AMTRAK’S PRODUCTIVITY IN THE NORTHEAST CORRIDOR
Author: Andrés Felipe Archila. Advised by Professor Joseph Sussman
Executive Summary

This report summarizes the findings of a recent MIT Master’s thesis focused on the productivity of intercity passenger rail in the Northeast Corridor (NEC) (Archila 2013). The NEC is a 450-mile railway line that connects Boston, New York, Philadelphia, and Washington, D.C., which is the most densely populated corridor and one of the economic engines of the country.

Productivity analysis is used to evaluate the performance of the NEC and its main services during FY 2002-2012, and to make inferences about high-speed rail (HSR) in the NEC for the next 30 years. A non-parametric single factor productivity (SFP) Törnqvist trans-log index approach with several metrics is used. Ridership, revenue, revenue passenger-miles (RPM), and available seat-miles (ASM) are set as outputs, and operating costs as inputs.

We find that the NEC experienced considerable yet highly volatile productivity growth during FY 2002-2012 (in the range of ~1-3% per year). Amtrak, the National Railroad Passenger Corporation, increased its ability to fill up trains and economically exploit the available capacity, but did not perform equally well on the supply side. Service changes, technical problems with train sets, targeted capital investments, and economic recession and recovery were the main drivers of productivity change. Amtrak’s two primary 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.

We also studied future productivity based on Amtrak projections for the post-2012 period. The geographic and socioeconomic characteristics of the NEC reveal a potential for a successful introduction of HSR. But while Amtrak’s vision for HSR in the NEC is realistic in terms of productivity, it is risky and possibly inadequately ambitious in terms of speed of implementation. We recommend revising the current projections to make them more aggressive, incorporating additional planning approaches, accelerating key stages of the vision, and including the FAA in the planning process.
1. Amtrak and the NEC Overview

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, and today operates a 22,000-mile passenger rail nationwide system.

The Northeast Corridor (NEC) stretches from Washington, D.C., to Boston, MA. With more than 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. The 457-mile NEC-spine alignment is shared between Amtrak (363 route miles), the MBTA (38 miles), and the states of New York and Connecticut (46 miles). Figure 1 shows the NEC infrastructure ownership and operations.

Figure 1 NEC Ownership and Operations (NEC MPWG 2010)
1.1. NEC Intercity Passenger Rail Services
Amtrak offers multiple services along the NEC, two of which are a focus of this report; they are hereafter 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 HSR, 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. 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, introduced in 1995, 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. 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. The Northeast Regional offers coach class and business class. Table 1 shows certain trip characteristics of the Acela and Northeast Regional services.

Additional passenger services on the NEC include the Keystone, from New York to Philadelphia and Harrisburg; the *Pennsylvanian*, on the route New York—Harrisburg—Pittsburgh; *NEC Special Trains*, for exceptional occasions; and the *Empire* service, on the route New York—Albany—Toronto. These operate partly on the NEC spine.

<table>
<thead>
<tr>
<th>Service</th>
<th>Route</th>
<th>Distance (miles)</th>
<th>Weekday Round Trips</th>
<th>Scheduled Travel Time (hr:min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acela Express</td>
<td>Boston – New York</td>
<td>232</td>
<td>10</td>
<td>From 3:25 to 3:35</td>
</tr>
<tr>
<td></td>
<td>Boston – Washington</td>
<td>457</td>
<td>10</td>
<td>6:30 to 6:40</td>
</tr>
<tr>
<td>Northeast Regional</td>
<td>Boston – New York</td>
<td>232</td>
<td>9</td>
<td>4:00 to 4:20</td>
</tr>
<tr>
<td></td>
<td>Boston – Washington</td>
<td>457</td>
<td>9</td>
<td>7:40 to 8:05</td>
</tr>
</tbody>
</table>
1.2. Amtrak Performance in 2000-2012

Amtrak has had substantial but not uniform ridership and revenue growth since 2000, despite a setback of two to three years due to the economic recession of 2008-09. Nevertheless, it has remained unprofitable.

After remaining stagnant at 21 million annual passengers for nearly two decades, Amtrak’s system-wide ridership has grown 55% since 2000, to an all-time high of 31 million riders in FY 2012. Meanwhile, system-wide real ticket revenue has increased 38% up to $2 billion\(^1\) (see Figure 2).

This growth, however, has not been homogenous. The greatest ridership growth occurred in Short-Distance (SD) trains, from 8.6 to 15.1 million annual riders (+76%), followed by the NEC, from 8.4 to 11.4 million riders (+36%), while Long-Distance (LD) ridership increased from 4 to 4.7 million (+18%). The NEC and SD trains augmented their share of Amtrak’s ticket revenue, while LD trains diminished their relative importance.

Although Amtrak demonstrated persistent unprofitability from 2000-2012, its percentage losses nevertheless decreased during these years. Net losses were $1.27 billion from $2.88 billion total revenue in FY 2012, 44%, down from 52% in 2002.

Operational losses, however, fluctuated and were not ubiquitous. In FY 2012, NEC-spine trains and a few SD routes made operational contributions of $289 million and $10 million, respectively, which contrasted with the $760 million combined loss of the remaining routes (excluding depreciation, capital charge and interest)\(^2\). Contrasts are accentuated because most infrastructure costs were included in the performance of the LD and SD trains—as Amtrak paid usage fees to infrastructure owners, namely, the freight railroads—but not in the almost entirely Amtrak-owned NEC—where Amtrak did not pay internal usage fees (i.e., vertical integration).

All in all, in spite of substantial subsidies\(^3\) to long routes, short routes became more utilized and profitable. Ultimately, while the NEC grew between 2000 and 2012, contributing to half of Amtrak’s revenue and a third of its ridership, Amtrak remained unprofitable system-wide.

---

2. Financial performance of routes is reported before capital charges, depreciation and interest, which would lower the above-reported figures once taken into account.
3. Subsidies to Amtrak have been a matter of harsh criticism and public debate for decades. Amtrak counters that other modes have been more heavily subsidized: while Amtrak received $36 billion from federal funding in 40 years, aviation received $421 billion and highways at least $1 trillion (Amtrak 2011c).
1.3. NEC Performance during FY 2002-2012

The NEC intercity transportation system has been plagued for decades with congestion, especially at airports and highways, and it 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:

2. Recurrent technical problems with the braking system of the Acela trains in 2002 and 2005. The problems were severe enough that from April to July 2005, the entire Acela fleet was shelved, and did not resume full service until September 2005.
3. Economic recession of 2008-09
4. Allocation of federal funding for capital investments on the NEC, starting in 2009
From 2002-2012, the NEC improved its market share relative to air, in spite of the economic recession of 2009. However, an infrastructure maintenance backlog of $8 billion has yet to be addressed, and improved traffic growth, while gratifying to Amtrak, burdens an already capacity-constrained corridor.

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. The NEC reported a $289 million operational contribution (excluding depreciation, capital charge and interest) in FY 2012. Most recently, ridership on NEC-spine trains grew at 500,000 riders per year. By FY 2011, train services captured 77% and 54% of the Washington—New York and New York–Boston air/rail markets, respectively (Amtrak 2012).

**Figure 3 a) NEC Ridership and b) Ticket Revenue FY 2002-2013**

There were important differences between Express and Regional services on the NEC. Ridership on Express services was flat at 3-3.4 million annual passengers from FY 2002 to 2012,

---

4 See footnote 2.
5 The Clocker Service ran between Philadelphia and New York, mostly serving commuters and day travelers until 2005. It is usually excluded from calculations of the NEC performance.
6 Express services include the Acela Express and the Metroliner. Regional services include the Federal and the Northeast Regional. The Federal and the Metroliner have been out of service since 2006.
despite downturns in FY 2005 that resulted from persistent 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 (which 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. Finally, despite having only half the ridership of Regional services, Express services contributed half the ticket revenue of the NEC and 72% of the operational contribution.

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 by many definitions. There is a still low (but improving) average load factor (ALF) of the trains relative to air: 63% on the Acela and 48% on the Northeast Regional. With capacity constraints on the corridor, partly evidenced by the modest growth of ASM, most of the new riders are accommodated on the available surplus capacity, not on new capacity.

1.4. Amtrak and the NEC in the New Millennium – Conclusion

Route changes, recurrent technical problems with Acela trains, economic recession, regional congestion, increased transportation demand, and federal funding for capital investments marked the period from 2000 to 2012 for Amtrak and the NEC. At a system level, Amtrak exhibited substantial though not uniformly distributed ridership and revenue growth beginning in 2000, but remained unprofitable. In contrast, the capacity-constrained NEC gained significant air/rail market share and operational surplus, with a particularly profitable Acela Express, but maintenance backlogs and infrastructure constraints have yet to be addressed. System-wide unprofitability, capacity constraints in the NEC, and public support for further funding remain as three of the most pressing challenges that Amtrak faces.
2. Rail Passenger Transportation Productivity Review

2.1. Definition

Productivity is, at the most fundamental level, a relationship (or 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.

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.

2.2. 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.

2.3. Methods
Productivity metrics (SFP, MFP or TFP) require data processing techniques, namely, methods 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 or non-parametric methods to aggregate multiple outputs or inputs. The interested reader can find a more thorough explanation of the terms in Archila 2013.

2.4. 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 of for international locations. These studies generally employ many and differing outputs, inputs, metrics, and methods used in those studies. 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 usage. Some commonly used inputs are labor, capital – terms used in mainstream economic literature – and energy – which is specific to transportation.

The interested reader can find a more thorough review of past studies in Archila 2013.
2.5. Passenger Rail Transportation Productivity – Findings and Conclusion

Productivity analyses can assess performance and determine the drivers of performance in intercity passenger rail transportation, but there are some drawbacks. The literature is sparse. The few existing studies on U.S. railroads do not examine U.S. rail passenger transportation in isolation. Most of the results are not comparable due to distinct methods, outputs, and/or inputs, even if the scope is similar. The available guidelines are confusing, contradictory, and rarely specific to transportation studies. Thus, the new guidelines for productivity analyses in intercity passenger rail transportation developed as part of this research explicitly address method and results, as well as selection of data, metrics, and methods for future studies (see Archila 2013). We hope this approach will be useful to future researchers.

3. NEC Productivity FY 2002-2012

3.1. Methodology

Output and input data were directly retrieved or indirectly derived from Amtrak’s year-end monthly performance reports from 2003 to 2012. Due to several format changes in Amtrak’s reporting categories, the available outputs were ridership, (ticket) revenue, RPM, and ASM, and the available inputs were operating costs. Monetary quantities were inflated by the corresponding CPI to 2012 dollars. Since some routes entered or exited service, and data were sometimes reported for combined routes, the analyzed routes were NEC level, Express (Acela + Metroliner), and Regional (Northeast Regional + Federal).

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.

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

---

7 For simplicity, the words “operating costs” are removed from the productivity label, as it is the sole input of each SFP metric.
calculations. 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).

3.2. SFP Analysis

As shown in Table 2, 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 interrupt what might otherwise have been an ever-increasing trend in SFP.

Table 2 NEC, Express, and Regional Year-To-Year SFP Growth, FY 2002-2012

<table>
<thead>
<tr>
<th>FY</th>
<th>NEC SFP</th>
<th>Express SFP</th>
<th>Regional SFP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ridership</td>
<td>Revenue</td>
<td>RPM</td>
<td>ASM</td>
</tr>
<tr>
<td>2011-2012</td>
<td>10%</td>
<td>11%</td>
<td>8%</td>
</tr>
<tr>
<td>2010-2011</td>
<td>15%</td>
<td>20%</td>
<td>16%</td>
</tr>
<tr>
<td>2009-2010</td>
<td>3%</td>
<td>0%</td>
<td>5%</td>
</tr>
<tr>
<td>2008-2009</td>
<td>-11%</td>
<td>-13%</td>
<td>-8%</td>
</tr>
<tr>
<td>2007-2008</td>
<td>-11%</td>
<td>10%</td>
<td>17%</td>
</tr>
<tr>
<td>2006-2007</td>
<td>2%</td>
<td>7%</td>
<td>4%</td>
</tr>
<tr>
<td>2005-2006</td>
<td>-18%</td>
<td>-10%</td>
<td>-19%</td>
</tr>
<tr>
<td>2004-2005</td>
<td>9%</td>
<td>2%</td>
<td>---</td>
</tr>
<tr>
<td>2003-2004</td>
<td>9%</td>
<td>3%</td>
<td>---</td>
</tr>
<tr>
<td>2002-2003</td>
<td>1%</td>
<td>-4%</td>
<td>---</td>
</tr>
</tbody>
</table>

Yearly Average Growth

<table>
<thead>
<tr>
<th>FY</th>
<th>NEC SFP</th>
<th>Express SFP</th>
<th>Regional SFP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ridership</td>
<td>Revenue</td>
<td>RPM</td>
<td>ASM</td>
</tr>
<tr>
<td>2005-2012</td>
<td>0.9%</td>
<td>2.8%</td>
<td>2.5%</td>
</tr>
<tr>
<td>2002-2012</td>
<td>2.4%</td>
<td>2.0%</td>
<td>---</td>
</tr>
</tbody>
</table>

Figure 4 NEC Cumulative SFP Growth FY 2002-2012

(2005 index = 100)
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). Remarkably, the economic downturn of 2008-09 made less of an impact on the NEC productivity than the problems associated with the stoppage of the Acela services 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, given that Acela rolling stock greatly increased the operating costs of transportation services.

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.

3.2.1. SFP Metrics Comparisons
In this period, Amtrak increased its ability to exploit 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.

Increased transportation demand combined with a low marginal cost per RPM yielded economies of scale that boosted productivity on the demand side in recent years. Most of the new ridership was accommodated on existing, idle capacity, at low extra costs.

These economies of scale had little effect on the supply side, though. ASM productivity improved only after 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.

Also, cumulative RPM SFP exceeded ridership SFP, suggesting that people were traveling longer distances on the existing NEC services.
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.

### 3.2.2. 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, which differed depending on the service.

There are two important differences in the evolution of SFP for Express and Regional services. First, after FY 2006, the ASM productivity of express services kept declining while the regional ASM productivity 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 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.

#### Figure 5 a) Express and b) Regional Cumulative SFP Growth FY 2002-2012

![Graph showing cumulative SFP growth for Express and Regional services from FY 2002 to FY 2012.](image)

#### 3.3. Synthesis of Findings on Historical HSR Productivity in the NEC

From FY 2002-2012, the NEC experienced highly volatile but considerable SFP growth (in the range of ~1-3% per year), which was boosted by the notable SFP improvements of the past three years. Amtrak increased its ability to fill up and economically exploit the available capacity, but did not perform equally well on the supply side. Service changes, technical problems with trains,
targeted capital investments, and economic recession and recovery were the main drivers of productivity change. Nowadays, users travel longer distances by rail on the NEC and trains are becoming more competitive in short-haul air markets (i.e., Boston – New York, Washington – New York).

Express and Regional services were very sensitive to external events, had large economies of scale, and implemented slow adjustment of capacity, but their performance was not uniform. Express services were more sensitive than Regional services to changing conditions.

As far as productivity concerns go, the ability to implement and operate HSR in the NEC was tied to the state of the regional economy. Also, 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. NEC Future Productivity FY 2012-2040

Three cases for the future productivity of the NEC were developed:

1. EXTRAPOLATION: A 20-year projection of the trends for the four distinct SFP metrics analyzed earlier. This is a hypothetical example created by the author. Neither Amtrak nor the Federal Railroad Administration (FRA) claim to sustain such productivity growth rates. In addition, this case does not specify the interventions on the NEC that would allow it to sustain such productivity growth rates, but speculates on possible factors that might do so.

2. NEC MASTER PLAN (NECMP) 2010-2030: The NECMP was an Amtrak-led multi-stakeholder initiative, a $52-billion expenditure plan from 2010 to 2030, to bring existing infrastructure to a state of good repair, increase capacity to accommodate expected growth of commuters, intercity travelers, and freight trains, and modestly improve trip time between cities along the corridor (see NEC MPWG 2010). However, the NECMP did not consider an international-quality HSR deployment such as that developed in Japan or Europe. In the NECMP, the duration of the Boston-New York trip would have been reduced by 23 minutes, from 3:31 to 3:08, and the New York-Washington route by 30 minutes, from 2:45 to 2:15. Our analysis of the NECMP is restricted to a qualitative assessment of productivity, due to lack of operating cost, ridership, and revenue data that would have permitted the calculation of productivity metrics.
3. NEC VISION 2012-2040: The NEC VISION is *Amtrak’s Vision for HSR in the NEC*, a $150-billion stair-step phasing investment strategy with two sequenced programs: the NEC Upgrade Program (NEC-UP) and the NEC Next Generation HSR (NextGen HSR) (see Amtrak 2012). Our analysis of the NEC VISION is quantitative.

It is worth noting that the NEC VISION is not only more ambitious than the NECMP in terms of the time frame (extending beyond 2030 to 2040) and total investments, but also different in its path towards 2030. While the NECMP mainly focuses on bringing the NEC to a state of good repair, the NEC VISION seeks to improve HSR services significantly both prior and subsequent to 2030.

4.1. NEC EXTRAPOLATION 2012-2030

This hypothetical case is created by extrapolating the SFP trends found in section 3. From FY 2005-2012, ridership, revenue, RPM, and ASM SFP with respect to operating costs grew at a yearly average of 0.9%, 2.8%, 2.5%, and 0.4%, respectively, and provide reasonable estimates of long-term productivity growth in the NEC. If the recent market success of the NEC is maintained, then productivity, and perhaps profitability, could keep growing in the next two decades.

As shown in Figure 6, by 2030, projected demand-side productivity would increase ~50%, as measured by revenue SFP and RPM SFP, and supply-side productivity would increase 10%, as measured by ASM SFP. Ridership SFP, another metric of demand-side productivity, would increase by 20% by 2030, suggesting that the NEC would not simply accommodate new riders but also many riders taking longer-distance trips on the corridor.

The specific drivers that could sustain such productivity growth rates are not made explicit in Amtrak’s analysis, but there are some candidates that could do so without exceeding physical limits of inputs (e.g., load factors cannot be more than 100%, train arrivals/departures must have a reasonable headway, there are capacity constraints in the corridor). For example, exploiting the economies of scale in the corridor or having rising travel demand due to population growth and airport and highway congestion might help increase productivity in the NEC. Transport funding and investment, federal and state fiscal policies, taxes, private and

---

8 Another relevant prospect led by the FRA, the NEC FUTURE – Passenger Rail Corridor Investment Plan in 2012-2015 (NEC FUTURE 2013), was not considered as a case for analysis because it is at the early stages of development, where only preliminary alternatives without detailed information are available.
foreign investment, and environmental policies might also drive productivity change in the NEC (see Sussman et al. 2012a, Chapters 1 and 5).

**Figure 6** EXTRAPOLATION a) Year-to-Year and b) Cumulative SFP Growth FY 2005-30

4.2. NEC Master Plan (NECMP) 2010-2030

The second case of analysis is an examination of the prospects described in the *NEC Master Plan* (NECMP) of 2010. If the recent market trends continue and the NECMP (as described by Amtrak) is indeed implemented, then the following is plausible:

On the supply side, ASM SFP is likely to increase for two reasons. First, the introduction of additional Acela coach cars to lengthen the existing trainsets by FY 2014 will exploit the corridor’s large economies of scale. Second, the NECMP contemplates a number of capital expenditures to increase railroad capacity (i.e., the numerator of the ASM SFP metric) and reduce operating costs (i.e., the denominator): upgrades to tunnels, bridges, tracks, terminals, signals, catenaries, and other facilities.

On the demand side, RPM SFP could increase if the current trend of more riders on longer and longer train trips on the NEC persists.
Under NECMP, higher profitability of the NEC would be likely. The NECMP assumes 76% growth in NEC ridership and revenue, to 23 million annual riders and $1.84 billion revenue, and 36% growth in daily trains to 210 trains by 2030, which might increase the gap between revenue SFP and ASM SFP – as utilization increases much more than capacity. The NEC also has very profitable incremental ridership that could be realized if transportation demand continues to grow. Moreover, Amtrak recently reorganized its business lines focused around key market segments, giving special attention to two critical aspects of the NEC: operations and infrastructure (Gardner 2013). Additional improvements in management practices might increase Amtrak’s ability to implement and operate enhanced HSR services effectively. Given that the ability to operate HSR can be as important to productivity growth as the state of the regional economy, a successful management reorganization within Amtrak and the stakeholders of the NEC might lead to improved productivity, reduced risk, and, possibly, profitability.

However, the NECMP’s investment strategies would limit the potential for profitability in the NEC even though the expected economic conditions and population growth seem promising for realization of corridor opportunities for HSR. The NECMP limits the potential for productivity improvements, as it contemplates expanding Regional services on a greater scale than Express services, but the former were less sensitive to interventions than the latter. An expansion of Express services would require large capital investments that the NECMP did not envision, although market potential might justify such investments over time.

Finally, the few anticipated targeted capital investments of the NECMP would not achieve substantial trip time reductions nor an international-quality HSR service. The NECMP is, in brief, a conservative case that is not overly ambitious. The plan suggests future productivity increments that unfortunately could not be quantified due to lack of projected data available to the researchers. These increments don’t take into account uncertainties related to political support, external events – such as economic conditions and environmental policies - additional investments, or management changes that might affect future NEC performance.

4.3. NEC VISION 2013-2040
The third case of analysis corresponds to an examination of the projected future data laid out by Amtrak in “The Amtrak Vision for the Northeast Corridor: 2012 Update Report” (Amtrak 2012) with the methodology of productivity analysis developed in this research.
4.3.1. Methodology

Output and input data were digitized from publicly available graphs in Amtrak 2012. Outputs were *Ridership* and *Revenue*, and inputs were *Operating Costs*. Data on RPM and ASM were unavailable to the researchers. Additional data constraints required restricting the analysis to an overall NEC level. The fact that similar outputs and inputs as earlier are used throughout this analysis permits a comparison of past productivity with future productivity, but *only* at the NEC level. Two distinct SFP metrics are used to strengthen the analysis, both on the demand side, and none on the supply side: ridership and revenue SFP with respect to operating costs.9

As earlier, each year-to-year SFP metric was calculated via a non-parametric Törnqvist trans-log index, and then compounded to obtain the cumulative SFP, with 2013 as the base year in this case. Finally, a sensitivity analysis showed that results were robust to changes in assumptions regarding data generation and variations of the forecasts.

4.3.2. Characterization

The NEC VISION is a projected $150 billion stair-step phasing investment strategy, consisting of two sequenced programs and six milestone stages. Figure 7 shows the characterization of outputs and inputs of the NEC VISION for the period 2013-2040, overlapped with the investment stages. The left axis shows revenue and operating costs in $ billions and the right axis shows ridership in million passengers.

*Figure 7 Characterization of the NEC VISION 2013-2040*

For simplicity, the words “operating costs” are removed from the productivity label.
The NEC Upgrade Program (NEC-UP) 2015-2025 encompasses a sequence of incremental improvements that would bring infrastructure to a state of good repair, enhance capacity of the NEC through procurement of additional Acela trains, and reduce travel time through track improvements. It also includes the special Gateway Program in New York City, which would increase the tunnel and terminal capacity from New York to Newark. The top speed of the trains would reach 160 mph and even though travel time would improve only slightly, reliability, capacity and frequency of the NEC services would be considerably enhanced.

- **Stage 1)** 40% additional capacity of the Acela Express achieved through additional passenger cars on existing trainsets by 2015
- **Stage 2)** Doubling of the HSR frequencies from New York to Washington by 2020
- **Stages 3) & 4)** Improved and expanded service on the entire alignment, thanks to the Gateway program, track improvements, and additional HSR trains by 2025

The NEC Next Generation HSR (NextGen) 2030-2040 consists of new, fully dedicated HSR tracks to be implemented in two phases. The Washington-New York track would be completed by 2030, at a cost of $52 billion, followed by the New York-Boston link by 2040, at a cost of $58 billion. Traveling at top speeds of 220 mph, trip time between New York to either Boston or Washington would be 94 minutes each way. The projections of travel demand and revenue are 43.5 million annual riders and $4.86 billion revenue by 2040.

- **Stage 5)** Completion of the New York-Washington NextGen HSR segment by 2030
- **Stage 6)** Full establishment of the Boston-Washington NextGen HSR service by 2040

### 4.3.3. Limitations

Additional aspects that influence the analysis are worth pointing out explicitly. First, forecasts from Amtrak are assumed to be accurate (while, of course, recognizing that “the forecast is always wrong,” whether by Amtrak or anyone else). The stair-step milestones are assumed to be implemented at the specified times. Thus, the uncertainty of the forecasts is ignored. Given the inherent inaccuracy of travel demand projections and that large infrastructure projects usually have cost and schedule overruns, ignoring uncertainty is unrealistic but unavoidable. However, these “expected value” results can still give some insight into the performance of the NEC.

Second, to the best of the authors’ knowledge, current forecasts omit technological or managerial improvements that might change productivity. It is possible that Amtrak considered such improvements in its forecasts, but these assumptions have not been made public.
Finally, Amtrak’s forecasts do not explicitly consider large, unexpected events that might change productivity. As history demonstrates, performance on the NEC is quite sensitive to external disruptions, so forecasts ignore such events at their peril. The only major single events included in Amtrak’s projections are the capacity enhancements currently planned.

**4.3.4. Projected SFP**

Figure 8 shows the actual and predicted cumulative ridership SFP and revenue SFP growth for the NEC in 2000-2012 and 2013-2040, overlapped with the stages of the NEC VISION. In general terms, the NEC would become 20–40% more productive (on the demand side) by 2040 with respect to 2013. The expected yearly average growth in ridership (0.7%) and revenue SFP (1.3%) would be within the ranges of what the NEC achieved in the past (~0.5%–3.0%), though perhaps on the low side. Productivity increments would be highly variable and most likely occur in stages. Peak changes, however, are within the ranges of productivity gains or losses that the NEC showed in the past: +/- 13–18% on peak years.

**Figure 8 NEC VISION Cumulative SFP Growth FY 2002-12 and 2013-40**

Perhaps counterintuitively, not every stage of the NEC VISION would increase ridership and revenue SFP. Productivity would go down after Stage 1, with the additional capacity of the Acela, and then slightly increase after Stage 2, with the higher frequency of HSR service between New York and Washington. Productivity rises dramatically after Stages 3 and 4, with completion of the Gateway project and several capital upgrades, and is set to improve even more in Stages 5 and 6, with the introduction of the NEC Next Generation (NextGen) HSR in the entire alignment.
4.3.5. Comments on the NEC VISION

In Amtrak’s projections, the drivers of productivity change are operational interventions and market effects, which exclude major (unknown) external events or managerial changes. For example, the increased HSR capacity in 2015–2020 would decrease ridership SFP and revenue SFP, as the new trains become immediately more expensive to operate per rider and the market takes time to respond to stimulus of new services\(^\text{10}\). Also, a key stage in productivity growth is the Gateway Program targeted for completion in 2025, which would make it much easier for travelers to enter and exit New York City. This stage would bring similar productivity increments as the surge in ridership of FY 2010-12. So, efforts to accelerate this project should be included in any reasonable strategy. Finally, the ever-increasing gap between revenue SFP and ridership SFP with respect to operating costs after 2020 suggests that Amtrak may have assumed that travelers pay higher fares, possibly due to a combination of two effects. On the one hand, new HSR services might be accompanied by a new fare structure and mix of business and leisure travelers embedded in Amtrak’s projections\(^\text{11}\). On the other hand, the trend of people traveling longer distances on the NEC could continue, thus increasing the average revenue per rider.

Air/rail interactions are unclear at this point, and it is unknown if Amtrak anticipated the reaction of the competition in making its forecasts. For example, there could be fierce opposition and competition. Air lobbyists could push Congress to block rail investments or approve airport expansions. Airlines could also improve services or lower fares in the NEC. However, the large air/rail market share of Amtrak in the NEC may have reduced the leverage the airline industry can exert on the NEC decision-making process. Also, government might favor funding HSR infrastructure rather than air infrastructure, as stringent environmental dictates or cleaner energy policies hasten and substantially expand the energy and CO2 emission savings of HSR (Clewlow 2012). In addition, there are possibilities of cooperation between airlines and HSR, but the success of any alliance depends on such unique challenges as complex network economics and financing/funding for air/rail intermodal connections (Clewlow 2012). Whether competition or cooperation dominates the relationship between airlines and HSR is unclear. At this point, the NEC VISION opens the possibility for air/HSR intermodal connections (e.g., stops at the

\(^{10}\) The author assumed that Amtrak accounted for this in the forecasts.
\(^{11}\) It is currently unknown by the author if Amtrak used a selective or an across-the-board fare increase for the services in the revenue forecasts, or a fare increase at all.
Baltimore, Philadelphia, and Newark airports), but does not provide details on how these will be developed, should they be developed at all. From the author’s perspective, the relationship between air and rail is vital, not only to the success of HSR but to the mobility within the NEC as a whole. However, the current planning process of the NEC VISION and the NEC FUTURE lacks involvement of the FAA and other stakeholders of the airline industry.

Ridership and revenue projections could be underestimated, given the characteristics of the NEC and the introductory effect of HSR. Once the NextGen HSR is introduced in 2030, (followed by substantial trip time reductions,) productivity of the NEC will not increase significantly. This contrasts with the recent market success of the NEC in the absence of true HSR, and the fact that the introduction of HSR in some nations “resulted in substantial decline in air traffic on short-haul routes” (Clewlow 2012). For instance, an improved level of service might be accompanied by a substantial increase in travel demand. HSR amenities and add-ons (e.g., food services, baggage fees or Wi-Fi charges) could further increase revenue.

As projections of ridership are often overestimated while projections of costs are underestimated when compared with reality (Flyvbjerg et al. 2002), the 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 such a system in the NEC (Table 3)12. 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 (De Rus and Campos 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, the NEC VISION forecasts 30% more ridership on the NEC after the first NextGen HSR segment is implemented in 2030 (with respect to 2025), and 66% more ridership once the full 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.

12 These international corridors, which have now been expanded, are compared with the projected introduction of the NextGen 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 NextGen HSR alignment is finally completed in 2040.
Table 3 International Comparisons of HSR Lines (Adapted from Sakamoto 2012, Thompson and Tanaka 2011 Cheng 2010, and Vickerman 1997)

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

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 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.

4.4. Conclusions and Recommendations

Although the geographic and socioeconomic characteristics of the NEC reveal a potential for the successful introduction of a true HSR service, determining a consensual implementation strategy is challenging but mandatory to advance HSR in the NEC effectively. In this sense, the three cases of analysis developed provided different perspectives on the future of the NEC.
The EXTRAPOLATION of past productivity determined a ballpark estimate of what productivity in the future could be, and suggested drivers of productivity change that could help sustain such productivity growth rates. If the recent market success of the NEC continues, then productivity, and perhaps profitability, could continue growing in the next two decades.

The analysis of the NECMP revealed that higher productivity levels could be expected, and that the prospects for bringing the corridor to a state of good repair and accommodating some capacity growth were credible. However, such interventions will prevent the NEC from truly deploying an international-quality HSR service, and there might be a greater potential for increased productivity and services, which the NECMP did not consider.

The analysis of the NEC VISION showed that the future performance on the NEC is sensitive to several operational interventions and market effects, and the projected productivity levels are volatile and especially low at the beginning of the proposed interventions. Thus, productivity benefits may take years to realize. If financial leverage and political support are lacking during adverse times, or if the market and managers are slow in adapting to changing conditions, the successful implementation of HSR is not a certainty. Amtrak’s critics might use this fact to question its ability to implement the strategy. Current optimism might fade and jeopardize long-term plans.

On the other hand, the NEC VISION lacks ambition in some ways, since projected cumulative productivity growth is low in comparison to the growth of the past decade (20-40% in the next 30 years v. 20% in the past 10 years). The international benchmark and the past decade of the NEC suggest that Amtrak’s projections of ridership and revenue are reasonable, but might be on the low side. Also, the plan to improve management is not explicitly mentioned in the NEC VISION. As productivity is sensitive to management practices, improved management within Amtrak and coordination with other major travel modes may reveal a greater potential for productivity improvements.

Thus, we offer the following recommendations to decision-makers: revise projections of ridership and revenue; involve the FAA in the planning process and consider air/rail cooperation explicitly; consider the possibility of improved management practices within Amtrak and other stakeholders of the NEC; prioritize stages of the implementation that promise the highest productivity improvements, e.g., the Gateway Program; and use scenario planning and design flexibility in the investment alternatives.
References