ERS
Bibliographies & Literature of Agriculture Number 133

An Economic Research Service Report

Highway Investment and Rural Economic Development

An Annotated Bibliography

Dennis M. Brown

It's Easy To Order Another Copy!

Just dial 1-800-999-6779. Toll free in the United States and Canada.

Ask for ***Highway Investment and Rural Economic Development: An Annotated Bibliography*** (BLA-133).

For additional information about ERS publications, databases, and other products, both paper and electronic, visit the ERS Home Page on the Internet at http://www.econ. ag.gov/

National Agricultural Library Cataloging Record:

Brown, Dennis M.
Highway investment and rural economic development : an annotated bibliography.
(Bibliographies and literature of agriculture ; no. 133)
1. Roads--Economic aspects--United States--Bibliography.
2. Rural development--United States--Bibliography. I. Title.
aZ5076.A1U54 no.133

Highway Investment and Rural Economic Development: An Annotated Bibliography. By Dennis M. Brown. Food and Rural Economics Division, Economic Research Service, U.S. Department of Agriculture. Bibliographies and Literature of Agriculture No. 133.

Abstract

This annotated bibliography summarizes studies of the rural economic development implications of highway investment. Primary emphasis is on research dealing with rural areas, but some urban studies are also cited. Topics covered include the aggregate economic effects of highway investment, the effects of highway investment on business location decisions and employment expansion, the effects of highway investment on different industries, local and regional spatial effects of highway investment, and highway effects over time.

Keywords: Highways, investment, rural economic development.

Washington, DC 20036-5831 April 1999

Contents

Summary

This bibliography summarizes recent studies that look at the role of highway investment in rural economic development. Because of the wide-ranging and multidisciplinary nature of the topic, material is drawn from a variety of academic disciplines, including transportation economics, planning, regional science, and geography. Most of the studies find that transportation infrastructure is important in generating local economic development, but other factors are sometimes found to be more important. A number of studies have also found that not all places and industries benefit equally from transportation investment.

Highway expenditures have been found to help increase rural employment, particularly in manufacturing and retail industries, and studies have shown that new highways tend to benefit rural counties near metro areas. Benefits also include the potential for improved access for rural residents and businesses, reduced transportation costs and travel time for motorists, decreased vehicle operating costs, safety and environmental gains, and cost savings for local consumers as goods and services become more competitively priced. An improved highway network that leads to growth in the local economy can also bring higher wages for workers and greater net income for owners of local businesses.

Highway investment can also entail costs for rural areas if new investment diverts economic activity from an already existing road within the region. Highway projects often include a variety of unknown or unexpected costs. Projects in underdeveloped regions that lack adequate financial resources may also be particularly vulnerable to cost overruns. Highway maintenance costs may also be a burden on localities that have too many roads and too few people to pay for their upkeep.

Highway Investment and Rural Economic Development

An Annotated Bibliography

Dennis M. Brown

Introduction

Investing in highways has often been viewed as an effective economic development strategy, particularly for underdeveloped rural areas (*Appalachia*, 1982). The Federal Government, recognizing the importance of investing in transportation infrastructure, has long had an important role in providing aid for the Nation's highways. In June 1998, the Federal highway program was reauthorized, sharply increasing money for Federal highways (those roads that are eligible for Federal assistance because they serve the national interest). The Transportation Equity Act for the 21st Century (TEA-21) is the single largest public works bill in U.S. history, providing $175 billion for the Nation's most important highways over the 6-year period 1998-2003, a 40-percent funding increase over the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), which provided funding for the previous 6-year period (1992-97).

Activities such as building new roads, widening existing ones, putting in new interchanges, or constructing bridges can result in various benefits for nonmetro areas, including improved access to services and jobs for rural residents, better access to customers for businesses, and reduced transportation costs (Forkenbrock and others, 1990). Other potential benefits include reductions in travel time for motorists, lower vehicle operating costs, safety and environmental gains, and cost savings for local consumers as goods and services become more competitively priced. If an improved highway network leads to growth in a local area's economic base, it may also bring higher wages for workers and greater net income for owners of local businesses.

But investing in highways can entail development risks. Road construction projects or highway improvements may actually harm some areas if new investment diverts economic activity from an already existing road within the region. Some areas may also be harmed as highway development results in "sprawl" in some previously undeveloped rural areas (Lamb, 1983, and Peck, 1991). And because highway projects often include a variety of unknown or unexpected costs, underdeveloped regions that lack adequate financial resources may be particularly vulnerable to such things as cost overruns. For example, transportation enhancements, which are environmental, recreational, or general project development activities unrelated to highway construction, can take scarce resources away from rural highway needs by using money for programs other than roads and bridges. Highway maintenance costs can also be a burden on localities that have too many roads and too few people to pay for their upkeep. For these reasons, effective highway investment usually requires good foresight and planning.

The literature on the economic effects of highway investment is wide ranging. Most studies have underpinnings, at least implicitly, in a handful of economic theories. *Regional development theory*, derived from development economics, focuses on identifying which policies most effectively bring about economic development. One or several competing policies thought to lead to development impacts are typically examined and empirically tested. In the case of highway impact studies, a good example is Forkenbrock and Foster (1996). They examined various State-level highway investment policies and concluded that maintenance and relatively minor improvements are likely to be more cost-effective economic development strategies than expensive highway construction projects.

Regional growth theory is less concerned with the effects of specific policies. It focuses instead on economic factors thought to affect growth rates of variables such as employment and income. Interregional

differences in rates of economic growth are often explained using econometric techniques. Twark, Eyerly, and Nassy (1980), for example, used a forecasting model to identify factors thought to lead to economic development at highway interchanges in Pennsylvania.

Growth pole theory is closely related to regional development theory and focuses on centers of economic activity, or "growth poles," which are thought to attract investment due to their agglomerative powers. Growth pole proponents, such as Hansen (1971), usually argue that investing scarce infrastructure resources will be more efficient in areas exhibiting some degree of prior urbanization, with population threshold estimates varying anywhere between 30,000 (Allen and MaClennan, 1970) and 250,000 residents (Hansen, 1971).

According to *location theory*, transportation costs are one of the key determinants of industrial site choice. This theory has its origins in work by von Thünen (1842) and Alonso (1964). Because lower transportation costs encourage economic activities and people to locate farther away from population centers, highways have the potential to open up underdeveloped regions for economic development. But, as noted by Rephann (1997), highways can also lead to negative development effects; they may provide conduits for economic activity to leave underdeveloped regions.

Trade theory is another construct sometimes used to study the effects of highway investment. Arising from the seminal international trade work of Ricardo, trade theory attempts to explain international and interregional flows of labor and capital based on national and regional comparative advantages. Extensions of international trade theory have been made in the field of interregional analysis. Siebert (1969), for example, argued that subnational regions also tend to specialize in the production of goods in which they have comparative advantages over other regions. Kraft, Meyer, and Valette (1971) went further by incorporating transportation costs and argued that regions tend to specialize in products that can be both produced and transported more cheaply than other products.

Applying these and other theories to accurately measure the economic effects of highway investment can be difficult. The chief difficulty lies in ascertaining whether economic growth arising from the investment would have occurred even if the road had not been built. Also, did the highways create the development or was it the other way around? Still another problem concerns the potential for highways to merely redistribute development without adding to overall economic activity (Fox and Murray, 1990).

Regional econometric models are frequently used to assess the impact of transportation investment on regional economic activity. These models typically examine the effects of transportation investment on industry output and employment. For example, Carlino and Mills' (1987) landmark study examined various factors, including different measures of employment, thought to affect U.S. county population growth during the 1970's. Andersson, Anderstig, and Harsman (1990) analyzed relationships between infrastructure and regional productivity in Sweden and identified specific variables, such as the existence of roads, that contributed to regional productivity.

Various limitations exist in the use of econometric modeling techniques. Most studies have tended to look at the effects of highway investment in a relatively narrow framework. Few, if any, studies attempt to measure the economic effect of highway investment in a comprehensive fashion (Rephann and Isserman, 1994). Although much has been written about highways and economic development, especially during the years following the initial construction of the Interstate Highway System in the 1960's and early 1970's, most empirical studies have been concerned with examining the relationship between highways and a small number of economic variables, such as growth in county employment, income, and population. Missing from most studies is an attempt to view highway investment as part of the larger process of regional economic growth. According to Rephann and Isserman (1994), highways have "network properties" that are both spatial and economic in nature. Not only do highways have the ability to affect communication channels linking people and businesses but they also serve as inputs into the production of private and public sector goods and services. Highway investment also influences location decisions of households in their commuting patterns. In turn, these residential choices can affect the location decisions of firms and industries. Studies that ignore these relationships may, therefore, incorrectly measure the effects of highways.

While some econometric models have been developed to deal explicitly with transportation effects, they also are not without their limitations. For example, the Harvard Macroeconomic Transport Simulation Model (Meyer, 1971) focuses on the effect of transportation costs in developing countries. The Pennsylvania Highway Corridor Model (Sauerlender and Davinroy, 1971) analyzes economic changes in small geographic areas located along highway corridors. The Multiregional, Multi-Industry Forecasting Model (Harris, 1980) assesses the effects of transportation costs and other locational factors on regional output. All of these models have shortcomings, however, including, perhaps most importantly, issues relating to the quality of the data used (Bolton, 1985). For example, the Multiregional, Multi-Industry Forecasting Model uses transportation input data derived through linear programming techniques, but the sensitivity of the results to other specifications remains unclear (Rephann, 1997).

Another technique used to estimate the economic effects of highway investment is input-output modeling, which estimates direct and indirect effects of highway investments based on a disaggregated industrial framework. For example, Liew and Liew (1984) use a multi-regional variable input-output model to estimate industrial output, personal income, and employment impacts resulting from a proposed transportation system in Alabama. Rephann (1997) notes, however, that, "input-output adapted for transportation analysis may be impracticable and require data that are inadequate or unavailable." Because of a paucity of useful data, transportation cost data must, therefore, frequently be independently derived, something that requires considerable skill, time, and effort. Nevertheless, assuming that such data can be obtained, input-output analysis represents a powerful tool for assessing the distributional effects of highway investment, that is, measuring what industrial sectors and places experience the largest impacts.

An important distinction must be made for the case of new highways, in which shorter term economic effects are realized during the construction phase, in contrast to longer term post-construction effects. As noted by Rephann (1997), the economic effects arising from construction of new roads stem from a variety of factors, including economic linkages already existing in the region, the amount of money spent on construction, and how the money is spent. Rephann also notes, though, that in most cases because the post-construction phase has a longer duration than the actual building of the road, the regional effect is usually greater after the road has been built. Furthermore, while urban areas may be better able to benefit from post-construction effects because they already have an existing "agglomeration potential," rural areas in close proximity to urban areas may also be able to take advantage of benefits that ensue from being adjacent to these "growth poles." Although highways may be an important factor in explaining rural development, distance to an urban area is often a much greater determinant of nonmetro growth (Harris, 1980). And Rephann and Isserman's (1994) study also supports this conclusion, finding that isolated rural interstate counties and off-interstate counties benefit little from interstate highway investment. Hence, close proximity to built-up areas can be seen to lead to "spread" effects, in which rural areas can draw on the development effects of adjacent urban areas.

Although many studies find that transportation infrastructure is important in generating local economic development, other factors are often identified as necessary, as well. A frequently quoted phrase found in a number of studies is that highways are a "necessary, but not sufficient condition" for generating rural economic development. Of course, this statement begs the question, "what are the other conditions required for growth?" However, there is currently little consensus on which factors are most significant in determining growth. According to Henry and Johnson (1993), this absence of consensus stems largely from a lack of good regional data that would allow for objective testing of hypotheses from alternative models of growth. Better regional data sources, perhaps through the use of Geographic Information Systems (GIS), might help to identify the factors most important in bringing about regional growth.

Many studies seem to agree on a few general conclusions regarding the potential impact of highway investments on rural economic development:

- Rural counties in close proximity to metro areas, and those with some prior degree of urbanization, benefit economically, at least in the short term, by new highways, especially interstates. Less clear is whether these counties benefit in the longer run and what advantages more isolated rural counties derive from highway construction.

• Highway construction expenditures benefit rural employment in the manufacturing and retail sectors, with effects strongest in the short term.

• Little consensus exists about how highways affect rural areas over the long term. Some studies argue that highways merely redistribute development potential from other areas.

• Accurately measuring the economic effects of highway investment is difficult because of the problems of isolating highway effects from the larger processes associated with regional economic growth. Future research may benefit if these issues are better understood.

• Current data sources are inadequate for measuring the economic effects of highway investment. Future efforts should be directed at developing better regional data sources for detecting highway-specific effects, perhaps through the use of GIS applications.

This annotated bibliography is intended to provide a framework for better understanding the role of highway investment in generating economic development. Most of the studies included here deal with rural areas, although I did include some that focused on urban areas when the issues involved had relevance to nonmetro America. In addition, while most of the studies were conducted within the last 20 years, some earlier citations are also included.

Citations are organized into six categories, although some overlap exists among the groupings.[1] First are studies dealing with the aggregate economic effects of highway investment. Second are studies dealing with the effects of highway investment on business location decisions and employment expansions. Third, industry studies are described in the context of how different industries and sectors respond to highway investment. Fourth, studies that focus on spatial effects are discussed, in terms of both local and regional issues. Fifth are temporal studies, or those dealing with the length and timing of the effects of highway investment. Finally, studies not fitting into one of the previous groupings are discussed.

[1]Categories in this bibliography are similar to those used by Rephann and Isserman (1994).

Aggregate Economic Studies

Studies that deal with the aggregate economic effects of highways examine a variety of economic indicators, including employment, income, output, population, and rates of migration. These studies are generally concerned with answering the question, "Do highways affect regional economic development?" Most of the authors accomplish this through the use of regression analysis. A good example of this type of study is the article by Carlino and Mills (1987), which examines the effect of highways on county employment in the United States during the 1970's.

A limitation of the aggregate economic studies is that they usually control for only a small number of economic variables (Rephann, 1993). Many of these studies also do not incorporate important temporal variables such as the date of construction of the highway and the date of its opening.

Andersson, Ake. E., Christer Anderstig, and Bjorn Harsman. 1990. "Knowledge and Communications Infrastructure and Regional Economic Change," *Regional Science and Urban Economics*, Vol. 20, pp. 359-76.

Analyzes relationships between infrastructure and regional productivity in Sweden during the 1970's by looking at cross-sectional data of firms' factors of production to assess the role of specific infrastructure variables. Econometric tests are made on a set of "A-regions," the commuting regions of Sweden. A region's highway capacity is one of the most important factors explaining regional gross productivity. Other important variables include communication links and regional research and development capacity.

Blum, U. 1982. "Effects of Transportation Investments on Regional Growth: A Theoretical and Empirical Investigation," *Papers of the Regional Science Association*, Vol. 49, pp. 169-84.

Investigates the influence of various "input potentials," including traffic capacity, on regional production in Germany for 1976. Regional traffic capacity is measured as length of long-distance highways and length of all other roads for 325 regions in the Federal Republic of Germany. Transportation infra-

structure is an important determinant of regional output.

Boarnet, Marlon G. 1995 (Fall). "New Highways and Economic Growth: Rethinking the Link," *Access: Research at the University of California Transportation Center*, No. 7, pp. 11-15.

Examines the effects of highway spending on local economic activity. Counties in California where highway spending rose between 1969 and 1988 experienced increased economic activity, but counties adjacent to them experienced reduced output. Argues that highway spending often redistributes economic activity from one location to another.

Botham, R. W. 1980. "The Regional Development Effects of Road Investment," *Transportation Planning and Technology*, Vol. 6, No. 2, pp. 97-108.

Conducts an empirical analysis of the British road-building program during the 1960's. Regional development effects of highway building are positive but small. Argues that legislative influences, such as taxes or restrictions on driving hours, may have a more significant influence on the economy. The British road program was also found to have a centralizing effect on the distribution of employment.

Carlino, Gerald A., and Edwin S. Mills. 1987. "The Determinants of County Growth," *Journal of Regional Science,* Vol. 27, No. 1, pp. 39-54.

Explores factors affecting U.S. county population and employment growth. Finds that during the 1970's total employment, manufacturing employment, and population densities were positively affected by the presence of limited access highways. Concludes that the interstate highway program contributed to a redistribution of population and employment in the United States, although this was not an original intention of the program.

Deno, Kevin T. 1988. "The Effect of Public Capital on U.S. Manufacturing Activity: 1970-1978," *Southern Economic Journal*, Vol. 55, No. 2, pp. 400-11.

Using a national sample for the period 1970-78, derives estimates of manufacturing firms' demand and supply characteristics for several measures of public capital stock, including roads and highways. Variables collected at the firm level include data on the price of manufacturing, private capital and labor, the stock of private and public capital, and output and employment in manufacturing. Public capital plays an important role in manufacturing firms' output supply and input demand decisions. Empirical analysis suggests that highway investment has a significant effect on regional output, especially in declining regions. The effect on demand for private capital and labor is also great in declining regions.

Eberts, Randall W. 1990. "Public Infrastructure and Regional Economic Development," *Economic Review*, Federal Reserve Bank of Cleveland, Vol. 26, No. 1, pp. 15-27.

Summarizes recent work on the effect of public infrastructure on economic activity at State and local levels. Identifies the significant role that transportation systems play in determining regional economic output. Sees transportation as a necessary, but not sufficient, condition for economic growth.

Forkenbrock, David J., Thomas F. Pogue, David J. Finnegan, and Norman S. J. Foster. 1990. "Transportation Investment to Promote Economic Development," in *Infrastructure Investment and Economic Development: Rural Strategies for the 1990's*, AGES-9069, U.S. Dept. Agr., Econ. Res. Serv., November.

Examines different modes of transportation in the context of rural development. Argues that "highways are necessary but not sufficient for economic growth and development." Provides a good overview of the literature, including a discussion of empirical studies, and summarizes some of the major costs and benefits associated with highway investment.

Henry, M., and T. G. Johnson. 1993. *The Contribution of Transportation to Rural Economic Development*. Southern Rural Development Center, Mississippi State University, No. 171, pp. 35-46.

Provides an overview of the literature on highways and rural economic development. Most studies support the conclusion that a positive association exists between highways and economic growth, but individual studies vary in methodology. Offers a num-

ber of recommendations to improve analyses of the effects of highways.

Hilewick, Carol L., Edward Deak, and Edward Heinze. 1980. "A Simulation of Communications and Transportation Investments," *Growth and Change*, Vol. 11, No. 3, pp. 26-38.

Looks at rural growth effects of investing in transportation networks compared with the effects of investing in communications systems. Empirically estimates the relative employment and income effects for rural counties in Pennsylvania and North Carolina for the 1970's. Employment and income growth are positively related to the presence of highways, but the strength of the relationship is weaker for rural than urban areas. Concludes that investing in communications results in stronger short- and long-term effects on population, jobs, income, gross regional product, and overall economic structure than for similar investments in transportation.

Kusmin, Lorin D., John M. Redman, and David W. Sears. 1996. *Factors Associated with Rural Economic Growth: Lessons from the 1980's*. TB-1850, U.S. Dept. Agr., Econ. Res. Serv., September.

Identifies characteristics of rural areas conducive to economic growth for 1979-89. Using multiple regression analysis, explains growth in total real earnings by place of work for nonmetro U.S. counties. Access to interstate highway interchanges contributed to earnings growth in rural areas, although the relationship is not among the most important factors in the analysis. Each interchange brought approximately 0.42 percent additional income growth during the period.

McHugh, Richard J., and James T. Wilkinson. 1988. "A Random Effects Approach to Substate Growth Models: A Comment on 'The Determinants of County Growth,'" *Journal of Regional Science,* Vol. 28, No. 2, pp. 271-73.

Provides an alternative estimation technique to that used by Carlino and Mills (1987). Argues that a simple random effects model more clearly accounts for determinants of county-level population and employment growth during the 1970's. Agrees with Carlino and Mills that total employment, manufacturing employment, and population density are positively affected by the presence of limited-access highways.

Nijkamp, Peter. 1986. "Infrastructure and Regional Development: A Multidimensional Policy Analysis," *Empirical Economics*, Vol. 11, No. 1, pp. 1-21.

Examines the role of infrastructure in determining regional development. Uses cluster and scaling methods and a quasi-production function to develop a multidimensional typological analysis of regional development in the Netherlands during the 1970's. Transportation infrastructure is an important determinant of regional output for both urban and rural areas.

Industrial Location Studies

Studies that focus on industrial location decisions usually look at how highways affect a firm's decision-making process. Frequently, the importance of highways as a firm's locational factor in moving into or out of a region is assessed through surveys. A good example is the work by Walker and Calzonetti (1990). Surveys have also been used to measure the importance of highways on business startups, expansions and contractions, and failures.

Bartik, Timothy J. 1985. "Business Location Decisions in the United States: Estimates of the Effects of Unionization, Taxes, and Other Characteristics of States," *Journal of Business and Economic Statistics*, Vol. 3, No. 1, pp. 14-22.

Examines how corporate decisions about the location for a new manufacturing plant are influenced by State rates of unionization, taxes, and the number of road miles per State. Uses a conditional logit regression model to show that number of road miles was a significant factor affecting the location of new manufacturing plants during the 1970's, with businesses more likely to locate where adequate roads already existed. Other important variables include pro-union sympathies of States and State tax rates: higher rates of each correlated with a lower likelihood that a plant would locate in that State.

Bartik, Timothy J. 1989. "Small Business Start-Ups in the United States: Estimates of the Effects of

Characteristics of States," *Southern Economic Journal*, Vol. 55, No. 4, pp. 1004-18.

Estimates how various characteristics of States affect small business startups. Using panel data, finds that highway access does not appear to have affected firm startups during 1976-82. One explanation for this finding may be that the study's scope of geographic inquiry, conducted at the State level for a number of different States, does not fully capture the influence of the transportation access variable, which is viewed primarily as a "micro-level" factor, one that influences within-region searches.

Blair, John P., and Robert Premus. 1987. "Major Factors in Industrial Location: A Review," *Economic Development Quarterly*, Vol. 1, No. 1, pp. 72-85.

Reviews recent findings of industrial location literature to assess which factors are most important in determining a firm's location. While traditional location factors, including transportation, are still important determinants in industrial location decisions, evidence from the 1980's indicates the importance of new factors, such as tax rates, education, and labor skills. The enhanced importance of these new factors is partly due to the increasing tendency of many industries to become more footloose.

Charney, Alberta H. 1983. "Intraurban Manufacturing Location Decisions and Local Tax Differences," *Journal of Urban Economics*, Vol. 14, pp. 184-205.

Examines the importance of fiscal and other community factors on manufacturing firms' decisions about where to locate in the three-county metro area of Detroit during 1970-75. Uses distance to the nearest highway as a measure of the importance of roads for firms choosing among different sites. Proximity to highways is less important in the decisionmaking process than it was earlier.

Forkenbrock, David J., and Norman S. J. Foster. 1996. "Highways and Business Location Decisions," *Economic Development Quarterly*, Vol. 10, No 3, pp. 239-48.

Examines the degree to which investments in high-capacity highways are likely to influence business location decisions. Through case studies, concludes that access to highways generally has become a less important factor in location decisions than it was earlier. State-level highway investment policies that emphasize proper maintenance and relatively minor improvements are likely to be more cost-effective strategies for economic development than expensive highway construction projects.

Fox, William F. 1981. "Fiscal Differentials and Industrial Location: Some Empirical Evidence," *Urban Studies*, Vol. 18, pp. 105-11.

Examines the influence of various local fiscal and community variables in determining industrial site demand in suburban Cleveland. Results of regression analysis indicate that availability of highways in 1969, although initially hypothesized to have a positive effect, was insignificant. This unexpected finding may have resulted from the small sample size.

Fox, William F., and Matthew N. Murray. 1990. "Local Public Policies and Interregional Business Development," *Southern Economic Journal*, Vol. 57, No. 2, pp. 413-27.

Provides a comprehensive examination of the effects of different local public policies on the business location process in Tennessee during 1980-86. Findings based on an analysis of State-level employment data indicate that the presence of an interstate highway within a county is an important locational attribute, leading to higher entry rates for most firms, regardless of size. Less clear is whether interstates create new economic activity or simply redistribute existing activity across different sites.

Harris, Curtis C. 1980. "New Developments and Extensions of the Multiregional, Multi-Industry Forecasting Model," *Journal of Regional Science*, Vol. 20, No. 2, pp. 159-71.

Uses the Multiregional, Multi-Industry Forecasting Model (MRMI) to assess how major industrial location decisions are made. Describes a set of industry location equations that explain changes in output by region for 1970-74, with independent variables representing components of profits. Employment growth and income growth are positively related to highway access, but the relationship is much weaker for nonmetro areas. Distance to a metro or larger urban area is a much greater determinant of nonmetro growth than the presence of highways.

Toft, Graham S., and Hani S. Mahmassani. 1984. "Transportation and High Technology Economic Development," Transportation Research Record, No. 984, pp. 22-29.

Explores the interrelationships between transportation and high-technology-based economic development. Reports findings of a nationwide survey conducted by the Joint Economic Committee of the U.S. Congress in 1982, which shows that proximity to highways ranks relatively high in high-tech firms' locational decisions. Argues that this is because high-tech firms view the existence of a good highway network as a means to attract high-quality employees, with good roads reducing commuting time.

Walker, Robert, and Frank Calzonetti. 1990. "Searching for New Manufacturing Plant Locations: A Study of Location Decisions in Central Appalachia," *Regional Studies*, Vol. 24, No. 1, pp. 15-30.

Analyzes the search behavior of manufacturers in Central Appalachia during 1972-86. Evaluates regional and local search processes using data collected from interview surveys of plant managers and develops a model of hierarchical decisionmaking under imperfect information. Argues that transportation access in the locational decisionmaking process is primarily a "micro-level" factor, with firms considering the transportation system only once they have already selected a region in which to locate.

Walker, Robert, and David Greenstreet. 1991. "The Effect of Government Incentives and Assistance on Location and Job Growth in Manufacturing," *Regional Studies*, Vol. 25, No. 1, pp. 13-30.

Addresses the effect of government business assistance programs on the manufacturing sector in Appalachia. Finds that access to good highways is not a significant factor in explaining firm expansion during the 1980's, something not initially hypothesized. Concludes that this may be explained by a high degree of negative collinearity between the road variable and county unemployment (an indicator of the availability of low-cost labor), a relationship that may obscure the true effect of road access on business expansions.

Wasylenko, Michael J. 1980. "Evidence of Fiscal Differentials and Intrametropolitan Firm Relocation," *Land Economics*, Vol. 56, No. 3, pp. 339-49.

Investigates local factors that influence the location decisions of firms. Results indicate that access to highways was an important factor influencing the location of manufacturing firms within metro Milwaukee during 1964-74, but an insignificant factor for the construction, wholesale/retail, finance/insurance/real estate, and service sectors.

Studies of Industries

Studies that focus on particular industries or sectors examine how investments in transportation affect different industries. Most of these studies highlight differential impacts of highway investment in at least one of four major industrial sectors: manufacturing, retail trade, wholesale trade, and services. A good example is the article by Stephanedes and Eagle (1986a), which investigates how highway expenditures affect employment in manufacturing compared with the retail sector.

Briggs, Ronald. 1980. *The Impact of Interstate Highway System on Non-Metropolitan Growth.* U.S. Department of Transportation, Office of University Research.

Examines the effects of the Interstate Highway System and other limited-access highways on the long-term demographic and economic development of nonmetro areas during 1950-75, with specific reference to the manufacturing sector. Using national-level data on net migration and employment change, finds that the presence of an interstate highway in a county leads to the channeling of nonmetro development along interstate corridors, resulting in only minor economic benefits.

Goldstein, Gerald S., and Robert H. Pittman. 1984. "Transportation and the Commodity Composition of Interstate Trade," *Growth and Change*, Vol. 15, No. 3, pp. 15-24.

Estimates a model assessing the importance of transportation infrastructure for regional economic activity in manufacturing industries using available data on interstate regional trade flows. Tests the

hypothesis that transportation infrastructure is an important determinant of U.S. interstate trade. Concludes that highways help improve regional output for a large number of manufacturing industries.

Hirschl, Thomas A., and Gene F. Summers. 1982. "Cash Transfers and the Export Base of Small Communities," *Rural Sociology*, Vol. 47, No. 2, pp. 295-316.

Proposes an export-based model of local employment growth for the 1960's and 1970's with cash transfer payments specified as one of the "export" sectors. The model is tested with a sample of U.S. counties using income and employment data from secondary sources. Interstate highways do not stimulate employment in nonmetro nonbasic industries (those serving local demand). Links to the Interstate Highway System are counted as the number of interstate highway exits within the county.

Isserman, Andrew M., Terance Rephann, and David J. Sorenson. 1989. "Highways and Rural Economic Development: Results from the Quasi-Experimental Approaches." Paper presented at the Seminar on Transportation Networks and Regional Development, Leningrad, U.S.S.R., May 23-26.

Investigates the effect of highways on smaller communities and rural areas by examining income growth rates, by employment sector, during 1969-84. Rural counties with highways did not grow significantly faster than those without highways. Rural towns with more than one highway link did not grow more rapidly than rural towns with just one link.

Lichter, Daniel T., and Glenn V. Fuguitt. 1980. "Demographic Response to Transportation Innovation: The Case of the Interstate Highway," *Social Forces*, Vol. 59, No. 2, pp. 492-512.

Investigates the relationships between date of completion of an interstate highway and employment and population characteristics for various service industries in nonmetro counties during 1950-75. Counties with interstate highways consistently maintained an advantage over other counties in net migration and employment growth. Population growth was also greatest in interstate highway counties, with positive effects of highways on net migration strongest in less remote areas.

Liew, Chong K., and Chung J. Liew. 1984. "Measuring the Development Impact of a Proposed Transportation System," *Regional Science and Urban Economics*, Vol. 14, pp. 175-98.

Introduces a methodology for measuring possible economic development impacts arising from a proposed transportation system in Alabama. Uses a Multi-Regional Variable Input-Output model to empirically estimate future local and regional industrial output, personal income, and employment effects for 31 industries over a 40-year period. Concludes that the proposed transportation project would reduce the cost of shipping commodities, which would stimulate the economy of the region and the rest of the State.

Porterfield, Shirley L. 1990. "Producer Services: A Viable Option for Rural Economic Development?" Unpublished paper presented at the 29th Annual Meeting of the Southern Regional Science Association, Washington, DC, March.

Measures employment growth by industrial sector for manufacturing and producer services in rural areas for 1981-86. Separate models are estimated for metro counties, nonmetro counties adjacent to metro areas, and remote nonmetro counties. Access to interstate highways may be a significant factor for job growth in producer services, but proximity to an interstate highway did not facilitate employment growth in the manufacturing sector.

Stephanedes, Yorgos J., and David M. Eagle. 1986a. "Highway Expenditures and Non-Metropolitan Employment," *Journal of Advanced Transportation,* Vol. 20, No. 1, pp. 43-61.

Investigates the relationships between transportation and rural employment for different economic sectors using data on State highway expenditures in Minnesota for 1957-82. Causality tests and time-series analyses indicate that highway expenditures affect manufacturing and retail employment. Highway-induced economic stimulation is strongest in areas with some degree of prior urbanization. Highway expenditures also appear to respond quickly to increased needs caused by retail improvements.

Stephanedes, Yorgos J., and David M. Eagle. 1986b. "Time-Series Analysis of Interactions Between

Transportation and Manufacturing and Retail Employment," *Transportation Research Record*, No. 1074, pp. 16-24.

Examines the relationship between county-level highway construction expenditures and job growth by industry in Minnesota for 1957-82. Spending levels in urban areas reflected employment gains in the manufacturing and retail trade sectors for the entire study period, but in rural areas the results depended on the time period examined. Over the short term, rural employment gains occurred, largely because of highway construction effects, but highways had little or no effect on rural employment over the long term.

Studies of Spatial Effects

Studies examining the spatial effects of highways usually focus on either local impacts, often measured at interchanges along a limited-access road, or regional impacts. A good example of a local study is Moon's (1987), which looked at various land-use issues, including patterns of industrial, commercial and residential development, along rural highway interchanges in western Kentucky. Munnell's (1990) article, which represents a good example of a regional study, examined the regional effects of transportation systems on various economic variables, such as employment, income, and population.

Appalachia. 1982. "Appalachian Highways Are Catalysts of Change," Vol. 15, Nos. 2/3, pp. 8-17.

Examines how the Appalachian Development Highway System (ADHS) has affected economic development in Appalachia. Using a 1981 survey of State highway departments that was designed to determine the importance of highways for businesses located in Appalachia, results show that the ADHS has broadly aided employment, industrial growth, and provision of services in the region. Advocates the need for continued funding of this highway system, especially in light of benefits it has brought to the region.

Appalachian Regional Commission. 1998. *Economic Impact of the Appalachian Development Highway System*. Prepared by Wilbur Smith Associates.

Evaluates the extent to which the Appalachian Development Highway System (ADHS), a 1,400-mile network of roads in Appalachia, has attained its economic development objective. Finds that ADHS has created over 16,000 jobs and made travel in Appalachia easier and more cost-effective. Total economic impact of the ADHS system is estimated at $6.9 billion.

Broder, Josef M., Teresa D. Taylor, and Kevin T. McNamara. 1992. "Quasi-Experimental Designs for Measuring Impacts of Developmental Highways in Rural Areas," *Southern Journal of Agricultural Economics*, Vol. 24, No. 1, pp. 199-207.

Uses regression-discontinuity analysis to compare economic changes in counties with "developmental" highways (those designed to bring about development) with economic changes in adjacent and nonadjacent control counties for 1975-81. Results show statistically significant changes in population, per capita income, and taxable sales related to highway development in highway counties. Most counties benefited from developmental highways, although some were unaffected, and a few even experienced economic decline. Results also indicate that adjacent county control models may have understated highway-related effects, while nonadjacent county models may have overstated these effects.

Eyerly, Raymond W., Richard Twark, and Roger H. Downing. 1987. "Interstate Highway System: Reshaping the Non-Urban Areas of Pennsylvania," *Transportation Research Record*, No. 1125, pp. 1-14.

Describes the economic changes that occurred in the 1970's in nonmetro Pennsylvania communities adjacent to interstate highways. Finds that changes in per capita income at the county level were positively related to the presence of interchanges. Concludes that the economies of many nonurban communities along interstates experienced large increases in residential, commercial, and industrial growth.

Lamb, Richard F. 1983. "The Extent and Form of Exurban Sprawl," *Growth and Change*, Vol. 14, No. 1, pp. 40-47.

Discusses the issue of "sprawl," as it relates to exurban areas, or rural countryside situated on the edge

of expanding urban areas. Identifies different problems associated with sprawl, including traffic problems and how they affect local development. Discussion also provides a measure of the extent of exurban sprawl and indicates ways in which it can be more effectively controlled.

Miller, James P. 1979. "Interstate Highways and Job Growth in Nonmetropolitan Areas: A Reassessment," *Transportation Journal*, Vol. 19, No. 1, pp. 78-81.

Uses employment data to assess whether interstate highways benefit nonmetro areas. During the early 1970's, rapid employment growth in commercial and industrial activities occurred in nonmetro counties without interstate highway access. This may be partly explained by the fact that during the 1970's much of the nonmetro growth occurred in more remote counties, those not adjacent to metro areas, and these counties were less likely to have access to interstate highways. During the 1970's, States tended to use highway funds for noninterstate roads (after the interstate system had been largely completed), which may have led to development in these areas.

Moon, Henry E., Jr. 1987. "Interstate Highway Interchanges Reshape Rural Communities," *Rural Development Perspectives*, Vol. 4, No. 1, pp. 35-38.

Examines factors important in explaining development prospects along interchanges on rural interstates during the mid-1980's. Analyzes five factors thought to contribute to development along a rural interchange in Kentucky and two factors believed to detract from development. Factors most important in explaining the level of development around an interchange were the existence of previous development, regional location of the interchange, distance to nearest interchange, traffic volume, whether alcoholic beverages were available for sale ("dry" counties hinder development), distance to nearest city (proximity to a city encourages development), and topography (commercial developers prefer flatter terrain).

Moon, Henry E., Jr. 1988. "Interstate Highway Interchanges as Instigators of Nonmetropolitan Development," *Transportation Research Record*, No. 1125, pp. 8-14.

Looks at the nonurban impact of the Interstate Highway System by examining 65 nonmetro interchanges in Kentucky in 1985. Analyzes the cyclic pattern of evolution of nonmetro interchanges and discusses possible developmental effects for these previously remote and isolated interchange sites. Nonmetro interstate interchanges often vary according to different functions that they perform, with some acting as "interchange villages," performing the role of central places in their regions. Fills a void in the literature by providing an in-depth nonurban analysis based on a significantly large number of observations.

Munnell, Alicia H. 1990. "How Does Public Infrastructure Affect Regional Economic Performance?" *New England Economic Review*, Federal Reserve Bank of Boston, September/October, pp. 11-33.

Explores the effect of public capital on economic activity at the State and regional levels for 1970-86. States that have invested in infrastructure, including transportation, have greater output, more private investment, and more employment growth. Highways have the greatest effect on regional output in the South.

Peck, Robert A. 1991. "Editorial: Taming America's Highway System," *Connecticut Preservation News*, Vol. 14, No. 5, p. 8.

Examines the role of highway planning in inducing "sprawl" in rural areas. Advocates different strategies for more effectively dealing with the issue of sprawl and environmental pollution. Assesses ways in which the Federal Government can more effectively combat such problems.

Rephann, Terance J. 1993. "Highway Investment and Regional Economic Development: Decision Methods and Empirical Foundations," *Urban Studies*, Vol. 30, No. 2, pp. 437-50.

Reviews Federal and State highway programs in the context of regional development theory. Identifies factors in determining where highways are routed, such as socioeconomic, spatial, resource, and institutional "triggering forces." Advocates the need for further research to assess the effect of regional development theories on local highway planning practices.

Rephann, Terance J., and Andrew M. Isserman. 1994. "New Highways as Economic Development Tools: An Evaluation Using Quasi-Experimental Matching Methods," *Regional Science and Urban Economics*, Vol. 24, No. 6, pp. 723-51.

Examines the effectiveness of highway investment as an economic development tool. Uses a quasi-experimental matching method to examine the effects of interstate highways on counties that obtained interstate links during 1963-75. Economic growth of counties with interstate highways is greatest for those close to large cities or those with some degree of prior urbanization. "Interstate counties" that are isolated or rural have few benefits.

Siccardi, A. J. 1986. "Economic Effects of Transit and Highway Construction and Rehabilitation," *Journal of Transportation Engineering*, Vol. 112, No. 1, pp. 63-76.

Using responses to a questionnaire directed to States, explores the economic effects of highway construction arising from the Federal Economic Growth Center Development Highways program. Identifies various indirect benefits received by rural areas.

Twark, Richard D., Raymond W. Eyerly, and Richard B. Nassy. 1980. "Quantitative Technique for Estimating Economic Growth at Nonurban, Limited-Access Highway Interchanges," *Transportation Research Record*, No. 747, pp. 12-19.

Introduces a quantitative modeling technique for estimating economic development at nonurban interstate interchange sites. Uses a forecasting model of a set of simultaneous linear equations to describe economic, demographic, geographic, and traffic environments of 128 nonurban Pennsylvania interchanges during the 1970's. Average daily highway traffic volume was one of the most significant factors affecting economic development at interchanges. Possible uses of the model include land-use regulation and planning issues, design of future interchanges, and redesign of obsolete interchanges.

Studies of Temporal Effects

Studies that focus on temporal effects examine the role of highways in creating economic development over different periods of time. A good example of this approach is the study by Gaegler, March, and Weiner (1979), who find short- and long-term effects arising from the building of an interstate in Connecticut. Keeble (1980) looked at the relationship between highway investment and the state of the national economy and found that highway effects vary over time primarily because inadequate capital is available during recessions.

Cromley, Robert G., and Thomas R. Leinbach. 1981. "The Pattern and Impact of the Filter Down Process in Nonmetropolitan Kentucky," *Economic Geography*, Vol. 57, No. 3, pp. 208-24.

Examines the role of several economic variables, including transportation, on the spatial development of branch plants in nonmetro towns in Kentucky during 1950-80. Access to limited-entry highways is important in accounting for a town's long-term employment level. Over the short term, employment changes are more a function of external rather than internal factors.

Eagle, David, and Yorgos J. Stephanedes. 1987. "Dynamic Highway Impacts on Economic Development," *Transportation Research Record*, No. 1116, pp. 56-62.

Develops a time-series methodology to differentiate between the effects of highways on development from the effects of development on highways for all counties in Minnesota during 1957-82. The methodology, which includes both structural plot analysis and causality tests, is based on pooled time series and cross-sectional data on highway construction expenditures and county employment. Increases in highway expenditures do not generally lead to employment increases other than temporary gains in the year of construction in most cases, although expenditures do have a positive long-term effect in important, "regional center" counties.

Gaegler, Annette M., James W. March, and Paul Weiner. 1979. "Dynamic Social and Economic Effects of the Connecticut Turnpike," *Transportation Research Record*, No. 716, pp. 28-32.

Summarizes the long-term social and economic effects of the Connecticut Turnpike on the regional economy of eastern Connecticut. The turnpike has

influenced the level and distribution of economic activity and population in the study region during 1965-78. Increases in manufacturing employment, retail sales, and land values were concentrated along the turnpike, although not all towns in the region grew equally.

Keeble, D. E. 1980. "Industrial Decline, Regional Policy, and the Urban-Rural Manufacturing Shift in the United Kingdom," *Environment and Planning A*, Vol. 12, No. 8, pp. 945-62.

Reports changes in manufacturing employment in Britain during the early 1970's. Identifies a very marked urban-to-rural shift in manufacturing employment through the use of shift-share and regression analyses of county variations in manufacturing employment. Argues that temporal variations in highway effects occur because government policies are weakened during recessions as investment capital moves less freely (compared with when the economy is growing).

Other Studies

Studies not fitting into one of the previous groupings are classified as "other." A common theme of this group is the issue of costs versus benefits of highway investment. For example, Allen, Baumel, and Forkenbrock (1994) examined cost-saving elements of competing State highway projects as they relate to "just-in-time" manufacturing. Fruin and Halbach (1992) looked at different strategies for maintaining and improving roads in a rural Minnesota county, concluding that cost savings may be realized by abandoning many local roads and bridges.

Allen, Benjamin J., C. Phillip Baumel, and David J. Forkenbrock. 1994. "Expanding the Set of Efficiency Gains of a Highway Investment," *Transportation Journal*, Vol. 34, No. 1, pp. 39-47.

Proposes a comprehensive approach for measuring the benefits of a highway improvement project. Suggests a framework for incorporating logistical cost savings into States' evaluations of competing highway projects. Benefit-cost analyses of various highway improvement projects are examined. Specific attention is paid to the role of highway investments in facilitating "just-in-time" manufacturing.

Allen, Kevin, and M. C. MaClennan. 1970. *Regional Problems and Policies in Italy and France.* Beverly Hills, CA: Sage.

Uses growth pole theory to identify centers of economic activity that are believed to attract investment because of their "agglomerative" powers. Identifies growth poles as urban areas having population thresholds ranging between 30,000 and 200,000 residents. Rural areas close to these cities may benefit from "spread effects."

Alonso, William. 1964. *Location and Land Use.* Cambridge, MA: Harvard University Press.

Extends von Thünen's analysis to the study of urban residential location. Argues that lower transportation costs encourage individuals to locate farther away from their place of employment in the central business district. Provides support for the argument that highways, especially new ones, provide access to underdeveloped regions and enhance economic development opportunities.

Bolton, Roger. 1985. "Regional Econometric Models," *Journal of Regional Science*, Vol. 25, pp. 495-520.

Provides a survey of regional econometric models. Discussion concentrates on large operational econometric models of single regions, with a brief mention of multiregional models. Examines key variables important in regional econometric models, but provides little explicit mention of the role of transportation.

Forkenbrock, David J. 1990. "Putting Transportation and Economic Development in Perspective," *Transportation Research Record*, No. 1274, pp. 3-11.

Discusses the relationship between transportation and economic development. Identifies six standards for the types of trade-offs that local development practitioners must make when choosing among different projects with limited resources. Also presents a series of "decision screens" to provide a practical basis for applying the principles discussed.

Forkenbrock, David J., and David Plazak. 1986. "Economic Development and State-Level Transportation Policy," *Transportation Quarterly*, Vol. 40, No. 2, pp. 143-57.

Examines the role of State departments of transportation in facilitating economic development. Discusses a series of policy issues with reference to how a State can increase the competitive advantage of its communities by funding certain types of highway improvements. Specific reference is made to Iowa's RISE (Revitalize Iowa's Sound Economy) program.

Fruin, Jerry, and Dan Halbach. 1992. *Rural Roads, Investment and Disinvestment in a Minnesota County.* Dept. of Agr. and Applied Econ., Univ. of Minnesota, Staff Paper No. 92-25.

Examines the importance of the local road system for rural residents and businesses in Polk County, Minnesota. Methodology consists of evaluating different strategies for maintaining and improving roads with limited resources. Concludes that up to 40 percent of rural roads and bridges in the study area could be abandoned with little impact on local economic development.

Hansen, Niles M. 1971. *Intermediate-Size Cities as Growth Centers.* New York: Praeger.

Uses regional development theory to determine the best use of infrastructure investment. Argues that investment in public infrastructure should be concentrated in urban areas that have some level of prior "dynamism" or development. Sets a minimum population threshold of 250,000 for areas deemed worthy of infrastructure investment.

Huddleston, Jack R., and Prem P. Pangotra. 1990. "Regional and Local Economic Impacts of Transportation Investments," *Transportation Quarterly*, Vol. 44, No. 4, pp. 579-94.

Presents an "impact assessment" framework for the regional economic analysis of transportation investments. Describes the types of stimuli that transportation provides for regional economies. Identifies a broad array of local economic variables that may be affected by transportation investments.

Jarzab, James T. 1986. "Economic Impacts and Transportation Projects," *Journal of Transportation Engineering*, Vol. 112, No. 3, pp. 276-86.

Offers insights into available methods of evaluating the economic effects of transportation projects and programs at the State and local levels. Includes a discussion of the advantages and disadvantages of the 1) Economic Impact Forecast System; 2) Regional Economic Models, Incorporated, model; and 3) Regional Science Research Institute model. The author evaluates the economic effects of specific transportation projects using these models.

Kraft, Gerald, John R. Meyer, and Jean-Paul Valette. 1971. *The Role of Transportation in Regional Economic Development.* Lexington, MA: Lexington Books.

Introduces transportation costs into trade theory. Argues that comparative advantages for regions will be realized in both price differences in commodities at the site of production and in the cost of moving goods to the market. Concludes that regions will specialize in goods that can be both produced and transported more cheaply than elsewhere.

Meyer, John R., ed. 1971. *Techniques of Transport Planning (Volume 1): Systems Analysis and Simulation Models.* Washington, DC: Brookings Institution, Transport Research Program.

Transport model developed for use primarily in developing countries. The model has two parts: a macroeconomic model, which estimates final demand flows of commodities, and a transport model, which assigns commodities to regions based on transport costs for different modes. Argues that effects of transportation changes will likely be more pronounced in developing countries because of market imperfections.

Rephann, Terance J. 1997. *Highways and Regional Economic Development: What Can We Learn from Regional Economics Theory and Models?* Allegany College of Maryland, Discussion Paper.

Reviews and evaluates theories and models that describe highways' economic effects. Argues that regional economic theory is a useful construct for answering questions about the relationship between highways and economic development. Effects of

different regional economic policies are thought to be conditioned by various regional and extra-regional characteristics, thereby influencing highways' economic effects.

Ricardo, David. 1951-73. *The Works and Correspondence of David Ricardo.* Edited by Piero Sraffa, with the collaboration of M. H. Dobb, 11 vols. Cambridge, UK: Cambridge University Press.

Seminal, 19th-century work in the field of international trade theory, developed to explain interregional movements of commercial goods. Argues that individual nations tend to specialize in goods in which they have "comparative advantages." Does not mention the role of transportation costs in shipping goods and raw materials.

Sauerlender, Owen H., and Thomas B. Davinroy. 1976. *The Highway Corridor: Predicting the Consequences of Alternative Highway Locations: Phase II.* Pennsylvania State University, Pennsylvania Transportation Institute.

Describes the Pennsylvania Highway Corridor model, which was created to simulate economic changes occurring in small areas within highway corridors. Model specification includes several dozen structural equations, including a variety of macroeconomic variables, such as local employment, income, population, and real estate values. Results allow planners to consider alternative highway locations and forecast locational-specific impacts for each variable.

Siebert, Horst. 1969. *Regional Economic Growth: Theory and Policy.* Scranton, PA: International Textbook Company.

Uses trade theory to explain interregional flows of goods. Views regions as having comparative advantages over other subnational areas as measured by the opportunity costs of producing goods compared with other products. No explicit mention is made of the role of transportation costs in determining commodity production costs.

von Thünen, Johann-Heinrich. 1842. "Der Isolierte Staat." In P. Hall, ed., *Von Thünen's Isolated State.* 1966. London: Pergamon.

Classic, 19th-century work from the field of location theory. Identified a process in which the growing of crops and the raising of livestock are located in a regular series of concentric zones surrounding urban markets. Such a zone structure results from the influence of transport costs on the "location rent" of land at increasing distances from the market combined with the sensitivity of different products to the cost of transport.

Index of Authors

United States Department of Agriculture
Economic Research Service
1800 M Street, NW
Washington, DC 20036-5831