Alternatives to URCS

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March 2022

Final Report

Prepared for
The Surface Transportation Board
Washington, DC

Acknowledgements

This report was prepared under U.S. Department of Transportation Contract 693JK420C900001. A. Thomas Bozzo was the project manager for Christensen Associates. Senior members of our study team were Daniel Hansen, Mark Meitzen, and Kevin Roth. Daniel McLeod and Van Ngo made key contributions to the econometric analyses presented here. Casey Shuster abstracted the large volume of stakeholder comments in the Ex Parte 431 sub-number 3 and 4 dockets and assisted with stakeholder interviews. Philip Schoech and Kelly Eakin provided insights on cost methodology issues. Nicholas Crowley, Tyler Drown, and Alex Schmidt provided data analysis and programming support. Teresa Sholts prepared the report manuscript.

We also thank the stakeholders who participated in our study in one way or another, providing valuable information, institutional knowledge, and insights.

William Brennan of the STB Office of Economics served as the STB project manager and our liaison with the STB. Michael Boyles and Paul Lowengrub of the STB Office of Economics provided invaluable institutional background, data, models, and technical support related to the URCS model and the Carload Waybill Sample without which our analysis could not have proceeded. Any remaining errors are, of course, our own.

Abbreviations

AAR	Association of American Railroads
ATC	Average Total Cost
BNSF	Burlington Northern Santa Fe (Railway)
CD	Car-Day
CFR	Code of Federal Regulations (also "C.F.R.")
CM	Car-Mile
CN	Canadian National (Railroad)
COFC	Container on Flat Car
CP	Canadian Pacific (Railway)
CR	Conrail
CSXT	CSX Transportation
CWB	Carload Weighted Block
CWS	Carload Waybill Sample
DLR	Depreciation, Lease, and Rental
E/L	Empty/Loaded (ratio)
EP	Ex Parte
FC	Fixed Cost
GPCS	General Purpose Costing System
I&I	Inter-train and Intra-train (switching)
IC	Incremental Cost
ICC	Interstate Commerce Commission
KCS	Kansas City Southern (Railroad)
LUM	Locomotive Unit Mile
MC	Marginal Cost
MR	Marginal Revenue
MMM	Maximum Markup Methodology
NEIO	New Empirical Industrial Organization
NPR	Notice of Proposed Rulemaking
NS	Norfolk Southern (Railway)
R/VC	Revenue to Variable Cost (ratio)
RAPB	Railroad Accounting Principles Board
RCAF	Rail Cost Adjustment Factor
RCS	Rail Cost Study
ROI	Return on Investment
RPTM	Revenue Cost per Ton-Mile
RSAM	Revenue Shortfall Allocation Methodology
SAC	Stand Alone Cost
SARR	Stand Alone Railroad
SEM	Switch Engine Minute(s)
SNPR	Supplemental Notice of Proposed Rulemaking
STB	Surface Transportation Board (also "Board")
STCC	Standard Transportation Commodity Code
TC	Total Cost
TCU	Trailer or Container Unit
TIH	Toxic by Inhalation

TOFC	Trailer on Flat Car
UP	Union Pacific (Railroad)
URCS	Uniform Rail Costing System
USC	United States Code (also "U.S.C.")
USDOT	United States Department of Transportation
VC	Variable Cost
VCPTM	Variable Cost per Ton-Mile
WCTL	Western Coal Traffic League
3B	Three Benchmark (methodology)
4R Act	Railroad Revitalization and Reform Act of 1976

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EXECUTIVE SUMMARY

A. GOALS OF THE PROJECT AND KEY FINDINGS

The *Alternatives to URCS* project set out to identify and evaluate possible alternatives to the Uniform Rail Costing System (URCS) that could better or more efficiently reflect the operating environment of the modern railroad industry. The project focused on costing methodologies that could be used as replacements or major structural updates to URCS to generate movement-specific variable costs for regulatory purposes. Specifically, the project:

- Assessed the economic cost measure(s) that URCS or a successor cost system should represent given the regulatory applications of URCS
- Identified economic assumptions under which URCS or successor cost systems produce economically appropriate measures of costs for railroad movements
- Evaluated whether alternative costing methodologies and structural updates to URCS could generate economically valid railroad variable costs for regulatory purposes
- Implemented URCS alternatives and updates and compared model costs and revenue-to-variable cost (R/VC) ratios to current-methodology URCS
- Quantified the effects of URCS alternatives and updates on the application of the Surface Transportation Board's jurisdictional threshold for market dominance determinations
- Considered advantages and disadvantages of URCS alternative and updated approaches, including the ability to reflect current railroad operations and adherence to the costing principles in the Railroad Accounting Principles Board (RAPB) Final Report

Based on the project's analysis, we reached the following main conclusions:

- Short-run economic costs (marginal and incremental costs) are appropriate for the statutory application of URCS
- URCS and similarly structured models can produce short-run economic costs for railroad movements, but URCS costs depend materially on input values based on "stale" analyses and non-empirical assumptions
- Using Carload Waybill Sample (CWS) data to reveal movement cost information has promise but also practical and theoretical challenges
- URCS variability inputs can and should be updated, but limitations of the R-1 annual report data may merit consideration of changes to cost reporting requirements
- The "Hybrid" model is a feasible alternative for costing Class I movements, and its costs generally are plausible where different from legacy URCS
- Updates to URCS Phases I and III can improve movement costing largely within the existing URCS framework
- Both the Hybrid alternative and URCS update approaches have merit, with the key tradeoffs related to the validity of the Hybrid's use of NEIO regression models to measure movement-specific costs

- Implementing either the Hybrid model or a significant URCS update will materially affect application of the STB's statutory jurisdictional threshold

Section I of the report provides background information on the origins of URCS, the structure of URCS implementation "phases," and the uses of URCS in the STB's regulatory proceedings. Section II of the report assesses the economic content of URCS costs and considers the appropriate economic cost concept and time orientation given the regulatory uses of URCS. Section II also details stakeholder feedback on URCS and priorities for URCS improvements. Section III describes the Hybrid model, presents the econometric analyses of CWS and cost data required to implement the Hybrid model, and reports summary results for variable costs and R/VC ratios. The cost analysis also is used (in part) in updated URCS models. Section IV reviews URCS model updates, including updates to variability inputs (Phase I) and the movement costing model (Phase III). Costs and R/VC ratios from updated URCS models are compared to corresponding Hybrid model results. Finally, Section V offers overall conclusions.

B. Background and Review of URCS Methodology

The statutory application of URCS is to determine variable costs for the STB's jurisdictional threshold, where railroads are deemed not to exercise "market dominance" over traffic with an URCS R/VC ratio below 180 percent. The statute (49 U.S.C. §10707) requires that variable costs for application of the threshold be obtained either from URCS or a successor cost system adopted by the STB in lieu of URCS. Significantly, the 180 percent R/VC threshold is fixed in the statute. As a result, any cost methodology change—whether a modification or replacement of URCS—with a material effect on measured variable costs will affect the volume of rail freight subject to the jurisdictional threshold. URCS also has several non-statutory applications for STB regulatory activities.

URCS implementation consists of three phases. Phase I defines cost pools for analytically relevant groups of railroad operating costs, and implements econometric cost equations used to derive "variability factors" indicating the portions of those costs that are variable with railroads' outputs—i.e., variable cost. Phase I was conducted once, prior to the Interstate Commerce Commission (ICC)'s adoption of URCS. Phase II is an annual process that compiles data from the railroads' R-1 annual reports and other sources on railroad costs and outputs. Phase II is implemented as a set of linked electronic (Microsoft Excel) workpapers that compute unit variable costs and other statistics for Class I railroads that serve as inputs to movement-level costs. Phase III computes variable costs for railroad freight movements using an engineering-economic model that combines movement characteristics with unit variable costs and other data from Phase II.

We describe the general economic structure of URCS costs and review the set of guiding principles for railroad costing methodology, established by the RAPB under a mandate in the Staggers Rail Act of 1980. The RAPB principles, particularly the Causality principle, continue to provide useful guidance for railroad costing. The Causality principle implies that URCS should measure variable costs that would be analytically equivalent to the economic concepts of marginal and/or incremental costs.

Given the applications of URCS and the RAPB principles, we consider the appropriate type of economic costs that URCS should represent. Economic interpretation of URCS costs fundamentally flows from the RAPB's Causality principle, which correctly defined causal variable costs consistent with the economic concepts of marginal and incremental costs. Since the main application of URCS relates to measurement of railroads' exercise of market power, the appropriate time horizon for URCS costs should be a form of the economic "short run." The economic short run is characterized by limitations on railroads' ability to freely adjust all of their input usage over relevant decision horizons—generally, the time periods over which railroad rates potentially subject to STB review are in effect. Notably, capital inputs such as way, structures, and equipment may be viewed as less flexible over shorter time horizons than inputs comprising railroads' operating costs. Technically, the "intermediate run" orientation of URCS variable costs constitutes a type of short run costs, but is implemented by applying non-empirical ("default") variability factors for capital costs of way, structures, and equipment.

Section II of the report assesses whether the URCS model structure and implementation are compatible with short-run marginal and incremental costs and reviews critiques of URCS from other stakeholders. We find that URCS can produce marginal and incremental costs insofar as Phase I variabilities and other cost allocators are equivalent to cost elasticities with respect to railroad outputs (output elasticities). Methods that produce estimates of average variable costs generally are inconsistent with the Causality principle. The Phase I variabilities can be interpreted as output elasticities given the specific form of the models, though Phase I as originally implemented was not intended to produce output elasticities in general. The use of "default" variabilities for capital costs is not necessarily inconsistent with the causality principle, but the validity of the cost allocations depends on the ability to empirically justify the assumed variabilities. Changes in railroad cost structure have markedly increased the share of Class I railroad costs subjected to default variabilities, from 22 percent as of the adoption of URCS to 44 percent in 2019.

Validity and accuracy of URCS costs also depends critically on the appropriate implementation of efficiency adjustments for certain categories of movements in Phase III, such as the "make-whole" carload efficiency adjustments to switching costs. Given their importance for URCS costing, the Phase I models and Phase III efficiency adjustments were, not surprisingly, identified as potential priorities for URCS improvements by stakeholders in STB proceedings on URCS[1] and in direct stakeholder interviews we conducted as part of the study.

From these findings we conclude that the focus for URCS alternatives and updates has three main parts:

[1] Dockets Ex Parte 431 Sub-no. 3 and Sub-no. 4.

1. Updating or replacing the Phase I variability analysis consistent with a goal of producing short-run marginal and incremental costs
2. Improving the structure and accuracy of movement-specific cost adjustments in URCS Phase III or an alternative movement costing approach such as the NEIO or Hybrid models
3. Conducting scenario or sensitivity analysis to identify whether model parameters that cannot be directly validated have material effects on costs, to inform where resources may be prioritized for future empirical work

The project pursued two tracks of investigation. First, the project considered alternatives to URCS identified in the STB's 2010 Report to Congress on URCS.[2] Second, we examined updates to URCS combining Phase I-equivalent variabilities generated in the URCS alternative track with structural changes to Phase III that had been proposed in Docket No. Ex Parte 431 sub-no. 4. We consider a comparison between alternative cost models and an updated URCS model to be more appropriate than a comparison of alternatives with legacy URCS.

C. AN ALTERNATIVES TO URCS: THE HYBRID MODEL

The first track investigated the "new empirical industrial organization" (NEIO) model developed by Bitzan and Wilson[3] and the "Christensen Hybrid" (or simply "Hybrid") model presented in the Christensen Associates 2009 Competition Study.[4] Both alternatives employ econometric models of freight rate (revenue per ton-mile) data from the CWS to derive movement-specific costs. The Hybrid model combines the NEIO model's CWS regression analysis with a separate econometric cost model.

Both the NEIO and Hybrid models yield short-run costs in principle, as the modeling of CWS rate data would reveal railroads' perceived costs over the limited time horizon that the rates would be in effect. A chief advantage of these alternatives is that they avoid the need to specify, via operational studies or analyst judgment, a broad array of URCS cost allocators and other inputs used both to derive generic unit variable costs (Phases I and II) and movement-specific cost differences or efficiency adjustments (Phase III). In particular, the CWS regressions directly produce empirical estimates of movement-specific cost differences. The large and rich CWS datasets allow the NEIO regressions to be estimated using only recent data and thus reflect current railroad operations.

We eliminated the NEIO model as a stand-alone URCS alternative on theoretical grounds related to the absence of direct cost information in the CWS and proceeded with implementations of the Hybrid model. The Hybrid model requires estimating generic (non-shipment-specific) marginal

[2] Surface Transportation Board, "Report to Congress Regarding the Uniform Rail Costing System," May 27, 2010 (STB 2010). We also reviewed additional costing alternatives based on economic cost function estimation not identified in the STB's 2010 report and explain why we did not consider those approaches further in Section III of the report.

[3] Wilson, Wesley W., and John D. Bitzan, "Costing Individual Railroad Movements," Federal Railroad Administration (September 2003) (Bitzan and Wilson 2003).

[4] Christensen Associates, "A Study of Competition in the Freight Railroad Industry and Analysis of Proposals That Might Enhance Competition," November 2009 (Christensen 2009), Chapter 11.

costs in addition to the CWS modeling in the NEIO approach. In the 2009 Competition Study, the generic marginal costs were derived from econometric estimation of an "industry variable cost" function based primarily on R-1 annual report data. Generic marginal (or unit variable) costs in the Hybrid model also can be derived from cost equations like those used in URCS Phase I. We implemented both generic cost approaches and found that sample size limitations of the R-1 annual report data require using relatively long data series in the cost modeling. The need to use long R-1 cost data series blunts some of the Hybrid model's advantages from basing movement cost adjustments on CWS data reflecting relatively current railroad operations.

We refined the NEIO regression component of the Hybrid model to remedy several significant limitations of the model presented in the 2009 Competition Study. The refinements allow the Hybrid model to cost all railroad movements for which generic marginal cost data are available,[5] improve costing of intermodal movements, and to allow increased flexibility of movement-specific costs with respect to cost-causing characteristics including movement distance and size in carloads. We also conducted an analysis of current-methodology URCS costs using the NEIO model framework to allow us to compare effects of movement cost characteristics between URCS and the Hybrid alternative.

The NEIO regression results indicate several differences between the cost structure implied by rate data in the CWS and the current-methodology URCS model. Notably, there are:

- Smaller economies with respect to movement size (carloads) than URCS, and no support for the step function structure of URCS carload efficiencies
- Larger economies with respect to movement distance than URCS
- Larger cost efficiencies for intermodal movements (relative to single-carload non-intermodal movements) compared to URCS
- Smaller implicit rental costs for railroad-owned equipment relative to URCS
- Significant rate premiums for hazardous material movements that may in part reflect implicit or explicit costs of such movements that are absent from URCS

The updated Phase I models reconsidered both the URCS assignments of operating expenses to cost pools and the linear (levels) specifications of the current URCS Phase I models. We also extended the Phase I variability analysis to produce empirical short-run cost elasticities for capital costs—return on investment, depreciation, lease, and rental expenses—that do not have empirical variabilities in URCS.

The econometric cost analysis required to implement the Hybrid model yielded the following significant findings:

[5] In the 2009 Competition Study, the original Hybrid model costs could only be computed for a subset of movements in the CWS involving a single Class I railroad, and thus did not cover movements involving interchanges among railroads.

- The overall degree of cost variability derived from both cost modeling approaches—the industry-level variable cost function and updated Phase I cost equations—is materially lower than that of current-methodology URCS
- In the updated Phase I analysis, lower overall variabilities were driven, plausibly, by cost pools exhibiting higher degrees of variability with respect to network size measures, including cost pools for yard and running track maintenance and general administrative expenses
- Empirical short-run cost elasticities with respect to output for capital costs assigned "default" variabilities in URCS also are markedly lower than the assumed URCS variabilities
- Recent R-1 annual report data provide at best limited ability to reliably estimate parameters of "flexible" cost functions such as the translog industry variable cost function based on the 2009 Competition Study, leading us to prefer costs based on updated Phase I models

Other things equal, the generally lower cost variability relative to current-methodology URCS will reduce measured variable costs for railroad movements and increase R/VC ratios.

We implemented four cost scenarios for the Hybrid model:

- URCS variabilities ("URCS" scenario)
- A limited Phase I update retaining URCS default variabilities and thus the "intermediate run" orientation of current URCS methodology ("CA1" scenario)
- A full Phase I update including empirical capital cost elasticities, implementing a short-run cost model ("CA2" scenario), our preferred approach.
- Short-run costs derived from the industry variable cost function ("CA3" scenario)

The URCS scenario serves to isolate differences in movement costs from replacing URCS Phase III with the NEIO regressions in the Hybrid model from differences related to changes in cost variability from the updated Phase I or industry variable cost models. The URCS and CA1 scenarios both also retain URCS default variabilities for return on investment, depreciation, lease, and rental costs. Differences between those scenarios and the CA2 and CA3 results are due primarily to changes in the effective variabilities for the costs subject to the assumed URCS default variabilities.

Tables ES-1 and ES-2 compare variable cost per ton-mile by movement size categories for the Hybrid model scenarios and URCS. Qualitatively, the Hybrid model and URCS agree that single-carload and intermodal movements have the highest variable cost per ton-mile (on average), while unit train movements over 75 carloads have the lowest costs. Using URCS variabilities to isolate the effects of movement costing changes, the Hybrid model shifts costs from intermodal movements to URCS multiple (6+) carload movements, with notably large increases in measured costs for shipment size categories above breaks in the URCS carload step functions. Costs for movements in the 1-5 carload range are little changed. Incorporating updated cost elasticities from the updated Phase I and industry variable cost models broadly reduces measured variable costs, with the largest cost differences resulting from the incorporation of empirical capital cost elasticities in the "Full Phase I Update" scenario.

Table ES-1. 2019 Variable Cost Per Revenue Ton-Mile by Shipment Size Category, Legacy URCS and Hybrid Models

	2019 Cents/RTM				
Size Category	Legacy URCS	Hybrid-URCS Variabilities	Hybrid-CA1	Hybrid-CA2	Hybrid-CA3
1 Carload	3.58	3.50	3.33	2.43	2.73
2-5 Carloads	2.98	2.99	2.83	2.08	2.30
6-24 Carloads	2.57	2.96	2.80	2.06	2.22
25-49 Carloads	2.58	2.70	2.57	1.89	1.99
50-74 Carloads	2.24	2.97	2.81	2.06	2.23
75+ Carloads	1.55	1.82	1.71	1.26	1.38
Intermodal	3.84	3.24	3.05	2.25	2.50

Table ES-2. Changes in 2019 Variable Cost Per Revenue Ton-Mile by Shipment Size Category, Hybrid Models Versus Legacy URCS

	Percent Change vs. Legacy URCS			
Size Category	Hybrid-URCS Variabilities	Hybrid-CA1	Hybrid-CA2	Hybrid-CA3
1 Carload	-2%	-7%	-32%	-24%
2-5 Carloads	0%	-5%	-30%	-23%
6-24 Carloads	15%	9%	-20%	-14%
25-49 Carloads	5%	-1%	-27%	-23%
50-74 Carloads	32%	25%	-8%	-1%
75+ Carloads	18%	10%	-19%	-11%
Intermodal	-16%	-21%	-42%	-35%

Table ES-3 compares shares of freight traffic (in tons) above 180 percent R/VC in the 2019 CWS sample compared to the Hybrid models. In the 2019 CWS sample using legacy URCS costs, 45 percent of rail tonnage moves above 180 percent R/VC overall. Intermodal movements have the lowest share above 180 percent R/VC at 23 percent, reflecting relatively high intermodal unit costs in legacy URCS. The 50-74 carload size category has the highest share of traffic above 180 percent R/VC in legacy URCS, 82 percent.

Holding variability levels constant, the Hybrid model yields a 33 percent share of traffic (in tons) above 180 percent R/VC which is considerably lower than the 45 percent share based on the current URCS methodology. This is due to two factors. First, the larger intermodal efficiencies in the Hybrid model generally shift variable costs from intermodal to carload movements, tending to reduce R/VC ratios for carload movements. Second, the NEIO-based movement costs put less traffic in the upper tails of the R/VC distributions compared to URCS.

Using the updated Phase I operating cost variabilities but retaining URCS defaults in the Hybrid model still results in a lower share of freight tons above 180 percent R/VC compared to current-methodology URCS, 38 versus 45 percent. Using a full set of empirical cost elasticities including capital cost elasticities, 69 percent of tons are above 180 percent R/VC. Basing the Hybrid costs on the industry variable cost model results in 56 percent of tons above 180 percent R/VC, still materially higher than current-methodology URCS. Unit train movements with 75+ carloads have the lowest share of tons above 180 percent R/VC in all Hybrid model scenarios.

Table ES-3. 2019 Shares of Freight Traffic (Tons) Above 180 Percent R/VC, Legacy URCS and Hybrid Models

Shipment Category	Legacy URCS	Hybrid-URCS Variabilities	Hybrid-CA1	Hybrid-CA2	Hybrid-CA3
1 Carload	46%	40%	46%	77%	65%
2-5 Carloads	38%	35%	41%	75%	64%
6-24 Carloads	53%	32%	37%	71%	61%
25-49 Carloads	49%	36%	40%	70%	57%
50-74 Carloads	82%	35%	39%	75%	60%
75+ Carloads	46%	26%	31%	60%	47%
Intermodal	23%	37%	43%	74%	63%
Total	45%	33%	38%	69%	56%

Table ES-3 shows that any implementation of the Hybrid model will materially affect shares of traffic subject to the STB's jurisdictional threshold. The largest differences result from the replacement of URCS default variabilities with empirical estimates in the Full Phase I Update scenario. Maintaining a relatively constant share of freight traffic (tons) subject to the STB's jurisdiction would require a bridge adjustment in the absence of a change to the statutory 180 percent R/VC threshold.

D. UPDATES TO URCS

The second track of the project is presented in Section IV of the report. We investigated costing updates largely within the current URCS modeling framework, particularly to the current Phase I and Phase III models. This track is motivated by three main considerations. First, it is theoretically possible for the URCS framework to produce variable costs for railroad movements that both would be consistent with the Causality principle and would closely resemble costs from the Hybrid model. Second, stakeholder views tended to favor Phase I and Phase III updates over clean-sheet alternatives. Third, major elements were readily available to allow a significantly updated URCS model to be implemented. These elements include cost modeling for the Hybrid model providing updated variabilities that can be applied in the URCS Phase II workpapers, and the "carload weighted block" (CWB) model of switching costs from the Ex Parte 431 sub-no. 4 proceeding providing an alternative model of carload efficiencies which, like the NEIO model, eliminates the step functions incorporated in legacy URCS.

Section IV first considers the merits of a variety of potential URCS model updates affecting all three URCS phases. URCS Phase I is overdue for reconsideration of some methodological details and general updating irrespective of the model framework (Hybrid or URCS). The CWB model for carload-related switching cost efficiencies replaces the legacy URCS model's step functions with a continuous function that includes a component based on the event (or block) and a component based on the number of carloads. The cost per event and cost per carload are unknown *a priori*. The STB proposed to determine the unknown cost parameters by calibrating the CWB curves to the legacy URCS efficiency adjustments. The CWB model's elimination of step functions in the legacy URCS carload efficiency adjustments with a linear approximation to the true costs is a clear structural improvement. However, the correct parameterization of the CWB cost curves is an open empirical question, and we consider both the STB proposal and an alternative parameterization presented in Ex Parte 431 sub-no. 4 featuring generally smaller carload-related economies for large movements.

Section IV also assesses the sensitivity of URCS costs to URCS inputs that are based on old operational studies or, in some cases, assumptions made by the analysts who developed URCS. These include factors used to annualize certain expenses, car-mile and car-day parameters used to develop mileage and dwell time in switching operations, and "equated switching factors" used to allocate aggregate switch equipment minutes to types of switching (i.e., industry, interchange, intertrain and intratrain). Insofar as the STB's 2010 Report to Congress indicated that a comprehensive update of study-based URCS inputs would be very costly, the sensitivity analysis is intended to provide information to guide priorities for future data collection or other research into URCS updates.

As in the Hybrid model analysis, we produced costs from updated URCS models using multiple scenarios for variability factors, largely similar to the Hybrid model scenarios:

- Current URCS variabilities ("URCS" scenario)
- A limited Phase I update retaining URCS default variabilities ("CA1" scenario)
- A full Phase I update including empirical capital cost elasticities ("CA2" scenario).

We did not implement variabilities based on the industry variable cost model as we judged its elasticity assumptions to be too restrictive for application in the URCS framework. In addition, we considered two parameterizations of the CWB model. One represents the STB's proposal in the Ex Parte 431 sub-no. 4 Supplemental Notice of Proposed Rulemaking ("431s4" scenarios). The second ("30/70" scenarios) uses a 30 percent weighting on the carload component of the CWB model, based on a submission from Association of American Railroads (AAR) consultants in Ex Parte 431 sub-no. 4. The carload efficiencies in the 30/70 scenarios are generally smaller than the STB's proposal from the SNPR reflected in the 431s4 scenarios. We used modified Phase II workpapers and Excel implementations of the Phase III models to compute alternative costs and R/VC impacts for a stratified random subsample of waybills from the 2019 CWS.

Tables ES-4 and ES-5 summarize variable costs per ton-mile from the updated URCS scenarios. Using URCS variabilities, the Phase III model changes have little effect on measured costs for intermodal movements. The STB's CWB approach in the 431s4 scenario slightly increases unit variable costs for 1-carload and 50+ carload movements, while reducing costs for other multiple-carload movements. Holding variabilities constant, measured variable costs increase (decrease) for movement categories where the CWB efficiency curve is above (below) the legacy step function. The 30/70 scenario results in higher measured costs for unit train movements as its CWB curves feature smaller efficiencies for large movements than the legacy efficiency adjustments; this in turn reduces measured costs for 1-carload movements relative to URCS. Incorporating updated variabilities in the CA1 and CA2 scenarios results in fairly uniform downward shifts of measured costs, mirroring the effects of the same variability models when applied to the Hybrid model. The lower updated variabilities will tend to shift R/VC distributions up, other things equal, again tending to increase shares of traffic above 180 percent R/VC.

Table ES-4. Impact of URCS Updates on Variable Cost Per Ton-Mile by Shipment Size Category

Shipment Category	Unit Variable Cost (2019 Cents/Ton-Mile)						
	Current URCS	URCS +431s4	CA1 +431s4	CA2 +431s4	URCS +30/70	CA1 +30/70	CA2 +30/70
1 Carload	3.591	3.66	3.365	2.405	3.454	3.197	2.316
2-5 Carloads	3.157	2.58	2.383	1.756	2.606	2.406	1.79
6-24 Carloads	2.584	2.326	2.184	1.617	2.448	2.286	1.699
25-49 Carloads	2.632	2.311	2.177	1.613	2.472	2.311	1.715
50-74 Carloads	2.35	2.456	2.301	1.659	2.72	2.519	1.821
75+ Carloads	1.567	1.612	1.492	1.09	1.691	1.555	1.137
Intermodal	3.859	3.875	3.662	2.832	3.875	3.662	2.833

Table ES-5. Percent Changes in Variable Cost Per Ton-Mile by Shipment Size Category Compared to Current-Methodology URCS

Shipment Category	URCS +431s4	CA1 +431s4	CA2 +431s4	URCS +30/70	CA1 +30/70	CA2 +30/70
1 Carload	2%	-6%	-33%	-4%	-11%	-36%
2-5 Carloads	-18%	-25%	-44%	-17%	-24%	-43%
6-24 Carloads	-10%	-15%	-37%	-5%	-12%	-34%
25-49 Carloads	-12%	-17%	-39%	-6%	-12%	-35%
50-74 Carloads	4%	-2%	-29%	16%	7%	-23%
75+ Carloads	3%	-5%	-30%	8%	-1%	-27%
Intermodal	0%	-5%	-27%	0%	-5%	-27%

Table ES-6 shows the shares of tons above 180 percent R/VC in the updated URCS models. The non-variability updates have relatively little effect on the overall shares of tons above 180 percent R/VC. However, there are some material changes within the range of carload size categories as the CWB models tend to raise measured costs for movements above 50 carloads and reduce measured costs for 2-49 carload movements. Effects on 1-carload movements are mixed. The scenarios incorporating updated variabilities increase traffic above 180 percent R/VC. Compared to the Hybrid model results in Table ES-4, the updated URCS scenarios yield higher fractions of tons above 180 percent R/VC due in part to higher allocations of costs to intermodal movements (reducing costs and increasing R/VCs in carload categories) and greater variability of measured R/VCs in URCS. Effects of costing changes on the jurisdictional threshold are mitigated by the large share of rail freight traffic for commodities or car types, and/or moving at contract rates, that is not subject to rate regulation irrespective of R/VC.[6]

Table ES-6. Share of Tons Above 180 Percent R/VC, by Size Category (431s4 Scenarios)

Shipment Category	URCS	URCS +431s4	CA1 +431s4	CA2 +431s4	URCS +30/70	CA1 +30/70	CA2 +30/70
1 Carload	47%	44%	53%	80%	50%	59%	84%
2-5 Carloads	32%	62%	68%	91%	60%	68%	89%
6-24 Carloads	53%	61%	65%	88%	55%	62%	85%
25-49 Carloads	48%	60%	66%	90%	50%	59%	87%
50-74 Carloads	83%	67%	71%	97%	57%	66%	94%
75+ Carloads	46%	44%	48%	74%	39%	44%	72%
Intermodal	24%	24%	27%	49%	24%	27%	49%
Total	45%	44%	50%	76%	43%	49%	75%

The URCS update scenarios did not implement changes to efficiency parameters affecting costs of intermodal movements, as those were outside the scope of the Ex Parte 431 sub-no. 4 model

[6] An analysis of 2018 CWS data provided by the STB showed that 8.4 percent of carloads and 14.2 percent of tons were for nonexempt movements at tariff rates and thus are potentially subject to STB jurisdiction.

changes. However, we conducted a calibration exercise to estimate the effects of reducing intermodal costs in line with the Hybrid model results, which shifts costs from intermodal to carload movements. This reduces the share of tons above 180 percent R/VC by two percentage points in the CA1 scenarios and by three percentage points in the CA2 variability scenarios—in the latter scenarios, this accounts for approximately half the distance between the Hybrid (69 percent over 180 percent R/VC) and updated URCS models (75-76 percent). We found that URCS costs from the 30/70 scenarios were closer to Hybrid model results than the 431s4 scenarios.

As with the Hybrid model, the main effects on the jurisdictional threshold result from variability changed affecting the overall level of variable costs, with additional effects from distributional changes resulting from reallocations of carload movements' costs using the CWB efficiency adjustments. The modified URCS models' relatively high shares of tons above 180 percent R/VC with the full variability update including defaults (CA2 scenario) may entail larger bridge adjustments than the Hybrid model.

The scenario analysis of other URCS input parameters found small effects of most of the investigated changes on measured URCS costs. We found that some switching inputs had largely offsetting effects when changed. For instance, reducing dwell times increased unit variable costs per car-day, but reduced car-days per event. The inputs with the largest effects on 2019 costs were cost annualization factors intended to smooth some costs that the original URCS design anticipated could be incurred irregularly. Since the annualized costs are broadly declining per unit of output, cost annualization increases 2019 variable costs (and thus reduces measured R/VC ratios) compared to the use of actual 2019 expenses throughout the model. We could not compute alternative costs for multiple years to determine the extent to which annualization succeeds in smoothing costs.

E. Conclusions and Recommendations

Given the primary role of URCS in evaluating whether railroads exert market dominance in their rates, short-run costs (marginal and/or incremental costs) are the most appropriate economic cost concept for URCS variable costs. Short-run marginal and incremental costs are consistent with the Causality principle underlying URCS methodology and are feasible to produce using existing data. The same general framework also may be used to produce costs using the "intermediate run" time orientation in current-methodology URCS.

For the Alternatives to URCS project, we implemented the "Hybrid" model as an URCS alternative. To provide an appropriate basis for evaluating the Hybrid model, we also implemented modified URCS models with significant changes to the Phase I variabilities and Phase III movement costing models. Variable costs derived from both the Hybrid model and updated URCS models exhibit some material differences from current-methodology URCS costs in all model scenarios we investigated. The largest differences from current-methodology URCS result from the implementation of variabilities (cost elasticities) that implement short-run costs in

the Hybrid and updated URCS models. Additional material differences in model costs result from changes to the calculations of movement-specific variable costs.
We consider both the Hybrid model and updated URCS models to be promising alternatives to current-methodology URCS. The Hybrid and updated URCS models share new Phase I variabilities that improve upon the legacy URCS analysis from 1988, and we recommend that the Phase I models be updated regardless of the modeling approach. Using the full set of short-run cost elasticities—including the empirical replacements for URCS default variabilities—greatly mitigates (but does not eliminate) the URCS critique that an excessive share of freight traffic moves below its measured variable cost.

The Hybrid model's use of an econometric analysis of CWS data to model marginal cost differences across movements has significant advantages and disadvantages relative to current URCS methods. The main advantage is that the Hybrid's NEIO regression model of CWS data provides empirical estimates of nearly all movement-specific cost adjustments required to implement the model, and thus in principle eliminates the need to maintain numerous URCS model parameters derived from studies of railroad operations or—in some cases—analyst judgment. The CWS regression models are straightforwardly updated with new CWS data as it becomes available and may thus be refreshed annually or periodically as desired. The Hybrid model can potentially be enriched with improved econometric methods that allow better exploitation of the rich CWS data.

The Hybrid model's main disadvantage is a technical econometric issue but a potentially serious one, which is closely related to our rationale for rejecting the NEIO model as a stand-alone URCS alternative. The NEIO regression is a "reduced form" model in which it is not technically possible to ensure that the "cost" variables in the regression only capture effects of movements' cost characteristics and are not contaminated with effects of factors determining markups. An additional consideration is that the NEIO regression amounts to a "black box" from which the cost mechanisms underlying the model cannot be observed or validated. Finally, the Hybrid model has a limited ability to produce costs for Class II and III railroads, since the regional URCS proxy costs currently used in URCS are not suitable inputs for the Hybrid model. Possibilities are to require some level of cost and output reporting of Class II and III railroads, or retaining URCS to cost Class II and III movements in the absence of data to justify a change in methodology.

The advantages and disadvantages of the URCS update approach are, in large part, the antipodes of those of the Hybrid model. The modified URCS models are relatively transparent in that the development and application of costs and cost adjustments can be traced through the Phase II and Phase III models. However, the URCS cost calculations depend on numerous parameters whose values are difficult if not impossible to obtain from data periodically reported by railroads to the STB. As our sensitivity analysis suggests, many such parameters may not have material effects on measured movement costs even if their values are grossly inaccurate; immaterial inaccuracies may be tolerated under the RAPB's Practicality principle. However, important parameters such as carload and intermodal efficiency adjustments are material and are not easily measured.

Results from the Hybrid model analysis suggest that intermodal cost efficiencies should increase, and carload efficiencies should decrease, relative to current URCS values. However, because of model structure differences, Hybrid model data do not imply specific values for URCS model inputs. Thus while we believe that the adoption of the CWB model for URCS switching costs would be a significant structural improvement over current methodology, further study may be needed to determine appropriate parameters for the CWB approach.

URCS is fundamentally tied to the railroad regulatory system by statute. While some researchers have argued for systems of railroad rate regulation that do not employ costs at all, those approaches are not consistent with current law.[7] Without Congressional action, URCS can only be replaced in the statutory test for STB jurisdiction over rates by an alternative cost system that produces variable costs for railroad movements. Adoption of either an alternative cost system or a substantial update to URCS will materially affect the amount of railroad traffic subject to the jurisdictional threshold, and use of a short-run cost model specifically will increase traffic subject to the threshold by generally lowering levels of measured variable costs. Effects of costing changes on rail traffic subject to the jurisdictional threshold may be mitigated by implementing a "bridge adjustment" with current-methodology URCS. A more flexible threshold, which would also require changes to statute, could be linked to a breakeven markup over short run economic costs.

[7] See, e.g., Wilson, Wesley W., and Frank A. Wolak, "Freight Rail Costing and Regulation: The Uniform Rail Costing System," *Review of Industrial Organization* (May 3, 2016); Transportation Research Board, *Modernizing Freight Rail Regulation*, Special Report 318, 2015, pp. 206-208.

I. INTRODUCTION AND BACKGROUND

A. THE ALTERNATIVES TO URCS PROJECT

The Uniform Rail Costing System (URCS) is the Surface Transportation Board's (STB or Board) general purpose costing methodology used to estimate "variable costs" for freight movements by U.S. railroads. The STB adopted the URCS methodology in 1989, and, as currently implemented, URCS largely retains the 1989 methodology.

The *Alternatives to URCS* project set out to identify and evaluate possible alternatives to the STB's URCS that could better or more efficiently reflect costs of rail freight movements under the operating environment of the modern railroad industry. The project has focused on costing methodologies that could be feasibly implemented using existing data sources to replace or improve URCS for generating movement-specific "variable costs" for regulatory purposes. To this end, we:

- Assessed the appropriate economic cost concepts to be measured by URCS or a successor costing system and whether, or under which conditions, current-methodology (or "legacy") URCS variable costs are valid estimates of economic costs for railroad movements
- Evaluated whether alternative or otherwise improved costing methodologies could feasibly and reliably measure railroad variable costs for regulatory purposes
- Implemented alternative and improved costing methodologies, compared key results to URCS, and discussed advantages and disadvantages of the prospective changes
- Considered how the alternatives adhere to the principle of cost causality and other principles outlined in the Railroad Accounting Principles Board (RAPB) Final Report
- Identified and quantified the effects of the costing methodology changes on the application of the STB's jurisdictional threshold

This section of the report provides background information on URCS and its uses that we reference throughout the report, and an overview of the subsequent sections reporting the analyses performed for the project.

B. ORIGINS AND USES OF URCS

1. Origin of URCS

Costs have long played a central role in railroad regulatory oversight. Starting in 1939, the Interstate Commerce Commission (ICC) used statistical techniques to estimate the "variable costs" of various rail services using a cost accounting system called Rail Form A. Rail Form A applied statistical techniques and engineering-economic models to annual data on operations and expenses reported by the railroads to the ICC. In 1976, Congress enacted the Railroad Revitalization and Reform Act (4R Act). Part of the 4R Act instructed the ICC to develop a more accurate costing system. The Staggers Rail Act of 1980 (Staggers Act) established the RAPB to provide guidance to the ICC on costing methodology and to establish and evaluate principles governing the determination of direct and indirect costs, including variable costs, associated with movements of goods by rail.

Between 1980 and 1989, the ICC developed URCS with guidance from the RAPB. Compared to Rail Form A, URCS incorporated expense data from an improved system of railroad accounts, incorporated additional detail in the model such as costs specific to freight car types, and used more sophisticated econometric methodology to develop railroads' variable costs as costs that vary with the levels of rail traffic measures (i.e., outputs).

The RAPB's work culminated in 1987 with the Railroad Accounting Principles Board Final Report (RAPB Final Report). The RAPB Final Report established eight railroad accounting principles, four "general Principles," and four "specific Principles," and discussed the interrelationship of these principles and different regulatory applications.[8] The RAPB also provided guidance, based on the general principles, for several specific costing methodology issues relevant to the development of URCS. We review the RAPB's principles and guidance for costing methodologies in Section II.D., below.

The ICC adopted URCS as its "general purpose costing system" (GPCS) in 1989. URCS provides the railroad industry and shippers with a standardized costing model and is used for a variety of regulatory functions. Most prominently, URCS variable costs for freight traffic are established by statute as the denominator of the revenue-to-variable cost ratio (R/VC) test determining whether rail rates are subject to the STB's jurisdiction.[9] In addition to the role in market dominance determinations, URCS costs are used for other purposes in railroad rate reasonableness proceedings. In 2006 and 2007 rulemakings, the STB increased its reliance on URCS across the spectrum of rate cases. URCS is used in the Stand Alone Cost (SAC), Maximum Markup Methodology (MMM), Simplified SAC, and the Three Benchmark (3B) methodologies.[10]

URCS is also used for cost determinations in abandonments, certain trackage rights cases, and other proceedings. URCS is used to cost the Board's Carload Waybill Sample to develop industry cost information and to provide interested parties with basic cost information on the Class I railroad industry.

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[8] Railroad Accounting Principles Board, "Railroad Accounting Principles: Final Report," (RAPB Final Report) Volume 1 – Summary of Report," Chapter 1, September 1, 1987.

[9] See 49 USC § 10707(d)(1)(B). Notably, the STB may adopt an alternative cost methodology in lieu of URCS, but the 180 percent R/VC jurisdictional threshold is codified in § 10707(d)(1)(A) and would require an act of Congress to change. The RAPB notes that "The statute requires the use of GPCS to calculate variable costs." See RAPB Final Report, Vol. 2, p. 5.

[10] Surface Transportation Board, "Report to Congress Regarding the Uniform Rail Costing System," May 27, 2010 (STB 2010 URCS Report), pp. 7-8.

2. *URCS Implementation: Phases of URCS*

URCS uses a multi-stage process to estimate variable costs for rail shipments using expense and operating data reported annually by Class I railroads, as well as inputs derived from special studies. The implementation stages of URCS are called "phases" and are distinguished by the types of cost information generated and the frequency of updates. Descriptions of URCS including URCS alternatives and updates throughout this report reference the phases extensively, and we summarize the URCS phases below.

a) Phase I

URCS Phase I defines activity-based cost pools—subsets of railroad expenses reported in the R-1 annual reports—and associated econometric cost models that relate the expenses to railroad output and "capacity" (network size) measures. Estimated parameters of the cost models are used to determine cost variability factors (or "variabilities"). The variabilities indicate the portion of expenses in the cost pools that are treated as variable costs and assigned to rail freight movements. As we discuss in Section II, the economic interpretation of the Phase I variabilities is a key to the economic meaning of URCS variable costs. Updates to Phase I were expected to be conducted periodically after the adoption of URCS. However, URCS Phase I has been conducted once thus far, prior to the adoption of URCS as the GPCS.

b) Phase II

URCS Phase II is an annual process that compiles Class I railroad expense and operating data for the most recent five years, computes variable costs associated with various railroad outputs based on estimated variability factors derived from the Phase I models, and combines data on output quantities and variable costs to compute non-movement specific unit variable costs by railroad that serve as inputs to the subsequent movement costing stage (Phase III). In addition to railroad-specific costs for Class I railroads, Phase II produces costs for regional (East and West) composites of Class I railroad data that are used to cost freight movements on Class II and III railroads. Phase II also develops operating factors used to apply the unit variable costs to individual rail movements.[11]

While the annual updates to Phase II are a largely mechanical process, and Phase II is often characterized as a mechanical exercise, the Phase II calculations encompass some economically significant portions of the URCS model. These include calculations of variable costs for road property and equipment using "default" variabilities (which are not estimated in Phase I, but rather based on assumptions carried over from Rail Form A), allocations of variable costs among railroad outputs to reflect patterns of cost causation not explicitly modeled in Phase I.[12] The Phase II stage also derives quantities of railroad outputs, based on special study values, for

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[11] Interstate Commerce Commission, "Preliminary 1979 Rail Cost Study: Uniform Railroad Costing System," September 1981 (1979 Rail Cost Study), p. 76.

[12] The 1979 Rail Cost Study, p. 82, characterizes this as a "semi-default" cost variability method. In these cases, the variability factor for the expense account is obtained econometrically, but the output variable used in the econometric equation is not assumed to be the only independent (output) variable determining costs.

outputs that are not available from annual report data—for example, switch engine minutes (SEM) by type of switching activity. Many special study inputs employed in Phase II pre-date URCS, and the Phase II cost allocation methods, like the Phase I econometric analysis, have not been subject to routine updating since the adoption of URCS.

c) Phase III

URCS Phase III is an engineering-economic model that combines unit variable costs and other inputs from Phase II with characteristics of individual rail movements to derive variable costs for specific rail movements. Phase III estimates quantities of railroad outputs including (but not limited to) gross ton-miles, locomotive unit miles, SEM, and other service units associated with the movement. The Phase III model computes the movement variable costs by applying Phase II unit variable costs to the movement-specific outputs, and by carrying out adjustments to the resulting movement costs intended to reflect production efficiencies associated with multiple-carload, unit train, and intermodal shipments. The Phase III model—encompassing results from Phases I and II—is used to assign costs to observations in the Carload Waybill Sample and for other regulatory purposes as discussed below.

3. Regulatory Applications of URCS

The STB uses URCS in several regulatory applications:

> URCS is used by the Board for a variety of statutory and non-statutory functions. URCS is statutorily required for making the jurisdictional determination in railroad maximum rate reasonableness proceedings. It also has a prominent role in determining whether a rate is reasonable and what relief a rail shipper should receive. URCS is also used to develop variable costs for making cost determinations in abandonment proceedings; to provide the railroad industry and shipper community with a standardized costing model; to cost the Board's Carload Waybill Sample; and to provide interested parties with basic cost information.[13]

Below, we describe the use of URCS in these applications and the potential effects of changes in URCS for each of these applications

a) Jurisdictional Threshold for Rate Review

A primary use of URCS is in the statutory jurisdictional threshold test that determines whether the STB can exercise regulatory oversight for rail traffic subject to a given rate. The jurisdictional threshold is a revenue to "variable cost" ratio of 180 percent (i.e., R/VC = 1.8) for the traffic in question. The test is established by statute (49 U.S.C. § 10707) and requires the use of URCS—or an alternative costing system adopted by the STB in lieu of URCS—to determine variable cost for use in the test.[14] The term "variable cost" itself is not defined by statute.

[13] See https://www.stb.gov/reports-data/uniform-rail-costing-system/#URCS-uses (accessed February 22, 2022).
[14] The RAPB also notes that "[t]he statute requires the use of GPCS to calculate variable costs." See RAPB Final Report, Vol. 2, p. 5.

If R/VC is less than 180 percent for a given movement, the statute requires the STB to find that the railroad does not have "market dominance" over the rail traffic,[15] and rates for this traffic cannot be challenged. However, if R/VC is greater than or equal to 180 percent for a given movement, the result does not establish a presumption that the railroad exercises market dominance over the traffic. The test only determines whether a rate can be challenged to determine its reasonableness.

A notable feature of the test is that the R/VC threshold is fixed, but the variable cost methodology can be changed by the STB. This creates a near certainty that a material methodological change for railroad costing will affect the stringency of rate regulation for railroads. Changes to URCS methodology can affect the application of the jurisdictional threshold in two main ways. First, changes affecting the overall level of variable costs may shift the distribution of R/VC for all rail traffic up or down. For example, lower Phase I variabilities would reduce measured variable costs (other things equal) and increase the share of traffic at or above 180 percent R/VC. Other model changes could increase or decrease variable cost differences across types of rail traffic—for instance, Phase II or Phase III URCS model changes that narrowed the distribution of R/VC values across rail movements could reduce the share of traffic above 180 percent R/VC even in the absence of Phase I variability changes.

Effects on the jurisdictional threshold may be offset by other regulatory action of the STB. When URCS was adopted by the ICC to replace Rail Form A, the ICC implemented a "bridging factor" with the intent of maintaining a constant share of rail traffic at or above the 180 percent R/VC threshold.

b) Uses of URCS in STB Rate Reasonableness Determinations

In addition to the use of URCS in determining whether traffic meets or exceeds the 180 percent R/VC jurisdictional threshold, URCS is used in the three STB procedures for determining rate reasonableness—the Stand Alone Cost (SAC) test, the Three Benchmark test, and the Simplified SAC test. Below, we describe the use of URCS in these applications.[16] These applications are non-statutory, and thus could be subject to modification by STB regulation.

(i) Stand-Alone Cost (SAC) Test

The SAC test relies on URCS in two ways: as part of the allocation of cross-over traffic revenue, and as part of the rate prescription process. In addition, URCS might be used to estimate the stand-alone railroad's (SARR) operation costs. However, these costs are usually developed from the ground up as part of construction of the SARR. Currently, relevant system-average figures,

[15] Market dominance is defined as "absence of effective competition from other rail carriers or modes of transportation for the transportation to which a rate applies." 49 U.S.C. § 10707(a).

[16] See Intervistas, "An Examination of the STB's Approach to Freight Rail Rate Regulation and Options for Simplification," Project FY-14-STB-157, September 2016; and Christensen Associates, "A Study of Competition in the Freight Railroad Industry and Analysis of Proposals That Might Enhance Competition," November 2009 (Christensen 2009 Competition Study), Vol. 3, Chapter 20.

derived from URCS (Phase II) data, are used for the movements in question and no movement-specific adjustments (Phase III) are allowed.

Revenue of cross-over traffic (traffic that does not originate and/or terminate on the SARR) in the SAC traffic group is allocated to the SARR based on the relative average total cost (ATC) of the traffic on and off the SARR; URCS is the basis of the ATC calculation. ATC calculations, as distinct from average variable costs, should not be affected by methodology changes in URCS Phase I. URCS is also used to establish a variable cost (VC) floor for each segment so that revenue does not fall below VC on any segment.

Rate prescriptions under the SAC are set by the MMM, which sets allowable rates at the maximum of SAC or 180 percent R/VC. Modification of URCS costing methodology may affect whether 180 percent R/VC constitutes a reasonable maximum markup for rail traffic given railroads' needs to maintain revenue adequacy.

(ii) Three Benchmark Test

The Three Benchmark test is one of the two "simplified" STB rate reasonable tests (Simplified SAC is the other). Three R/VC ratios are used to determine rate reasonableness. The role of URCS in each of the benchmarks is described below. As with the SAC test, relevant system average costs from URCS are used and no movement-specific adjustments are allowed. Since 2012, parties have access to unmasked waybill data once a complaint is filed.

Revenue Shortfall Allocation Methodology (RSAM) measures the uniform markup over variable cost that would be needed from every shipper of potentially captive traffic (R/VC > 180 percent) that would allow the railroad to recover all its URCS "fixed" costs. RSAM is computed by the STB every year and approximates what a railroad would need to charge potentially captive shippers to be revenue adequate. When a carrier is not 'revenue adequate' under the Board's annual calculations, its RSAM figure (what it needs to collect) should be greater than its actual markup for R/VC > 180 traffic (what it actually collects); when a carrier is revenue adequate under that determination, its RSAM figure should be lower than its actual markup for potentially captive traffic.

Revenue to Variable Cost Ratio for Comparable Traffic (R/VC_{COMP}) measures the markup of defendant railroad traffic that has the same characteristics as the traffic at issue (i.e., similar commodities moving under similar transportation conditions) with R/VC ratios over 180 percent. Each side proposes initial traffic for comparison from the Waybill Sample provided at the onset of the case. The parties meet and confer in a technical conference to attempt to resolve differences. Each of the parties then proposes a final offer concerning the traffic to be used for comparison. The Board selects the final offer that it concludes is most like the traffic at issue.

R/VC over 180 percent ($R/VC_{>180}$) measures the average markup over variable cost earned by the railroad for all potentially captive traffic of the railroad and is computed by the STB every year. The purpose of this measure is to ensure that the complaining shipper is not paying a disproportionate rate for the traffic at issue. It compares the traffic subject to review with the average R/VC of all other potential captive movements.

Changes in URCS methodology may affect whether the 180 percent R/VC threshold is appropriate to identify other potentially captive traffic for the benchmarking exercise. For example, methodology changes generally reducing measured variable costs may warrant an increase in the threshold.

For rate prescriptions, all three benchmarks are used to determine the maximum rate:

$$\text{Three Benchmark Measure} = [R/VC_{COMP} / R/VC_{>180}] * RSAM.$$

The statutory 180 percent R/VC level is considered the floor for any rate relief. As with the MMM, changing URCS variable cost methodology may affect whether 180 percent R/VC is an appropriate floor value.

(iii) Simplified SAC Test

The Simplified SAC test modifies the full SAC test with the intent of making rate review proceeding quicker and more affordable to potential complainants. For example, instead of building a hypothetical SARR network, the Simplified SAC test uses existing railroad routes and infrastructure. URCS is used in the Simplified SAC test to estimate SARR operating expenses. As with the full SAC test, URCS is used in the determination of costs for cross-over traffic and rate prescriptions are based on the MMM, which sets allowable rates at the maximum of SAC or 180 percent of R/VC.

c) Uses of URCS in Rail Abandonment or Service Discontinuance Proceedings

URCS is used in rail abandonment or service discontinuance proceedings to determine "off-branch" avoidable costs. Off-branch costs reflect the costs incurred for branch line traffic moving off the branch line and over other lines of the railroad. The branch avoidable costs are based on actual costs. The specific components and how to use URCS in calculating off-branch costs are specified in 49 CFR 1152.32 (the computation of branch avoidable costs can also be found in 49 CFR 1152.32). Branch and off-branch avoidable costs are part of a rail abandonment or service discontinuance application (49 CFR 1152.22). Changes to URCS that generally reduced (increased) measured variable costs would tend to reduce (increase) avoided costs for off-branch movement of traffic from the branch line. Effects of other URCS costing changes would depend on the service characteristics of the traffic from the branch line and thus are ambiguous.

C. OVERVIEW AND ORGANIZATION OF THE REPORT

The rest of the report proceeds as follows.

Section II examines the URCS costing framework, including the RAPB costing principles that guide URCS methodology, and reviews its key economic assumptions under current URCS methodology. We consider the appropriate economic cost concept(s) that URCS should seek to measure given its regulatory applications. Given URCS's primary role in assessing railroads' exercise of market power, we conclude that short-run marginal and incremental costs are the most appropriate cost measure for URCS. for assessing railroads' exercise of market power. We show that while current methodology URCS is not designed to estimate short-run costs, the URCS model framework is adaptable for the purpose. Section II also reviews stakeholder concerns regarding URCS methodology both from STB proceedings related to URCS and stakeholder interviews we conducted for this project.

Section III presents an alternative costing system, called the "Hybrid New Empirical Industrial Organization" ("Hybrid NEIO" or simply "Hybrid") model, as a potential alternative to URCS for deriving short-run marginal (and/or incremental) costs for railroad movements. The STB identified the Hybrid model as a potential URCS alternative in a 2010 report to Congress on URCS.[17] Section III also briefly describes alternative costing methods from the STB URCS Report and related literature that we determined to be infeasible. The Hybrid model's name reflects its combination of separate econometric analyses of railroad cost and price data, neither of which alone could replace URCS as a costing system for railroad movements. The Hybrid model differs from legacy URCS foremost in its use of an econometric analysis—a "NEIO regression"—modeling price data from the STB's Carload Waybill Sample (CWS) to derive the relative effects of freight movement characteristics on movement-specific costs. The NEIO regression effectively replaces URCS Phase III in the Hybrid model. The econometric cost analysis is needed because the CWS does not provide any data on railroad costs directly. The cost analysis can, in principle, be implemented by estimating economic cost functions for the freight railroad industry or by modeling disaggregated costs for railroads' operating activities like in URCS Phase I. Indeed, the disaggregated costing approach provides an update to URCS Phase I that we also employ in Section IV. We identify preferred specifications for both the NEIO and cost analyses, compute movement-level cost estimates for the 2019 CWS sample for our preferred Hybrid model specifications, and compare results with legacy URCS. Section III concludes by assessing the Hybrid model's consistency with the RAPB costing principles and noting pros, cons, and limitations of the model.

Section IV describes and implements costing improvements that update the URCS model largely within the framework of the legacy URCS model. By addressing known methodological issues with legacy URCS, we view the URCS update approach as providing a more appropriate basis for evaluating an URCS alternative such as the Hybrid model than comparisons with legacy URCS. The implementation of URCS updates also is responsive to stakeholder views that generally did not reveal preferences for clean-sheet alternatives but rather indicated common views that updates and/or improvements to URCS Phase I and Phase III methods were warranted. We assess issues with the URCS Phase II and Phase III models raised by URCS

[17] Surface Transportation Board, "Report to Congress Regarding the Uniform Rail Costing System," May 27, 2010 (STB URCS Report).

stakeholders[18] and specify URCS update scenarios encompassing changes to variable costs in Phases I and II as well as to the Phase III movement costing model. We also investigate the sensitivity of URCS costs to various model inputs to determine where resources may be prioritized if the STB should seek to update URCS special studies in the future. We assess the impact of URCS model updates on costs and R/VC ratios by implementing updated URCS models for a random subsample of movements from the 2019 CWS. We compare updated URCS results to corresponding Hybrid model results and note causes of material differences between the two approaches, notably intermodal costing.

Finally, Section V provides overall conclusions and recommendations.

[18] These include parties to STB Dockets Ex Parte (EP) 431 sub-numbers 3 and 4 as well as the interviewees for this project.

II. REVIEW OF URCS ECONOMIC METHODOLOGY

A. INTRODUCTION

In this section, we describe the methods currently employed by URCS to compute "variable costs" for railroad activities. We assess the consistency of current URCS costing methods with the costing principles established by the RAPB to guide the development of URCS. URCS has been the subject of extensive commentary and criticism from stakeholders to STB rulemaking proceedings on URCS and from economists studying railroad regulation. We review critiques of URCS to identify areas of relative consensus for potential modifications to URCS and/or its costing methods. As part of the review, we consider the economic cost concept(s) that URCS should implement given the regulatory applications described in Section I of the report.

B. VARIABLE COSTS FOR RAIL FREIGHT MOVEMENTS IN URCS

"Variable costs" are defined in the economics of the firm as costs of productive inputs that vary with the quantities of output(s) produced by a firm. "Fixed costs" similarly are the costs of inputs that do not vary with the firm's outputs. This gives rise to a basic decomposition of costs that serves as the starting point for much economic cost analysis:

(II-1) $$TC(Q) = FC + VC(Q).$$

Whether an input is "variable" or "fixed" depends on the time frame in which inputs and outputs may vary. The economic "short run" is defined as any time frame in which some of the firm's inputs are fixed; in the "long run" all inputs may be varied. It is common, though not necessary, to assume that firms' managers adjust variable inputs to produce the output Q at the minimum cost conditional on the fixed inputs.[19]

Equation II-1 is the starting point for URCS costs for railroad movements.[20] In URCS, the time frame of the analysis is characterized as reflecting an "intermediate run" in which capacity-limiting inputs are considered partly variable with output. Thus, while URCS costs are technically a form of short-run costs, $VC(Q)$ in URCS includes some capacity-related costs that could be considered fixed over a sufficiently short time horizon.

To produce costs for railroad movements (or other activities), URCS costing methods address two central issues. First, total cost is observable but variable cost $VC(Q)$ is not directly observed.

[19] Cost analysis may proceed from an assumption that there is a stable operating plan underlying observed data on cost and output. See, e.g., Wesley W. Wilson and Frank A. Wolak, "Freight Rail Costing and Regulation: The Uniform Rail Costing System," *Review of Industrial Organization,* May 3, 2016 (Wilson and Wolak 2016), p. 14. Consideration of non-minimum costs most often arises for state-owned enterprises or private firms subject to cost-of-service or other lower-powered forms of regulation, where incentives to minimize costs may be weak.
[20] See M. Daniel Westbrook, "Research Report on URCS Regression Equations," October 17, 1988 (Westbrook 1988), p. 6.

Second, it is necessary to determine what portion of $VC(Q)$ may be assigned to a given portion of the firm's output—i.e., a movement of freight—along with a (rational) basis for the assignment of costs.

The URCS Phase I analysis determines variable costs for railroads by partitioning railroads' costs into "cost pools" and estimating "variability factors" (or "variabilities") for railroad operating costs using econometric cost equations applied to each of the cost pools, which we discuss in greater detail below. URCS variable costs also include some return-on-investment (ROI) and depreciation, lease, and rental (DLR) costs using assumed ("default") variabilities. For the k^{th} cost pool, variable cost is:

(II-2) $$VC_k = v_k TC_k; k = 1, \ldots, K.$$

In Equation II-2, TC_k is the total (observed) cost in cost pool k and v_k is the variability factor which may be econometric or "default." The sum of VC_k over all K cost pools is the total variable cost $VC(Q)$.

The development of movement-specific costs involves two steps corresponding to URCS Phases II and III. In URCS Phase II, non-shipment-specific or "generic" unit variable costs are developed for several variables representing railroad outputs. Outputs include (but are not limited to) gross ton-miles, locomotive unit miles, and SEM. For the j^{th} output, the generic unit variable cost is:

(II-3) $$UVC_j = \left(\sum_{k=1}^{K} s_{jk} v_k TC_k\right) / Q_j.$$

In equation II-3, the factors s_{jk}—called "semi-default" allocators[21]—are shares that allocate portions of $VC_k = v_k TC_k$ to the output given by Q_j (with $\sum_{j=1}^{J} s_{jk} = 1$).

Finally, in the Phase III model, the calculations of movement-specific costs combine the generic unit variable costs from equation II-3, movement-specific output quantities Q_{ij} (for the i^{th} movement), and cost efficiency adjustment factors θ_{ij}. The efficiency adjustments allow movements with specified characteristics to be assigned unit variable costs that differ from the generic values of UVC_j. An example is the "make-whole" carload efficiency adjustments in URCS Phase III that adjust switching costs to reflect cost economies associated with multiple carload and unit train shipments. The variable costs of movement i may be specified as:

(II-4) $$VC_i = \sum_{j=1}^{J} Q_{ij} \theta_{ij} UVC_j.$$

[21] The semi-default allocations allow specified costs to be related to multiple outputs where it is impractical to estimate a multi-output cost equation econometrically.

From equations II-2 to II-4, the economic meaning and validity of URCS variable costs hinge on a few interrelated factors. First, the economic interpretation and statistical accuracy of the total and unit variable costs depend on the procedures used to determine the variabilities and semi-default variable cost allocators. Second, the outputs derived in the Phase III model for a specific movement $(Q_{i1}, Q_{i2}, \dots, Q_{ij}, \dots, Q_{iJ})$ must appropriately characterize the contribution of railroad movements to the railroad's use of variable inputs and hence variable cost. Third, the efficiency adjustments must adequately capture differences in unit variable costs applicable to specified movements that result from cost-causing characteristics of the movement not addressed by other model parameters.

Of course, it is possible that methodological decisions in legacy URCS may be appropriate for some cost objectives but not others. Thus, before we assess the economic content of URCS costs under current methodology, we consider the implications of the guidance from the RAPB general costing principles for URCS.

C. RAPB General Principles and Implications for URCS Methodology

The RAPB was established by the Staggers Rail Act of 1980 to develop a set of principles to guide costing methodologies for railroad regulation. The RAPB's 1987 reports established four "general principles" and four "specific principles" representing the RAPB's consensus views.[22]

The RAPB promulgated four general principles: Causality, Practicality, Homogeneity, and Data Integrity. In addition, the RAPB discussed several methodological issues related to railroad general-purpose costing systems (GPCS)—both Rail Form A and URCS—in light of the general principles. Below, we review the RAPB's general principles and the methodological issues related to GPCS implementation raised in the RAPB report.

Overall, we find that the RAPB principles remain relevant. The general principles, collectively, make an unexceptionable (to economists) case that URCS or a replacement GPCS should be well-grounded in causal costing methods, use reliable data parsimoniously, and not create undue burdens for railroad data reporting or analysts by pursuing immaterial refinements to costing systems. While the RAPB principles and related methodological considerations allow considerable analyst discretion in many details of the implementation of URCS or a successor GPCS, in totality they provide clear guidance as to the economic quantities that URCS inputs should represent. Below, we discuss each principle in turn.

1. Causality

The Causality principle states that:

[22] The RAPB Final Report was released in two volumes, with the first volume serving as an executive summary of the more detailed findings presented in the second volume. Insofar as most of the detailed discussion that is germane to the URCS Alternatives project is contained within the second volume, that was the focus of our review. We do not discuss the specific principles here, as they are mostly not germane to the analyses conducted for this project.

> Costs shall only be attributed to cost objectives when a causal relationship exists (the cost would not have been incurred but for the requirements of the cost objective). A cost objective is the result of the use of resources.[23]

The Causality principle has direct implications for the type of economic costs that URCS or a successor GPCS should measure. Its implications for the time horizon or length-of-run that causal costs should represent depend on the costing application.

a) Causality and Economic Cost Concepts

The RAPB based the Causality principle on the "concept of avoidability" determined "on an incremental basis." In economic costing terms, the causality principle aligns with the concepts of incremental and marginal cost. Consider a general multiproduct cost function of the form:

(II-5) $$C(X_1, X_2, \cdots, X_i, \cdots, X_N; w; Z).$$

In equation II-5, the variables X_i denote the "true" outputs of the firm, where the number of outputs *N* may be very large. For a freight railroad, X_i may be a measure such as tons of freight of a particular commodity moving between a specific origin-destination pair. The terms w and Z represent vectors of factor prices and quasi-fixed factors affecting costs, respectively.[24] We use the X_i notation to distinguish a hypothetical ideal representation of outputs from the model outputs Q_i. The marginal cost (MC) of output X_i is defined as

(II-6) $$MC_i = \partial C(X_1, X_2, \cdots, X_i, \cdots, X_N; w; Z)/\partial X_i$$

and the incremental cost (IC) of providing the output X_i is

(II-7) $$IC_i = C(X_1, X_2, \cdots, X_i, \cdots, X_N; w; Z) - C(X_1, X_2, \cdots, 0, \cdots, X_N; w; Z).$$

Equation II-6 describes the increment of cost caused by a small increase in the output X_i. Equation II-7 measures the increment of cost caused by the entire output X_i as the cost difference between producing the entire output of the firm including X_i and the cost of producing the same output except for X_i, or equivalently the cost avoided by the firm when X_i is not produced. Wilson and Wolak 2016 notes that the incremental cost in II-7 also may be written as an integral of the marginal cost curve over the range of output for product *i*:

[23] Railroad Accounting Principles Board, "Railroad Accounting Principles: Final Report, Volume 2 – Detailed Report", September 1, 1987, p. 9 (RAPB Report, Vol. 2).
[24] This general specification is the basis for the critique of URCS in Wilson and Wolak 2016.

(II-8) $$IC_i = \int_{s=0}^{X_i} (\partial C(X_1, X_2, \cdots, s, \cdots, X_N; w; Z)/\partial X_i)\, ds + F_i.$$ [25]

As a general matter, both MC and IC depend on X_i, the levels of other outputs, factor prices, and quantities of fixed inputs.

Whether URCS movement costs comply with the causality principle in the sense of measuring a movement's incremental cost depends on the extent to which (or the assumptions under which) URCS variable costs for a railroad movement, given by equation II-4, measure incremental costs in equation II-7. Wilson and Wolak 2016 goes so far as to contend that URCS variable cost cannot equate to movement incremental cost, a claim which we address below in Section II.E.

b) Time Horizon or Length of Run for Causal Costs

The RAPB's statement of the Causality principle further notes that depending on the costing application, the appropriate cost measurement may be backward- or forward-looking and further depends on the time horizon or length of run under consideration. The Causality principle does not prescribe a length of run but rather states that the appropriate orientation of costs is specific to the regulatory application in question.

Costs used as the basis for pricing decisions typically are forward-looking, as of the decision point, at least in theory. Firms including railroads will usually set or negotiate prices or rates in advance, and the costs that inform the rate-setting process thus will reflect ex ante cost expectations. In practice, those costs will reflect the Marshallian short run, insofar as prices or rates will be in effect for limited periods of time and firms will make decisions:

> …with whatever stock of capital equipment, training of labor, and business organization that the past has produced; decisions are being taken today on the basis of expectations about the future.[26]

The primary regulatory application of URCS costs is, however, retrospective review of rates. For that purpose, a backward-looking or retrospective costs incurred for the traffic subject to review when the rate in question was in effect is an appropriate cost measure. *Ex post*, costs of rail movements may vary widely because of numerous factors (measured or otherwise) whose specific effects may not have affected pricing decisions.

Short- and long-run cost concepts in economics are defined by the extent to which inputs may be varied in service of a cost objective. In the short run and intermediate run, some inputs are considered fixed—at least to some degree—whereas in the long run, all inputs can be varied

[25] Wilson and Wolak 2016 omits the term F_i, which allows for product-specific quasi-fixed costs. These are costs that do not vary with the level of output X_i but may be avoidable if product *i* is not produced. Examples include product-specific advertising costs or, in a railroad context, costs of quasi-fixed inputs such as way and structures investments used to provide service for a given route.
[26] Joan Robinson, "The Second Crisis of Economic Theory," *American Economic Review* Vol. 62 (1972), No. 1/2 (1972), p. 4.

fully. Railroads can profitably price some traffic close to short-run marginal cost, but rail rates overall must recover total costs (including returns on investment).

c) Implications for Cost Methodology

The RAPB was relatively agnostic on methodologies for determining the existence of cost causation, noting that relationships could be established by observation, engineering analysis, or statistical studies. However, the RAPB noted the need for statistical analysis techniques such as regression models to identify joint and common costs and to establish the degree of cost variability with respect to activity or output levels.

The RAPB noted that the "time orientation" of GPCS is an intermediate-run horizon in which capacity-related costs are considered partially variable.[27] The intermediate-run horizon presumes a cost application in which the time horizon is long enough to allow some adjustment of railroads' capacity. In legacy URCS, costs reflect an intermediate length of run primarily by including some capacity-related capital costs, which may be considered fixed costs over a shorter time horizon, in measured variable costs. Thus, the inclusion of capacity costs in URCS variable costs is not necessarily non-causal,[28] though whether the URCS methodology generates economically appropriate measures of marginal costs depends on whether the "default" variabilities are empirically justified.

The RAPB did not identify any alternatives to the causality principle that it considered. This is consistent with the fundamental role of causal costs in economics. Non-causal costing approaches (e.g., fully distributed costs or FDC) exist and are used by some multiproduct firms in network industries for management purposes. In economics, FDC and other non-causal costing methods are regarded as "arbitrary" as they inherently rely on judgmental allocations of joint and common costs to activities.[29]

2. *Practicality*

The Practicality principle states, "Cost and related information should be feasible to obtain, efficiently determined, and material in amount."[30]

The practicality principle is derived in substantial part from statutory requirements that railroad reporting requirements should minimize reporting requirements (and hence compliance costs) and that the benefits and costs of additional requirements be considered.

The practicality principle has been cited in support of URCS model changes that place no additional reporting requirements on railroads and/or attempt to avoid the need for additional

[27] RAPB Report, Vol. 2, p. 95.
[28] In contrast, Wilson and Wolak 2016, p. 15, contends that such costs are non-causal.
[29] See Ronald R. Braeutigam, "An Analysis of Fully Distributed Cost Pricing in Regulated Industries," *Bell Journal of Economics*, 11 (1) (1980). pp. 182-196.
[30] RAPB Report, Vol. 2, p. 17.

empirical studies. More broadly, it may be manifested in a preference to live within the confines of existing data reporting. However, the application of the principle does not generally rule out the possibility that benefits of additional analyses or additional data reporting could pass cost-benefit muster.

The Practicality principle also serves as a basis for assessing some categories of critiques of URCS. For example, a claim that URCS variable costs do not implement economic incremental costs in their most general form (i.e., equation II-7 or II-8) is, at some level, true. However, it is not necessarily relevant to the extent implementing a highly general costing system is impractical. Similarly, the inevitable modeling abstractions and simplifications in any practical costing system may be acceptable under the Practicality principle insofar as they do not have material adverse effects on the measured costs for a given regulatory application.

The feasibility and efficiency of various types of data provision are subject to change over time as costs of data acquisition and storage technologies change (and have tended to greatly decrease). It stands to reason that railroads, like many other firms, have responded to decreasing costs of passive data collection systems by collecting increasingly detailed data on their own operations. However, the RAPB emphasizes that the efficient determination of information includes costs of validation, litigation, potential disclosure, and analysis or interpretation.[31] Even if additional data happen to be available in existing databases, it is possible that use of such information may not have benefits materially outweighing substantial costs of putting new data to use.

3. Homogeneity

The Homogeneity principle states that:

> Cost information shall be organized into homogeneous cost pools. A homogeneous cost pool is a group of costs which are governed by essentially the same set of determinants and which respond to changes in output in essentially an identical manner.[32]

Applied to cost measurement in URCS or an alternative GPCS, the homogeneity principle can facilitate causal analyses of costs by favoring the development of cost pools (activity or expense groups) that can be parsimoniously related to common sets of outputs. Less-homogeneous cost pools (potentially up to the total costs of a railroad) are likelier to have material dependencies on broader sets of "determinants" such as output measures or other cost-causing characteristics. Cost models with more explanatory variables tend to have greater information requirements for empirical implementation—potentially beyond the available data—and can in practice exhibit tradeoffs between the degree of detail included in the model and the statistical properties of the resulting estimates (implicating the other general principles).

[31] RAPB Report, Vol. 2, p. 18.
[32] RAPB Report, Vol. 2, p. 13.

While dividing costs into cost pools may facilitate cost modeling in some ways, economic critiques of URCS and similar systems commonly note that use of additively separable cost pools imposes significant economic restrictions on the cost function underlying URCS, which may or may not be warranted theoretically or empirically. Notably, separability may assume away possibilities for factor substitution when relative factor prices change. Econometric cost models that relax such restrictions, such as estimation of economic cost functions and/or factor demand systems, commonly use cost data that are (in URCS terms) aggregated over cost pools. In Section III of this report, we consider both aggregated and disaggregated models as vehicles for determining railroad variable costs.

The RAPB described an Interchangeability principle as a "subset" of the homogeneity principle. The interchangeability principle states that interchangeable resources should be costed at common (average) rates.[33] This serves to reduce the possibility that variability in specific resource costs (e.g., wage rates for train crew members) that is irrelevant to the cost application will lead to "chance variability" of measured costs. Interchangeability also interacts with the causality and practicality principles. The interchangeability principle reduces costing information requirements, as it may be unnecessary to track specific assets employed in railroad activities or characteristics that affect activities' costs *ex post* but may not be relevant for the forward-looking cost expectations underlying rates.

The RAPB's cautionary note is that it is necessary to carefully determine cases where resources may not be interchangeable and where material differences in costs may be present. The homogeneity and interchangeability principles also inform the use of multi-year average costs in GPCS to reduce variations in costs due to the timing of expenses that may be irregularly incurred.

The RAPB did not consider alternatives to the homogeneity principle as such, but assessed whether requiring reporting by cost centers, such as density or geographic groupings, would facilitate the creation of homogeneous cost pools. The RAPB concluded that the costs of such reporting likely would have exceeded the benefits of disaggregation at the time. However, Class I railroad consolidation since the RAPB report has effectively increased the level of aggregation of railroad reporting.

4. Data Integrity

The Data Integrity principle states, "Cost and related information should be valid, accurate, and verifiable."[34] Compliance with the data integrity principle ensures sufficient data quality for information used in GPCS and for other regulatory cost applications. Much of the RAPB's discussion of the data integrity principle concerns audit procedures and standards within the scope of what it considered to be the administrative choices of the ICC.[35] It declined to

[33] RAPB Report, Vol. 2, p. 14.
[34] RAPB Report, Vol. 2, p. 21.
[35] RAPB Report, Vol. 2, p. 23.

recommend more stringent audit standards that might significantly increase railroads' accounting and audit costs in contravention of the practicality principle. For special study data, the RAPB emphasizes review of data and methods by parties to relevant proceedings.

5. *RAPB Discussion of General-Purpose Cost System Methodology*

The RAPB report also analyzed several specific GPCS methodology issues affecting Rail Form A and URCS considering the general principles. The RAPB did not address the merits of suggestions made at the time that URCS be replaced by purely econometric models or hybrid econometric-engineering models, though it noted potential disadvantages of such methods relative to URCS. Those included the observation that simple econometric models were unlikely to be able to generate data suitable to estimate individual movement costs accurately, and that complex models may require additional data and could be less transparent to stakeholders.[36] These considerations remain valid for consideration of potential URCS alternatives.

The RAPB considered two important methodology issues specifically affecting the URCS Phase I variability analysis. As the issues analyzed by the RAPB are central both to the economic interpretation of URCS variable costs and to methodology for an update of the URCS Phase I analysis, we discuss these briefly below.

a) Variability Calculations

A central requirement for a GPCS is to reliably identify variable costs within cost pools representing railroad expenses. The RAPB assessed three variability methods, the "percent variable" method, "direct coefficient application," and "cost elasticity."[37] The percent variable approach divides the predicted variable costs from the variability equations by the predicted total costs ("the value of the entire equation"). The direct coefficient method would directly use predicted variable costs from the regression models without dividing by predicted total costs. The cost elasticity method would employ the percent changes in cost from (infinitesimal) changes in outputs Q_j, $\partial \ln TC_k / \partial \ln Q_j$, for the variabilities.

The RAPB concluded that the cost elasticity or direct coefficient methods would be compatible with the Causality principle. However, they rejected the direct coefficient method as incompatible with URCS.[38] The cost elasticity method is consistent with the Causality principle because it produces unit variable costs that may be interpreted as marginal costs. That is, with $v_k = \partial \ln TC_k / \partial \ln Q_j = (\partial TC_k / \partial Q_j)(Q_j / TC_k)$, equation II-2 yields unit variable costs equivalent to marginal costs:

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[36] RAPB Report, Vol. 2, p. 96.

[37] RAPB Report, Vol. 2, pp. 103-105.

[38] Technically, variable costs and/or unit variable costs derived directly from the cost regressions would replace portions of the Phase II variable cost calculations in the direct coefficient method. A significant complication of the direct coefficient method is a need to implement adjustments to the predicted variable costs for changes in input price and productivity changes, which are not necessary in the percent-variable or elasticity methods.

(II-9) $$VC_k = v_k TC_k = (\partial TC_k/\partial Q_j)(Q_j/TC_k)TC_k \Rightarrow VC_k/Q_j = \partial TC_k/\partial Q_j.$$

Since the adopted URCS econometric cost equations are linear in the levels of the output and capacity variables, the URCS variabilities can be characterized as reflecting either the percent variable or the elasticity method. The RAPB recognized, and Westbrook also noted, that the distinction between the methods is mooted for linear (in levels) cost equations because the two methods yield the same variabilities (i.e., the output elasticity from such a model is also the percent-variable). More generally, the elasticity and percent-variable methods diverge for nonlinear cost specifications. The RAPB also favored the elasticity method for its applicability to both linear (levels) and non-linear models.

The RAPB preferred methods that would provide railroad-specific elasticities, which—like the URCS percent-variable formula—would derive cost elasticity formula(s) from the regression equations and evaluate the formulas using railroad-specific data. Various functional forms commonly used in applied cost analysis can produce railroad-specific elasticity estimates, at least in principle. Whether such elasticities can be estimated reliably in practice depends on the available data. Not all cost functions, moreover, necessarily yield cost elasticities that would vary with the levels of output, network size, or other variables. An example is cost function of the form:

(II-10) $$C = \alpha_0 \prod_{j=1}^{J} Q_j^{\beta_j}.$$

In equation II-10, the cost elasticity with respect to Q_j is $\partial \ln C/\partial \ln Q_j = \beta_j$, where β_j is a constant. Equation II-10 is useful as a simple model (that is linear in natural logarithms) that does not impose constant returns to scale on the cost function. In Section III, we investigate the performance of variability regression specifications that allow railroad-specific elasticities or variabilities as well as constant-elasticity specifications like equation II-10.

b) Alternative Regression Forms and Economies of Density

The RAPB recommended that the ICC analyze models incorporating density measures as well as test functional forms that would be better able to reflect economies of size and/or density in railroad operations than the linear cost models used in URCS. The RAPB noted numerous studies of railroad costs showing significant economies of density, as well as criticism of the URCS models for not including density economies as a model feature, distinguishing the spreading fixed costs over a larger base of output (allowed in the URCS models) from declining marginal and/or average incremental costs due to economies of density.[39] The RAPB report discusses some families of alternative model specifications, including linear models (implemented in URCS), exponential models like equation II-10, and quadratic forms, without

[39] RAPB Report, Vol. 2, p. 107.

recommending any specific approach. For the URCS alternative project, we primarily considered linear and exponential models as potential specifications for variability models.[40]

The inflexibility of the statutory 180 percent R/VC threshold clearly is a challenge both for the conceptual definition of variabilities and the form of the cost regressions. The fixed 180 percent R/VC criterion ensures that almost any material change to variable cost measurement or methodology will affect the amount of traffic subject to regulation. To the extent the causality principle occupies a central (if not primal) position for costing in a GPCS, it is not generally possible to maintain existing relationships of empirically based causal movement costs with respect to the regulatory threshold. We note that maintaining the legacy URCS methodology (variable cost ratio from linear models) need not minimize changes to measured costs resulting from an update; we address this further in Section III, below.

D. Costs for Assessing Railroads' Exercise of Market Power: Short-Run Marginal and Incremental Costs

We now consider the appropriate economic cost concept for URCS or an URCS alternative serving as a successor GPCS given the regulatory application of assessing the exercise of market power and the fairness of rail rates and the RAPB principles. For the reasons we discuss below, the appropriate costs for the application are, technically, short run marginal and incremental costs.

The time frames used in analyzing firm behavior and industry performance can vary from "the very short run"—a market period sufficiently brief that no inputs are variable—to "very long run" periods allowing full adjustment of inputs to optimal values as well as substantial shifts in production technologies and preferences of the firm's customers. In between these two extremes are the traditional analysis periods of "the short run" and "the long run." The difference between the short run and the long run is more descriptive and relative in terms of the flexibilities and inflexibilities faced by decision makers rather than being any precise length of time.

The textbook definition of the short run is a period in which not all inputs can be adjusted, while the long run is defined as a period over which full adjustment of inputs to changes in output can take place.[41] These definitions suggest that time frame is more of a continuum with a shorter run being characterized by more restricted adjustment possibilities than the longer run.
Alfred Kahn succinctly stated that "it is the short-run marginal cost to which price should at any given time–*hence always*– be equated, because it is short-run marginal cost that reflects the social opportunity cost of providing the additional unit that buyers are at any given time trying to decide whether to buy."[42]

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[40] The exponential models we studied included quadratic models with the variables in logarithms, or "translog" specifications.
[41] Paul A. Samuelson and William D. Nordhaus, *Economics*, Thirteenth Edition, McGraw-Hill 1989.
[42] Alfred E. Kahn, *The Economics of Regulation*, Volume I, p. 71, MIT Press, 1988. (italics in original)

We advocate a short-run time frame for pricing analysis in recognition that railroad pricing decisions are expected to be made under conditions where the railroads' inputs—especially inputs determining railroad capacity—have limited flexibility. This is congruent with the RAPB's preference for an "intermediate run" (which is technically a variety of economic short run) horizon, if not necessarily the legacy URCS approach to producing intermediate run costs. We discuss a variety of implications of short run costs below.

1. *Value and Efficiency*

Short-run marginal cost (*MC*) reflects the social cost of providing an additional unit of output while price (*P*) indicates the marginal social benefit. If *P* exceeds *MC*, then the benefit of marginal consumption exceeds the marginal opportunity cost of production. Net social benefit would increase with another unit of the good being produced and consumed. Conversely, if *P* were less than *MC*, then the last unit costs more to produce than the resulting social value and a marginal reduction in production and consumption would increase net social benefit. Thus, economic efficiency is achieved when $P = MC$ because net social value from a market is maximized.[43]

Comparing revenue (*R*) to variable cost (*VC*) provides a non-marginal view of efficiency. Once productive investment is in place, then if at some levels of production and sales total revenue (*R*) exceeds total variable cost (*VC*), then it is socially desirable to produce the product. This is true in the presence of fixed costs. If *R* exceeds *VC*, then the total value of production exceeds the opportunity cost.

2. *Firm Behavior*

Short run cost is also central to firm behavior under the traditional economic assumptions of profit maximization. The first decision is whether to produce anything. From the firm's perspective, if price exceeds average variable cost (*AVC*), then some production levels yield producer surplus, meaning the firm will be more profitable producing at those levels than if it shut down.[44]

If $P > AVC$, then the firm decides how much to produce and offer for sale. For a competitive (i.e., price-taking) firm, the equation of price and marginal cost ($P = MC$) indicates the profit maximizing production level. That is, the competitive firm's supply curve is its *MC* curve above *AVC*. More generally—and more relevant to the railroad industry—a profit-maximizing firm in an imperfectly competitive environment determines its output level by the equation of marginal revenue and marginal cost ($MR = MC$).

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[43] This efficiency condition assumes no externalities and that other first-best conditions are met. While externalities, second-best considerations, and distributional issues make it incorrect to say that setting P = MC in a market maximizes social welfare, it is generally accepted that a large deviation between price and marginal cost in a market is sub-optimal and that moving price closer to marginal cost increases the value generated by a market.
[44] R > VC is equivalent to P > AVC. P = AVC is called the shutdown point. See Paul A. Samuelson and William D. Nordhaus, *Economics*, Thirteenth Edition, McGraw-Hill 1989, pp. 543-545.

The relationship between P and MR is given by:

(II-11) $$MR = P(1 + 1/e)$$

where e is the elasticity of demand perceived by the firm.[45] [note: $e < -1$]

Thus, the profit-maximizing behavior by the firm implies[46]

(II-12) $$P = MC(e/(1 + e)).$$

That is, in general the short-run marginal cost curve determines the profit-maximizing firm's response. If the firm has some market power, $e > -\infty$, $P > MC$ and the supply response also depends on the perceived elasticity of demand.

The condition that $P \geq AVC$ can be rewritten as

(II-13) $$MR \geq AVC\ (1 + e)/e.$$

The balance between demand and cost considerations is obtained by combining the $P \geq AVC$ and MR=MC conditions such that

(II-14) $$e/(1 + e) \geq 1/\eta$$

where η is the elasticity of variable cost with respect to output ($\partial \ln VC/\partial \ln Q$). Thus, both the perceived elasticity of demand and the economies of density measure ($1/\eta$) are embedded in the firm's supply response decisions.

3. *Short-Run or Long-Run Marginal Cost*

The upshot of this discussion is that value, efficiency and behavior are grounded in the short run and that short run costs provide the appropriate benchmarks for assessing pricing. However, there is a long-established debate in the literature about marginal cost pricing. The debate centers

[45] It is important to note that *e* is not the market elasticity of demand but instead *e* is what the firm perceives as the elasticity of demand for its brand. The determinants of *e* are the market elasticity of demand, the number of competitors offering a similar product, and consumer preferences for the firm's product in particular (e.g., brand loyalty).

[46] The relationship between price and marginal cost is sometimes expressed as $(P - MC)/P$, which is known as the Lerner Index. For the profit-maximizing firm, the Lerner Index equals the inverse of the negative of the price elasticity of demand. That is, $(P - MC)/P = -1/e$. This is equivalent to $P/C = e/(1 + e)$.

on public utility (i.e., regulated or state-run natural monopoly) pricing.[47] Part of that debate is whether it is short-run or long-run marginal cost that is the appropriate benchmark for price comparison.[48]

Our assessment of this short-run versus long-run debate is that it largely revolves around questions of inducing optimal investment for a regulated (or state-run) natural monopoly.[49] That is, long-run marginal cost is more applicable in planning or very strong regulation, than in market-based oversight. The post-Staggers Act railroad industry is not a public utility or natural monopoly. Instead, rail regulatory oversight is more general, less heavy-handed and tends to defer to market forces (i.e., the interaction of consumer and producer behavior) to determine pricing, investment and resource allocation. This is the basis for our belief that a short-run time frame is appropriate for purposes of assessing the exercise of market power and the fairness of rail rates.

4. Sustainability

Over time, to remain in business the firm needs to recover its fixed costs (FC). That is, total revenue must be greater or equal to total cost ($TR \geq TC = VC + FC$). This implies that the minimum sustainable per unit price is equal to average total cost ($P = ATC$). We can characterize the difference between a sustainable (breakeven) price for a firm with fixed cost and economies of density in terms of two components. The first component scales marginal cost by the inverse of the cost elasticity to account for economies of density. That is,

(II-15) $$AVC = MC/\eta.$$

Note in equation II-15 that AVC and MC are identical in the absence of density economies. The second adjustment scales average variable cost upward to incorporate coverage of fixed costs. That is,

(II-16) $$ATC = AVC(1 + FC/VC).$$

Combining these two adjustments gives:

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[47] The public utility pricing issue dates back to Jules Dupuit, "On the Measurement of Utility of Public Work," *Annales des Ports et Chaussees*, 2nd Series, Vol. 18, 1844 (in International Economic Papers, Vol. 2 [1952], pp. 83-110). Hotelling advocated marginal cost pricing with the resulting losses being covered from general tax revenues. Harold Hotelling, "The General Welfare in Relation to Problems of Taxation and of Railway and Utility Rates," *Econometrica*, Vol. 6, 1938, pp. 242-269. This stoked the "marginal cost controversy" as critics argued that the welfare basis of Hotelling's proposal was not valid because of, among other things, the distributional impacts of having non-consuming taxpayers pay. Mark Blaug, *Economic Theory in Retrospect*, Fourth Edition, Cambridge University Press, 1985, pp. 601-605 and Roland Andersson and Mats Bohman, "Short- and Long-Run Marginal Cost Pricing: On Their Alleged Equivalence," *Energy Economics*, October 1985, pp. 279-288 provides summaries of this literature.

[48] Jack Wiseman, "The Theory of Public Utility Price—An Empty Box," *Oxford Economic Papers*, Vol. 9, No. 1 (Feb. 1957), pp. 56-74.

[49] The issue is at the core of peak load pricing theory.

(II-17) Breakeven Price = $MC(1/\eta)(1 + FC/VC)$, and

(II-18) Breakeven Markup = $(P/MC)_{breakeven} = (1/\eta)(1 + FC/VC)$.

Thus, in cases where there are economies of density and fixed costs, marginal cost pricing is not sustainable and $(P/MC)_{breakeven} > 1$.[50]

5. *Multiproduct Pricing*

We now consider the multiproduct/multi-market situation that better characterizes freight rail markets. Regulatory oversight of railroad rate reasonableness typically focuses on a commodity-specific traffic between specific locations. That is, the commodity and the origin-destination define the relevant market. The railroad's outputs may be viewed as quantities of freight in each relevant market. Railroads can be viewed as operating in a large number of markets.

Railroad movements in this case may differ in cost and demand characteristics. The profit-maximizing price for movement *i* is:

(II-19) $P_i = MC_i(e_i/(1 + e_i))$.

The railroad is willing to provide service (in the short run) provided that revenue from the movement *i* exceeds the movement's incremental cost. Equation II-19 indicates that movement prices vary due to differences in both marginal cost and the demand elasticities perceived for the product. Sustainability continues to require an overall markup (over average marginal costs) that adjusts for density economies and covers fixed costs. An unconstrained firm will impose higher markups on movements with less elastic demand.

Finally, we can consider a threshold markup for regulatory jurisdiction.[51] Let *T* be a threshold markup (over marginal cost) such that a price is only reviewable if $P_i/MC_i > T$. It may be desirable for the threshold to allow a degree of "headroom" relative to the breakeven markup, to avoid review of rates with relatively low markups, given a policy that some exercise of market power is necessary to for railroads to achieve breakeven. A jurisdictional threshold may be considered as having positive headroom if it exceeds the breakeven markup:

(II-21) $T > (1/\eta)(1 + FC/VC)$.

However, the threshold *T* does not constrain the railroad's price for a movement *i* if:

(II-20) $T \geq e_i/(1 + e_i)$.

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[50] Non-linear pricing relaxes this tension to the extent that some costs are recovered through non-volumetric access fees.

[51] This is like the STB's statutory jurisdictional threshold in 49 U.S.C. §10707, but specified in explicit terms of economic cost rather than statutory "variable cost."

A railroad's rate in such a situation can be suboptimally high—compared to, say, a Ramsey-type price maximizing an index of consumer and producer surplus[52]—but unreviewable.

There is consequently a tradeoff in the post-Staggers Rail Act regulatory system between allowing railroads to freely exercise market power to provide for revenue sufficiency (higher *T*), and ensuring railroad customers are not charged inefficiently high rates (lower *T*). With *T* for railroad rate regulation fixed (with respect to "variable cost") by statute, breakeven markups based on short-run marginal (or incremental) costs may be used by the STB as a basis for establishing a bridging adjustment such that changes in cost methodology do not affect the stringency of rate regulation.

E. LEGACY URCS ECONOMIC AND ECONOMETRIC METHODOLOGY ISSUES

As noted above, the goal of URCS is to estimate "variable costs" caused by railroad movements. The RAPB's Causality principle establishes that costing should be based on the "concept of avoidability" and determined "on an incremental basis."[53] In this framing, the cost caused by a movement (indexed by i) is the cost that the railroad hypothetically would have avoided if it had not provided the shipment, other things equal. Conceptually, the avoided cost of a movement is the incremental cost of producing the output(s).

A central question for the viability the URCS framework is whether and under what assumptions URCS can be regarded as producing incremental costs. The answer suggested in Wilson and Wolak 2016 is that URCS is incompatible with incremental costs and thus yields economically arbitrary costs. In this section, we describe theoretical conditions under which URCS variable costs are equivalent to incremental costs. We also discuss implementation details of current-methodology URCS, especially with respect to the Phase I and Phase III models, that may affect the quality of URCS variable costs.

1. Conditions for Equivalence of URCS Variable Costs and Incremental Costs, the Causality Principle

Recall from above that the URCS variable cost estimate VC_i for railroad movement i can be described by the following equations:

(II-4) $$VC_i = \sum_{j=1}^{J} Q_{ij}\theta_{ij}UVC_j.$$

(II-3) $$UVC_j = \left(\sum_{k=1}^{K} s_{jk}v_kTC_k\right)/Q_j.$$

[52] Ramsey prices address the problem of breakeven pricing in a multiproduct context, from the perspective of a regulator or planner with an objective of maximizing total (consumer and producer) surplus or another social welfare measure.

[53] RAPB Report, Vol. 2, p. 9.

The variable cost in equation II-4 is computed as the product of generic unit variable costs UVC_j, movement-specific outputs Q_{ij}, and efficiency adjustment factors θ_{ij} that adjust some unit variable costs to reflect characteristics of movement i. The unit variable costs depend on variable costs $v_k TC_k$ for cost pool k, railroad outputs Q_j, and allocators s_{jk} that associate the variable costs in cost pool k with outputs Q_j. Provided that the sum of all movement costs $\sum_{i=1}^{N} VC_i$ equals total variable costs $VC(Q)$, then Wilson and Wolak (2016) is correct in describing URCS as a system that distributes estimated variable costs to railroad movements. However, the claim that the URCS variable cost distribution is inherently incompatible with economic incremental costs is incorrect.[54]

An approximate equivalence of URCS variable costs and causal economic incremental costs requires the following conditions:

1. The terms $s_{jk}v_k$ are equivalent to the elasticities $\partial \ln TC_k / \partial \ln Q_j$;
2. The efficiency adjustment factors θ_{ij} satisfy $\theta_{ij}UVC_j = \partial TC_k / \partial Q_{ij}$;
3. The movement-specific outputs Q_{ij} are small relative to railroads' total outputs Q_j.

Condition 1 requires an equivalence between the products of the URCS variabilities and semi-default allocators and elasticities of costs in cost pool k with respect to model output Q_j. Under this condition, the generic unit variable costs in URCS are interpretable as marginal costs. The result follows from equation II-9, above.

Condition 2 ensures that URCS efficiency adjustments, where applied, appropriately adjust generic unit variable costs to movement-specific values. Insofar as URCS does not comprehensively adjust all unit variable costs in Phase III, where $\theta_{ij} = 1$ the condition requires that the generic unit variable cost be applicable to movement i.

Condition 3 provides for the (approximate) equivalence of the URCS variable cost calculation and incremental cost assuming the other conditions are satisfied. In general, the integral of the marginal cost function in equation II-8 differs from the product of output and marginal cost. (The difference is called "inframarginal cost" in Panzar 2014.) Panzar 2014 shows that the inframarginal cost wedge is larger, other things equal, the greater the economies (or

[54] This discussion draws heavily on works describing the economic interpretation of costs from the U.S. Postal Service's annual Cost and Revenue Analysis (CRA) and engineering-economic models based on CRA results. See Michael D. Bradley, Jeffrey L. Colvin, and Marc A. Smith, "Measuring Product Costs for Ratemaking: The United States Postal Service," in Crew and Kleindorer (eds.), *Regulation and the Nature of Postal and Delivery Services,* Kluwer, 1993, pp. 133-157. Michael D. Bradley, Jeff Colvin, and John C. Panzar, "On Setting Prices and Testing Cross-Subsidy with Accounting Data," *Journal of Regulatory Economics* 16 (1999), pp. 83-100; and John C. Panzar. "The Role of Costs for Postal Regulation," https://www.prc.gov/sites/default/files/reports/J%20Panzar%20Final%20093014.pdf (Panzar 2014). In URCS terminology, the USPS CRA is comparable to Phases I and II of URCS and produce generic "unit volume variable costs" for postal products that are intended to be equivalent to marginal costs. Products' marginal costs are, in turn, used to approximate incremental costs. CRA-based engineering-economic models are like URCS Phase III and are used to derive marginal costs for categories of USPS output below the product level.

diseconomies) of density exhibited by cost function, exhibits larger economies (or diseconomies) of density (cost elasticities differ from 1) and/or the share of output Q_j that movement i's output increment Q_{ij} represents. Thus:

(II-21) $$IC_i \approx \sum_{j=1}^{J} Q_{ij} \cdot MC(Q_{ij}).$$

Note that if costs are linear in Q_{ij}, then $MC(Q_{ij})$ is constant and the equality is exact. If Q_{ij} is sufficiently small relative to Q_j, then the effect of non-constant marginal costs on the approximation equation II-21 is immaterial (see Panzar 2014, pp. 23-24).

Insofar as the legacy URCS framework is at least theoretically capable of producing (approximate) economic incremental costs, it is not necessary to replace the URCS framework in its entirety to satisfy a goal of producing causal costs for railroad movements. However, a natural question is whether the current URCS methodology plausibly meets the required conditions.

2. *Assessing Consistency of the Legacy URCS Model with the Conditions for Causal Costing*

The conditions that are most relevant for evaluating the economic content of current-methodology URCS are the conditions equating variabilities in Phases I and II with cost elasticities (condition 1) and requiring validity of movement-specific cost adjustments in Phase III (condition 2).[55] With respect to each condition, current URCS methodology does not overtly violate the condition, but costing methods could be improved to better align cost methodology for URCS or a successor system with economic cost concepts and hence the Causality principle. Below, we discuss issues related to the legacy URCS variabilities and URCS efficiency adjustments.

a) Legacy URCS Variabilities

As we established above, using cost elasticities for URCS variabilities implements the Causality principle because it allows generic unit variable costs from Phase II to be interpreted as marginal costs, and movement variable costs from Phase III to be interpreted as approximate incremental costs. The legacy URCS variabilities may be interpreted as cost elasticities, and thus comport with the Causality principle. However, in the legacy URCS framework this occurs because the elasticity and percent-variable methods happen to coincide given the linear (levels) specification of the cost equations estimated by Westbrook for Phase I.

Westbrook specified and estimated the following linear (level) model for each cost pool (indexed by *k*):

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[55] Condition 3 is subject to checking. Results in Panzar 2014 (p. 24) imply that differences between URCS movement costs and incremental costs related to the movement's share of railroad output are small (i.e., under 1 percent of measured cost) until the movement exceeds 20 percent of railroad output.

(II-22) $$C_{jkt} = a_{jk} + \gamma_{kt} + \beta_{kN} N_{jkt} + \beta_{kQ} Q_{jkt} + e_{jkt}, k = 1, \ldots, 15.$$

In equation II-22, the terms a_{jk} and γ_{kt} are, respectively, constants (in the equation for cost pool *k*) specific to railroads (indexed by *j*) and time periods (indexed by *t*). Those "fixed effects" terms are included in the model to capture the effects of otherwise unmeasured variables representing cost causing characteristics specific to a given railroad or time period. Controlling for railroad and year effects is possible as the R-1 dataset is a panel dataset with has multiple annual observations of each reporting Class I railroad.

We view the Phase I equations as appropriately representing a form of short run response of costs with respect to railroad outputs. This orientation of the Phase I models reflects two main features of the cost equations. First, the equations model only a contemporaneous effect of output on costs for the annual observations, and do not model any longer-term adjustment processes. Second, the equations condition costs on the railroad's capacity or network size measure, as well as other unobserved railroad characteristics via the fixed effects. It might be argued that at least for some Phase I operating cost pools—e.g., fuel expenses—railroads' managers can adjust costs to levels of output relatively quickly given the railroad's capacity. Given the annual frequency of the data, the models also do not (and could not) reflect an "very short run" time orientation where inputs are minimally adjustable. Over longer-run time horizons, railroad capacity would be (more) adjustable, and those adjustments may partly drive operating costs.[56]

Westbrook favored the "percent variable" approach considered by the RAPB over the elasticity method, largely ignoring the connection between the elasticity method and the Causality principle. Westbrook computed estimated variable cost ratios as:

(II-23) $$\hat{R}_{jkt} = \hat{\beta}_{kQ} Q_{jkt} / (\hat{\beta}_{kN} N_{jkt} + \hat{\beta}_{kQ} Q_{jkt}).$$

In this formulation, variability ratios for each equation will vary by railroad and over time depending on the railroads' levels of output and capacity variables. Dropping subscripts, the variable cost ratio in Westbrook's notation is defined such that $R = VC(Q)/TC(Q)$.

Substituting R for the cost elasticity η in the calculation of URCS unit variable costs, we obtain:

(II-24) $$UVC_j = \left(\sum_{k=1}^{K} s_{jk} R_k TC_k\right)/Q_j = \left(\sum_{k=1}^{K} s_{jk} VC_k\right)/Q_j \equiv VC_j/Q_j,$$

which is the average variable cost allocated to output Q_j and not, generally, the marginal cost except in the special case where $MC = AVC = c$ (a constant), and hence $\eta = R$.

Westbrook correctly observed that the difference between the elasticity/marginal cost and variable cost ratio/average variable cost formulations has implications for the STB's jurisdictional threshold. If marginal cost is below average variable cost—e.g., due to economies

[56] It is an empirical matter whether the data are sufficiently rich to allow modeling of such longer-run cost dynamics.

of density—then more traffic will be above the 180 percent R/VC threshold using the elasticity method than the variable cost ratio method, other things equal.[57]

However, in our view Westbrook inadequately considered the implications of the Causality principle appropriately in arriving at his preference for the percent variable approach. If a shipment is assigned costs based on average variable costs exceeding average incremental cost (which is approximately marginal cost), then the allocation of variable cost to the shipment associated with the portion of average variable cost that exceeds average incremental is arbitrary (in an economic sense) because that portion of average variable cost is not caused by the shipment.[58]

b) URCS "Default" Variabilities and "Semi-Default" Allocators

In addition to potential issues with the conceptual basis for econometric variabilities noted above, URCS also applies assumed or "default" variabilities for certain categories of costs—most notably return on investment (ROI) and depreciation, lease, and rental (DLR) costs for way, structures, and equipment. The default variabilities are 0.5 for costs related to way and structures assets and 1 for equipment (including locomotives and freight cars). The default variabilities are assumed rather than empirically-based values. The use of default variabilities does not necessarily render URCS ROI and DLR costs non-causal,[59] but it may make them materially inaccurate if the default variabilities are not empirically justifiable.

It is important to note that as a general matter, long-run costs cannot be modeled by applying a 100 percent variability factor to observed (backwards-looking) costs, notwithstanding the truism that "all costs are variable" in the long run. Implicit in the economic long run is that with full adjustability of inputs, the resulting long-run costs reflect an unconstrained optimum for usage of all inputs. Actual input usage observed at any time is likely not to be at the long-run optimum.[60] There is thus a considerable risk that the application of the default variabilities does not validly reflect any time orientation. Thus, we investigate empirical ROI and DLR output elasticities in Section III.

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[57] Westbrook 1988, p. 8. As we show in Section III below, the "other things equal" qualifier is important as a practical matter. The measured level of variable costs depends on econometric specification details as well as the conceptual basis of the variabilities.

[58] The claim that URCS costs are economically arbitrary is a major feature of the critique in Wilson and Wolak 2016. Regulatory practice does, in some cases, use non-causal costs due to statutory requirements. However, these practices tend to be justified on grounds other than economic cost theory. For example, national postal regulators in the European Union (EU) in some cases evaluate postal rates for cross-subsidy using average variable cost or fully-allocated cost tests rather than incremental cost tests, pursuant to EU Postal Services Directive 2008/6/EC. These practices at least in part reflect practical issues in incremental cost measurement. See "ERGP Report on Cross-Subsidization Practices" (2019), at https://ec.europa.eu/docsroom/documents/38864/attachments/3/translations/en/renditions/native. For a seminal discussion of fully-distributed cost pricing in regulated industries, see Braeutigam 1980.

[59] Wilson and Wolak 2016 asserts that the ROI and DLR costs are non-causal and thus economically arbitrary.

[60] Under cost minimization, long-run costs form a lower bound on the set of all short-run costs.

Changes in railroads' cost structures over time have increased the relative importance of costs subject to default variabilities. The STB's 2010 report to Congress noted that the Phase I econometric analysis originally covered 78 percent of railroad costs, with the remaining 22 percent of expenses using default variabilities. Changes in Class I railroad cost structure has materially decreased costs subject to econometric Phase I variabilities and increased costs subject to the default assumptions. Table II-1 shows that in the 2019 URCS worktables, operating expenses—almost entirely using regression-based variabilities—are 56 percent of total Class I railroad expenses. The 2019 share of DLR and ROI expenses using default variabilities is 44 percent. Given the increased importance of DLR and ROI costs, we consider empirical cost elasticities for these expenses in Section III.D of this report.

Table II-1. 2019 Operating, DLR, and ROI Expenses and Expense Shares, Class I Railroads

Expense Category	2019 Expense ($000)	Percent of Total
Operating	36,553,806	56%
DLR	10,717,182	16%
ROI	18,002,183	28%
Total	65,273,171	100%

Source: 2019 URCS worktables, worksheet D8P4.

In URCS, expenses need not be assigned entirely to one (and only one) output, such as the output variable included the econometric equation for the cost pool. URCS Phase II incorporates what is termed "semi-default" variability application in which portions of costs associated with a given cost equation are assigned to other outputs.[61] These are the factors s_{jk} in equation II-3, above.

The assumption in semi-default cases is that the econometric equation successfully estimates the overall output variability applicable to the cost pool but that it may not be possible to reliably measure effects on all independent variables that affect the costs in question. An example is assigning variable costs for freight car expenses to car types. The semi-default method recognizes that it may be impractical to estimate variabilities for expenses related to multiple outputs directly through multi-output extensions of cost equations such as the Phase I models in equation II-22.

With sufficiently rich cost and output data, it may be possible in principle to estimate the combined terms $s_{jk}v_k$ directly as cost elasticities from multiple-output cost equations. As a practical matter, the data available for the Phase I variabilities are limited by the small number of Class I railroads and the annual frequency of the data they report. Given these limits, obtaining sufficiently precise variability estimates for multiple outputs or other independent variables that tend to be highly intercorrelated is a significant practical challenge. The inclusion of the

[61] 1979 Rail Cost Study, p. 82.

allocators s_{jk} in lieu of direct estimation of variabilities thus may be justifiable under the Practicality principle. Moreover, it is consistent with the Causality principle to the extent $s_{jk}v_k$ reasonably approximates the "true" cost elasticity derived from a multi-output model. However, the semi-default allocators are not easily validated or empirically updated.

c) Generic and Shipment-Specific Costs in Phases II and III

URCS Phase III incorporates cost adjustment factors (θ_{ij} in Equation II-4, above) that adjust generic unit variable costs to reflect economies (or diseconomies) associated with the movement's characteristics—e.g., shipment size—that are not incorporated in the generic costs from Phase II.

While the URCS framework as given by equation II-4 potentially allows fully movement-specific adjustments to the generic unit variable costs, the implementation of cost adjustments in legacy URCS Phase III is much less flexible in practice. Some departure from full movement-specific cost flexibility is inevitable, given information limits—and may even be desirable, considering the Interchangeability subset of the RAPB Homogeneity principle. However, the legacy URCS efficiency adjustments are likely subject to improvement.

The most prominent cost adjustment factors in legacy URCS are the "make-whole" carload efficiency adjustments for switching costs. These are implemented as step functions, with the adjustment factors constant within categories of shipments. For example, the carload-based adjustment for industry switching costs, has the form (the subscript *i* indicates the movement):

(II-25) $$\theta_{i,industry} = \begin{cases} \theta_{industry,single}(>1), \text{ if } carloads_i \leq 5 \\ 0.5, \text{ if } 5<carloads_i < 49 \\ 0.25, \text{ if } carloads_i \geq 50 \end{cases} .$$

The legacy URCS cost adjustments are applied in a two-step process. In the first step, the cost reductions are applied to the movement categories whose adjusted costs are below the generic unit variable cost—in this case, multi-carload and unit train movements. The second step reallocates the total (absolute) amount of cost reduction as an upward adjustment to the remaining movement categories (i.e., those without reductions) so that the entirety of the applicable variable cost is assigned to shipments. A main limitation of the legacy URCS cost adjustments is that they do not provide for movement economies within the categories defining the step functions.[62] A restrictive adjustment may very well be preferable to no adjustment for movement-specific economies and may have reflected past informational and computational limitations. However, more continuous adjustments are likely to better reflect actual patterns of cost causality; we consider these below in Sections III and IV.

[62] Additionally, fixed cost reductions relative to system averages will make the relative differences in adjusted unit costs among shipment categories at least somewhat dependent on the railroad's traffic mix. Fixed cost reductions relative to system averages also cannot hold for all mixes of traffic. As an extreme case, if a hypothetical railroad's traffic consisted entirely of unit train movements, unit variable costs for those movements could not be lower than the railroad's system average.

3. *Economic Costs in Legacy URCS: Summary*

Overall, the URCS cost framework largely constitutes a system capable of generating valid economic cost measures for rail movements, consistent with the RAPB's Causality principle, within the limits of available data (and hence the Practicality principle). URCS variable costs for a movement can be interpreted as approximate incremental costs to the extent that the generic unit variable costs measure marginal costs, and that the URCS efficiency adjustments accurately capture the effects movement characteristics on the generic costs.

We expect that refining the step function approach to URCS Phase III cost adjustments would tend to improve the adjustments' consistency with the true patterns of cost causation, though a significant empirical question is whether the cost reduction factors (and the derivative cost increases) reflect actual shipment economies.

In legacy URCS, the unit variable costs derived econometrically (including the semi-default method) are interpretable as marginal costs conditional on the linear variability models being correctly specified, because the percent-variable and elasticity methods yield the same variable costs under the linear model. Consistency with the RAPB Causality principle in general implies use of the elasticity method for URCS variability factors. Consequently, the alternative and updated URCS models we investigate in Sections III and IV of the report use cost elasticities for variabilities.

Unit variable costs for components employing default variabilities may or may not differ from marginal costs (over the appropriate length of run), depending on the extent to which the default variabilities are empirically justifiable. The assignment of default costs to shipments, nevertheless, is consistent with the causality principle given the values of the default variabilities employed in URCS. However, the high share of costs subject to default assumptions in current-methodology URCS warrants investigation of empirical variabilities for ROI and DLR expenses.

F. STAKEHOLDER VIEWS OF URCS AND PRIORITIES FOR URCS UPDATES

We conducted interviews with representatives of outside stakeholder groups to gain insights into perceived problems with URCS that may not have been readily apparent from comments filed in the Ex Parte (EP) 431 sub-no. 3 and EP 431 sub-no. 4 dockets, and to solicit views on potential approaches to rectifying these problems. The respondents were two consultants and an attorney who primarily represent shipper interests, and two consultants and an attorney who primarily represent railroad interests. This section reports the main highlights from these interviews. Generally, the interviews reflected the various views and positions that were presented in EP 431 sub-no. 3 and EP 431 sub-no. 4. In other words, there was relative consensus on a few topics (e.g., updating data and, possibly, regressions in Phase I), but a diversity of views on many other topics (e.g., Phase III adjustments).

Aside from discussing problems with URCS and potential solutions, an important point made in these interviews was that URCS is tied to the jurisdictional threshold that determines dominant traffic. Several respondents noted that URCS was the result of political compromise and does not produce pure economic measures of cost. It was opined that the statutory requirement to use a measure of variable cost must be maintained, whatever revision to or replacement for URCS is contemplated. In this regard, one respondent stated that a measure of variable cost that includes a margin over marginal cost is required for the purpose of computing the jurisdictional threshold. There was disagreement among the respondents on the impact that changes to URCS would have on the proportions of traffic above and below the jurisdictional threshold. Some respondents opined that any changes to URCS or a replacement for URCS may require a "linking factor" to maintain the same proportions of traffic above and below the jurisdictional threshold. However, another respondent said that if the proportions change significantly with changes to URCS, it is evidence that URCS was wrong.

Before summarizing the comments received, we provide a brief overview of EP 431 sub-no.3 and EP 431 sub-no. 4.

1. *Overview of EP 431 sub-no. 3 and EP 431 sub-no. 4*

a) EP 431 sub-no. 3

STB Ex Parte No. 431 (Sub No. 3), entitled Review of the Surface Transportation Board's General Costing System, was issued on April 6, 2009 and noticed a public hearing to take place on April 30, with written testimony and submissions due by April 23. The purpose of the proceeding was "to receive public comment on how best to revise the existing URCS model."[63] While welcoming suggestions for additional aspects of URCS that the STB might review (excluding the costs of transporting hazardous materials which was the subject of its own proceeding), the Board specifically encouraged parties to address 13 specific topics:

1. Improve the efficiency adjustments associated with unit-train and multi-car movements;
2. Update the historical studies used in URCS;
3. Improve the costing of trailer or container on flat car (TOFC/COFC) traffic;
4. Update the URCS national car tare weight calculation to account for the number of car miles that each car type operates;
5. Update the number of miles between non-intermodal inter-train/intra-train (I&I) switches by URCS car type;
6. Disaggregate loss and damage information by carrier and by two-digit Standard Transportation Commodity Code (STCC) groupings;
7. Revise the Train Switching Conversion factor used to place all road train crew wages on a common mileage basis;
8. Require carriers to report their average switch engine speeds in order to better reflect switching expenses;

[63] Review of the STB's Gen. Costing Sys., EP 431 (Sub-No. 3), Apr. 6, 2009, p. 2.

9. Revise the ratio of urban and rural land values to allocate expenses between running and switching;
10. Revise the URCS car types to eliminate outdated car types and add new car types to reflect those currently used in the railroad industry;
11. Revise the spotted to pulled factor for each car type;
12. Revise the approach used in individual proceedings to index URCS in order to use the RCAF indexes published by the Board; and
13. Update the various statistical relationships used in URCS, including the variability estimates.

In its 2010 report to Congress, the STB provided an overview of the three primary criticisms it received in the proceeding. First, a "pervasive" criticism was that the URCS statistical and engineering methods were outdated.[64] It has been many years since the statistical relationships used in URCS have been reviewed and the engineering special studies upon which URCS is based date back to the 1930s through the 1960s, which predates modern rail operations. There was concern that URCS costs, being based upon outdated methods, may no longer as reliable and accurate as possible. USDOT indicated that because URCS is still largely using the same econometric methodology of 20 years ago, it does not take into account changes in rail operations over this period that directly impact allocation of costs to movements.[65] Various respondents indicated that the increased use of URCS for regulatory purposes compelled the need to update and improve URCS.

A second criticism was that URCS fundamental flaws make it less suitable for use as a railroad costing system.[66] Some industry analysts questioned whether URCS reliance upon linear regressions was a fundamental problem; suggesting that rail costs were not linear and that other functional forms should be tested.[67] Stakeholders expressed concerns that system average regressions were inappropriate for costing specific movements—in particular, both certain shippers and smaller carriers indicated that the efficiency of their movements were not reflected in the use of system averages.[68] Respondents indicated that URCS did not take traffic density or productivity into account. Parties indicated that certain variability factors should be changed and that the default variability factors should be empirically supported with current, actual data. Concerns were expressed regarding flaws in the R-1 operating statistics.

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[64] STB 2010 URCS Report, p. 12.
[65] USDOT submission, EP 431 (Sub-No. 3), p. 3.
[66] STB 2010 URCS Report, p. 13.
[67] Bereskin suggested that the current railroad market may be experiencing diseconomies of scale and additional traffic costs will follow a non-linear pattern. Bereskin Submission, EP 431 (Sub-No. 3), p. 3. McCullough indicated that the Board should consider whether it is feasible to use a regression-based costing system to project movement-specific costs. McCullough submission, EP 431 (Sub-No. 3), pp. 2-3.
[68] WCTL submission, EP 431 (Sub-No. 3), p. 8; KCS submission, EP 431 (Sub-No. 3), pp. 2-3. KCS indicated that the use of URCS in proceedings involving KCS was unfair and inaccurate and does not allow long term opportunity to achieve revenue adequacy. One specific problem raised by KCS was that the cost of capital component, based upon average of the four largest carriers (all of which had significantly lower capital cost structures than KCS), did not accurately reflect cost of carriers like KCS.

The third criticism noted by the STB was that certain elements of URCS should be revised to better reflect actual railroad costs.[69] Respondents noted that URCS should reflect full variability of all costs and that the costs should be fully allocated as precisely as possible.[70] At least one shipper indicated that accuracy should be the main issue.[71] Some respondents highlighted specific issues of concern, such as the make-whole adjustment, TOFC/COFC costing, cost treatment of privately owned railcars, and costs of capital expenditures. Parties also suggested the use of carrier's accounting systems versus USOA to calculate service costs, changes to the treatment of fuel surcharges, and adjusting circuity factors.

In addition to those criticism highlighted by the STB's report to Congress, various respondents also expressed concerns regarding the burden of URCS review process itself and the implementation of changes to URCS. Various parties indicated that the Board should carefully consider how the URCS review process should be organized in terms of cost and complexity. Several parties noted that the identified potential benefits of any changes should outweigh the costs of inquiry and implementation.[72] Parties indicated that the Board should consider the impact of any modification on other pending proceedings. Shipper interests indicated that revision efforts must be transparent, providing a "level playing field" with adequate opportunity to develop, audit, replicate, and validate special studies and other results with access to carrier data and records, computer code, and documentation. USDOT also indicated that current technology and computation power could simplify use of tools and make the process more transparent for all users. Railroad interests expressed concern about the burden of implementing any revisions to the costing system, suggesting that changes in accounting and reporting should be designed to minimize administrative burden and system adaptations. A few parties indicated that an updated/revised cost system should be flexible or adaptable to ensure future changes can be accommodated in an efficient way and to ensure continued accuracy.

b) EP 431 sub-no. 4

In February 2013, the Board issued a Notice of Proposed Rulemaking (NPR) regarding the Board's proposals to modify URCS. Economies of scale related to shipment size (in carloads) are not taken into account in the Phase II calculations of system-average unit costs, but instead are accounted for in "make-whole adjustments." Make-whole adjustments are applied as a two-step process. First, a downward "efficiency adjustment" relative to system average unit costs is applied to shipments in high-carload categories.[73] Second, the total amount of cost reduction

[69] STB 2010 URCS Report, p. 14.
[70] This position was taken by stakeholders from all sides. For example, see AAR Submission, EP 431 (Sub-No. 3), pp. 3, 5; WCTL Submission, EP 431 (Sub-No. 3), p. 3. USD Submission, EP 431 (Sub-No. 3), p. 3.
[71] Wheat and Barley Commission Submission, EP 431 (Sub-No. 3), p. 3.
[72] AAR suggested an "analytical triage" to focus available resources on improvements on issues that can be justified for inquiry. One shipper, WCTL, specified that a comprehensive review of URCS would be an expensive and time consuming proposition for all parties to participate properly in any such proceeding, and "shippers can only meaningfully participate in a comprehensive review of URCS by retaining experts and working side-by-side with the Board and its contractors to address complex issues that will be reopened and revisited in a new URCS proceeding." WCTL submission, EP 431 (Sub-No. 3), p. 4.
[73] In legacy URCS, the "single" category includes shipments of 1-5 carloads, the "multi" category includes 6-49 carload movements, and the "unit train" category represents shipments of 50 or more carloads.

resulting from the efficiency adjustment is then redistributed to shipment size categories that are not subject to the cost reductions, usually the "single" (1-5 carload) category. The combined effect of the cost reductions and subsequent reallocation increases unit variable costs for smaller shipments relative to system average costs.

The application of the make whole adjustments yields several problematic results. Notably, make-whole adjusted unit costs do not vary within shipment size categories, and the unit cost step functions unreasonably assume that scale economies are only present between, and not within, the carload size categories. Moreover, the unit cost step functions result in total shipment costs for some cost elements that decrease with the number of carloads at the category boundaries. These cost patterns do not comport to underlying patterns of cost causation.[74]

The NPR sought to eliminate the "make-whole adjustments" applied in the legacy URCS costing framework. The Board proposed to change how certain system-average costs were calculated to better reflect rail operations and account for economies of scale and thereby avoiding the need for the make-whole adjustment. The NPR also suggested changes to the locomotive unit-mile (LUM) cost allocation.

In August 2016, after receiving and evaluating the comments on the NPR, the Board served a Supplemental Notice of Proposed Rulemaking (SNPR) with "modified proposals for eliminating the make-whole adjustment and LUM cost allocation and a new proposal to modify train-mile cost allocations."[75] The Board held a technical workshop regarding the SNPR proposal in September 2016 and received comments and reply comments in October and November 2016, respectively. The Board eventually closed the docket without adopting changes to URCS, citing a lack of consensus among stakeholders as to the merits of the proposals.

2. General Problems/Issues with URCS Noted in Stakeholder Interviews

In general, URCS was acknowledged to have problems but that it could probably be reasonably fixed without disregarding the model completely (e.g., "URCS is not necessarily bad, but could be improved"). While this was the general sentiment, it was not unanimous as one of the respondents opined that EP 431 sub-no. 4 was "a waste of time and effort," and that the proposals were "cosmetic" and a "band aid." The respondent continued that if an effort was made to "fix" URCS, a major overhaul was called for along the lines of the issues raised in EP 431 sub-no. 3 (described above). However, another respondent opined that it will be hard to get stakeholder buy-in to change the system in a "massive" way and that even small changes have been difficult to achieve. Most of the focus of respondents was on problems in Phase III movement costing, with some acknowledgement of issues in Phase I. In particular, the use of system average costs without an ability to adjust for movement-specific factors in Phase III was

[74] While the legacy URCS implementation may be preferable to omitting cost economies with respect to shipment size entirely, the limitations of the step function implementation are not (as we discuss below) justifiable on practicality grounds.
[75] Surface Transportation Board Decision Docket No. EP 431 (Sub-No. 4), June 6, 2019, p. 1.

seen as a major problem. Problems generally acknowledged in Phase I were the reliance on outdated data and regression results.

a) Specific Problems/Issues with URCS Noted in Stakeholder Interviews

Phase I

The criticisms of Phase I were that the regressions were old and that some of the variabilities go back to Rail Form A. It was recommended that, at the very least, the data used to estimate the regressions should be updated. However, it was questioned whether there would be sufficient data to do this given that there are currently only seven Class I railroads. In addition, while this would not necessarily mean that the functional form of the regressions need to be modified, it was also noted that alternative econometric model specifications could be considered.

Phase II

None of the interviews noted problems or issues with Phase II.

Phase III

The bulk of URCS criticisms from respondents focused on Phase III. It was generally felt that Phase III needed to be substantially revised or reformulated. In its current state, one respondent opined that the costs coming out of Phase III could be misstated by as much as 25 percent. One respondent said that the make-whole adjustment was the biggest problem in Phase III, followed by toxic by inhalation (TIH) costing. Regarding the make-whole adjustment, it was noted that the resulting step functions indicated fundamental problems with the make-whole adjustment. One respondent opined that spreading additional cost over non-unit train traffic that is required by the make-whole adjustment takes a lot of this traffic out of consideration for rate relief as the additional cost pushes this traffic below the jurisdictional threshold. With regard to TIH insurance costs, the current practice of spreading these costs over all traffic was seen as incorrect as chemical shippers did not bear the full costs of their traffic.

Aside from these issues, the use of system average costs and an inability to make movement-specific adjustments is seen as a fundamental problem with Phase III. Currently, the costs resulting from Phase III are not a reflection of any piece of traffic. One respondent noted that there used to be flexibility in making adjustments until the early 2000s. Features of railroad operations and traffic movement detail missing from Phase III adjustments noted are:

- Line density and congestion
- Train type detail is too restrictive
- Signaling
- Precision railroading
- Positive train control

b) Potential Solutions Noted in Stakeholder Interviews

Phase I

As noted above, at the very least, data used to estimate the URCS regressions needs to be updated. In addition, changes to the functional form of the regression models could be investigated.

Phase III

Based on their critiques noted above, eliminating the make-whole adjustment and its resulting step functions, and properly attributing TIH insurance costs to chemical shipments are two important changes to Phase III that were generally seen as necessary to improve URCS. However, one respondent (who labeled EP 431 sub-no. 4 as "a waste of time") did not think the step functions were problematic.

In addition, the ability to reflect current and future railroad operations and traffic types is important. This largely entails allowing appropriate adjustments to move from system averages to movement-specific costs. This would include adjustments for those aspects of Phase III that were noted above as missing.

One suggestion for accomplishing these deficiencies is to have costs for "archetypes" of train types—e.g., coal, intermodal, chemical—that are the basis of costs for these various types of trains.

Along these lines, one respondent noted that one-size-fits-all adjustments are not sufficient for costing particular movements:

- Nine inputs for every type and location of traffic may not be enough
- Only three options to define traffic (i.e., 1-5, 6-49, 50+) does not reflect all types of movements; need to reflect full operations and not just these three.

In this regard, having more flexibility (i.e., more categories for adjustment) would result in better movement-specific costing.

Finally, respondents noted that additional and more current data would likely be required to achieve many of these suggested changes. It was speculated that railroads might have a lot of the necessary data and that, possibly, the STB may issue new reporting requirements as there is precedent for changing data reporting requirements.

G. Conclusions

URCS is fundamentally tied to the railroad regulatory system by statute. Without Congressional action, URCS can only be replaced by another costing system meeting the objective of producing variable costs for rail freight movements for use in evaluating the STB's jurisdictional threshold for reviewing rail rates.

We find that the URCS costing framework as a general matter does not need to be fundamentally changed to produce economic costs. URCS can be refined or improved by updating inputs including variabilities, efficiency adjustments, and other cost allocators. Any costing system developing generic unit variable costs from railroad reports (like URCS Phases I and II) and then projecting movement costs from efficiency-adjusted generic costs and movement characteristics (like Phase III) can be embedded in the general URCS framework. A common costing framework encompasses the Hybrid NEIO alternative model we develop in Section III and updated URCS models we present in Section IV, below.

The economic interpretation of URCS "variable costs" fundamentally follows from the RAPB's Causality principle, for which the RAPB correctly defined causal costs in economic terms consistent with marginal and incremental costs. The most important practical question for the economic interpretation of costs is whether variabilities and other cost allocators in the URCS Phase I and II model measure cost elasticities with respect to railroad outputs. Features of current-methodology URCS analysis including the use of default variabilities and semi-default VC allocations do not necessarily violate the causality principle in theory but may result in cost inaccuracies if they are not empirically justifiable.

Both our review of URCS methodology and stakeholder comments identify updates to Phase I models and Phase III efficiency adjustments as priorities for URCS alternatives or updates. Stakeholder views were mixed as to implications of URCS changes for the jurisdictional threshold. While the merits of doing so may be debatable, bridging adjustments could be derived to limit the extent to which changes to URCS methodology affect the volume of railroad movements subject to the statutory jurisdictional threshold.

III. AN ALTERNATIVE TO URCS: THE HYBRID NEIO MODEL

A. BACKGROUND

1. URCS Alternatives in the 2010 STB Report to Congress

The STB's 2010 URCS Report described a track of research into URCS alternatives which could be investigated in parallel with updates to the URCS model.[76] The STB specifically mentioned two alternative clean-sheet approaches to shipment costing, both of which make use of disaggregated shipment-level data from the Carload Waybill Sample (CWS). One approach, termed the "New Empirical Industrial Organization" (NEIO) model, would determine shipment costs entirely from the estimated coefficients of regression models relating shipment prices measured in CWS to cost and market characteristics of the shipment. The second, which the report calls the "Christensen Cost Model," is a hybrid model that combines results from a NEIO regression analysis with marginal cost estimates from an econometric cost analysis. We call the second approach the "Hybrid" or "Hybrid NEIO" model below. In the Hybrid model, the cost function analysis provides estimates of non-shipment-specific or "generic" marginal costs (akin to URCS Phases I and II) and estimated coefficients on cost-related variables from the NEIO regression serve as the basis for computing shipment-specific adjustments to the generic costs (functionally like URCS Phase III). We describe the conceptual frameworks of the NEIO and Hybrid models in Section III.B, below.

The STB noted that a common challenge for the NEIO and Hybrid alternatives is that CWS data do not directly provide cost information. Rather, CWS data include shipment characteristics and revenues. The STB also noted that the NEIO and Hybrid models both yield estimates of short-run marginal costs rather than longer-run variable costs for the R/VC test codified in 49 USC §10707. As we discussed in Section II, the §10707 test does not codify a length of run, and for the purpose of evaluating railroads' exercise of market power, the use of short-run marginal costs is economically appropriate. To the extent that the NEIO model does identify costs, the costs it measures are the subjective (marginal) costs that railroads base their pricing decisions upon. In theory, these would be marginal costs corresponding to the period(s) the prices would be in effect—technically, short-run costs.

The limitation that CWS data do not contain cost information is a more fundamental issue for the "pure" NEIO model. The NEIO regression framework cannot reliably measure shipment costs, as opposed to shipment cost differences, using only pricing data. Some of the NEIO model's parameters unavoidably combine cost and markup effects, such that pure cost levels (or pure markups) cannot be disentangled from the results without additional information obtained from outside the NEIO regressions.

[76] STB 2010 URCS Report, pp. 28-32.

The Hybrid approach overcomes the absence of cost level information in the CWS by incorporating cost data from outside the CWS to identify levels of non-shipment-specific ("generic") marginal or unit variable costs. The cost information can be obtained by various means. In the Christensen 2009 Competition Study, we derived generic marginal costs of revenue ton-miles by railroad and year from estimated parameters of a translog cost function.[77] For this study, we updated the 2009 cost function analysis, and additionally developed generic costs using cost elasticities estimated from cost equations like the URCS Phase I models. In both cases, the cost modeling is based primarily on data from Class I railroads' R-1 annual reports to the STB.

In addition, the Hybrid model can be used to de-average any generic costs, not only short-run marginal costs, at least as a mechanical matter.[78] Our main use of unit variable costs from current-methodology or legacy URCS in the Hybrid model framework is to isolate effects on shipment costs and R/VC ratios arising from the use of NEIO-based cost de-averaging (in place of URCS Phase III) from cost level differences arising from using our econometric cost models instead of legacy URCS variable costs.

As implemented in the Christensen 2009 Competition Study, the original Hybrid model only estimated costs for the subset of Class I railroad movements not involving an observed interchange with another railroad. We update and extend the Hybrid model implementation here to produce costs for any movement for which a generic cost estimate is available. Given the coverage of the R-1 annual report data, we can effectively estimate marginal costs for all Class I railroad movements.

We review the NEIO and Hybrid model frameworks in Section III.B. Section III.C presents the NEIO price (revenue per ton-mile, or RPTM) regression models and compares the NEIO RPTM models' implied marginal cost structures to URCS variable costs per ton-mile. The generic costs based on both an industry variable cost model and a disaggregated model based on URCS Phase I methods are presented in Section III.D. Finally, in Section III.E, we compare shipment cost estimates from Hybrid models using our preferred NEIO regression specification with legacy URCS costs and show the impacts of the Hybrid costs on the fractions of traffic above and below 180 percent of measured cost. We conclude with a discussion of pros and cons of the Hybrid model as an URCS replacement in section III.F.

2. *Alternatives Based on Cost Function Estimation*

In addition to the NEIO and Hybrid models, some researchers have proposed URCS alternatives based on estimation of econometric cost functions derived from economic cost and production theory. The econometric cost function alternatives use aggregated cost, input, and output data,

[77] See the Christensen 2009 Competition Study, Vol. 2, Chapter 9.
[78] Since they are based on NEIO regression results, shipment-level cost differences in the Hybrid model will in principle reflect relative differences in the short-run marginal costs that underlie prices, regardless of the length-of-run of the generic costs.

like URCS Phases I and II. As such, these cost theoretic alternatives mainly address critiques of URCS related to the theoretical foundations of the URCS cost equations. Examples include the "hedonic" translog cost function estimated in Bitzan and Wilson 2003 and the multi-output translog model estimated in Bereskin 2001.[79] Here, we briefly note some characteristics and key limitations of these approaches that explain their omission from consideration for this study as well as from the STB report's alternatives.

The main feature of the cost function alternatives is a specification of cost functions with multiple outputs and/or output characteristics as a means of bridging the URCS cost equations with standard economic cost functions. This contrasts with the common use of single outputs—typically gross or revenue ton-miles—in econometric cost function models of railroads intended to characterize railroad cost structure features such as scale and/or density economies at a high level. The underlying issue is that two firms with the same measured output in terms of (say) ton-miles could have materially different costs depending on how the ton-miles are incurred. For instance, a railroad with a greater share of ton-miles resulting from unit train shipments would be expected to have lower cost than a railroad producing the same ton-miles with a greater share of small shipments in manifest trains.

The Bitzan and Wilson 2003 model incorporates separate outputs for unit train ton-miles and through and way train ton-miles, and allows for the inclusion of variables describing output characteristics such as length of haul and shipment sizes. The Bereskin 2001 model includes five intermediate outputs[80] plus "miles of rail" representing "fixed factors of production." The richer output specifications effectively estimate non-shipment-specific unit (marginal) costs in a single econometric estimation step rather than using the multi-step URCS Phase I and II procedures.

By combining multiple outputs with second-order flexible functional forms such as the translog, these models require large numbers of parameters relative to the number of railroad-year observations. For example, the Bitzan and Wilson 2003 model has 94 parameters in addition to railroad fixed effects. The 15-year 1983-1997 dataset Bitzan and Wilson used contained 240 firm years of data. With seven Class I railroads, the 15-year period ending in 2019 contains only 105 firm-year observations. In updating the marginal cost inputs for the Hybrid model, we found that it was not possible to obtain credible estimates from a single-output translog model without imposing parameter restrictions. As a practical matter, the available contemporary data likely will be insufficient to reliably estimate the parameters of more general cost functions.

Also, while the cost function alternatives might be able replace the unit variable cost computations in URCS Phases I and II, at least if they could be feasibly estimated, they do not necessarily eliminate the need for URCS Phase III. Estimating costs for individual movements in the cost function alternatives still requires calculating incremental amounts of outputs associated with the movements, which is a Phase III function in legacy URCS. The cost function

[79] Bitzan and Wilson 2003; C. Gregory Bereskin, "Sequential Estimation of Railroad Costs for Specific Traffic," *Transportation Journal* (Spring 2001).

[80] The outputs are gross ton-miles, car mile, train miles, horsepower-miles, and road plus yard switching hours.

alternatives also do not necessarily measure shipment-level efficiencies and thus will generally require auxiliary analyses akin to the Phase III efficiency adjustments to de-average the non-shipment-specific unit costs. In this regard, the Bitzan and Wilson 2003 hedonic cost model may have a theoretical advantage over the Bereskin 2001 model in that it allows output characteristics to modify unit costs, though Bitzan and Wilson observed that movement costs did not vary much within the through/way train and unit train groups and concluded that the translog model explained system costs well but performed poorly as a movement cost model.[81] Indeed, Bitzan and Wilson 2003 motivated the use of disaggregated data in the NEIO model in part with the failure of the hedonic model as a basis for movement costing.

B. NEIO AND HYBRID NEIO MODEL FRAMEWORK

1. *Relationship of Shipment Prices and Costs*

The NEIO and Hybrid models have a common foundation in econometric models using shipment-level data from the CWS to characterize aspects of railroads' pricing behavior, such as how shipment pricing responds to movement characteristics or measures of railroad competition.[82] The CWS does not directly provide any data on railroads' costs. Rather, it provides data on shipment revenues and (some) cost-causing characteristics of shipments, including the characteristics that are used to determine shipment costs in legacy URCS. To estimate costs from pricing data, the NEIO and Hybrid models use a model of profit maximization under conditions of constrained market power that shows how the price of a rail movement may be decomposed into components related to the movement's marginal costs and to factors determining the markup over marginal cost.

The theoretical underpinning of the NEIO and Hybrid models is the pricing behavior of profit-maximizing railroads subject to shippers' participation constraints and the presence of competition from other railroads and/or other transportation modes.[83] It can be shown that the resulting shipment rates (r_i) satisfy:

(III-1) $$(r_i - MC_i)/r_i = (\lambda_i - 1)/\varepsilon_i.$$

Where the term λ_i reflects the value to the railroad of relaxing the shipper's participation constraint (allowing the railroad to charge a higher price and still retain the traffic) and ε_i is the demand elasticity. Rearranging terms and taking natural logarithms leads to the following equation decomposing (log) rates (r_i measured as revenue per ton mile) into marginal cost and markup terms:

(III-2) $$\ln r_i = \ln MC_i + \ln(\varepsilon_i/(\varepsilon_i - \lambda_i + 1)).$$

[81] Bitzan and Wilson 2003, p. 29-30.
[82] See Bitzan and Wilson 2003, Appendix B, for a review of earlier railroad pricing models employing CWS data.
[83] See Bitzan and Wilson 2003, pp. 35-37; Christensen 2009 Competition Study, Vol. 2., pp. 11-3 to 11-6. We use the notation from the Christensen 2009 Competition Study here.

Equation III-2 gives rise to an estimating equation (which we will call the "NEIO regression") expressing the marginal cost and markup terms as functions of explanatory variables characterized as cost-related and markup-related factors determining rates:

(III-3a) $\ln r_i = \text{cost effects} + \text{markup effects} + \text{other effects} + \text{residual}.$

(III-3b) $\ln r_i = \sum_{n=1}^{N} \beta_{cn} X_{cn,i} + \sum_{p=}^{P} \beta_{mp} X_{mp,i} + \alpha_0 + \sum_{l=1}^{L} \delta_l Z_{l,i} + u_i.$

In Equation III-3b, the terms β_{cn} and $X_{cn,i}$ represent *N* coefficients and the associated variables determining marginal cost. The terms β_{mp} and $X_{mp,i}$ represent *P* coefficients and the associated variables determining markups. The model may also include the effects of other explanatory variables Z_l (with parameters δ_l) which may include trend terms, railroad, route, or commodity fixed effects, and the like. The term u_i is a model residual. Equations III-3a and III-3b incorporate a crucial assumption that the decomposition of rates into cost and markup terms is valid, and thus that the terms $\beta_c \cdot X_{c,i}$ determine (relative) marginal costs and do not partly capture market structure effects determining markups.[84] Likewise, the markup variables $X_{m,i}$ must be assumed not to affect railroads' marginal costs:

(III-4) $\ln MC_i \sim \beta_c \cdot X_{c,i};\ \ln(\varepsilon_i/(\varepsilon_i - \lambda_i + 1)) \sim \beta_m \cdot X_{m,i}.$

While we will accept this assumption for the purposes of the following analysis, it is important to keep in mind that it is a foundational assumption not unlike Westbrook's crucial assumptions underpinning the variability analysis in Phase I of legacy URCS.

2. *Movement Costs in the NEIO and Hybrid Models*

The NEIO and Hybrid models differ primarily in the techniques they use to compute shipment-level costs. The NEIO model in Bitzan and Wilson 2003 purports to measure costs directly from the price regressions. From Equations III-3b and III-4, this requires all variables in the NEIO regression model to be able to be classified as either a cost or a market structure variable. In contrast, the Hybrid model identifies costs using generic (non-shipment-specific) cost estimates from an outside analysis of cost data, such as estimation of an econometric cost function, and uses the NEIO regression to determine how shipment-level costs vary with observed movement characteristics relative to the generic costs.

The Bitzan-Wilson NEIO model develops shipment costs using only pricing model results, combining the above equations to obtain:

(III-5) $\ln MC_i \approx \beta_c \cdot X_{c,i} \Rightarrow MC_i^{NEIO} \approx exp(\hat{\beta}_c \cdot X_{c,i}).$[85]

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[84] Note that the vector product $\beta_c \cdot X_{c,i} = \sum_{n=1}^{N} \beta_{cn} X_{cn,i}$.

[85] Bitzan and Wilson 2003, p. 37.

The identification challenge with the NEIO model is that some variables in the NEIO price regression—including the regression intercept, "other" explanatory variables in Z_l, and the regression residuals—are not uniquely related to either movement costs or markups. Instead, they will capture combined effects of cost and market structure factors not measured by other variables. For instance, a route fixed effect can capture cost effects (e.g., resulting from the terrain that the movement traverses) as well as competitive or demand effects related to the markets served by the route, insofar as those effects are not fully captured by other variables included in the model. Similarly, if the model includes railroad-specific fixed effects, those generally will capture both aspects of the railroad's cost structure and market power to the extent other variables do not completely characterize those effects.

As a result, while marginal costs depend on $exp(\hat{\beta}_c \cdot X_{c,i})$ as in Equation III-5, they are not completely determined by the "cost variables" $X_{c,i}$. Rather, movement marginal costs also include an (unknown) portion of the effects $\alpha_0 + \sum_l \delta_l Z_{l,i} + u_i$. Further, the NEIO model in Bitzan and Wilson 2003 does not specify explicit identifying assumptions for the NEIO cost analysis including how, if at all, the intercepts, other explanatory variables Z_l (including fixed effects), and/or the regression errors were used to estimate movement costs. We conclude that movement costs are not measurable solely from CWS-based price regressions.[86]

The Hybrid model was developed as part of an analysis of CWS data that was primarily intended to characterize how rail rates responded to cost and market structure variables.[87] As part of that analysis, we considered how external marginal cost information could be combined with NEIO regression results to mitigate the NEIO model's cost identification problem and allow calculations of markups—Lerner markup indexes $(r_i - MC_i)/r_i$—for shipments or groups of shipments.[88] In that exercise, calculation of shipment-specific markup indexes generated estimates of shipment-specific marginal costs as a byproduct.

The Hybrid model does not assume that the level of marginal cost for a shipment can be measured directly from the reduced form price Equation III-3b. Instead, the Hybrid model interprets the function $exp(\hat{\beta}_c \cdot X_{c,i})$ in Equation III-5 as a cost shifter that may be used to adjust (or de-average) a non-movement-specific or generic marginal cost (per ton-mile) for the observed cost-related characteristics of the movement. The generic marginal cost estimate itself is derived from a separate analysis such as estimation of an econometric cost function.

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[86] We also reviewed unpublished workpapers from further research on NEIO models carried out by Wilson for the STB, which also did not include sufficient information on the models' movement cost calculations to allow us to evaluate the underlying economic and/or econometric assumptions.

[87] See, generally, Christensen 2009 Competition Study, Chapter 11. Several predecessor studies employing regression analysis of CWS data similarly were intended to characterize the effects of a variety of cost- and market-related factors on rail rates for various commodities. See, e.g., James M. MacDonald, "Competition and Rail Rates For the Shipment of Corn, Soybeans, and Wheat," *Rand Journal of Economics* 18 (1987), pp. 151-163; James M. MacDonald, "Effects of Railroad Deregulation on Grain Transportation," U.S. Department of Agriculture, Economic Research Service, Technical Bulletin No. 1759 (June 1989).

[88] Christensen 2009 Competition Study, Vol. 2, pp. 11-6 to 11-7.

Thus, as originally formulated, the Hybrid model's movement-specific marginal cost is the product of the generic marginal cost per ton-mile and a movement-specific adjustment factor (θ_i) derived from coefficients of the NEIO regression model:

(III-6) $$\theta_i = \exp(\hat{\beta}_c \cdot X_{c,i}) / \exp(\hat{\beta}_c \cdot \overline{X_c}).$$

(III-7) $$MC_i^{hybrid} = \theta_i \cdot MC^{generic}.$$

(III-8) $$VC_i^{hybrid} = Q_i \cdot MC_i^{hybrid} = Q_i \cdot \theta_i \cdot MC^{generic}.$$

The numerator of θ_i in Equation III-6 is evaluated at the values of the cost-related variables for movement i, ($X_{c,i}$), and the denominator is evaluated at a vector of 'average' cost characteristics denoted by $\overline{X_c}$ that are consistent with the generic marginal cost. In the original Hybrid model, we estimated generic marginal costs by railroad and year using a translog variable cost function for the Class I railroad industry primarily using data from the R-1 annual reports.[89] We estimated the coefficients on the cost variables $\hat{\beta}_c$ using commodity-level NEIO regression models following the form of Equation III-3 using CWS waybill records as the units of observation. The movement's variable cost in Equation III-8 is simply the product of the Hybrid marginal cost for the movement (Equation III-7) and the total ton-miles $Q_i$associated with the movement.

Note that Equation III-8 shows the Hybrid model to be a special case of the general URCS cost equation (Equation II-4) from Section II:

(II-4) $$VC_i = \sum_{j=1}^{J} Q_{ij}\theta_{ij}UVC_j.$$

The Hybrid model differs from URCS in that it specifies a single generic marginal cost per ton-mile as the unit variable cost and derives the movement-specific factors θ_i from the NEIO regression rather than the URCS Phase III efficiency adjustments.

A desirable feature of the Hybrid movement costs is consistency with the generic marginal costs in the sense that the generic and de-averaged costs yield the same total variable costs in aggregate.[90] That is, the shipment marginal costs should satisfy the relationship:

(III-9) $$\sum_i MC_i Q_i = MC^{generic} \cdot Q_{TOT} = \varepsilon_Q \cdot TC = VC(Q).$$

Where ε_Q is an output elasticity, *TC* is total cost, and Q_{TOT} is total ton-miles, where $Q_{TOT} = \sum_i Q_i$. This condition ensures that the costs varying on the margin with output, $\varepsilon_Q \cdot TC$, are not over- or under-allocated to shipments in total. Equation III-9 gives rise to alternative forms of the Hybrid shipment marginal cost:

[89] Christensen 2009 Competition Study, Vol. 2, Chapter 9.

[90] This is similar to the make-whole feature of efficiency adjustments in legacy Phase III.

(III-10)

$$MC_i^{hybrid} = \exp(\hat{\beta}_c \cdot X_{c,i}) \cdot \frac{MC^{generic} \cdot Q_{TOT}}{\sum_i Q_i \exp(\hat{\beta}_c \cdot X_{c,i})}$$

$$= \exp(\hat{\beta}_c \cdot X_{c,i}) \cdot \frac{\varepsilon_Q \cdot TC}{\sum_i Q_i \exp(\hat{\beta}_c \cdot X_{c,i})}$$

$$= MC^{generic} \cdot \frac{\exp(\hat{\beta}_c \cdot X_{c,i})}{\sum_i w_i \exp(\hat{\beta}_c \cdot X_{c,i})}.$$

In the first and second equalities, the NEIO cost index $\exp(\hat{\beta}_c \cdot X_{c,i})$ is scaled such that it sums to the variable cost $\varepsilon_Q \cdot TC$, or equivalently $MC^{generic} \cdot Q_{TOT}$. In the third equality, the fraction $\exp(\hat{\beta}_c \cdot X_{c,i})/\sum_i w_i \exp(\hat{\beta}_c \cdot X_{c,i})$ can be viewed a shipment-specific adjustment to the generic marginal cost that produces the shipment-level cost. This formula again yields total variable costs of $\varepsilon_Q \cdot TC$ when the Hybrid model's movement-specific costs are totaled. Note that $w_i = Q_i/Q_{TOT}$ is a weight equal to the share of ton-miles associated with movement i. The de-averaging formulation satisfying Equation III-9 yields a denominator of the cost adjustment θ_i that is a weighted average of $\exp(\hat{\beta}_c \cdot X_{c,i})$ over all movements underlying the generic marginal cost.

A useful feature of the forms of the Hybrid cost formulations in Equation III-10, compared to Equations III-6 to III-8, is that they do not require knowledge of the set of movement characteristics X_c that determine the generic marginal cost. This is useful insofar as the generic costs are likely to be developed from data sources or analyses that do not (or cannot) explicitly condition the generic marginal cost estimates on the full set of cost characteristics that may be included in the NEIO price model. For instance, in the 2009 Hybrid model, average length of haul was the only railroad output characteristic explicitly included in the econometric cost model determining the generic marginal costs. The weighted sum $\sum_i w_i \exp(\hat{\beta}_c \cdot X_{c,i})$ from Equation III-10 can be computed without knowledge of the aggregate output characteristics implicit in the cost model.

3. Extensions and Modifications of the 2009 Hybrid Model

The Hybrid model implementation for this study remedies some significant limitations of the original Hybrid model from the 2009 Competition Study. Notably, the original model did not produce cost estimates for interchanged shipments, and its cost estimates for intermodal (COFC/TOFC) shipments implausibly implied that the median intermodal movement was priced substantially below marginal cost. The STB's 2010 Report to Congress also expressed concern that the short-run marginal costs produced by the NEIO and Hybrid models, while not necessarily inappropriate, could create issues with respect to the 180 percent R/VC threshold.

As described below, we address these issues by modifying the Hybrid model to allow costs to be assigned to movements by shipment segments (i.e., portions of the movement operated by different railroads) for movements with interchanges, by changing estimation procedures to better identify efficiencies associated with intermodal shipments.

We show results from Hybrid model formulations in which the generic marginal costs in Equation III-9 are replaced with URCS variable costs to separate effects on the jurisdictional threshold from the use of the NEIO regression to develop movement-specific costs from effects of implementing a short-run marginal (or incremental) cost concept. This analysis, in Section III.E, indicate that using empirical short-run cost elasticities to develop movement variable costs in the Hybrid model materially increases the volume of freight traffic above the jurisdictional R/VC threshold. A bridging adjustment between the Hybrid model and current-methodology URCS may be required if the STB sought to implement a Hybrid short-run cost model (or an URCS-based short-run cost model, as shown in Section IV) without expanding its jurisdiction for rate regulation.

a) Extension for Shipments with Interchanges

The original Hybrid model implementation from the Christensen 2009 Competition Study only produced cost estimates for waybills where the observed movement involved a single (Class I) railroad. This subset of shipments includes shipments originated and terminated by the same railroad, as well as "rebilled" shipments where the observed portion of the movement was handled by a single railroad. In large part, this was a limitation of the software implementation of the model, which could not assign distinct generic costs to portions of the movement operated by different railroads. Movements involving interchanges also present complications for the NEIO regression models, notably for estimation of economies related to shipment distance.

For interchanged shipments, the originating, intermediate, and/or terminating railroads generally will have different generic marginal costs. Furthermore, each serving railroad's segment of the shipment may have costs that are higher or lower than the railroad's generic costs depending on how the shipment and segment characteristics compare to the railroad averages. For example, a short-distance segment on a railroad with a relatively long average haul will tend to have higher marginal cost per ton-mile than the generic cost due to length-of-haul diseconomies for the short movement relative to the average haul.

Waybill-level modeling without appropriate accommodation of interchanges can affect estimation of length-of-haul economies since length-of-haul economies will depend on segment lengths. An end-to-end movement of (say) 1,000 miles may be expected to have distinct costs from a movement consisting of two 500-mile segments, even if the railroads operating the segments otherwise have similar marginal costs. Our 2009 CWS price models, among other similar regression models of CWS data, did not distinguish waybill records involving interchanges.

We addressed the problem of costing shipments with multiple segments operated by different railroads by developing a CWS estimation dataset with shipment segments as the units of observation and estimating the NEIO regression(s) using the segment-level data. A byproduct of this change is to facilitate comparisons of the implied cost structure from the NEIO price regressions with the cost structure of legacy URCS, where shipment costs are estimated by segment and the segment-level costs are aggregated to produce costs for the waybill.

To generalize the Hybrid costs for shipments with multiple segments identified on the waybill, we compute the Hybrid marginal costs by shipment segment. This gives rise to a straightforward generalization of the Hybrid cost for movement *i* and segment *s*:

(III-11) $$MC_{i,s}^{hybrid} = MC_{RR\_s}^{generic} \cdot \exp(\hat{\beta}_c \cdot X_{c,i,s}) / \sum_j I_{j,RR\_s} w_j \exp(\hat{\beta}_c \cdot X_{c,j}),$$

where I_{j,RR_s} is an indicator variable equal to 1 for segments operated by the railroad indicated by RR_s and zero otherwise. Thus, the summation in the denominator is over the set of all shipment segments associated with the generic marginal cost for the railroad RR_s operating the segment. With generic marginal cost estimates by railroad and year, the summation is over the segments in the CWS operated by the railroad in the specified year. The variable cost for waybill *i* then is obtained by summing the products of the segment marginal cost per ton-mile and segment ton-miles:

(III-12) $$VC_i = \sum_{s=1}^{N} Q_{i,s} \times MC_{i,s}^{hybrid}.$$

Where *s* is an index of shipment segments for movement *i* and $Q_{i,s}$ is the ton-miles for segment *s*. A weighted-average marginal cost per ton-mile for the movement is:

(III-13) $$\overline{MC_i} = \sum_{s=1}^{N} w_{i,s} \times MC_{i,s}^{hybrid}.$$

The weights $w_{i,s}$ are the shares of the total shipment ton-miles for each segment, which are equivalent to the shares of the total shipment *distance* carried over each railroad (since the tons of freight in the movement are constant across segments). This reduces to the original Hybrid costs for single-segment movements.

The segment-level models do potentially complicate modeling of markup or market structure effects. NEIO regression models with waybills as the unit of observation typically assume that rail rates are constrained by railroad and modal competition at the shipment origin and/or destination and do not, for instance, consider whether there are additional pricing constraints arising from any ability of the shipper to bypass a portion of the end-to-end movement. We leave such questions as a matter for future research and retain the types of market structure variables we employed in the 2009 study in our updated models.

b) Pooling of Commodities in the NEIO Regressions

The NEIO regressions in the Christensen 2009 Competition Study were estimated separately for a variety of commodity groups, with intermodal (COFC/TOFC) shipments included in a separate regression equation. Estimating separate equations by commodity allows model coefficients to vary by commodity group. This approach was driven in part by the 2009 study's primary goal of characterizing states of competition that may have varied among groups of shippers. However, this approach limited the ability of the models to measure some cost differences that are important for accurate costing. In particular, the specification of a separate intermodal equation allowed us to estimate cost differences within intermodal shipments (subject to the general limitations of the NEIO/Hybrid model framework) but limited our ability to accurately characterize cost differences between intermodal and other freight movements. The 2009 Hybrid models effectively treated intermodal containers as low-weight single carload shipments—which tend to have relatively high costs per ton-mile—and yielded implausible estimated markups and, by extension, marginal costs.

A related broader question is whether the underlying marginal cost functions should differ by commodity. In initial updates of the 2009 models at the commodity level, we observed that the coefficients on cost-shifting variables, such as movement distance, number of carloads, and tons per carload, were qualitatively similar across commodities. Thus, pooling commodities with the primary purpose of estimating the coefficients on the cost-related variables in the NEIO model did not appear to be inconsistent with the data. Within the pooled estimation approach, it is straightforward to estimate efficiency effects associated with intermodal shipments from the data using basic techniques such as dummy variables as shifters. The pooled estimation approach similarly may improve estimation of coefficients related to shipment characteristics that may have little variation within commodity groups but considerable between-commodity variation—such factors may include freight car types and indicators of hazardous material shipments.

c) Hybrid Model with URCS Phase I and II Costs

The Christensen 2009 Competition Study's implementation of the Hybrid model used marginal costs per ton-mile derived from econometric estimation of a firm-level variable cost function as the model's generic (not shipment-specific) costs. However, an econometric cost function approach is not the only available method for developing marginal cost estimates for rail freight movements. As described in Part II of the report, cost elasticities from activity-level cost models can also be used to compute unit variable costs that have an economic interpretation as marginal costs.[91] We thus compute costs from Hybrid models using marginal costs both from an econometric cost function approach, updating the 2009 Competition Study model, and using updated activity- or cost pool-level Phase I cost equations presented in Section III.D.2. We also extend the analysis of railroad operating costs in Phase I to estimate cost elasticities econometrically for capital costs (return on investment, depreciation, rental, and lease costs) that have assumed or "default" variabilities in legacy URCS.

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[91] That is, variable costs from URCS Phase II, on a per ton-mile basis, are equivalent to marginal cost per ton-mile when cost elasticities are specified for the variabilities.

Additionally, the Hybrid model mechanically can de-average *any* generic cost that is supplied to the model. We also produce costs from the Hybrid model using legacy URCS variable costs (per revenue ton-mile) as the generic cost inputs. This effectively substitutes the NEIO for URCS Phase III, allowing the effect of the NEIO model on relative shipment-specific costs, compared to URCS Phase III, to be isolated from effects of using updated cost elasticities (and hence marginal costs) in place of legacy URCS variabilities.

d) NEIO Regression Modeling of Legacy URCS Costs

In addition to the NEIO regression models with the natural log of revenue per ton-mile (RPTM) as the dependent variable, we estimate models with log of legacy URCS variable cost per ton-mile (VCPTM) as the dependent variable. The purpose of the VCPTM models is to compare the legacy URCS cost structure—as approximated by the NEIO models—with the shipment cost structure of the Hybrid model implied by the NEIO RPTM regressions.

A possibility, however remote, was that the cost variables in the NEIO regressions could have essentially identical effects on both RPTM and VCPTM. In such a case, there would be no need to pursue the Hybrid model as an URCS alternative since URCS Phase III would already be producing an equivalent cost allocation. Not unexpectedly, while cost shifters in the NEIO model generally affect both RPTM and VCPTM in the same direction, differing magnitudes of most effects indicate that the NEIO and legacy URCS models' cost structures do differ materially, as we discuss below.

C. NEIO MODEL SPECIFICATION AND ESTIMATION

The Hybrid model implementation involves two econometric analyses: disaggregated NEIO regression modeling of price data from CWS, used to estimate factors that cause shipment-level cost differences, and a cost analysis from which estimates of generic (not shipment specific) marginal costs are derived. We describe the NEIO regression models and main results in this section, and present two alternatives for the marginal cost analysis in Section III.D, below.

1. NEIO Regression Model Specification

As noted above, both the pure NEIO and Hybrid models have a common starting point in regression models with the general form:

(III-3b) $$\ln r_i = \sum_c \beta_c X_{c,i} + \sum_m \beta_m X_{m,i} + \alpha_0 + \sum_l \delta_l Z_{l,i} + u_i.$$

Recall that the variables $X_{c,i}$ represent shipment characteristics assumed to affect rates through marginal costs; $X_{m,i}$ are variables related to market structure, affecting markups; and $Z_{l,i}$ are variables that affect rates but which may affect rates through both costs and markups. The pricing model specifications used in our implementation of Equation III-3b broadly follow the form of the estimating equations from the Christensen 2009 and Bitzan and Wilson 2003. The explanatory variables include:

- Shipment Cost Characteristics
  - Length of haul
  - Size of load
  - Tons per car
  - Type of car
  - Railroad car ownership
  - Volume in tons between origin and destination states

We expect negative signs on the coefficients of the variables indicating shipment distance, size, and loading characteristics. This reflects underlying components of railroad cost components that may be partly fixed or non-increasing with respect to distance or shipment size, for instance costs of switching and classifying cars. A positive coefficient on the indicator of railroad-owned cars is expected because shippers supplying their own freight cars should avoid implicit rental charges for use of railroad-owned equipment. The volume of shipments between the origin and destination states was interpreted in MacDonald 1987 and MacDonald 1989 as an indicator of the ability to form unit trains or other relatively efficient shipment configurations on shipment routes.

- Market Structure (Railroad and Modal Competition) Indicators
  - Distance from shipment origin to nearest port or waterway facility
  - Distance from shipment destination to nearest port or waterway facility
  - Railroad competition at origin
  - Railroad competition at destination

Increasing the distances to port and waterway facilities would tend to reduce modal competition and thus railroad pricing constraints from water transport, as the cost of accessing the alternative mode increases. Thus, we would expect increasing distances to waterway facilities would tend to increase rail rates, other things equal. Conversely, the presence of additional railroad competitors may be expected to reduce rail rates, though in the Christensen 2009 Competition Study we found that effects of competition measured by Herfindahl indexes were sometimes insignificant and/or wrong-signed.[92] Our NEIO specifications also include dummy variables for origin and destination counties served by a single railroad, as our 2009 models generally found that a single serving railroad at an end of the movement was associated with higher prices, other things equal.

[92] There is a potential reverse causality issue as the presence of railroad competition may not be separable from other market characteristics that could be associated with higher prices. We investigated instrumental variable (IV) models to investigate endogeneity of competition measures and found that addressing the issue had little effect on estimates of the cost-related parameters of interest.

- Other Control Variables
  - Year indicators
  - Quarter indicators
  - Railroad indicators
  - Origin and destination state indicators
  - Commodity indicators

These sets of categorical control (dummy) variables allow for seasonal, secular, and locational differences in rates. They also help control for the effects of unmeasured or "latent" cost and competition factors. The origin-destination state variable used for the shipment location indicator allows the effects of shipments from state A to state B to differ from the effects of shipments from state B to state A. The coefficients on the year indicator variables can show trends (if any) in "real" RPTM, controlling for the other factors included in the pricing model.

The current NEIO regression models for this study incorporate additional variables to investigate URCS cost structure issues and more broadly to refine the models. These include:

- URCS size categories for "single" (1-5 carload) and unit train shipments (50+ carloads),
- Indicators of movement segments involving interchanges among railroads,
- Indicators for intermodal shipments,
- Indicators for hazardous materials shipments.

The URCS size categories were incorporated in the regressions to allow the data in the CWS to "speak" regarding the existence and size of any discontinuities in the relationship between shipment size, measured in carloads, and costs. The legacy URCS model, as noted in Section II, uses step functions to incorporate shipment size economies in shipment costs. These produce large discontinuities in legacy URCS unit costs at the carload size category breaks. The indicators for intermodal shipments are intended to measure efficiencies of intermodal shipments (which mostly appear as single-TCU shipments in the CWS) relative to non-intermodal single-carload shipments. The hazardous materials indicators measure RPTM premiums for hazardous material shipments that may reflect additional costs (or shadow costs) of those shipments that are not currently reflected in URCS shipment costs.

The basic estimating equation is of the form:

(III-14):

$$
\begin{aligned}
\ln RPTM = {} & \alpha_0 + \delta_{ORTR} + \delta_{WYEAR} + \delta_{QTR} + \delta_{RR} + \delta_{STCC2_{NOHAZ}} + \beta_1 \ln SEG_{MILES} \\
& + \beta_2 \ln NUMCAR + \beta_3 \ln TONSCAR + \beta_4 \ln VOL\_TONS + \beta_5 INTERMODAL \\
& + \beta_6 HAZMAT + \beta_7 INTERCHANGE + \sum_n \beta_{8n} D\_CARTYPEn \\
& + \beta_9 D\_SINGLE\_URCS + \beta_{10} D\_UNIT\_URCS + \beta_{11} CAR\_OWNER\_RR \\
& + \gamma_1 DLM\_ORG + \gamma_2 RRCOMP\_ORG + \gamma_3 DLM\_TER + \gamma_4 RRCOMP\_TER \\
& + \gamma_5 KMWATER\_ORG + \gamma_6 KMWATER\_TER + u.
\end{aligned}
$$

The VCPTM models simply substitute the natural log of VCPTM for ln *RPTM* in the estimating Equation III-14, retaining the market structure variables in the model. We would expect the market structure variables to have small (or smaller) coefficients in the VCPTM regressions relative to the RPTM model, as the market structure variables are not determinants of variable cost in legacy URCS. Of primary interest are the differences in the coefficients (betas) on cost variables between the NEIO RPTM and VCPTM models, which will indicate differences in the marginal effects of cost variables between the NEIO (and hence Hybrid) models and legacy URCS.

Variables used in the NEIO regression analysis are defined in Table III-1, below.

Table III-1. Variables Used in NEIO Regression Models

Variable	Definition	Source
RPTM	Real segment revenue per ton-mile: ((SEG_REV/EXPFAC)/(SEG_MILES*TONS))/GDPPI	Calculated
VCPTM	Real segment variable cost per ton-mile: ((SEG_VC/EXPFAC)/(SEG_MILES*TONS))/GDPPI	Calculated
EXPFAC	CWS sample expansion factor	CWS item 88
SEG_MILES	Segment distance in miles	CWS items 113-119, 122
SEG_REV	Segment expanded revenue	CWS items 103-112
SEG_VC	Segment expanded variable cost	CWS items 185-192
TONS	Billed weight for the shipment, in tons	CWS item 13
NUMCAR	Number of shipment carloads or TCUs	CWS item 5
TONSCAR	TONS/NUMCAR	Calculated

CAR_OWNER_RR	Dummy variable = 1 for railroad-owned cars, 0 otherwise	Calculated from CWS item 6 (car initials)
SINGLE_URCS	Dummy variable = 1 if NUMCAR <=5, 0 otherwise	Calculated
UNIT_URCS	Dummy variable = 1 if NUMCAR >=50, 0 otherwise	Calculated
UNIT_75	Dummy variable = 1 if NUMCAR >=75, 0 otherwise	Calculated
INTERMODAL	Dummy variable = 1 if STB car type is 46, 49, 52, or 54 and TOFC_CODE is not blank	Calculated
D_CARTYPE*n*	Dummy variable = 1 for specified car type(s) *n*, 0 otherwise, based on CAR_TYPE_STB	Calculated
CAR_TYPE_STB	STB car type code	CWS item 90
TOFC_CODE	COFC/TOFC service code	CWS item 8
HAZMAT	Dummy variable = 1 if STCC2 = 49, 0 otherwise	Calculated

Variable	Definition	Source
STCC2	2-digit STCC commodity code	CWS item 12
STCC2_NOHAZ	2-digit STCC commodity code, without STCC 49 hazardous material code	CWS item 76
INTERCHANGE	Dummy variable = 1 if JCT_FREQ = 0 and REBILL_CODE = 0	Calculated
SEG_TYPE	URCS segment type (depends on JCT_FREQ, REBILL_CODE, and segment position in movement)	Calculated
JCT_FREQ	Waybill junction (interchange) frequency	CWS item 87
REBILL_CODE	Rebill code	CWS item 25
VOL_TONS	Annual tons by originating-destinating state pair and COMM_CS	Calculated
RRCOMP_ORG	Reciprocal of the Herfindahl index for the waybill origin county, based on railroad shares of expanded tons, computed using 2013-2019 CWS data	Calculated
RRCOMP_TER	Reciprocal of the Herfindahl index for the waybill termination county, based on railroad shares of expanded tons, computed using 2013-2019 CWS data	Calculated
DLM_ORG	Dummy variable = 1 if RRCOMP_ORG = 1, 0 otherwise	Calculated
DLM_TER	Dummy variable = 1 if RRCOMP_TER = 1, 0 otherwise	Calculated
KMWATER_ORG	Distance in kilometers from centroid of origin county to the nearest port or waterway facility served by a railroad	GIS analysis of port location data
KMWATER_TER	Distance in kilometers from centroid of termination county to the nearest port or waterway facility served by a railroad	GIS analysis of port location data

WYEAR	Year of the waybill date	CWS item 3
QTR	Calendar quarter of the waybill date	CWS item 3
RR	Railroad code for the segment	CWS items 33, 35, 37, 39, 41, 43, 45, 51
COMM_CS	Commodity group from Christensen 2009 (including "other" group for commodities not otherwise classified)	Based on 5-digit STCC[93]
ORTR	Originating-terminating state combination for the waybill	CWS items 124, 134
GDPPI	GDP price index	Bureau of Economic Analysis

The cost-related terms in the log-log form of the NEIO estimating equation constitute a first-order approximation to a general functional form for the marginal cost function. The coefficients on the cost-related variables are interpreted as elasticities of RPTM (and, by extension, marginal cost) with respect to those variables. If the elasticities are negative, the implied marginal costs are decreasing as the cost variable increases. A negative coefficient on $\ln NUMCAR$, for instance, indicates the presence of cost efficiencies related to shipment size (carloads).

A limitation of a first-order log-log model is that the elasticities are assumed to have a constant value over the entire ranges of the cost-related variables. For the number of carloads and the segment distance, the range of valid values of the data are wide—we observe movements from 1 to over 150 carloads, and segment distances from tens to thousands of miles. If the elasticities are not actually constant, then the first approximation may perform poorly over some portion of the ranges of the data. To allow for more flexibility in the effects of the cost variables, we also considered two additional specifications allowing variable effects of some of the continuous cost variables.

One alternative specification is a "log-spline" model, which specifies the distance and shipment size (carloads) variables as linear splines. Linear spline values allow piecewise linear effects of the splined variables, where the effects are allowed to change at pre-specified breakpoints (called knots). The spline models thus relax the assumption of constant elasticities in the basic log-log NEIO model. The log-spline model has the form:

[93] See Christensen 2009 Competition Study, page 11-8.

(III-15)

$$\begin{aligned}
\ln RPTM = {} & \alpha_0 + \delta_{ORTR} + \delta_{WYEAR} + \delta_{QTR} + \delta_{RR} + \delta_{STCC2_NOHAZ} + \sum\nolimits_m \beta_{1m} \ln SEG_MILES_m \\
& + \sum\nolimits_n \beta_{2n} \ln NUMCAR_n + \beta_3 \ln TONSCAR + \beta_4 \ln VOL_TONS \\
& + \beta_5 INTERMODAL + \beta_6 HAZMAT + \beta_7 INTERCHANGE \\
& + \sum\nolimits_n \beta_{8n} D_CARTYPEn + \beta_9 D_SINGLE_URCS + \beta_{10} D_UNIT_URCS \\
& + \beta_{11} CAR_OWNER_RR + \gamma_1 DLM_ORG + \gamma_2 RRCOMP_ORG + \gamma_3 DLM_TER \\
& + \gamma_4 RRCOMP_TER + \gamma_5 KMWATER_ORG + \gamma_6 KMWATER_TER + u.
\end{aligned}$$

Equation III-15 includes spline variables $\ln SEG\_MILES_m$ and $\ln NUMCAR_n$ to allow elasticities of segment distance and number of carloads on ln *RPTM* to vary. In the results reported below, we estimated models with a knot at 50 carloads for ln *NUMCAR*—allowing one inflection point at the legacy URCS unit train size minimum.[94] The carload elasticities thus are $\partial \ln RPTM / \partial \ln NUMCAR = \beta_{21}$ for shipments with *NUMCAR*<50 and $\partial \ln RPTM / \partial \ln NUMCAR = \beta_{22}$ for *NUMCAR*≥50. The values of the parameters β_{21} and β_{22} are not constrained *a priori*. We also set a knot at the unweighted median segment distance (891 miles) for the ln *SEG_MILES* splines.

The other alternative specification we examined features a second order specification in the *SEG_MILES*, *NUMCAR*, and *TONSCAR* variables. This "translog" model adds squared and interaction terms in those variables:

(III-16)

$$\begin{aligned}
\ln RPTM = {} & \alpha_0 + \delta_{ORTR} + \delta_{WYEAR} + \delta_{QTR} + \delta_{RR} + \delta_{STCC2_NOHAZ} + \beta_1 \ln SEG_MILES \\
& + \beta_{11} (\ln SEG_MILES)^2 + \beta_2 \ln NUMCAR + \beta_{22} (\ln NUMCAR)^2 \\
& + \beta_3 \ln TONSCAR + \beta_{33} (\ln TONSCAR)^2 + \beta_{12} \ln SEG_MILES \ln NUMCAR \\
& + \beta_{13} \ln SEG_MILES \ln TONSCAR + \beta_{23} \ln NUMCAR \ \ln TONSCAR \\
& + \beta_4 \ln VOL_TONS + \beta_5 INTERMODAL + \beta_6 HAZMAT + \beta_7 INTERCHANGE \\
& + \sum\nolimits_n \beta_{8n} D_CARTYPEn + \beta_9 D_SINGLE_URCS + \beta_{10} D_UNIT_URCS \\
& + \beta_{11} CAR_OWNER_RR + \gamma_1 DLM_ORG + \gamma_2 RRCOMP_ORG + \gamma_3 DLM_TER \\
& + \gamma_4 RRCOMP_TER + \gamma_5 KMWATER_ORG + \gamma_6 KMWATER_TER + u.
\end{aligned}$$

[94] We also estimated more flexible spline models in carloads, with additional knots at 5, 10, and/or 30 carloads. These models allowed the effect of ln *NUMCAR* to vary over the 1-49 carload range. We found that the carload effects were relatively constant over the 1-49 carload range and that the additional spline variables added little explanatory power to the NEIO models.

The second-order specification differs from the log-log and log-spline models in that it produces continuously variable elasticities of RPTM with respect to the cost variables with squared and interaction terms. In contrast to the log-spline model, the differences in elasticities over the ranges of the variables follow a parametric function. For instance, the elasticity of RPTM—and, by extension, marginal cost—with respect to *NUMCAR* is:

(III-17) $\partial \ln RPTM / \partial \ln NUMCAR = \beta_2 + 2\beta_{22} \ln NUMCAR + \beta_{12} \ln SEG\_MILES + \beta_{23} \ln TONSCAR.$

The *NUMCAR* elasticity thus is a linear function of ln_N*UMCAR*—and may be increasing or decreasing in carloads, depending on the sign of β_{22}—and on the values of ln_*SEG_MILES* and ln_*TONSCAR*. The elasticities with respect to *SEG_MILES* and *TONSCAR* also, per Equation III-17, depend on their own (log) values and those of the interaction variables.

2. *Estimation and Results*

a) Estimates from Pooled (Industry-Level) Regressions

Our main results are based on regressions using CWS data from 2016-2019. We also obtained CWS data from 2013-2015 but opted to use the more recent data due to a change in methodology for measuring shipment distances in the CWS implemented in 2015.[95]

We lightly screen the CWS data to eliminate anomalous observations. Wolfe (1986) notes that the CWS is mandated to exhibit low (no more than one percent) error rates overall, and to avoid "repetitive" or "serial" errors. We avoid screening directly on (log) revenue or RPTM to avoid potential bias associated with truncating the distributions of dependent variables in regression models. However, zero values (in levels) of RPTM and other regressors are undefined when transformed by natural logs, and thus are dropped from the regression samples as unusable. The samples exclude waybills for shipments originating or terminating outside of the 48 contiguous U.S. states, since competition variables are not available at a county-equivalent level for those observations. Additionally, we excluded observations in the outer 0.5-percent tails of the distributions of TONSCAR (computed separately for intermodal and carload waybills) and URCS R/VC (computed over all movements). Excluding extremes of R/VC is intended to exclude movements where observed revenues may be out of line with the underlying movement costs due to the waybill's inclusion of revenues, such as fuel surcharges or volume-based discounts that applicable to multiple shipments and not solely the observed movement. We also exclude small numbers of observations of shipments over 180 carloads, and some very short- and long-distance segments.[96]

[95] We were informed by the STB Office of Economics that there were some transitional difficulties implementing the new method, which relies on operational data produced by the railroads to determine shipment routing.
[96] We exclude segments over 2,000 miles for Eastern and over 3,000 miles for Western railroads, as well as segments under 5 miles for all railroads.

The estimating equations (Equations III-14 to III-16) describe panel data models that are linear in the parameters, and we estimate the models by linear regression with fixed effects. We use a sandwich estimator for the covariance matrix to allow for heteroskedastic disturbances.

Tables III-2 and III-3 show estimated NEIO regression coefficients for the cost-related variables in the log-log, log- spline and translog model specifications, using both log revenue per ton-mile (Table III-2) and log variable cost per ton-mile (from legacy URCS, Table III-3) as the dependent variables. For Tables III-2 and III-3, we estimate a single regression equation with observations from all railroads and commodities. For the translog models, we report estimated elasticities for the *SEG_MILES*, *NUMCAR*, and *TONSCAR* variables, evaluated at 2019 mean values of the variables.[97]

The RPTM models have coefficients of determination (R^2) ranging from approximately 0.741 for the log-log model to 0.749 for the translog model. The model fits of these NEIO RPTM regressions are comparable to previous NEIO regression analyses. For comparison, the commodity-specific models estimated for the 2009 Competition Study (with a log-log specification) had R^2 values ranging from 0.21 to 0.68; Bitzan and Wilson 2003 (also log-log) reported R^2 between 0.62 and 0.82 covering a narrower set of commodities. The NEIO regression specifications also explain most of the variation in URCS VCPTM, fitting VCPTM better than RPTM. R^2 values range from 0.915 for the log-log model to 0.936 for the translog specification. The NEIO models therefore provide reasonably close parametric approximations to URCS variable costs. We compare the marginal cost functions from the RPTM and VCPTM regressions to compare patterns of cost causation in the NEIO-Hybrid and legacy URCS models.

The arithmetic signs of the coefficients (elasticities for the translog model) on the *SEG_MILES*, *TONSCAR*, and *NUMCAR* variables are negative in all regressions in Tables III-2 and III-3. This is consistent with our expectations that movement marginal costs per ton-mile should be declining (or at least nonincreasing) in the movement distance, shipment size (carloads), and car or TCU loading. From Equation III-2, we expect the resulting differences in log marginal costs to be passed through to log RPTM, and to be represented by the NEIO model parameters.

[97] In the translog model, the coefficients on the terms involving the ln *SEG_MILES*, ln *TONSCAR*, and ln *NUMCAR* variables (including squared and interaction terms) do not have a simple economic interpretation in themselves. The full sets of model coefficients, including underlying translog coefficient estimates used to develop the elasticities per Equation III-17 and estimated coefficients on market structure and other explanatory variables, are voluminous. Full NEIO regression output was provided in output logs supplied to the STB.

Table III-2. NEIO RPTM Regression Results for Cost-Related Variables

Variable		log-log RPTM	log-spline RPTM	translog RPTM
ln_seg_miles*	coefficient	-0.560		-0.350
	t-statistic	-29.537		
ln_seg_miles_s1	coefficient		-0.587	
	t-statistic		-28.475	
ln_seg_miles_s2	coefficient		-0.309	
	t-statistic		-7.468	
ln_numcar*	coefficient	-0.063		-0.024
	t-statistic	-6.810		
ln_numcar_s1	coefficient		-0.051	
	t-statistic		-7.942	
ln_numcar_s2	coefficient		-0.180	
	t-statistic		-4.484	
ln_tonscar*	coefficient	-0.935	-0.936	-0.877
	t-statistic	-119.517	-122.273	
ln_vol_tons	coefficient	-0.027	-0.027	-0.027
	t-statistic	-5.874	-5.807	-5.715
d_intermodal	coefficient	-1.609	-1.606	-1.500
	t-statistic	-34.957	-36.302	-26.721
d_hazmat	coefficient	0.125	0.126	0.123
	t-statistic	7.510	7.566	7.154
d_single_urcs	coefficient	-0.028		
	t-statistic	-1.446		
d_unit_urcs	coefficient	-0.050		
	t-statistic	-1.982		
car_owner_rr	coefficient	0.033	0.032	0.029
	t-statistic	2.405	2.341	2.187
d_interchange	coefficient	-0.081	-0.079	-0.076
	t-statistic	-5.125	-4.944	-4.995
R^2		0.741	0.743	0.749
N		2,609,602	2,609,602	2,609,602

* Elasticity at sample mean reported for the translog model.

Table III-3. NEIO VCPTM Regression Results for Cost-Related Variables

Variable		log-log VCPTM	log-spline VCPTM	translog VCPTM
ln_seg_miles*	coefficient	-0.445		-0.164
	t-statistic	-27.031		
ln_seg_miles_s1	coefficient		-0.477	
	t-statistic		-29.113	
ln_seg_miles_s2	coefficient		-0.160	
	t-statistic		-7.281	
ln_numcar*	coefficient	-0.007		-0.001
	t-statistic	-1.174		
ln_numcar_s1	coefficient		-0.010	
	t-statistic		-1.724	
ln_numcar_s2	coefficient		0.027	
	t-statistic		0.453	
ln_tonscar*	coefficient	-0.775	-0.776	-0.743
	t-statistic	-112.780	-110.797	
ln_vol_tons	coefficient	-0.001	-0.002	0.001
	t-statistic	-0.461	-0.693	0.692
d_intermodal	coefficient	-1.160	-1.158	-1.161
	t-statistic	-56.317	-54.244	-47.033
d_hazmat	coefficient	-0.004	-0.003	-0.011
	t-statistic	-0.768	-0.533	-2.421
d_single_urcs	coefficient	0.249	0.246	0.206
	t-statistic	12.018	15.598	10.786
d_unit_urcs	coefficient	-0.314	-0.326	-0.267
	t-statistic	-15.408	-9.491	-11.087
car_owner_rr	coefficient	0.124	0.122	0.124
	t-statistic	8.396	8.336	8.601
d_interchange	coefficient	-0.151	-0.148	-0.145
	t-statistic	-13.239	-13.649	-13.283
R^2		0.915	0.919	0.936
N		2,609,602	2,609,602	2,609,602

* Elasticity at sample mean reported for the translog model.

b) Differences in Implied Rail Movement Cost Structure Between NEIO RPTM Models and URCS Costs

Comparing the magnitudes of the coefficients between the NEIO RPTM and VCPTM models indicates areas where the marginal cost function implied by the NEIO RPTM model differs from legacy URCS costs. The comparison indicates that the marginal cost structure implied by the NEIO regressions differs materially from that of legacy URCS variable costs in several areas, including with respect to efficiencies related to shipment distance, shipment size, and intermodal shipments.

(i) Economies of Shipment Distance

The NEIO RPTM and VCPTM models both show negative coefficients on segment distance variables, implying that costs per ton-mile decrease as the distance of the waybill segment increases. Additionally, the log-spline and translog models indicate that the distance economies are not constant, and specifically tend to be decreasing, over the range of observed distances. In the log-spline RPTM model, the distance elasticity for below-median distances is -0.587 compared to -0.309 for above-median distances.

In the translog model, distance economies depend on the movement distance, the number of carloads, and the tons per carload, based on Equation III-17. A positive second-order coefficient on *ln_seg_miles* implies that distance economies are diminishing (elasticities move towards zero) as the movement distance increases, which comports with the reduction in the distance elasticity in the log-spline model. The interactions among shipment distance, shipment size, and tons per carload imply that distance economies in the translog NEIO model also decrease with shipment carloads and tons per carload. These interaction effects will tend to reduce distance economies associated with unit train movements (with high carloads) and to increase distance economies for intermodal shipments (which have low weight per TCU).[98]

The NEIO regressions using URCS VCPTM models also exhibit distance economies, and like the RPTM models also exhibit declining distance economies in the log-spline and translog models. However, the URCS VCPTM distance elasticities are smaller in absolute value than in the NEIO RPTM models. This implies that URCS variable costs generally feature smaller distance economies are implied for the marginal costs underlying RPTM in the NEIO RPTM regressions.

Distance economies in the legacy URCS model arise largely from costs in non-distance related cost elements—e.g., industry switching and certain carload-related costs—being spread over more ton-miles in longer-distance movements. Distance-related variable costs in legacy URCS otherwise are typically linear in the segment distance. The resulting distance-related URCS variable costs are constant (with respect to distance) on a per ton-mile basis—i.e., those costs per

[98] The effect of the car loading interaction is small for values of tons per carload typical of bulk commodity movements. For example, in our preferred translog models, the estimated distance economies for a single-car, 90-ton movement differ from the distance economies for a comparable 100-ton movement by no more than 2.5 percent.

ton-mile have zero elasticity with respect to distance. The NEIO RPTM models, in contrast, allow for nonlinearities in distance-related costs such that distance economies in distance-related costs can reinforce (or, potentially, distance diseconomies could offset) distance-related efficiencies arising from non-distance-related costs being spread over a larger base of ton-miles in longer hauls.

(ii) Economies of Shipment Size

Shipment size economies in the NEIO regressions are be reflected in the effects of the ln *NUMCAR* variable(s) and/or dummy variable shifters for the legacy URCS single-car (1-5 carload) and unit train (50+ carload) size categories. We ran NEIO RPTM models with and without dummy variables for the URCS single-car and unit train size categories, in addition to the ln *NUMCAR* variable (or splined variables). The inclusion of the URCS size category dummies in the NEIO RPTM models allows us to investigate the extent to which carload efficiencies in the NEIO model take the form of a continuous curve, as in the Ex Parte 431 sub 4 Carload Weighted Block models, step functions as used in the legacy URCS make-whole adjustments, or both. Overall effects on shipment size economies may combine the effects of the size category and *NUMCAR* effects. The models of URCS VCPTM all include the size category dummies given that we know that there are step functions underlying the URCS costs.

The NEIO model specifications establish the URCS 6-49 carload (multi-car) size category as the base category. Thus, the URCS step functions would be expected to result in positive coefficients on *D_SINGLE_URCS*, reflecting higher unit costs for 1-5 carload movements versus 6+ carload movements, and negative coefficients on *D_UNIT_URCS* reflecting additional cost reductions associated with unit train movements.

Table III-4, excerpted from Table III-3, shows that the URCS size dummies in the VCPTM regressions show, as we would expect, large and statistically significant steps with correct signs in VCPTM at the URCS size category breakpoints. The coefficients on NUMCAR variables are small and statistically insignificant at standard confidence levels. The VCPTM results indicate that the NEIO models can show the presence of step functions to the extent they are present in the data.

Table III-4. NEIO VCPTM Coefficients on Shipment Size Variables

Variable		log-log VCPTM	log-spline VCPTM	translog VCPTM
ln_numcar*	coefficient	-0.007		-0.001
	t-statistic	-1.174		
ln_numcar_s1	coefficient		-0.010	
	t-statistic		-1.724	
ln_numcar_s2	coefficient		0.027	
	t-statistic		0.453	
d_single_urcs	coefficient	0.249	0.246	0.206
	t-statistic	12.018	15.598	10.786
d_unit_urcs	coefficient	-0.314	-0.326	-0.267
	t-statistic	-15.408	-9.491	-11.087

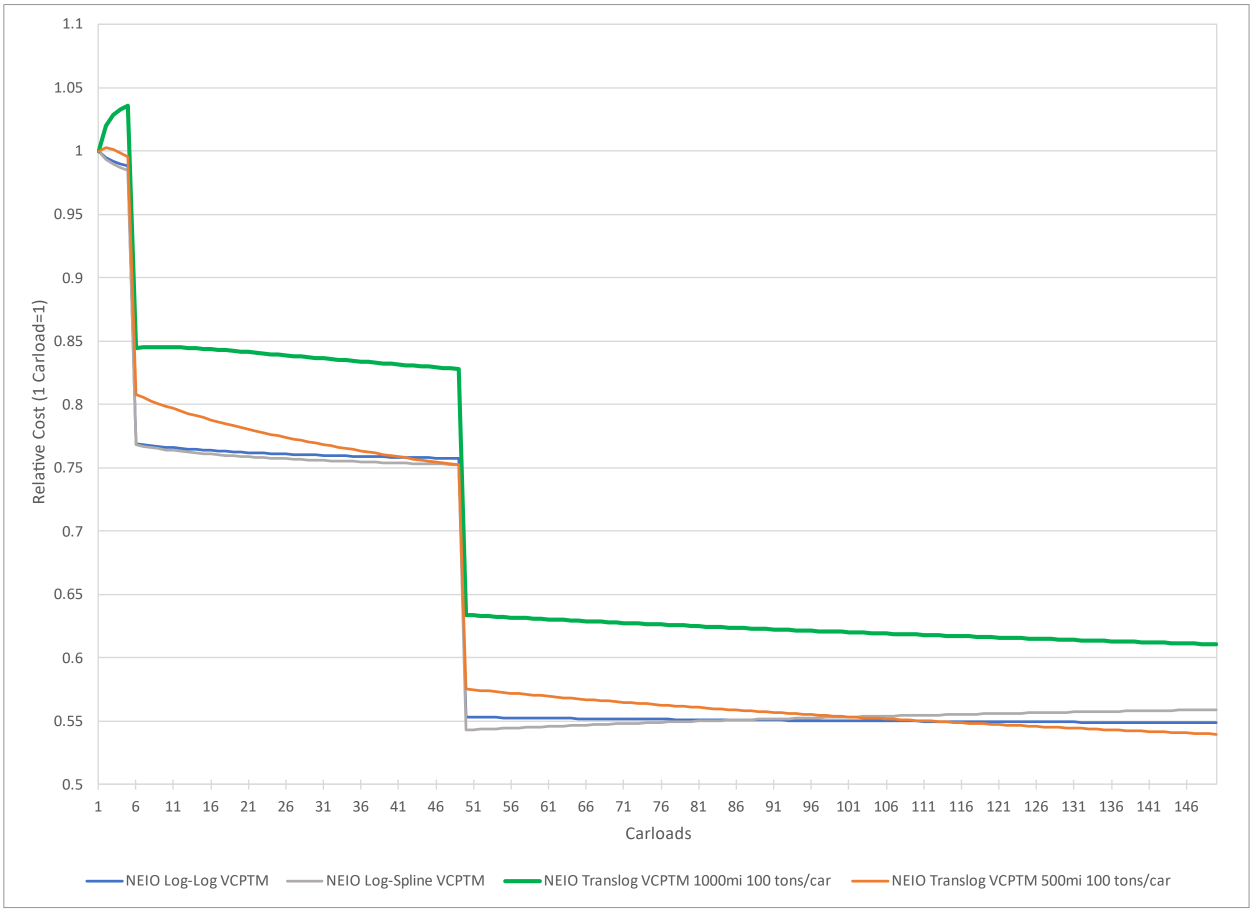
* Elasticity at sample mean reported for the translog model.

Figure III-1 shows the carload efficiency curves for the VCPTM models, which incorporate the effects of the *NUMCAR* variable(s) and the URCS size dummies. The curves normalize the unit cost of a 1-carload movement to 1, therefore showing changes in relative costs (other things equal) as carloads increase. The carload efficiencies in the VCPTM models result largely from the dummy variable step functions in the URCS "make-whole" efficiency adjustment and effects of ln_*NUMCAR* are small. The carload efficiency curves in the translog model depend on the movement distance and tons per carload. It should be noted that actual URCS costs are constant within the 1-5 carload and 6-49 carload ranges, and the slopes of the curves from the NEIO VCPTM models are artifacts of the fit of the URCS variable costs to the logarithmic NEIO regression specifications.

We show translog-based efficiency curves for 500-mile and 1000-mile movements, which indicate that the interaction between distance and carloads produces smaller carload efficiencies for longer hauls. Longer-distance movements have smaller carload efficiencies than shorter-distance movements in the NEIO models using both RPTM and VCPTM.[99] Smaller carload efficiencies for longer movements may reflect larger shares of variable costs for such movements in cost elements that are not subject to shipment size economies. For instance, gross ton-mile and car-mile costs in legacy URCS are constant with respect to carloads by construction.

[99] The arithmetic sign on the interaction term between carloads and distance is positive and statistically significant in both the RPTM and VCPTM translog models.

Figure III-1. Carload Efficiency Curves for URCS VCPTM Regressions



In contrast to the VCPTM results, the NEIO RPTM models including URCS size dummy variables show statistically significant carload economies associated with the *NUMCAR* variables and much smaller effects at the URCS breakpoints, as shown in Table III-5. The dummy variable effects, shown in Table III-5, are considerably smaller in absolute value than the corresponding VCPTM results and include wrong-sign and statistically insignificant coefficients on the size dummies. For instance, the effect of *d_unit_urcs* (-0.05) in the log-log RPTM model is one-sixth the -0.314 effect in the VCPTM regression. Indeed, the largest statistically significant size category effect, that of *d_single_urcs* in the translog model, has the wrong sign.

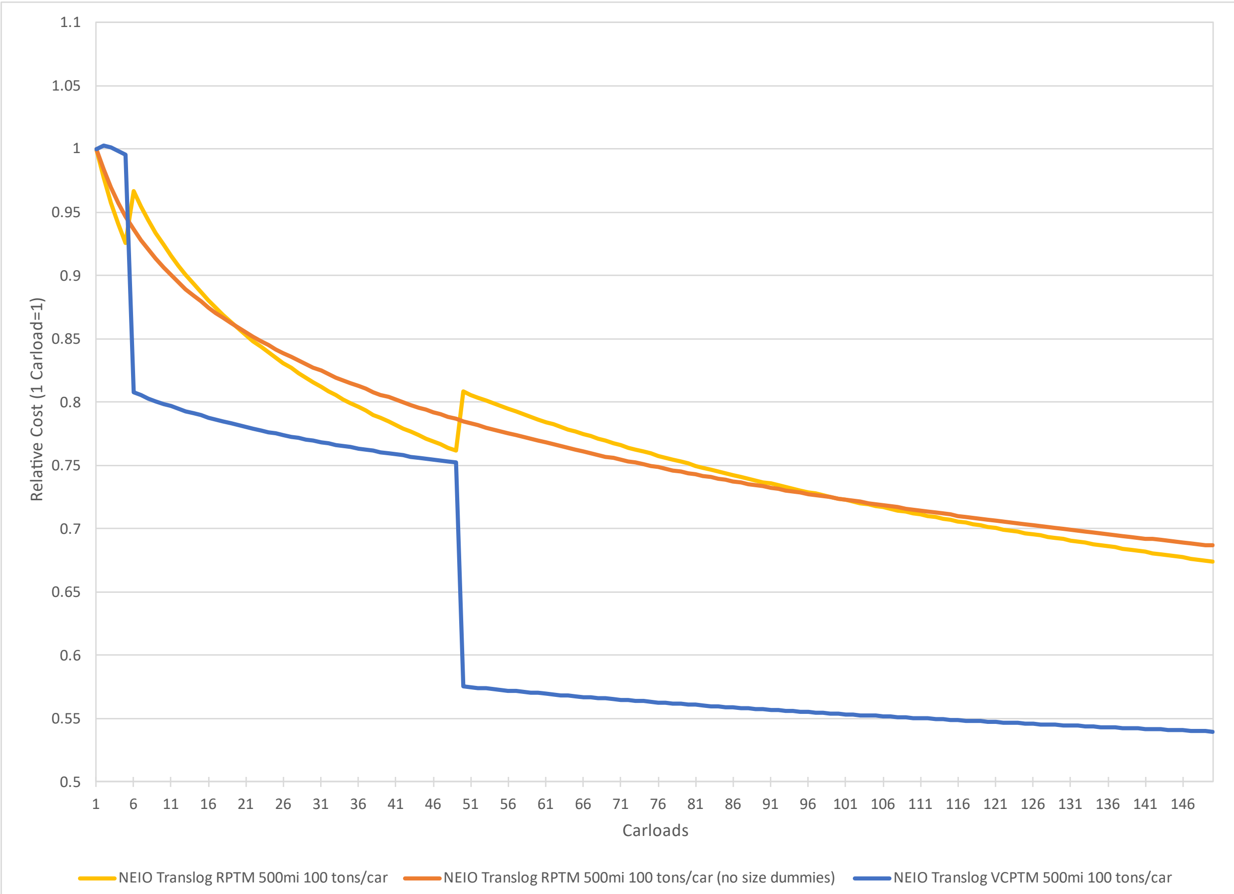
Table III-5. NEIO RPTM Coefficients on URCS Shipment Size Dummy Variables

Variable		log-log RPTM	log-spline RPTM	translog RPTM
ln_numcar*	coefficient	-0.063		-0.024
	t-statistic	-6.810		
ln_numcar_s1	coefficient		-0.051	
	t-statistic		-7.942	
ln_numcar_s2	coefficient		-0.180	
	t-statistic		-4.484	
d_single_urcs	coefficient	-0.028	0.002	-0.057
	t-statistic	-1.446	0.132	-2.592
d_unit_urcs	coefficient	-0.050	0.028	0.062
	t-statistic	-1.982	0.608	1.247

* Elasticity at sample mean reported for the translog model.

Generally, the NEIO RPTM model results do not reveal carload efficiencies that resemble the legacy URCS step functions in the actual costs underlying rates in the CWS. In Figure III-2, we show translog carload efficiency curves (for a 500-mile movement with 100 tons/carload) based on the coefficients in Tables III-2 (RPTM models without size dummies) and III-5 (with size dummies). The figure also shows the corresponding translog VCPTM curve. The efficiency curves from the RPTM models with and without the dummy variable shifters largely track each other. The shifts in the carload efficiency curve from the NEIO regression with size dummies at the 6- and 50-carload breakpoints are smaller and in the opposite direction of the URCS step functions. The NEIO RPTM models also exhibit generally smaller carload efficiencies compared to the curves from the VCPTM models, which is a result common to the three NEIO regression specifications.

Figure III-2. Example Carload Efficiency Curves for Translog NEIO Regressions with RPTM and VCPTM



Since the carload economies in legacy URCS costs arise largely through the make-whole efficiency adjustments, the NEIO models imply that the legacy URCS model overstates cost differences between small and large shipments implicit in railroads' pricing. That is, the NEIO models indicate that railroads price their shipments as if the actual carload-related cost differences are smaller than the results of the URCS make-whole adjustments. The NEIO models also indicate that rail rates do not feature underlying step functions of the magnitude and direction of the URCS adjustments for multi-car and unit train movements.

The differences in shipment size efficiencies may also be driven in part by differences between legacy URCS variabilities and the cost elasticities implicit in the NEIO marginal costs, which can affect the relative share of costs that we might expect to be sensitive to the number of carloads in the movement—notably switching costs—in actual variable (or marginal) costs per ton-mile. However, to the extent the legacy URCS efficiency adjustments are too large, the URCS make-whole adjustment over-distributes costs to single-carload shipments (increasing the cost differentials between the URCS single-carload, multi-car and/or unit train size categories), and/or under-assigns costs to multi-car and unit train shipments. Thus, while the NEIO models generally support the use a continuous carload efficiency curve over the legacy step functions, the results do not necessarily support calibrating the curves to the legacy make-whole cost adjustments.

(iii) Effects of Traffic Density

The *VOL_TONS* variable measures the tons of freight for a given commodity moving by rail between the origin and destination state pair indicated on the waybill. As we noted above, the inclusion of *VOL_TONS* was originally motivated in econometric studies of CWS data on shipment prices as an indicator of the ability of railroads to move shipments in more efficient configurations on routes with greater traffic density.

This type of effect is difficult if not impossible to incorporate within the traditional URCS framework, since the firm-level cost data available in the R-1 reports do not shed light on route-level cost differences within railroads. The URCS model accordingly does not include any factors relating effects of route-level traffic or density on costs. The VCPTM models not surprisingly show very small and statistically insignificant coefficients on *ln_VOL_TONS* in Table III-2, with estimated elasticities ranging from -0.002 to +0.001.

The NEIO models can potentially measure such effects by exploiting movement-level differences in RPTM, holding other factors related to cost and market structure constant. All three RPTM specifications show modest but statistically significant effects of *ln_VOL_TONS* with elasticities rounding to -0.027.[100] Other things equal, this effect will tend to reduce estimated shipment costs for movements between state pairs with higher traffic and to increase costs for pairs with thinner volumes.

(iv) Effects of Other Categorical Cost-Related Variables

Several cost-related variables in the NEIO regression specifications are categorical, including dummy variables for intermodal shipments, use of privately-owned cars, for shipments of hazardous materials, and for shipments involving interchanges.

Negative coefficients on the intermodal dummy variables indicate large cost efficiencies associated with intermodal shipments, relative to other single-carload shipments with comparable characteristics, in both the NEIO models and URCS variable costs. The NEIO RPTM models' intermodal efficiencies are somewhat greater than those in legacy URCS. This will tend to reallocate variable costs away from intermodal and towards other carload movements in Hybrid model costs, compared to URCS.

Shipments in railroad-owned cars have higher RPTM and VCPTM than comparable shipments in privately-owned cars, presumably reflecting implicit rental payments for use of the railroad-owned equipment. The effect of car ownership in the NEIO RPTM model is smaller than the

[100] We included this variable in the NEIO model in the Christensen 2009 Competition Study, but did not report coefficients in the summary regression output. MacDonald 1989, p. 31, reported volume elasticities of a similar magnitude for wheat shipments, and larger effects for corn shipments.

effect on URCS VCPTM and will tend to reduce shipment cost differences related to car ownership relative to URCS.

The coefficients on the Hazmat dummy variable indicates that hazardous materials shipments move at higher RPTM than non-hazmat shipments. The legacy URCS model does not allocate additional costs to hazmat shipments, and effects of the Hazmat dummy variable in the VCPTM regressions are small and statistically insignificant. Including Hazmat effects in Hybrid cost calculations increases costs for several commodity categories including portions of chemical shipments and for flammable materials such as shipments of petroleum and refined petroleum products.

The most notable “wrong-sign” results we observe among the NEIO categorical variables are the negative coefficients on the *d_interchange* dummy variables. While interchanges are explicitly costly in the URCS model, we observe negative coefficients on the interchange dummy variable in both the RPTM and VCPTM models. Presumably, the interchange indicator is capturing the effects of correlated factors associated with lower rates and/or costs.[101]

c) Results from Region-Specific NEIO Regressions

While the NEIO RPTM regressions reported in Table III-2 incorporate railroad fixed effects, they do not otherwise allow cost- or market structure-related parameters to differ by railroad. Regional and/or railroad-level differences in length of haul, traffic density, and other network features could have distinct effects on individual movements’ cost-causing factors that would not be reflected in industrywide parameter estimates. To investigate, we estimated the NEIO RPTM models in Table III-2 by railroad (Class I railroads individually, with Class II and III railroads consolidated by region) and by region (Eastern and Western railroads, using the region assignments in URCS).

Counts of CWS observations (waybill segments) by railroad are large enough to make estimating railroad specific NEIO regressions feasible for Class I railroads, though smaller sample sizes at the railroad level will tend to increase the standard errors of the coefficient estimates compared to a pooled model, other things equal. Exploratory analysis found that railroad-level models produced unstable results apart from a basic log-log NEIO RPTM model. An issue is that the distribution of CWS observations by railroad is unequal, with approximately 90 percent of CWS segments associated with one of the four large Class I railroads (BNSF, CSX, NS, and UP) and all other railroads in CWS accounting for the remaining 10 percent of observations.

Estimates from NEIO regressions estimated by region produce coefficient estimates that are generally consistent with the results from the combined regressions reported in Table III-2. The regional regressions are less problematic in part because each uses rough half-samples of the CWS data, and thus avoid issues with smaller CWS sample sizes outside the four large Class I

[101] We observed that coefficients on interchange dummy variables in models using the waybill as the unit of observations typically had the expected positive signs, suggesting the presence of an unobserved confounding factor.

railroads. Like the combined regressions, the region-specific NEIO models fit the CWS data reasonably well, noting that the model fit (R^2) is lower for the Eastern regressions (range 0.715 to 0.721) and higher for the Western regressions (range 0.787 to 0.792). The translog models have slightly higher R^2 values for both regions.

Tables III-6 (East) and III-7 (West) show coefficient estimates for selected cost-related variables in the RPTM regressions by region. We report *NUMCAR*, *TONSCAR*, and *SEG_MILES* elasticities evaluated at the region-specific means of the data based on equation III-17 for the translog model. The means of distance and number of carloads are larger for Western railroad movements —respectively, 1,402 miles and 7.5 carloads or TCUs—than Eastern movements—667 miles and 6 carloads.[102]

Several cost-related variables have materially different effects for Eastern and Western railroads, notably segment distance. The Eastern railroads' distance elasticities imply larger distance economies than the Western railroads. The differences in distance economies are somewhat exaggerated by the length-of-haul differences by region, as Eastern railroads' movements tend to be concentrated in shorter hauls for which distance economies are larger in the spline and translog models using the full CWS sample.

While there are some differences in coefficients related to shipment size by region, the regional models' differences in shipment size economies are small in comparison to the differences between the implied economies in the NEIO RPTM models and in legacy URCS as indicated by the VCPTM models. Figure III-3 shows example carload efficiency curves for the East and West translog model compared to the full-sample translog results. While the efficiency curves from the East and West regressions initially diverge as carloads increase, second-order effects lead the curves to converge for high numbers of carloads.[103] Thus, large unit train movements tend to exhibit similar carload-related efficiencies for both Eastern and Western railroads.

[102] The difference in mean tons per carload by region is small. The averages of shipment tons per carload are 41.1 tons and 40.9 tons for the Western and Eastern regions, respectively.
[103] The rate of convergence depends on the interaction variables.

Table III-6. Selected NEIO RPTM Regression Results, CWS Eastern Railroad Subsample

Variable	Statistic	Log-log	Log-spline	Translog
ln_seg_miles*	Coefficient	-0.645		-0.530
	t-statistic	-24.267		
ln_seg_miles_s1	Coefficient		-0.645	
	t-statistic		-22.143	
ln_seg_miles_s2	Coefficient		-0.623	
	t-statistic		-7.613	
ln_numcar*	Coefficient	-0.067		-0.042
	t-statistic	-4.861		
ln_numcar_s1	Coefficient		-0.066	
	t-statistic		-6.609	
ln_numcar_s2	Coefficient		-0.156	
	t-statistic		-2.983	
ln_tonscar*	Coefficient	-0.945	-0.945	-0.910
	t-statistic	-59.673	-59.696	
ln_vol_tons	Coefficient	-0.031	-0.031	-0.030
	t-statistic	-5.283	-5.254	-5.077
d_intermodal	Coefficient	-1.673	-1.673	-1.603
	t-statistic	-26.798	-26.802	-19.959
d_hazmat	Coefficient	0.098	0.098	0.093
	t-statistic	3.707	3.704	3.440
d_single_urcs	Coefficient	-0.012		
	t-statistic	-0.489		
d_unit_urcs	Coefficient	-0.064		
	t-statistic	-2.055		
car_owner_rr	Coefficient	0.049	0.049	0.046
	t-statistic	3.322	3.287	3.354
d_interchange	Coefficient	-0.064	-0.063	-0.076
	t-statistic	-3.091	-3.066	-4.013
Constant	Coefficient	4.830	4.815	7.485
	t-statistic	24.951	24.722	9.449
r2		0.715	0.715	0.721
N		1,194,069	1,194,069	1,194,069

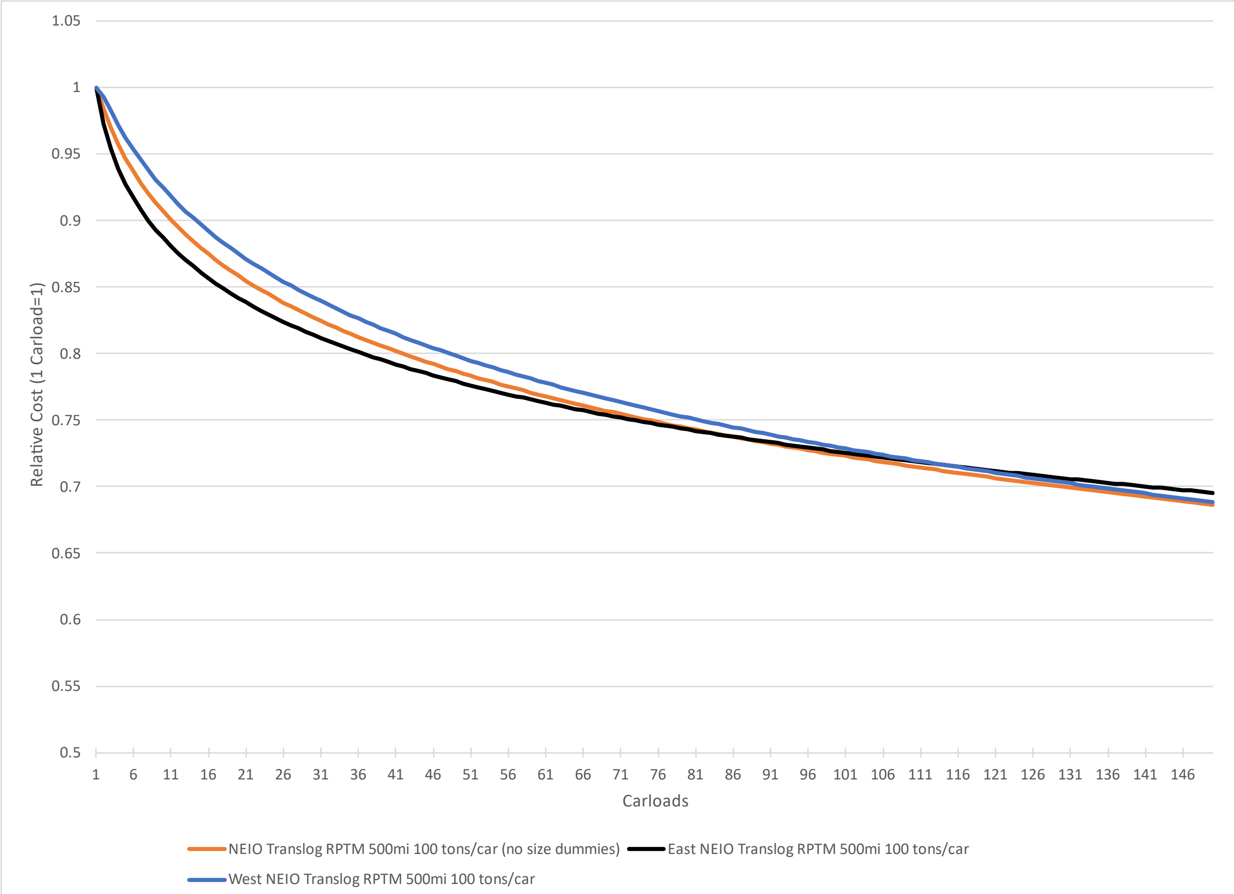
* Elasticity at sample mean reported for the translog model.

Table III-7. Selected NEIO RPTM Regression Results, CWS Western Railroad Subsample

Variable	Statistic	Log-log	Log-spline	Translog
ln_seg_miles*	Coefficient	-0.531		-0.346
	t-statistic	-21.552		
ln_seg_miles_s1	Coefficient		-0.553	
	t-statistic		-23.231	
ln_seg_miles_s2	Coefficient		-0.372	
	t-statistic		-5.732	
ln_numcar*	Coefficient	-0.048		-0.017
	t-statistic	-5.392		
ln_numcar_s1	Coefficient		-0.041	
	t-statistic		-5.816	
ln_numcar_s2	Coefficient		-0.184	
	t-statistic		-3.951	
ln_tonscar*	Coefficient	-0.944	-0.944	-0.879
	t-statistic	-119.832	-122.015	
ln_vol_tons	Coefficient	-0.019	-0.019	-0.018
	t-statistic	-3.338	-3.384	-3.550
d_intermodal	Coefficient	-1.569	-1.568	-1.459
	t-statistic	-29.114	-30.119	-25.328
d_hazmat	Coefficient	0.151	0.153	0.154
	t-statistic	9.573	9.743	9.975
d_single_urcs	Coefficient	-0.021		
	t-statistic	-1.088		
d_unit_urcs	Coefficient	-0.086		
	t-statistic	-3.012		
car_owner_rr	Coefficient	0.031	0.030	0.024
	t-statistic	1.538	1.550	1.284
d_interchange	Coefficient	-0.091	-0.088	-0.078
	t-statistic	-3.981	-3.793	-3.401
Constant	Coefficient	4.927	4.959	7.265
	t-statistic	19.218	22.682	18.157
r2		0.787	0.788	0.792
N		1,415,533	1,415,533	1,415,533

* Elasticity at sample mean reported for the translog model.

Figure III-3. Example NEIO RPTM Carload Efficiency Curves, East and West Models



3. Selecting a NEIO Regression Specification

Ideally, we would have prior knowledge of which NEIO model specification was the closest to the true functional relationship between price, costs, and market structure. In the absence of such information, we might in principle observe that some specifications under investigation clearly outperformed some alternatives. We may prefer the added flexibility afforded by the log-spline and translog specifications, but even with the large CWS samples, may also be concerned that effects of added variables—splines, squared variables, interaction terms—could result in overfitting the data. Choosing a preferred specification on within-sample fit alone does not address the concern.

We considered model selection using both within-sample criteria that penalize inclusion of additional variables and using a criterion based on out-of sample prediction, similar to an adjusted R^2. The within-sample criterion we use is the Schwarz-Bayes Information Criterion (BIC).[104] The BIC criterion selects the model that minimizes the statistic:

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[104] See, e.g., George G. Judge, *et al.*, *The Theory and Practice of Econometrics*, Second Edition (Wiley, 1985), pp 871-873.

(III-18) $$BIC = k \ln n - 2 \ln L(\hat{\beta}).$$

Where k is the number of parameters in the model, n is the number of observations in the data, and $L(\hat{\beta})$ is the likelihood function of the model evaluated at the parameters $\hat{\beta}$ that maximize the likelihood. Reducing the error variance (or unexplained variation in the data) will reduce BIC, other things equal. However, the net effect of adding parameters—which will decrease unexplained variation— is ambiguous because of the $k \ln n$ penalty term.

The out-of-sample selection criterion uses a model selection process, whereby each specification is estimated using a "training" dataset and then tested by evaluating its performance on a "test" dataset. Performance on the test set is quantified using the mean squared prediction error (MSE): the average of the squared difference between the model's predictions of the dependent variable and its actual values for the observations in the test dataset. A key feature of the out-of-sample selection criterion is that improving a regression model's fit to the regression observations by adding explanatory variables will not necessarily improve out-of-sample prediction accuracy.

For the NEIO models, we use a portion of the 2019 CWS data as the test dataset and use the rest of the CWS dataset as the training dataset. Using the models estimated on the training dataset, we predict RPTM for the test observations and compare them to the actual RPTM. The differences are the differences are then squared and averaged across all observations in the test set. Specifically, we randomly assigned half of the 2019 CWS observations to the test set. We repeated this process five times to reduce dependence on the specific test samples drawn and averaged the results over the repeated trials. We computed MSEs for six model combinations: the log-log, log-spline, and translog equations, each applied to both a pooled CWS sample and subsamples for Eastern and Western railroads.

Results for R^2, BIC, and the prediction MSE are in Table III-8. We find that the translog specification estimated separately on the Eastern and Western regional CWS subsamples narrowly outperforms the other specifications by both the in-sample BIC and out-of-sample criterion: the translog specification both minimizes the BIC and has the smallest out-of-sample prediction MSE. The results indicate that the data are more consistent with region-specific parameters as well as the translog form's non-constant elasticities of RPTM with respect to the NEIO cost variables. In Section III.E, below, we use the region-specific parameters of the translog NEIO regressions in Tables III-6 and III-7 to compute Hybrid model shipment-specific costs and R/VC statistics.

Table III-8. NEIO Model Selection Criteria

Specification:	Log-log	Log-spline	Translog	Log-log	Log-spline	Translog
Data:	Pooled	Pooled	Pooled	East/West	East/West	East/West
In-Sample Fit						
R^2	.743	.745	.752	.748	.749	.756
BIC	1411.6	1391.4	1331	1365.8	1351.4	1289.6
Out-of-Sample Prediction						
MSE	.117	.116	.114	.115	.115	.112

D. ESTIMATING GENERIC MARGINAL COSTS FOR THE HYBRID MODEL

In addition to the NEIO regression model, the Hybrid model requires estimates of generic marginal costs as a component of the movement-specific costs specified in Equations III-10 to III-12, above. The generic costs may vary by railroad and year but are not specific to any movement within a railroad's yearly freight traffic. This section describes estimation approaches for the generic marginal costs using available data from the R-1 annual reports.

In regulatory costing practice, two broad cost modeling approaches are often considered: a cost-theoretic approach based on econometric cost and/or production models, and an activity equation approach related to activity-based modeling of firms' operations. The cost variability models in legacy URCS, and the updated Phase I models we describe in below in this section, are examples of the activity equation approach. The industry VC model we used to generate marginal cost inputs for the original 2009 Hybrid model is an example of a cost-theoretic model. While these approaches differ considerably in the economic assumptions incorporated in the models, we do not suggest that either approach is clearly more appropriate in all empirical applications.

Cost-theoretic models implemented in many econometric cost studies have primary goals of investigating aspects firms' cost and production structures, such as the substitutability of factors of production (inputs), the existence of economies of scale or density, and the like. These models typically impose or imply strong economic behavioral assumptions on the part of the firm and the input and output markets they participate in, including maximizing behaviors and the existence or non-existence of market power. Econometric cost studies also commonly implement cost functions that usually radically simplify general multiproduct cost models. For example, the industry variable cost model below characterizes railroad output entirely in terms of revenue ton-miles.[105]

The Hybrid model from the Christensen 2009 Competition Study derived marginal costs from estimated parameters of a translog variable cost function for the Class I railroad industry. The

[105] This follows the modeling approach we used in Christensen 2009 Competition Study, Vol. 2, p. 9-5. A similar model presented by Bitzan and Wilson 2003 differentiates unit train and way-and-through train ton-miles.

variable cost function was estimated using a dataset derived primarily from R-1 annual report data. A potential concern with the cost function approach is whether the relatively large number of parameters of the translog cost model can be reliably estimated from the railroad-year observations available from the R-1 reports. We describe updates to the model, data, and estimation approach in Section III.D.1, below.

As an alternative approach to translog cost function estimation, we also consider obtaining generic marginal costs using disaggregated activity-level cost equations derived from the URCS Phase I models. This uses the result, described in Section II, that unit variable costs using cost elasticities with respect to outputs as variability factors can be interpreted as economic marginal costs. Of course, in addition to potentially providing cost inputs to the Hybrid model, the disaggregated cost elasticities could also be used to update the variable cost calculations in URCS Phase II. The updated Phase I analysis is detailed in Section III.D.2.

The activity equation approach typically incorporates industry or firm-specific knowledge to associate expenses and outputs (which may be intermediate outputs of the railroad) at the level of cost pools below the firm level. In contrast to cost-theoretic models, activity-level analyses tend to focus more narrowly on estimating relationships between expenses and outputs. Disaggregating uses knowledge of firm activity and cost structures to allow expenses to be associated with distinct output measures as appropriate. Relatedly, disaggregating can allow cost pool-level expenses to have different degrees of variability (elasticity) with respect to output(s), where cost-theoretic models may only model aggregate elasticities.

A significant limitation of the legacy Phase I models is that they cover a collection of railroad operating costs and do not provide cost elasticities with respect to output for return-on-investment (ROI), depreciation, lease, and rental (DLR) costs, which comprise a substantial fraction of railroads' total cost. In legacy URCS, ROI and DLR costs are assigned "default" variabilities of either 50 percent or 100 percent. The default variabilities depend on the type of expense, with ROI and DLR expenses for way and structures assigned the 50 percent variability, while ROI and DLR costs for equipment including locomotives and freight cars are treated as 100 percent variable. In Section III.D.3, we detail the implementation of econometric models of ROI and DLR costs for way and structures, locomotives, and freight cars to provide empirical cost elasticities that may be used in place of the URCS defaults to produce short-run (marginal or unit variable) costs.

Finally, Section III.D.4 discusses advantages and disadvantages of the econometric cost function and Phase I-based approaches to generating marginal costs for the Hybrid model.

1. *Aggregated Approach to Marginal Costs: Class I Industry Variable Cost Model*

a) The Short Run Economic Cost Function

A short run cost function applies when one or more of the inputs cannot be adjusted to the cost-minimizing level(s).[106] Short-run total cost is the payments to the variable inputs X_i^V plus the payments to the fixed inputs X_i^F. That is,

(III-19) $$TC = TVC + TFC$$

where $TVC = \sum_i W_i^V X_i^V$ and $TFC = \sum_i W_i^F X_i^F$, where W_i^V and W_i^F are input prices.

Dividing both sides of equation IV-18 by TVC gives

(III-20) $$TC/TVC = 1 + TFC/TVC.$$

This equation shows that the overhead collection burden is determined by the ratio of fixed cost to variable cost. If revenues were just sufficient to cover total costs, the industry R/VC ratio would equal $1 + TFC/TVC$. Equation III-19 provides the rationale for firms' need to exercise market power to cover their costs.

b) Marginal Cost and the Output Elasticity of Cost

Short run marginal cost (MC) is the partial derivative of the short run cost function with respect to output Q. That is:

(III-21) $$MC = \partial TC/\partial Q = \partial TVC/\partial Q.$$

Correspondingly, the short-run cost elasticity with respect to output (hence forth output elasticity or η_Q) is the partial derivative of the natural log of the cost function with respect to natural log of output:

(III-22) $$\eta_Q = \partial \ln TVC / \partial \ln Q = MC/AVC \Leftrightarrow MC = \eta_Q VC/Q.$$

If the output elasticity is less than one, then adding more output onto the existing network results in variable cost increasing less than proportionately with output. This is called economies of density. Density economies are commonly found in analyses of costs for railroads and firms in other network industries.[107]

[106] Such an input can be referred to as a conditional input, a fixed input, or a quasi-fixed input.
[107] Conversely, when the output elasticity is greater than one, there are diseconomies of density, as producing more output on the same network increases variable cost more than proportionately.

c) The Importance of Short Run Marginal Cost and the Output Cost Elasticity

Short-run marginal cost is the supply curve for a competitive firm. Short-run marginal cost is also the basis from which to measure the exercise of market power.[108] Thus, it is short run marginal cost that is an important measure in assessing the performance of a market.
The output cost elasticity reveals the extent of density economies. When there are economies of density, marginal cost pricing would fail to fully recover the variable cost. When there are diseconomies of density, marginal cost pricing would collect more than variable cost. When the output cost elasticity equals 1, marginal cost pricing would exactly recover variable cost.
The presence of fixed costs adds a recovery burden. This burden taken together with the under- or over-collection from density economies or diseconomies, it may be necessary for price to exceed marginal cost for the firm to recover total costs. The needed markup of price over marginal cost that allows the firm to just recover total cost is given by

(III-23) $$\tau = (1/\eta_Q) \cdot (1 + TFC/TVC) - 1.$$

That is, the breakeven markup depends on the inverse of the output cost elasticity and the ratio of fixed to variable cost.[109] [110]

While marginal cost and the output cost elasticity are important measures to guide and assess the performance of an industry, these measured are not directly observed. As a result, firms and regulators sometimes use AVC as a proxy for MC.[111] However, doing so implicitly assumes away any economies or diseconomies of density. Likewise, interpreting an *R/AVC* ratio as a measure of the exercise of market power will be inaccurate to the extent there are economies or diseconomies of density.

d) Cost Function Specification and Data

Since marginal cost is not directly observed, it instead must be estimated econometrically or otherwise inferred. To undertake estimation, we represent railroad production technology in terms of a single output—revenue-ton miles—being produced using five inputs—way and structures capital, labor, materials, equipment, and fuel. The production function also includes two output characteristics, average length of haul and network size. Network size is measured by the railroad's miles of road.

---

[108] The Stigler measure of the exercise of market power is *P/MC*. An equivalent transformation of this measure is the Lerner Index of Monopoly Power given by (*P-MC*)/*P*.
[109]This result is derived in the Christensen 2009 Competition Study, Vol. 2, Chapter 10.
[110] $(1+\tau)$ can be a floor in establishing the appropriate R/VC ratio threshold.
[111] See, e.g., Phillip Areeda and Donald F. Turner, "Predatory Pricing and Related Practices under Section 2 of the Sherman Act," *Harvard Law Review*, Vol. 88, No. 4 (Feb., 1975), pp. 697-733.

We treat way and structures capital as a quasi-fixed input[112] with all other inputs variable. The corresponding variable cost function is a function of revenue ton-miles, the variable input prices, the quasi-fixed capital stock, the average length of haul, and miles of road.

In the Christensen 2009 Competition Study, we used a transcendental logarithmic (translog) functional form for the variable cost function. The translog specification provides a second-order approximation in natural logarithms to a general cost function.[113] When all the second-order terms—squares and products of the variables in the cost functions—have coefficients of zero, the translog specification reduces to a Cobb-Douglas (log-log) first-order approximation.[114] Below, we estimate both first-order and second-order specifications of the cost function.

The measure of variable cost includes three major categories of railroad expenses obtained from the R-1 annual reports: railroad operating costs, generally corresponding to the collection of accounts covered by the URCS Phase I econometric variability analysis; locomotive ROI and DLR costs; and freight car ROI and DLR costs. Since way and structures capital is treated as a quasi-fixed input, variable cost excludes ROI and DLR costs for way and structures capital. Under this treatment, way and structures ROI and DLR costs are assumed to have zero short-run cost elasticity. Locomotive and freight car ROI and DLR costs, which are 100 percent variable as a matter of assumption in legacy URCS, are allowed to have non-zero (but not necessarily unit) output elasticity as they are considered part of variable cost.

Definitions of variables used in the industry variable cost model are provided in Table III-9, below. We estimate the models using annual data from 2000-2019.

Specification 1

We begin with a linear model in natural logarithms for industry variable costs with time and railroad fixed effects. This can be viewed as a first-order approximation to the "true" industry variable cost function.

(III-24)

$$lnC_{jt}^{V} = \alpha_0 + \alpha_Q \ln RTM_{jt} + \alpha_N lnN_{jt} + \delta_H lnALH_{jt} + \delta_K lnK_{jt}$$
$$+ \sum_i \beta_i lnW_{ijt} + \tau_T Time_{jt} + \sum_j d_j\, Firm_j + \epsilon.$$

[112] A "quasi-fixed" input may be adjusted over time, but is considered invariant with respect to output over some limited time horizon of the analysis.
[113] Laurits R. Christensen, Dale W. Jorgenson, and Lawrence J. Lau, "Conjugate Duality and the Transcendental Logarithmic Production Function," *Econometrica*, 39, 1971, pp. 255-256; and Laurits R. Christensen, Dale W. Jorgenson, and Lawrence J. Lau, "Transcendental Logarithmic Production Frontiers," *Review of Economics and Statistics*, 55, pp. 28-45.
[114] Charles W. Cobb and Paul H. Douglas, "A Theory of Production," *American Economic Review*, 18(1) Supplement, 1928, pp. 139-165.

Specification 2

Next, we consider the following translog functional form, a second-order approximation to the industry variable cost function. Note that railroad-year subscripts are omitted for brevity.

(III-25a)

$$
\begin{aligned}
lnC^V = {} & \alpha_0 + \alpha_Q \ln RTM + \alpha_N \ln N + \delta_K lnK + \delta_H lnALOH + \sum_i \beta_i lnW_i + \tau_T Time \\
& + \alpha_{QQ}(\ln RTM)^2 + \alpha_{QN} \ln RTM \ln N + \delta_{QK} \ln RTM \ln K + \delta_{QH} \ln RTM \ln ALOH \\
& + \sum_i \alpha_{Qi} \ln RTM\, lnW_i + \tau_{QT} \ln RTM\, Time \\
& + \alpha_{NN}(\ln N)^2 + \delta_{NK} \ln N \ln K + \delta_{NH} \ln N \ln ALOH + \sum_i \alpha_{Ni} \ln N\, lnW_i + \tau_{NT} \ln N\, Time \\
& + \alpha_{KK}(\ln K)^2 + \delta_{KH} \ln K \ln ALOH + \sum_i \alpha_{Ki} \ln K\, lnW_i + \tau_{KT} \ln K\, Time \\
& + \alpha_{HH}(\ln ALOH)^2 + \sum_i \alpha_{Hi} \ln ALOH\, lnW_i + \tau_{HT} \ln ALOH\, Time \\
& + \textstyle\sum_i \sum_j \beta_{ij} \ln W_i \ln W_j + \sum_i \tau_i\, lnW_i\, Time \\
& + \tau_{TT} Time^2 + \sum_l d_l\, Firm_l + \epsilon.
\end{aligned}
$$

Specification 2 - restricted

Finally, we consider a parsimonious version of Specification 2 that eliminates all but three second-order terms involving revenue ton-miles and miles of road.

(III-25b)

$$
\begin{aligned}
lnC^V_{jt} = {} & \alpha_0 + \alpha_Q \ln RTM_{jt} + \alpha_{QQ}(\ln RTM)^2 + \alpha_N lnN_{jt} + \alpha_{NN}\left(lnN_{jt}\right)^2 + \\
& + \alpha_{QN} \ln RTM \ln N + \delta_H lnALH_{jt} + \delta_K lnK_{jt} + \textstyle\sum_i \beta_i lnW_{ijt} + \tau_T Time_{jt} + \\
& \textstyle\sum_j d_j\, Firm_j + \epsilon.
\end{aligned}
$$

Table III-9. Variable Definitions for the Industry Variable Cost Model

Variable Name	Variable Definition or Source
<u>Variable Cost</u>	
Real Variable Cost ($\boldsymbol{C^V}$)	VARIABLE_COST ⁄ GDPPI
VARIABLE_COST	OPERCOST + ROIROAD + ROILOCO + ROICARS – ROADCOST
GDPPI	Price Index for the Gross Domestic Product (Year 2000 = 1.0): Bureau of Economic Analysis
OPERCOST	Operating cost: R-1, Sched. 410, Line 620, Col. F
ROIROAD	Return on investment in road: (ROADINV – ACCDEPR) × COSTKAP
ROADINV	Road investment: R-1, Sched. 352B, Line 31
ACCDEPR	Accumulated depreciation on road: R-1, Sched. 335, Line 30, Col. G
COSTKAP	Cost of capital: Association of American Railroads, Railroad Facts
ROILOCO	Return on investment in locomotives: [(IBOLOCO + LOCOINVL) – (ACDOLOCO + ACDLLOCO)] × COSTKAP
IBOLOCO	Investment base in owned locomotives: R-1, Sched. 415, Line 5, Col. G
LOCOINVL	Investment base in leased locomotives: R-1, Sched. 415, Line 5, Col. H
ACDOLOCO	Accumulated depreciation on owned locomotives: R-1, Sched. 415, Line 5, Col. I
ACDLLOCO	Accumulated depreciation on leased locomotives: R-1, Sched. 415, Line 5, Col. J
ROICARS	Return on investment in cars: [(IBOCARS + CARSINVL) – (ACDOCARS + ACDLCARS)] × COSTKAP
IBOCARS	Investment base in owned cars: R-1, Sched. 415, Line 24, Col. G
CARSINVL	Investment base in leased cars: R-1, Sched. 415, Line 24, Col. H
ACDOCARS	Accumulated depreciation on owned cars: R-1, Sched. 415, Line 24, Col. I
ACDLCARS	Accumulated depreciation on leased cars: R-1, Sched. 415, Line 24, Col. J
ROADCOST	(ROADINV – ACCDEPR) × COSTKAP + ANNDEPRD
ANNDEPRD	Annual depreciation in road: R-1, Sched. 335, Line 30, Col. C
<u>Input Shares of Variable Cost</u>	
Labor Share of Variable Cost	LABORCOST ⁄ VARIABLE COST
LABORCOST	SWGE + FRINGE
SWGE	Total salary and wages: R-1, Sched. 410, Line 620, Col. B
FRINGE	Fringe benefits: R-1, Sched. 410, Lines 112-114, 205, 224, 309, 414, 430, 505, 512, 522, 611, Col. E

Equipment Share of Variable Cost	(LOCOCOST + CARSCOST) ⁄ VARIABLE COST
LOCOCOST	ROILOCO + ANNDEPLOC + RENTLOCO
ANNDEPLOC	Annual depreciation on locomotives: R-1, Sched. 410, Line 213, Col. F
RENTLOCO	Net leases and rentals, locomotives: R-1, Sched. 415, Line 5, Col. F
CARSCOST	ROICARS + ANNDEPRCAR + RENTCARS
ANNDEPCAR	Annual depreciation on cars: R-1, Sched. 410, Line 232, Col. F
RENTCARS	Net leases and rentals, cars: R-1, Sched. 415, Line 24, Col. F
Fuel Share of Variable Cost	FUELCOST / VARIABLE COST
FUELCOST	Cost of diesel fuel: R-1, Sched. 755, Line 105, Col. B
Materials Share of Variable Cost	MATCOST ⁄ VARIABLE COST
MATCOST	Materials Cost: VARIABLE COST – LABORCOST – LOCOCOST – CARSCOST – FUELCOST
Output and Network	
Revenue Ton-Miles (RTM)	R-1, Sched. 755, Line 110, Col. B
Miles of Road (N)	R-1, Sched. 700, Line 57, Col. C
Capital Stock	
Way and Structures Capital per Mile of Track	[(ROADINV – ACCDEPR) ⁄ MOT] ⁄ GDPPI
MOT	Miles of track: R-1, Sched. 720, Line 6, Col. B
Input Prices (W_i)	
Real Price of Labor	(LABORCOST ⁄ LABHOURS) ⁄ GDPPI
LABHOURS	Labor hours: Wage Form A, Line 700, Col. 4 and Col. 6
Real Price of Equipment	Weighted average equipment price: Return on investment plus annual depreciation per car and locomotive weighted by that type of equipment's share in total equipment cost, all divided by GDPPI.
Real Price of Materials	AAR railroad price index for materials and supplies.
Real Price of Fuel	(FUELCOST ⁄ FUELGAL) ⁄ GDPPI
FUELGAL	Gallons of diesel fuel: R-1, Sched. 750, Line 4, Col. B
Other Variables	
Average Length of Haul (ALH)	RTM ⁄ REVTONS
RTM	Revenue ton-miles: R-1, Sched. 755, Line 110, Col. B
REVTONS	Revenue tons of freight: R-1, Sched. 755, Line 105, Col. B
Capital Stock (K)	Index of capital stock[115]
Time Trend	Year minus 2000

[115] See Christensen 2009 Competition Study, Vol. 2, pp. 9-3 to 9-4. The capital stock series extends the method in Anne F. Friedlaender, Ernst R. Berndt, Judy Shaw-Er Wang Chiang, M. Showalter, and Christopher A. Vellturo, "Rail Costs and Capital Adjustments in a Quasi-regulated Environment," *Journal of Transport Economics and Policy* 27(2), 1993, pp. 131-152.

CAPCOST1	REVENUE-VARCOST
REVENUE	Freight-related revenue: R-1, Sched. 210, Line 13, Col. D
Capital Employment Variables	
CAPCOST2	ROADCOST
CAPCOST_RATIO1	CAPCOST1 / VARCOST
CAPCOST_RATIO2	CAPCOST2 / VARCOST
IMPUTED_PK1	CAPCOST1 / (Way and Structures Capital per Mile of Track)
IMPUTED_PK2	CAPCOST2 / (Way and Structures Capital per Mile of Track)

e) Estimation

There are two primary challenges in estimation of the parameters of the industry variable cost function. First, many of the right-hand-side variables in the translog Specification 2 are highly correlated with one another. Consequently, there is little variation in ton-miles, for instance, once one has controlled for the remaining variables in the model. This problem of multicollinearity leads to less precise estimates of the regression coefficients other things equal. Second, because the data are at the railroad-year level, the number of observations is relatively small at 138. To overcome these challenges, we choose estimators for each specification with the goal of obtaining parameter estimates that are as precise as possible given the data.

We estimate the variable cost model in a Seemingly Unrelated Regressions (SUR) framework in which we jointly estimate the cost function and a set of factor share equations obtained via Shephard's Lemma. When a railroad minimizes costs with respect to its variable inputs, Shephard's lemma states that an input i's cost share S_i is equal to the partial derivative of lnC^V with respect to lnW_i. The share equations are:

(III-26) $$S_i = \partial \ln\ C^V/\partial \ln W_i = \beta_i + \sum_j \beta_{ij} \ln W_j\ + u_i.$$

We also impose linear homogeneity restrictions on the coefficients on prices.[116] The homogeneity restrictions provide that a proportional increase in all factor prices will increase costs by the same proportion, other things equal. The theory-based parameter restrictions allow us to use the available data more efficiently. We use nonlinear least squares to estimate the cost and factor share system with the homogeneity restrictions and report standard errors clustered by railroad to allow for autocorrelation within railroads and between-railroad heteroskedasticity.

f) Results: Elasticities and Marginal Costs

Estimates of the elasticity of variable cost with respect to output (revenue ton-miles) can be found in Tables III-10 and III-11. The underlying parameter estimates are provided in Tables III-13 (Specification 1) and III-14 (Specification 2). The output elasticity is equal to the partial derivative of lnC^V with respect to $lnRTM$ in our model. Note that in Specification 1, this is equal

[116] The homogeneity restrictions are that the first-order coefficients on prices β_i sum to 1, and the second-order coefficients sum to zero $\sum_i \beta_{ij}\ = \sum_j \beta_{ji}$ for all i and j, $\sum_i \alpha_{Qi} = \sum_i \alpha_{Ni} = \sum_i \tau_i = 0$.

to α_Y and is thus constant across railroads and time periods. In Specification 2, this estimate will vary across railroads and time periods, and we report the elasticity evaluated at the average observation in our sample in Table III-10 and elasticities evaluated at railroad-specific averages in Table III-11. The estimates for Specification 1 imply that a 1 percent increase in revenue ton-miles is associated with a roughly 0.749 percent increase in variable costs. In Specification 2, the elasticity evaluated at the average value in the data is 0.672 for the general model and 0.689 for the restricted model. While this difference is nontrivial, differences of this magnitude are not necessarily unexpected given the large number of parameters in Specification 2 and the 0.136 standard error of the Specification 1 elasticity.

Using our estimated elasticities, we provide estimates of the returns to density, which are said to exist if the proportional increase in variable cost resulting from a proportional increase in revenue ton-miles is less than 1, holding fixed the railroad's capital stock, network size and average length of haul.[117] In other words, a railroad experiences returns to density if its variable costs rise more slowly than its output, holding fixed features of its network. This implies that returns to density exist if

(III-27) $\partial lnC^v/\partial lnQ < 1$, or $RTD = 1 / (\partial lnC^v/\partial lnQ) > 1$.

The returns to density measure is above 1 across specifications, though the large standard errors generally prevent us from confidently concluding the presence of economies of density. Additionally, we provide estimates of the returns to scale, which exist if the proportional increase in total cost resulting from a proportional increase in output and network size is less than 1, holding fixed average length of haul. Christensen, Caves, and Swanson 1981[118] shows that even though this concept is fundamentally related to total costs, it can be recovered from variable cost estimates using the relation

(III-28) $$RTS = (1 - \partial lnC^v/\partial lnK) / (\partial lnC^v/\partial lnQ + \partial lnC^v/\partial lnN).$$

The returns to scale measure is below 1 across specifications. While this appears to imply diseconomies of scale at first glance, the large standard errors generally do not allow us to confidently reject constant returns to scale or even economies of scale.

We can derive generic marginal costs by railroad and year using the definition of the elasticity of variable costs with respect to revenue ton-miles.

(III-29) $$\eta_Q^{C^V} = (\partial C^V/\partial Q)(Q/C^V) \Rightarrow MC = \partial C^V/\partial Q = \eta_Q^{C^V}(C^V/Q).$$

[117] Average length of haul need not be held fixed as discussed in the Christensen 2009 Competition Study. However, because this is not the focus of our analysis, we take a simpler approach here.
[118] Douglas W. Caves, Laurits R. Christensen, and Joseph Swanson, "Productivity Growth, Scale Economies, and Capacity Utilization in U.S. Railroads, 1955-74," *American Economic Review*, vol. 71(5) (1981), pp. 994-1002.

Estimated marginal costs evaluated at the railroad means of the data are in Table III-12, as well as estimated marginal costs by railroad in 2019. An examination of the range of estimated marginal costs by railroad in 2019 shows that the estimated parameters of our variable cost model become unstable as more terms are added. For instance, BNSF's estimated marginal cost falls nearly in half from Specification 1 to Specification 2, and then more than doubles when some interaction terms are restricted to have coefficients of zero. For this reason, we use marginal cost estimates from derived from Specification 1 to develop marginal costs by railroad and year for use in Hybrid model results in Section III.E, below.

Table III-10. Summary of Elasticities in the Variable Cost Model

	Specification 1	Specification 2 (at mean)	Specification 2 - Restricted (at mean)
Output (RTM) Elasticity	.749 (0.136)	.672 (0.084)	.689 (0.137)
Network-Size Elasticity	.488 (0.423)	.878 (0.481)	.785 (0.529)
Capital Stock Elasticity	-.11 (0.139)	.071 (0.068)	-.089 (0.123)
Density Elasticity	1.336 (0.242)	1.488 (0.186)	1.452 (0.289)
Scale Elasticity	.898 (0.323)	.598 (0.177)	.739 (0.249)

Standard errors of estimates in parentheses.

Table III-11. Output Elasticities by Railroad

	Specification 2			Specification 2 Restricted		
Railroad	Estimate[119]	Standard Error	Range	Estimate	Standard Error	Range
BNSF	.647	.134	(0.4 - 1.04)	.906	.101	(0.78 - 0.98)
CNGT	.351	.057	(0.25 - 0.48)	.639	.145	(0.46 - 0.76)
CP	.762	.112	(0.60 - 1.006)	.545	.192	(0.401 - 0.68)
CSX	.672	.175	0.36 - 0.94	.647	.204	(0.56 - 0.71)
KCS	.915	.129	(0.70 - 1.03)	.673	.143	(0.53 - 0.75)
NS	.619	.174	(0.30 - 0.86)	.591	.25	(0.49 - 0.66)
UP	.707	.151	(0.41 - 1.05)	.816	.108	(0.73 - 0.87)

[119] The point estimate of the elasticity is evaluated at railroad means of the data.

Table III-12. Marginal Costs by Railroad from Industry VC Specifications (2019 cents per RTM)

	Mean			2019		
Railroad	Spec. 1	Spec. 2	Spec. 2 Restricted	Spec. 1	Spec. 2	Spec. 2 Restricted
BNSF	1.63	1.41	1.98	1.6	.85	2.01
	(0.30)	(0.29)	(0.22)	(0.29)	(0.36)	(0.25)
CNGT	2.68	1.25	2.28	2.81	1.38	2.77
	(0.48)	(0.20)	(0.52)	(0.51)	(0.73)	(0.46)
CP	2.35	2.39	1.71	2.04	1.66	1.63
	(0.42)	(0.35)	(0.60)	(0.37)	(0.44)	(0.44)
CSX	2.85	2.56	2.46	2.76	1.34	2.29
	(0.52)	(0.67)	(0.78)	(0.50)	(0.73)	(0.82)
KCS	2.34	2.86	2.1	2.6	2.99	2.49
	(0.42)	(0.40)	(0.45)	(0.47)	(0.74)	(0.51)
NS	3.17	2.62	2.5	2.88	1.17	2.41
	(0.57)	(0.74)	(1.06)	(0.52)	(0.71)	(0.83)
UP	1.99	1.88	2.17	2.15	1.2	2.08
	(0.36)	(0.40)	(0.29)	(0.39)	(0.58)	(0.49)

Standard errors in parentheses.

Table III-13. Specification 1 Coefficient Estimates

	Coefficient	Standard Error
ln(Ton-Miles)	.749	.136
ln(Miles_of_Road)	.488	.423
ln(Capital_Stock)	-.11	.139
ln(Average_Length_of_Haul)	-.318	.481
ln(Price_Labor)	.357	.014
ln(Price_Equipment)	.127	.007
ln(Price_Fuel)	.154	.014
Year	-.01	.005
N	138	

Table III-14. Specification 2 Coefficient Estimates

	Specification 2		Specification 2 Restricted	
	Coefficient	Standard Error	Coefficient	Standard Error
ln(Ton-Miles)	.909	.193	.792	.099
ln(Miles_of_Road)	1.624	.619	.858	.682
ln(Capital_Stock)	-.491	.159	-.089	.123
ln(Average_Length_of_Haul)	-.907	.225	-.155	.486
ln(Price_of_Labor)	.349	.017	.357	.014
ln(Price_of_Equipment)	.137	.01	.127	.008
ln(Price_of_Fuel)	.189	.01	.155	.014
ln(Ton-Miles)^2	-.768	.314	.487	.472
ln(Ton-Miles)*ln(Miles_of_Road)	-.754	.505	-.551	.623
ln(Miles_of_Road)^2	-.612	.829	1.167	.752
ln(Capital_Stock)^2	-1.166	.557	.	.
ln(Capital_Stock)*ln(Average_Length_of_Haul)	-1.958	.624	.	.
ln(Average_Length_of_Haul)^2	-3.352	.319	.	.
ln(Ton-Miles)*ln(Capital_Stock)	.952	.423	.	.
ln(Ton-Miles)*ln(Average_Length_of_Haul)	1.294	.211	.	.
ln(Miles_of_Road)*ln(Capital_Stock)	1.041	.473	.	.
ln(Miles_of_Road)*ln(Average_Length_of_Haul)	2.134	.797	.	.
ln(Price_of_Labor)*ln(Price_of_Labor)	.197	.052	.	.
ln(Price_of_Labor)*ln(Price_of_Equipment)	-.014	.01	.	.
ln(Price_of_Labor)*ln(Price_of_Fuel)	-.022	.017	.	.
ln(Price_of_Equipment)^2	.024	.017	.	.
ln(Price_of_Equipment)*ln(Price_of_Fuel)	-.033	.007	.	.
ln(Price_of_Fuel)^2	.128	.009	.	.
ln(Ton-Miles)*ln(Price_of_Labor)	-.016	.03	.	.
ln(Ton-Miles)*ln(Price_of_Equipment)	.056	.011	.	.
ln(Ton-Miles)*ln(Price_of_Fuel)	.113	.022	.	.
ln(Miles_of_Road)*ln(Price_of_Labor)	.008	.035	.	.
ln(Miles_of_Road)*ln(Price_of_Equipment)	-.092	.02	.	.
ln(Miles_of_Road)*ln(Price_of_Fuel)	-.124	.026	.	.
ln(Capital_Stock)*ln(Price_of_Labor)	.154	.036	.	.
ln(Capital_Stock)*ln(Price_of_Equipment)	.01	.032	.	.
ln(Capital_Stock)*ln(Price_of_Fuel)	-.029	.019	.	.
ln(Average_Length_of_Haul)*ln(Price_of_Labor)	-.219	.1	.	.
ln(Average_Length_of_Haul)*ln(Price_of_Equipment)	.02	.109	.	.
ln(Average_Length_of_Haul)*ln(Price_of_Fuel)	.059	.034	.	.
Time	-.01	.009	-.009	.006
Time^2	.	.001	.	.
Time*ln(Ton-Miles)	-.034	.016	.	.

	Specification 2		Specification 2 Restricted	
	Coefficient	Standard Error	Coefficient	Standard Error
Time*ln(Miles_of_Road)	-.071	.012	.	.
Time*ln(Capital_Stock)	.073	.015	.	.
Time*ln(Average_Length_of_Haul)	.073	.023	.	.
Time*ln(Price_of_Labor)	.	.001	.	.
Time*ln(Price_of_Equipment)	-.001	.001	.	.
Time*ln(Price_of_Fuel)	.	.001	.	.
N	138		138	

2. *Disaggregated Approach to Variable and Marginal Costs (Phase I Update)*

Implementing generic marginal costs for the Hybrid model using disaggregated elasticities of costs with respect to output requires defining cost pools to partition railroad expenses into analytically useful groups and specifying associated cost equations from which the elasticities can be estimated econometrically. For Class I railroads' operating costs[120] the cost pools and econometric models specified for the legacy URCS Phase I analysis provide an obvious starting point. The cost partition assigns expenses into relatively homogeneous cost pools to facilitate analysis consistent with the Causality and Homogeneity principles. Westbrook's linear models can provide estimates of cost elasticities for railroad outputs, though the original choice of the level specification in legacy Phase I was opaque and we consider alternative specifications.

Our analysis considered both simple updates of the URCS Phase I models using contemporary data, and updates involving alterations to the Phase I partition of operating costs and changes to the econometric specification of the cost equations. Since a substantial fraction of URCS variable costs are developed using non-empirical "default" elasticities assigned to capital costs, we also extended the Phase I econometric analysis by modeling capital costs for way and structures, freight cars, and locomotives.

a) Cost Pools, Outputs, and Capacity Variables in Legacy Phase I

Westbrook 1988 estimated activity equations for sixteen URCS cost pools, which may be characterized as subsets of expenses for several broader activity categories. The expense (dependent), capacity, and output variables assigned to each are listed in Table II-1, below. While analyzed in Westbrook 1988, econometric results for the CARREPS equation were not incorporated in URCS.[121] Lists of the R-1 accounts included in each dependent variable are provided in Appendix A.

[120] Specifically, operating costs here exclude annual depreciation and equipment rental expenses reported on R-1 Schedule 410.

[121] This appears to be because the CARREPS equation produced variable cost ratios exceeding 1 for all of the railroads in his analysis; see Westbrook 1988, p. 107. Westbrook 1988 did not otherwise discuss the CARREPS result. While cost elasticities with respect to output that are greater than 1 are not anomalous in themselves—it implies that $MC > AVC$, decreasing returns to scale or density—the econometric results may have been substituted to avoid the appearance of allocating more than 100 percent of the expenses in the cost pool to shipments.

The cost pool definitions in Table III-15 were established for the ICC's *1979 Rail Cost Study* (1979 RCS) models, and the scope of Westbrook 1988 did not include consideration of alternative cost pool definitions. For this study, the STB provided disaggregated data on expenses (i.e., account-level data before aggregation to cost pools) and independent variables, primarily compiled from the R-1 annual reports. We used the data both to replicate the legacy URCS cost pools and to investigate alternative cost pool definitions.

Figure III-4 shows the composition of Class I railroad expenses in the URCS econometric cost pools (including CARREPS) for the 2000-2019 period. The nine largest cost pools total over 90 percent of reported expenses for the sixteen groups (which totaled $32,395 million in the 2019 R-1 Reports). In the absence of major changes in industry structure over this period, cost shares for the larger cost pools appeared to be relatively stable overall. We observed greater variability in cost shares for the smaller cost pools, particularly below the Class I industry aggregates. See also Appendix B for comparable figures for Eastern and Western railroads.

Figure III-4. Shares of Class I Railroad Expenses by URCS Cost Pool, 2000-2019

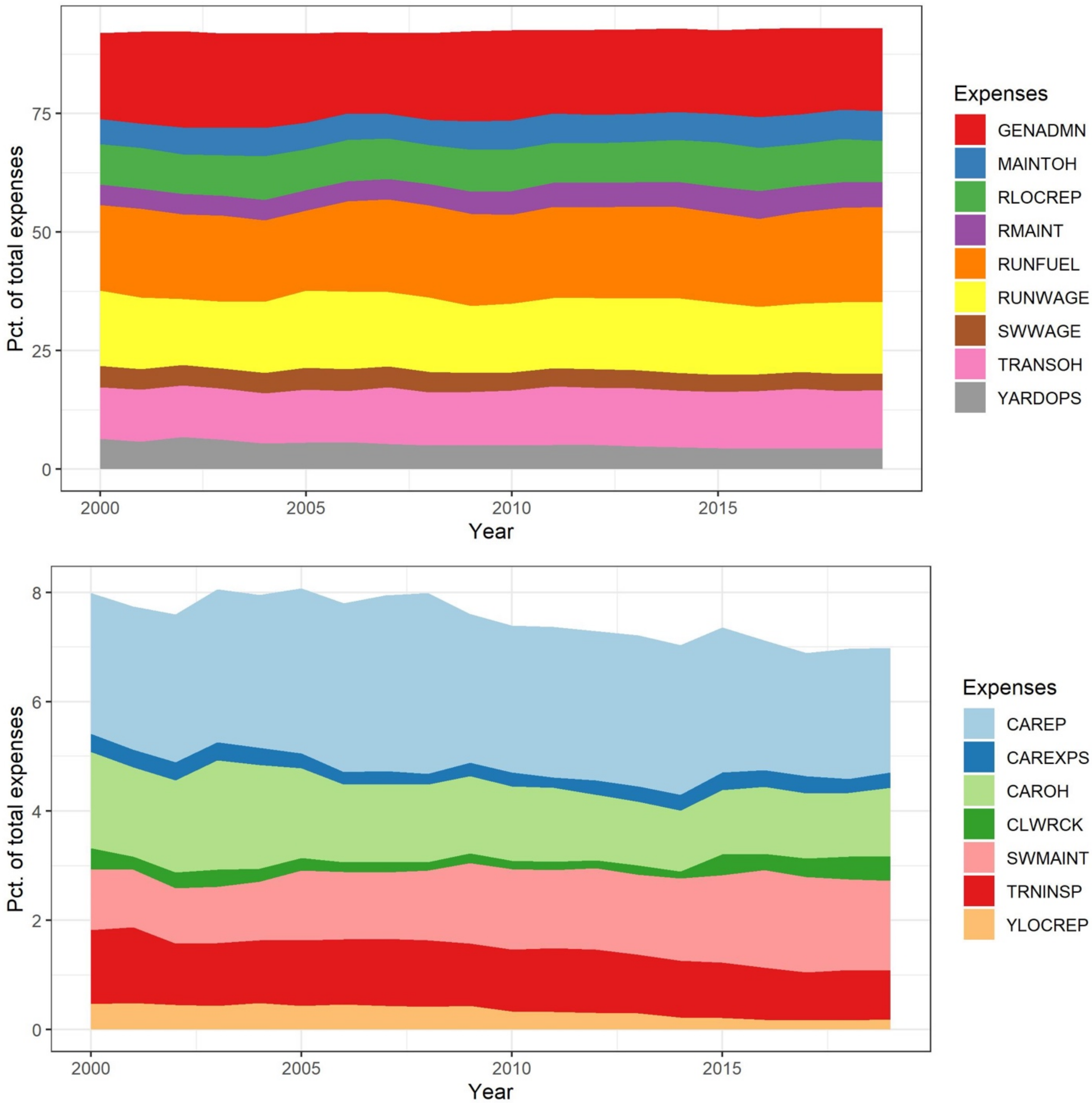


Table III-15A. Railroad Cost Pools in Legacy URCS Phase I

Regression Name	Regression Description	Capacity Variable	Output Variable
1. Maintenance of Road, Structures, and Other Equipment			
RMAINT	Running Track Maintenance	Track Miles, Running (TR)	Gross Ton-Miles (GTMC)
MAINTOH	Track Maintenance Overhead; Other Equip. Maint. & Overhead	TR	GTMC
2. Road Train Expenses			
RUNWAGE	Running Crew Wages	TR	Train Miles (TM)
TRANSOH	Transportation Overhead Expense	TR	TM
RUNFUEL	Transportation Fuel Expense	TR	Locomotive Miles (LRM)
RLOCREP	Road Locomotive Service, Repairs, & Overhead	TR	Locomotive Miles (LRM)
TRNINSP	Road Train Inspection	TR	TM
CLWRCK	Wreck Clearing Expenses	TR	TM
3. Switching and Yard Operations			
SWMAINT	Switching Maintenance & Overhead	Switching Track Miles (ST)	Train Hours – Total Switching (THS)
YARDOPS	Yard Operations	Yard Switching Track Miles (YST)	Train Hours – Yard Switching (THY)
SWWAGE	Switching Crew Wages	YST	THY
YLOCREP	Yard Locomotive Repairs	YST	THY
4. Carload-Related Expenses			
CAREP	Carload-Related Expenses	TR	Carload Originations/ Received (CLOR)
5. General and Administrative Expenses			
GENADM	General/Administrative Expenses	TR	GTMC
6. Freight Car Repair Expenses			
CARREPS /1	Freight Car Repair Expenses	TR	Freight Car Miles (CMPD)
CAROH	Freight Car Repair Overhead Expenses	TR	CMPD

1/ Cost Pool in Westbrook analysis, does not use regression variability in URCS.
Source: Westbrook 1988; URCS Phase II worktables, worksheet ‘C Summary.’

The 1979 RCS did not describe in detail the analysis used to develop the legacy URCS cost pools and the associated output and capacity/network measures shown in Table III-15A, above. Rather, it summarizes the process as the result of applying industry knowledge to develop variables and an exploratory data analysis to identify variable associations based on correlation statistics.

The assignments of output and network measures appear to be reasonable, for the most part, if not unassailable. For example, gross ton-miles are an ostensibly reasonable index of the output-related wear-and-tear on road, track, and other structures for use in the RMAINT and MAINTOH equations, though it is not necessarily a complete descriptor of the effects of railroads' output on maintenance requirements. For a cost pool such as GENADM, it is less clear that gross ton-miles is a conceptually superior output measure to (say) revenue ton-miles. In other cases, the application of a single output measure may be somewhat restrictive—fuel expenses could depend both upon locomotive-miles and the tons of freight and cars moved. A practical limitation on refining the output measures is that high correlations among the output measures limit the ability to reliably estimate parameters for multi-output models.

Similarly, alternative capacity/network variables such as miles of road or broader track measures could reasonably substitute for the running track mileage (TR) used as a capacity variable in several equations. As with output measures, alternative network measures are highly correlated with each other, thus making it relatively unlikely that substituting miles of road or broader track mileage for the legacy URCS capacity measures would have large effect on model results.[122]

b) Exploratory Review of URCS Phase I Operating Expense Data

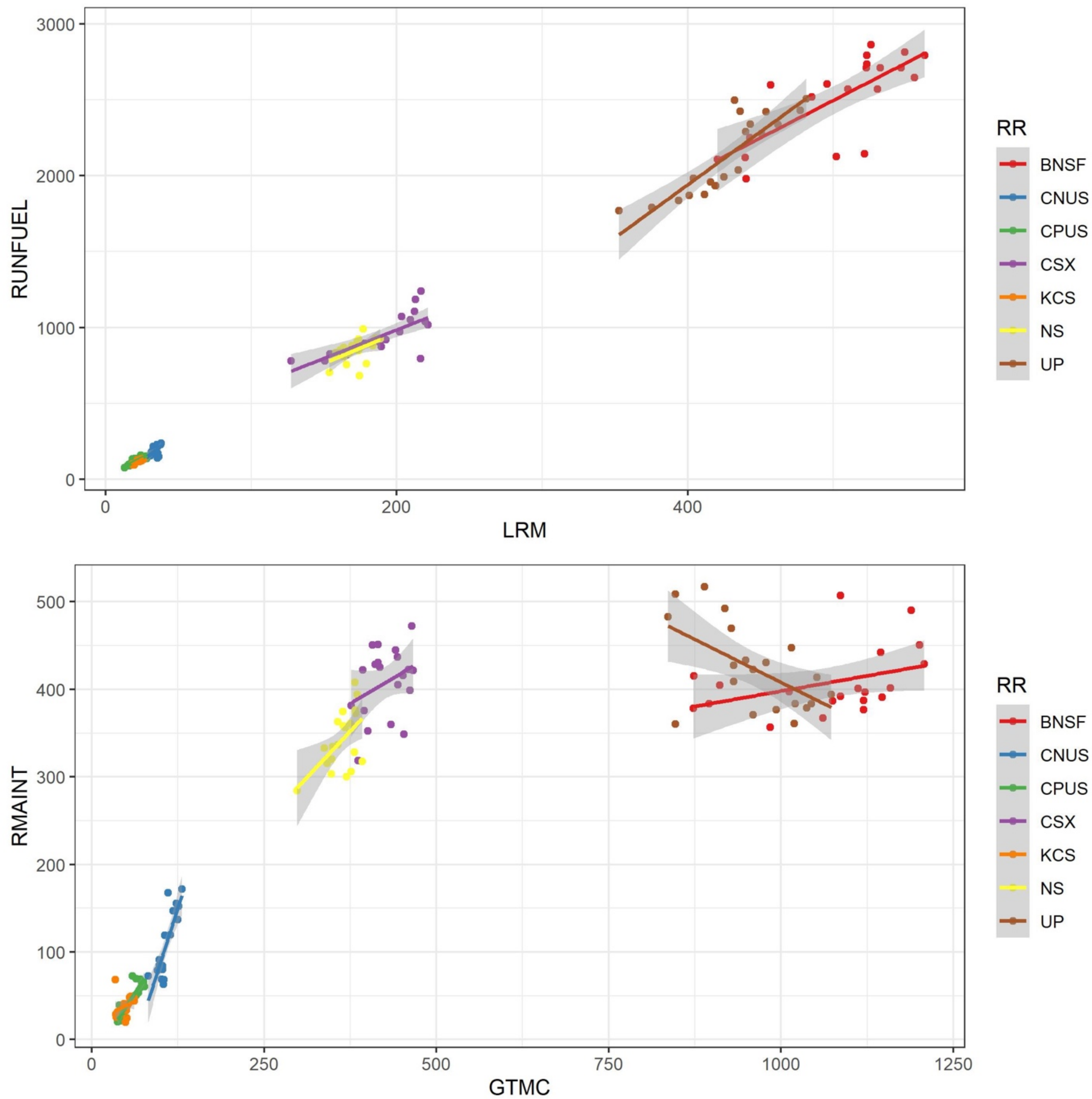
As an initial step in implementing an update of the Phase I models, we used R-1 annual report data by railroad, year, and account to generate a dataset covering the 1990-2019 time period, containing the dependent (cost) and independent (output and capacity) variables used in Westbrook's Phase I models. Examination of the data showed that while some equations' expense-output pairs appeared to have relationships consistent with the Westbrook model's assumption of common slopes with (possibly) railroad-specific intercepts, whereas other equations exhibited more variable expense-output relationships for the railroads in the panel.[123] Figure III-5 shows expense-output plots for RUNFUEL, where linear fits to the data exhibit

[122] This was confirmed in the course of exploring certain alternative model specifications.

[123] In addition to reviewing plots of cost data against outputs, we conducted simple update of cost models using Westbrook's econometric methods on 2000-2019 R-1 data. We initially considered 2000 as the starting year for a new panel dataset as it followed the period of industry consolidation in the 1980s and 1990s. Within the 20-year post-consolidation period, we excluded 2000-2001 data for CN separately reported under the IC and GTR railroad IDs to avoid definitional problems with the railroad fixed effects. The direct update found variabilities relatively close to URCS values for some of the legacy equations. Overall, though, the update exhibited large variability differences compared to legacy URCS including several equations where variabilities were outside the unit interval due to negative capacity and/or output coefficients. Screening outliers and influential observations from the sample mitigated but did not eliminate the anomalous results.

nearly constant slopes, and RMAINT, where both slopes and intercepts of fitted lines vary considerably by railroad.[124] Similar figures for all of the Phase I cost pools are in Appendix B.

Figure III-5. Expense-Output Plots for RUNFUEL and RMAINT Cost Pools



Insofar as the exploratory analysis suggested that the data were not necessarily consistent with the linear panel data models from legacy URCS, we considered changes both to the URCS cost pool definitions and to the econometric methods for updated Phase I econometric models. We describe these below.

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[124] Westbrook 1988 specifically cited RMAINT as a cost pool providing analytical challenges going back to the initial URCS Rail Cost Study.

c) Updating Cost Pools for Phase I Variabilities

Our construction of alternative cost pools for updating the Phase I variabilities was based on both *a priori* considerations and the exploratory analysis. While the legacy Phase I cost pool definitions are not clearly objectionable, we found some of the decisions to be ripe for review given the lack of detailed justification for the expense categorizations in the original URCS RCS documentation. We notably focused on decisions in which certain categories of related expenses sometimes were assigned to different cost pools representing "direct" and "overhead" costs.

An example is the assignment of wage and salary expenses in the RUNWAGE and SWWAGE cost pools, and the associated fringe benefits costs, into different cost pools. The fringe benefit expenses are assigned to cost pools for linehaul train operation overheads and assorted yard operations (TRANSOH and YARDOPS, respectively) along with some nonlabor costs for those operations. We would expect wage and non-wage labor costs to be determined jointly, and for fringe benefit costs to potentially have distinct patterns of cost causation compared to nonlabor costs in TRANSOH and YARDOPS. Cost pools comprising total labor costs may also be relatively robust to changes in the shares of wages and benefits in total compensation. We accordingly consider combining wage and benefit accounts into the same cost pools to be consistent with the RAPB's Causality and Homogeneity principles.

The legacy URCS cost pool definitions are, in fact, somewhat inconsistent in whether categories of "overhead" expenses are analyzed separately. For instance, the SWMAINT cost pool (switching maintenance and overhead) combines types of expenses that are separated among the RMAINT and MAINTOH cost pools. As with wage and benefits costs for labor, we also would not expect costs in cost pools such as RMAINT and MAINTOH to be determined independently with respect to either output or network (capacity) variables. Whether the cost pools have reliably distinguishable variabilities is an empirical matter.

Last, we observed some cases that appeared to represent changed or inconsistent reporting of expenses in smaller cost pools for some railroads. In the case of wreck clearing expenses, we saw instances of railroads inconsistently using wreck clearing expense accounts mapped to the CLWRCKS and YARDOP cost pools in URCS. For example, BNSF appears to have booked expenses to the account in CLWRCKS for part of the period covered by the R-1 dataset and to the account in YARDOP in some other years.[125] We combined the two wreck clearing accounts into a CLWRCK2 cost pool, since CLWRCKS contains most of the combined expenses. BNSF also ceased reporting expenses for accounts in the yard locomotive repair expense (YLOCREP) cost pool beginning in 2010. We could not determine with certainty where the expenses subsequently were recorded, and we did not alter the YLOCREP cost pool definition.

Our updated Phase I regression models employ the fourteen cost pools shown in Table III-15, below. Lists of specific R-1 accounts for each are provided in Appendix A. Most of the

[125] Also, recorded wreck clearing expenses for KCS were erratic throughout the analysis period. We dropped KCS observations from the estimation sample for the CLWRCK2 account.

reassignments of accounts we pursued were among cost pools with the same output and capacity variable assignments in legacy URCS, and we retained the URCS variable assignments for the modified cost pools. For CLWRCK2, we used the output and capacity/network variables for the CLWRCKS equation in URCS.

Table III-15B. Railroad cost components in the updated URCS variability analysis

Regression Name	Regression Description	Capacity Variable	Output Variable
1. Maintenance of Road, Structures, and Other Equipment			
RMAINT_T	RUNNING TRACK MAINTENANCE & OTHER EQUIP MAINTENANCE & OVERHEAD	Track Miles (TR)	Gross Ton-Miles (GTMC)
2. Road Train Expenses			
RUNWAGE2	RUNNING CREW WAGES & FRINGES	Track Miles (TR)	Train Miles (TM)
TRANSOH2 /1	TRANSPORTATION OVERHEAD EXPENSE	Track Miles (TR)	Train Miles (TM)
RUNFUEL	TRANSPORTATION FUEL EXPENSE	Track Miles (TR)	Locomotive Miles (LRM)
RLOCREP	ROAD LOCOMOTIVE SERVICE, REPAIRS, & OVERHEAD	Track Miles (TR)	Locomotive Miles (LRM)
TRNINSP	ROAD TRAIN INSPECTION	Track Miles (TR)	Train Miles (TM)
CLWRCK2 /2	WRECK CLEARING EXPENSES	Track Miles (TR)	Train Miles (TM)
3. Switching and Yard Operations			
SWMAINT	SWITCHING MAINTENANCE & OVERHEAD	Switching Track Miles (ST)	Train Hours – Total Switching (THS)
SWWAGE2	SWITCHING CREW WAGES & FRINGES	Yard Switching Track Miles (YST)	Train Hours – Yard Switching (THY)
YARDOPS2 /3	YARD OPERATIONS	Yard Switching Track Miles (YST)	Train Hours – Yard Switching (THY)
YLOCREP	YARD LOCOMOTIVE REPAIRS	Yard Switching Track Miles (YST)	Train Hours – Yard Switching (THY)
4. Carload-Related Expenses			
CAREP	CARLOAD-RELATED EXPENSES	Track Miles (TR)	Carload Originations/ Received (CLOR)

Regression Name	Regression Description	Capacity Variable	Output Variable
5. General and Administrative Expenses			
GENADM	GENERAL & ADMINISTRATIVE EXPENSES	Track Miles (TR)	Gross Ton-Miles (GTMC)
6. Freight Car Repair			
CARR_T	FREIGHT CAR REPAIR EXPENSES & OVERHEAD	Track Miles (TR)	Freight Car Miles (CMPD)

1/ Excludes Train Fringes included in legacy URCS TRANSOH variable.
2/ Expenses reported in R1 Schedule 410, lines 412 and 429.
3/ Excludes Yard Fringes included in legacy URCS YARDOPS variable.

d) Cost Equation Specifications and Estimators

We considered three specifications for the updated models: first, a regression in levels, which is largely consistent with the Westbrook models employed in legacy URCS; second, a first-order model in logs (a Cobb-Douglas form, called an "exponential-multiplicative" form in the URCS RCS); and third, and a second-order model in logs (translog). Each has potential advantages and disadvantages. The linear and first-order log models both are highly parsimonious, which is useful given the limited railroad-year observations available for the analysis. The linear model allows elasticities to differ by railroad, though it imposes constant returns to scale. The first-order log model allows arbitrary returns to scale but imposes constant elasticities. The translog specification allows non-constant elasticities and arbitrary returns to scale, but reliably estimating the second-order parameters can be a challenge given limitations of the data (as was the case with the cost function estimation described above).

Specification 1 (Level)
For each railroad cost pool k, we begin by estimating regressions that take the following form.

(III-30) $$E_{jt}^{k} = \beta_{j}^{k} + \sum_{p} \delta_{p}^{k} T_{p,t} + \beta_{1}^{k} Q_{jt}^{k} + \beta_{2}^{k} N_{jt}^{k} + \epsilon_{jt}^{k}$$

where the following definitions hold:

- E_{jt}^{k} is the real annual expenditure for cost pool k incurred by a railroad j for a given activity in year t.
- $T_{p,t}$ are linear time trend variables at time *t*, defined over time periods p.[126]
- Q_{jt}^{k} is the output measure associated with cost category k, for instance, gross ton-miles.

[126] This reduces to a linear time trend if there is a single trend variable T_t. We also allow the constant term to vary by period.

- N_{jt}^k is the "capacity" (network size) measure associated with cost category k, for instance, miles of track.
- The intercept β_j^k may be railroad-specific and the trend coefficient δ_p^k may be allowed to vary over the regression data period.
- ϵ_{jt}^k is a disturbance term.

The linear-level model given by Specification 1 is closely related to the legacy URCS Phase I cost equations estimated in Westbrook 1988 (see Equation II-22 in Section II.D). The main difference is that Specification 1 uses a segmented time trend rather than year dummy variables. This provides for a more parsimonious specification given the longer time period and smaller number of railroads in the updated R-1 panel dataset. We allow for separate time trends for pre-2000 (consolidation and merger era), 2000-2007 (post-consolidation, pre-financial crisis), and post-2007 (post-financial crisis).

The primary purpose of time effects is to proxy for railroad input prices and productivity, which arguably can be captured with trend variable(s) to the extent the factors have largely common effects across railroads within a given period. For example, in the 2009 Competition Study we showed that the RCAF-A index, summarizing input prices and productivity, fell steadily throughout the 1990s before leveling off in the 2000s.[127]

Specification 2 (Log)
We also consider a log model that takes the following form.

(III-31) $$\ln E_{jt}^k = \beta_j^k + \sum_p \delta_p^k T_{p,t} + \beta_1^k \ln Q_{jt}^k + \beta_2^k \ln N_{jt}^k + \epsilon_{jt}^k$$

where $\ln X_{it}$ corresponds to the natural logarithm of the variable X_{it}.

Specification 3 (Translog)
Finally, we allow for a translog specification, where variables on the right-hand-side of Specification 2 are interacted to allow for marginal effects that depend on the railroad's output and capacity variables.

(III-32)
$$\ln E_{jt}^k = \beta_j^k + \sum\nolimits_p \delta_p^k T_{p,t} + \beta_1^k \ln Q_{jt}^k + \beta_2^k \ln N_{jt}^k + \beta_3^k \left(\ln Q_{jt}^k\right)^2 + \beta_4^k \left(\ln N_{jt}^k\right)^2 + \beta_5^k \ln Q_{jt}^k \ln N_{jt}^k + \epsilon_{jt}^k.$$

The output elasticity is denoted $\eta^s(Q;N)$, where s corresponds to the specification (omitting some sub- and superscripts):

[127] See Christensen 2009 Competition Study, Vol. 2, p. 8-15 to 8-18.

(III-33) $\eta^1(Q;N) = \beta_1 Q/(\beta_j + \sum_p \delta_p T_p + \beta_1 Q + \beta_2 N)$.

(III-34) $\eta^2(Q;N) = \beta_1$.

(III-35) $\eta^3(Q;N) = \beta_1 + 2\beta_3 \ln Q + \beta_5 \ln N$.

Equation III-33 for the linear model reduces to the URCS variability formula if the intercept and trend coefficients are zero.[128] Equation III-35 reduces to Equation III-34 if the second-order terms in the translog model are zero.

Because the data are at the railroad-year level, we have access to a relatively small number of observations and, particularly for data following the end of the period of railroad mergers and acquisitions in the 1990s, the amount of variation within the data series for individual Class I railroads is limited. This problem is made worse by the fact that output and capacity variables in our regressions are often highly correlated. A final concern is measurement error that may result from railroad accounting practices (e.g., estimation or imputation steps used to develop data, including values of the independent variables) as well as from misspecification of the output and capacity variables.

Accurately characterizing the sampling properties of the estimates requires that we account for regression disturbances that violate classical regression assumptions of independent and identically distributed errors across the sample. The size distribution of Class I railroads would be expected to produce unequal error variances (heteroskedasticity) across railroads, and the disturbances also are likely to be correlated within the railroad series. To deal with this issue, we employ a Feasible Generalized Least Squares (FGLS) estimator, accounting for heteroskedasticity and serial correlation present in our data. Specifically, in our FGLS estimator, we allow and correct for railroad-specific heteroskedasticity and autocorrelation following a first-order autoregressive, or AR(1), stochastic process.

e) Phase I Estimation Results and Preferred Specification

We estimate our regressions using R-1 data from 1990 to 2019. Our principal results for output elasticities are in Tables III-16 and III-17. Additional regression output including the underlying model coefficients and railroad-specific elasticities for the linear and translog specifications is provided in Appendix C. In Table III-16, the models are estimated without railroad fixed effects; in Table III-17, railroad fixed effects are included. In addition to output elasticities, we report "scale" elasticities—the sum of the output and network elasticities—for the log and translog

[128] It is unclear why Westbrook 1988 omitted the year and railroad effects from the elasticity formula. While Westbrook's "crucial assumptions" that variable expenses equal $\beta_1 Q$ and fixed expenses equal $\beta_2 N$ imply that the other coefficients are zero, those assumptions are not consistent with Westbrook's econometric specification with railroad and time dummy variables. Among other things, the overall or railroad-specific intercepts would have an interpretation as fixed costs that are not related to the capacity variable *N*. As a practical matter, though, the differences in variabilities between the general formula III-4 and the URCS variability formula $\beta_1 Q/(\beta_1 Q + \beta_2 N)$ are not large.

specifications. For the level specification, the scale elasticities are constrained to 1. We report cost and scale elasticities for the level and translog models evaluated at the means of the data. To allow comparison of the specifications on the overall level of variable cost for the full set of Phase I cost pools, we also report average elasticities weighted by 2019 costs.

Our preferred approach is Specification 2, the log-log model, estimated without railroad fixed effects. An advantage of the log-log specification is that, unlike the linear and translog specifications (Specifications 1 and 3, respectively), the log-log model does not directly rely on precise estimation of capacity coefficients to obtain reasonable estimates of the output elasticities. While Specification 2 does not allow for elasticities that vary by railroad, in practice legacy URCS variabilities exhibited relatively limited differences across most Class I railroads.[129]

Our modeling efforts showed that combining direct and overhead cost pools for the RMAINT-MAINTOH and CARREPS-CAROHEX pairs yields output elasticities or variabilities that are more robust to model specification choices than the disaggregated cost pools. For combinations of wages and fringe benefits, we also found that combined wage and fringe benefit cost pools (RUNWAGE2 and SWWAGE2) yielded elasticities close to those estimated from the wage cost pools alone, with similar or slightly smaller estimated standard errors. In these regards, the updated Phase I cost pools improve modestly on the legacy cost pool structure.

[129] The validity of the differences in variabilities across railroads in legacy URCS also depends on the appropriateness of the models' linear specification as well as the specific estimated parameters from the Westbrook regressions using data from the 1980s.

Table III-16. Mean Elasticity Estimates, No Railroad Fixed Effects

Cost Pool	Output Elasticity			Scale Elasticity	
	Level	Log	Translog	Log	Translog
Running Track Maintenance and Overhead	0.22	0.55	0.23	0.98	1.04
	(0.08)	(0.07)	(0.12)	(0.04)	(0.07)
Running Crew Wages	0.79	0.82	0.84	1.03	1.08
	(0.05)	(0.04)	(0.06)	(0.02)	(0.04)
Transportation Overhead	0.80	0.65	0.87	0.91	1.09
	(0.17)	(0.14)	(0.19)	(0.07)	(0.11)
Transportation Fuel Expenses	0.92	0.87	0.89	1.00	1.03
	(0.02)	(0.03)	(0.03)	(0.01)	(0.02)
Road Locomotive Service and Repair	0.64	0.63	0.61	1.10	1.07
	(0.05)	(0.05)	(0.07)	(0.03)	(0.05)
Road Train Inspection	0.52	0.70	0.60	1.05	1.05
	(0.11)	(0.07)	(0.10)	(0.08)	(0.09)
Wreck Clearing	0.66	0.53	0.74	0.99	0.94
	(0.19)	(0.14)	(0.24)	(0.08)	(0.15)
Switching Maintenance and Overhead	0.42	0.38	0.50	0.92	0.97
	(0.15)	(0.12)	(0.13)	(0.11)	(0.14)
Yard Operations	0.31	0.37	0.35	0.94	0.88
	(0.08)	(0.07)	(0.08)	(0.08)	(0.11)
Switching Crew Wages	0.43	0.52	0.57	1.01	1.03
	(0.04)	(0.04)	(0.05)	(0.04)	(0.06)
Yard Locomotive Repairs	0.61	0.63	0.58	1.13	1.30
	(0.09)	(0.07)	(0.08)	(0.08)	(0.10)
Carload Related Expenses	-0.61	0.08	-0.25	0.73	-0.02
	(0.48)	(0.22)	(0.30)	(0.16)	(0.21)
General and Administrative	0.26	0.57	-0.12	0.95	1.05
	(0.15)	(0.13)	(0.23)	(0.05)	(0.11)
Freight Car Repair Expenses and Overhead	0.65	0.69	0.70	0.99	1.07
	(0.10)	(0.08)	(0.09)	(0.05)	(0.07)
Expense Weighted Average	0.59	0.68	0.55	0.99	1.05

Note: Scale elasticity is 1 in the Level model (Specification 1).

We estimated the cost pool models both with and without railroad fixed effects for each specification.[130] Westbrook 1988 argues for the inclusion of fixed effects on the standard grounds that the fixed effects model mitigates bias that may result from omitted variables.[131] Omission of relevant explanatory variables certainly is a valid concern given the parsimony of the cost equations. However, potential benefits from including railroad fixed effects involve tradeoffs with potential costs.

The main cost of including railroad fixed effects is that we lose access to potentially important variation in our output and capacity variables. When railroad fixed effects are included, we are using only variation over time in output, capacity, and expenses *within* the series of observations for each railroad. If there is limited within-railroad variability in the data, we may not be able to estimate the regression models' coefficients with sufficient precision.

With limited within-railroad variability in the independent variables, we may also be more concerned about the effects of measurement error in output and network capacity variables. Measurement error in regressions' independent variables can lead to biased and inconsistent estimates of the model coefficients. Generally, it is difficult to know the direction or magnitude of the bias, as this will depend on the structure of the measurement error, though measurement error may be expected to be more problematic when the variance of the true data is small relative to the measurement error variance.[132] A well-known issue with fixed effects estimation is that the use of within-panel variation in the data increases the relative measurement error variance and can worsen bias or inconsistency of the estimates.[133]

To quantify the benefit of our parsimonious approach, for each cost pool, we regressed output on capacity with railroad and year fixed effects in the first case and period-specific time trends in the second case. We then repeated this exercise with capacity as the dependent variable and output as the independent variable. If, for example, output and fixed effects almost perfectly predict a railroad's capacity, this implies that very little variation in capacity is being used to estimate the coefficients in each of our three specifications above, since these explanatory variables are effectively being held fixed when we are estimating the effect of capacity on costs. This idea can be captured in the R^2 of these two sets of regressions: if the R^2 approaches 1 when we regress output on capacity and fixed effects, for instance, that implies very little residual variation in output after controlling for these explanatory variables.

For the first set of these regressions, controlling for the capacity variable, we explain about 98% of the variation in our output variable on average across our regressions when we include year and railroad fixed effects. In our specification with only the time trends, this number falls to

[130] Where railroads combine due to mergers and acquisitions during the time period of the data, we assign distinct fixed effects (railroad dummy variables) to the pre- and post-combination entities.
[131] Westbrook 1988, p. 23.
[132] In the special case where the measurement error is uncorrelated with the true output and network values, measurement error leads to "attenuation bias" in the coefficient estimates, which pushes the estimates toward zero.
[133] See, e.g., Cheng Hsiao, *Analysis of Panel Data*, Cambridge University Press 1986, pp. 63-65.

about 92%, leaving more variation in output when all other variables are controlled for. Similarly, controlling for the output variable, we explain about 99.5% of the variation in our capacity variable when fixed effects are included, versus 91.8% in our specification. Thus, our specification gives us more residual variation in our capacity variables as well.

While the output elasticities are broadly similar across Tables III-16 and III-17, at least for the linear (level) and log specifications, the inclusion of fixed effects leads to problems with the estimation of the capacity-related coefficients (and elasticities). This may be seen in the scale elasticity estimates for the log and translog specifications. While the weighted averages show near-constant returns to scale overall, we observe a variety of implausibly large deviations from unit scale elasticities for several cost pools in the fixed-effects results. This result can arise if cost effects from (comparatively fixed) network characteristics are captured by the fixed effects terms due to collinearity with the measured capacity variables; the collinearity leads to relatively imprecise estimates of the capacity and scale elasticities.

Ultimately, the impact of including or excluding fixed effects in the URCS variability analysis is an empirical matter. In our preferred log specification, including fixed effects has relatively small effects on output elasticities while the estimation of capacity and scale elasticities is clearly worse. As a result, we conclude that given the available data, the Phase I elasticity estimates are more reliably estimated without the use of fixed effects.

As we noted above, a limitation of the preferred first-order log specification is that it imposes common, constant elasticities across railroads at the cost pool level. The RAPB preferred railroad-specific variability factors, though that preference does not flow ineluctably from the RAPB's costing principles. Rather, we regard it as a practical question of whether the available data permit reliable estimation of railroad-specific elasticities. We investigated estimating the first-order log models allowing elasticities to differ by size and regional groups (large versus small, and eastern versus western railroads) and concluded that the data do not support reliable estimation of group-specific cost elasticities; results of the analysis are presented in Appendix F.

Given the similar technologies employed by Class I railroads, it is arguably the case that disaggregating costs into cost pools may mitigate some differences in railroad cost structure that may be expected to be present at higher levels of cost aggregation. For instance, we would likely expect two railroads with identical miles of running track and locomotive unit-miles to have similar responses of fuel expenses to a given percentage change in locomotive unit-miles. The disaggregated models can be less restrictive than the aggregated cost function approach in that the effective cost elasticities for each railroad can differ based on their cost structures.

Table III-17. Mean Elasticity Estimates, With Railroad Fixed Effects

	Output Elasticity			Scale Elasticity	
Cost Pool	Level	Log	Translog	Log	Translog
Running Track Maintenance and Overhead	0.22	0.60	0.28	1.11	1.81
	(0.09)	(0.08)	(0.13)	(0.20)	(0.40)
Running Crew Wages	0.77	0.88	1.02	1.33	1.53
	(0.09)	(0.04)	(0.07)	(0.11)	(0.25)
Transportation Overhead	0.43	0.81	1.09	1.91	1.41
	(0.13)	(0.18)	(0.26)	(0.41)	(0.79)
Transportation Fuel Expenses	0.89	0.82	0.81	1.05	0.88
	(0.07)	(0.05)	(0.08)	(0.08)	(0.19)
Road Locomotive Service and Repair	0.73	0.75	0.81	1.06	0.28
	(0.11)	(0.05)	(0.10)	(0.14)	(0.29)
Road Train Inspection	0.59	0.75	0.56	0.93	0.67
	(0.14)	(0.07)	(0.11)	(0.22)	(0.39)
Wreck Clearing	0.85	0.67	1.11	1.32	1.29
	(0.33)	(0.13)	(0.27)	(0.59)	(0.70)
Switching Maintenance and Overhead	0.83	0.23	0.29	0.29	0.20
	(0.64)	(0.11)	(0.13)	(0.22)	(0.35)
Yard Operations	0.37	0.26	0.23	0.28	0.27
	(0.12)	(0.07)	(0.10)	(0.17)	(0.28)
Switching Crew Wages	0.61	0.45	0.47	0.70	0.65
	(0.14)	(0.04)	(0.05)	(0.15)	(0.18)
Yard Locomotive Repairs	0.55	0.60	0.55	1.06	1.11
	(0.13)	(0.07)	(0.09)	(0.27)	(0.27)
Carload Related Expenses	-0.08	0.05	-0.28	0.92	-0.27
	(0.20)	(0.22)	(0.31)	(0.30)	(1.07)
General and Administrative	0.36	0.74	0.53	0.85	0.94
	(0.26)	(0.13)	(0.19)	(0.15)	(0.61)
Freight Car Repair Expenses and Overhead	1.07	0.64	0.69	0.57	0.63
	(0.45)	(0.09)	(0.10)	(0.23)	(0.38)
Expense Weighted Average	0.62	0.73	0.71	1.06	1.07

Standard errors in parentheses. Note: Scale elasticity is 1 in the Level model.

f) Comparison with Legacy Phase I Variabilities

Table III-18 compares output elasticities for our preferred specification and estimation method with the current (2019) Phase I variabilities by cost pool. The Total values for the updated elasticities and URCS variabilities are expense-weighted averages. Overall, the 2019 cost-weighted average elasticity is 13 percent lower in the updated models compared to legacy URCS. The overall difference between the updated elasticities and the legacy variabilities is smaller for the log model than for the comparable translog and linear specifications.

The overall decrease is driven by markedly lower estimated elasticities for cost pools associated with switching and yard operations, and for general and administrative expenses (GENADMIN). Other large cost pools with elasticities substantially lower than legacy URCS values include running track maintenance (RMAINT) and transportation overhead (TRAINOH).

Table III-18. Comparison of Updated Elasticities with Legacy URCS Variabilities

URCS Cost Pool	Cost Pool Description	New Output Elasticity	URCS 2019 Avg.	% Change	2019 Total Expense New Cost Pools	2019 Total Expense URCS
RMAINT	Running Track Maintenance	0.55	0.69	-21%	1,768	1,768
MAINTOH	Track Maintenance Overhead	0.55	0.57	-4%	2,072	2,072
RUNWAGE	Running Crew Wages	0.82	0.80	3%	7,208	4,945
TRANSOH	Transportation Overhead	0.65	0.77	-17%	1,804	4,067
RUNFUEL	Transportation Fuel Expenses	0.87	0.94	-8%	6,596	6,596
RLOCREP	Road Locomotive Service and Repair	0.63	0.68	-8%	2,829	2,829
TRNINSP	Road Train Inspection	0.70	0.53	31%	293	293
CLWRCKS	Wreck Clearing	0.53	0.56	-7%	157	147
SWMAINT	Switching Maintenance and Overhead	0.38	0.86	-56%	541	541
YARDOPS	Yard Operations	0.37	0.61	-41%	894	1,420
SWWAGES	Switching Crew Wages	0.52	0.86	-39%	1,698	1,181
YLOCREP	Yard Locomotive Repairs	0.63	0.76	-17%	63	63
CAREXPS	Carload Related Expenses	0.08	0.90	-92%	92	92
GENADMN	General and Administrative	0.57	0.82	-31%	5,757	5,757
CARREPS	Freight Car Repair Expenses	0.69	0.86	-20%	750	750
CAROHEX	Freight Car Repair Expenses, Overhead	0.69	0.26	166%	414	414
	Total	0.68	0.78	-13%	32,935	32,935

Note: the URCS 2019 variability for CARREPS is not regression based.

Costs in the GENADMIN pool include labor costs for railroads' administrative personnel, and operating costs for administrative facilities and equipment such as computers and communications equipment. While we may expect such expenses to be related to the size of the firm, they need not necessarily be highly sensitive to rail traffic levels in the short run. In this regard, the legacy URCS variability—similar in magnitude to the variabilities for train crew wages—arguably is anomalously high.[134] It is also conceivable that computerization of railroad accounting and other administrative and record-keeping functions could have reduced the sensitivity of general administrative costs to output since the 1980s period of the legacy URCS regression data.

While switching and yard operations exhibit generally lower output elasticities than the current URCS models across all three model specifications, the capacity elasticities do not indicate major departures from constant returns to scale in the preferred log models.[135] The implication is that switching and yard operation costs have higher capacity (network) elasticities compared to Westbrook's results from the 1980s. Relatively large fixed costs in yard operations would serve as a source of cost savings from yard closures initiated as part of Precision Scheduled Railroading or other railroad cost reduction initiatives.

Lower variability for running track maintenance and overhead (RMAINT_T) is largely due to a variability difference for the legacy RMAINT cost pool. Westbrook's RMAINT elasticity had a reported standard error of approximately 0.1, implying that the 0.14 difference between the RMAINT_T elasticity and the legacy RMAINT variability is not statistically significant. The variability difference for the legacy MAINTOH portion, which contributes more than half of the total expense to the combined RMAINT_T cost pool, is small. We regard it as reasonable that running track maintenance expenses should have a relatively high degree of variability with respect to track mileage in addition to rail traffic.

The lower variability for train overhead (TRAINOH2) compared to the legacy TRAINOH cost pool appears to be a byproduct of the transfer of train fringe benefits costs to the RUNWAGE2 cost pool. The 0.79 cost-weighted elasticity for the combined RUNWAGE2 and TRAINOH2 cost pools is nearly the same as the combined variability of RUNWAGE and TRAINOH using the legacy models.

The inclusion of train fringes in RUNWAGE2 has a relatively small (2.3 percent) and statistically insignificant effect on the variability of train labor costs compared to the variability for legacy RUNWAGE, consistent with our expectation that wage and nonwage components of

[134] A recent Bureau of Labor Statistics analysis of railroad employment data from January 2018 to December 2020 found that "the greatest job losses occurred in the occupational groups most directly involved with the actual operation and maintenance of trains on the railroads," also suggesting that employment in administrative functions is somewhat insensitive to short-term fluctuations in operating or business conditions. See https://www.bls.gov/opub/mlr/2021/article/employment-in-rail-transportation-heads-downhill-between-november-2018-and-december-2020.htm (accessed February 4, 2022).

[135] One large variability reduction, for the SWMAINT cost pool, likely is statistically insignificant. Westbrook reported a standard error of 0.27 for his SWMAINT variability (Westbrook 1988, p. 117).

labor expenses should have similar variabilities. Both RUNWAGE2 and RUNFUEL retain elasticities well above the system averages, consistent with our expectation that both expense categories should feature a high degree of proportionality with respect to their outputs, respectively train miles and locomotive unit miles.
The estimated elasticity for freight car repairs and overhead (CARR_T) is well within one estimated standard error of the 0.65 average variability for the legacy CARREPS and CAROHEX cost pools, which are combined in CARR_T. The 0.86 variability for CARREPS in legacy URCS is a proxy value, which appears to have substituted for an econometric variability greater than 1 in Westbrook 1988, p. 107. The variability difference between CARREPS and CAROHEX in legacy URCS is an unexplained anomaly.

The updated models perform relatively poorly for the carload-related expenses (CAREXPS) cost pool in all specifications. Insofar as CAREXPS is the second-smallest cost pool by 2019 R-1 expenses, the effect on the overall output elasticity of operating costs is minor.

We observe relatively large decreases in elasticities for cost pools representing running track maintenance and overhead (RMAINT_T), switching and yard operations (YARDOPS2), and for GENADMIN. The updated models yield larger capacity (network) elasticities for those cost pools, and for running track maintenance and overhead, compared to the legacy URCS results.

The RUNWAGE elasticity increases slightly with a larger associated expense while applying to a larger expense to the inclusion of fringe benefits in the updated RUNWAGE2 cost pool.

g) Empirical Elasticities for Capital Costs

The computation of generic unit costs requires estimates of the degree of cost variability with respect to output for all relevant costs. While legacy URCS obtains variabilities for operating costs using the Westbrook 1988 econometric models, as discussed above, it relies on “default” variabilities of either 50 or 100 percent that are set judgmentally rather than empirically for ROI and DLR costs. Generally, legacy URCS treats ROI and depreciation expenses as 50 percent variable for way and structures, and 100 percent variable for equipment including locomotives and freight cars; lease and rental expenses are assumed 100 percent variable. The assumed variable proportions of ROI and DLR costs for way and structures, locomotives, and freight cars comprise a substantial portion of legacy URCS variable costs.

While it is not inappropriate *per se* to include ROI and DLR costs that vary with output in marginal costs, the lack of an empirical basis for the default ROI and DLR variabilities creates a possibility that the costs based on URCS default assumptions could differ materially from empirical short-run (marginal) costs. In this section, we model ROI and DLR costs for way and structures, locomotives, and freight cars to provide an empirical alternative to the “default” variability approach for capital costs.

Capital Cost Variables

We begin by constructing capital costs for way and structures, locomotive, and freight cars, using the same methods as the freight car and locomotive ROI and DLR costs included in the aggregated variable cost model, above. The R-1 annual reports provide data on gross investment, accumulated and annual depreciation, and lease/rental expenses by type of asset. We calculate ROI costs as the product of net investment (i.e., gross investment less accumulated depreciation) and the cost of capital. We use the cost of capital determined annually by the STB in Docket No. EP 558.[136] We add annual depreciation, rental, and lease expenses to the ROI cost to obtain the total ROI and DLR costs for the asset category. We call the variables *ROADCOST*, *LOCCOST*, and *CARCOST* following the terminology of the cost function analysis. See Table III-9, above, for definitions of *ROADCOST*, *LOCCOST*, and *CARCOST*.

By distinguishing capital costs for these three asset categories, we preserve the feature of URCS that way and structures and equipment-related capital costs are allowed to have different variabilities. We also allow freight car and locomotive costs to have different variabilities. It is also possible for our econometric models to produce the default variabilities (subject to statistical variability of the elasticities) if the default assumptions are consistent with the data.

Regression Specification

Equation III-36 specified regression used to estimate the elasticity of capital costs with respect to output, which is the parameter η_Q. This equation corresponds to the first-order logarithmic specification for the updated Phase I operating cost models. The equation can be viewed as producing a short-run elasticity in that η_Q measures the contemporaneous effect of output on costs, noting the annual frequency of the data.

(III-36) $$\ln C_{jt} = \alpha_j + \eta_Q \ln Q_{jt} + \varepsilon_N \ln ROAD_{jt} + \delta_{0p} + \delta_{1p} T_{jt} + u_{jt}.$$

C_{jt} is railroad j's capital cost in period t with $C \in [ROADCOST, LOCCOST, CARCOST]$, deflated by the GDP price index. The parameter α_j is the fixed effect for railroad j reflecting unmeasured (constant) factors potentially affecting capital costs, Q_{jt} is the output measure for the regression for railroad j in period t, $ROAD_{jt}$ is to miles of road serving as a measure of the network size, δ_{0p} is a time period dummy term, $\delta_{1p} T_{jt}$ is a period-specific trend term with $p \in [1990 - 1999, 2000 - 2007, 2008 - 2019] = [PERIOD1, PERIOD2, PERIOD3]$, and u_{jt} is the error term.

For freight car and locomotive capital costs, $Q = CMP$ and $Q = LRM$, respectively.[137] For *ROADCOST*, we set $Q = GTM$.[138] We also estimate a fourth specification with C_{jt} equal to the

[136] See https://www.stb.gov/reports-data/economic-data/#tab-cost-of-capital (accessed February 6. 2022).

[137] We also estimated car and locomotive capital cost regressions with GTM as the output variable and found very similar results.

[138] Some way and structures DLR and ROI costs are allocated to other outputs in URCS Phase II. For example, costs related to locomotive servicing facilities are treated as locomotive-mile costs. Phase II also allocates locomotive

sum of the capital costs in $ROADCOST$, $LOCCOST$, and $CARCOST$: $SUMCOST = ROADCOST + LOCCOST + CARCOST$.

The primary difference between this specification and our preferred Phase 1 regressions is the inclusion of railroad fixed effects. As we noted above, the general rationale for inclusion of fixed effects is to mitigate omitted variables bias in regression models with panel data. We would expect that unobserved features of a railroad's network and/or other railroad-specific characteristics may be more likely to have material effects on capital costs than on disaggregated operating costs.

While we are primarily interested in a short-run estimate of how these costs respond to output, we also considered dynamic specifications that potentially would allow estimation of both short-run and longer-run elasticities. These specifications included models with lagged outputs, models using differenced data, and an error correction model (with differenced data and lags). For instance, in a model with lagged outputs, the sum of the contemporaneous and lagged effects can be interpreted as a long-run effect. However, we found relatively small and statistically insignificant effects from adding dynamic features to the models. This may in large part reflect a limitation of the data, as a variable and its lags may tend to be highly correlated, especially for short lag lengths. Additional investigation of longer-run responses of capital costs to outputs is thus a matter for future research.

Data and Estimator

As with the updated Phase I models, a primary issue for estimating output elasticities for capital costs is the limited variation in the data, both as a result of the smaller sample size and high degrees of correlation among the model's explanatory variables. To help overcome this issue, we estimate the models using data from 1990 to 2019 and use a Generalized Least Squares (GLS) estimator, as in the Phase I update. The GLS estimator utilizes information about the covariance structure of the error terms to yield more efficient estimates of the cost model parameters of interest, including the output elasticities. However, it is necessary to place some restriction on the error covariance structure to implement GLS. We assume, as in the Phase I models, that the regression error terms may be correlated within a railroad's observations over time, but not between railroads in a given year, and that the error variances may differ by railroad.

Results

Our regression estimates can be found in Table III-19. The estimated output elasticities—the coefficients on LNQ—are markedly lower the default variabilities used in URCS Phase II. The output elasticity for *ROADCOST* also is slightly less than half the estimated elasticities for *LOCCOST* and *CARCOST*. The *LOCCOST* and *CARCOST* elasticities differ by statistically insignificant amounts. The *SUMCOST* output elasticity expectedly has an estimate between the *ROADCOST* and *LOCCOST/CARCOST* elasticities, but we do not prefer it over the detailed

ROI and DLR costs between road and yard locomotives, and assigns portions of freight car costs to assorted car-mile and car-day outputs. Our analysis does not change those "semi-default" allocations.

elasticities, particularly insofar as the elasticities for *LOCCOST* and *CARCOST* are higher by material and statistically significant amounts.

We note that the inclusion of fixed effects does not give rise to unreasonable elasticities of capital costs with respect to the network (or capacity) variables, unlike the Phase I models where the inclusion of fixed effects adversely affected the capacity elasticities. For the capital cost models, the sum of the output and capacity elasticities is reasonably close to 1—implying that capital costs for the given variable would approximately double if both output and capacity were to double. We found that the output elasticity estimates otherwise are not notably sensitive to the inclusion of fixed effects.

We consider it reasonable that way and structures capital expenses in *ROADCOST* are less elastic with respect to output in the short run than those for freight cars and locomotives. For instance, we would expect railroads to have greater ability to obtain or dispose of cars and locomotives in secondary markets in response to shorter-term output fluctuations than to adjust fixed assets such as road, track, and structures. However, we find that way and structures costs do have some short-run elasticity with respect to output, in contrast to the industry variable cost model's assumption that those costs are fixed in the short run.

Table III-19. Capital Cost Regression Results

Variable	(1) ln(ROADCOST)	(2) ln(LOCCOST)	(3) ln(CARCOST)	(4) ln(SUMCOST)
LNQ	0.194	0.447	0.415	0.265
	(0.031)	(0.064)	(0.042)	(0.032)
LNROAD	0.748	0.614	0.728	0.817
	(0.117)	(0.183)	(0.151)	(0.104)
YEAR	0.004	0.029	0.014	0.012
	(0.004)	(0.008)	(0.007)	(0.005)
PERIOD2	0.041	0	-0.071	-0.005
	(0.033)	(0.036)	(0.034)	(0.03)
PERIOD2*YEAR	0.238	0.073	-0.129	0.144
	(0.115)	(0.112)	(0.122)	(0.088)
PERIOD3	0.033	-0.012	-0.041	0.015
	(0.012)	(0.014)	(0.014)	(0.01)
PERIOD3*YEAR	0.015	-0.016	-0.029	0.003
	(0.009)	(0.011)	(0.011)	(0.007)
Q	GTM	LRM	CMP	GTM
Observations	255	255	255	255

Standard errors (clustered by railroad) in parentheses.

3. *Comparison of Variable Cost and Unit Variable Costs with Aggregated and Disaggregated Elasticities*

To obtain marginal costs per revenue ton-mile (RTM) using the disaggregated elasticities, we use the result that unit variable costs, with cost elasticities with respect to output serving as the variability factors, can be interpreted as marginal costs:

(III-37) $$MC = \left(\sum_i \eta_{Qi} \cdot C_i\right)/RTM.$$

In Equation III-37, the summation is over all expenses C_i with a defined output elasticity η_{Qi}. Mechanically, the variable costs $\sum_i \eta_{Qi} \cdot C_i$ in equation III-37 can be calculated for Class I railroads by substituting the estimated elasticities η_{Qi} for the legacy URCS variabilities assigned to the corresponding expenses in the URCS Phase II workbooks.[139] The Phase II workbooks also report a total expense, allowing calculations of the percent of variable costs by railroad.

Table III-20 shows the 2019 total costs, variable costs, and percent variable using disaggregated variabilities and in legacy URCS. Apart from CP, the percentages of variable costs are within a range of +2 to -3 percentage points of the 71 percent Class I industry composite. With only the Phase I operating cost variabilities updated, the overall Class I variable cost percentage declines 8 percent. The range of variable cost percentages is somewhat narrower (62 to 67 percent) in the update as CP is no longer a low-variability outlier. The effect on variable costs of introducing the empirical ROI and DLR elasticities is larger, reducing the overall Class I percentage of variable costs to 49 percent. We observe that the railroads with higher percentages of variable cost in legacy URCS—BNSF, CSX, and NS—also tend to have higher variable cost fractions with the updated variabilities.

Overall, the cost elasticities from the updated cost equations result in ranges of variable cost percentages by railroad that are similar to legacy URCS. Differences in railroads' cost composition are sufficient to drive differences in variability levels by railroad using the disaggregated models, notwithstanding that the first-order log models do not produce railroad-specific elasticities at the cost pool level.

[139] In the URCS Phase II workbooks, variabilities are applied to operating costs at the level of R-1 expense lines, and to ROI and DLR costs by types of capital assets. Thus, it is (at least conceptually) straightforward to apply our cost elasticity estimates to the appropriate expenses. This involves linking expenses with legacy econometric variabilities to the correct equation in the update and replacing default variabilities with empirical values appropriate for the types of capital expenses.

Table III-20. 2019 Variable Costs ($000) by Railroad, Legacy URCS and Updated Variabilities

Railroad	Total Cost	Variable Cost			Percent Variable Cost		
		URCS	Phase I Update w/ ROI/DLR Defaults	Phase I Update w/ Econometric ROI/DLR	URCS	Phase I Update w/ ROI/DLR Defaults	Phase I Update w/ Econo-metric ROI/DLR
BNSF	20,762,229	15,184,462	13,688,416	10,395,343	73%	66%	50%
CN	3,737,057	2,528,429	2,403,639	1,710,085	68%	64%	46%
CP	1,470,219	922,327	913,155	711,169	63%	62%	48%
CSXT	10,455,527	7,302,274	6,897,256	5,278,655	70%	66%	50%
KCS	1,645,122	1,125,701	1,071,583	765,116	68%	65%	47%
NS	10,431,455	7,365,918	6,943,813	5,206,862	71%	67%	50%
UP	16,771,562	11,607,720	10,826,244	7,766,724	69%	65%	46%
Total	65,273,171	46,036,831	42,744,106	31,833,955	71%	65%	49%

Table III-21 shows 2019 variable costs per RTM using legacy URCS variabilities, updated Phase I elasticities with URCS ROI and DLR default variabilities, the full set of disaggregated cost elasticities, and the aggregate elasticities from the industry variable cost model (from Table III-10, above).

Table III-21. Summary of 2019 Unit Variable Costs per Revenue Ton-Mile, Class I Railroads

Railroad	2019 Cents per Revenue Ton-Mile			
	URCS	Phase I Update w/ ROI/DLR Defaults	Phase I Update w/ Econometric ROI/DLR	Industry VC Model MC (Aggregate Elasticity)
BNSF	2.28	2.06	1.56	1.60
CN	4.04	3.84	2.73	2.81
CP	2.46	2.43	1.89	2.04
CSXT	3.67	3.46	2.65	2.76
KCS	3.45	3.28	2.35	2.60
NS	3.80	3.58	2.68	2.88
UP	2.74	2.56	1.83	2.15
Total	2.85	2.65	1.97	2.12

The differences in the unit variable costs in Table III-21 mirror the percent variable results in that unit variable costs for a given railroad decrease with the use of cost elasticities from the updated Phase I analysis and the econometric ROI and DLR models. The marginal costs from the industry cost function analysis also are approximately 8 percent higher overall than the Phase I update with econometric ROI and DLR elasticities, as the 0.749 output elasticity for variable costs in the aggregated industry VC model is higher than the overall variability in the disaggregated approach, despite the implicit zero elasticity for way and structures ROI and DLR costs in the industry VC model. The differences by railroad vary in magnitude and (for UP) sign between the aggregated and disaggregated analyses.

There is no clear relationship in Table III-21 between the percent of variable costs for a railroad and the level of unit variable costs. Unit variable costs should be, and seemingly are, strongly influenced by characteristics of the railroads' freight traffic. BNSF has the lowest estimated unit variable cost per RTM across all the variability approaches; UP, the other large western railroad, also has unit costs below the system average using disaggregated variabilities and near the average in the industry VC model. Both railroads have relatively long average hauls and carry substantial volumes of coal in unit trains moving to and from the Wyoming Powder River Basin, which we would expect to lower costs per revenue ton-mile. Conversely, shorter average hauls tend to increase variable cost per RTM for the Eastern railroads and for KCS.

The key tradeoff between the aggregated econometric cost function and disaggregated Phase I-style approaches to estimating cost elasticities involves restrictions on economic behavior built into each method. The cost equation approach used in URCS Phase I is often characterized as restrictive in that it does not capture some aspects of firms' behavior, notably responses to input price changes. However, the disaggregated approach can employ parsimonious models will, to the extent output elasticities differ by cost pool, allow railroad costs' output elasticities to vary by operationally relevant categories.

The econometric cost function approach models economic effects such as those of factor prices on railroad costs that are omitted in the URCS Phase I cost equation approach. However, obtaining this additional behavioral richness comes at the cost of either requiring estimation of many more model parameters of "flexible" functional forms, which may not be possible to implement reliably using available data, or imposing strong restrictions on cost elasticities or other parameters at the firm level to address estimation problems.

Other practical concerns include econometric issues underlying the elasticity estimates. We find that it is not possible to reliably estimate all parameters of a flexible (translog) cost function with the available data, even with specification of a single output in the cost function. The first-order cost function yields a plausible industry-level cost elasticity with respect to RTMs. But by imposing a single cost elasticity on all railroads, the cost function approach is most at odds with the RAPB's preference for railroad-specific elasticities. The lack of railroad-specific elasticities in the disaggregated models using the first-order log specification is less of a concern insofar as the more homogeneous cost pools also have relatively homogeneous cost elasticities across railroads.

The aggregate and disaggregated models also differ in the statistical efficiency of the elasticity estimates. The standard error of the aggregate cost elasticity from the first-order Cobb-Douglas cost function estimation (0.09) is within the range of the standard errors for the preferred disaggregated models (0.03-0.22).[140] The disaggregated models may produce overall variability percentages with lower standard errors than the aggregate result from the industry cost function if the estimation errors in the elasticities are not too strongly correlated across cost pools.[141]

Last, while the disaggregated elasticity approach can be used to generate marginal costs for use in the Hybrid model, it also can be used as a set of updated variability inputs within the traditional URCS framework. To be certain, it is also possible to update URCS with a single aggregate cost elasticity applicable to all expenses while maintaining fidelity to the causality principle. However, it is not desirable to do so unless the aggregate elasticity represents the limit of the information on the responses of costs to output changes that can be obtained from the available data. Insofar as there are material and plausible elasticity differences across cost pools, the balance of considerations favors the use of elasticities from the disaggregated models.

E. HYBRID MODEL COST AND REVENUE/VARIABLE COST (R/VC) ESTIMATES

We compute Hybrid costs using cost coefficient estimates using our preferred NEIO RPTM regressions reported above and with four sets of (unit) variable cost or marginal cost estimates to show the effects of cost methodology differences on the derived costs of rail movements and on the shares of rail traffic with revenue above the 180 percent statutory R/VC threshold and with revenue below estimated variable costs. The Hybrid model generic cost scenarios are:

- Legacy URCS unit variable costs ("URCS" scenario)
- Updated Phase I elasticities with legacy URCS default ROI and DLR variabilities ("CA1" scenario)
- Updated Phase I elasticities with empirical elasticities for ROI and DLR costs for way and structures, freight cars, and locomotives ("CA2" scenario)
- Aggregate elasticity from industry variable cost model ("CA3" scenario)

The Hybrid scenario using legacy URCS unit costs is intended to isolate effects on shipment costs that result from the use of the NEIO model to compute shipment costs instead of the URCS Phase III model (i.e., holding variabilities constant). The CA1 scenario using the URCS default ROI and DLR variabilities maintains the legacy URCS approach to placing URCS on an "intermediate-run" orientation while updating the Phase I operating cost variabilities. The CA2 and CA3 cost scenarios compare results from variable costs that are equivalent to short-run

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[140] The 0.22 standard error is for carload-related expenses, the smallest of the URCS cost pools. The next largest standard error from the Phase I update is 0.14.

[141] For instance, in the limiting case where the updated Phase I elasticities are uncorrelated, the expense-weighted average elasticity of 0.68 would have an estimated standard error of 0.027, compared to a standard error of 0.087 for the 0.66 elasticity from the Cobb-Douglas cost function. It is thus possible for the disaggregated models to have lower overall sampling standard errors than the aggregated models even in the presence of some correlation of results across cost equations.

marginal costs (including ROI and DLR costs) based on the disaggregated and aggregated cost models (respectively).

1. *Summary Results for Shipment Variable Costs Per Ton-Mile and R/VC*

Table III-22 shows variable cost per revenue ton-mile (RTM) for legacy URCS and the four Hybrid model scenarios, by shipment size categories. The shipment size categories are based on the URCS "single" multi-carload, and unit train categories, with additional detail within the categories, including breakouts of 1-carload and 2-5 carloads within the legacy single-carload group, and of 50-74 carload unit trains and 75+ carload trains within the legacy unit train category. Intermodal (COFC/TOFC) shipments are reported as a separate category. Table III-23 shows the percentage changes for the Hybrid model costs compared to legacy URCS. Commodity-level results (primarily 2-digit STCCs) are provided in Appendix D.

Comparing legacy URCS costs per ton-mile with the first Hybrid-URCS scenario using legacy URCS variabilities shows that the NEIO model in the Hybrid reduces unit variable cost for intermodal shipments and increases measured unit variable cost for shipments in the legacy URCS unit train (50+ carload) size category and in the lower portion (6-24 carloads) of the URCS multi-carload category. Hybrid costs for 1-5 carload and 25-49 carload movements exhibit smaller changes compared to URCS.

The cost shifts from URCS to the Hybrid-URCS scenario reflect a few key results from the NEIO models discussed in Section III.C, above. First, the NEIO models imply larger cost efficiencies for intermodal shipments than are present in the legacy URCS model. Since the allocation of total variable cost is zero-sum, the effect is to reallocate costs from intermodal to carload movements. Second, the NEIO models also produce a narrower range of relative costs between single carload and large unit train movements. This tends to reduce costs for single-carload and increase costs for large unit train movements. Third, the lack of a step function in the NEIO carload efficiency curves affects measured costs near the breakpoints of the legacy URCS cost functions.

Table III-22. Variable Cost per Revenue Ton-Mile by Shipment Size Category, Legacy URCS and Hybrid Models

	2019 Cents/RTM				
Size Category	Legacy URCS	Hybrid-URCS	Hybrid-CA1	Hybrid-CA2	Hybrid-CA3
1 Carload	3.58	3.50	3.33	2.43	2.74
2-5 Carloads	2.98	2.99	2.83	2.08	2.31
6-24 Carloads	2.57	2.96	2.80	2.06	2.22
25-49 Carloads	2.58	2.70	2.57	1.89	1.99
50-74 Carloads	2.24	2.97	2.81	2.06	2.23
75+ Carloads	1.55	1.82	1.71	1.26	1.38
Intermodal	3.84	3.24	3.05	2.25	2.50

Table III-23. Changes in Variable Cost per Revenue Ton-Mile by Shipment Size Category, Hybrid Models versus Legacy URCS

	Percent Change vs. Legacy URCS			
Size Category	Hybrid-URCS	Hybrid-CA1	Hybrid-CA2	Hybrid-CA3
1 Carload	-2%	-7%	-32%	-24%
2-5 Carloads	0%	-5%	-30%	-23%
6-24 Carloads	15%	9%	-20%	-14%
25-49 Carloads	5%	-1%	-27%	-23%
50-74 Carloads	32%	25%	-8%	-1%
75+ Carloads	18%	10%	-19%	-11%
Intermodal	-16%	-21%	-42%	-35%

Large (75+ carloads) unit train movements are the movements with the lowest variable cost per RTM across all scenarios. Other multiple carload movements, including movements in the lower end of the URCS unit train carload range (50-74 carloads) have lower cost per RTM than 1-carload movements but are not uniformly declining as the number of carloads increases.

Incorporating the Phase I variability update in the CA1 scenario reduces unit variable costs by 5-6 percent compared to using legacy URCS variabilities. The effect of the reduction in variabilities in the update is moderated by the ROI and DLR costs that continue to use the legacy URCS default variabilities in this scenario. Incorporating the empirical elasticities for ROI and DLR costs in the CA2 scenario has a much larger effect, reducing measured variable costs 26-27% compared to the Hybrid-CA1 model updating only the variabilities for Phase I operating costs. The Hybrid-CA3 costs based on the industry VC model's marginal costs are somewhat higher than the CA2 scenario using disaggregated elasticities. The effective overall degree of cost variability from the industry VC model's 0.749 output elasticity in CA3 is higher overall despite the industry VC model's treatment of way and structures capital as a quasi-fixed input with zero short-run output elasticity.

Table III-24 shows revenue to variable cost (R/VC) ratios by size category for URCS and the Hybrid model scenarios, and percentage changes in the R/VC ratios are in Table III-25. These results, not surprisingly, largely reverse the arithmetic signs of the unit cost differences, since the costs are in the denominators of R/VC while revenues are not affected by the cost methodology differences. In legacy URCS, intermodal movements have the lowest average R/VC ratio, and shipments in the 50-74 carload portion of the unit train size category have the highest estimated R/VC. Relatively high R/VCs for the 50-74 and 6-24 carload categories appear to be an artifact of the URCS make-whole adjustment's step functions.

The Hybrid model's shift of costs from intermodal to unit train shipments produces a narrower range of R/VC ratios by shipment category in the Hybrid scenario using legacy variabilities. The lack of a carload step function in the Hybrid model also moderates R/VC ratios for 6-24 and 50-

74 carload movements. Substituting the NEIO model for URCS Phase III at legacy variabilities, the lowest R/VC shipment category is 75+ carload movements in the URCS unit train category. Updating the variabilities in the Hybrid model increases R/VC ratios more-or-less uniformly relative to the Hybrid scenario with legacy variabilities. In the CA1 scenario, R/VCs by size category are (coincidentally) distributed around 1.8. Including the empirical ROI and DLR elasticities in the CA2 scenario mirrors the large effects via the change in ROI and DLR elasticities on unit variable costs, with average R/VCs above 180 percent for all size categories and intermodal. The Hybrid-CA3 scenario's higher unit variable costs reduce R/VC ratios compared to the CA2 model, though average R/VC ratios remain over 180 percent for all of the shipment categories shown.

Table III-24. RVC by Shipment Category, Hybrid Models, and Legacy URCS and Hybrid Models

Size Category	Revenue/Variable Cost Ratio				
	Legacy URCS	Hybrid-URCS	Hybrid-CA1	Hybrid-CA2	Hybrid-CA3
1 Carload	1.64	1.68	1.76	2.42	2.15
2-5 Carloads	1.68	1.67	1.76	2.39	2.17
6-24 Carloads	1.87	1.63	1.72	2.34	2.17
25-49 Carloads	1.80	1.72	1.81	2.47	2.34
50-74 Carloads	2.41	1.82	1.93	2.62	2.43
75+ Carloads	1.67	1.42	1.52	2.05	1.88
Intermodal	1.43	1.69	1.80	2.44	2.19

Table III-25. Changes in Variable Cost per Revenue Ton-Mile by Shipment Size Category, Hybrid Models versus Legacy URCS

Size Category	R/VC Percent Change vs. Legacy URCS			
	Hybrid-URCS	Hybrid-CA1	Hybrid-CA2	Hybrid-CA3
1 Carload	2%	7%	47%	31%
2-5 Carloads	0%	5%	43%	29%
6-24 Carloads	-13%	-8%	25%	16%
25-49 Carloads	-4%	1%	37%	29%
50-74 Carloads	-24%	-20%	9%	1%
75+ Carloads	-15%	-9%	23%	12%
Intermodal	19%	26%	71%	54%

2. *Summary Results for the Impact of the Hybrid Model on the Statutory 180 Percent R/VC Threshold*

Tables III-26 to III-30 provide shares of rail traffic in the 2019 CWS (in tons and ton-miles) in legacy URCS and the four Hybrid model cost scenarios for three ranges of R/VC: the shares of tons and ton-miles below 100 percent of variable cost; the shares at or above 100 percent R/VC but below 180 percent R/VC; and the shares exceeding180 percent R/VC. In addition to the

summary data in Tables III-26 to III-30 reported in total and by shipment size categories, we provide additional R/VC distribution data at the commodity level in Appendix D.
Table III-26 shows the R/VC distributions for legacy URCS. Overall, 45 percent of tons and 30 percent of ton-miles in the CWS move at RPTM above 180 percent of variable cost. The shares of tons and ton-miles with R/VC below 100 percent are 12 percent and 16 percent, respectively. The lower shares of ton-miles (versus tons) above 180 percent appears to result from relatively limited distance-related economies realized in the URCS Phase III model. Movements with high ton-miles (given the shipment size or weight) will be longer-distance movements. The URCS data imply that longer movements tend to have lower markups over variable costs than shorter-distance movements.

URCS data also show two notable shipment categories with shares of traffic below 100 percent of variable cost that differ markedly from the overall average for the legacy model. For intermodal shipments, 30 percent of tons and 28 percent of ton-miles have revenue below variable cost. Conversely, for 50-74 carload shipments—the lower end of the URCS unit train category, which have the highest overall R/VC in URCS—only 1 percent of tons and 2 percent of ton-miles are below 100 percent R/VC. While the existence of shipments below 100 percent R/VC is not anomalous in itself, particularly given the degree to which ROI and DLR costs are allocated to shipments in the URCS model, we believe that the outlying distributions for 50-74 carload and intermodal shipments are likelier to be artifacts of the Phase III model than reflecting differences in railroads' pricing behavior. The result for 50-74 carloads appears to be a result of the step function in the URCS make-whole carload efficiency adjustment. Intermodal costs are likewise driven by efficiency adjustment parameters in the Phase III model that may not reflect actual cost efficiencies associated with intermodal movements.

Table III-26. Distributions of 2019 CWS Tons and Ton-Miles by RVC Category, Legacy URCS

Shipment Category	Share of Tons			Share of Ton-Miles		
	R/VC<1	1<=R/VC<1.8	R/VC>1.8	R/VC<1	1<=R/VC<1.8	R/VC>1.8
1 Carload	10%	45%	46%	12%	54%	35%
2-5 Carloads	10%	52%	38%	10%	59%	31%
6-24 Carloads	6%	40%	53%	8%	52%	40%
25-49 Carloads	9%	42%	49%	11%	52%	37%
50-74 Carloads	1%	17%	82%	2%	36%	62%
75+ Carloads	11%	43%	46%	15%	57%	28%
Intermodal	30%	47%	23%	28%	50%	22%
Total	12%	43%	45%	16%	54%	30%

Table III-27. Distributions of 2019 CWS Tons and Ton-Miles by RVC Category, Hybrid Model—URCS Variabilities

Shipment Category	Share of Tons			Share of Ton-Miles		
	R/VC<1	1<=R/VC<1.8	R/VC>1.8	R/VC<1	1<=R/VC<1.8	R/VC>1.8
1 Carload	11%	49%	40%	9%	53%	38%
2-5 Carloads	10%	55%	35%	7%	59%	33%
6-24 Carloads	13%	55%	32%	10%	58%	32%
25-49 Carloads	15%	49%	36%	8%	52%	40%
50-74 Carloads	11%	54%	35%	5%	53%	42%
75+ Carloads	20%	53%	26%	26%	56%	18%
Intermodal	11%	52%	37%	8%	56%	36%
Total	15%	52%	33%	16%	55%	29%

Table III-28. Distributions of 2019 CWS Tons and Ton-Miles by RVC Category, Hybrid Model—CA1 Scenario

Shipment Category	Share of Tons			Share of Ton-Miles		
	R/VC<1	1<=R/VC<1.8	R/VC>1.8	R/VC<1	1<=R/VC<1.8	R/VC>1.8
1 Carload	9%	45%	46%	8%	47%	45%
2-5 Carloads	8%	50%	41%	6%	53%	41%
6-24 Carloads	10%	52%	37%	7%	55%	38%
25-49 Carloads	13%	47%	40%	7%	44%	49%
50-74 Carloads	10%	51%	39%	4%	47%	49%
75+ Carloads	16%	53%	31%	20%	58%	23%
Intermodal	9%	48%	43%	6%	51%	43%
Total	12%	50%	38%	12%	52%	35%

Table III-29. Distributions of 2019 CWS Tons and Ton-Miles by RVC Category, Hybrid Model—CA2 Scenario

Shipment Category	Share of Tons			Share of Ton-Miles		
	R/VC<1	1<=R/VC<1.8	R/VC>1.8	R/VC<1	1<=R/VC<1.8	R/VC>1.8
1 Carload	4%	20%	77%	4%	17%	80%
2-5 Carloads	3%	23%	75%	2%	20%	78%
6-24 Carloads	2%	27%	71%	2%	23%	76%
25-49 Carloads	4%	27%	70%	3%	16%	81%
50-74 Carloads	2%	23%	75%	2%	10%	88%
75+ Carloads	6%	33%	60%	6%	42%	52%
Intermodal	3%	23%	74%	2%	20%	77%
Total	5%	27%	69%	4%	28%	68%

Table III-30. Distributions of 2019 CWS Tons and Ton-Miles by RVC Category, Hybrid Model—CA3 Scenario

Shipment Category	Share of Tons			Share of Ton-Miles		
	R/VC<1	1<=R/VC<1.8	R/VC>1.8	R/VC<1	1<=R/VC<1.8	R/VC>1.8
1 Carload	5%	29%	65%	5%	28%	67%
2-5 Carloads	3%	33%	64%	3%	31%	66%
6-24 Carloads	4%	36%	61%	2%	34%	63%
25-49 Carloads	6%	37%	57%	2%	25%	72%
50-74 Carloads	5%	36%	59%	2%	21%	77%
75+ Carloads	6%	48%	46%	7%	53%	39%
Intermodal	5%	32%	63%	4%	31%	65%
Total	6%	39%	56%	6%	39%	55%

Comparing the results in Table III-27 with Table III-26 shows the effects of substituting the NEIO model for URCS Phase III to assign costs to shipments, holding variabilities fixed at legacy URCS levels. Computing shipment costs based on the Hybrid NEIO model instead of Phase III generally shifts R/VC distributions downwards. The Hybrid model at URCS variabilities puts 15 percent of tons under 100 percent R/VC (versus 12 percent in URCS), though ton-miles under 100 percent R/VC are little changed at 16 percent. Movements above 180 percent R/VC comprise 33 percent of tons and 29 percent of ton-miles. The narrower gap between tons and ton-miles over 180 percent R/VC, compared to URCS, is likely the result of stronger distance-related efficiencies in the NEIO model. Larger economies for intermodal shipments in the NEIO model versus Phase III reduce intermodal tons below 100 percent R/VC to 11 percent; large unit train movements (over 75 carloads) have relatively low markups over variable cost in the Hybrid model, with 20 percent of tons in the 75+ carload category below 100 percent R/VC and 26 percent of tons above 180 percent R/VC. Shipments of one carload have the highest share of tons above 180 percent R/VC (40 percent) in this scenario.
Tables III-28 and III-29 show the effects on the jurisdictional 180 percent R/VC threshold from introducing updated Phase I (CA1) and econometric ROI and DLR (CA2) variabilities to the Hybrid model.

The Hybrid-CA1 scenario in Table III-28 updates Phase I variabilities but retains default ROI and DLR variabilities. This results in 38 percent of tons and 35 percent of ton-miles above 180 percent R/VC for the 2019 CWS. Intermodal and single-carload movements have above average shares of tons above 180 percent R/VC—46 and 43 percent, respectively—and 75+ carload shipments are below average with 31 percent of tons and 23 percent of ton-miles under 180 percent R/VC. Combining the Hybrid model with a limited variability update revising only the Phase I variabilities would have relatively modest effects on the application of the statutory 180 percent R/VC threshold, in part because the upward shift of the R/VC distribution for intermodal will not increase the amount of rail freight subject to regulation.

Table III-29 shows that using the full set of empirical cost elasticities in the CA2 scenario—which places Hybrid variable costs on a short-run marginal cost basis—has a large effect on traffic above the 180 percent R/VC threshold, as 69 percent of 2019 CWS tons and 68 percent of ton-miles are above 180 percent of short-run marginal cost. Substituting marginal costs derived from the aggregate elasticities estimated in the industry variable cost function (Table III-30) yields similarly high shares of tons and ton-miles above 180 percent R/VC (69 and 70 percent, respectively). The Hybrid-CA2 models' estimated shares of tons and ton-miles below 100 percent R/VC are low (4-5 percent) relative to URCS and to the CA1 scenario using ROI and DLR default variabilities, but not zero.

The CA3 scenario using the industry VC model's marginal costs moderates the share of tons and ton-miles over 180 percent R/VC to, respectively, 56 and 55 percent (with 6 percent of tons and 5 percent of ton-miles moving below estimated cost). Compared to legacy URCS, the impact on the jurisdictional threshold is greater for tons than ton-miles because of differences in distance economies in the Hybrid model compared to URCS Phase III. The Hybrid NEIO regression's larger implied distance economies tend to shift costs from longer-distance movements to shorter-distance movements, which tends reducing measured costs and increasing R/VCs for movements with relatively high ton-miles.

The shares of rail freight above 180 percent of R/VC in the marginal cost models are not necessarily extraordinary results. We expect railroads' costs to exhibit substantial economies of density, and as we have showed above, increasing economies of density increases the break-even markup over marginal cost. Compared to legacy URCS, the marginal cost-based Hybrid models in the CA2 and CA3 scenarios plausibly shift a substantial fraction of ROI and DLR costs treated as "intermediate run" variable costs in legacy URCS to short-run fixed costs that must be recovered through markups over short-run marginal cost.

Since the 180 percent R/VC threshold in 49 USC §10707(d)(1)(A) is fixed by statute, adopting a marginal cost-based Hybrid model as an alternative methodology for determining variable cost will materially reduce the amount of traffic that the statutory test would deem not to be subject to "market dominance" in the absence of a bridging adjustment to account for the change in cost methodology.

F. Conclusion and Assessment of the Hybrid Model as an Alternative to URCS

The Hybrid cost model described in this section produces estimates of variable cost for rail freight shipments that have an economic interpretation as short-run marginal costs. As its name suggests, the Hybrid model combines two analyses to produce shipment-level marginal costs.

One component of the analysis is an econometric analysis of cost data, primarily using Class I railroads' R-1 annual reports to the STB, to derive estimates of non-shipment-specific marginal costs by railroad and year. The costing methods we considered were econometric analysis of an industry variable cost function, which produces an aggregate cost elasticity with respect to output applicable to total Class I railroad costs, and an analysis that updates of the econometric modeling from URCS Phase I, which produces output elasticities that are disaggregated in that they apply to economically relevant subsets of railroads' costs. While the Hybrid model's predecessor from the 2009 Competition Study used the industry cost function approach, we favor the disaggregated method in light of limitations of the R-1 data—most notably, the limited number of annual observations available from the remaining Class I railroads. The cost elasticities from the disaggregated analysis are somewhat lower than variabilities in the legacy URCS model for operating costs and significantly lower than assumed values of "default" variabilities applied to ROI and DLR costs in URCS Phase II.

The other main component of the Hybrid model is a reduced-form econometric model ("NEIO regression") of railroad price (revenue per ton-mile) data, using shipment-level observations from the Carload Waybill Sample. Under an economic model of profit maximization, railroads will pass through differences in (log) marginal cost to (log) RPTM. The NEIO regressions relate RPTM to variables characterizing shipments' cost-causing characteristics and to variables related to railroads' exercise of market power in order to measure the cost differences implied by the effects of the cost-causing variables on RPTM. While the NEIO regression does not measure cost directly, it can provide an index indicating relative costs for each shipment. The Hybrid cost model combines the relative cost index with estimates of generic marginal (or unit variable) costs to derive shipment-specific costs. Our preferred NEIO regression models improve on the 2009 Competition Study in that they expand the scope of the Hybrid model to all movements by Class I railroads; allow greater flexibility of the shipment-level cost responses to shipment distance, carloads, and tons per car: and incorporate separate NEIO regressions for Eastern and Western railroads.

The cost structure implied by the NEIO regression models differs from URCS Phase III in several notable ways. Cost efficiencies associated with larger shipments (in terms of carloads) are smaller than the "make-whole" carload efficiency adjustments in the Phase III model, and efficiencies related to movement distance are larger than in URCS. The NEIO models also suggest that the step function structure of the URCS make-whole efficiency adjustment is not present in the marginal costs underlying rates. As a result, the Hybrid model tends to shift costs away from intermodal movements and longer-distance movements and towards shorter-distance and certain multiple-carload movements, compared to URCS.

The overall degree of cost variability (i.e., cost-weighted average output elasticities) using short-run cost elasticities is much lower than the overall variability in legacy URCS. The difference primarily arises due to the different treatment of ROI and DLR costs. In the Hybrid short run marginal cost models (CA2 and CA3 scenarios), ROI and DLR costs have low elasticity with respect to outputs compared to the URCS default variabilities, and are largely short-run "fixed" costs to be recovered through markups.

Our preferred Hybrid-CA2 model cost estimates using disaggregated cost elasticities show 69 percent of tons and 68 percent of ton-miles in the CWS above the 180 percent R/VC jurisdictional threshold in 49 USC §10707, compared to 45 percent of tons and 30 percent of ton-miles above 180 percent R/VC in legacy URCS. The Hybrid-CA3 scenario based on the industry VC model's marginal cost show the shares of traffic above 180 percent R/VC as 56 percent of tons and 55 percent of ton-miles. Other Hybrid model scenarios preserving some elements of the legacy URCS model such as the ROI and DLR default variabilities also change the amount of rail freight subject to the jurisdictional threshold by potentially material amounts compared to URCS. A bridging adjustment may be warranted to limit the extent to which any cost methodology change would effectively re-regulate or de-regulate portions of the industry. Whether the bridging adjustment should attempt to fully neutralize the change to the regulatory threshold is a policy question beyond the scope of this report.

1. *Assessing the Hybrid Model through the RAPB Principles*

One way the Hybrid cost model can be assessed is by considering how it comports to the costing principles articulated by the RAPB.

a) Causality

The Causality principle states that costs for rail movements should be determined "on an incremental basis" using causal analysis. In economic terms, causal costs are marginal (or incremental) costs, depending on the increment of railroad output(s) that the movements represent. The Hybrid model is consistent with the Causality principle as it is a short-run marginal cost model by construction. The model's marginal cost calculations are implemented using cost elasticity methodology favored by the RAPB in its discussion of GPCS implementation issues.

The short-run orientation of the Hybrid model is a departure from the "intermediate run" orientation of URCS, primarily in its empirical treatment of ROI and DLR costs for way and structures, locomotives, and freight cars. The appropriate length of run does not flow directly from the Causality principle, but rather depends on the cost application. For evaluating railroads' exercise of market power, a short-run orientation is justifiable as railroads' prices will typically be set for periods in which some inputs will be fixed (or nearly so).

As a mechanical matter, it is possible to use legacy URCS variabilities or to retain the ROI and DLR default variabilities in Hybrid model cost calculations. We implemented Hybrid model scenarios using those costs for the primary purpose of showing the relative roles of the NEIO model and cost elasticity changes in cost differences between Hybrid marginal costs and URCS, though in principle they could be considered a form of intermediate run variable cost in the same sense as current URCS costs.

b) Practicality

The Practicality principle states that cost information "should be feasible to obtain, efficiently determined, and material in amount." The Practicality principle is related to statutory provisions that seek to minimize regulatory reporting burdens on railroads. The Hybrid model is feasible, at least for Class I railroads, insofar as it uses or repurposes existing data from the R-1 annual reports and the CWS. Once specified and coded, the econometric analyses and other computational procedures underlying the Hybrid model can be carried out on personal computers using off-the-shelf data analysis software.[142] Running code to implement the Hybrid model requires only a few minutes of computation time, and the code can be straightforwardly adapted to incorporate new data and roll out old data (as appropriate). By comparison, the STB's 2010 report to Congress estimated that comprehensively updating the array of cost studies underlying URCS Phase III would be a multi-year, multi-million-dollar endeavor. Avoiding such an effort was undoubtedly part of the theoretical appeal of the NEIO and Hybrid alternatives for the STB in 2010. Hybrid model costs differ materially from URCS both in the degrees of cost variability (cost elasticities) and in the NEIO-based allocation of costs to shipments compared to URCS Phase III.

c) Homogeneity

The Homogeneity principle states that cost information should be "organized into homogeneous cost pools." In the Hybrid model, the choice between aggregated (industry cost function) and disaggregated (Phase I cost pool) cost elasticity methods involves the Homogeneity principle. Homogeneity of cost pools can allow the use of parsimonious cost models, which is important given sample size limitations for railroads' annual report data. Some cost pool updates we implemented relative to URCS Phase I were intended to increase the homogeneity of some cost pools compared to the original URCS definitions.

One area where the Hybrid model necessarily uses an aggregated cost is the generic marginal (unit variable) cost itself. This is a fundamental limitation of the pricing data available in the CWS. CWS allows total revenue (or RPTM) for movements to be observed, and railroads' component activities that might in principle be linked to more homogeneous cost pools or are not separately priced and thus cannot be separately modeled in the NEIO regressions. This particularly affects the Hybrid model's ability to produce valid costs for movements on Class II and Class III railroads.

d) Data Integrity

The Data Integrity principle states that cost information "should be valid, accurate, and verifiable." The Hybrid model's cost data sources largely coincide with public data employed in URCS. CWS data used in the NEIO regressions are compiled and edited to minimize data errors. While the NEIO regressions use unmasked confidential CWS data, the computer code implementing the NEIO model and other Hybrid model calculations could be open for review.[143] However, the NEIO regressions are in some respects inherently less transparent than the URCS

[142] Because of the size of the datasets, processing and analyzing multiple years of CWS data is the most computationally intensive, and specifically memory-intensive, part of the analysis. Nevertheless, all of the computational procedures employed for this report can be run on a Microsoft Windows or Apple Macintosh computer with a 64-bit processor and 32 GB of RAM.
[143] Presumably, the nonpublic source datasets could be made available for review under suitable protective conditions.

model: while the regressions may be able to be verified or replicated, they are a "black box" where the underlying cost relationships affecting the regression parameters cannot be inspected.

In general, we view the Hybrid model as maintaining a high degree of consistency with the RAPB principles. The Hybrid model is not clearly dominated by the existing URCS model in any of the principles. Arguably the most significant tradeoff is between the potential lack of transparency of the NEIO regression model (versus URCS cost formulas), versus the employment of large numbers of inputs in URCS that range from difficult-to-verify to pure assumptions.

2. *Hybrid Model Limitations and Cautions*

We note a few limitations of the Hybrid model that may limit its ability to replace legacy URCS costing methods in its entirety.

First, the Hybrid model's dependence on generic marginal costs by railroad from the R-1 annual reports at best limits its ability to cost movements by Class II and III railroads. The key cost input for shipment costing in the Hybrid model is a railroad-specific "generic" marginal (or unit variable) cost. Among other considerations, a railroad's generic costs will depend critically on factors such as its mix of freight traffic and average length of haul. These vary substantially within the Class I railroads, which have significant differences in generic marginal costs, and are also likely to be much different between Class I and Class II and III railroads. Simply applying Class I cost averages to Class II and III railroads' movements is unlikely to result in valid costs. In the absence of cost data for Class II and Class III railroads, URCS costs may be the best available estimates for Class II and III movements largely by default.[144] Of course, the accuracy of URCS proxy costs for Class II and III railroad movements is unknown.

Second, the NEIO regressions have limited ability to distinguish commodity-specific effects on costs, since any commodity-specific parameter would also capture effects on RPTM specific to the commodity's market (product markets and markets for shipping the commodity) and hence the markup. This limitation may require some back-end adjustments to Hybrid model costs. For example, loss and damage costs are disproportionately incurred for shipments of transportation equipment (automobiles) and other manufactured goods.

Finally, and most importantly, it is necessary to recognize that the Hybrid model (like the NEIO model) critically relies on the assumption that the model is specified such that variables we consider to be cost-related do not inadvertently pick up market structure effects. In such a case, the NEIO regression coefficients used in the Hybrid model's shipment cost calculations would reflect a combination of cost and markup effects. While the implied costs from the NEIO

[144] It is possible to use URCS Phase III to compute preliminary estimates of total variable costs for Class II and Class III railroads, which are effectively Class I railroads' unit variable costs adjusted for differences in characteristics of Class II and III railroads' freight traffic. Those costs may then be reallocated to shipments using the NEIO model parameters. Obtaining direct estimates of generic unit costs for Class II and III railroads would require collection of cost and output data for those railroads. Since Class II and III railroads are privately held firms, we cannot obtain data on those railroads' costs and outputs from public sources.

regressions differ from URCS costs in largely plausible ways, there are some "wrong sign" coefficient estimates, such as interchange effects, that should provide a cautionary note that confounding effects of included (or omitted) variables could be present. More generally, since the NEIO regressions are not structural models, it is not possible to guarantee theoretically that the model produces pure marginal cost differences.

3. Conclusion

The Hybrid NEIO cost model is a feasible method for computing shipment costs for Class I railroads. Unit variable cost estimates from the Hybrid model differ materially from legacy URCS costs, resulting both from differences between the Hybrid model's cost elasticities and URCS variabilities, and from shipment-level cost differences between the NEIO regression models and the URCS Phase III model. The main driver of differences between the Hybrid marginal cost model and URCS in the share of rail freight moving above 180 percent R/VC is the Hybrid model's cost elasticities implementing short-run marginal costs, which are materially lower than legacy URCS variabilities. The NEIO regression in the Hybrid model also produces a different allocation of costs than URCS Phase 3, implying among other things that current-methodology URCS may tend to over-cost intermodal shipments and under-cost unit train shipments, other things equal. The resulting differences in rail freight above 180 percent R/VC may warrant the use of a bridging adjustment to keep the amount of rail freight subject to STB jurisdiction relatively constant.

A key feature of the Hybrid model is that its cost allocations are entirely empirically based, using a NEIO regression model with recent CWS data. The Hybrid model thus can avoid the need for many if not most URCS model inputs that are derived from assumptions or stale operational studies. However, the Hybrid framework is not conducive to identifying specific cost elements or mechanisms that may account for the measured cost differences with URCS. Finally, we reiterate the caution that the NEIO framework—including the Hybrid model—is critically dependent on the ability to effectively separate cost factors influencing price from non-cost factors.

IV. UPDATES TO URCS

INTRODUCTION

In Section III, we compared costs and R/VC ratios from the Hybrid model with results from legacy URCS. However, comparisons with the existing URCS model are not the best basis for assessing whether the Hybrid model (or other hypothetical alternatives) should replace URCS. In its current form, URCS incorporates numerous stale inputs, perhaps foremost the Westbrook variabilities, as well as questionable model elements such as the step functions in the "make-whole" carload efficiency adjustments. Under the circumstances, it would be a surprise if the Hybrid model did not produce materially different results than URCS.

To decide whether URCS should be replaced, however, Hybrid versus legacy URCS is an apples-to-oranges comparison. As we discussed in Section II, the URCS framework conceptually is quite flexible, and can accommodate alternative cost elasticities (variabilities) and other alternative cost allocators either within the existing model implementation or with relatively straightforward modifications. A fairer comparison is between the Hybrid model versus an updated and improved URCS-based model that addresses shortcomings of the existing URCS model where possible.

Thus, in this section we investigate updates and improvements to the URCS model with a primary aim of establishing an appropriate basis for assessing whether the Hybrid model materially improves upon traditional URCS. The updates within the URCS framework also address issues raised in stakeholder comments both in Docket No. EP431 sub-no. 3 and in our current stakeholder interviews, where the main priorities for URCS improvements were updating the Phase I variability analysis and evaluating structural changes to Phase III to eliminate unrealistic model elements such as the make-whole step functions.

This exercise benefits from the econometric cost analysis conducted to implement the Hybrid model, which contributes an updated Phase I cost variability analysis as well as empirical cost elasticities that can replace URCS default variabilities for ROI and DRL costs. We also make use of the CWB model developed in Docket No. EP431 sub-no. 4 to investigate structural changes to the URCS carload efficiency adjustments.

Many URCS model inputs cannot be updated within the scope of this project, such as switching model inputs based on studies of railroad operations. Other inputs are essentially judgmental, such as annualization factors applied to certain types of costs. In these cases, we conduct sensitivity analyses to identify inputs that have more material effects on URCS costs and thus may be priorities for future investigation.

Below, we first review updates and improvements to URCS and identify changes to implement in modified URCS models. We cover changes affecting Phases I and II in Section IV.A and changes for Phase III in Section IV.B. In Section IV.C, we describe our analysis of the effects of the implemented model changes, in which we employ modified URCS Phase II and III models (implemented in Microsoft Excel workbooks) to cost a subsample drawn from the 2019 Carload Waybill Sample dataset for several alterative URCS cost scenarios. Section IV.D reports the results of the analysis and compares modified URCS results with our preferred Hybrid model. We offer conclusions in Section IV.E.

A. UPDATES TO URCS PHASES I AND II

1. Updated Phase I Variabilities

A common criticism of URCS is that the Phase I analysis, which provides cost variability factors for fifteen categories of railroad operating costs, is outdated and/or could be improved in its econometric implementation. The Phase I models from the Westbrook 1988 analysis employ data from the 1980s. Westbrook's use of cost equations that are linear in levels of railroad outputs and capacity variables also has been a matter of controversy. Updated variability models can employ more recent data from the Class I railroads' R-1 annual reports and revisit Westbrook's econometric specification choices given current data and methods.

Assessment
We agree that the URCS Phase I analysis is outdated and should be updated. We employ the cost elasticities we estimated for the Hybrid model, described in detail in Section III.D.2 of the report, as variability inputs for our updated URCS cost calculations. Like our Hybrid model analysis, we evaluate URCS costs for two variability scenarios: one scenario updates the Phase I operating cost variabilities but retains URCS default variabilities for ROI and DRL costs, which largely preserves the legacy URCS approach to developing "intermediate run" costs; the second scenario adds empirical cost elasticities for ROI and DRL costs to produce (unit) variable cost estimates that would be interpreted as short-run marginal costs.

The Phase II worktables are structured to allow variability factors to be modified for expenses at the R-1 schedule and line level by updating a lookup value for the econometric equation for the cost pool where the expense is included. The updated Phase I variabilities largely avoided changes to the output variables for expenses that were moved to different cost pools from the legacy URCS assignments. That is, the updated and legacy cost pools generally assign the same output variables to the component accounts. As a result, we mostly implemented the revised variabilities simply by changing the variability equation lookups for expense lines where needed to match the revised cost pool definitions for the econometric equations. The relatively minor exception is the change to wreck clearing expenses. The legacy output variable assignment of Schedule 410 line 429 expenses, to the YARDOPS cost pool, is train hours in yard switching; for the legacy CLWRCKS and updated CLWRCKS2 pool, the output variable is train miles. We moved the line 429 expense such that it was also treated as a train-mile expense, which we do not expect would have a material effect on costs insofar as the line 429 expenses are relatively small.

2. *Phase II Calculations of Generic Unit Variable Costs*

The Phase II calculations of generic (non-shipment specific) unit variable costs have several features that merit re-examination in our review of URCS. While Phase II concerns did not arise directly in the stakeholder interviews, previous critiques have noted the advanced age of special studies and the validity of cost allocators used in Phase II to develop generic unit variable costs that are inputs to the Phase III movement costing model.

Updating special study inputs to URCS was beyond the scope of this study. However, we ran scenario analyses to investigate the sensitivity of URCS costs and R/VC ratios to some special study inputs and other URCS parameters to help prioritize future research efforts. URCS inputs that have small effects on variable costs can have lower priority for updating under the Practicality principle's emphasis on efficiency of implementation and materiality for cost information. We conducted sensitivity analyses for three categories of Phase II inputs:

- "Equated switching factors" that determine relative switch engine minutes (SEMs) for switching types
- Car-day (CD) and car-mile (CM) factors used to calculate switching-related components of unit costs per CD and CM for railroad-owned cars
- Factors that determine whether multi-year averages of certain costs are used to reduce year-over-year cost variations due to expense timing

Finally, we examined the STB freight car type categories used in URCS to identify possibilities for revising or streamlining the freight car categories considering current operations.

a) "Semi-Default" Variable Cost Allocations

In addition to computing variable costs, the D worktables in the URCS Phase II workbooks include calculations that allow costs to be reassigned among specified sets of output variables, called "semi-default" allocations in the URCS Rail Cost Study. The underlying concept is that some costs in the Phase I analysis may depend on multiple outputs, but to the extent the outputs are highly correlated, it may not be possible to estimate multiple output elasticities (or variabilities) reliably. Semi-default allocations assign certain costs related to freight cars to car types. Other railroad operating expenses are viewed in URCS as depending on multiple output variables—e.g., on train miles, locomotive miles, and/or ton-miles—but the Phase I variability models only specify one output variable. An example is RUNFUEL, which is 20 percent of the 2019 costs assigned regression-based variabilities ($6.6 billion). The Phase II model assigns approximately 45 percent of RUNFUEL costs to gross ton-miles rather than locomotive running miles (the econometric output variable).

Since various URCS unit costs differ in whether and how efficiency adjustments are applied to them for movement costing purposes in Phase III, the allocations of variable costs to outputs in Phase II can affect movement costs even in cases where the outputs are highly correlated, which otherwise might tend to mitigate effects of output misspecification.

Assessment

We reviewed the "semi-default" allocations of variable costs to independent variables other than the output variable specified in the Phase I models as part of the implementation of updated Phase I variabilities. The allocations are generally logical, though the specific allocation percentages cannot be straightforwardly validated. With sufficient data, the allocation percentages could (in principle) be estimated directly as part of the Phase I analysis. Unfortunately, actual annual Class I data have a limited ability to estimate cost elasticities or other variability percentages for models with multiple outputs. High output correlation will tend to result in relatively large standard errors of the estimates compared to single-output models, which would make it especially difficult to validate allocations involving small shares of variable costs. In exploratory analysis of a multiple output model for RUNFUEL, we found that the legacy allocations were at least broadly consistent with the data, so no adjustment to the allocation is warranted, though relatively high standard errors of the elasticities do not allow very precise estimation of the allocation percentages.

We also observed that one semi-default allocation of variable costs in the legacy model was not necessarily consistent with the updated variability models, affecting train fringe benefit expenses. Train fringe benefit expenses were included in the train overhead (TRAINOH) cost pool in legacy Phase I but are combined with train and locomotive crew wages (the legacy RUNWAGE cost pool) in the updated analysis. In legacy Phase II, expenses assigned to the TRAINOH cost pool (including the train fringes) have a different allocation to outputs than the RUNWAGE expenses. The legacy Phase II allocation is based on a composite of the other cost pools for train operating expenses, including wage and fuel expenses, which may be a reasonable treatment for general train overheads. However, the Causality and Homogeneity principles would favor a common treatment of all variable labor costs, since wages and benefits will tend to be jointly determined. Incorporating fuel expenses in the legacy allocator is problematic because train fuel expenses would be expected to have a different causal relationship to locomotive miles and gross ton-miles than train labor. We included a modification of the allocation of train fringes to use the same allocator for wage expenses in our scenario analysis below.

b) URCS Switching Special Study Inputs

The Phase II models rely on old special studies for calculation of switching cost inputs including SEMs by types of switching and CDs and CMs incurred in switching activities. The SEM calculations use "equated switching factors" that define SEMs for interchange, intertrain and intratrain (I&I), intraterminal, and interterminal switching activities relative to industry switching (which is normalized to 1). The CD and CM inputs define time and distances per switching event by switching type. The Phase II worktables permit these factors to vary by car type, though the factors are the same for all car types as implemented in current-methodology URCS. Updating the underlying studies is beyond the scope of this study, but likely would be costly and time-consuming.

Assessment
The effects of the equated switching factors on URCS cost estimates are somewhat ambiguous. Changing an equated switching factor for a given switching type, other things equal, has the effect of increasing or decreasing SEMs per event relative to industry switching and other switching types; other switching types would maintain the same SEMs relative to industry switching. For example, the factors for interchange and I&I switching are 0.55 and 0.25, respectively—SEMs per interchange event are 55 percent of SEMs for an industry switching event, and SEMs per I&I event are 25 percent of an industry switching event. Increasing the factor for I&I switching to 0.3, for example, will increase I&I SEMs relative to industry and interchange switching, while industry and interchange switching retain their relative SEMs per event. The effect of the increased I&I factor then is to reallocate total SEMs (from annual report data) such that I&I SEMs will increase and SEMs for other switching types will have offsetting decreases. The implications for movement costs will depend on the movement's mix of switching events by type and on the incidence of shipment size economies. Increasing I&I SEMs per event (and relatedly decreasing SEMs for other switching types) may thus be expected to increase costs for small shipments, since unit train movements largely avoid I&I switching in URCS.

In Phase II, the switching CD and CM factors partly determine the yard components of total CDs and CMs in running linehaul and yard operations, as the yard portion is computed as the product of the CD (or CM) factor and the number of switching events. The total CDs and CMs in turn determine unit variable costs for CD and CM components of freight car-related variable costs. In the CD and CM unit cost calculations, the running linehaul and yard CDs and CMs appear both as allocators of costs to running linehaul and yard components and as the denominators of the unit costs. As a result, the CD and CM factors affect unit costs through their effect on total CDs and CMs. For instance, unit costs per running linehaul CD $UVC(R)_{CD}$ have the form:

(IV-1) $$UVC(R)_{CD} = VC_{CD} \times (CD_R/(CD_R + CD_Y))/CD_R = VC_{CD}/(CD_R + CD_Y).$$

Unit costs per CD in yard operations and unit costs per running linehaul CM are defined as in Equation IV-1; unit costs per yard car-mile incorporate a weighting factor such that:

(IV-2) $$UVC(Y)_{CM} = VC_{CM} \times w_{CMY} \times (CM_Y/(CM_R + CM_Y))/CM_Y = w_{CMY} \times VC_{CM}/(CM_R + CM_Y).$$

Both the weight w_{CMY} and the semi-default allocation factors that assign variable costs to VC_{CD} and VC_{CM} are constants and also derived from cost studies. Increasing a CD or CM factor, other things equal, thus reduces unit costs per CD (or CM) by increasing the total CDs or CMs in the denominator of the unit cost. This effect will be partly offset in the movement costing phase as the lower CD or CM unit cost will be multiplied by higher CDs or CMs for the movement's switching events. Yard operations account for a larger share of total car-days than car-miles, relative to running linehaul operations. Thus, for typical movements, it might be expected that costs would be more responsive to the switching CD factors than the CM factors.

Absent an update to the underlying studies, we investigated the sensitivity of URCS variable costs to the equated switching factors, CMs per switching event, and CDs per switching event by running cost scenarios where the factors were increased or decreased by set percentages for all car types.[145] The results of the scenario runs are reported in Section IV.D, below.

c) URCS Annualization Factors

The Phase II calculations allow railroad expenses to be annualized with the intent of reducing year-to-year volatility resulting from potentially irregular incurrence of certain operating expenses for way and structures and equipment.[146] For the applicable expense categories, URCS uses 5-year or 3-year moving averages of expenses rather than current-year expenses. The tradeoff for reduced volatility is that the moving averages of expenses may be systematically different from current expenses if the averaged expenses have an underlying trend—the multi-year moving average of a systematically declining expense will tend to be higher than the current-year expense.

Assessment

Table IV-1 shows the difference for 2019 between current-year operating expenses and the partly annualized URCS expenses. Eliminating annualization decreases measured expenses for all but one Class I railroad, as well as for the East and West Class I composite groups. The effect is driven by way and structures expenses, which are broadly lower in 2019 than the multi-year averages. Equipment expenses are also lower overall, but three of the seven Class I railroads have higher 2019 equipment expenses than the annualized expenses. Expenses not subject to annualization attenuate the overall effect.

We carry out a cost scenario without cost annualization to quantify the effects of annualization on movement costs. The Table IV-1 data lead us to expect that the overall decreases in expenses from eliminating cost annualization will slightly increase the share of rail traffic exceeding 180 percent R/VC in 2019. We are not able to assess the effect of annualization on year-over-year cost volatility, or to determine whether the effect on R/VC would be persistent, as we did not re-cost multiple years of data from the Carload Waybill Sample.

[145] We varied the equated switching factors by 20 percent and the CM and CD factors by 50 percent, to allow for the possibility that factors derived from a study of current operations may differ markedly from the study results incorporated in URCS.

[146] The URCS worktables partly hard-code the expense annualization calculations, so it is not generally possible to change the period of time over which costs are annualized without changing annualized expense formulas in the worktables.

Table IV-1. 2019 Class I Railroad Operating Expenses Without and With URCS Annualization

Railroad	2019 Operating Costs ($000)		Difference	% Change
	W/o Annualization	With Annualization		
BNSF	14,987,045	15,172,175	-185,130	-1.2%
CN	2,500,562	2,497,439	3,123	0.1%
CP	1,040,972	1,076,288	-35,316	-3.3%
CSXT	7,673,331	7,995,968	-322,637	-4.0%
KCS	1,132,789	1,148,110	-15,321	-1.3%
NS	7,658,894	7,895,727	-236,833	-3.0%
UP	12,894,042	13,261,252	-367,210	-2.8%
EAST	17,832,785	18,389,133	-556,348	-3.0%
WEST	30,054,845	30,657,825	-602,980	-2.0%

Source: 2019 URCS Worktables; Christensen Associates calculations.

d) URCS Freight Car Type Categories

The EP 431 sub-no. 3 proceeding considered criticisms of URCS car type classifications as being potentially outdated. The Phase II worktables estimate unit costs by car type and pass through other car type-specific parameters such as car tare weights and Empty/Loaded (E/L) ratios to the Phase III model. The STB car types are defined as ranges of more detailed AAR car type codes, so at issue is whether the STB car types appropriately aggregate the AAR car types for annual reporting and subsequent analytical purposes.[147]

Concerns for costing include the ability to reliably distinguish costs for relatively uncommon car types, particularly to the extent small allocation errors (in absolute terms) may lead to large relative errors in costs at the car type level, while conversely costs and other inputs may be excessively aggregated for more common types. Costs for some less common car types already are homogenized by substitution of costs from other car types or for regional composites of Class I railroads in the factor substitution process.[148]

Assessment
Table IV-2 shows the distribution of (expanded) carloads by STB car type from the 2019 CWS. The car type distributions were similar in the earlier years of CWS data (2013-2018) we obtained for this study. Five STB car types—37, 44, 45, 48, and 52—each account for less than 0.3 percent of 2019 carloads. One type—36, for plain box cars under 50'—was not observed at all in the 2013-2019 CWS samples and appears to be superfluous; its costs are largely proxied by car type 37 via factor substitution. At a minimum, it appears types 36 and 48 can be combined with

[147] See, e.g., 2019 Surface Transportation Board Carload Waybill Sample Reference Guide, https://prod.stb.gov/wp-content/uploads/2019-STB-Waybill-Reference-Guide.pdf, p. 164.
[148] Factor substitution replaces Phase II E table results that are missing or have unreasonable values with proxies prior to input into the Phase III movement costing model. The STB provides tables of substituted values annually to accompany the URCS Phase II worktables.

other existing categories (i.e., 37 and 49, respectively) with negligible impact on other car categories.

At the other extreme, type 46 flat cars for TOFC and COFC service is primarily double-stack cars (AAR car type codes beginning with "S"), but because of its size includes many TCU movements using other flat car varieties that may have distinct cost characteristics. Adding detail for intermodal car types may help in refining costing for intermodal shipments. Within other car types, there may be opportunities to use some freight car data at finer levels of detail. The STB car types aggregate over car size and/or capacity categories within groups. Car statistics such as tare weights used in estimation of movement gross ton-miles may be refined by using such detail.[149] Costs and other operating statistics such as E/L ratios may be used at higher levels of aggregation as data availability permits.

Table IV-2. 2019 Carloads or TCUs by STB Car Type

STB Car Type	Description	2019 Carloads	% of Total
37	Plain Box Cars 50' and longer	100,438	0.3%
38	Equipped Box Cars	770,612	2.2%
39	Plain Gondola Cars	3,292,074	9.3%
40	Equipped Gondola Cars	579,461	1.6%
41	Covered Hopper Cars	4,601,892	13.0%
42	Open Top Hopper Cars-General Service	882,083	2.5%
43	Open Top Hopper Cars-Special Service	3,056,342	8.6%
44	Refrigerator Cars-Mechanical	60,328	0.2%
45	Refrigerator Cars-Non-Mechanical	23,812	0.1%
46	Flat Cars TOFC/COFC	16,109,737	45.6%
47	Flat Cars-Multi-Level	1,700,588	4.8%
48	Flat Cars-General Service	2,312	0.0%
49	Flat Cars-Other	563,678	1.6%
50	Tank Cars-Under 22,000 Gallons	753,760	2.1%
51	Tank Cars-22,000 Gallons and Over	2,788,375	7.9%
52	All Other Freight Cars	48,840	0.1%
Total		35,334,332	100.0%

Source: 2019 CWS.

[149] Actual tare weights for cars in sampled waybills are reported in the CWS.

B. UPDATES TO URCS PHASE III—EX PARTE 431 SUB-NO. 4 (SNPR) PROPOSALS

In Ex Parte (EP) 431 sub-no. 4 (EP431 sub 4), the Supplemental Notice of Proposed Rulemaking (SNPR)[150] the STB presented revisions to elements of the URCS Phase III model to remedy perceived problems with the Phase III make-whole adjustments and other Phase III cost calculations. Modifications were proposed for the following categories in the SNPR:

1. Switching costs related to SEM
2. Equipment costs for the use of railroad-owned cars
3. Station clerical costs
4. Car-mile costs
5. I&I switching mileage
6. Unit train definition
7. Locomotive unit miles (LUMs)
8. Train miles

Below, we assess the Board's proposals on these modifications and review stakeholder responses to these proposals.

1. Switching Costs Related to SEMs

The SNPR proposed to change the allocation of SEM costs from a per-carload basis to one which includes both a time component (carload basis) and an event component (shipment basis) of switching that would eliminate the step functions between single-car and multi-car shipments and between multi-car and unit train shipments and eliminate the need for the make-whole adjustment.[151] Economies of scale would also be recognized as shipment size increases. The Board proposed to implement this approach through the CWB adjustment that creates an asymptotic curve that results in reduced costs as shipment size (e.g., number of carloads) increases.[152]

While most parties agree that SEM cost allocations should consider both time and event components, they did not accept the proposed CWB approach. For example, based on the preliminary work of Baranowski and Fisher, the AAR recommended that SEM costs be allocated on a 70% shipment, 30% carload basis.[153] Union Pacific also argued that both time and event dimensions be included in SEM cost allocations and proposed a different method that set event-related SEM costs as the current single-car costs and the per-car costs determined by dividing the remaining SEM costs by the number of cars in the shipment.[154] Interest Party witness Mulholland proposed a logarithmic function that produces results similar to the Board's CWB

[150] Docket No. EP 431 (Sub-No. 4), Supplemental Notice of Proposed Rulemaking (SNPR), August 4, 2016.
[151] SNPR, p. 8.
[152] SNPR, p. 9.
[153] AAR Comments, Docket No. EP 431 (Sub-No. 4), June 2013, p. 16.
[154] UP Comments, Docket No. EP 431 (Sub-No. 4), June 2013, p. 8.

method.[155] In contrast, the Western Coal Traffic League (WCTL) argued that the NPR's per-shipment proposal to allocate SEM costs is superior to the various time-and-event approaches.[156]

Assessment

A central question for assessing the CWB approach is whether carload efficiencies should be assigned based on continuous curves or with the step function approach of the existing make-whole adjustments. To the extent the costs switching events have an event and time components, with the latter depending on the number of carloads in the event, the existing step functions are clearly unwarranted. As we discussed in Section III.C of the report, our modeling of revenue per ton-mile data from the CWS also shows little evidence from rail pricing of the existence of size-based step functions of any sort. Thus, the CWB methodology represents a clear improvement over the existing make-whole adjustments, subject to empirical studies to refine the shapes of the cost curves.

An area of concern with the CWB approach is the negative slope for total I&I switching costs, which arises from the calibration of the CWB curve to the existing 100 percent efficiency adjustment at the unit train carload breakpoint, which places a negative weight on the carload. The Board opined that this is the price to be paid for eliminating the step functions in SEM costs,[157] but this is not an entirely satisfactory answer. In the event-component and time-component model of switching costs, there is no logical basis for the time component declining with the number of carloads in the block—that the cost is entirely event (or shipment/block) based is a limiting condition. Very low or negative weights on the carload in the CWB approach thus are symptomatic of the legacy efficiency adjustments being too large and/or miscalibration of the CWB cost curves. For I&I switching, it may be inappropriate to calibrate the CWB curve to zero cost at the minimum unit train breakpoint both because unit train movements may not completely avoid I&I switching events and because movements at the minimum unit train breakpoint are not necessarily moved as unit trains.

The criticism that the CWB approach simply replaces one step function with another also is unwarranted. Steps in the CWB model arise from the discrete nature of the carload variable rather than the arbitrary specification of a step at a round number of carloads. However, it is important to get the shapes of the curves correct. The calibration of the CWB curves to the existing efficiency adjustments preserves that aspect of legacy URCS methodology but has limited empirical justification otherwise. Thus, there is not a clear basis to prefer CWB curves based on the current efficiency factors over alternative curves such as curves using the 30 percent carload/70 percent shipment factors proposed by the AAR for all switching types.

Figure IV-1 shows an illustrative comparison of the cost-per-carload curves in legacy URCS, the SNPR proposal, and the 30% carload weighting proposal, for Class I industry switching. Here, the SNPR CWB curve slightly increases costs for a 1-carload shipment versus the legacy URCS

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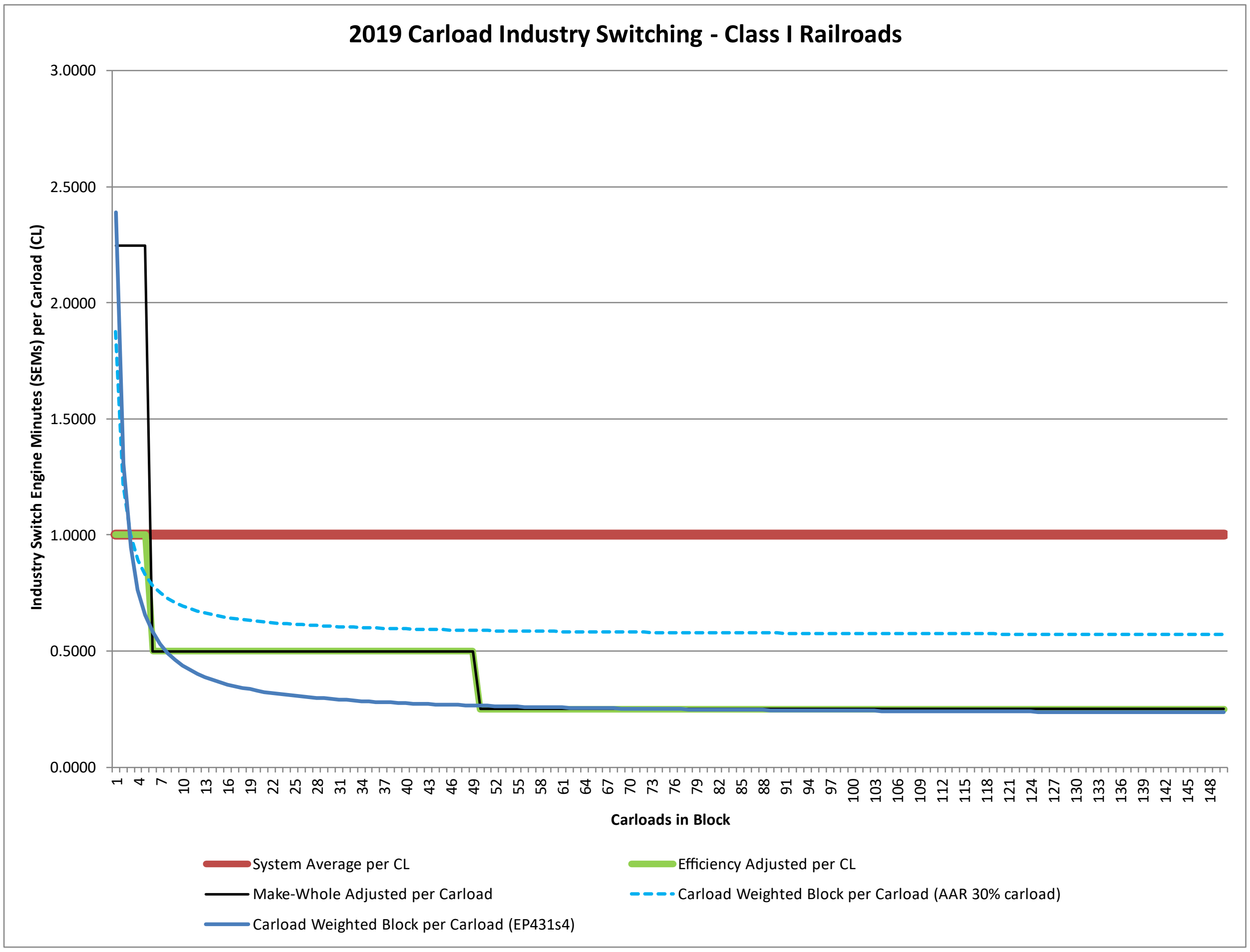
[155] Mulholland Verified Statement, Docket No. EP 431 (Sub-No. 4), October 2016, pp. 37-42.
[156] WCTL Comments, Docket No. EP 431 (Sub-No. 4), October 2016, p. 11.
[157] SNPR, p. 11.

make-whole adjustment, though the CWB industry switching costs are lower than legacy URCS for most other shipment sizes up to 49 carloads. With 30% carload weighting, in contrast, industry switching costs are lower than legacy URCS for the 1-5 carload range, and higher than legacy URCS for shipments of 6 or more carloads, including unit train shipments. At a 75-carload unit train breakpoint, the relative cost per carload in the SNPR model is 10.5 percent of the cost for a single-carload shipment, compared to 31 percent of the single-carload cost with 30% carload weighting. The potential switching cost differences appear large enough to warrant further investigation.[158]

Figure IV-1. Industry Switching Costs, Class I Railroads—Legacy URCS, SNPR CWB, and 30% Carload CWB



Although conducting studies of switching activities is outside the scope of the current project, the ultimate solution to these issues and criticisms is to collect additional data and/or conduct studies to empirically determine the SEM cost curves. In our analysis of the impact of Phase I and Phase III changes, we show cost impacts for both CWB calibration to the legacy efficiency

[158] This is not necessarily to endorse the AAR proposal. Among other considerations, the implied economies of scale from 30 percent carload weighting will not necessarily be appropriate across all switching types.

adjustments and CWB curves based on the 30% carload weighting per the AAR proposal to assess the materiality of the switching cost differences with the SNPR proposal.

2. *Equipment Costs for the Use of Railroad-Owned Cars During Switching*

The SNPR agreed with AAR and BNSF that the current efficiency adjustment for this category distributes cost savings from a few equipment types that have a high percentage of unit train service onto the costs of types of equipment that have a high percentage of single-car service. Thus, equipment costs of equipment in single car service are overstated and equipment costs of equipment in unit train service are understated.[159]

To remedy this, the SNPR proposes to modify Phase II inputs for car-days and car-miles in the following way: (1) if greater than 50% of shipments for one car type move by unit train, efficiency-adjusted inputs for car-days and car-miles will be used; (2) if the majority of shipments for that car type is single-car service, unadjusted inputs for car-days and car-miles will be used; and (3) if there is no majority of shipments moving by a particular shipment size, efficiency adjustments will be applied depending on whether the adjustment reduces costs for multi-car shipments.[160]

The AAR acknowledges the SNPR proposal eliminates the mismatch of efficiency-related cost savings from one type of equipment to other types. However, it notes that efficiency differences currently recognized by URCS between different shipment sizes (e.g., unit train vs. single car) would be ignored and recommends two alternative approaches: (1) using the same CWB approach that was proposed for SEM costs and calculate an asymptotic curve for each car type; or (2) using average car-days to calculate unit cost instead of the SNPR's "all or nothing" use of either adjusted or unadjusted car days.[161] WCTL disagrees with the claim that there is a mismatch of the efficiency adjustment and car types and that the SNPR proposal causes distortions. WCTL proposes that the *status quo* be retained.[162]

Assessment
We believe that the SNPR proposal is a valid attempt to correct the mismatch of efficiency cost savings by car types and should, conditionally, be adopted as an improvement over current URCS methodology. Regarding the AAR's proposals, the use of the CWB approach to estimate cost savings for each car type is inappropriate as there is little reason to expect switching distances or dwell time per switching event to exhibit economies with respect to shipment size as the CWB model would imply. In the CWB model, significant size economies for switching equipment costs arise because, for instance, a switching locomotive can switch two freight cars in (nearly) the same time and distance as a comparable switch of one car. In such a case, however, the car time and distance per carload is essentially unchanged with shipment size.

[159] SNPR, p. 15.
[160] SNPR, p. 15.
[161] AAR Comments, Docket No. EP 431 (Sub-No. 4), October 2016, pp. 16-18, Baranowski/Fisher Verified Statement, Docket No. EP 431 (Sub-No. 4), October 2016, pp. 12-14.
[162] WCTL Comments, Docket No. EP 431 (Sub-No. 4), October 2016, pp. 12-14.

However, the AAR proposal to use average car days to calculate unit costs has some appeal since it overcomes the "all or nothing" car days adjustment that is contained in the SNPR proposal. The downside of the AAR average car day proposal is that it is at odds with URCS legacy methodology that uses one value or the other (i.e., unadjusted vs. efficiency adjusted). However, the legacy methodology is all-or-nothing in part because the minimum unit train breakpoint is treated as a real breakpoint, but as we discuss below the breakpoint is somewhat artificial. If it is not known whether a shipment actually is being moved as a unit train, as is currently the case for waybills in the CWS, a blended or averaged cost could be more appropriate. The practical question is whether there is sufficient data to develop an appropriate average, and how material the differences are between using averages versus the SNPR's approach.

3. *Station Clerical Costs*

Currently, there is a large break point in station clerical costs between single-car and multi-car shipments, but no break point between multi-car and unit train shipments. The Docket No. EP 431 (Sub-No. 4) NPR originally proposed to allocate station clerical costs on a per-shipment basis rather than a per-car basis in Phase II as the Board stated "operationally, there is little difference in the administrative costs between shipment of different sizes."[163] However, the AAR responded that this proposal does not cite any evidence that accounting for these costs on a per-shipment basis will be any more accurate and stated that these costs (as well as SEM costs) have both a time component and an event component.[164] Conversely, WCTL supports the Board's proposal and "believes that any future studies will confirm that the Board's approach will produce the most accurate cost results for unit train movements."[165]

The SNPR took a different approach to eliminate the break point. The SNPR proposes to apply a CWB adjustment in Phase III for single-car shipments with the carload and block percentages determined by solving for values that cause station clerical costs to be reduced at the six-car level to the same amount as is currently done by URCS.[166] The AAR notes that the SNPR proposal causes shifts in variable costs among single car shipments "without justification," but offers no alternative.[167] Interested Party witness Mulholland notes that the Phase III station clerical cost function already reflects economies of scale within and between shipment types to some extent. He proposes to align the station clerical cost curve with the industry switching cost curve, "based on the theory that cars switched at industry together would be billed and processed together."[168]

Assessment

We conditionally accept the SNPR proposal to use a CWB approach to eliminate the breakpoint between single-car and multi-car shipments. However, the balance of stakeholder feedback suggests that the legacy efficiency target may be too low. The result of the 75% carload/25%

[163] NPR, p. 7.
[164] AAR Comments, Docket No. EP 431 (Sub-No. 4), June 2013, pp. 15-16.
[165] WCTL Comments, Docket No. EP 431 (Sub-No. 4), September 2013, p. 10.
[166] SNPR, p. 17.
[167] AAR Comments, Docket No. EP 431 (Sub-No. 4), October 2016, pp. 15-16.
[168] Mulholland Verified Statement, Docket No. EP 431 (Sub-No. 4), October 2016, p. 51.

shipment allocation is that large shipments are assigned large multiples of single-car clerical costs. For example, a 150-car shipment's clerical cost assignment is 113 times larger than that of a single-car shipment. It is at least plausible that an empirically determined CWB curve could have a much smaller assignment to the carload rather than the shipment, yielding lower proportions of clerical costs for large shipments relative to single-carload shipments. These effects, however, may be mitigated by the small fraction of shipment variable costs that station clerical costs are likely to constitute. For prioritizing empirical studies for CWB curve determination, we consider the switching curves to be a higher priority.

4. Car Mile Costs

To obtain car mile costs, URCS currently applies Empty/Loaded (E/L) ratios based on actual data (by car type) for single-car and multi-car shipments and uses an E/L ratio of 2.0 for unit trains. The SNPR proposes to use actual E/L ratios for all shipment types.[169]

WCTL opposes the change in the E/L ratio for unit trains and advocates an E/L ratio = 2.0 be retained for unit trains. It notes that E/L ratios are reported by car types and not types of service. WCTL opines that if actual E/L ratios for unit trains are to be used, data should be collected that identify unit train car types and that this be used in the Phase III adjustments.[170]

Assessment
We generally agree with the SNPR proposal to use actual E/L ratios, but believe the WCTL criticism merits further investigation. A possible modification/improvement would be to adopt the WCTL proposal and have train types reported in waybills if possible so that specific types of trains that have specific operating characteristics (e.g., coal unit trains E/L ratio = 2.0) can be identified and the proper E/L ratio can be assigned.

5. I&I Switching Mileage

Currently, URCS assumes single-car and multi-car shipments receive I&I switching every 200 miles. The SNPR proposes to increase this to every 268 miles.[171] The SNPR also proposes to remedy an inconsistency in I&I switching for intermodal shipments between Phase II and Phase III so that both use 4,163 miles as the I&I switching factor for intermodal shipments.[172]

Generally, there were no objections to the proposal to increase I&I switch mileage, although WCTL noted that the increase in distance would have the net effect of transferring costs that were previously in the I&I category to Industry switching.[173] Union Pacific was "not comfortable" with the assumption that I&I switching mileage has increased in direct proportion

[169] SNPR, p. 20.
[170] WCTL Comments, Docket No. EP 431 (Sub-No. 4), October 2016, pp. 15-16.
[171] SNPR, p. 21.
[172] SNPR, p. 22.
[173] WCTL Comments, Docket No. EP 431 (Sub-No. 4), October 2016, p. 16.

to the average length of haul. Union Pacific found that I&I switching for manifest trains occurred every 250-260 miles between 2013-2015.[174]

Assessment
Our analysis of 2019 data suggests the SNPR proposed 268 miles may be conservative. The 2019 figure is almost 300 miles based on the Board's analysis in support of the proposal, shown in Table IV-3. The average length of haul, on which this is based, appears to be increasing by about 30 miles every 10 years. However, Union Pacific is conceptually correct to note that I&I switching mileage need not increase in direct proportion to average length of haul. The consensus appears to be that the 200-mile figure is too low, but average length of haul changes do not solely determine what the correct figure should be. It appears that switching frequency could be measured directly by the railroads to resolve the empirical issue.

Table IV-3. Changes in Average Length of Haul, 1990-2019

Includes Single Car and Multi Car Shipments Only

Railroad		1990			2019			
		Records	Miles	Avg Miles	Records	Miles	Avg Miles	Change
103	CN	25,473	9,217,847	361.9	37,261	18,785,892	504.2	39.3%
105	CP	14,675	7,256,974	494.5	17,102	9,022,294	527.6	6.7%
190	CR	36,081	16,616,793	460.5	0	0	0.0	-100.0%
400	KCS	3,032	838,505	276.6	9,018	4,265,786	473.0	71.0%
555	NS	64,437	23,502,074	364.7	47,933	27,561,330	575.0	57.7%
712	CSXT	55,040	23,354,237	424.3	46,197	29,592,984	640.6	51.0%
777	BNSF	43,921	33,744,671	768.3	42,314	46,747,152	1,104.8	43.8%
802	UP	90,883	54,903,375	604.1	66,804	66,474,702	995.1	64.7%
Total		333,542	169,434,475	508.0	266,629	202,450,141	759.3	49.5%
						Adjusted Distance Between I&I Events	200.0	**298.9**

6. *Unit Train Definition*

The SNPR proposes to increase the minimum number of cars in a unit train from the current 50 to 75. Analysis cited by the STB in the SNPR showed that average through train lengths for Class I railroads exceeded the unit train threshold, and that average unit train length using similar methodology exceeded 100 carloads. The STB viewed these results as indicating that the 50-carload unit train threshold was too low.[175]

Interested Party witness Mulholland noted that individual railroad data exhibit deviations from the aggregate data on which the 75-car unit train definition is based. Mulholland further contended that the Board ignored other spikes in the data that were less than 75 cars and that unit

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[174] Union Pacific Comments, Docket No. EP 431 (Sub-No. 4), October 2016, p. 5.
[175] SNPR, p. 24.

train shipments are often less than 75 cars.[176] Moreover, he stated that the 75-car definition (or any other number of cars) is meaningful only to calibrate the CWB curve and is meaningless in defining how a shipment is handled.[177] WCTL did not object to the 75-car definition but claims that it is not based on any empirical analysis of shipment size, "other than a review of R-1 and waybill data wherein the Board considered the frequency of shipment size."[178]

Assessment
As with the I&I switching distance, there is greater consensus that the 50-carload breakpoint is too low than there is on a specific alternative breakpoint. We updated the STB's analysis of the weighted average size of through-train and unit train size with 2019 data, which shows that the 75-car definition may be conservative as the weighted average train length is 80.1 carloads. The most recent five-year average (2015-2019) is 77.6 carloads. See Table IV-4, below.

Table IV-4. Analysis of Unit Train Size, 2019 Data

Description	BNSF	CN	CP	CSXT	KCS	NS	UP	Total
Through + Unit Train Miles	155,050	13,854	7,545	48,808	7,783	58,262	107,975	399,278
Car Miles, Through + Unit Trains	11,620,024	1,376,632	741,773	4,103,833	690,303	4,048,987	9,394,841	31,976,393
Average Cars per Train, Through + Unit Trains	74.9	99.4	98.3	84.1	88.7	69.5	87.0	**80.1**

Description	BNSF	CN	CP	CSXT	KCS	NS	UP	Total
Through + Unit Train Miles	157,883	12,680	7,385	57,813	7,507	61,363	120,740	425,371
Car Miles Through + Unit Trains	11,693,944	1,299,242	726,286	4,488,064	664,066	4,168,696	9,979,131	33,019,430
Average Cars per Train, Through + Unit	74.1	102.5	98.3	77.6	88.5	67.9	82.6	**77.6**

Source: URCS Worktable A1P1.

However, the breakpoint between multi-car and unit train shipments is, at some level, artificial. A railroad may move shipments below the breakpoint as a unit train if it is efficient to do so, and likewise could handle shipments above the threshold in manifest trains. We would expect only that the probability that a shipment is efficiently moved as a unit train increases as the number of cars in the shipment increases. Thus, there is likely a continuum of shipment sizes (in terms of the number of cars) above and below the selected definition that are shipped by unit train. This reasoning also supports the idea that there should not be a step function between multi-car and unit train shipments as the "true" costs do not exhibit such a discontinuity.

We employ the 75-car breakpoint in our main impact analysis scenarios for URCS model changes, but regard the best course of action as minimizing the role and impact of size

[176] Mulholland Verified Statement, Docket No. EP 431 (Sub-No. 4), October 2016, pp. 19-22.
[177] Mulholland Verified Statement, Docket No. EP 431 (Sub-No. 4), October 2016, p. 18.
[178] WCTL Comments, Docket No. EP 431 (Sub-No. 4), October 2016, pp. 16-17.

breakpoints in URCS. We also investigated the effects of using 50- and 80-carload breakpoints with the updated methodologies from the EP 431 sub-no. 4 SNPR and found mostly small effects on shipment variable costs.

7. *Locomotive Unit Miles (LUMs)*

The current URCS allocation for LUMs produces a step function between multi-car and unit train shipments. To eliminate the step function, the SNPR proposes to cap the Phase III allocation of LUMs to multi-car shipments to be less than or equal to LUMs allocated to a 75-car shipment (the minimum size of a unit train).[179]

The AAR contends that the SNPR proposal is arbitrary and should not be implemented. The AAR claims that the breakpoint between multi-car and unit train shipment is not a problem because it is based on the transition from using through train data to using unit train data to allocate costs—i.e., it is data driven.[180] WCTL has no objection to the cap proposed in the SNPR, but advocated a return to the NPR proposal to allocate LUMs on a shipment basis.[181]

Assessment

We conditionally agree with eliminating the breakpoint between multi-car and unit train shipments, although the SNPR's proposed transition in the LUM allocation between multi-car and unit train shipments is not the only possible shape of the LUM curve. A possible modification/improvement would be to conduct a study to determine whether there is an upward slope between multi-car and unit train shipments, or whether there is, indeed, a breakpoint between multi-car and unit train shipments.

8. *Train Miles*

For single-car and multi-car shipments, URCS currently allocates train miles by multiplying total train miles by the ratio of the gross tons of a shipment to the average gross tons of the train. Unit train shipments receive all train miles. This allocation method can produce a positive or negative step function between multi-car and unit train shipments. To eliminate instances of negative step functions, the SNPR proposes in Phase III to cap the train miles allocated to multi-car shipments to be less than or equal to those of the 75-car (proposed minimum size) unit train. The SNPR asserts that a positive step function should rarely happen and does not propose a remedy.[182]

As with LUMs, the AAR claims that the breakpoint between multi-car and unit train shipment is not a problem because it is based on the transition from using through train data to using unit train data to allocate costs—i.e., it is data driven.[183]

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[179] SNPR, p. 27.
[180] AAR Comments, Docket No. EP 431 (Sub-No. 4), October 2016, pp. 16-17.
[181] WCTL Comments, Docket No. EP 431 (Sub-No. 4), October 2016, pp. 17-18.
[182] SNPR, p. 28.
[183] AAR Comments, Docket No. EP 431 (Sub-No. 4), October 2016, p. 18.

Assessment

We have no objection to the SNPR proposal to cap train miles allocated to multi-car shipments to be less than or equal to those allocated to 75-car shipment as there is little reason to believe that there is an actual step function at the URCS unit train breakpoint. A possible improvement would be to conduct studies to determine the transition between multi-car and unit train shipments, and whether there is, indeed, any breakpoint (i.e., a negative step function) between multi-car and unit train shipments.

C. IMPACT ANALYSIS OF URCS MODEL CHANGES

A primary goal of the project is to assess the impact of proposed alternative to URCS on the STB's jurisdictional thresholds and on other URCS applications. To make the assessment for changes to URCS Phases I and III, we conducted scenario analyses in which we obtained a subsample of waybills from the 2019 CWS and computed alternative shipment variable costs for the subsample based on appropriately modified URCS models, including Phase II worktables and the Phase III shipment cost calculations. The STB provided Excel versions of the Phase III models reflecting current URCS procedures as well as a modified model accommodating EP431 sub 4 proposals that facilitated the analysis. Using the alternative costs for the subsample, we can estimate impacts of model changes on shipment variable costs, on revenue-to-variable cost (R/VC) ratios, and on shares of shipments with R/VC exceeding 180 percent.

1. Waybill Subsample

The sampling frame for the Waybill subsample is the set of all records from the 2019 CWS dataset with non-zero billed weight (field 13 in the CWS 900-byte record layout). Waybills are uniquely identified in the annual CWS file by a serial number (SN; CWS field 1), which we use to identify the primary sampling units. We also excluded a small number of records for intermodal shipments where more than one TCU was reported in the Number of Carloads field (CWS field 5). In total, there are 667,928 SNs in the sampling frame. We randomly sampled 4,000 waybill SNs within each of the following strata:

1. Intermodal
2. Single-car trains (< 6 cars)
3. Multi-car trains (legacy URCS definition, ≥ 6 cars and < 50 cars)
4. Unit trains (≥ 50 cars)

The total sample sizes and sampling rates are shown in Table IV-5, below. We sampled multi-car and unit train waybills at relatively high rates to provide better resolution of impacts of URCS changes on shipments in those categories, compared to an equal-probability subsample. We developed subsample weights as the inverse of the subsampling probabilities. These allow us to compute valid expanded (population) estimates by combining the original CWS and subsample expansion factors.

Table IV-5. Waybill Subsample Statistics

Stratum	SNs in Sample Frame	SNs Sampled	Num. Segments	Subsampling Probability	Subsample Expansion Factor
Intermodal	401,994	4,000	4,475	1.00%	100.450
Single	215,041	4,000	5,070	1.86%	53.76
Multi	15,653	4,000	4,656	25.55%	3.91
Unit	35,240	4,000	4,551	11.35%	8.81
Total	667,928	16,000	18,752	–	–

Table IV-6 shows tons and ton-miles for carload size categories within the CWS subsample strata. Tons, ton-miles, and revenue in the CWS subsample are concentrated in 1-carload movement, unit train movements over 75 carloads, and intermodal shipments. Shipments from 2-74 carloads comprise relatively small shares of tons, ton-miles, and freight revenue—respectively, 13 percent, 8 percent, and 10 percent.

Table IV-6. Expanded Tons, Ton-Miles, and Revenue for Waybill Subsample by Size Categories

Stratum	Carloads	Expanded Subsample Totals		
		Tons	Ton-miles (000s)	Revenue
Single	01	785,497,464	559,394,504	32,803,472,353
Single	02-05	50,244,330	37,714,386	2,030,570,446
Multi	06-24	105,385,654	53,904,648	2,610,061,082
Multi	25-49	81,978,032	34,806,702	1,670,828,519
Unit	50-74	68,960,619	19,102,703	1,113,646,877
Unit	75+	1,004,749,092	699,632,009	18,269,172,427
Intermodal	n/a	229,807,910	308,041,572	17,011,787,109

2. *Main Alternative URCS Cost Scenarios*

For the impact analysis, we characterize cost impacts of URCS model changes using the following sets of URCS model scenarios (some of which are combined):

- Baseline using current-methodology URCS ("URCS" scenario)
- Updated Phase I variability models with default ROI and DRL variabilities ("CA1" scenario)
- Updated Phase I variability models with econometric ROI and DRL variabilities ("CA2" scenario). In this scenario, unit variable costs can be interpreted as short-run marginal costs as they use short-run output elasticities to develop all Phase II unit variable cost outputs.
- URCS model from the EP 431 sub-no. 4 SNPR, updated for 2019 data ("431s4" scenario)
- URCS model from the 431s4 scenario, modified to use 30 percent carload weighting in the CWB switching models ("30/70" scenario)

We also ran the 431s4 and 30/70 scenarios with and without the Phase I variability changes—i.e., retaining legacy variabilities—for a total of six main CWB scenarios. We did not run the CA1 and CA2 scenarios without the EP 431 sub-no. 4 modifications to avoid complexities in re-calculating the legacy URCS make-whole adjustments with alternative Phase II unit cost inputs. Insofar as the changes should be largely unidirectional and relatively uniform (reducing generic unit variable costs), based on the Hybrid model analysis, we believe the effects of the variability changes are adequately addressed in the scenario analysis.

To facilitate the analysis, the STB provided Excel workbooks implementing the Phase III cost model for current-methodology URCS and for the Phase III model incorporating changes from the EP 431 sub-no. 4 SNPR. As part of their on-going efforts to improve URCS, the STB's staff identified a series of technical errors in the legacy URCS costing program. The current-methodology Excel workbook incorporates a new version of the URCS Phase III model developed by the STB's staff that corrects these technical errors, but otherwise leaves intact the existing algorithms. The STB applied this workbook to the 2020 CWS dataset. We used the new workbook to cost 2019 CWS observations to provide current-methodology baseline costs. The effects of correcting the errors in the legacy URCS model are small—there is no effect on the measured variable cost for most sampled waybills, and small and analytically insignificant impacts elsewhere (generally less than 0.5 percent). The new current-methodology Excel workbook also serves as the base for further Phase III model modifications in the 431s4 and 30/70 scenarios.

In addition to the scenarios above, we ran additional scenarios not reported here to test the sensitivity of the costs in the 431s4 scenarios to small changes in the URCS make-whole cost reduction factors, and to assess the sensitivity of costs to Phase II model parameters including car-mile and car-day inputs affecting some costs for railroad-owned cars, and inputs controlling the use of multi-year averages for some costs. The car-mile and car-day inputs are based on old special studies, and the sensitivity analysis was intended to assess whether the inputs have sufficiently material effects on measured URCS costs to justify updates.

3. Modifications to Phase II Worktables

The scenario runs required some modifications to the Phase II worktables to generate appropriate unit cost inputs for the Phase III models. These changes were mostly to update variabilities for the updated Phase I variabilities in the "C Summary" worksheet. Since the log-specification's elasticities do not depend on output or capacity levels, we used the same elasticity for the current-year, two, three, four, and five-year average variabilities. We modified variability equation numbers in the D table variable cost calculations to assign the updated variabilities correctly to expense accounts that move to different equations.[184] A scenario reported below also modifies the semi-default allocation of train fringes to match the corresponding allocation of wage costs. We also made changes required to implement the EP431 sub-no. 4 SNPR proposals,

[184] In most cases, this simply adjusts a lookup formula. However, for wreck-clearing expenses, we consolidated expenses for the two accounts in the updated cost pool.

notably updating the average miles between I&I switches to 268 in the Phase II "A1P7" worktable (with the only exception being for FLAT-TOFC, which was set to 4,163).

4. Modifications to Phase III Workbooks

The main update required for the Phase III workbooks was to replace unit costs and related inputs in the "RailroadUnitCostXML" sheet with the values from the modified Phase II worktables. In cases where the Phase II workbooks output a missing value, we did not update the E table input values in the Phase III workbooks. The differences reflect factor substitutions made between the Phase II E table outputs and the Phase III inputs and have little effect on our results.

For the 30/70 scenario models, we updated the carload weighting proportions to 0.3 (eCodes E3L101C2-E3L106C2) and recomputed the carload-weighted block (CWB) ratios (E3L101C1-E3L106C1) using workpapers for the CWB switching model provided by the STB.

D. Impacts on Phase III Shipment Costs

1. Results for Main URCS Update Scenarios

a) Variable Costs Per Ton-Mile for URCS Update Scenarios

Tables IV-7 and IV-8 show variable costs per ton-mile (VCPTM) and percent changes in VCPTM relative to the current-methodology URCS baseline, by shipment size groups, in the 431s4 scenarios. Tables IV-9 and IV-10 report similar results for the scenarios with 30% carload weighting for the CWB model ("30/70" scenarios). The tables show VCPTM using current (2019) URCS variabilities (URCS, 431s4, and 30/70 scenarios), "CA1" scenarios with updated Phase I and URCS default ROI and DRL variabilities, and "CA2" scenarios with both updated Phase I variabilities and econometric variabilities for ROI and DRL costs. Current-methodology URCS costs are included for comparison.[185] Tables with results by commodity groups are provided in Appendix E.

Both the 431s4 and 30/70 CWB scenarios increase VCPTM, relative to current-methodology URCS, for shipments in the legacy URCS unit train size category (50+ carloads). This correspondingly reduces costs for other multiple carload (2-49 carloads) movements. The CWB carload efficiency curves and shift in the unit train threshold to 75 cars reduces carload efficiencies for larger carload shipments. The 30/70 scenario also generally reduces carload efficiencies compared to the 431s4 scenario.

Effects on VCPTM for 1-carload movements are relatively small—a 2 percent increase in the 431s4 scenario and a 4 percent decrease in the 30/70 scenario. As shown in Figure IV-1, the

[185] The current-methodology URCS costs are a modified baseline incorporating pending technical corrections to the URCS model used to cost the CWS. Thus, the URCS costs reported in this section differ slightly from the URCS costs reported in Section III of this report which are based on the costs in the CWS. Small differences also arise due to sampling variation as we computed the modified baseline costs for the CWS subsample described in Section IV.C.1.

30/70 scenario mostly has smaller carload efficiencies for higher-carload shipments compared to the 431s4 CWB model (which is calibrated to legacy URCS unit train efficiency adjustments). The distance between the CWB efficiency curves and the make-whole adjusted URCS step functions cause the cost shifts to vary over size ranges. In the 30/70 scenario, shipment size diseconomies for 1-carload shipment are not as pronounced, relative to the system average, as in the 431s4 scenario, accounting for the different arithmetic sign of the 1-carload cost impacts compared to URCS. Neither the 431s4 nor the 30/70 scenario modifications materially affect VCPTM for intermodal shipments.

Adding variability updates to the 431s4 and 30/70 scenarios broadly reduces measured variable costs, as expected. Like the effects in the Hybrid model, the effects of the Phase I variability update retaining URCS ROI and DRL defaults are smaller than the effects of incorporating the empirical ROI and DRL elasticities from Section III.D.3. Table IV-11 shows that the effects of adding variability updates are relatively uniform across size categories, compared to the effects of implementing the CWB model and other changes (compared to current-methodology URCS) in the 431s4 and 30/70 scenarios with legacy URCS variabilities. Differences in variability impacts by size category result from the non-uniform changes in the updated variabilities, compared to URCS variabilities. The non-uniform variability changes have differential effects on URCS Phase II cost outputs (i.e., unit costs for gross ton-mile, locomotive-miles, SEMs, etc.) and, in turn, on shipments of different sizes and other cost-causing characteristics.

Table IV-7. Impact of Model Changes on Variable Cost Per Ton Mile (VCPTM) by Shipment Size Category (431s4 Scenarios)

Shipment Category	VCPTM (2019 Cents)			
	URCS	431s4	CA1 +431s4	CA2 +431s4
1 Carload	3.591	3.66	3.365	2.405
2-5 Carloads	3.157	2.58	2.383	1.756
6-24 Carloads	2.584	2.326	2.184	1.617
25-49 Carloads	2.632	2.311	2.177	1.613
50-74 Carloads	2.35	2.456	2.301	1.659
75+ Carloads	1.567	1.612	1.492	1.09
Intermodal	3.859	3.875	3.662	2.832

Notes: CA1 updates Phase I variabilities, retains URCS ROI and DRL defaults.
CA2 adds empirical ROI and DRL variabilities to CA1.

Table IV-8. Percent Changes in Variable Cost Per Ton Mile by Shipment Size Category Compared to Current-Methodology URCS (431s4 Scenarios)

Shipment Category	VCPTM % Change Vs URCS		
	431s4	CA1 +431s4	CA2 +431s4
1 Carload	2%	-6%	-33%
2-5 Carloads	-18%	-25%	-44%
6-24 Carloads	-10%	-15%	-37%
25-49 Carloads	-12%	-17%	-39%
50-74 Carloads	4%	-2%	-29%
75+ Carloads	3%	-5%	-30%
Intermodal	0%	-5%	-27%

Table IV-9. Impact of Model Changes on Variable Cost Per Ton Mile by Shipment Size Category (30/70 Scenarios)

Shipment Category	VCPTM (2019 Cents)			
	URCS	30/70	CA1 +30/70	CA2 +30/70
1 Carload	3.591	3.454	3.197	2.316
2-5 Carloads	3.157	2.606	2.406	1.79
6-24 Carloads	2.584	2.448	2.286	1.699
25-49 Carloads	2.632	2.472	2.311	1.715
50-74 Carloads	2.35	2.72	2.519	1.821
75+ Carloads	1.567	1.691	1.555	1.137
Intermodal	3.859	3.875	3.662	2.833

Table IV-10. Percent Changes in Variable Cost Per Ton Mile by Shipment Size Category Compared to Current-Methodology URCS (30/70 Scenarios)

Shipment Category	VCPTM % Change Vs URCS		
	30/70	CA1+30/70	CA2+30/70
1 Carload	-4%	-11%	-36%
2-5 Carloads	-17%	-24%	-43%
6-24 Carloads	-5%	-12%	-34%
25-49 Carloads	-6%	-12%	-35%
50-74 Carloads	16%	7%	-23%
75+ Carloads	8%	-1%	-27%
Intermodal	0%	-5%	-27%

Table IV-11. Percentage Changes in VCPTM by Size Category Due to Variability Changes

Shipment Category	431s4 Scenarios		30/70 Scenarios	
	CA1 vs URCS	CA2 vs CA1	CA1 vs URCS	CA2 vs CA1
1 Carload	-8%	-29%	-7%	-28%
2-5 Carloads	-8%	-26%	-8%	-26%
6-24 Carloads	-6%	-26%	-7%	-26%
25-49 Carloads	-6%	-26%	-7%	-26%
50-74 Carloads	-6%	-28%	-7%	-28%
75+ Carloads	-7%	-27%	-8%	-27%
Intermodal	-5%	-23%	-5%	-23%

b) Revenue-to-Variable Cost Ratios for URCS Update Scenarios

Tables IV-12 and IV-13 show R/VC ratios by shipment size category. As expected, in categories where VCPTM increases (decreases) relative to the current-methodology URCS baseline, R/VC ratios decrease (increase) as revenue (per ton-mile) is unchanged across URCS update scenarios and VCPTM is in the denominator of the calculation. Both the 431s4 and 30/70 scenarios reduce R/VCs for shipments in the 50+ carload legacy unit train size category and increase R/VCs for other multiple carload movements. The smaller carload economies for large shipments in the 30/70 scenario results in larger R/VC reductions for the 50+ carload categories compared to the 431s4 scenario—notably, R/VC for the 75+ carload category is 1.67 in URCS, 1.62 in the 431s5 scenario, and 1.54 in the 30/70 scenario. The model updates in the 431s4 and 30/70 scenarios do not materially affect overall R/VC ratios for intermodal shipments compared to the URCS baseline.

Updating variabilities in the CA1 and CA2 scenarios increases average R/VCs by size category as the lower variabilities reduce variable costs. In the CA2 scenarios incorporating updated cost elasticities for the URCS Phase I variabilities and the econometric cost elasticities for ROI and DRL costs, average R/VC is over 180 percent for all size categories using either the 431s4 or 30/70 CWB curves.

Table IV-12. Impact of Model Changes on Revenue/Variable Cost (R/VC) Ratios by Shipment Size Category (431s4 Scenarios)

Shipment Category	R/VC			
	URCS	431s4	CA1 +431s4	CA2 +431s4
1 Carload	1.63	1.60	1.74	2.44
2-5 Carloads	1.71	2.09	2.26	3.07
6-24 Carloads	1.87	2.08	2.22	2.99
25-49 Carloads	1.82	2.08	2.21	2.98
50-74 Carloads	2.48	2.37	2.53	3.51
75+ Carloads	1.67	1.62	1.75	2.39
Intermodal	1.43	1.43	1.51	1.95

Table IV-13. Impact of Model Changes on Revenue/Variable Cost (R/VC) Ratios by Shipment Size Category (30/70 Scenarios)

Shipment Category	R/VC			
	URCS	30/70	CA1 +30/70	CA2 +30/70
1 Carload	1.63	1.70	1.83	2.53
2-5 Carloads	1.71	2.07	2.24	3.01
6-24 Carloads	1.87	1.98	2.12	2.85
25-49 Carloads	1.82	1.94	2.08	2.80
50-74 Carloads	2.48	2.14	2.31	3.20
75+ Carloads	1.67	1.54	1.68	2.30
Intermodal	1.43	1.43	1.51	1.95

Table IV-14 shows the estimated shares of freight tons above 180 percent R/VC for the 431s4 scenarios. Table IV-15 shows the corresponding shares of tons below 100 percent R/VC.

In the base 431s4 scenario without updated variabilities, the R/VC distributions of both tons and ton-miles shift upwards for the 2-49 carload categories and down for the 1-carload and 50+ carload size categories, mirroring VCPTM shifts. The overall share of tons above 180 percent R/VC declines slightly as the 1-carloads and 75+ carload categories with lower measured R/VCs are larger than the categories with higher R/VCs.

Incorporating the Phase I variability update in the CA1 scenario shifts the R/VC distributions upward due to the lower overall variable cost level. The effect is relatively uniform over shipment size categories. In the 431s4+CA1 scenario, the total shares of tons over 180 percent R/VC increases by six percentage points over the 431s4 scenario and five percentage points over legacy URCS. Adding the econometric elasticities for ROI and DRL expenses in the CA2 expenses increases the share of tons over 180 percent R/VC to 76 percent overall, though intermodal movements are considerably below average with 49 percent of intermodal tons above 180 percent R/VC. The 2-74 carload categories have considerably above average shares of tons over 180 percent R/VC, ranging from 88 to 97 percent. Conversely, with the CA2 variabilities, only 4 percent of tons are below 100 percent of estimated variable cost, compared to 13 percent of freight tons below variable cost using legacy URCS variabilities. In all scenarios, intermodal shipments show above-average shares of tons revenue below estimated variable costs. Like the Hybrid results with the same variabilities reported in Section III, the CA2 scenario's unit variable costs—which can be interpreted as short-run marginal costs—greatly reduce but do not eliminate freight traffic moving below estimated costs.

Table IV-14. Share of Tons Above 180 Percent R/VC, By Size Category (431s4 Scenarios)

Shipment Category	URCS	431s4	431s4+ CA1	431s4+ CA2
1 Carload	47%	44%	53%	80%
2-5 Carloads	32%	61%	69%	90%
6-24 Carloads	53%	60%	65%	88%
25-49 Carloads	48%	60%	66%	89%
50-74 Carloads	83%	67%	71%	96%
75+ Carloads	47%	44%	48%	74%
Intermodal	23%	23%	27%	49%
Total	46%	44%	50%	76%

Table IV-15. Share of Tons Below 100 Percent R/VC, by Size Category (431s4 Scenarios)

Shipment Category	URCS	431s4	431s4+ CA1	431s4+ CA2
1 Carload	9%	11%	7%	3%
2-5 Carloads	11%	4%	2%	0%
6-24 Carloads	6%	4%	3%	1%
25-49 Carloads	9%	5%	4%	1%
50-74 Carloads	1%	1%	1%	1%
75+ Carloads	13%	14%	9%	4%
Intermodal	28%	29%	25%	13%
Total	13%	13%	9%	4%

Table IV-16 shows the estimated shares of freight tons above 180 percent R/VC for the 30/70 scenarios. Table IV-17 shows the corresponding shares of tons below 100 percent R/VC. Overall shares of traffic in tons both above 180 percent R/VC and below 100 percent R/VC are close to the corresponding 431s4 scenarios. However, the 30/70 scenarios modestly reduce the shares of multiple (2+) carload shipments above 180 percent R/VC, while the share of 1 carload tons over 180 percent R/VC increases from 80 percent in the 431s4+CA2 scenario to 84 percent in the 30/70+CA2 scenario. Reduced carload efficiencies in the 30/70 lower the shares of tons over 180 percent R/VC for multiple-carload categories, mostly offset by increased tons over 180 percent R/VC for 1-carload categories compared to the 431s4 scenarios.

Table IV-16. Share of Tons Above 180 Percent R/VC, By Size Category (30/70 Scenarios)

Shipment Category	URCS	30/70	30/70+ CA1	30/70+ CA2
1 Carload	47%	50%	58%	84%
2-5 Carloads	32%	60%	67%	89%
6-24 Carloads	53%	55%	62%	85%
25-49 Carloads	48%	50%	59%	86%
50-74 Carloads	83%	57%	66%	94%
75+ Carloads	47%	38%	44%	72%
Intermodal	23%	23%	27%	49%
Total	46%	43%	49%	76%

Table IV-17. Share of Tons Below 100 Percent R/VC, By Size Category (30/70 Scenarios)

Shipment Category	URCS	30/70	30/70+ CA1	30/70+ CA2
1 Carload	9%	8%	6%	2%
2-5 Carloads	11%	4%	2%	0%
6-24 Carloads	6%	5%	4%	1%
25-49 Carloads	9%	5%	5%	2%
50-74 Carloads	1%	1%	1%	1%
75+ Carloads	13%	16%	12%	6%
Intermodal	28%	29%	25%	13%
Total	13%	14%	9%	5%

c) Comparisons of Updated URCS Models with Hybrid Models

Tables IV-18 and IV-19 compare (respectively) VCPTM by size category from the CA1 and CA2 scenarios of the updated URCS models with our preferred Hybrid model results using the same variabilities. The cost differences for a given variability scenario mostly result from the Hybrid model's use of the NEIO regression to compute shipment-level costs while the 431s4 and 30/70 scenarios use modified versions of the URCS Phase III model.

The most significant source of differences between the Hybrid model results and the modified URCS scenarios is larger effective cost efficiencies for intermodal shipments arising from the Hybrid model's NEIO regressions. This reallocates costs from intermodal to carload movements in the Hybrid model costs, compared to URCS. Intermodal costs using the modified URCS models are 20 percent higher than in the Hybrid model using the CA1 variability scenario, and 26 percent higher using the CA2 variabilities. Average VCPTM for 1-carload shipments are close in the Hybrid and modified URCS models—costs in the 431s4 scenarios are within 1 percent of the Hybrid costs using either set of variabilities; 1-carload costs in the 30/70 scenarios are lower than the Hybrid model costs but within 5 percent. The Hybrid and modified URCS models agree that 75+ carload unit train shipments are the lowest-VCPTM movements and that multiple-carload shipments move at average VCPTM below that of single-carload movements; the models disagree as to whether intermodal shipments have lower VCPTM than non-intermodal 1-carload shipments and with respect to the size of cost differences between single-carload and multiple-carload movements. The Hybrid model yields lower intermodal VCPTM and smaller average cost differences between single-carload and smaller multiple carload shipments.

Table IV-18. VCPTM in the Hybrid and Modified URCS Models (CA1 and CA2 Variability Scenarios)

Shipment Category	CA1 Variability Scenario			CA2 Variability Scenario		
	Hybrid	431s4	30/70	Hybrid	431s4	30/70
1 Carload	3.33	3.36	3.20	2.43	2.40	2.32
2-5 Carloads	2.83	2.38	2.41	2.08	1.76	1.79
6-24 Carloads	2.80	2.18	2.29	2.06	1.62	1.70
25-49 Carloads	2.57	2.18	2.31	1.89	1.61	1.71
50-74 Carloads	2.81	2.30	2.52	2.06	1.66	1.82
75+ Carloads	1.71	1.49	1.56	1.26	1.09	1.14
Intermodal	3.05	3.66	3.66	2.25	2.83	2.83

Table IV-19. Percent Differences in VCPTM, Modified URCS Models Compared to Hybrid Model (CA1 and CA2 Variability Scenarios)

Shipment Category	CA1 Variability Scenario		CA2 Variability Scenario	
	431s4	30/70	431s4	30/70
1 Carload	1%	-4%	-1%	-5%
2-5 Carloads	-16%	-15%	-16%	-14%
6-24 Carloads	-22%	-18%	-22%	-18%
25-49 Carloads	-15%	-10%	-15%	-9%
50-74 Carloads	-18%	-10%	-20%	-12%
75+ Carloads	-13%	-9%	-14%	-10%
Intermodal	20%	20%	26%	26%

Table IV-20 shows shares of freight tons above 180 percent R/VC in the Hybrid model and modified URCS scenarios. Given the set of variabilities, the Hybrid model yields lower shares of costs over 180 percent R/VC. In contrast to the modified URCS models, intermodal shipments have slightly above average shares of tons above 180 percent R/VC in the Hybrid model. The higher average costs in the Hybrid model for 2+ carload shipments lead to lower shares of freight tons over 180 percent R/VC than in the modified URCS models.

Table IV-21 shows the percentages of freight tons with R/VC less than 100 percent for the Hybrid and modified URCS models. For the CA2 variabilities, the Hybrid model's share of tons below 100 percent R/VC is slightly higher than the 431s4 URCS model and roughly the same as the 30/70 model. However, the modified URCS models have higher fractions of intermodal tons under 100 percent R/VC than the Hybrid model; the Hybrid model produces higher fractions of tons in the carload size categories below R/VC.

Table IV-20. Shares of Tons Above 180 Percent R/VC By Shipment Size Category, Hybrid Model and Modified URCS (CA1 and CA2 Scenarios)

Shipment Category	CA1 Variability Scenario			CA2 Variability Scenario		
	Hybrid	431s4	30/70	Hybrid	431s4	30/70
1 Carload	46%	53%	59%	77%	80%	84%
2-5 Carloads	41%	68%	68%	75%	91%	89%
6-24 Carloads	37%	65%	62%	71%	88%	85%
25-49 Carloads	40%	66%	59%	70%	90%	87%
50-74 Carloads	39%	71%	66%	75%	97%	94%
75+ Carloads	31%	48%	44%	60%	74%	72%
Intermodal	43%	27%	27%	74%	49%	49%
Total	38%	50%	49%	69%	76%	75%

Table IV-21. Shares of Tons Below 100 Percent R/VC By Shipment Size Category, Hybrid Model and Modified URCS (CA1 and CA2 Scenarios)

Shipment Category	CA1 Variability Scenario			CA2 Variability Scenario		
	Hybrid	431s4	30/70	Hybrid	431s4	30/70
1 Carload	9%	7%	6%	4%	3%	2%
2-5 Carloads	8%	2%	2%	3%	0%	0%
6-24 Carloads	10%	3%	4%	2%	1%	1%
25-49 Carloads	13%	4%	5%	4%	2%	2%
50-74 Carloads	10%	1%	1%	2%	1%	1%
75+ Carloads	16%	10%	11%	6%	4%	6%
Intermodal	9%	24%	24%	3%	13%	13%
Total	12%	9%	10%	5%	4%	5%

d) Differences Between Updated URCS and Hybrid Model Results Related to Intermodal Costs

In Section III, we noted that NEIO regression results produce greater cost efficiencies for intermodal movements compared to current-methodology URCS. Since intermodal cost efficiencies in URCS are not modified in the 431s4 and 30/70 URCS models, a natural question is whether and to what extent larger cost efficiency adjustments for intermodal in URCS would reduce cost differences between the Hybrid results and those of the modified URCS models.

Setting intermodal efficiency parameters in URCS to replicate Hybrid model costs is not a straightforward exercise. However, it is possible to approximate the Hybrid intermodal effects in URCS by calibrating URCS intermodal VCPTM to the Hybrid model's VCPTM, and then increasing costs for carload movements to keep total variable costs constant. In the calibration exercise, carload costs in the modified URCS models increase approximately 5.8 percent in the CA1 variability scenario and 7.7 percent with CA2 variabilities to offset the lower intermodal costs.[186] Table IV-22 shows the carload costs resulting from calibrating the modified URCS intermodal cost to the Hybrid model.

Table IV-22. Alternative VCPTM Calibrating 431s4 and 30/70 Models to Hybrid Intermodal Costs (CA1 and CA2 Variabilities)

Shipment Category	CA1 Variability Scenarios			CA2 Variability Scenarios		
	Hybrid	431s4	30/70	Hybrid	431s4	30/70
1 Carload	3.33	3.56	3.39	2.43	2.59	2.49
2-5 Carloads	2.83	2.52	2.55	2.08	1.89	1.93
6-24 Carloads	2.80	2.31	2.42	2.06	1.74	1.83
25-49 Carloads	2.57	2.30	2.45	1.89	1.74	1.85
50-74 Carloads	2.81	2.44	2.67	2.06	1.79	1.96
75+ Carloads	1.71	1.58	1.65	1.26	1.17	1.23
Intermodal	3.05	3.05	3.05	2.25	2.25	2.25

Table IV-23 shows the percent differences between the recalibrated URCS costs and the Hybrid model. Compared to Table IV-19, the calibration exercise reduces differences between the Hybrid model and modified URCS models for the carload size categories. Costs from the 30/70 Phase III model are uniformly closer to the Hybrid model costs than costs using the 431s4 modifications. In the 30/70 model scenarios, costs for the larger 1-carload and 75+ carload shipment categories are within 2-4 percent of the Hybrid model VCPTMs; the range of VCPTM differences for the 431s4 model is +/- 7 percent in those shipment size categories. The 30/70 scenarios also more closely match Hybrid model VCPTM for the smaller multi-carload size categories.

The generally smaller carload cost efficiencies with the 30 percent carload weight in the 30/70 scenarios, relative to current-methodology URCS, is at least directionally consistent with differences between the Hybrid model and current-methodology URCS. Remaining differences may be due both to differences in the shape of the carload efficiency curves between the Hybrid model—where logarithmic curves may affect measured cost efficiencies within the multiple carload range—and the CWB-modified URCS models. Other differences in model structure such as larger distance economies in the Hybrid model relative to URCS may also affect the VCPTM differences.

[186] We assume the increase in carload costs is distributed proportionally over carload movements.

Table IV-23. Percent Differences in Intermodal Alternative VCPTMs Compared to Hybrid Model

Shipment Category	CA1 Variability Scenarios		CA2 Variability Scenarios	
	431s4	30/70	431s4	30/70
1 Carload	7%	2%	6%	3%
2-5 Carloads	-11%	-10%	-9%	-8%
6-24 Carloads	-18%	-14%	-15%	-11%
25-49 Carloads	-10%	-5%	-8%	-2%
50-74 Carloads	-13%	-5%	-13%	-5%
75+ Carloads	-7%	-4%	-7%	-3%
Intermodal	0%	0%	0%	0%

Finally, Table IV-24 shows the estimated effects of calibrating intermodal costs in the modified URCS models to Hybrid VCPTM on the shares of traffic by size category over 180 percent R/VC. The combination of lower intermodal VCPTM and higher VCPTM in carload categories generally reduces tons greater than 180 percent R/VC compared to the results shown in Table IV-20, above. Differences in intermodal costing between the modified URCS model and the Hybrid model explain 2-3 percentage points of the differences in freight above 180 percent R/VC between the modified URCS models and the Hybrid model.

Table IV-24. Shares of Freight Tons Over 180 Percent R/VC with Intermodal Alternative VCPTMs

Shipment Category	CA1 Variability Scenarios			CA2 Variability Scenarios		
	Hybrid	431s4	30/70	Hybrid	431s4	30/70
1 Carload	46%	47%	53%	77%	75%	79%
2-5 Carloads	41%	64%	62%	75%	86%	85%
6-24 Carloads	37%	61%	57%	71%	82%	78%
25-49 Carloads	40%	60%	53%	70%	86%	79%
50-74 Carloads	39%	69%	59%	75%	94%	89%
75+ Carloads	31%	45%	41%	60%	69%	66%
Intermodal	43%	43%	43%	74%	67%	67%
Total	38%	48%	47%	69%	73%	72%

2. *Sensitivity Analyses for Other URCS Inputs*

In addition to the main URCS update scenarios described above, we ran additional sensitivity analyses to investigate the response of URCS costs to selected URCS input values that would require significant additional data collection effort to update or validate. In most cases, we used a scenario with CWB switching costs from the 431s4 scenario and variabilities from the CA1 scenario as the baseline costs.[187] We then modified the Phase II and/or Phase III inputs or formulas to implement the desired model input changes, computed variable costs for the CWB subsample using the modified URCS models, and compared results to the baseline. Inputs with small effects on URCS results may be given lower priority for future data collection and analysis resources should the STB eventually pursue additional updates to URCS inputs.

a) Equated Switching Factors

The "equated switching factors" determine relative SEMs for interchange and I&I switching relative to industry switching. As discussed above in Section IV.A.2, changing the equated switching factors alters the allocation of SEMs by type of switching, and thus may affect movement costs insofar as certain movements or types of movements avoid (or disproportionately incur) switching activities whose costs change.

With little guidance as to the extent to which the equated switching factors could change if they were to be reviewed, our sensitivity analysis increased the equated switching factors for interchange and I&I switching (individually) by 20 percent.[188] We also ran scenarios increasing both factors by 20 percent, and increasing one factor and decreasing the other factor, to check for offsetting and/or additive effects.

Table IV-25 summarizes changes in variable cost per ton-mile (VCPTM) by shipment size categories (including intermodal as a shipment category) for scenarios individually increasing the interchange and I&I factors. Table IV-26 shows the effects for the scenarios in which both equated switching factors are adjusted simultaneously.

We find that the VCPTM impacts are generally small (between -0.3% and +0.2%) and symmetric—if the sign of percent change in the equated switching factor is reversed, the VCPTM percent changes have opposite sign and approximately same magnitude. Increasing the I&I factor slightly increases costs for 1-carload movements and reduces them for movements over six carloads. The effects of increasing both the interchange and I&I factors are partly offsetting.

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[187] This baseline differs from the 431s4+CA1 scenario above in that the 431s4+CA1 scenario includes, and the baseline excludes, Phase II modifcations related to the allocation train fringes. The train fringe allocation change is assessed in Section IV.D.2.g below.
[188] While we do not report results for reducing the factors, we also checked the effects of reducing factors by 20 percent to confirm that the effects shown are symmetric.

Table IV-25. Variable Cost Per Ton-Mile—Equated Switching Factor Scenarios (Pt. 1)

Size Category	Variable Cost Per Ton-Mile (cents)			% Change vs. Baseline	
	Baseline	Interchange +20%	I&I + 20%	Interchange +20%	I&I + 20%
1 Carload	3.357	3.358	3.363	0.0%	0.2%
2-5 Carloads	2.381	2.381	2.381	0.0%	0.0%
6-24 Carloads	2.185	2.186	2.181	0.1%	-0.1%
25-49 Carloads	2.177	2.179	2.173	0.1%	-0.2%
50-74 Carloads	2.293	2.294	2.287	0.0%	-0.3%
75+ Carloads	1.502	1.503	1.5	0.1%	-0.2%
Intermodal	3.666	3.667	3.666	0.0%	0.0%

Table IV-26. Variable Cost per Ton-Mile—Equated Switching Factor Scenarios (Pt. 2)

Carload Size Category	Variable Cost Per Ton-Mile (cents)			% Change vs. Baseline	
	431s4+ CA1	Interchange and I&I +20%	Interchange +20% I&I -20%	Both +20%	Interchange +20% I&I - 20%
1 Carload	3.357	3.364	3.352	0.2%	-0.2%
2-5 Carloads	2.381	2.381	2.381	0.0%	0.0%
6-24 Carloads	2.185	2.183	2.189	-0.1%	0.2%
25-49 Carloads	2.177	2.175	2.183	-0.1%	0.3%
50-74 Carloads	2.293	2.287	2.3	-0.2%	0.3%
75+ Carloads	1.502	1.501	1.506	-0.1%	0.2%
Intermodal	3.666	3.666	3.667	0.0%	0.0%

b) Switching CM and CD Factors

Our review of switching CM and CD factors above suggested that CM and CD factors' effects may be partly offsetting. For instance, a change in a factor may increase unit costs per CD or CM, but the higher unit cost is then applied to fewer CDs or CMs in the Phase III model.[189]

Initially, we examined relatively small changes in the CM and CD factors (e.g., +/- 10 percent) and saw little effect on the cost outputs. We eventually increased the changes in the CM and CD factors to +/- 50 percent to obtain measurable impacts. As with the equated switching factors, we found that the effects of changing the factors were symmetric, and thus we report results from increasing the CM and CD factors individually in Table IV-27 and simultaneously in Table IV-28. We find that the effects of the factors on URCS costs are small, especially for the CM factors. This is reasonable because switching CMs are not a large share of total CMs for most rail

[189] A cautionary note is that the Phase II worktables have hardcoded assignments of costs to CMs and CDs using a fixed 50% CM/50% CD allocator. If CMs or CDs were dramatically different, it may stand to reason that the Phase II allocator should also change.

movements; in contrast dwell times in switching operations can be a relatively large portion of a movement's time in transit. Commodity-level impacts are also small – within approximately +/- 0.5% of the baseline costs. The commodity-level differences are due to additional variability in length-of-haul and switching event incidence by commodity, compared to the size category groups. CM and CD effects on intermodal movements are not exactly zero, but there is no difference in measured intermodal VCPTM rounded to thousandths of cents.

Table IV-27. Variable Cost Per Ton-Mile (Cents)—Scenarios Changing CM or CD Factors

Carload Size Category	Variable Cost Per Ton-Mile (cents)			% Change vs. Baseline	
	Baseline	CM Factors -50%	CD Factors -50%	CM Factors -50%	CD Factors -50%
1 Carload	3.357	3.358	3.36	0.0%	0.1%
2-5 Carloads	2.381	2.381	2.383	0.0%	0.1%
6-24 Carloads	2.185	2.185	2.183	0.0%	0.0%
25-49 Carloads	2.177	2.177	2.176	0.0%	0.0%
50-74 Carloads	2.293	2.291	2.285	-0.1%	-0.3%
75+ Carloads	1.502	1.502	1.504	0.0%	0.1%
Intermodal	3.666	3.666	3.666	0.0%	0.0%

Table IV-28. Variable Cost Per Ton-Mile (Cents)—Scenario Changing Both CM and CD Factors

Carload Size Category	Baseline	CM and CD Factors -50%	% Change
1 Carload	3.357	3.36	0.1%
2-5 Carloads	2.381	2.384	0.1%
6-24 Carloads	2.185	2.184	0.0%
25-49 Carloads	2.177	2.176	0.0%
50-74 Carloads	2.293	2.283	-0.4%
75+ Carloads	1.502	1.504	0.1%
Intermodal	3.666	3.666	0.0%

c) Cost Annualization Factors

We compared the URCS cost annualization approach with an alternative that eliminates all multi-year averaging of expenses in URCS Phase II. The alternative thus would use 2019 expenses directly in all cases. Since the expenses subject to annualization have been generally declining, we expected to find that eliminating annualization would generally reduce VCPTMs in the alternative scenario.

Table IV-29 shows that VCPTMs decreased for most URCS shipment size categories, though measured costs increased for 1-carload (non-intermodal) movements by 4 percent; the largest decreases in measured costs were for 75+ carload unit train movements (-8 percent) and intermodal (-6 percent). Table IV-30 shows differences in the distribution of R/VC (shares of tons) for the no-annualization scenario versus the baseline. Tons of freight above 180 percent R/VC increases overall (52% vs 50% of tons) as lower VCPTM for multiple-carload and intermodal movements more than offsets increased VCPTM for 1-carload shipments.

Since the effects of annualization are somewhat material, it may be worth considering whether the original motivations for cost averaging—avoiding instability due to expenses that may be incurred irregularly—remain valid.

Table IV-29. Variable Cost per Ton-Mile (Cents)—Expense Annualization Scenarios

Carload Size Category	Baseline	Baseline w/ No Annualization	% Change
1 Carload	3.357	3.507	4%
2-5 Carloads	2.381	2.339	-2%
6-24 Carloads	2.185	2.08	-5%
25-49 Carloads	2.177	2.06	-5%
50-74 Carloads	2.293	2.188	-5%
75+ Carloads	1.502	1.389	-8%
Intermodal	3.666	3.461	-6%

Table IV-30. Freight Tons with R/VC > 180 Percent, Expense Annualization Scenario

Scenario	R/VC <0.9	0.9<= R/VC<1	1<=R/VC <1.7	1.7<= R/VC <1.8	1.8<= R/VC<3	R/VC>=3	Total R/VC >=1.8
No Annualization	7%	2%	33%	5%	36%	16%	52%
Baseline	7%	2%	35%	5%	34%	16%	50%

d) Unit Train Threshold

To investigate the effects of changing the URCS minimum unit train size, we compared the 75-carload threshold proposed in Docket No. Ex Parte 431 sub-no. 4 to the 50-carload threshold in legacy URCS and an 80-carload threshold based on the 2019 average carloads for through and unit trains in Table IV-4. The scenario models recomputed the CWB SEM curves by calibrating to the URCS unit train efficiency adjustment at the specified unit train threshold. The effects of the change are somewhat ambiguous. Increasing the unit train threshold will tend to reduce the effective efficiency adjustment for movements below the threshold. However, since the cost allocation is (approximately) zero-sum, some movements will see declining costs to the extent they have below-average reductions in carload efficiencies.

Table IV-31 shows the changes in VCPTM from increasing the unit train threshold from 50 to 75 and from 75 to 80 carloads. The largest impacts are increases in VCPTM for the shipment size categories below the former threshold—25-49 carloads for the 50 to 75 change, and 50-74 carloads for the 75 to 80 carload change. Most other VCPTM changes are relatively small, especially for the increase from 75 to 80 carloads. Specifying the shape of the carload efficiency curve has material effects on at least some costs, which is also evident from comparing VCPTM in the 431s4 to the 30 percent carload weight scenario above. However, minor adjustments such as the effect of the 75 to 80 carload increase in the unit train threshold have expectedly small cost impacts overall.

Table IV-31. Variable Cost Per Ton-Mile (Cents)—75, 50, and 80 Carload Unit Train Scenarios

Carload Size Category	Minimum Unit Train Threshold 50 Carloads	75 Carloads	80 Carloads	% Change 75 vs 50	% Change 80 vs 75
1 Carload	3.362	3.357	3.357	-0.2%	0.0%
2-5 Carloads	2.38	2.381	2.382	0.1%	0.0%
6-24 Carloads	2.18	2.185	2.185	0.2%	0.0%
25-49 Carloads	2.135	2.177	2.178	1.9%	0.1%
50-74 Carloads	2.306	2.293	2.314	-0.6%	0.9%
75+ Carloads	1.499	1.502	1.502	0.2%	0.0%
Intermodal	3.666	3.666	3.666	0.0%	0.0%

e) Station Clerical Costs

Our alternative scenario for CWB-based station clerical costs calibrates the station clerical CWB efficiency curve to a 60 percent cost reduction at the URCS multi-car threshold (6 carloads) instead of a 25 percent cost reduction.[190] The effect overall is to increase station clerical efficiencies for multiple carload shipments. While station clerical costs are not a large component of costs for most movements, Table IV-32 shows that the increased cost reduction has a measurable effect on costs, with larger effects on movements of 25 or more carloads. The reduction in the assignment of station clerical costs to multiple carload movements leads to an offsetting increase in VCPTM for 1-carload shipments by 0.2 percent.

[190] We also considered a 75 percent cost reduction but found that drove some of the CWB carload weights negative. Given that operational considerations suggest that station clerical costs may have some dependency on carload, we wanted the scenario to maintain some effect of carloads on costs rather than a full weight on the shipment. The alternative scenario also does not change the treatment of intermodal shipments.

Table IV-32. Variable Cost Per Ton-Mile (Cents)—Station Clerical Scenarios

Carload Size Category	Station Clerical Efficiency		% Change
	25% Cost Reduction	60% Cost Reduction	
1 Carload	3.357	3.364	0.2%
2-5 Carloads	2.381	2.38	-0.1%
6-24 Carloads	2.185	2.177	-0.3%
25-49 Carloads	2.177	2.165	-0.5%
50-74 Carloads	2.293	2.273	-0.8%
75+ Carloads	1.502	1.496	-0.4%

f) I&I Switching Distance

The alternative scenario to investigate the sensitivity of costs to the I&I switching distance input extends the distance between I&I events to 300 miles, per Table IV-3, from 268 miles in the base scenario. We would expect somewhat offsetting effects as the increase in the I&I distance input will tend to reduce the number of I&I events per movement but increase the variable cost per event. Any net cost shifts will tend to result from different incidence of I&I costs by size due to efficiency adjustments in the model. Table IV-33 shows that increasing the distance between I&I events has small effects on VCPTM, amounting to a small shift of costs from 1-carload shipments to multiple carload movements.

Table IV-33. Variable Cost Per Ton-Mile (Cents)—I&I Distance Scenarios

Carload Size Category	Distance Between I&I Switches		% Change
	268 miles	300 miles	
1 Carload	3.357	3.353	-0.1%
2-5 Carloads	2.381	2.381	0.0%
6-24 Carloads	2.185	2.186	0.1%
25-49 Carloads	2.177	2.179	0.1%
50-74 Carloads	2.293	2.297	0.2%
75+ Carloads	1.502	1.503	0.1%
Intermodal	3.666	3.667	0.0%

g) Phase II Semi-Default Allocation of Train Fringes

In legacy URCS Phase II, train fringe benefit expenses are allocated over multiple outputs including train miles, locomotive running miles, and gross ton-miles, reflecting the inclusion of the fringe benefit expenses with other (non-labor) train overhead costs in the cost pools for the legacy Phase I variability models. The alternative scenario applies the same allocator used for train and locomotive crew labor—which mostly assigns the costs to train-miles (with a small

fraction of costs assigned to way switching). We consider the alternative scenario to be more representative of cost causality for train crew labor costs (both wages and benefits).
Table IV-34 shows the effects of reallocating the train fringes on VCPTM. The effect of the change is small for most size categories. The largest effect is an 0.7 percent reduction in average VCPTM for 75+ carload movements. This impact occurs because gross ton-mile costs in URCS (on a per ton-mile basis) do not vary with the number of carloads in the movement. Additionally, train-mile costs (unlike locomotive-mile costs) decline with shipment size past the unit train breakpoint. While the allocation of train fringes has modest effects outside of 75+ carload movements, we view the change as worth considering for inclusion in the Phase II model as it may be implemented as a technical fix to the allocator without requiring costly additional study.

Table IV-34. Variable Cost Per Ton-Mile (Cents)—Alternative Train Fringes Allocation

Carload Size Category	Legacy Train Fringes Allocation	Alternate Train Fringes Allocation	Pct. Diff.
1 Carload	3.357	3.365	0.2%
2-5 Carloads	2.381	2.383	0.1%
6-24 Carloads	2.185	2.184	0.0%
25-49 Carloads	2.177	2.177	0.0%
50-74 Carloads	2.293	2.301	0.3%
75+ Carloads	1.502	1.492	-0.7%
Intermodal	3.666	3.662	-0.1%

E. CONCLUSIONS

In this section, we considered the effects on rail freight variable costs and R/VC ratios of improvements to costing methods largely within the URCS framework. The notable improvements include the use of cost elasticities estimated in Section III of the report to update cost variability factors in URCS Phase II, and the use of the CWB model to replace step functions for carload-related cost efficiencies in the legacy URCS make-whole adjustments. We also assessed the sensitivity of URCS costs to various URCS model parameters including switching-related parameters based on old studies of railroad operations and cost annualization factors assigned judgmentally in the development of URCS. We compared results of the modified URCS models with the closest corresponding Hybrid models.

We find that the most important URCS inputs affecting shipment-level variable costs are the cost variability factors and carload efficiency adjustments applied to switching costs. Since costs subjected to annualization in URCS have generally been decreasing prior to 2019, we also find that the URCS annualization procedures increased measured shipment costs by effectively slowing the incorporation of relatively low 2019 costs.

Since the updated Phase I cost elasticities are mostly lower than the current URCS variabilities derived from the legacy Phase I models, incorporating the variability updates reduces costs in general and does so relatively uniformly across shipment types. Adding the econometric short-run cost elasticities for ROI and DRL costs leads to large additional reductions in variable costs. In this case, where unit variable costs may be interpreted as short-run marginal costs, variable costs are approximately 30 percent lower, overall, than current-methodology URCS. This has a correspondingly large effect on the measured fraction of freight traffic moving at R/VC over 180 percent and thus potentially subject to regulatory review. The overall fraction of rail freight tons over 180 percent R/VC increases from 50 percent in current-methodology URCS to 75 or 76 percent in the modified URCS models. Moreover, shares of tons over 180 percent R/VC are above average for shipments under 75 carloads.

Comparing costs from modified URCS models with the Hybrid model, we find material differences in the models' costing of intermodal shipments and allocations of costs among carload categories. It appears, however, that differences between the Hybrid and modified URCS models would be materially reduced if intermodal cost efficiencies in URCS were increased to the NEIO-based intermodal cost efficiencies in the Hybrid model. While intermodal costing is not the only source of differences between Hybrid and modified URCS model results, it is a major and economically significant driver of differences among the models. We find that costs from modified URCS models using the 30 percent CWB carload weight proposed by AAR declarants in Docket No. Ex Parte 431 sub-no. 4 are materially closer to Hybrid model costs than the STB's proposal calibrating CWB efficiency curves to the legacy URCS efficiency adjustments.

As with the Hybrid model, the increase in traffic with measured R/VC over 180 percent in the updated URCS models may warrant adoption of a bridging factor to avoid or limit the extent to which URCS methodology changes increase or decrease the amount of freight traffic subject to STB jurisdiction. Most of the effects of URCS model changes on traffic subject to the jurisdictional threshold in the updated URCS scenarios result from variability changes, though implementing a CWB model for carload efficiencies tends to redistribute costs among size categories for carload movements. Increasing efficiency adjustments for intermodal shipments in updated URCS models in line with Hybrid model costs mitigates the increase in carload traffic over 180 percent R/VC.

Our sensitivity analysis of other URCS parameters finds that inputs such as equated switching factors and car-mile and car-day factors used to develop switching costs do not have large, systematic effects on measured variable costs, even when subjected to large changes from the current URCS input values. These inputs' effects on measured costs are limited as they tend to operate through offsetting effects—e.g., increasing the number of switching events of a given type while simultaneously reducing the cost-per-event. Thus, updating these factors may be given lower priority for future resources than resolving issues related to factors with larger impacts such as carload and intermodal efficiency adjustments.

V. CONCLUSIONS AND RECOMMENDATIONS

A. SUMMARY OF KEY FINDINGS

The *Alternatives to URCS* project set out to identify and evaluate possible alternatives to URCS that could better or more efficiently reflect the operating environment of the modern railroad industry. The project focused on costing methodologies that could be used as replacements or major structural updates to URCS to generate movement-specific variable costs for regulatory purposes. Specifically, the project:

- Assessed the economic cost measure(s) that URCS or a successor cost system should represent given the regulatory applications of URCS
- Identified economic assumptions under which URCS or successor cost systems produce economically appropriate measures of costs for railroad movements
- Evaluated whether alternative costing methodologies and structural updates to URCS could generate economically valid railroad variable costs for regulatory purposes
- Implemented URCS alternatives and updates and compared model costs and revenue-to-variable cost (R/VC) ratios to current-methodology URCS
- Quantified the effects of URCS alternatives and updates on the application of the Surface Transportation Board's jurisdictional threshold for market dominance determinations
- Considered the advantages and disadvantages of the URCS alternative and URCS update approaches, including the ability to reflect current railroad operations and adherence to the costing principles in the RAPB Final Report

Our analyses lead to the following main findings.

1. *Short-Run Economic Costs (Marginal and Incremental Costs) are Appropriate for the Statutory Application of URCS*

Economic interpretation of URCS costs fundamentally flows from the RAPB's Causality principle. The RAPB correctly defined causal variable costs in a manner consistent with the economic concepts of marginal and incremental costs. Economic characterizations of the exercise of market power in pricing are linked to marginal costs since competitive market outcomes equate price with marginal cost. For industries such as the railroad industry marked by fixed costs and/or economies of density, marginal cost pricing does not recover firms' total costs and is not sustainable. Markup levels required for sustainable (breakeven) pricing thus may be characterized relative to marginal costs.

Since the main application of URCS relates to measurement of railroads' exercise of market power, the appropriate time horizon for URCS costs should be a form of the economic "short run." The economic short run is characterized by limitations on railroads' ability to freely adjust all of their input usage over relevant decision horizons. Generally, we consider the relevant decision horizon(s) to be the time period(s) over which railroad rates potentially subject to STB review are in effect. Notably, capital inputs such as way, structures, and equipment may be viewed as less flexible over shorter time horizons than inputs comprising railroads' operating costs. Technically, the "intermediate run" orientation of URCS variable costs constitutes a type of short run costs that assumes limited variability of way and structures capital costs with respect to output, though that is implemented in current methodology by applying non-empirical ("default") variability factors for capital costs of way, structures, and equipment.

2. *URCS and URCS-Like Models Can Produce Short-Run Economic Costs for Railroad Movements, but URCS Costs Depend Materially on Non-Empirical and/or Stale Input Values*

Variable costs for railroad movements in URCS can be characterized as the result of two stages of cost calculations, which we describe in Section II. The first stage computes "generic" (railroad average) unit variable costs for an assortment of railroad outputs; this stage combines URCS Phases I and II. The second stage (URCS Phase III) computes outputs for a given movement and applies unit variable costs from the first stage to the movement-specific outputs along with adjustments to the generic costs based on movement characteristics. This costing approach is consistent with economic costing under the Causality principle provided that the unit variable costs (generic and movement-adjusted) can be interpreted as marginal costs. This interpretation is correct insofar as Phase I variabilities and other cost allocators are equivalent to cost elasticities with respect to railroad outputs (output elasticities). Methods that produce estimates of average variable costs generally are inconsistent with the Causality principle.

The current URCS Phase I variabilities can be interpreted as output elasticities given the specific form of the models, though Phase I as adopted for URCS was not intended to produce output elasticities in general. However, since the Phase I models have not been updated since the adoption of URCS, the variable cost calculations use parameters from regression models using data from the 1980s that are ripe for review. URCS variable costs also depend heavily on the use of assumed values of "default" variabilities for capital costs that were not covered by the Phase I models. The default variability application is not necessarily inconsistent with the causality principle, but the accuracy of the resulting variable cost allocations (as short-run marginal or incremental costs) depends on the empirical justifiability of the assumed default variabilities. Changes in railroad cost structure have markedly increased the share of Class I railroad costs subjected to default variabilities, from 22 percent as of the adoption of URCS to 46 percent in 2019.

Validity and accuracy of URCS costs also depends critically on the appropriate implementation of efficiency adjustments for certain categories of movements in Phase III, most notably the "make-whole" carload efficiency adjustments to switching costs for multiple carload and unit train movements. Given their importance for URCS costing, the Phase I models and Phase III efficiency adjustments were, not surprisingly, identified as potential priorities for URCS improvements by stakeholders in STB proceedings on URCS[191] and in direct stakeholder interviews we conducted as part of the study.

3. *Using Carload Waybill Sample Data to Reveal Movement Cost Information Has Promise But Also Practical and Theoretical Challenges*

The STB's 2010 Report to Congress on URCS identified the "NEIO" and "[Christensen] Hybrid" models as potential URCS alternatives meriting further analysis and consideration, which the Alternatives to URCS project has conducted. A common feature of the NEIO and Hybrid models is their use of data from the STB's CWS to infer information on movement costs from rate or pricing information. The fundamental challenge for these approaches is that while CWS provides rich data on revenues and characteristics of sampled railroad movements, it does not directly provide any information on costs. To extract cost information from the CWS data, the NEIO and Hybrid models use a result that railroads' profit-maximizing prices can be decomposed into marginal cost and markup components. That this decomposition can be accurately measured using a "NEIO regression" of revenue per ton-mile from the CWS on characteristics that relate to costs and market conditions should be considered a crucial assumption of the NEIO and Hybrid alternatives. The Hybrid model's incorporation of a separate marginal cost model does not eliminate the assumption.

The specifications of the NEIO regressions used in the Hybrid model cost calculations are broadly consistent with prior research characterizing the relationship between rates and movement characteristics in the CWS, including our analysis for the Christensen 2009 Competition Study, the Bitzan and Wilson 2003 NEIO models, and prior CWS analyses. As with any econometric analysis of sufficient complexity, the specifications involve choices where other researchers may apply different criteria or otherwise prefer different approaches. We expect that if the STB were to pursue the Hybrid model as an URCS Alternative, both the validity and specification details of the NEIO regressions would be areas of major controversy.

4. *URCS Variability Inputs Can and Should Be Updated, but Limitations of the R-1 Annual Report Data May Merit Investigation of Changes to Cost Reporting Requirements*

Both the Hybrid alternative and URCS require cost elasticity inputs to determine generic unit variable costs. As a mechanical matter, it is possible to use legacy URCS variabilities in the Hybrid model or as an input to modified URCS Phase III models.[192] However, given the considerable changes to railroad industry organization since the adoption of URCS, the URCS Phase I cost variability models are overdue for updating.

Our update to the URCS Phase I models included a re-evaluation of the cost pools for railroad operating costs used by Westbrook as well as the model specification choices that led Westbrook

[191] STB Dockets Ex Parte 431 Sub-No. 3 and Sub-No. 4.
[192] Doing so has a practical benefit of isolating cost variability changes from other movement costing changes in the alternative and updated models.

to prefer linear (levels) cost equations and the "percent variable" method for determining variabilities. Cost pool changes included combining wage and fringe benefit expenses into cost pools for labor expenses and combining "direct" and "overhead" cost pools for road and freight car maintenance expenses.

We agree with the RAPB that the Phase I analysis should estimate cost elasticities as inputs to calculation of unit variable costs that are equivalent to marginal costs and thus consistent with the Causality principle. The choice of model specification is open under the RAPB costing principles, though the RAPB articulated a preference for methods that can produce railroad-specific elasticities. We considered regressions models in levels, closely related to the legacy Phase I equations, and first- and second-order logarithmic models using annual observations from 1990-2019. We rejected the second-order logarithmic models as data limitations lead to unstable estimates of some model parameters. While the Westbrook-type levels models and the first-order logarithmic models yield similar overall variabilities (expense-weighted averages), we prefer the logarithmic models as the levels models produce less stable results. With the logarithmic models, the expense-weighted average of the updated cost elasticities is 0.68, 13 percent lower than the 0.78 weighted average of the 2019 URCS variabilities.

We also extended the Phase I analysis to model ROI and DRL expenses and thus obtain empirical short-run cost elasticities for comparison with URCS defaults. We estimated three cost equations—with ROI and DRL costs for asset categories as the dependent variables—for way and structures, freight car, and locomotive expenses. The models otherwise used first-order logarithmic specifications and the 1990-2019 period as in the preferred Phase I operating cost models. We found the empirical cost elasticities to be much lower than the URCS default values (either 50 or 100 percent depending on the type of expense). The estimated elasticities for way and structures, freight car, and locomotives were 0.19, 0.42, and 0.45 (respectively). The empirical ROI and DRL cost elasticities have large downward effects on measured variable costs in cost scenarios where they replace the URCS defaults.

Finally, we attempted to update the "industry variable cost" model from the Christensen 2009 Competition Study, which was the source of marginal cost inputs to the original formulation of the Hybrid model presented in the 2009 study.[193] The 2009 industry variable cost model used a translog cost function (a second-order approximation to a general, unknown cost function) that allows for input substitution among other economic behavioral features that the URCS Phase I models may be criticized for omitting. The translog functional form has a large number of parameters involving squared and interaction terms for railroad output, network size, capital stock, input prices, and other explanatory variables; those parameters affect estimates of cost elasticities with respect to output and network size. We found that railroad-specific cost elasticities from the translog model were unstable and had implausibly large ranges. A first-order

[193] Cost elasticities from the industry variable cost model are not necessarily compatible with the structure of URCS, though it is mechanically possible to assign a common cost elasticity with respect to output to all expenses (or all "variable" expenses) in the URCS Phase II workbooks.

(Cobb-Douglas) functional form yielded reasonable industry aggregate cost elasticities but may be overly restrictive as a source for railroad-specific marginal costs.

The difficulties in estimating more "flexible" cost specifications for both the Phase I cost equations and economic cost functions is in large part a reflection of the limited data with which to estimate models with highly collinear regressors. The R-1 annual reports currently provide seven observations per year, requiring longer time series to equal the numbers of observations available to researchers in previous studies. While the stable industry configuration for most of the 2000s has some benefit in reducing the need to address railroad mergers and acquisitions, we found that limited within-railroad variation in the data made it difficult to obtain statistically precise estimates of cost model parameters.

The RAPB considered whether railroad cost reporting should be required for "cost centers" below the firm level and concluded that the burden of additional reporting detail was likely not justified by its benefits. It is a matter of speculation what data Class I railroads could provide and how useful it might be for future cost modeling. An initial step for the STB could be to inquire as to the types of additional cost information that railroads currently collect.

In addition, the total lack of cost and output data for Class II and III railroads means that the accuracy of Class I proxy costs for Class II and III movements in URCS is unknown. While the full Class I reporting detail may not be necessary, some data reporting from Class II and III railroads could be justifiable.

5. *The "Hybrid" Model is a Feasible Alternative for Costing Class I Movements, and Its Costs are Plausible Where Different from Legacy URCS*

For this study, we refined the Hybrid model to remedy several significant limitations of the model presented in the 2009 Competition Study. The refinements allow the Hybrid model to cost all railroad movements for which generic marginal cost data are available,[194] improve costing of intermodal movements, and allow increased flexibility of movement-specific costs with respect to cost-causing characteristics including movement distance and movement size in carloads. We also conducted an analysis of current-methodology URCS costs using the NEIO model framework to allow us to compare effects of movement cost characteristics between URCS and the Hybrid alternative. We can produce Hybrid costs using either disaggregated cost elasticities derived from cost equations that update the URCS Phase I models or by estimating a variable cost function for the Class I railroad industry. While the latter approach has theoretical appeal as it models features of economic behavior such as input substitutability that is omitted from the Phase I models, limitations of the available cost data for estimating flexible cost functions leads us to prefer the disaggregated approach.

[194] In the Christensen 2009 Competition Study, the original Hybrid model costs could only be computed for a subset of movements in the CWS involving a single Class I railroad, and thus did not cover movements involving interchanges among railroads.

The NEIO regression results and resulting Hybrid model costs show notable differences between the cost structure implied by rate data in the CWS and the current-methodology URCS model:

- Smaller economies with respect to movement size (carloads) than URCS, and do not support the step function structure of URCS carload efficiencies
- Larger economies with respect to movement distance than URCS
- Larger cost efficiencies for intermodal movements (relative to single-carload non-intermodal movements) compared to URCS
- Smaller implicit rental costs for railroad-owned equipment compared to URCS
- Significant rate premiums for hazardous material movements that may in part reflect implicit or explicit costs of such movements that are not modeled in URCS

Hybrid model costs consequently remedy some anomalies in measured costs from current-methodology URCS. For example, URCS results show relatively high shares of intermodal movements moving at revenues below measured variable cost. In the Hybrid model, shares of intermodal movements under 100 percent R/VC are near or slightly lower than the system average. In contrast, carload movements in URCS just above the 50-carload unit train breakpoint have exceptionally high measured R/VC as a group, compared both to multiple-carload movements below the breakpoint and to larger (75+ carload) movements. We view this result as an artifact of the step functions used in legacy URCS to implement efficiencies related to movement size. The Hybrid model costs eliminate the R/VC discontinuity in the vicinity of the legacy unit train breakpoint. Using variabilities that implement short-run marginal costs, the overall share of freight traffic moving below measured marginal cost is low—on the order of 5 percent of tons or ton-miles—though not zero.[195]

A notable limitation of the Hybrid model relates to costing movements on Class II and III railroads. Since Class II and III railroads do not report cost or output data to the STB,[196] it is not possible to estimate generic marginal costs for Class II and III railroads directly. It is possible to use NEIO model results to characterize differences in cost characteristics between movements on Class I and Class II-III railroads and adjust Class I generic marginal costs accordingly to serve as a basis for non-Class I movements. However, the results of such adjustments are not entirely satisfactory. While they expectedly show that Class II and III railroads' movements are relatively high cost per ton-mile (due both to shorter movement distances and other movement characteristics), the NEIO-based adjustment may tend to over-cost the movements as indicated by relatively high fractions of Class II and III traffic moving below estimated short-run marginal cost. This may reflect a fundamental limitation of the NEIO regression approach for identifying cost differences between railroads. Successfully extending the Hybrid model to Class II and III movements may require developing direct data on those railroads' generic marginal costs.

195 The result is primarily driven by the updated variabilities used in the Hybrid model.

196 Moreover, since the Class II and III railroads are privately held, there is no public financial information of any sort for that segment of the industry

6. *Updates to URCS Phases I and III Improve Movement Costing Within the Existing URCS Framework*

In Docket No. Ex Parte 431 Sub-No. 4 (EP431 sub 4), the SNPR,[197] the STB presented revisions to elements of the URCS Phase III model to remedy perceived problems with the Phase III make-whole adjustments and other Phase III cost calculations. The changes pursued in EP431 sub 4 would, if adopted by the Board, improve the Phase III model structure compared to the legacy efficiency/make-whole adjustments.[198] Combined with implementation of updated cost elasticities to replace the legacy URCS Phase I variabilities, feasible updates to URCS can better reflect cost causation for railroad freight movements while largely retaining the current URCS model structure.

Perhaps the most consequential was the proposed modification of SEM cost allocations. The SNPR proposed to change the allocation of SEM costs basis to a model based on a time component (carload basis) and an event component (shipment basis) of switching. The CWB model implementing this approach would eliminate the step functions between single-car and multi-car shipments and between multi-car and unit train shipments and also eliminate the need for the make-whole adjustment in the legacy URCS model. The CWB curves result in reduced costs as shipment size (e.g., number of carloads) increases.[199] While most parties in EP431 sub 4 agreed that SEM cost allocations should consider both time and event components, they did not accept the SNPR's CWB approach, which calibrated the CWB curves to the legacy URCS efficiency adjustment. For example, based on preliminary analysis, the AAR recommended that SEM costs be allocated on a 30% carload, 70% shipment basis (the basis of "30/70" CWB scenarios in Section IV).

To the extent the costs of switching events are appropriately characterized as having event and time components, with the latter depending on the number of carloads in the event, the existing step functions are unwarranted. Our modeling of revenue per ton-mile data from the CWS for the Hybrid model also shows little evidence from rail pricing of the existence of size-based step functions underlying costs. The CWB methodology represents a clear improvement over the existing make-whole adjustments, subject to empirical studies to refine the shapes of the cost curves.

A central question for implementing the CWB approach is determining the appropriate carload and shipment basis in setting the CWB curves. Results from the Hybrid model analysis suggest that actual intermodal cost efficiencies are larger, and carload efficiencies are smaller, than the efficiencies in the current URCS model. However, because of model structure differences, Hybrid model data do not translate into specific values for URCS model inputs including

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197 Docket No. EP 431 (Sub-No. 4), SNPR, August 4, 2016.

198 Modifications were proposed for the following categories in the SNPR: (1) Switching costs related to SEM; (2) Equipment costs for the use of railroad-owned cars; (3) Station clerical costs; (4) Car-mile costs; (5) I&I switching mileage; (6) Unit train definition; (7) LUMs; and (8) Train miles.

199 EP431 sub 4 SNPR, p. 9.

parameters of the CWB efficiency curves. The "431s4" scenarios partly preserve current URCS methodology by calibrating the CWB efficiency curves to the legacy URCS adjustments. Based on the scenario analysis using the 431s4 and 30/70 CWB curves, changing the shapes of the CWB curves (i.e., SNPR methodology vs the AAR 30% carload weighting proposal) has limited effects on the overall volumes of freight above/below 180 percent R/VC, other things equal, but has material effects on the composition of such traffic. Costs from the 30/70 scenarios tend to be closer to Hybrid model results otherwise using the same set of variability factors.

Regarding the other SNPR proposed changes, we generally agreed with them and, together, the SNPR modifications (431s4 scenarios) had limited impact on results. Our sensitivity analysis of other URCS parameters finds that inputs such as equated switching factors and car-mile and car-day factors used to develop switching costs do not have large, systematic effects on measured variable costs, even when subjected to large changes from the current URCS input values. These inputs' effects on measured costs are limited as they tend to operate through offsetting effects—e.g., increasing the number of switching events of a given type while simultaneously reducing the cost-per-event. Thus, updating these factors may be given lower priority for future resources than resolving issues related to factors with larger impacts such as carload and intermodal efficiency adjustments.

Since the updated Phase I cost elasticities are mostly lower than the current URCS variabilities derived from the legacy Phase I models, incorporating the variability updates reduces costs in general and does so relatively uniformly across shipment types. Adding the econometric short-run cost elasticities for ROI and DRL costs leads to large additional reductions in variable costs. In this case, where unit variable costs may be interpreted as short-run marginal costs, variable costs are approximately 30 percent lower, overall, than current-methodology URCS.

7. Advantages and Disadvantages of the Hybrid Alternative and URCS Update Approaches

The Hybrid model's use of an econometric analysis of CWS data to model marginal cost differences across movements has significant advantages and disadvantages relative to current URCS methods. The main advantage is that the Hybrid's NEIO regression model of CWS data provides empirical estimates of nearly all movement-specific cost adjustments required to implement the model, and thus in principle eliminates the need to maintain numerous URCS model parameters derived from studies of railroad operations or—in some cases—analyst judgment. The CWS regression models are straightforwardly updated with new CWS data as it becomes available and may thus be refreshed annually or periodically as desired. The Hybrid model can potentially be enriched with improved econometric methods that allow better exploitation of the rich CWS data.

The Hybrid model's main disadvantage is a technical econometric issue but a potentially serious one, which is closely related to our rationale for rejecting the NEIO model as a stand-alone URCS alternative. The NEIO regression is a "reduced form" model in which it is not technically possible to ensure that the "cost" variables in the regression only capture effects of movements' cost characteristics and are not contaminated with effects of factors determining markups. An additional consideration is that the NEIO regression amounts to a "black box" from which the cost mechanisms underlying the model cannot be observed or validated. Finally, the Hybrid model has a limited ability to produce costs for Class II and III railroads, since the regional URCS proxy costs currently used in URCS are not suitable inputs for the Hybrid model. Possibilities are to require some level of cost and output reporting of Class II and III railroads, or retaining URCS to cost Class II and III movements in the absence of data to justify a change in methodology.

The advantages and disadvantages of the URCS update approach are, in large part, the antipodes of those of the Hybrid model. The modified URCS models are relatively transparent in that the development and application of costs and cost adjustments can be traced through workpapers implementing the URCS Phase II and Phase III models. However, the updated URCS models' cost calculations still depend on numerous inputs that are difficult if not impossible to obtain from data periodically reported by railroads to the STB. Thus, maintaining the modified URCS models can require costly operational studies, imposing analysts' assumptions, or tolerating potentially outdated input values. Our sensitivity analysis suggests that many such parameters do not have material effects on measured movement costs even if their values in URCS are grossly inaccurate; immaterial inaccuracies may be tolerated under the RAPB's Practicality principle. However, important parameters such as carload and intermodal efficiency adjustments are material and are not easily measured.

8. *Implementing an URCS Alternative or Update Will Materially Affect Application of the STB's Jurisdictional Threshold*

Our results from both the Hybrid and modified URCS models show that any non-trivial changes to the URCS model can have potentially significant effects on the application of the statutory R/VC threshold test for the STB's jurisdiction. Even using legacy URCS variabilities to develop movement costs, other methodological changes in the Hybrid and CWB-modified URCS models will materially affect costs, and hence R/VC ratios, for at least some categories of railroad movements, and can shift portions of freight rail traffic over or under the 180 percent R/VC threshold. Implementing empirical variabilities in place of the current URCS default values for ROI and DRL costs has the largest effects on measured R/VC ratios of the URCS alternatives we explored. Using the same set of variabilities, the Hybrid model tends to produce less traffic (in tons) above 180 percent R/VC than current-methodology or modified URCS models.

A challenge for the application of short-run costs is that the 180 percent threshold is tied to variable cost levels in legacy URCS (or perhaps Rail Form A, which was the GPCS as of enactment of the Staggers Rail Act). A "bridge adjustment" applied to costs from an URCS alternative or update could, in principle, limit the extent to which cost changes re-regulate or de-regulate portions of railroad traffic. Such an adjustment may need to be both permanent and relatively large to counteract the effects of cost methodology changes relative to current-methodology URCS. Additionally, effects of cost changes on the overall stringency of freight rail regulation are moderated by the large share of traffic that is exempt from rate regulation irrespective of R/VC, including movements at contract rates and movements of exempted commodities or freight car types. It may be logical to tie the jurisdictional threshold to a figure such as the (average) breakeven markup over marginal costs required to cover railroads' total costs. However, such an approach would require a legislative change.

B. CONCLUSION

URCS is fundamentally tied to the railroad regulatory system by statute. Without Congressional action, URCS can only be replaced in the statutory test for STB jurisdiction over rates by an alternative cost system that produces variable costs for railroad movements.[200]

Given the primary role of URCS in evaluating whether railroads exert market dominance in their rates, short-run costs (marginal and/or incremental costs) are the most appropriate economic cost concept for URCS variable costs. Short-run marginal and incremental costs are consistent with the Causality principle underlying URCS methodology and are feasible to produce using existing data. The same general framework also may be used to produce costs using the "intermediate run" time orientation in current-methodology URCS.

For the Alternatives to URCS project, we implemented the "Hybrid" model as an URCS alternative. To provide an appropriate basis for evaluating the Hybrid model, we also implemented modified URCS models with significant changes to the Phase I variabilities and Phase III movement costing models. Variable costs derived from both the Hybrid model and updated URCS models exhibit some material differences from current-methodology URCS costs in all model scenarios we investigated. The largest differences from current-methodology URCS result from the implementation of variabilities (cost elasticities) that implement short-run costs in the Hybrid and updated URCS models. Additional material differences in model costs result from changes to the calculations of movement-specific variable costs.

We consider both the Hybrid model and updated URCS models to be promising alternatives to current-methodology URCS. The Hybrid and updated URCS models share new Phase I variabilities that improve upon the legacy URCS analysis from 1988, and we recommend that the Phase I models be updated regardless of the modeling approach. Using the full set of short-run cost elasticities—including the empirical replacements for URCS default variabilities—addresses a criticism of the current URCS approach by greatly reducing (but not eliminating) the share of freight traffic calculated as moving below its measured variable cost.

In our view, an appropriate course of action would be to pursue either the Hybrid model or significant updates to URCS—Phase I variability updates plus structural changes to Phase III to replace the legacy make-whole adjustments for carload efficiencies. The choice depends on the weighting of the advantages and disadvantages of each approach. The Hybrid model uses

[200] While some researchers have argued for railroad rate regulation approaches that do not employ costs at all, those are at least partly inconsistent with current law. See, e.g., Wilson and Wolak 2016; Transportation Research Board, *Modernizing Freight Rail Regulation*, Special Report 318, 2015, pp. 205-208.

empirical estimates of all of the model parameters, which can in principle be updated by updating the CWS data in the NEIO regressions, but still hinges on an assumption that the NEIO regression model effectively disentangles cost from markup factors on rates. The updated URCS approach provides greater visibility into the development of movement variable costs but retains the URCS dependency on numerous hard-to-verify cost model inputs. If the URCS model structure were to be retained with structural updates, a top priority for further study should be to establish empirical parameterization of the CWB efficiency curves, including empirical review of efficiency adjustments for intermodal movements.

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