PRODUCTIVITY OF PASSENGER RAIL TRANSPORTATION SERVICES IN THE NORTHEAST CORRIDOR

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ABSTRACT

Technological changes, capital investment, organizational reforms, and external factors can impact railway productivity. Using non-parametric single-factor and multifactor productivity (SFP and MFP) Törnqvist trans-log index approaches, we evaluated the performance of high-speed rail (HSR) lines in the U.S. during FY 2002-2012.

Intercity rail transportation in the NEC experienced considerable yet highly volatile productivity growth during FY 2002-2012, in the range of ~1-3% per year. Amtrak increased its ability to economically exploit the available capacity, but did not perform equally well on the supply side. The NEC became cumulatively 20% more productive on the demand side but only 3% on the supply side of productivity with respect to 2005 levels. Service changes, technical problems with trains, targeted capital investments, and economic recession and recovery were the main drivers of productivity change.

The main train services, the Acela Express and Northeast Regional, were very sensitive to external events, had large economies of scale, and implemented slow adjustment of capacity via rolling stock and infrastructure improvements, which varied depending on the service.

In the face of ongoing planning efforts, the NEC could consider the resurgence of demand and recent substantial productivity improvements to launch ambitious plans for HSR. Additional ideas of organization and coordination of rail could reveal hidden opportunities for future HSR development.

1. INTRODUCTION

In this paper we evaluate the performance the Northeast Corridor (NEC) from FY 2002-2012 using productivity analysis. Then we discuss current planning processes for HSR development.

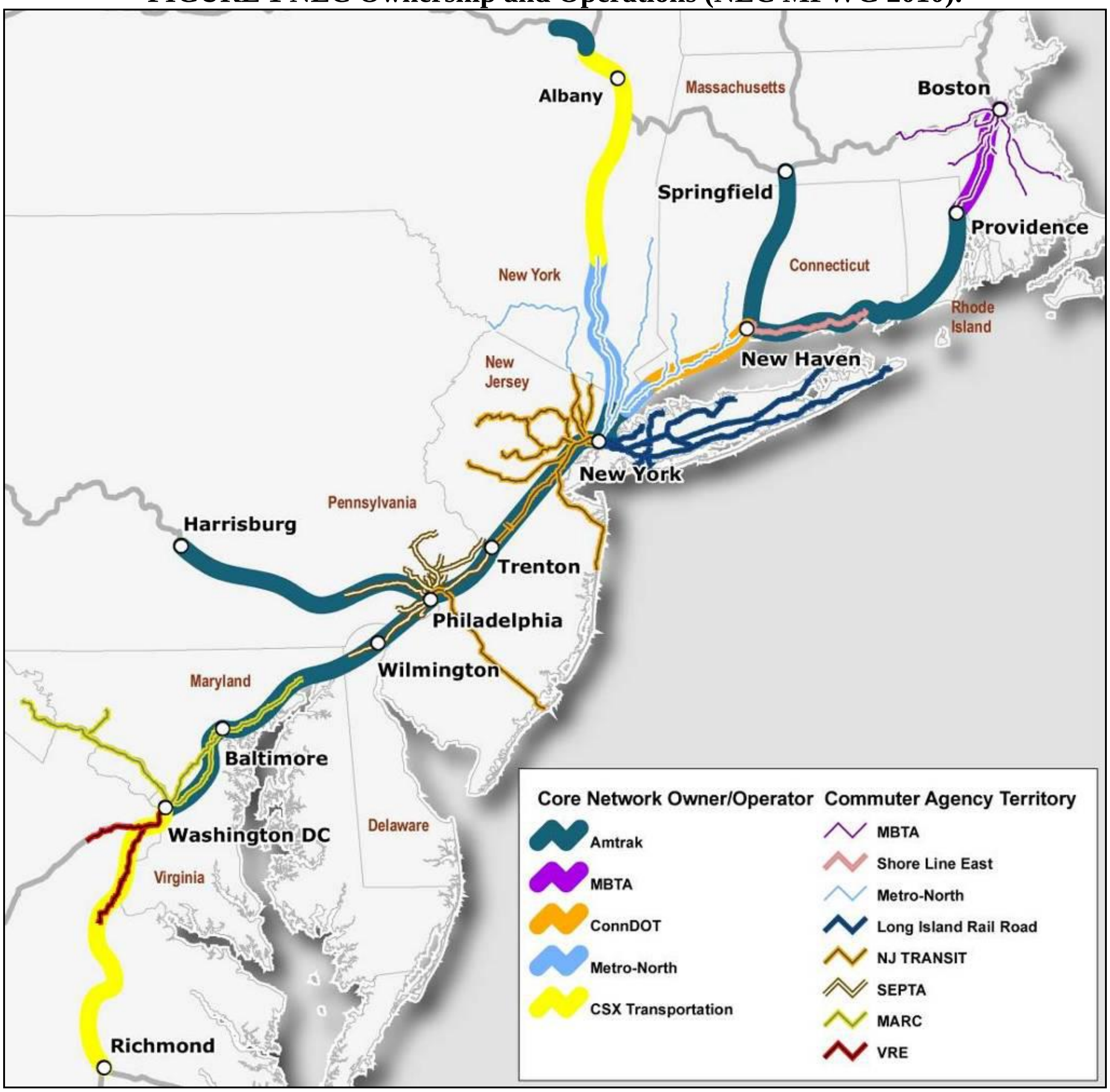
2. OVERVIEW OF AMTRAK AND THE NEC

Amtrak is the National Railroad Passenger Corporation, a publicly owned company operated and managed as a for-profit, private corporation. It began operations on 1971, after consolidation of several private passenger railroads, and nowadays operates a 22,000-mile passenger rail nationwide system.

The Northeast Corridor (NEC) stretches from Washington, D.C., to Boston, MA. With over 55 million people and a $2.6 trillion economy equal to one-fifth of the U.S. GDP, it is the most densely settled region and one of the economic engines of the country. The NEC is a complex multi-state, multi-operator, multi-use, and multi-owner railway corridor. It runs through several major metropolitan areas, 12 states and the District of Columbia. It involves eight commuter operators and one intercity-travel operator (Amtrak). It comprises multi-track alignments on which both freight and passenger trains run every day.

As shown in Figure 1, the 457-mile NEC-spine alignment is shared between Amtrak (363 route miles), the Massachusetts Bay Transportation Authority (MBTA) (38 route miles), and the states of New York and Connecticut (46 route miles). In addition, there are rail branches out of the NEC spine to Springfield, MA, Albany, NY, and Harrisburg, PA.

FIGURE 1 NEC Ownership and Operations (NEC MPWG 2010).



2.1. NEC Intercity Passenger Rail Services

Amtrak offers multiple services along the NEC, two of which are a focus of this paper; they are hereon referred to as NEC-spine trains:

The Acela Express, introduced in December 2000, runs from Boston to Washington via New York, Philadelphia, and Baltimore. It is the fastest rail service in the U.S., technically high-speed rail (HSR)[1], capable of achieving top speeds of 150 mph in short sections of the trip. Its average speed, though, is only on the order of 70-80 mph, which results in a scheduled travel time of approximately six and a half hours from Boston to Washington (~3½ hours from Boston to New York and ~2 hours 45 minutes from New York to Washington). The Acela Express currently offers various amenities such as first class (business class is the lowest option), on-board Wi-Fi access, and food services.

The Northeast Regional runs from Boston/Springfield to Washington and then to other cities in the State of Virginia (Richmond, Lynchburg, Newport News or Norfolk), via New York, Philadelphia, and Baltimore. The service had existed in various forms before Amtrak's inception, and is formally known as the Northeast Regional since 1995. While the top speed is 125 mph, the average speed is 60-65 mph. This results in a scheduled travel time of approximately eight hours from Boston to Washington (~4 hours from Boston to New York and ~3½ hours from New York to Washington). The Northeast Regional offers coach class and business class.

Additional passenger services that operate partly on the NEC spine, but are neither the focus of the paper nor considered as NEC-spine trains, include:

- Carolinian / Piedmont (New York—Washington— Raleigh, NC—Charlotte, NC)
- Keystone **(**New York—Philadelphia— Harrisburg, PA)
- Pennsylvanian (New York—Philadelphia— Harrisburg, PA—Pittsburgh, PA)
- Vermonter (Washington—New York— Springfield, MA—Burlington, VT—St. Albans, VT)
- NEC Special Trains (for exceptional occasions)
- Silver Service / Palmetto (New York— Savannah, GA— Miami, FL via Washington)
- Cardinal (New York— Chicago, IL via Washington): long-distance service
- Crescent (New York—New Orleans, LA via Washington): long-distance service

Other trains originate in cities on the NEC spine but do not run on NEC-spine tracks:

- Adirondack (New York—Albany, NY—Montreal, Canada)
- Downeaster (Boston North Station[2]—Portland, ME—Brunswick, ME)
- Empire (New York—Albany, NY—Toronto, Canada)
- Ethan Allen (New York—Albany, NY—Rutland, VT)
- New Haven, CT—Springfield, MA
- Washington—Lynchburg, VA
- Washington—Newport News, VA
- Capitol Ltd. (Washington—Chicago, IL): long-distance service
- Lake Shore Ltd. (New York/Boston—Albany, NY—Chicago, IL): long-distance

[1] The Acela Express could be classified as HSR-Regional according to the FRA (2009), because it reaches top speeds of 110-150 mph; however, it would not be deemed HSR by European standards (Council of the European Union Directive 96/48) or when comparing with countries with full-fledged HSR lines and similar network structure, like France, Japan, Korea or Taiwan.

[2] Boston's North Station is not part of the NEC spine but South Station is.

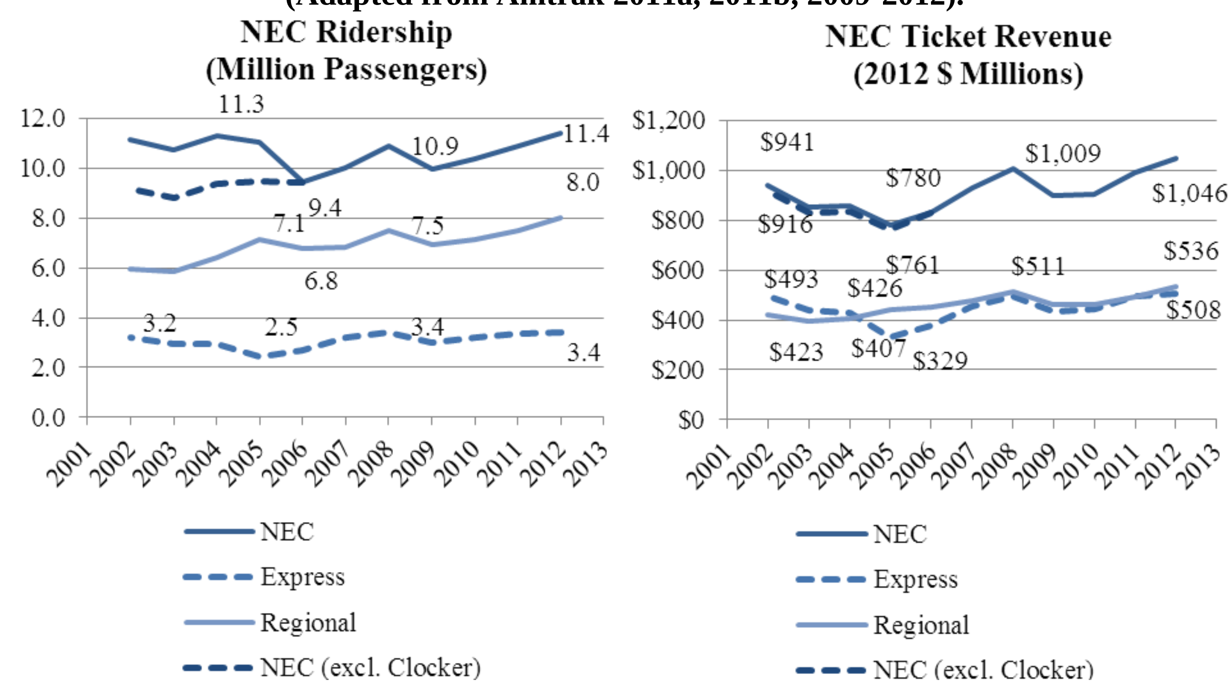
2.2. NEC Performance during FY 2002-2012

The NEC is currently the most heavily utilized railway corridor in the U.S. Every weekday, Amtrak operates 154 intercity trains, commuter agencies run more than 2,000 trains serving upwards of 750,000 commuters, and 70 daily freight trains from seven different companies run along shared tracks. The difference in operating speeds as well as infrastructure constraints (e.g., old bridges, short radii of curvature) – especially on the Boston-New York segment and in the New York metropolitan area – limit the ability of the rolling stock to maintain high speeds and contribute to the reduced available capacity of the corridor.

Four notable episodes marked the last decade in the NEC:

1. Removal of the Clocker Service in 2005, and Federal and Metroliner in 2006. The Clocker ran between Philadelphia and New York, mostly serving commuters and day-travelers until 2005. The Federal replaced a sleeper train on the NEC, and gradually merged operations with regional trains. The Metroliner ran from January 1969 to October 2006, and was discontinued as the Acela was implemented.
2. Technical problems with Acela trains in 2002 and 2005. Cracks in the power unit yaw damper brackets forced a temporary halt of the Acela fleet in 2002. Problems with the braking system in 2005 were severe enough that the entire Acela fleet was shelved from April to July, and did not resume full service until September.
3. Economic recession of 2008-2009.
4. Allocation of federal funding for capital investments on the NEC, starting in 2009.

FIGURE 2 a) NEC Ridership and b) Ticket Revenue[3] during FY 2002-2012[4] (Adapted from Amtrak 2011a, 2011b, 2009-2012).



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[3] Ticket revenue is in 2012 dollars, corrected for inflation with the transportation Consumer Price Index (CPI) series CUUR0000SAT 2002-2007 and CUUR0000SS53022 2007-2012 (USBLS 2013).

[4] The Clocker, a commuter service, distorts ridership figures and is usually excluded from calculation of NEC performance.

As shown in Figure 2, in FY 2012, NEC-spine trains carried 11.4 million passengers and generated $1.05 billion ticket revenue, growing 36% and 45% since FY 2003, respectively. This represented 52% of Amtrak's ticket revenue and 36% of Amtrak's overall riders in FY 2012. Quite different from the financial performance of Amtrak as a whole, the NEC reported a $289 million operational contribution (excluding depreciation, capital charge and interest)[5] in FY 2012. After the economic recession of 2009, ridership on NEC-spine trains grew at 500,000 riders per year. By FY 2011, Amtrak's services captured 77% and 54% of the Washington—New York and New York—Boston competitive air/rail markets (Amtrak 2012).

There were important differences between Express and Regional[6] services on the NEC. On one hand, ridership on Express services was flat at 3-3.4 million annual passengers from FY 2002 to 2012, despite downturns in FY 2005, due to technical problems on Acela trains, and in FY 2009, due to the economic recession. On the other hand, ridership on Regional services went up almost steadily at about 200,000 riders per year to 8 million annual passengers, with a temporary surge in FY 2005 that accommodated some of the spillover demand from Express services, and a dip in FY 2009. Although real ticket revenue has increased by 47% and 36% since FY 2003 on the Express and Regional services, respectively, the former were more sensitive to economic conditions than the latter. IT is notable that despite having only half the ridership of Regional services and a third of the overall NEC ridership, Express services contributed half the ticket revenue and 72% of the operational contribution of the NEC.

Contrary to the impressive market performance, the level of service offered to travelers has only marginally improved. Despite various HSR improvements to the NEC, such as electrification and procurement of HSR trains, substantial travel-time improvements have yet to be achieved and the NEC still lacks a true international-quality HSR service according to international benchmarks. Additionally, an infrastructure maintenance backlog of $8 billion has yet to be addressed.

Average load factor (ALF) of the trains is still low, relative to air, but rapidly improving: 63% on the Acela and 48% on the Northeast Regional in 2012, up from 51% and 42% in 2006, respectively. On the other hand, available seat-miles (ASM) have only grown modestly, from 3.2 to 3.5 billion during 2006-2012. Then, most of the new NEC riders are accommodated on the still available surplus capacity, not on new capacity, and improved traffic growth, while gratifying to Amtrak, burdens an already capacity-constrained corridor.

3. MEASURING PRODUCTIVITY IN PASSENGER RAIL TRANSPORTATION

3.1. Definition

Productivity is, at the most fundamental level, a ratio between outputs and inputs used to evaluate the performance of an entity such as a country, industry, firm, system or process. It is popular among economic researchers because it is an objective performance measure, and because productivity gains can help explain the long-term growth of an entity.

[5] Amtrak's monthly performance reports contained financial performance of routes before capital charges, depreciation and interest, which would lower the above-reported figures once taken into account.

[6] Express services include the Acela Express and the Metroliner. Regional services include the Federal and the Northeast Regional. Several format changes of the reports impede more specific route accountability for the selected time period. As mentioned in section 2.1., the Federal and Metroliner have been out of service since 2006, therefore, from 2006 on, Express refers exclusively to Acela Express, and Regional refers exclusively to Northeast Regional.

Productivity can be increased by producing the *same* outputs with *fewer* inputs, by producing *more* outputs with the *same* inputs, or by combining the two approaches. Of interest are the factors behind such a change in productivity, the *drivers* of productivity, which can be classified in three main categories:

1. Technological change, e.g., improved equipment, improved maintenance techniques
2. Organizational change, e.g., improved management practices, changing legislation
3. Externalities, e.g., industry/market behavior, external events, consumer preferences

So, with objective productivity metrics and identification of the drivers of productivity, decision-makers can understand how their entity behaves and take courses of action to attain more efficient processes and achieve long-term growth. However, productivity does not imply profitability, because financial performance depends on such additional factors as fares, competition, and liabilities. Rather, good productivity implies an improved process, and it is not a sufficient condition for profitability.

3.2. Productivity Metrics

Four classes of productivity metrics are commonly found but sometimes imprecisely used in productivity studies. They are identified by the number of outputs and inputs they relate. This research clarifies and uses them as follows:

1. Single-Factor Productivity (SFP), for a single-output single-input process, is the ratio of the output to the input.
2. Multi-Factor Productivity (MFP), in a single-output *multi-input* process, relates the single output to a function that aggregates the multiple inputs.
3. Total Factor Productivity (TFP), in a multi-output multi-input process, relates a function that aggregates the multiple outputs to another function that aggregates the multiple inputs.
4. Partial Productivity is an arbitrary ratio of an output to an input used in processes with multiple outputs and/or inputs. This measure is not recommended by the author, though commonly used in the literature.

Two common mistakes among researchers are to use MFP and TFP interchangeably and to label Partial Productivity as SFP.

3.3. Available Methods

Productivity metrics (SFP, MFP or TFP) require data processing techniques that depend on the question of interest, the type of data, the data availability, the computational resources, and other context-specific constraints.

A myriad of methods for calculating productivity are available and the main differences involve working with physical or monetary input and output data; using incremental productivity gains or absolute values of productivity; calculating year-to-year and/or cumulative productivity gains; and using parametric (estimation of production or cost functions through regression analyses) or non-parametric methods (no need for statistical estimation) to aggregate multiple outputs or inputs. The interested reader can find a more thorough explanation of the terms in Archila 2013.

3.4. Productivity Studies of Rail Transportation

To the best of the author's knowledge, there have been no previously published productivity studies of Amtrak or the NEC, but studies have been published for freight railroads or for international locations.

In the most relevant study of passenger rail transportation, Caves et al. (1980) determined that TFP of U.S. railroads, for passenger and freight rail, measured with parametric and non-parametric methods, increased 1.5% per year on average in 1951-1974. Then, Caves et al. (1981) concluded that the less regulated Canadian railroads achieved higher TFP gains than the more regulated U.S. railroads, measured with a parametric method, in 1955-1974. Tretheway et al. (1997) used partial productivity measures (labeled as SFP) and parametric and non-parametric TFP to analyze the effect of ownership, deregulation, and technological changes in two Canadian railways, CN and CP, in 1956-1991. Cantos el al. (1999) concluded that reforms that provided greater degrees of autonomy and financial independence contributed greatly to increases in productivity of European railways in 1970-1995, measured via a non-parametric TFP index. Finally, Cowie (2002) found via a non-parametric MFP index that ownership structure and not ownership per se was relevant as a determinant of productivity gains in British Rail.

Hence, these studies generally employ many and differing outputs, inputs, metrics, and methods. Sometimes "partial productivity" measures are used, freight and passenger transportation are combined, or results are inconclusive due to unreliable data. The focus of previous studies is economic and operational – mainly at the industry or carrier level, rarely at the corridor level – and there is little attention to the level of service or the quality of inputs and outputs.

Even though there is no consensus on outputs, inputs, metrics, and methods for passenger rail transportation productivity analysis, some commonly used outputs are revenue, available seat-miles (ASM) – as a proxy for transportation capacity – and revenue passenger-miles (RPM) – as a proxy for transportation volume. Some commonly used inputs are labor, capital – terms used in mainstream economic literature – and energy – which is specific to transportation.

4. PRODUCTIVITY ANALYSIS DURING FY 2002-2012

4.1. Data

Output and input data were directly retrieved or indirectly derived from Amtrak's year-end monthly performance reports from FY 2003 to 2012[7]. Section C, *Route Performance*, of Amtrak's reports included operational data at the individual route level. Section A, *Financial Results*, of Amtrak reports included data on ridership and revenue.

Amtrak changed the format of the monthly performance reports four times during the period of study: in FY 2005, 2006, 2009, and 2010. These format changes comprised different, sometimes incompatible cost breakdowns, allocation methods, or route definitions. Fortunately, each report included consistently-reported data from the current and previous fiscal year. This enabled valid year-to-year comparisons and calculations, which are the core of the method of analysis (see Section 4.2). In years with a format change, this also allowed to check that data categories under different formats were comparable. In the face of conflicted data for a given fiscal year, after consideration of format changes, priority was given to audited over preliminary reports and to newer over older reports.

[7] Unfortunately, reports prior to FY 2003 were not available to researchers, which could have used to estimate productivity metrics in years before the introduction of the Acela Express.

Amtrak's accounting systems have been imprecise because they rely heavily on cost allocation (i.e., the use of statistical estimation or other allocation methods) rather than cost assignment (i.e., the actual tracking of costs to a particular route or service), and have had trouble consolidating data from different sources. Congress mandated Amtrak to implement the FRA methodology for cost allocation in 2005 and design a modern accounting and reporting system in 2010, which has shown some improvement over previous systems. However, Amtrak is still unable to report costs more precisely because it "does not collect sufficiently detailed cost data" and assigns only about 20% of them (FRA, 2013).

After accounting for the several format changes in Amtrak's reporting categories, the available outputs were ridership, (ticket) revenue, RPM, and ASM, and the available input was operating costs. Monetary quantities were inflated by the corresponding CPI to 2012 dollars. Auxiliary metrics such as RPM and ASM were derived from reported data, where possible.

Since some routes entered or exited service, and data were sometimes reported for combined routes, the analyzed sets of routes were NEC level, Express (Acela + Metroliner), and Regional (Northeast Regional + Federal).

4.2. Method of Analysis

Given that there is only a single input but four outputs with different meanings, four distinct SFP metrics were used to strengthen the analysis. On the supply side, ASM SFP with respect to operating costs is a proxy for the effectiveness at generating transportation capacity; on the demand side, ridership, revenue, and RPM SFP with respect to operating costs are measures of the effectiveness at exploiting the available capacity. Revenue SFP with respect to operating costs, in particular, reflects how effective Amtrak was at economically exploiting the available capacity[8].

Each year-to-year SFP metric was calculated via a non-parametric Törnqvist trans-log index as follows, and then compounded to obtain the cumulative SFP, with 2005 as the base year for all calculations:

$$\ln\left(\frac{SFP_1}{SFP_0}\right) = \ln\left(\frac{y_1}{y_0}\right) - \ln\left(\frac{x_1}{x_0}\right)$$

Where y=output x=input, 1= current year, and 0=previous year

Finally, a sensitivity analysis with respect to the route definitions and the inflation parameters showed that results were robust to changes in key assumptions (see Archila 2013).

4.2. SFP Analysis of the NEC during FY 2002-2012

As shown in Table 1 and Figure 3, the NEC experienced considerable yet highly volatile SFP growth during FY 2002-2012 (in the range of ~1-3% per year), which was boosted by the notable SFP improvements of the past three years.

Since 2005, the yearly average growth in ridership, revenue, RPM, and ASM SFP at the NEC level was 0.9%, 2.8%, 2.5%, and 0.4% respectively. However, in recent times, yearly increments have reached as high as 20% for some SFP metrics, while unfavorable shocks in FY 2006 and 2009 resulted in yearly dips as low as -19%. Such dips interrupted what might otherwise have been an ever-increasing trend in SFP.

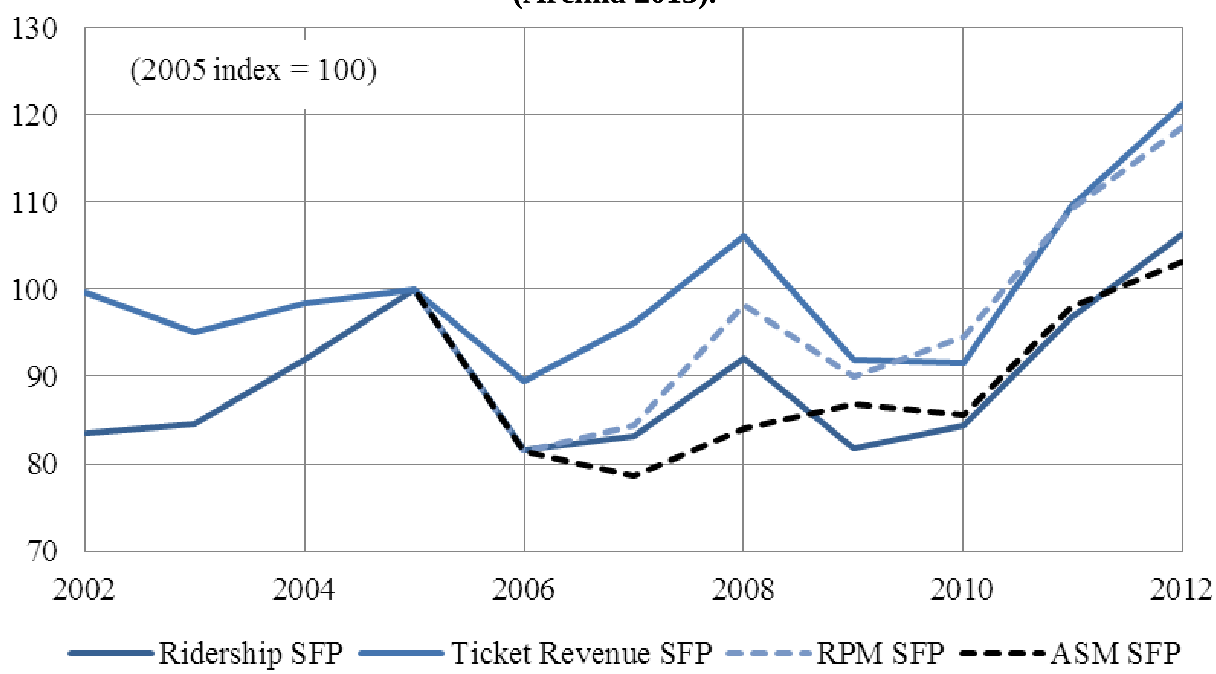
[8] For simplicity, the words "operating costs" are removed from the productivity label, as it is the sole input of each SFP metric.

After some oscillations, the NEC SFP net growth from FY 2005-2010 was negative, which contrasted with previous, though modest, improvements in ridership and revenue SFP. However, by 2012, the NEC became cumulatively 20% more productive on the demand side (as measured by revenue SFP and RPM SFP) though just 3% more productive on the supply side (ASM SFP) with respect to the 2005 levels.

TABLE 1 NEC, Express, and Regional Year-To-Year SFP Growth, FY 2002-2012 (Archila 2013)

	NEC SFP				Express SFP				Regional SFP			
FY	Ridership	Revenue	RPM	ASM	Ridership	Revenue	RPM	ASM	Ridership	Revenue	RPM	ASM
2011-2012	10%	11%	8%	5%	9%	11%	8%	9%	9%	11%	8%	2%
2010-2011	15%	20%	16%	15%	13%	20%	14%	9%	17%	19%	17%	18%
2009-2010	3%	0%	5%	-2%	12%	7%	13%	3%	-2%	-5%	0%	-5%
2008-2009	-11%	-13%	-8%	3%	-12%	-13%	-10%	1%	-11%	-14%	-8%	4%
2007-2008	11%	10%	17%	7%	3%	7%	6%	1%	16%	13%	24%	11%
2006-2007	2%	7%	4%	-3%	5%	6%	7%	-7%	2%	6%	2%	-1%
2005-2006	-18%	-10%	-19%	-19%	-17%	-13%	-15%	-20%	-18%	-10%	-20%	-17%
2004-2005	9%	2%	---	---	5%	-2%	---	---	12%	9%	---	---
2003-2004	9%	3%	---	---	6%	2%	---	---	10%	4%	---	---
2002-2003	1%	-4%	---	---	0%	-3%	---	---	1%	-4%	---	---
Yearly Average Growth												
2005-2012	0.9%	2.8%	2.5%	0.4%	1.3%	2.9%	2.8%	-1.1%	1.0%	2.1%	2.4%	1.3%
2002-2012	2.4%	2.0%	---	---	2.0%	1.7%	---	---	3.0%	2.4%	---	---

FIGURE 3 NEC Cumulative SFP Growth FY 2002-2012 (Archila 2013).



The major episodes listed earlier provided some causes for this varying productivity (service changes, technical problems with trains, targeted capital investments, and economic recession and recovery). Notably, the economic downturn of 2008-2009 made less of an impact on the NEC productivity than the problems associated with the stoppage of the Acela Express in some months of 2005. While the economic recession was mostly troublesome on the demand side, the train stoppage affected the supply side, hence increasing costs and underserving demand. As evidence, the NEC ASM SFP dropped -19% in FY 2005-2006, but increased 3% during the economic recession, whereas the RPM SFP decreased -19% and -8% in the two situations. Counterintuitively, the reestablishment of the Acela Express in FY 2006 largely reduced all SFP metrics, because Acela rolling stock greatly increased the operating costs of transportation services.

4.2.1. SFP Metrics Comparisons

In FY 2002-2012, Amtrak increased its ability to economically exploit the available capacity (by filling up trains with more passengers over longer distances), but did not perform equally well on the supply side (running trains more effectively). As evidence, cumulative RPM SFP diverged from and grew more than cumulative ASM SFP since FY 2006. Also, cumulative RPM SFP exceeded ridership SFP, suggesting that people were traveling longer distances on the existing NEC services.

Notably, since 2009, the resurgence of transportation demand combined with low marginal costs per RPM yielded economies of scale that boosted productivity on the demand side. Most of the new ridership was accommodated on existing capacity, at low marginal costs.

These economies of scale had little effect on the supply side, though. ASM productivity improved only after appropriations of government funding to address critical infrastructure bottlenecks on the NEC. This allowed the NEC to become just as ASM productive in FY 2012 as it was in FY 2005. The difference now is that the increased costs of running HSR rolling stock are balanced by a more efficient use of infrastructure. A complementary explanation for the recently-enhanced ASM productivity could be management improvements achieved through Amtrak's recent business reorganization, increased focus on the NEC, and other management changes.

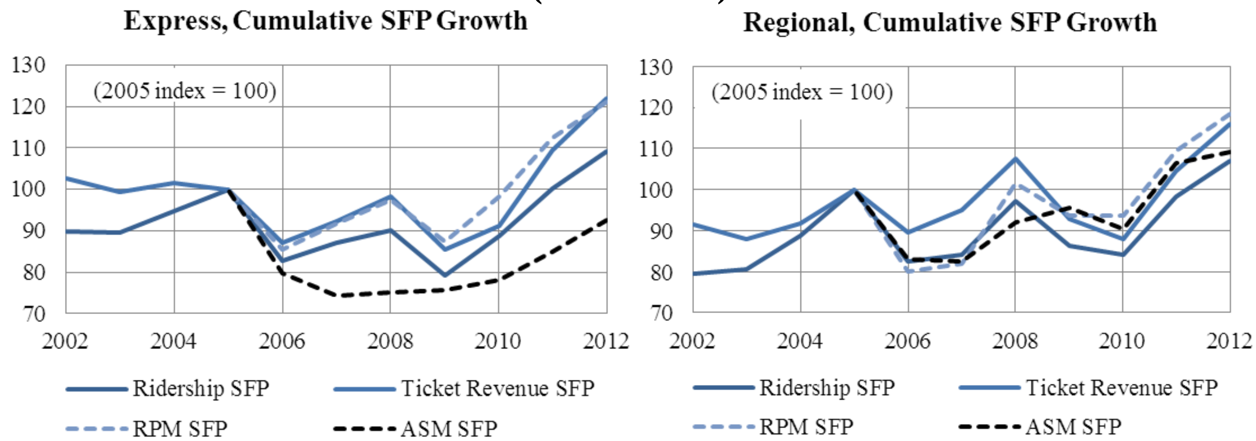
Finally, the usage of the capacity was more volatile with respect to external factors than the generation of capacity. For instance, the economic dip of 2009 greatly affected the demand side of the NEC (RPM, ridership and revenue SFP) but had little influence on the productivity of the supply side (ASM SFP). Ridership, revenue, and RPM SFP also increased at higher rates than ASM SFP in favorable years. Thus, demand-side productivity was more volatile with respect to external factors than supply-side productivity, which depended more on managerial and operational practices and events.

4.2.2. Route Comparisons

The Acela Express and Northeast Regional were both very sensitive to external events, had large economies of scale, and implemented slow adjustment of capacity via rolling stock and infrastructure improvements, but their performance was not uniform.

There are two important distinctions in the evolution of SFP for Express and Regional services. First, after FY 2006, the ASM productivity of express services kept going down while the ASM productivity of regional services recovered more rapidly. The introduction of more Acela services (newer rolling stock) and the removal of older trains (Metroliner) increased operating cost per train-mile. Such costs remained high for the express routes, i.e., low ASM productivity, until the recent capital investments in the NEC. Second, the productivity of express services was more volatile than that of regional services, displaying a greater range of performance. Therefore, Express services were more sensitive than Regional services to changing conditions.

FIGURE 4 a) Express and b) Regional Cumulative SFP Growth FY 2002-2012 (Archila 2013).



5. FUTURE OF HSR IN THE NEC

Plans for international-quality HSR in the NEC are afoot.

The FRA launched the most relevant initiative for rail development in the NEC: the NEC FUTURE – Passenger Rail Corridor Investment Plan. The overarching goal of this planning effort is to develop a rail network as part of an integrated, multi-modal transportation solution in the NEC through 2040. The NEC FUTURE will determine, assess and prioritize future investments on the NEC, and the ongoing planning process is expected to be completed by 2015.

The NEC FUTURE Preliminary Alternatives Report presented fifteen possible alternatives in April 2012. The alternatives focus on different levels of investment, alignments, and services, but exclude major institutional changes. While some alternatives do consider top speeds of 220 mph, others limit top speeds to 160 mph, and the do-nothing alternative is also being considered. At this early stage of planning, however, the alternatives do not provide sufficiently detailed information that would have enabled an analysis of projected productivity or ridership estimates.

In addition, Amtrak has developed plans to introduce international-quality HSR in the NEC. The productivity of a projected HSR implementation in the NEC from 2015-2040, the Amtrak Vision for the NEC, was calculated in Archila (2013). This prediction of productivity is made from publicly available data from Amtrak. Space constraints preclude inclusion of this analysis, but the interested reader is directed to Archila (2013).

The current planning processes offer the opportunity to seriously consider additional ideas for the future HSR development in the NEC. First, air/rail interactions are unclear in all prospects. Even though Amtrak does open the possibility for air/HSR intermodal connections in its vision, it does not provide details on how these could be developed. Also, the NEC FUTURE, led by the FRA, could involve the FAA in the planning process and consider air/rail cooperation explicitly.

In addition, a benchmark of international experiences of introduction of new HSR in four international corridors similar to the NEC may suggest what could actually happen in the first years of operation of an international-quality HSR system in the NEC (Table 2)[9]. In all four cases, the entrance of HSR significantly affected air traffic and other transportation modes. In three out of four cases, HSR presented considerable ridership increments above the forecasts made before the services were in place. In fact, HSR services usually enjoy spectacular growth in the initial years, which later declines as the market matures (Campos and de Rus 2009). For example, RPM increased sevenfold in the first decade of HSR operations in Japan (Sakamoto 2012), and ridership doubled in a decade in France (Vickerman 1997). However, in the case of Taiwan, HSR ridership was less than half of the forecast, attributed to poor intermodal connections, international economic conditions, and marketing (Cheng 2010). Currently, Amtrak forecasts 30% more ridership on the NEC after implementation of a HSR segment between New York and Washington in 2030 (with respect to 2025), and 66% more ridership once the full Washington-Boston alignment is operating in 2040 (with respect to 2030). Remarkably, ridership on NEC-Spine trains grew 36% from FY 2003-2012 with just a few capacity upgrades

Table 2 International Comparisons of HSR Lines (Adapted from Sakamoto 2012, Thompson and Tanaka 2011 Cheng 2010, and Vickerman 1997)

HSR Line	Construction (yrs.)	Start Ops.	Length (mi)	Actual Impacts on Traffic	Actual v. Forecast
Japan (Tokyo-Osaka)	5	1964	320	Traffic was diverted 23% from air, 16% from cars and buses and 6% induced demand (Cheng 2010)	Demand was higher than forecasted. In the first decade, RPM increased sevenfold, but then flattened (Sakamoto 2012).
France (Lyon-Paris)	7	1981	260	Most of the diverted passengers shifted from air. 49% induced demand (Cheng 2010, Vickerman 1997).	Demand was higher than forecasted. Total rail passengers in the corridor doubled in a decade (Vickerman 1997).
South Korea (Seoul-Pusan)	12	2004	206	Air traffic dropped 20%-30%. Traffic on short distances (<100 km) increased ~20% (Cheng 2010).	Demand was higher than forecasted (Thompson and Tanaka 2011).
Taiwan (Taipei-Kaohsiung)	9	2007	215	Air transportation almost exited the market. Passengers were diverted from conventional rail and buses. 8% induced demand, but still low ridership (Cheng 2010).	Demand was 50% of forecast (Cheng 2010).
US (WAS-NYC) (Projected)	15	2030	225	N/A	Additional 6 million annual riders (+30%).

The international comparisons illustrate three points. First, Amtrak's projections are realistic, in the sense that they are within the range of what the international benchmark of actual performance suggests (and within what Amtrak has achieved in the past decade). Second, Amtrak's projections may be a bit low. The actual HSR ridership was higher than forecasted in

[9] These international corridors, which have now been expanded, are compared with Amtrak's projected introduction of the HSR in the Washington-New York segment by 2030 –which is the first segment planned to operate from 2030-2040, until the New York-Boston HSR alignment is finally completed in 2040.

three out of four international cases and, in the case where it did poorly, it was largely due to poor planning and management. The ridership in the NEC might be higher than projections. Third, HSR construction times were faster than those proposed in the NEC VISION. This could possibly motivate Amtrak to revise current estimates of ridership and revenue, perhaps even to accelerate or modify the strategy, and to consider a careful implementation of HSR infrastructure and service in order to secure ridership, based upon international experiences.

6. CONCLUSIONS

The last decade in the NEC was marked by route changes, recurrent technical problems with Acela train sets, economic recession, regional congestion, increased transportation demand, and federal funding for capital investments. In this period, Amtrak's NEC services gained significant air/rail market share and operational surplus, but maintenance backlogs and infrastructure constraints are still to be addressed.

In terms of productivity, the NEC experienced highly volatile but considerable SFP growth in FY 2002-2012 (in the range of ~1-3% per year), which was boosted by the notable improvements of the past three years. Acela Express and Regional services were very sensitive to external events, had large economies of scale, and implemented slow adjustment of capacity, but its performance was not uniform. Express services were more sensitive than Regional services. In parallel, Amtrak increased the ability to fill up and economically exploit the available capacity, but did not perform equally well on the supply side.

In the face of ongoing planning efforts, the NEC could consider the resurgence of demand and recent substantial productivity improvements to launch ambitious plans for HSR. Additional ideas of organization and coordination of rail could reveal hidden opportunities for future HSR development.

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