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Bureau of
Transportation Statistics

Transportation Investment and GDP, Some Concepts, Data, and Analysis

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Executive Summary

Transportation investment consists of purchases of transportation fixed assets with a service life of more than one year and changes in inventories. Transportation fixed assets include transportation infrastructure, rolling stocks, and other equipment that are used in the provision of transportation services. Transportation investment, by implementing new technology, establishing continuity of routes and eliminating bottlenecks, and by improving the coverage and accessibility of the transportation network, helps augment the capacity and improve the efficiency of the transportation industry. Hence, statistics on transportation investment indicate the potential capacity and efficiency of transportation in future years. Transportation investment utilizes current economic resources. Transportation investment data show the quantity of economic resources allocated to transportation capital. Transportation investment data are also of great value to government for planning and budgeting purposes, to policy makers trying to understand the impacts of investment decisions, and to researchers interested in investigating the relationship between transportation investment and economic development or conducting other research in this area.

This report provides statistics on capital investment by sector (government, private business, and households), asset type (infrastructure, rolling stock, and other equipment used by transportation industries), and by mode of transportation (air, highway, water, mass transit, railroad, and pipelines). The investment dataset represents transportation investment before deducting depreciation of the existing capital; and this data is presented as a percentage of GDP, and wherever useful, as a percentage of total gross fixed capital formation. The report also provides a review of the literature that examines the linkage between transportation investment and economic performance, a survey of similar statistical works undertaken by other U.S. government agencies and agencies of foreign countries, a discussion of data sources and procedures used to develop the dataset, and a descriptive analysis of transportation investment in relation to GDP. The descriptive analysis is not intended to determine a causal relationship between transportation investment and economic development, which is beyond the scope of this report.

The following findings resulted from the descriptive analysis of transportation investment in relation to GDP:

- First, for the period of 1977 to 2000, overall transportation investment (including household purchase of rolling stock) on average accounted for more than 6% of GDP. Of this overall transportation investment, investment in rolling stock accounted for an average of 83%, and that in transportation infrastructure and other transportation equipment averaged 14% and 3%, respectively.
- Second, while households are the primary purchasers of rolling stock, government is the dominant investor in transportation infrastructure with the exception of railroads and pipelines modes in which the business sector appears to be the exclusive investor.

- Third, the share of highways in the total infrastructure investment stayed almost the same, averaging 66%, but the relative shares for other modes changed significantly during 1977-2000, with air almost doubling and pipeline dropping by about 90%.
- Fourth, whereas overall transportation investment (of which 83% is in rolling stock) closely echoed the business cycle, investment in transportation infrastructure evidently lagged behind the business cycle, notably during 1979-1982 when transportation infrastructure investment was accelerating, while GDP growth had already gone through a fast increase and begun to decline.
- Fifth, transportation investment has been more sensitive to the business cycle compared with non-transportation business investment.
- Finally, transportation investment made by non-transportation industries has been consistently greater than that of transportation industries. However, the intensity of use of transportation capital, particularly rolling stock, is much higher for transportation industries than for non-transportation industries.[1]

[1] Intensity of use of transportation capital is measured as the ratio of investment in transportation capital to value added (GDP) from transportation. GDP from transportation services is higher in the transportation industries relative to investment in transportation capital than it is for in-house transportation services in the non-transportation industries. This drives the above conclusion.

1. Introduction

Transportation investment is defined as additions to transportation fixed assets. Transportation fixed assets refers to structures, motor vehicles, and other machinery and equipment, which are used in the provision of transportation services for more than one year. Due to data limitations, we exclude other machinery and equipment that are used in transportation by non-transportation-entities. Our definition thus reflects a combination of asset type and business characteristics of investors. Therefore, our list of transportation fixed assets includes all fixed assets within transportation industries and fixed assets that are transportation-specific and acquired by entities outside transportation industries. A fixed asset is transportation-specific when its only use is in transportation. For example, a pickup truck is transportation-specific whether or not it is used by a transportation entity, while a computer is not transportation-specific even if it is used by a trucking company. Therefore, our list includes all pickup trucks but only the computers used by transportation industries. Our extended definition of transportation assets and the related investment measures better serve transportation analysis purposes than measures of investment on a pure asset basis or industry basis.

Many public policy questions focus on infrastructure, and there is interest in the levels and patterns of investment in infrastructure. The data in this paper address infrastructure, but they also cover the transportation equipment (aircraft, railroad cars, trucks) that use the infrastructure. Many issues relating to the impact of transportation investment on the economy, such as impact on aggregate demand and employment, relate just as much to equipment as to infrastructure. Infrastructure investment can leverage equipment investment, by improving equipment turn times, and can impact directly on equipment maintenance costs. On the other hand inadequate equipment investment can constrain the transportation system even if infrastructure is adequate. By providing total investment data, but breaking out infrastructure investment, we provide data that can be used to address these issues. In this way we also provide data that is comparable to investment data in national account statistics and in the Government Transportation Financial Statistics reports.

Transportation investment or additions to transportation fixed assets can take two forms, purchase of new assets and change in inventories. Both purchases of new fixed assets and change in inventories are incorporated in our transportation investment estimates. Purchases are conducted by government, business, and households. Change in inventories consists of the current production of goods for transportation use that are not used or sold. Examples of change in inventories include motor vehicle inventories in the hands of manufacturers and dealers, work in progress on construction of transportation infrastructure, etc. Here is another innovation of our approach to measuring transportation investment, i.e., counting household purchase of transportation assets as investment. The national accounts classify household purchase of motor vehicles under current consumption to satisfy current national accounting principles, but household transportation activities are an integral component of overall transportation operations and should be so treated for transportation analysis purposes. Such treatment on the operations side requires similar treatment on the investment side.

The total value of investment, calculated before deducting depreciation or the portion of investment that is used to replace depreciation of the existing transportation capital stock, is referred to as gross investment. Deducting the depreciation from gross investment provides net investment, which represents the net addition to the stock of transportation capital for the period. Whether the transportation capital stock increases or decreases over a given period of time depends upon whether gross investment is greater or less than depreciation. Although the net investment is often more informative than gross investment, calculating it requires extensive measurement work in capital stock accounting.

Transportation investment relates to the economy on both the demand and supply sides. Data on transportation investment have many different uses in dissecting the inter-relationship between transportation and the economy. First, as additions to the stock of transportation capital, transportation investment helps augment the capacity and efficiency of transportation by implementing new technology, establishing continuity of routes, eliminating bottlenecks, improving the coverage and accessibility of the transportation network. Thus, the level of transportation investment indicates the potential capacity and efficiency of transportation, and its contribution to the overall economy for years to come.

Second, as a component of aggregate demand, transportation investment shows the amount of economic resources devoted to transportation capital. A time series of transportation investment and its percentage share in GDP provide an overview of changes in the resource allocation, and the relationship between transportation and GDP over time.

Third, data on transportation investment can be used to support policy analysis on the dynamics of transportation infrastructure, transportation technology, and the industrial structure in relation to the overall economy. Moreover, the relationship between public and private investment in transportation has been an ongoing research interest of academics. For example, the data can support research studies that attempt to investigate whether an increase in public investment displaces private investment or encourages private investors to invest more.

Fourth, transportation investment as a final demand (use) is affected not only by the total output but also by structural changes in the economy. For example, during a given period, a steady increase in transportation investment as a percentage of GDP could be accompanied by an increase or a decrease in overall capital investment as a percentage of GDP. Change in transportation investment in relation to overall capital investment might indicate a change in the future structure of the economy.

Fifth, there are two major types of fixed capital, namely, infrastructure and rolling stock, for transportation. While the private sector is the major investor in rolling stock, government is the major investor in infrastructure. This may, however, differ among transportation modes. For example, whereas highway infrastructure is almost entirely funded by the government, railroad and pipelines are mostly investments of the private

sector. Therefore, data on transportation investment by sector of investors, types of assets, and transportation mode provide a clearer picture of transportation investment patterns for each of the transportation modes.

Finally, transportation investment by mode of transportation can indicate possible structural changes *within* the transportation industry, which is important for transportation policy making. For example, a significant switch in capital investment between different modes (e.g., from air transportation to public transit) or unmatched growth for different types of assets within a single mode (e.g., a rising annual growth rate in the number of motor vehicles on the road compared with a much lower growth rate in highway investment) may signal a need to adjust future transportation investment plans.

It is apparent from the above discussion that statistics on transportation investment are of great value for transportation planning and budgeting purposes, policy makers interested in understanding the impacts of transportation investment, and for researchers interested in investigating the link between transportation investment and economic development. In order to serve these and other related purposes, the data compilation effort should go beyond producing aggregate statistics on transportation investment. The effort should produce comprehensive statistics, incorporating public and private investment, and also it should be as detailed as possible.

2. Objective, Scope and Organization

The main purpose of this report is to provide time series data on transportation investment in fixed assets, which include infrastructure, rolling stock, and other equipment used in transportation activities. The data are reported by sector (private, government, and households), type of fixed assets (infrastructure, rolling stock, and other equipment), and by mode (highways, air, transit, railroads, water, and pipelines). The investment figures are presented before deducting depreciation of the existing transportation capital. While it is of paramount importance to compile data on net investment and/or depreciation of capital in order to determine the net addition to the capital stock, they are not covered in this report because of data limitations. Data on transportation investment as a percentage of GDP and a descriptive analysis of the trends in transportation investment in relation to GDP are also provided. The descriptive analysis is not intended to determine the causal relationship between transportation investment and GDP, which requires more rigorous work. Rather, it is a simple analysis that provides a bird's eye view of the statistical trends of transportation investment in relation to GDP.

All investments made by private business engaged in transportation activities as well as transportation-related investments made by non-transportation industries (such as agriculture, manufacturing, mining, construction, etc.) are covered. As far as non-transportation industries are concerned, only rolling stock is accounted for. The infrastructure components of transportation investments made by non-transportation industries are not included because of lack of comprehensive information. Government investment constitutes investments made by all levels of government, namely, federal, state and local government. Although the existing classification in the National Income and Product Accounts (NIPA) defines household purchases of rolling stock as consumption rather than capital investment, household purchases of rolling stock are treated as transportation investment in this report. Since household-owned automobiles account for about 60% of total investment and have a significant impact on the transportation network and the economy (Chen, Fang, Han, and Sloboda, 2002), it is appropriate, therefore, to classify household purchases of rolling stock as a component of transportation fixed capital.

The rest of this report is structured in four sections. Section III reviews literature that examines the linkage between transportation investment and economic performance. A survey of major statistical undertakings by other government agencies that contain datasets on transportation investment is provided in Section IV. Both the literature review and the survey of statistical works are aimed at gaining insights into the type and level of detail of transportation investment data that can better meet multifaceted research agendas and facilitate policy making. Section V discusses data sources and procedures used to develop the dataset, and a list of data sources is provided in Appendix A. The final section presents the data tables and a descriptive analysis of transportation investment in relation to GDP.

3. Review of Literature

The literature review covers the various research studies on the link between transportation investment and economic development. This literature review is intended to draw implications regarding the type, structure, and level of detail of transportation investment data that are needed to support transportation investment decisions. The objective here is not to critique the literature or provide an exhaustive review of all research on the subject; rather its purpose is to find out the data needs of current research efforts in order to narrow our data compilation effort towards meeting these and other related data needs.

Largely because of the work by Aschauer (1989), academics have undertaken numerous studies that explore the relationship between transportation investment and economic performance. Economic performance can be measured by output, value-added (GDP), productivity and employment (e.g., Demetriades and Mamuneas, 2000). Some studies have explored the impact of infrastructure investment on technical efficiency that enters the production function (e.g., Delorme, Thompson, and Warren, 1999). Similar studies have also been undertaken based on foreign data (e.g., Kim, Koo, and Lee for South Korea, Rioja for seven Latin American countries, Everaert and Heylen for Belgium, and Sturm, Jacobs, and Groote for the Netherlands). Three major literature reviews, which were conducted in the late 1990s, cover major literature and most research projects on this subject in the U.S. up to early 2000.[2] As pointed out above, by summarizing these literature reviews and some recent academic studies, we will draw observations that shed some light for our data work.

According to Bell and McGuire (1997), a major finding from studies up to early 1994 is that "a positive statistically significant but small effect of public capital on output has been confirmed by many." As pointed out in the report, however, *structural* changes in relation to infrastructure investment have received insufficient attention in the literature. These changes include "*differentiated economic linkage* between specific industry and specific type of infrastructure," the role of investment flows in examining "the *derived* demand for public infrastructure by private sector," and "the relationship between infrastructure types (e.g., complementary vs. substitutable)" (Bell and McGuire 1997, p. 9-10). The review indicates that research on the question of the relative productivity of different types of public infrastructure, which have been constrained by data limitations, requires data by infrastructure type or mode of transportation.

The subsequent literature review by Apogee Research and Greenhorne & O'Mara (1998) focused on evaluating the merits and limitations of techniques used in studies linking transportation investment and economic performance. This review divides the existing studies into macro- and microanalysis, with the former employing mainly production function and cost function methods and the latter cost-benefit analysis and case studies. In an attempt to find the impact of investment on productivity, the macroanalysis methods compare national trends in economic activity with levels of total public

[2] See Bell and McGuire (1997), Apogee Research, Inc. and Greenhorne & O'Mara (1998), and Weisbrod (2000).

infrastructure investment. According to the authors' view, these methods fail to address the causal relationship; instead they simply show how various data series are related to each other. The microanalysis methods, by focusing on the economic effects of a particular project, provide insights into how the private sector reacts to changes in transportation. The review points out that both methods lack "a solid understanding of the mechanisms by which transportation investment influence *structural* changes in a developed economy" (Apogee Research and Greenhorne & O'Mara 1998, p. 26).

A recent synthesis of practices for assessing economic development impacts from transportation investments (Weisbrod, 2000) covers studies by both academia and practitioners up to early 2000. The synthesis, aimed at providing sub-national (local, regional, and state) planners with analytical tools, defines the economic impact by using regional rather than national indicators (e.g., using gross regional product rather than gross domestic product). In addition to a literature review, the synthesis is primarily based on a survey of 75 transportation planning agencies (in the U.S., Canada and the United Kingdom) on their current research and practice in evaluating the relationship between transportation and economic development. It pointed out that the evaluation of economic impact of public investment in transportation infrastructure has to date "focused primarily on highway spending," implying the need to broaden the study to cover more transportation modes.

Among all the studies of the economic impact of transportation investment, Nadiri and Mamunees (1996) appeared to be the most influential.[3] The study used data on public highway capital, which was developed by Apogee Research, Inc., based on Federal Highway Administration capital outlay data. One of the findings that are most relevant to the design of our data work is that the economic impact of highway capital at the national level *differs* from that at the industry level and *varies by industry.* Furthermore, highway capital seems to have a *substitution effect* on private capital for most industries and is *complementary* for the rest. One comment on this ongoing study is that it overlooked the welfare benefits of highway capital to consumers that are "likely to be significant." (Eno, 1999, Appendix A).

Among other recent studies, Chandra and Thompson (2000) found that highways not only have "a differential impact across industries" but also "affect the *spatial allocation* of economic activity." Demetriades and Mamuneas (2000), using an inter-temporal optimization framework, found that in all 12 OECD countries, the magnitude of positive economic effect of public capital changes over time depending on the under-investment gap in infrastructure, which was wider during the 1970s and 1980s but narrowed down significantly by the early 1990s. Everaert and Heylen (2001), using single-equation co-integration analysis based on annual data, found a strong positive relationship with causality running from public capital (including roads, buildings, educational facilities, etc.) to multifactor productivity in Belgium for the period of 1953 to1996.

In summary, the above literature review tells us that past studies were mostly focused on the economic impact of government transportation investment. Most of the studies were

[3] Refer to Eno (1996, 1999).

concentrated on impacts of highway capital. Little attention has been paid to business transportation investment, its economic impact, and its interaction with government investment; and other modes. Furthermore, as pointed out by the aforementioned literature reviewers, more work needs to be done to explore the *structural* impact of characteristically different transportation investments on the economy. Structural impacts refer to those impacts that may be classified by industrial, geographical, and even demographic changes within an economy. As for characteristically different transportation investments, one may include a broad range of characteristics that can differentiate one type of investment from the other in terms of transportation mode, asset type, sector of investors, funding source, technology embedded, and the nature of investment (i.e., public goods, club goods, or private goods). Finally, few studies raise the issue of how economic development impacts transportation investment. That is, how economic development (e.g., economic growth and industrial restructuring) stimulates transportation investment in terms of both growing demand and increased funding sources for transportation services.

Ideally, new data development initiatives should be broader and more detailed to support a wide variety of future research undertakings. This report, which provides transportation investment by sector of investors, types of assets, and transportation modes, will fill some of the data gaps mentioned above, thus providing the basic data that will support policy decisions, and researches on transportation investment and economic development. Using the dataset developed by this report, researchers will be able to conduct those studies that they could not conduct in the past due to lack of data. For example, this report provides the infrastructure investment data by mode called for by Bell and McGuire. This is the first step towards the breakdown of infrastructure by type that they also suggest. Similarly, by providing comparable data across all modes, this paper emphasizes the need to move beyond the primary focus on highway spending that was pointed out by Wiesbrod. By bringing together data for infrastructure and equipment, and for government, industry and household sectors, it supports the kind of investigation of substitution and complentarity effects performed by Nadiri and Mamunees. Not only will this data begin to address some of the specific gaps mentioned above, but it may stimulate further related research.

4. Survey of Existing Statistical Work

This survey is focused on existing statistical works that are similar to this one. It covers only undertakings by other domestic and foreign government agencies that are comparable to either the Department of Transportation or the Bureau of Transportation Statistics. For broader coverage of works on a smaller scale and by lower-level government agencies, one may refer to Lakshmanan (Eno, 1996, Appendix C) and Weisbrod (2000).

Congressional Budget Office

The Congressional Budget Office (CBO) has in recent years (1992, 1993, 1995, and 1999) published its analysis on *Trends in Public Infrastructure Outlays and the President's Proposals for Infrastructure Spending*. The analysis is based on data supplied by the Office of Management and Budget, the U.S. Census Bureau, and CBO's Budget Analysis Division. As identified in its 1999 paper (Appendix), all the government capital outlays for transportation infrastructure are included in the public infrastructure outlays. They are highways, mass transit, rail, aviation, and water transportation (the other three types of public infrastructure are water resources, water supply, and wastewater treatment). Based on its analysis, the published CBO paper on this subject divides spending into capital outlays (primarily the purchase, construction, or rehabilitation of physical assets) and non-capital outlays (primarily the operation and maintenance of physical assets) for each type of public infrastructure. All the amounts are presented in both current dollars and constant dollars. The analysis covers the period of 1956 up to the latest year for which the budget estimates are available. Through 1994, based on the U.S. Census Bureau's Government Finances series (available only through 1994), CBO calculated government spending, in both amount and percentage share, by the level of government, the total including all levels of government, federal, and state and local. Federal spending is further divided into direct and indirect outlays, with the latter comprising grants and loans to state or local government entities; state and local outlays are categorized as total and net outlays, with the former including grants and loans from the federal government. As a result of this detailed calculation, the analysis shows trends in relative contributions of federal, state, and local governments split between capital and non-capital outlays and priorities for infrastructure programs. Since 1995, the CBO analysis of trends in public infrastructure spending has covered only federal government outlays.

Office of Management and Budget

The Office of Management and Budget (OMB) publishes historical tables that contain several time series on federal government capital outlays that are somewhat related to our work. The latest version of Historical Tables (OMB, 2003) covers the period of 1940 to 2003 for the federal government outlays on major public physical capital. In particular, Table 9.6 in Section 9 contains information on "grants for major public physical capital investment" in transportation by mode (highways, urban mass transportation, airports, and other). However, the publication does not provide further breakdown by asset type

(i.e., infrastructure vs. other capital outlays) since most of these grants are spent by state and local governments, over which OMB does not necessarily have control. Furthermore, the OMB publication is based on the federal government fiscal year, which is not directly comparable to statistics on transportation investment made by state and local governments and the private sector including both business and households.

5. Data Sources and Methodology

Key data used for our work are obtained from the U.S. Department of Commerce, the Bureau of Economic Analysis (BEA), and the U.S. Census Bureau (Census). None of these data sources, however, is readily usable for our purposes. Therefore, to produce tables presented in this report, we needed to fill in the gaps of these data sources. Our work is mainly based on BEA data, but we use data from the Census as a cross-reference. Appendix A contains a detailed list of the data sources used for our work. Following is a description of data sources and procedures used to produce tables presented in this report.

5.1 Government Investment in Transportation

Gross government capital investment in transportation is classified as investment in infrastructure and in rolling stock. The consensus is that equipment used for providing and maintaining the transportation infrastructure may be seen as a component of infrastructure despite the fact that the government sector must have made and will still make capital investment in transportation equipment other than rolling stock (e.g., computers for operating transportation facilities from highways to airports). It should be noted that there is no identifiable source of data that can be used for a reliable estimate of government investment in transportation equipment that is not blended with infrastructure. Therefore, we do not specify government investment in transportation equipment other than rolling stocks. The available data from the Census also show that government investment in transportation equipment is insignificant compared with government investment in construction, land, and existing structures, all of which are components of infrastructure.

Government investment in transportation infrastructure is grouped by transportation mode, such as highways, air, water, and transit, including railroad. Data on government investment in "highways and streets" are adopted from BEA, Fixed Assets Table 7.5. Data on government investment in other transportation infrastructures are obtained from BEA, the Government Division. The government annual purchase of motor vehicles, including automobiles, trucks and buses, is estimated from BEA, National Accounts, Table for Auto Output (i.e., underlying table 8.8U). More specifically, government purchase of motor vehicles (excluding employee reimbursement and government investment in motor vehicles for defense) is counted as government capital outlays on rolling stock for the highway and mass transit modes. At the current stage, there are no data available on government purchases of non-defense rolling stock for other transportation modes.[4]

5.2. Business Investment in Transportation

Estimates for business investment in transportation are developed based on BEA data on capital investment by industry and by asset type, 1901–2000. Our report groups

[4] Our communication with the BEA staff also indicated that government purchases for other type of rolling stocks such as airplanes and ships including investment in ship construction are exclusively for defense purposes, which is beyond our scope of work.

industries into two sectors for the purposes of measuring investment, the transportation industry, and all others, which we refer to as non-transportation industries. Six modes are specified within the transportation industry. They are: highways, air, water, mass transit, railroad, and pipelines. For the transportation sector, the following three types of assets are specified: infrastructure, rolling stock, and other. Non-transportation industries include agricultural, mining and construction, manufacturing, communications, utilities, trade, finance, insurance and real estate, and service industries. For non-transportation industries, only investment in rolling stock (including motor vehicles, aircrafts, ships and boats, and railroad equipment) is identified as transportation investment.

5.3. Households Purchase of Rolling Stock

Household purchase of rolling stock is classified into three modes: highways and streets (road), air, and water. For road transportation, household purchase of rolling stock includes automobiles, motorcycles, and bicycles. Household purchase of aircraft and boats are classified as air transportation and water transportation, respectively. As shown in Appendix A, all these data are obtained through personal communication with BEA and from various BEA web links.

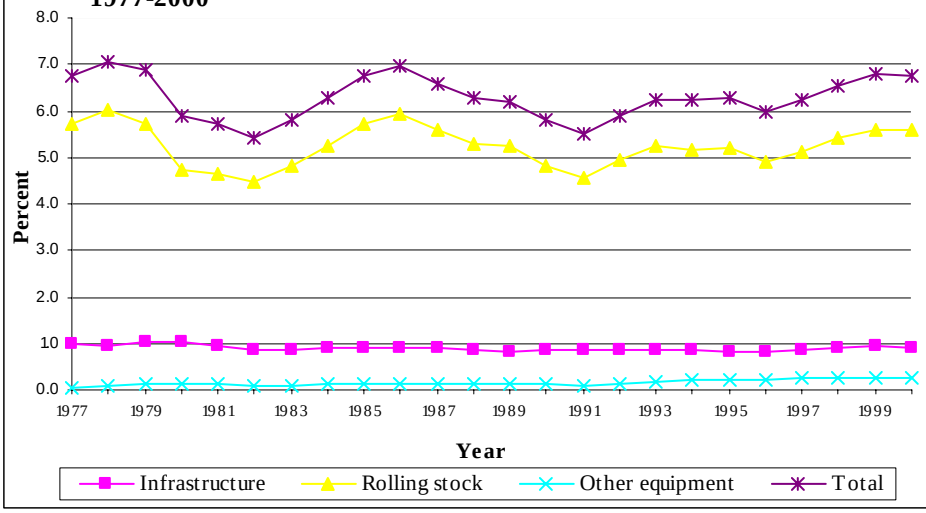
6. Trends in Transportation Investment

In this section, we discuss trends in transportation investment in the following sequence: *overall* transportation investment, transportation investment by sector, transportation investment *by asset type* (i.e., infrastructure and rolling stock) *and by sector of investors* (i.e., government, business, and household sector), business investment by category (i.e., transportation and non-transportation investment), and business investment in transportation by industry (i.e., transportation vs. non-transportation industries).

6.1. Overall Transportation Investment

The overall transportation investment accounted for more than 6% of GDP for most years during the period of 1977 to 2000 (Figure 1). Of this overall transportation investment, investment (including household expenditure) in rolling stock accounted for 83.3%, and that in transportation infrastructure and in other transportation equipment, 14.2% and 2.5%, respectively. As such, the trend of investment in rolling stock dominates the trend in transportation investment. It is also noteworthy that, whereas infrastructure investment appears to have been steady at around 0.9% of GDP since 1981 when it dropped below 1% of GDP, the overall expenditure in rolling stock (net of government purchase for defense) fluctuated along with the economic cycle. For example, the year-by-year drops in overall expenditure in rolling stock during the period of 1979 to 1982 echoed the repeated business downturns during that period (Figure 2). The picture for 1991 tells a similar story, whereas that for 1996 reflects a brief economic stagnation in 1995. Finally, business investment in transportation equipment (other than rolling stock) as a share of GDP, although insignificant, appeared to increase steadily for the second half of the 1990s, which may indicate technological advancement within the transportation industry during that period and warrants further study (Figure 1).

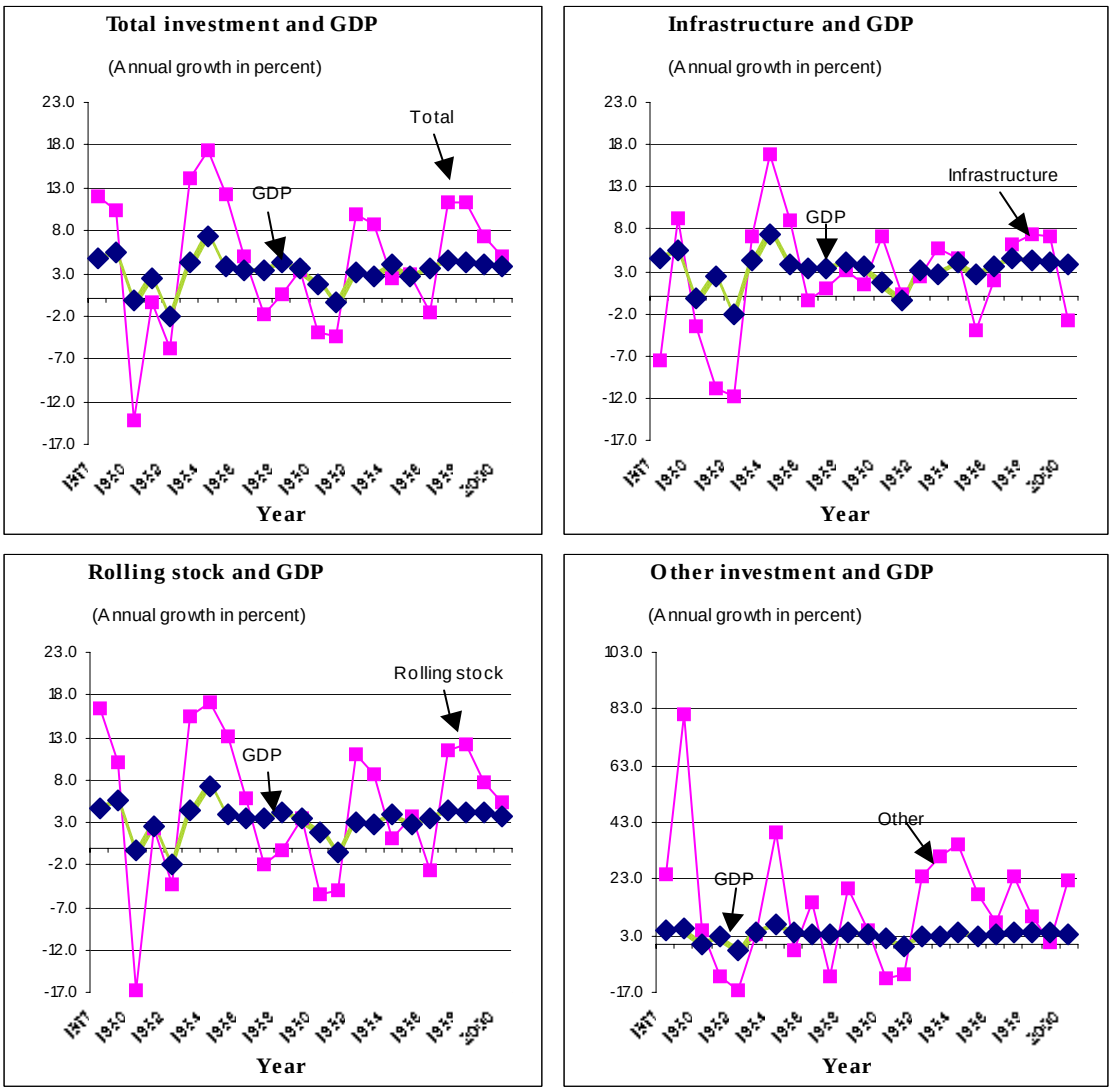
Figure 1.
Transportation investment as percentage of GDP by type of asset, 1977-2000



Note: Other equipment includes transportation industries' investment in all types of equipment excluding rolling stock.

Sources: BTS calculations based on data from U.S. Department of Commerce, Bureau of Economic Analysis (BEA), "Fixed Assets and Consumer Durables," "National Income and Product Account (NIPA) Tables," available at http://www.bea.gov, as of July 2002; and personal communication with BEA.

Figure 2.
Growth in transportation investment by type of asset compared with growth in GDP, 1977-2000



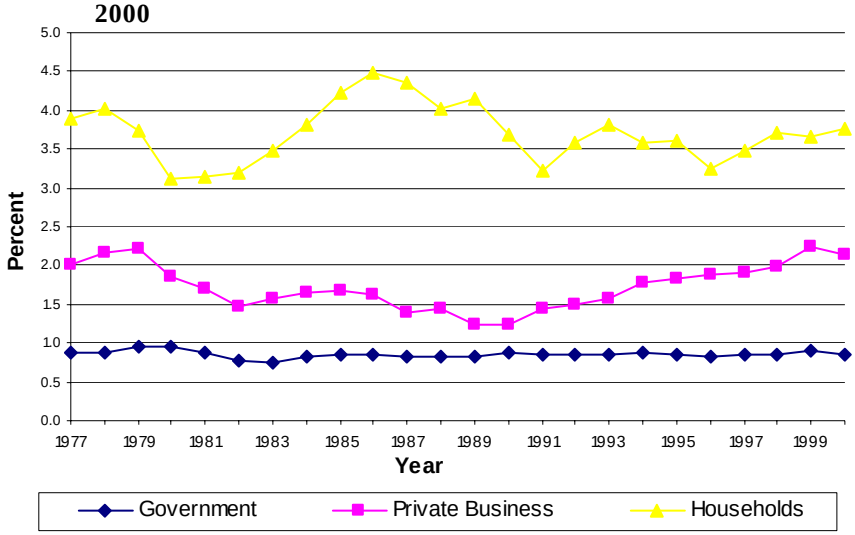
Note: All growth rates are calculated based on chained 1996 dollar values.

Sources: BTS calculations based on data from U.S. Department of Commerce, Bureau of Economic Analysis (BEA), "Fixed Assets and Consumer Durables," "National Income and Product Account (NIPA) Tables," available at http://www.bea.gov, as of July 2002; and personal communication with BEA.

6.2. Transportation Investment by Sector

Figure 3 illustrates transportation investment by sector, namely, households, private business, and government. As a share of GDP, government investment, which consists of infrastructure and rolling stock, stayed almost the same, averaging 0.9% for the entire period, while private business investment, which includes infrastructure, rolling stock and other equipment, declined until 1990 and showed a consistent increase since 1991. Transportation investment of the household sector has been consistently greater than that of the public and private business sectors combined during the period under consideration. As a share of GDP, transportation investment by the household sector averaged 3.7%, fluctuating between a low of 3.1% and a high of 4.5% during 1977-2000.

Figure 3.
Transportation investment as percentage of GDP by sector, 1977-2000



Sources: BTS calculations based on data from U.S. Department of Commerce, Bureau of Economic Analysis (BEA), "Fixed Assets and Consumer Durables," "National Income and Product Account (NIPA) Tables," available at http://www.bea.gov, as of July 2002; and personal communication with BEA.

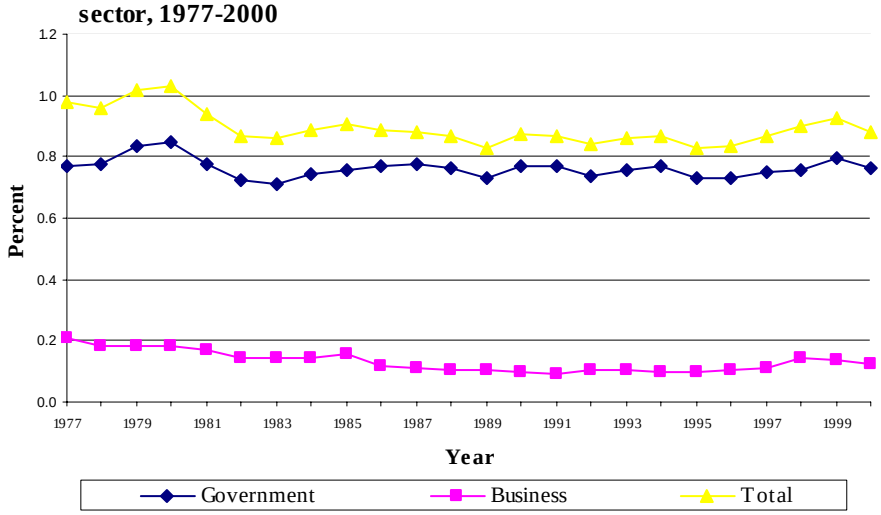
The role of government, private business, and households in transportation investment vary by asset type and mode of transportation (Figures 3 and 4). The public sector provides most transportation infrastructure with the exception of railroads and pipelines. For example, of the total government transportation investment, infrastructure accounted for an average of 89% for the period 1977-2000. The private business sector invests heavily in rolling stock and operates on publicly provided infrastructure. Private business investment in rolling stock and other equipment used for transportation activities accounted for about 92% of the total private sector transportation investment. The remaining 8% went to transportation infrastructure. A large proportion of the business infrastructure investment has been used for railroads and pipelines, which accounted for about 60% on average during 1977-2000. The household sector doesn't invest in

transportation infrastructure and hence its investment is entirely in rolling stocks (i.e., motor vehicles, trucks and vans, airplanes, boats, etc.).

6.3. Characteristics of Investment in Transportation Infrastructure

Figure 4 provides an enlarged picture of investment in transportation infrastructure in terms of time trend and by sector. Figures 5-7 further illustrates this type of investment by transportation mode and by sector of investors. Four observations can be drawn from these figures.

Figure 4.
Investment in transportation infrastructure as percentage of GDP by sector, 1977-2000

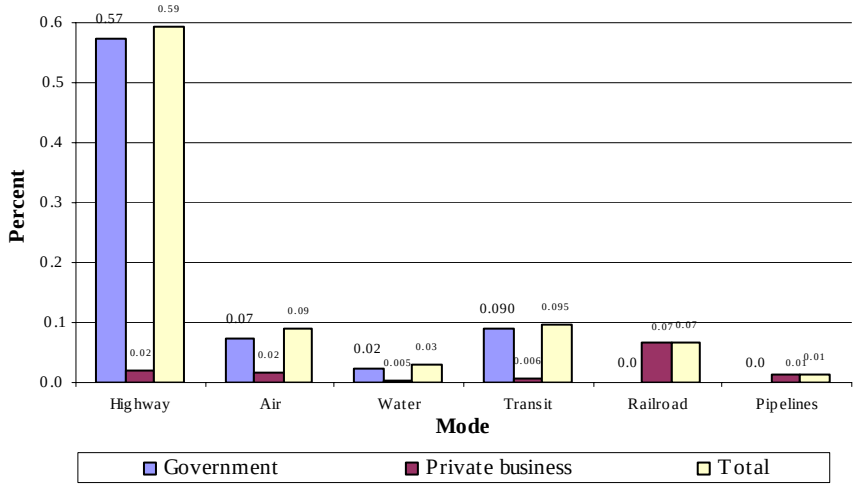


Sources: BTS calculations based on data from U.S. Department of Commerce, Bureau of Economic Analysis (BEA), "Fixed Assets and Consumer Durables," available at http://www.bea.gov, as of July 2002; and personal communication with BEA.

First, government is the predominant investor in transport infrastructure (Figure 4). Therefore, government investment clearly dominates the trend of investment in transportation infrastructure with only a few exceptions (e.g., in 1978, 1986, and 1987). For the period of 1977 to 2000, the government share in infrastructure investment, on average, is 97% for highways, 94% for transit, 81% for airports, and 84% for water transportation (Figure 5). While the business sector accounts for almost 100% of infrastructure investment for railroads and pipelines, total infrastructure investment for these two modes accounts for less than 0.1% of GDP since 1986 (Figure 5).[5] With its minor share, the business sector's investment in transportation infrastructure as a proportion of GDP had been dropping since 1977 when it accounted for 0.21% of GDP and stabilized since 1987 around 0.1% of GDP, with a brief rise to 0.14% of GDP for 1998 and 1999 (Figure 4).

[5] It is known that government invests in railroad infrastructure. Most of the public investment is, however, allocated to commuter rail and subways, which are counted in transit mode.

Figure 5.
Investment in transportation infrastructure as percentage of GDP by mode and by sector, average for 1977-2000

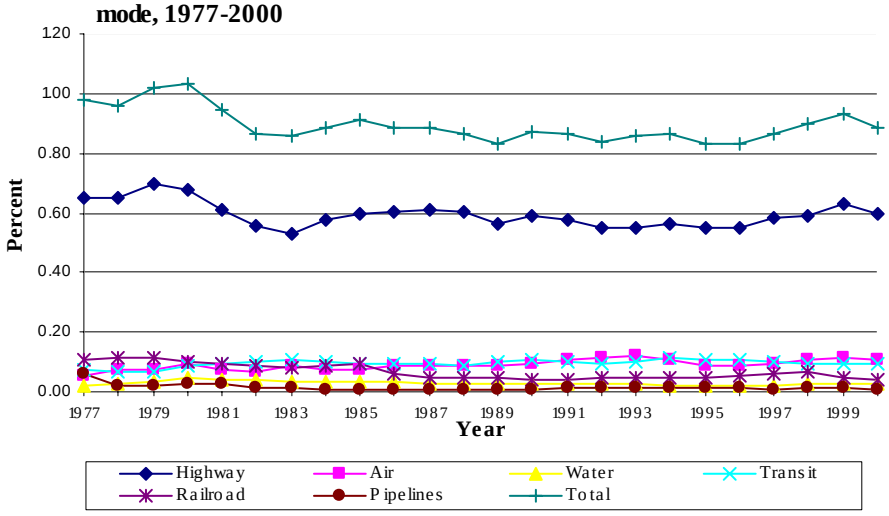


Sources: BTS calculations based on data from U.S. Department of Commerce, Bureau of Economic Analysis (BEA), "Fixed Assets and Consumer Durables," available at http://www.bea.gov, as of July 2002; and personal communication with BEA.

Second, investment in transportation infrastructure lagged behind the business cycle. Overall investment in transportation infrastructure peaked in 1980, followed by a sharp downturn that bottomed out in 1984 and has fluctuated ever since, with a strong pickup in the late 1990s when both government and business sectors increased their investment (Figure 4). It is interesting to note that overall investment in transportation infrastructure lagged behind the business cycles. For example, whereas overall transportation investment, of which about 80% is in rolling stock, started to drop in 1979 when business contraction was well underway (Figure 2), investment in transportation infrastructure rose in 1979 and receded in 1980 and 1981 when the economy showed a brief revival (Figures 4). This implies that infrastructure investment, particularly that funded by the government sector, is an induced variable of past economic performance; it could be also a result of government budget decisions, which is often counter cyclical.

Third, highway investment, on average, accounts for over 65% of total investment in transportation infrastructure for the period of 1977 to 2000 (Figures 5 and 6). Consequently, the trend in highway investment dominates the observed trend in the overall infrastructure investment.

Figure 6.
Investment in transportation infrastructure as percentage of GDP by mode, 1977-2000

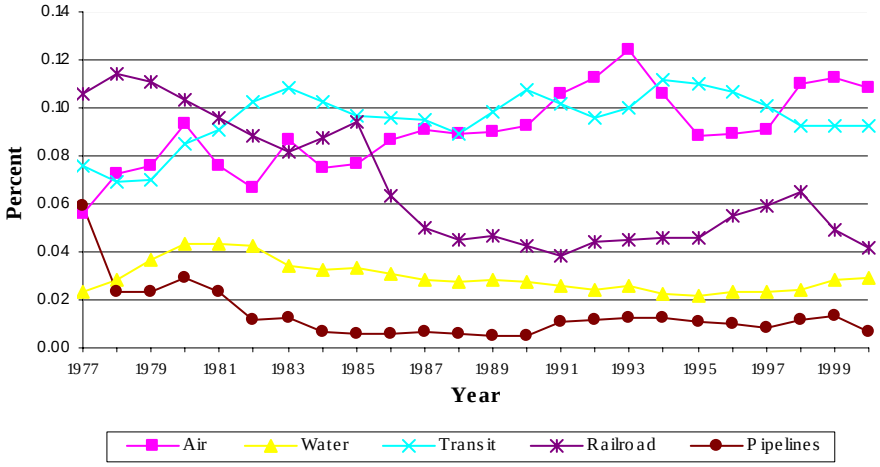


Notes: Transit includes relatively small amounts of government investment in railroad infrastructure. Transportation services include establishments furnishing services incidental to transportation, such as forwarding and packing services and the arrangement of passenger and freight transportation.

Sources: BTS calculations based on data from U.S. Department of Commerce, Bureau of Economic Analysis (BEA), "Fixed Assets and Consumer Durables," available at http://www.bea.gov, as of July 2002; and personal communication with BEA.

Finally, despite all the fluctuation, infrastructure investment in non-highway transportation modes changed significantly in relative shares. As illustrated by Figure 7, as a percentage of GDP, investment in air transportation (mainly airports) in 2000 (0.11%) was almost double that in 1977 (0.056%). Similarly, though less significantly, investment in both water transportation and public transit as a percentage of GDP increased by more than 20% from 1977 to 2000. In contrast, investment in railroad as a percentage of GDP has decreased over time by more than 60% and that in pipelines dropped by 90%.

Figure 7.
Investment in transportation infrastructure as percentage of GDP by mode, excluding highway, 1977-2000



Notes: Transit includes relatively small amounts of government investment in railroad infrastructure. Transportation services include establishments furnishing services incidental to transportation, such as forwarding and packing services and the arrangement of passenger and freight transportation.

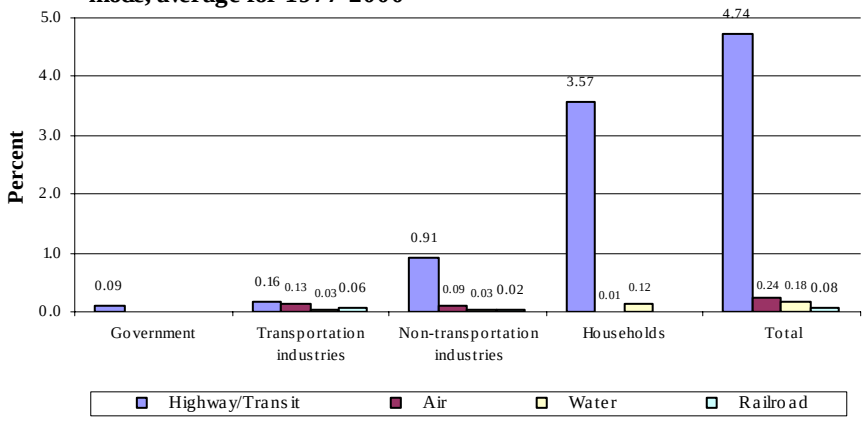
Sources: BTS calculations based on data from U.S. Department of Commerce, Bureau of Economic Analysis (BEA), "Fixed Assets and Consumer Durables," available at http://www.bea.gov, as of July 2002; and personal communication with BEA.

6.4. Characteristics of Investment in Rolling Stock

Figures 8-11 illustrate several characteristics of investment in rolling stock measured as a percentage of GDP.

First, households are the predominant investors in rolling stock, particularly motor vehicles (Figure 9). This is well documented in the National Account (for example, see the BEA website, Table 8.8U for Auto Output, at http://www.bea.gov). The annual change in household-dominated investment in rolling stock appeared to be closely related to the change in the annual growth rate in GDP (Figure 10). This is consistent with the close association between household spending and overall economic performance. In other words, as the growth in GDP speeds up, so does household purchase of rolling stock as a proportion of GDP (sometimes with a short time lag), and vice versa.

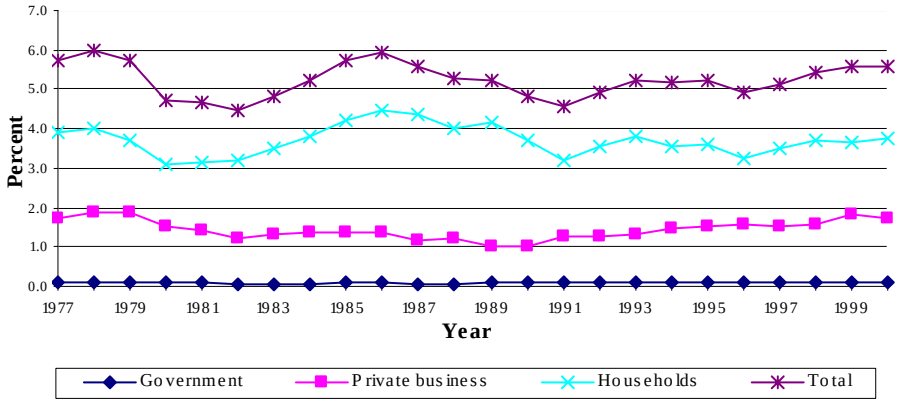
Figure 8.
Investment in rolling stock as percentage of GDP by sector and by mode, average for 1977-2000



Notes: Transportation industries cover establishments involved in providing railroad transportation, local and interurban passenger transit services, trucking and warehousing, water transportation, air transportation, pipelines except natural gas, and transportation services. Non-transportation industries include agriculture, mining and construction, manufacturing, communications, utilities, trade, finance, insurance and real estate, and services industries.

Sources: BTS calculations based on data from U.S. Department of Commerce, Bureau of Economic Analysis (BEA), "Fixed Assets and Consumer Durables," "National Income and Product Account (NIPA) Tables," available at http://www.bea.gov, as of July 2002.

Figure 9.
Investment in rolling stock as percentage of GDP by sector, 1977-2000

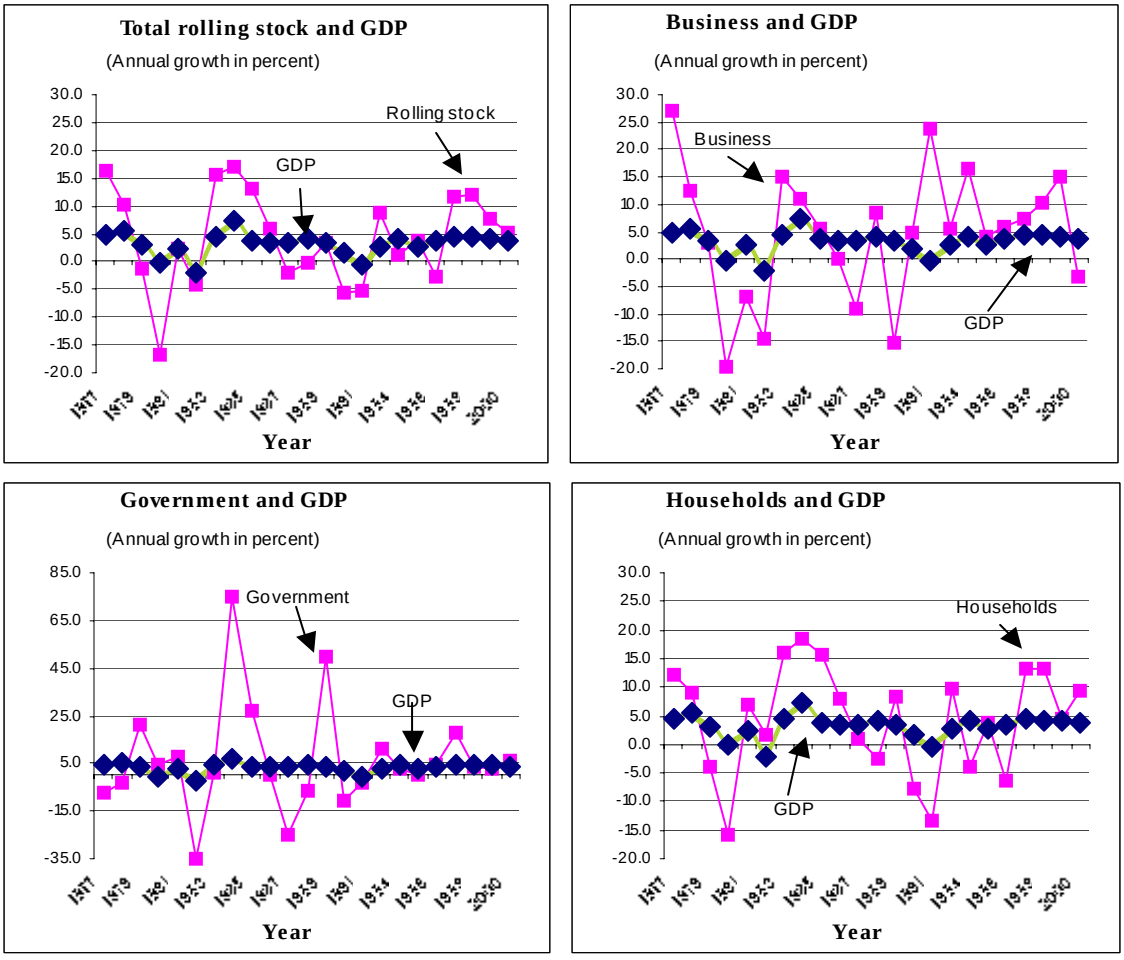


Notes: Transportation industries cover establishments involved in providing railroad transportation, local and interurban passenger transit services, trucking and warehousing, water transportation, air transportation, pipelines except natural gas, and transportation services. Non-transportation industries include agriculture, mining and construction, manufacturing, communications, utilities, trade, finance, insurance and real estate, and services industries.

Sources: BTS calculations based on data from U.S. Department of Commerce, Bureau of Economic Analysis (BEA), "Fixed Assets and Consumer Durables," "National Income and Product Account (NIPA) Tables," available at http://www.bea.gov, as of July 2002.

Second, compared with their investment in transportation infrastructure, government and business investment in rolling stock is more cyclical, although with more evident time lag than household purchase of rolling stock. On the other hand, similar to their investment in infrastructure, government and business investment in rolling stock showed a steady upward trend since 1992. This trend requires a further investigation of its economic driving forces and consequences.

Figure 10.
Growth of investment in rolling stock by sector compared with growth in GDP, 1977- 2000

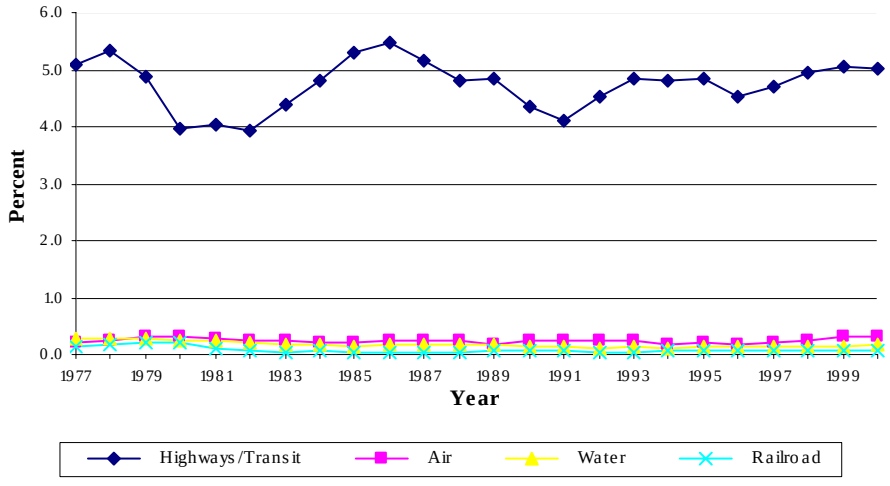


Note: All growth rates in this figure are calculated based on chained 1996 dollar values.

Sources: BTS calculations based on data from U.S. Department of Commerce, Bureau of Economic Analysis (BEA), "Fixed Assets and Consumer Durables," "National Income and Product Account (NIPA) Tables," available at http://www.bea.gov, as of July 2002.

Finally, the majority of investment in rolling stock is in motor vehicles, including automobiles, trucks and buses. As a result of this, investment in motor vehicles (for highway/transit modes) dominates the trend of investment in rolling stocks (Figure 11). Investment in motor vehicles, or rolling stock for highway and transit use, has been well above 90% of the total gross investment in rolling stock since 1983.

Figure 11.
Investment in rolling stock as percentage of GDP by mode, 1977-2000



Sources: BTS calculations based on data from U.S. Department of Commerce, Bureau of Economic Analysis (BEA), "Fixed Assets and Consumer Durables," "National Income and Product Account (NIPA) Tables," available at http://www.bea.gov, as of July 2002.

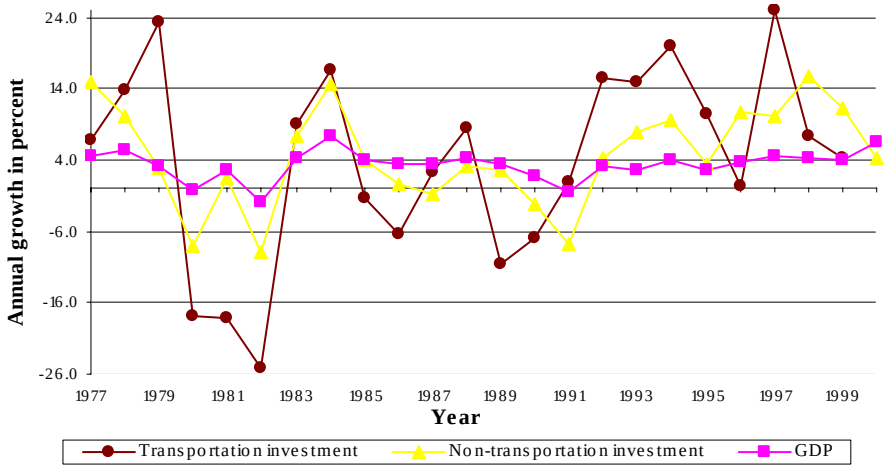
Figure 8 provides a summary of investment in rolling stock by sector and by transportation mode. As described above, the figure shows that household purchase of automobiles (for the highway mode) on average accounts for about 70% (=3.71%/5.24%) of gross investment in rolling stock. This is consistent with the study on household production of transportation services (Chen, Fang, Han and Sloboda, 2002). Since household purchase of motor vehicles is one of the major components of gross personal consumption expenditure (PCE) and follows closely the trend in GDP growth, it contributes significantly to the fact that PCE is used as a critical component of many economic indicators (e.g., manufacturers' new orders for consumer goods and materials, the personal consumption expenditure deflator for money supply, and consumer installment credit to income ratio, etc.).

6.5. Business Investment in Transportation Assets Compared with That in Non-Transportation Assets

The term “business investment” in our report is equivalent to the term “gross private fixed investment” used in the input-output (I-O) accounts. For our purposes, business investment, or gross private fixed investment (GPFI), can be classified as transportation and non-transportation investment. As mentioned before, business investment in

transportation includes all the investments made by the transportation industries and investments in rolling stock made by non-transportation industries; non-transportation investment includes the rest. Compared with non-transportation investment, transportation investment is more sensitive to the business cycle as measured by growth in GDP. Figure 12 illustrates this comparison. In other words, compared with non-transportation investment, transportation investment is more suppressed by economic contraction and more buoyed by economic recovery and boom. A possible explanation is that, compared with non-transportation investment, transportation investment (largely rolling stock as mentioned above) is more flexible in terms of its utilization and useful life, hence replacement cycle. On the other hand, several notable overshoots in transportation investment, particularly those appearing to go against the business cycle (e.g., in 1990-91), require further investigation.

Figure 12.
Growth of private business transportation and non-transportation investment: 1977-2000



Note: All growth rates are calculated based on chained 1996 dollar values.

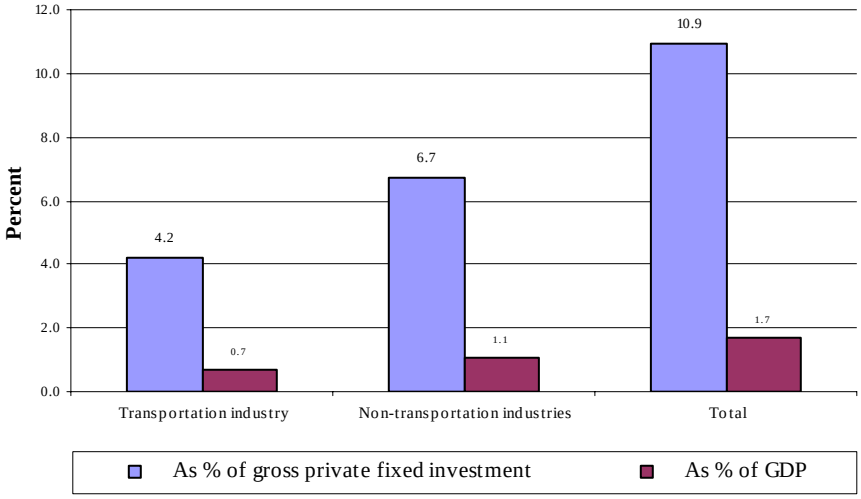
Sources: BTS calculations based on data from U.S. Department of Commerce, Bureau of Economic Analysis (BEA), "Fixed Assets and Consumer Durables," "National Income and Product Account (NIPA) Tables," available at http://www.bea.gov, as of July 2002.

6.6. Investment in Transportation Assets by Transportation Industries vs. Non-Transportation Industries

Transportation investment made by non-transportation industries accounts for 6.7% of GPFI and 1.1% of GDP, respectively, whereas that by the transportation industry accounts for 4.2% and 0.7%, respectively (Figure 13). In other words, transportation investment made by non-transportation industries (all in rolling stock) is about 60% more than that made by transportation industries (including infrastructure, rolling stock and other equipment). It is interesting to look at these statistics in reference to the transportation satellite accounts (TSA). As indicated in the 1992 TSA (BTS, 1999), in-house transportation services provided by non-transportation industries were about 60%

of the for-hire transportation services provided by transportation industries (i.e., in-house accounted for 1.9% of GDP; for-hire, 3.1%). This rough comparison indicates that the intensity of use of transportation capital (largely rolling stock) is higher for the transportation industries than that for non-transportation industries.

Figure 13.
Private business transportation investment by transportation and non-transportation industries, average for 1977-2000



Sources: BTS calculations based on data from U.S. Department of Commerce, Bureau of Economic Analysis (BEA), "Fixed Assets and Consumer Durables," "National Income and Product Account (NIPA) Tables," available at http://www.bea.gov, as of July 2002.

In summary, for the period of 1977 to 2000, overall transportation investment (including household purchase of rolling stock) on average accounted for more than 6% of GDP. Of this overall transportation investment, investment in rolling stock accounted for 83.3%, and that in transportation infrastructure and in other transportation equipment, 14.2% and 2.5%, respectively. Second, while households are the primary purchaser of rolling stock, government is the dominant investor in transportation infrastructure, except for railroads and pipelines, in which the business sector appears to be the exclusive investor. Third, besides the dominant share of highways in total infrastructure investment, which averaged 66%, the relative share of infrastructure investment among other modes changed significantly during 1977-2000, with air investment almost doubling and pipelines investment dropping by about 90%. Fourth, whereas the overall transportation investment (of which 83% is rolling stock) closely echoed the business cycle, investment in transportation infrastructure evidently lagged behind the business cycle. Fifth, within business investment, transportation investment is more sensitive to the business cycle compared with non-transportation investment. Finally, transportation investment made by non-transportation industries is greater than that by transportation industries. However, the intensity of use of transportation capital, particularly rolling stock, is much higher in transportation industries than in non-transportation industries. Readers should note that these findings require further study of their economic and policy background to facilitate future budgeting for transportation investment.

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Appendix A. Principal Data Sources

Data	Sources
Gross Domestic Product (GDP), and Chain-type price indexes	U.S. Department of Commerce, Economic and Statistics Administration, Bureau of Economic Analysis (BEA), "National Income and Product Accounts (NIPA) Tables," available at http://www.bea.gov/bea/dn/nipaweb/, as of July 2002.
Gross private fixed investment	U.S. Department of Commerce, Economic and Statistics Administration, Bureau of Economic Analysis (BEA), "Fixed Assets and Consumer Durables," available at http://www.bea.doc.gov/bea/dn/faweb, as of July 2002
Government gross investment in highways and streets	U.S. Department of Commerce, Economic and Statistics Administration, Bureau of Economic Analysis (BEA), "Fixed Assets and Consumer Durables," Table 7.5, available at http://www.bea.gov/bea/dn/faweb/, as of July 2002.
Government gross investment in transportation infrastructure by mode other than highways and streets	Personal communication with BEA, Government Division.
Gross government investment in autos and trucks.	U.S. Department of Commerce, Economic and Statistics Administration, Bureau of Economic Analysis (BEA), "National Income and Product Accounts Tables," historical underlying details, Table 8.8U Motor vehicle output, available at http://www.bea.gov/bea/dn1.htm, as of July 2002.
Government investment defense related automobiles	U.S. Department of Commerce, Bureau of Economic Analysis (BEA), "Fixed Assets and Consumer Durables," Table 7.5, available at http://www.bea.gov/bea/dn/faweb/, as of July 2002.
Private business transportation investment by type of asset (i.e., infrastructure, rolling stock, and other equipment)	U.S. Department of Commerce, Bureau of Economic Analysis (BEA), "Fixed Assets and Consumer Durables," Non-residential detailed estimates of historical cost investment, available at http://www.bea.gov/bea/dn/faweb/, as of July 2002.
Consumer expenditure on automobiles	U.S. Department of Commerce, Economic and Statistics Administration, Bureau of Economic Analysis (BEA), "Fixed Assets and Consumer Durables," Table 8.7, Historical cost investment in consumer durable goods, available at http://www.bea.doc.gov/bea/dn/faweb, as of July 2002.
Consumer expenditure on other rolling stock including bicycles, motorcycles, pleasure boats and aircrafts	U.S. Department of Commerce, Economic and Statistics Administration, Bureau of Economic Analysis (BEA), "National Income and Product Accounts Tables," historical underlying details, Table 2.6U, Personal consumption expenditures, available at http://www.bea.gov/bea/dn1.htm, as of July 2002.

Appendix B. Data Tables