous equations approach. *Journal of Urban Economics, 30*, 329-343.

Eberts, R.W. (1990). Public infrastructure and regional economic development. *Federal Reserve Bank of Cleveland Economic Review, 26*, 15-27.

English, E., & Cunningham, C. (2008). Work zone ahead? Repairing the Southeast's infrastructure. *EconSouth, 10*, 6-11.

Feltenstein, A., & Ha, J.M. (1995). The role of infrastructure in Mexican economic reform. *World Bank Economic Review, 9*, 287-304.

Garcia-Mila, T. & McGuire, T.J. (1992). The contribution of publicly provided inputs to states' economies. *Regional Science and Urban Economics, 22*, 229-241.

Garcia-Mila, T., McGuire, T.J., & Porter, R.H. (1996). The effect of public capital in state-level production functions reconsidered. *Review of Economics and Statistics, 78*, 177-180.

Gray, R. (2011, March 27). Construction to start at crowded intersection. *El Paso Inc.*, pp. B1-B2.

Hall, J.L. (2007a). Informing state economic development policy in the new economy: A theoretical foundation and empirical examination of state innovation in the United States. *Public Administration Review, 67*, 630-645.

Hall, J.L. (2007b). Developing historical 50-state indices of innovation capacity and commercialization capacity. *Economic Development Quarterly, 21*, 107-123.

Hansen, N.M. (1965). The structure and determinants of local public investment expenditures. *Review of Economics and Statistics, 48*, 150-162.

Hanson, G.H. (2001). U.S.-Mexico integration and regional economies: Evidence from border-city pairs. *Journal of Urban Economics, 50*, 259-287.

Holtz-Eakin, D. (1994). Public-sector capital and the productivity puzzle. *Review of Economics and Statistics, 76*, 12-21.

Iimi, A. (2011). Effects of improving infrastructure quality on business costs. *Developing Economies, 49*, 121-147.

Jorgenson, D.W. (1996). Empirical studies of depreciation. *Economic Inquiry, 34*, 24-42.

Jorgenson, D.W., Ho, M.S., & Stiroh, K.J. (2008). A retrospective look at the U.S. productivity growth resurgence. *Journal of Economic Perspectives, 22*, 3-24.

Marrocu, E., & Paci, R. (2010). The effects of public capital on the productivity of the Italian regions. *Applied Economics, 42*, 989-1002.

Meade, J.E. (1952). External economies and diseconomies in a competitive situation. *Economic Journal, 62*, 54-67.

Munnell, A.H. (1990). Why has productivity growth declined? Productivity and public investment. *Federal Reserve Bank of Boston New England Economic Review, January/February*, 3-22.

Noriega, A., & Fontenla, M. (2007). Infrastructure and economic growth in Mexico. *Trimestre Económico, 74*, 885-900.

Okubo, M. (2008). Public capital and productivity: A nonstationary panel analysis. *Applied Economics Letters, 15*, 95-99.

Otto, G.D., & Voss, G.M. (1998). Is public capital provision efficient? *Journal of Monetary Economics, 42*, 47-66.

Pagan, A.R. (1974). A generalised approach to the treatment of autocorrelation. *Australian Economic Papers, 13*, 260-280.

Pindyck, R.B., & Rubinfeld, D.L. (1998). *Econometrics models and economic forecasts, 4th Edition*. Boston, MA: Irwin McGraw-Hill.

Stock, J.H., & Watson, M.W. (2007). *Introduction to econometrics, 2nd Edition*. Boston, MA: Pearson Addison Wesley.

Tatom, J.A. (1991). Public capital and private sector performance. *Federal Reserve Bank of St. Louis Review, 73*, 3-15.

Tatom, J.A. (1993). Is an infrastructure crisis lowering the nation's productivity? *Federal Reserve Bank of St. Louis Review, 75*, 6, 3-21.

Figure 1. El Paso Metropolitan Economic Expansion: 1976-2009

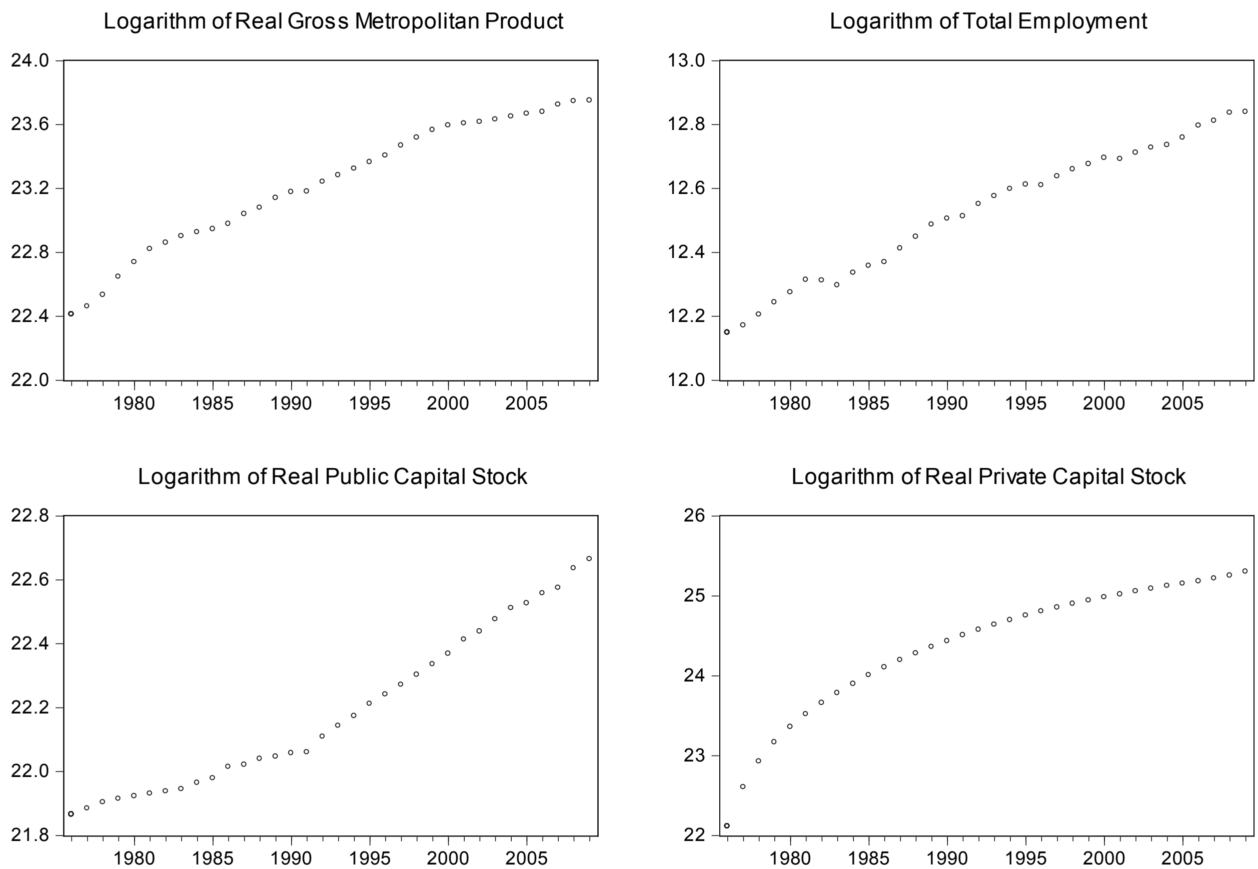

Figure 2. El Paso Infrastructure Categories: 1976-2009

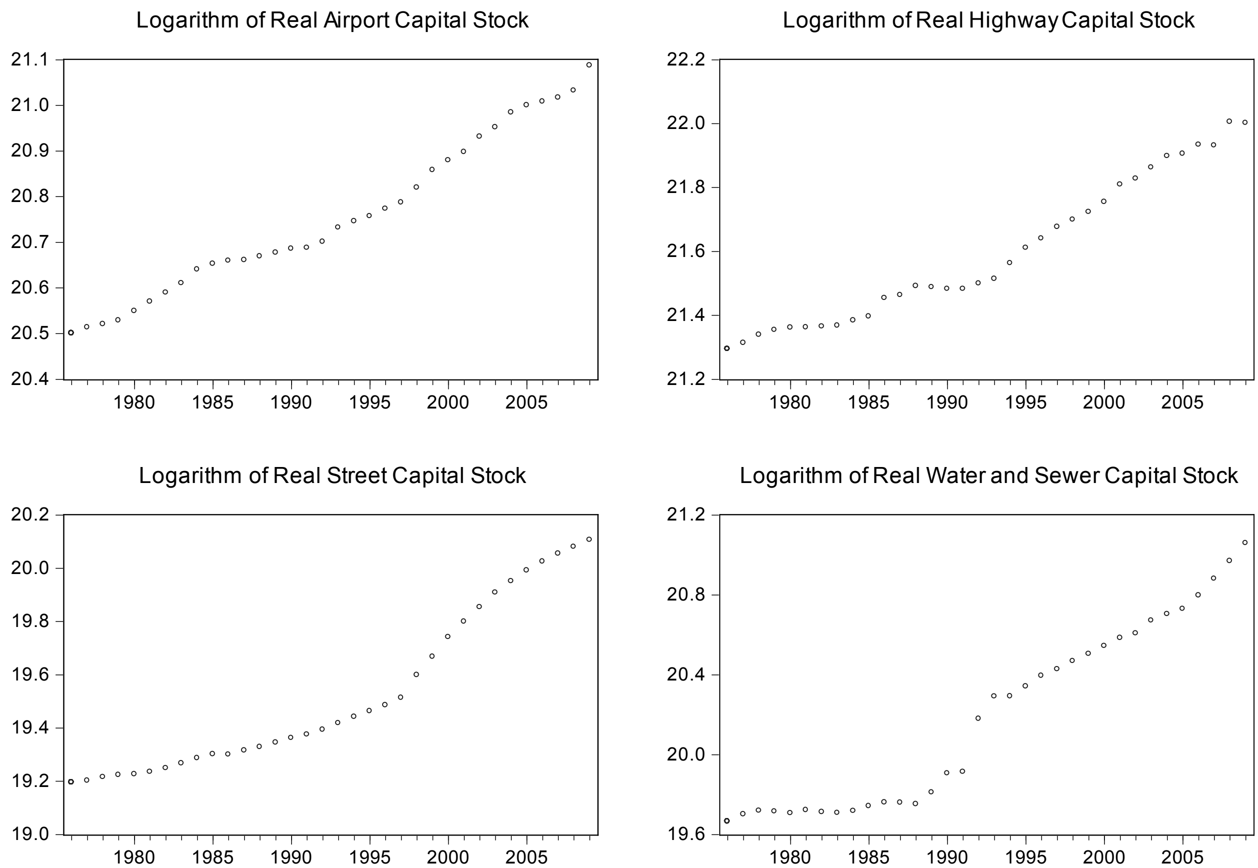

Table 1. Long-Run Cointegration Estimation Results

Dependent Variable: LGMP
Method: Nonlinear Least Squares
Sample: 1976 2009
Included observations: 34
Convergence achieved after 19 iterations
MA Backcast: 1975

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	2.343	0.904	2.591	0.015
LEMP	0.765	0.255	3.001	0.006
LKPUB	0.265	0.120	2.213	0.035
LKPVT	0.223	0.039	5.743	0.000
MA(1)	0.798	0.119	6.692	0.000

R-squared	0.997	Mean dependent var.	23.225
Adjusted R-squared	0.997	Std. dvn. dependent var.	0.401
F.D. R-squared	0.515	Akaike inf. Criterion	-4.591
Std. err. regression	0.023	Schwarz inf. Criterion	-4.366
Sum squared resid.	0.015	Hannan-Quinn criterion	-4.514
Log likelihood	83.041	Durbin-Watson statistic	1.461
F-statistic	2545.015	Inverted MA Roots	-0.800
Prob. (F-statistic)	0.000		

Notes:
Real GMP and total employment data are from the UTEP Border Region Modeling Project.
The public capital stock data are based on the records of the Texas Department of Transportation, the City of El Paso, and El Paso Water Utilities.
The private capital stock is based on data from the El Paso Central Appraisal District.
The F.D. R-squared is from the same model estimated with first-differenced data.

Table 2. Short-Run Error Correction Estimation Results

Dependent Variable: D(LGMP)
Method: Ordinary Least Squares
Sample (adjusted): 1977 2009
Included observations: 33 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	0.022	0.011	2.029	0.052
D(LEMP)	0.656	0.258	2.541	0.017
D(LKPUB)	-0.198	0.283	-0.701	0.489
D(LKPVT)	0.101	0.041	2.439	0.021
ERROR(-1)	-0.153	0.175	-0.875	0.389

R-squared	0.436	Mean dependent var.	0.041
Adjusted R-squared	0.355	Std. dvn. dependent var.	0.025
Std. err. regression	0.020	Akaike inf. criterion	-4.801
Sum squared resid.	0.012	Schwarz inf. criterion	-4.575
Log likelihood	84.222	Hannan-Quinn criterion	-4.725
F-statistic	5.410	Durbin-Watson statistic	1.165
Prob. (F-statistic)	0.002		

Table 3. Correlation Coefficients for Public Capital Stock Categories

	LAIR	LHWY	LSTR	LWNS
LAIR	1.000	.991	.982	.964
LHWY	.991	1.000	.987	.974
LSTR	.982	.987	1.000	.958
LWNS	.964	.974	.958	1.000

Notes:
Highway investment data are from the Texas Department of Transportation.
Airport and street investment data are from the City of El Paso.
Water and sewer capital stock data are from El Paso Water Utilities.

Table 4. NAFTA Structural Break Estimation Results

Dependent Variable: LGMP
Method: Nonlinear Least Squares
Sample: 1976 2009
Included observations: 34
Convergence achieved after 33 iterations
MA Backcast: 1975

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	3.695	1.184	3.121	0.004
LEMP	0.725	0.243	2.986	0.006
LKPUB	0.223	0.117	1.913	0.066
LKPVT	0.225	0.036	6.206	0.000
NAFTA*LEMP	0.003	0.002	1.724	0.096
MA(1)	0.735	0.129	5.710	0.000

R-squared	0.997	Mean dependent var.	23.225
Adjusted R-squared	0.997	Std. dvn. dependent var.	0.401
F.D. R-squared	0.516	Akaike inf. Criterion	-4.623
Std. err. regression	0.022	Schwarz inf. Criterion	-4.354
Sum squared resid.	0.014	Hannan-Quinn criterion	-4.531
Log likelihood	84.593	Durbin-Watson statistic	1.588
F-statistic	2154.207	Inverted MA Roots	-0.740
Prob. (F-statistic)	0.000		

Notes:
The data are from the same sources as in Table 1.
The F.D. R-squared is from the same model estimated with first-differenced data.

Table 5. Long-Run Estimation Results Controlling for Population

Dependent Variable: LGMPPC
Method: Nonlinear Least Squares
Sample: 1976 2009
Included observations: 34
Convergence achieved after 46 iterations
MA Backcast: 1975

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	4.440	1.423	3.120	0.004
LEMPPC	0.713	0.365	1.952	0.061
LKPUBPC	0.331	0.119	2.777	0.010
LKPVTPC	0.279	0.021	13.604	0.000
MA(1)	0.815	0.111	7.343	0.000

R-squared	0.992	Mean dependent var.	9.918
Adjusted R-squared	0.991	Std. dvn. dependent var.	0.244
F.D. R-squared [a]	0.399	Akaike inf. Criterion	-4.510
Std. err. regression	0.024	Schwarz inf. Criterion	-4.285
Sum squared resid.	0.016	Hannan-Quinn criterion	-4.433
Log likelihood	81.667	Durbin-Watson statistic	1.579
F-statistic	863.439	Inverted MA Roots	-.820
Prob. (F-statistic)	0.000		

Notes:
GMP, total employment, and capital stock data are from the same sources as in Table 1.
Population data are from the UTEP Border Region Modeling Project.
The F.D. R-squared is from the same model estimated with first-differenced data.

Table 6. Short-Run Estimation Results Controlling for Population

Dependent Variable: D(LGMPPC)
Method: Nonlinear Least Squares
Sample (adjusted): 1977 2009
Included observations: 33 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	0.015	0.006	2.466	0.020
D(LEMPPC)	0.632	0.264	2.397	0.024
D(LKPUBPC)	-0.118	0.242	-0.485	0.631
D(LKPVTPC)	0.092	0.045	2.052	0.050
ERROR(-1)	-0.110	0.177	-0.621	0.539

R-squared	0.314	Mean dependent var.	0.024
Adjusted R-squared	0.216	Std. dvn. dependent var.	0.023
Std. err. regression	0.020	Akaike inf. Criterion	-4.804
Sum squared resid.	0.012	Schwarz inf. Criterion	-4.578
Log likelihood	84.272	Hannan-Quinn criterion	-4.728
F-statistic	3.198	Durbin-Watson statistic	1.195
Prob. (F-statistic)	0.028		

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The authors of this publication are UTEP Professor & Trade in the Americas Chair Tom Fullerton and UTEP Associate Economist Adam Walke. Dr. Fullerton holds degrees from UTEP, Iowa State University, Wharton School of Finance at the University of Pennsylvania, and University of Florida. Prior experience includes positions as Economist in the Executive Office of the Governor of Idaho, International Economist in the Latin America Service of Wharton Econometrics, and Senior Economist at the Bureau of Economic and Business Research at the University of Florida. Adam Walke holds an M.S. in Economics from UTEP and has published research on energy economics, mass transit demand, and cross-border regional growth patterns.

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The authors of this publication are UTEP Professor & Trade in the Americas Chair Tom Fullerton and former UTEP Associate Economist Angel Molina. Dr. Fullerton holds degrees from UTEP, Iowa State University, Wharton School of Finance at the University of Pennsylvania, and University of Florida. Prior experience includes positions as Economist in the Executive Office of the Governor of Idaho, International Economist in the Latin America Service of Wharton Econometrics, and Senior Economist at the Bureau of Economic and Business Research at the University of Florida. Angel Molina holds an M.S. Economics degree from UTEP and has conducted econometric research on international bridge traffic, peso exchange rate fluctuations, and cross-border economic growth patterns.

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Professor Barraza is an award winning economist who has taught at several universities in Mexico and has published in academic research journals in Mexico, Europe, and the United States. Dr. Barraza currently serves as Research Provost at UACJ. Professor Fullerton has authored econometric studies published in academic research journals of North America, Europe, South America, Asia, Africa, and Australia. Dr. Fullerton has delivered economics lectures in Canada, Colombia, Ecuador, Finland, Germany, Japan, Korea, Mexico, the United Kingdom, the United States, and Venezuela.

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Professor Calderón is an award winning economist who has taught and published in Mexico, France, and the United States. Dr. Calderón spent a year as a Fulbright Scholar at the University of Texas at El Paso. Professor Fullerton has published research articles in North America, Europe, Africa, South America, and Asia. The author of several econometric forecasts regarding impacts of the Brady Initiative for Debt Relief in Latin America, Dr. Fullerton has delivered economics lectures in Canada, Colombia, Ecuador, Finland, Germany, Japan, Korea, Mexico, the United States, and Venezuela.

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