PERSPECTIVES

PHOENIX CENTER FOR ADVANCED LEGAL & ECONOMIC PUBLIC POLICY STUDIES

Infrastructure Investment in the Railroad Industry: An Econometric Analysis

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Prior to the Staggers Rail Act of 1980, over-zealous regulation brought the rail industry to the brink of total financial ruin.[1] By imposing constraints on regulatory intervention—that is, *regulating the regulator*—the Staggers Act, by easing or eliminated a swath of long-standing regulations on pricing and operations for the purpose of saving "the private railroads from extinction," led to an economic resurgence of the rail industry.[2] As noted by the National Academies of Science, deregulation "spur[ed] the development of a modern and more efficient railroad industry that was better able to compete with trucks, maintain and expand capacity, and respond flexibly to shippers' needs with less regulatory oversight and control."[3] Shipping rates fell and safety improved. Rates were rising 3% annually before the Act but fell 0.5% annually after; and between 1981 and 2009, the railroad industry saw a 65% decline in accidents.[4]

Even so, after nearly four decades since the Staggers Act was enacted, some firms in the rail industry struggle to earn a competitive return on their investments, a deficit verified annually by the industry's chief regulator—the Surface Transportation Board ("STB").[5] Each year, the STB is required by statute to "determine which rail carriers are earning adequate revenues," a decision based on a comparison of the return on investments to the an estimate of the cost of capital.[6] Only since 2012 has the industry *average* return on investment consistently met the STB's estimate of the cost of capital (see Figure 1 below).

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Despite its own evidence and a catastrophic regulatory past, the STB is now contemplating ways it may return to a more aggressive regulatory posture, including rate regulation and forced access.[7] Analysts and industry officials worry that a regulatory revival at the STB might unwind the significant progress experienced since deregulation, worsening an already precarious financial situation and threatening the continued investment in the sector at a time when the nation's critical infrastructure is crumbling. Edward Hamberger, the former President and Chief Executive Officer of the Association of American Railroads ("AAR"), warned that "re-instituting revenue caps would have far-reaching impacts on the freight-rail industry's ability to sustain the billions of private funds spent by railroads each year to build, maintain and upgrade their networks." Former Chief Executive Office of Norfolk Southern, Charles Moorman, stated it plainly: "[a]ny regulation of the railroad industry will lead to less capital investments by railroad companies."[8]

A reassertion of an interventionist approach to rail regulation is a complex issue. In this PERSPECTIVE, I attempt a modest contribution to

the ongoing debate by quantifying the relationship, if any, between industry revenues and returns on infrastructure investment by the largest firms in the railroad industry. Using Vector Autoregression Model ("VAR"), I find significant, causal relationships between the financial health of the rail industry and its investment behavior. While my analysis by no means addresses the full complexity of the issue, I hope this evidence serves as a valuable contribution to a rational debate over rail regulation—regulation that history has shown to be catastrophic.

Background, Briefly

Regulated nearly to death, in the late 1970s Congress began formulating a statutory response to the financial woes of the railroad industry. This effort culminated in the Staggers Rail Act of 1980, the purpose of which was to "provide for the restoration, maintenance, and improvement of the physical facilities and financial stability of the rail system in the United States."[9] Given the poor financial state of the industry at the time, restoring financial integrity was a dominant goal, establishing as policy that regulatory activity must "allow[] rail carriers to earn adequate revenues."[10] Revenue adequacy is now a central feature of modern rail regulation, a statutory design intentionally constraining regulatory interventions that may again threaten the financial viability and progress of the nation's rail transportation sector.

In recent years, several parties—mostly shippers and their advocates—have asked the STB to find ways to loosen the shackles of revenue adequacy constraint. As a result, the STB has issued a few *Notice of Proposed Rulemakings* and commissioned a study outlining how the Board might apply rate regulation and forced access (i.e., reciprocal switching) under a weak form of revenue adequacy.[11] The nature of this debate is beyond the scope of my analysis, but it is worth a brief review of the financial health of the industry prior to conducting my empirical analysis.

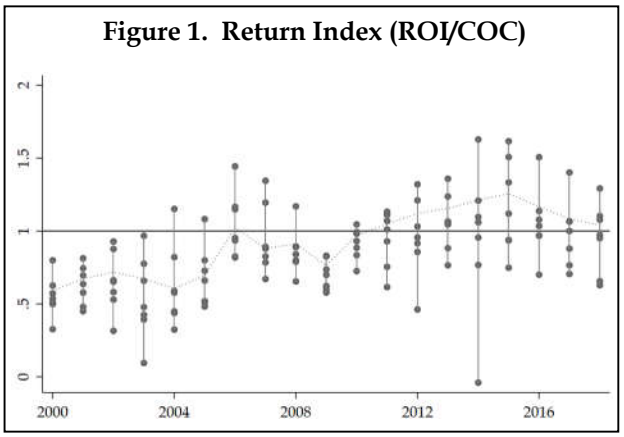
Railroads are a quintessential multiproduct firm, carrying many types of commodities along many different routes. Modern rate regulation proposals for the rail industry tend to focus on the price-cost relationship for particular commodities and routes rather than some global rate constraint. As a multiproduct firm, prices and margins are expected to vary along these dimensions for a variety of reasons, including the own-price and cross-price elasticity of demands.[12] Simplistic price-cost comparisons and the regulation of rates ignore, improperly I believe, the complexity of rate setting in a multiproduct environment. Furthermore, research shows that quantifying the cost of providing transportation services is a complex undertaking, so naive computations of price-cost margins may be grossly inaccurate.[13]

For the multiproduct firm, prices must deviate from marginal cost to cover fixed costs, so economic theory tells us that a multiproduct firm's total profit is the only meaningful measure of market power. The Staggers Act mandates that the regulation of the industry be subject to a revenue adequacy constraint, whereby the Board's regulatory efforts must ensure a railroad firm's revenues are sufficient "to cover expenses, earn a profit, continue prudent capital outlays, and attract sufficient capital for maintenance and improvement of the rail network."[14] Revenue Adequacy is a crude proxy for total firm profitability (that is, the ability to attract investment capital). Only during the past decade—thirty-years after the Staggers Act—have the railroads, at least on average, satisfied the Revenue Adequacy constraint.

Figure 1 provides the Return index defined as the Return on Investment ("ROI") divided by the STB's estimate of the Cost of Capital ("COC") since 2000 for the seven Class I railroads: (1) BNSF Railway; (2) CSX Transportation; (3) Grand Trunk Corporation; (4) Kansas City Southern Railway; (5) Norfolk Southern Combined; (6) Soo Line; and (7) Union Pacific.[15] While the ROI varies across firms, the COC is the same for all

firms by STB convention. The industry mean is indicated by the dashed line. The Return Index equals 1.0 when the Return on Investment equals the Cost of Capital.

Figure 1. Return Index (ROI/COC)



The trend in the average index is mildly positive. As for the distribution among firms, in no year did every Class I railroad satisfy the revenue adequacy constraint. The index reaches a peak, on average, in 2015, but even then the index was below 1.0 for some railroads. Since 2015, the index has moved closer to 1.0 (where the firms earns just enough income to cover an estimate of the cost of capital). In all, there appears to be little evidence of systematic excessive profits at the firm level. While some railroads have ROIs above the COC, many do not, and there is no pattern in returns to indicate meaningful market power in the industry.

On average, it appears that the largely deregulatory approach to railroads has barely, if even, satisfied the Staggers Act's mandate for revenue adequacy for the rail industry. Regulatory intervention to reduce prices are certain to make matters worse for the railroads. The rail industry's concerns that a regulatory revival at the STB might reverse the gains achieved from deregulation is sensible, though how curtailing revenues and returns in the industry influence investment has yet to be quantified. It is to that task I now turn.

Time Series Properties of the Data

My purpose is to quantify the relationship between investments (capital expenditures) made by Class I railroad firms and their revenues and returns. I do so by applying Vector Autoregression ("VAR") model. Revenue (in 2017 dollars) and investment are annual data spanning years 1980 through 2018 as reported by the STB.[16] Returns are measured as the *ratio* of the Return on Investment to the Cost of Capital (= ROI/COC).[17]

With time series analysis, the first task is to determine whether the series are stationary and whether a cointegrating (i.e., long run) relationship exists between them. Stationarity is evaluated using the Augmented Dickey-Fuller Test ("ADF").[18] The Return Index and the natural log of revenues and investment are found to be stationary in first differences (all at the 1% level) but not in their levels. The series are all I(1), so the VAR analysis is conducted with differenced data.

An additional concern is cointegration, which implies the series exhibit a long-run relationship. Johansen's Cointegration Test is conducted. Note that thirty-six years of annual data may not be adequate for such long-run analysis, especially for returns which are especially volatile in the 1980s and early 1990s. No cointegrating relationship is found between investment and revenues, or between investment and returns. Absent a cointegrating relationship, which admittedly may be the result of the short and volatile time series, it is sensible to focus on the short-run effects using VAR.

Some Descriptive Statistics

Over the sample period, real railroad revenue (in 2016 dollars) averages $55.9 billion annually. Investment averages $23.2 billion, so investment equals about $0.40 per dollar of revenue, on average, which is a commonly reported statistic.[19]

The ratio of the industry's Return on Investment to the Cost of Capital averages 0.67, with a minimum of 0.11 and maximum of 1.26. A histogram of the Return Index is provided in Figure 2. Over the thirty-eight years since the Staggers Act, the industry, on average, has failed to satisfy the revenue adequacy constraint for most years; in only eight years does the Return Index equal or exceed 1.00, which may be viewed (theoretically, at least) as the "competitive" return. (Note that accounting data need not accurately measure economic concepts.)

Figure 2. Distribution of the Return Index

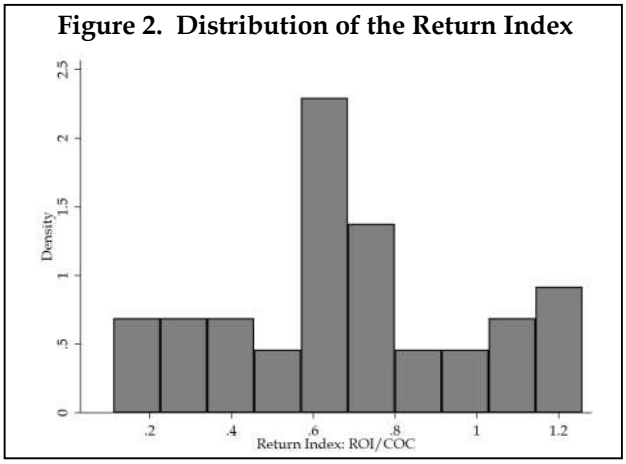


Figure 3 illustrates the pattern in the Return Index over the years 1980 through 2017. The Return Index has a positive drift, consistent with the recovery of the industry from the regulatory excesses addressed by the Staggers Act. Revenue adequacy, proxied by an index value exceeding 1.0, holds with some consistency only after 2010. Thus, restoring the industry to some modicum of financial stability took about thirty years after the signing of the Staggers Act. As shown in Figure 1, however, the financial condition of railroad firms is heterogenous, with some railroads falling well short of revenue adequacy in recent years.

A Return Index exceeding 1.0 for the few years following 2010 likely explains the STB's decision to reconsider the deregulatory approach to railroads, though the pattern in the index in the last few years reveals the STB may have acted too hastily. The index fell from 1.26 in 2015 to only 1.04 in 2018. In fact, the index is highly volatile and prone to downturns after periods of increase. For instance, the index reached a value of 1.02 in 2006 only to fall to 0.76 (a decline of 0.26) three years later. Also, when looking at the Return Index for individual firms, the evidence is decidedly mixed (see Figure 1).

Figure 3. Return Index Over Time, Average

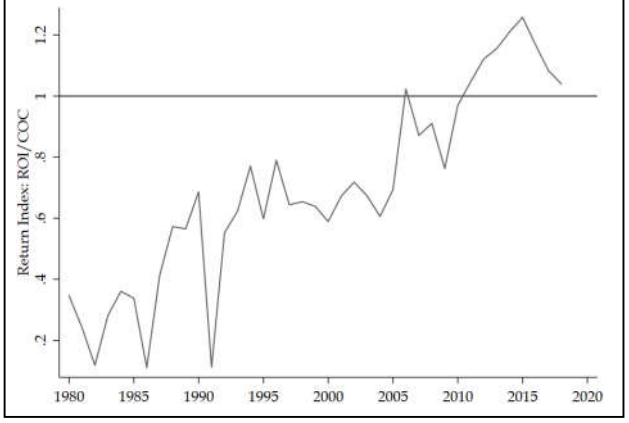


Figure 3 raises several interesting questions. First, what is the level of the Return Index (or some other measure of "adequacy") that warrants a return to a regulatory posture? It seems unlikely that a value of 1.0 would be appropriate, since returns are quite volatile, and the components of the index are subject to mis-measurement. As the STB has recognized, "there is no single simple or correct way to estimate the cost of equity for the railroad industry, and many model options are available."[20]

Take the Capital Asset Pricing Model ("CAPM"), which is used by the STB to estimate the Cost of Capital.[21] This model includes three terms: (1) the risk-free rate; (2) the equity risk premium; and (3) the financial Beta (β).[22] All three are estimates and may be determined using various methodologies, so each is subject to error. For instance, in the three years 2016 through 2018, using weekly returns data I estimate the β for CSX to be 1.15 with a 95% confidence interval of 0.86 to 1.45.[23] Even assuming that the risk-free rate and the equity risk premium are constants, the range on the estimated cost of equity is hundreds of basis points.[24]

Other questions include: what constitutes stability in revenue adequacy? Or, what value of the index that provides some comfort that expanded regulation of the sector mixed with normal volatility will not replicate the disastrous regulatory efforts of the past? And, what is the distribution of the index (e.g., given errors in measuring the cost of capital)? I leave these questions to future research.

While much can be learned from looking at sample averages, the more interesting question for assessing the likely consequences of a regulatory revival in the railroad industry is how investment responds to changes in revenues and returns in a dynamic sense. Quantifying such relationships requires a dynamic empirical model. In the following sections, I employ a dynamic model to quantify these potentially important relationships.

Vector Autoregression Model (VAR)

The m-dimensional and p-order VAR model may be written as,

$$y_t = a_0 + \sum_{i=1}^{p} \Phi_i y_{i-1} + u_t, \quad t = 1,2,...T, \quad (1)$$

where here $y_t = (y_{1t}, y_{2t}, \ldots y_{mt})$ are the stationary endogenous variables, a_0 is a m-element vector of fixed effects, Φ_i are $m \times m$ coefficient matrices, and u_t is a $m \times 1$ matrix of disturbances. As is standard, the lag-order (p) of the VAR is determined by minimizing the information criteria.[25]

Revenue and Investment

To begin, I consider a two-dimensional VAR includes the revenue and investment series. Information criteria indicate a single lag is best, though the results are robust to the inclusion of an additional lag. Specification tests are encouraging: the Lagrange Multiplier test indicates no autocorrelation in the disturbances (for up to two lags) and the VAR satisfies the stability condition.[26]

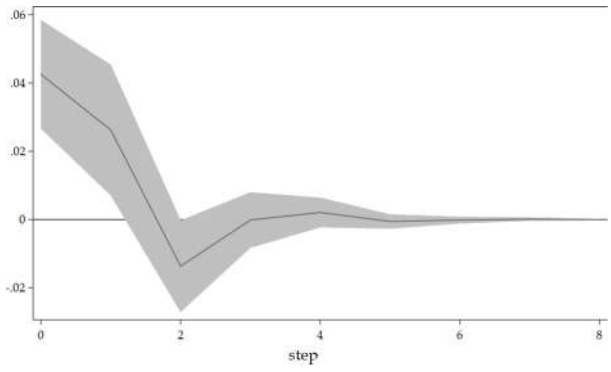
Table 1. VAR Results, Revenues

	$\Delta lrev_t$	$\Delta linv_t$
$\Delta lrev_{t-1}$	0.063	0.523
	(0.31)	(3.14)***
$\Delta linv_{t-1}$	-0.327	-0.341
	(-1.38)	(-1.74)*
Constant	0.027	0.012
	(1.95)	(1.00)
Obs.	35	35
R2	0.06	0.22
χ^2	2.20	9.87***

Stat. Sig. *** 1%, ** 5%, * 10%

With a single lag, the coefficients of the model, summarized in Table 1, are easily interpreted. In the investment equation, the (lag of) revenue has a coefficient of 0.523, which is statistically significant at better than the 1% level. This estimate is consistent with the average investment level of railroad firms: for every dollar of additional revenue, about $0.40 is invested.[27]

Figure 3. OIRF, Revenues-to-Investment



The relationship between revenues and investment is illustrated in Figure 3 using the Orthogonal Impulse Response Function ("OIRF") for a one-standard deviation shock to revenues.[28] The shaded area illustrates the 90% confidence bands. Statistically significant responses to the revenue shock occur for the first and second periods. In the first period, a 1% shock to revenue increases investment by 0.54%, and in the second the same shock increases investment by 0.33%. This analysis supports the

concern that revenue-attenuating regulations may reduce investment in the nation's critical railroad infrastructure.

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Returns and Investment

Now, I estimate the two-dimensional VAR with the Return Index and investment series. Again, information criteria indicate a single lag is best, and the Lagrange Multiplier test indicates no autocorrelation in the disturbances (for up to two lags) and the VAR satisfies the stability condition.[29]

Table 2. VAR Results, Returns

	$\Delta lret_t$	$\Delta linv_t$
$\Delta lret_{t-1}$	-0.402 (-2.68)***	0.170 (2.68)***
$\Delta linv_{t-1}$	-0.563 (-1.42)	-0.016 (-0.09)
Constant	0.050 (1.77)*	0.014 (1.13)
Obs.	35	35
R2	0.21	0.17
χ^2	9.52***	7.15**

Stat. Sig. *** 1%, ** 5%, * 10%

Table 2 summarizes the results.[30] In the investment equation, the (lag of) the return has a coefficient of 0.17, which is statistically significant at better than the 1% level. Investment is positively related to the Return Index (or, one might say, to revenue adequacy).

Figure 4. OIRF, Returns-to-Investment

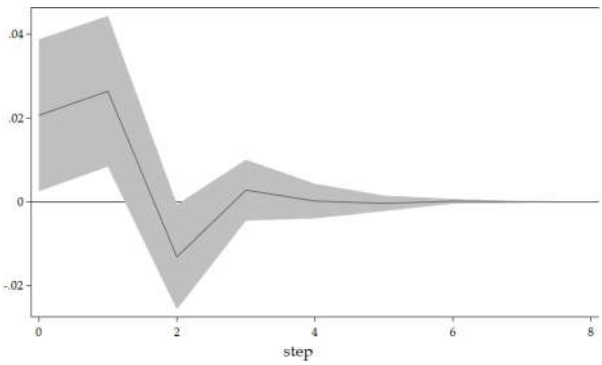

Figure 4 provides the OIRF for investment given a one-standard deviation shock to returns.[31] Statistically significant responses to the return shock occur for the first and second periods. In the first period, a 1% shock to revenue increases investment by 0.13%, and in the second the same shock increases investment by 0.17%. Regulatory efforts that reduce returns, which here is a measure of revenue adequacy, are expected to curtail investment.

Conclusion

Regulation of the nation's railroads has a long and gloomy history. Regulated to the brink of financial ruin, Congress passed the Staggers Rail Act of 1980 to restore financial integrity of the rail industry by curtailing regulatory intervention. By all measures, the deregulatory act was successful, though the return to financial stability was a long road. Today, some firms in the industry have adequate revenues and returns to attract capital, others not, but history also shows stability in the sector is volatile.

The Surface Transportation Board now seeks to return to a more aggressive regulatory agenda. Analysts and industry officials worry that a regulatory revival in the industry will reduce revenues and returns below that which permit continued investment in the sector. In this PERSPECTIVE, I contribute to this on-going debate by quantifying the relationship between industry revenues and returns on infrastructure investment. I find significant, causal

relationships between the financial health of the rail industry and its investment behavior. While this analysis by no means addresses the full complexity of the issue, this evidence may serve as an input to what is hopefully a rational debate over rail regulation—regulation that history has shown to be catastrophic.

NOTES:

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1 *See, e.g.,* D.W. Caves, L.R. Christensen, and J.A. Swanson, *The High Cost of Regulating U.S. Railroads*, 5 REGULATION (1981) (available at: https://www.lrca.com/wp-content/uploads/2014/10/Caves_Christensen_Swanson_High_Cost_of_Regulating_US_Railroads.pdf); B.K. Eakin, A.T. Bozzo, M.E. Meitzen, and P.E. Schoech, *Railroad Performance Under the Staggers Act*, REGULATION (Winter 2010-2011) (available at: https://www.lrca.com/wp-content/uploads/2014/10/Eakin_Bozzo_Meitzen_Schoech_Railroad_Performance_Under_the_Staggers_Act.pdf); R.B. Ekelund Jr., and R.F. Hebert, *Railroad Reregulation: Is the C.U.R.E Cure Worse Than the Disease?*, CATO INSTITUTE POLICY ANALYSIS No. 98 (January 20, 1988).

2 M. Scribner, *Slow Train Coming? Misguided Economic Regulation of U.S. Railroads, Then and Now*, COMPETITIVE ENTERPRISE INSTITUTE ISSUE ANALYSIS 2013 No. 1 (March 2013) (available at: https://cei.org/sites/default/files/Marc%20Scribner%20-%20Slow%20Train%20Coming.pdf); MODERNIZING FREIGHT RAIL REGULATION, Transportation Research Board of the National Academies (2016).

3 MODERNIZING FREIGHT RAIL REGULATION, *id.* at p. 1.

4 J. Palley, *Impact of the Staggers Rail Act of 1980,* Office of Rail Policy and Development, Federal Railroad Administration (March 2011) (available at: https://www.fra.dot.gov/Elib/Document/1645).

5 The annual reports are available at: https://www.stb.gov/decisions/readingroom.nsf/WebServiceDate?openform.

6 *See* 49 U.S.C. § 10704(a)(3).

7 *See, e.g., Petition for Rulemaking to Adopt Revised Competitive Switching Rules; Reciprocal Switching,* NOTICE OF PROPOSED RULEMAKING, 81 FED. REG. 51149 (August 3, 2016); *Revisions to the Board's Methodology for Determining the Railroad Industry's Cost of Capital,* NOTICE OF PROPOSED RULEMAKING, 84 FED. REG. 53094 (October 4, 2019); *Expediting Rate Cases,* NOTICE OF PROPOSED RULEMAKING, 82 Fed. Reg. 16550 (April 5, 2017); *see also* L.J. Spiwak, *Obama's Policies are Still Threatening the Freight Rail Industry*, THE HILL (October 13, 2017) (available at: http://thehill.com/opinion/white-house/355205-obamas-policies-are-still-threatening-the-freight-rail-industry); G.S. Ford, *Stopping the Surface Transportation Board from Running off the Rails,* THE HILL (January 18, 2017) (available at: http://thehill.com/blogs/pundits-blog/transportation/314677-stopping-the-surface-transportation-board-from-running-off).

8 *Proposed New Regulation Would Undermine Private Investment in Freight Rail Network*, GORAIL ISSUE BRIEF (2019) (available at: http://gorail.org/content/uploads/STB-Issue-Brief-092116.pdf); D.J. Hanford, *Norfolk Southern CEO: Regulation Would Stymie Investment*, DOW JONES NEWSWIRES (September 13, 2006) (available at: https://www.ble-t.org/pr/news/headline.asp?id=16945).

9 Section 3, Staggers Rail Act of 1980, Pub. L. 96-448 (October 14, 1980), 49 U.S.C. § 10101a (note).

10 49 U.S.C. § 10101a(3).

11 *Supra* n. 7; *see also* Rate Reform Task Force, REPORT TO THE SURFACE TRANSPORTATION BOARD (April 25, 2019).

12 S. Brown and D. Sibley, THE THEORY OF PUBLIC UTILITY PRICING (1986) at Ch. 3; B. Mitchell and I. Vogelsang, TELECOMMUNICATIONS PRICING: THEORY AND PRACTICE (1991) at Ch. 4.

13 *See, e.g.,* J. Hausman and S. Myers, *Regulating the United States Railroads: The Effects of Sunk Costs and Asymmetric Risks*, 22 JOURNAL OF REGULATORY ECONOMICS 287-310 (2002); M. Burton and C. Sims, *Understanding Railroad Investment Behaviors, Regulatory Processes, and Related Implications for Efficient Industry Oversight*, 49 REVIEW OF INDUSTRIAL ORGANIZATION 263-288 (2016).

14 49 U.S.C. § 10704(a)(2). For the rail industry's take on revenue adequacy, *see, e.g.,* https://www.aar.org/article/freight-rail-revenue-adequacy.

15 Data are obtained from: https://www.stb.gov/decisions/readingroom.nsf/WebServiceDate?openform.

NOTES CONTINUED:

[16] Revenue and Investment data available at: https://www.stb.gov/stb/industry/econ_reports.html. Investments include spending on both new equipment and maintenance. I am grateful to the AAR for providing summaries of these data.

[17] Data available at: https://stb.gov/decisions/readingroom.nsf/WebDecisionID/46756. I am grateful to the AAR for providing summaries of these data in an industry-average format.

[18] The test is conducted with four lags and includes a term for drift. Y.W. Cheung and K.S. Lai, *Lag order and critical values of the augmented Dickey–Fuller test*, 13 JOURNAL OF BUSINESS & ECONOMIC STATISTICS 277–280 (1995); G. Elliott, T.J. Rothenberg, J.H. Stock, *Efficient Tests for an Autoregressive Unit Root*, 64 ECONOMETRICA 813–836 (1996).

[19] *See, e.g., Freight Railroad Capacity and Investment*, American Association of Railroad (June 2019) (available at: https://www.aar.org/wp-content/uploads/2018/05/AAR-Freight-Railroad-Capacity-Investment.pdf) ("40 cents out of every revenue dollar, plowed right back into a rail network that keeps our economy moving").

[20] *Revisions to the Board's Methodology for Determining the Railroad Industry's Cost of Capital*, CORRECTED DECISION, Surface Transportation Board, Docket No. EP 664 (Sub-No. 4) (October 10, 2019) (available at: https://www.stb.gov/decisions/readingroom.nsf/9855c1fb354da09b85257f1f000b5f79/526786aacb5f512085258490006d2877?OpenDocument#_ftnref7).

[21] *Id*.

[22] *See, e.g., Methodology to be Employed in Determining the Railroad Industry's Cost of Capital*, DECISION, Surface Transportation Board, STB EX PARTE NO. 664 (January 17, 2008) at pp. 4-5 (available at: https://www.stb.gov/decisions/readingroom.nsf/UNID/00C41F34906CEF8A852573D30067E123/$file/38721.pdf).

[23] Weekly stock return data is obtained from finance.yahoo.com. The S&P 500 is used as the market index.

[24] Assuming, arbitrarily, that the equity risk premium is 7%, the range of the cost of equity exceeds 400 basis points.

[25] H. Lütkepohl, NEW INTRODUCTION TO MULTIPLE TIME SERIES ANALYSIS (2005).

[26] S. Johansen, LIKELIHOOD-BASED INFERENCE IN COINTEGRATED VECTOR AUTOREGRESSIVE MODELS (1995); J.D. Hamilton, TIME SERIES ANALYSIS (1994).

[27] Over the two-years following the shock, the elasticity of investment for changes in revenue is 0.88 and investment averages about 42% of revenue (0.88×0.42 = 0.37).

[28] The order is revenues to investment.

[29] S. Johansen, LIKELIHOOD-BASED INFERENCE IN COINTEGRATED VECTOR AUTOREGRESSIVE MODELS (1995); J.D. Hamilton, TIME SERIES ANALYSIS (1994).

[30] The STB altered the methodology for estimating the cost of capital in 2008 by moving from a single-stage Discounted Cash Flow Model to the Capital Asset Pricing Model. *Surface Transportation Board Calculates Rail Industry's 2006 Cost of Capital*, Surface Transportation Board (April 15, 2008) (available at: https://www.stb.gov/newsrels.nsf/29d1486804c22b1785256e59005e7e87/5cdddaae75c3ab2d8525742c0052a8cf?OpenDocument). In 2009, the STB added the multi-stage Discounted Cash Flow Model to its determination. *Surface Transportation Board Revises Its Cost of Capital Methodology*, Surface Transportation Board (January 28, 2009) (available at: https://www.stb.gov/__85256593004F576F.nsf/0/3551C8B4A52126478525754C0072C406?OpenDocument). Additional VAR models were run to evaluate the impact of the methodological change including estimating the VAR prior to 2008 and secondarily including a dummy variable as an exogenous factor in the full dataset. No meaningful differences in the results reported above were observed.

[31] The order is returns to investment.