5 TRANSPORTATION PRODUCTIVITY

Key Takeaways

• Labor productivity measures output per unit of labor input. From 1990 to 2016, air transportation experienced the largest increase (159.2 percent) in labor productivity among all transportation modes. Rail transportation experienced the second largest gains (100.9 percent), followed by trucking (33.6 percent), water transportation (26.2 percent), and pipeline transportation (5.7 percent). Transit transportation labor productivity declined by 15.2 percent from 1990 to 2016.

• Multifactor productivity (MFP) measures output per unit of weighted average of multiple factors, such as fuel, equipment, and materials. From 1990 through 2016, air transportation MFP increased the most across transportation categories, growing 107.3 percent. Rail and water transportation MFP grew 33.7 and 33.0 percent, respectively; pipeline and truck transportation had smaller increases of 27.6 and 10.2 percent, respectively; and the transit sector experienced a decline of 11.5 percent.

• Another measure of transportation productivity examines average revenue per passenger-mile and average freight revenue per ton-mile, both of which measure how much users are willing to pay for transportation services. Between 1990 and 2016, Amtrak/intercity rail average revenue per passenger-mile grew the most at 172.1 percent, while domestic air carrier average revenue per passenger-mile grew marginally at 1.8 percent from 1990 to 2017. In contrast, domestic air carriers average freight revenue per ton-mile increased 126.7 percent.

What is Productivity?

Productivity measures the rate at which workers produce goods or complete work. Economic productivity has a more precise definition: it is the ratio of total output to the inputs used in the production process. Inputs may include capital, labor, energy, materials, and services. Productivity increases when a business produces the same output more efficiently by using fewer (or lower-cost) inputs. The reverse is also true. Productivity decreases when a business produces the same output using more (or higher cost) inputs. In instances of productivity increases, the business may choose to produce more output, lower prices, invest in the business, or return income to shareholders.

Productivity may increase for several reasons. For example, new technology or training may help workers produce more goods in the same amount of time or with the same amount of resources. Likewise, policy changes may allow firms to operate more efficiently. Decreases in productivity could result from factors that impact inputs, such as changes in wage rates or the cost of intermediate goods. Temporary decreases in productivity may also occur when businesses expand faster than their output increases or businesses do not adjust to declining output.

Productivity growth can lead to increases in national income and improvements in the standard of living. One classic example is the Ford Motor Company’s Model T automobile, produced in the early 1900s. Ford greatly increased productivity by using interchangeable parts and a moving assembly line. Ford chose to use the increased productivity to sell the Model T for a lower price than competing vehicles. As a result, more people could afford an automobile.
Increases in productivity do not always lead to lower prices for consumers or increases in output. For example, demand for a business’ products may decline independent of an increase in productivity, which in turn may make the business unable to profitably increase output and lower its prices. Also, increases in productivity may not always lead to increases in total economic activity. For example, productivity increases achieved through automation may lead to worker layoffs and overall reductions in employment. In other words, productivity growth is necessary but not sufficient for increases in total economic activity.

This chapter highlights trends in transportation productivity by exploring three measures of productivity: labor productivity; multifactor productivity; and per passenger-mile or freight ton-mile revenue. The chapter also uses productivity measures to highlight the transportation sector’s contribution to economic growth in the United States.

**Productivity Measurements**

Productivity measures answer important questions about the performance of the transportation sector—for example, how efficiently transportation providers move people and goods, and whether the value of their services grew more rapidly than the costs of the inputs they use. The two main measures of transportation productivity include: labor (single-factor) productivity and multifactor productivity (MFP). Labor productivity measures the output per unit of labor input, while multifactor productivity measures the output per unit as a weighted average of multiple factors, such as fuel, equipment, and materials. The multifactor productivity ratio provides a more comprehensive measure of economic performance but is complex and difficult to isolate specific factor impacts on output. Labor productivity measures continue to have broad appeal because they are both simple to understand and, in many instances, labor is the major driver in changes to productivity.

In the United States, the Bureau of Labor Statistics (BLS) produces labor and multifactor productivity measures for industries (through its Industry Productivity Studies) as well as sectors and selected sub-sectors (in its Major Sector Productivity (MSP) program) as defined by the North American Industry Classification System (NAICS) (box 5-1). These measures show industry and sector changes in inputs, outputs, and productivity. This chapter presents transportation productivity data from BLS’ MSP program.

**Box 5-1  BLS Productivity Measures**

The Bureau of Labor Statistics (BLS) produces productivity statistics through its Major Sector Productivity (MSP) Program, its Industry Productivity Studies (IPS), and its value-added studies. The MSP program generally produces productivity measures at the North American Industry Classification (NAICS) sector (2-digit) and subsector (3-digit) level, while IPS publishes productivity statistics at the 4-digit NAICS industry level. Sometimes a 3-digit subsector is the same as a 4-digit industry in the NAICS system and, as a result, both MSP and IPS produce measures for the same NAICS industry.

BLS produces a productivity statistic for all industries aggregated in its value-added studies.

The three sets of productivity statistics differ due to methodological differences between the programs. The largest difference is in the measurement of output. The MSP program takes an aggregate approach and uses real gross output (less the portion consumed in the same industry) obtained from the Bureau of Economic Analysis. IPS takes a micro-level approach and uses deflated sales, values, or physical quantities for output. The value-added approach subtracts the value of the inputs used during the production process (e.g., fuel and materials) from gross output.

BLS’ productivity statistics presented in this chapter come from the MSP program because the MSP program produces statistics for all transportation sectors, whereas the IPS program produces statistics for only a few transportation industries.

The Bureau of Economic Analysis (BEA) also produces labor and multifactor productivity measures in the BEA/BLS Integrated Industry-Level Production Accounts (box 5-2). The Integrated Accounts take the BLS measures a step further by measuring the contribution of labor, capital, and other factors of production to economic growth.
Box 5-2 BEA/BLS Integrated Industry-Level Production Accounts

The Bureau of Economic Analysis (BEA) and the Bureau of Labor Statistics (BLS) collaborate to produce industry-level production accounts for the United States. To produce the accounts, BEA and BLS combine data on industry-level outputs and intermediate inputs from BEA’s GDP by industry accounts with data on capital inputs and labor hours from the BLS Productivity Programs. The integrated accounts show the contribution of labor, capital, multifactor productivity to economic growth. For more information, please see “A Prototype BEA/BLS Industry-Level Production Account for the United States,” available at https://www.bls.gov/mfp/bea_bls_industry_product_account.pdf.

These productivity measures assume that the quality of output does not change. For example, output measures, such as ton-miles and passenger-miles, measure the quantity of output but do not measure the quality of output. If the industry produced less to improve quality, productivity would appear to be declining due to less output being produced per unit of input.

Labor Productivity

To measure labor productivity, BLS measures outputs by industry and divides the output by paid labor hours. When an industry has multiple products or services, the outputs are weighted by value. BLS indexes the ratios to a common base year to allow for comparisons over time. BLS measures show industry responses to regulations and policies, changes in labor costs, and competitive pressures; the measures also enable comparisons across industries.

Figure 5-1 illustrates changes in labor productivity for selected transportation sectors from 1990 to 2016. Air transportation experienced the largest increase in labor productivity among all transportation modes, growing 159.2 percent from 1990 to 2016. Air transportation’s labor productivity grew most notably between 2001 and 2008. The gains during this period come from legacy carriers adopting aggressive labor-saving initiatives and from large output gains among low-cost carriers.1 Rail transportation experienced the second largest gains in labor productivity, increasing by 100.9 percent. These gains resulted from labor-saving technologies automating operational and administrative tasks.2 Labor-saving initiatives in air and rail resulted in a decline in labor hours with continued growth in output over the 1990 to 2016 period. During the same period, smaller labor productivity increases occurred in truck (33.6 percent) and water (26.2 percent) transportation. Labor productivity in pipeline transportation grew 5.7 percent despite declining output and labor hours from 2000 through 2016. Both transit transportation output and the amount of labor hours required to produce that output increased from 1990 to 2016, but labor productivity declined 15.2 percent due to labor hours rising faster (76.6 percent) than output (49.8 percent).

Multifactor Productivity (MFP)

To measure MFP, BLS divides output by a weighted set of inputs, including capital (e.g., equipment), labor, energy (e.g., fuel), materials, and purchased services. Unlike labor productivity, which is a single-factor measure of productivity, changes in MFP reflect the combined effect of multiple inputs. MFP more effectively captures the effect of new technologies, new regulations, or organizational changes if these changes influence other means of production besides labor.

From 1990 to 2016, MFP for the transportation sector grew 23.0 percent, a more modest increase than all other sectors except the finance and transportation sector grew 23.0 percent, a more modest increase than all other sectors except the finance and


services sectors (figure 5-2). MFP gains in the transportation sector resulted from the sector producing more per unit of combined inputs over time (figure 5-3). Of the inputs used, capital services (the cumulative value of the services rendered from the use of physical assets such as equipment, structures, and software over time) grew the most at 58.5 percent. Labor input, which is the combined effect of hours worked and the effort and skills of workers, grew 54.5 percent. Intermediate inputs, such as fuel, materials (e.g., tires), and purchased services, grew the least at 40.9 percent. Combined, capital services, labor, and intermediate inputs grew 49.0 percent, while output grew 83.0 percent. The greater growth in output led to an increase in MFP.

From 1990 through 2016, air transportation MFP increased the most across transportation categories, growing 107.3 percent (figure 5-4). The gain in air transportation reflects a 94.5 percent increase in output and a 6.2 percent decline in

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NOTES: Labor hours is the total number of hours worked by all workers in a sector to produce gross output. Gross output is the total value of goods and services produced by the sector. Gross output includes the value of the goods and services used to produce the sector output. Labor productivity measures a sector’s output per unit of labor input. Shaded areas indicate economic recessions.

Figure 5-2  Multifactor Productivity Indexes of Selected Sectors, 1990–2016 (index 1990 = 100)

NOTES: Finance includes finance and insurance and real estate rental and leasing. The services sector include professional and business services; education and health services; leisure and hospitality; and other services (NAICS 54–81). Shaded areas indicated economic recessions.


Figure 5-3  Transportation Multifactor Productivity and its Components, 1990–2016 (index 1990 = 100)

NOTE: Shaded areas indicate economic recessions.

combined inputs. Combined inputs fell, despite an increase in capital services, because of declines in labor inputs (18.5 percent) and intermediate inputs (10.7 percent), such as fuel and materials. The increase in capital services and the decline in labor result from the air transportation sector adopting labor-saving technologies, such as self-service kiosks.

Rail and water transportation experienced the next largest increases in MFP, growing 33.7 and 33.0 percent from 1990 to 2016, respectively. The gains suggest an adoption of practices to more efficiently produce transportation services but ones less impactful than those adopted by the air transportation sector. Unlike air and rail transportation MFP, the MFP of water transportation declined from 1997 to 2003—due to a decline in the output of water transportation services—and then began to rise.

MFP in pipeline transportation had a smaller increase of 27.6 percent from 1990 to 2016 and showed more year-to-year variation than other modes. Pipeline MFP had large spikes in 2001, 2008, and 2012. The largest spike in pipeline MFP resulted from the 2001 recession. During the 2001 recession, inputs to the production of pipeline transportation services (e.g., fabricated metal) declined faster than output (e.g., oil carried by pipeline), causing MFP to rise significantly. Likewise, a larger decline in inputs than output caused another spike in 2008 during the Great Recession (December 2007 to June 2009).

Sources of Economic Growth

The BEA/BLS Integrated Production Accounts show the contribution of labor, capital, and MFP to economic growth (box 5-2). Based on the accounts, transportation’s contribution has been smaller than other sectors. Between 2003 and 2007, transportation, with an average annual growth rate of 0.14 percent, contributed significantly less than the manufacturing, services, and finance, which all had average annual growth rates in excess of 0.50 percent (table 5-1). Almost all sectors, including transportation, experienced negative growth during the 2007 to 2009 economic recession. Since 2009 transportation
has contributed positively to economic growth. However, transportation’s average annual contribution to economic growth from 2009 to 2016 (the latest available year) is below its pre-recession level at 0.05 percent.

**Per-Mile Revenue Measures**

Labor productivity and MFP measure productivity from the industry perspective, namely, the ratio of total output to the inputs used in the production process (a measure of the rate of production). What users pay for each unit of the produced services can be thought of as a productivity measure from the user perspective—how much users are willing to pay for the produced services. For for-hire passenger transportation, the *average revenue per passenger-mile* measures what travelers pay per mile of purchased transport services. For for-hire freight transportation, the *average freight revenue per ton-mile* measures what freight shippers pay per ton mile of purchased transport. For modes where users do not typically pay per use, like driving a personal vehicle, data are difficult to obtain. These metrics differ from labor productivity and MFP because they incorporate revenue and thus capture price and quantity. By using revenue that incorporates prices for the service, this metric deals more effectively with outputs that have different levels of quality. For example, if two flights have the same origin and destination in which one flight is direct while the other includes layovers, revenue per mile would capture the difference in flight quality (time) through the difference in prices. However, quality is one of many determinates of price and can be difficult to isolate.

**Revenue per Passenger-Mile**

Figure 5-5 shows nominal changes in revenue per passenger-mile relative to the Consumer Price Index (CPI) for three industries: domestic air carriers, commuter rail, and Amtrak/intercity rail. Amtrak/intercity rail experienced the largest growth in revenue per passenger-mile, increasing 172.1 percent between 1990 and 2016 while commuter rail increased 94.7 percent. Both Amtrak/intercity rail and commuter rail experienced steady growth during that time period. In contrast, domestic air carrier revenue per passenger-mile fell after the September 2001 terrorist attacks, began to rise after reaching a low in 2002, and then fell again during the Great Recession to its 2002 level in 2009. Between 2009 and 2014, domestic air carrier revenue per passenger-mile rose 21.0 percent but then fell 6.6 percent between 2014 and 2017.

The price of goods and services generally increases over time. This is often referred to as inflation. Because revenue is price multiplied by quantity, all else being equal, revenue increases over time due to these rising prices. The CPI measures overall changes in prices paid by households. Comparing revenue per passenger-mile to the CPI shows whether revenue per passenger-mile is rising slower or faster than rising prices. If revenue per mile trends similarly to the CPI, these trends can typically be attributed to inflation. When these trends diverge from the CPI,
it implies that other factors may influence revenue per passenger-mile. The CPI increased by 87.5 percent from 1990 to 2017 while during that time period air revenue per passenger-mile grew more slowly, suggesting air carriers received less revenue per passenger-mile over time after accounting for inflation. In contrast, revenue per passenger-mile of Amtrak/intercity rail grew faster than the CPI, suggesting Amtrak/intercity rail received increasing revenue per passenger-mile over time after accounting for inflation. There are several possible explanations. Purchasers may have been willing to pay higher prices for Amtrak/intercity rail but possibly not for air transportation, which prevented air carriers from raising prices at the same rate that all goods and services increased. This does not indicate a preference for Amtrak/intercity rail; it only indicates a possibly greater tolerance toward price increases. It also may reflect differences in the cost to produce passenger transportation across modes. Rising costs may cause a transportation provider to increase their prices at a faster rate to boost revenue. There are additional possible explanations. More research is needed to explain divergences of revenue per passenger-mile from the CPI.

**Domestic Air Carrier Revenues**

Two developments have affected domestic air carrier revenues from 1990 to the present. First, average inflation-adjusted domestic air fares declined 27.4 percent between 1995 and the first quarter of 2018. As a result, fares have accounted for a lower percentage of operating revenues. In the 1990s domestic air carriers received around 90 percent of their revenues from passenger fares. In the 2000s, however, the percentage declined from 91.0 percent in 2000 to 72.9 percent in 2009, and has remained near the same percentage since then. Second, airlines began charging baggage fees and reservation change fees in 2008. In 2017 passenger airlines collected $3.6 billion from baggage fees and $1.9 billion from reservation change fees; these fees accounted for 2.7 and 1.4 percent of total operating revenue, respectively.

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4 For U.S. domestic average air fares in current and constant dollars, please see [https://www.bts.gov/content/annual-us-domestic-average-itinerary-fare-current-and-constant-dollars](https://www.bts.gov/content/annual-us-domestic-average-itinerary-fare-current-and-constant-dollars).

5 For more information on domestic air carrier revenues, please see the BTS airline financial data press releases at [https://www.bts.dot.gov/statistical-releases](https://www.bts.dot.gov/statistical-releases).
**Freight Revenue per Ton-Mile**

Figure 5-6 shows the average freight revenue per ton-mile for air, truck, rail, and pipeline compared to the Producer Price Index (PPI). The PPI measures overall changes in the selling prices received by transportation service providers for their services.

Nominal freight revenue per ton-mile increased for all freight modes; however, revenue increases exceeded producer price increases only for domestic air. Domestic air carriers experienced the largest increase in revenue per ton-mile. Unlike on the passenger side, domestic air carriers saw a significant increase in revenue from carrying freight but a smaller increase in ton-miles. This caused revenue per ton-mile to increase significantly (126.7 percent) from 1990 to 2017, whereas revenue per passenger mile grew marginally (1.8 percent). The largest gains in air revenue per ton-mile occurred between 2002 and 2014, despite a slight decline during the 2007 to 2009 recession. Air revenue per ton-mile remained virtually unchanged between 2012 and 2014, declined in 2015 and 2016 from its 2014 level, and increased 9.8 percent from 2016 to 2017.

Class I railroads, defined as line-haul freight railroads with annual operating revenues of $457.91 million or more as of 2015, experienced a smaller increase in revenue per ton-mile, at 50.1 percent, than domestic air carriers from 1990 to 2016 (latest year rail revenue per ton-mile data are available) due to an initial decline. Rail revenue per ton-mile declined 15.6 percent from 1990 to 2001 but then grew 77.9 percent from 2001 to 2016, with only a slight decline during the 2007 to 2009 recession and in 2015. Oil pipelines experienced an increase of 43.6 percent from 1990 to 2009, and trucks experienced an increase of 28.4 percent from 1990 to 2007. Data for pipelines after 2009 and for trucks after 2007 are unavailable.


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**Figure 5-6  Average Freight Revenue per Ton-Mile Indexes, 1990–2017 (Index 1990 = 100)**

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<thead>
<tr>
<th>Year</th>
<th>Domestic air carriers</th>
<th>Truck</th>
<th>Class I rail</th>
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**NOTE:** Data for Class I rail available only through 2016. Data for truck available only through 2007. Data for oil pipeline available only through 2009. Shaded areas indicate economic recessions.