Analysis of changes in coal transportation routes and costs in response to new fees for transit through Maryland

Task 1 Report

Submitted to:
Maryland League of Conservation Voters

Submitted by:
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About the Authors

Dr. Lisa A. Wainger is a Research Professor of environmental economics and decision science at the University of Maryland Center for Environmental Science. She received her Ph.D. in environmental economics from the University of Maryland and has a B.S. in geology from the University of California. She has over 25 years of experience in applying economic tools to analyze the performance of environmental policy. She manages a research group that conducts applied economic analyses, risk assessments, and spatial analysis using geographic information systems (GIS) that are used in a variety of decision contexts in federal and state government, nonprofit organizations, and private business.

She has designed and led many economic analyses for the Maryland Port Administration (MPA) Dredged Material Management Program. In over 20 years of working with the MPA, she has gained deep knowledge of Port of Baltimore operations and logistics. Her group is currently working on analyzing optimal infrastructure investments for the Port under climate change uncertainty.

She and her team have done prior transportation cost analyses to inform oyster policies in Maryland and coal mine permitting in Appalachia. For the Oysterfutures project (https://oysterfutures.wordpress.com/), her team built a GIS database of the network of channels in the Chesapeake Bay to reflect watermen's likely routes from fishing ports to oyster beds and compared average travel cost to fish under alternative oyster policy scenarios (Hayes, 2023). Those policies included different configurations of oyster sanctuaries and other policies that could exclude use of some areas. In work conducted for the US EPA, her team developed a spatial transportation cost model to assess the effect of mountain top coal mining on recreational fishing benefits. This analysis used distributions of travel distances by outdoor recreators to spatially model potential lost recreational fishing use and economic value (stream by stream) (Mazzotta et al., 2015).

For a full list of published articles and technical reports by Lisa Wainger and team members see https://www.researchgate.net/profile/Lisa-Wainger/research

Ms. Elizabeth W. Price is a faculty research assistant at the University of Maryland Center for Environmental Science with advanced GIS and data analysis skills. She received an M.S. in conservation science from the University of Minnesota and her B.S. in Biology from the University of North Carolina. She has 22 years of experience conducting a variety of economic and spatial data analyses for the MPA and many other agencies, non-profit organizations and businesses. The projects conducted for the MPA cover a wide range of applied issues including the public benefits of environmental restoration, cost savings of innovative reuse of dredged material, and social impacts of port activities. She is experienced in many advanced types of data and GIS analysis, included statistical and spatial network analysis, and she assisted graduate student Hayes in the analysis for OysterFutures. She is known for highly accurate data analyses and her detailed investigation of the costs of stormwater project investments by Maryland counties and spending by multiple agencies on agricultural practices has been read more than 800 times (Price et al., 2021).

Abstract

This analysis examines potential changes in rail freight costs for coal mines if they were to alter their transportation routes and ports of export in response to a proposed fee on coal transiting through Maryland. A fee of $13 per ton of coal has been proposed in the Maryland Legislature for all coal transiting through Maryland for all uses except on farms. By comparing travel distances using a spatial network analysis of rail lines, we examined how rail freight distances and costs could change for Appalachian mines (outside of Maryland) that are currently exporting from the Port of Baltimore, if they switched to the nearest coal terminal at Norfolk or Hampton Roads, in the Port of Virginia. The alternative routes use routes that do not cross into Maryland, as would be needed to avoid the fee.

Key Findings

Based on available data and information, the vast majority of coal exported from the Port of Baltimore is produced in Northern Appalachian mines. For all these mines, diverting coal exports from the Port of Baltimore to the Port of Virginia appears to cost more than paying the proposed $13/ton fee. Across the 70 Northern Appalachian mines included in the network analysis, the average increase in transportation distance by rail, when avoiding Maryland, was 597 miles, with an estimated average cost increase of $27.41 per ton delivered, which is more than double the cost of the proposed fee. The median increased cost per mine, after taking into account the amount of production per mine, is about $1.0 million. The 17 mines at the low end of the cost distribution have increased production-weighted transportation costs that range from $1,600 - $100,000. At the high end of the distribution, 8 mines have increased transportation costs that range from $3.3 million - $53.0 million (see Figure 9).

Central Appalachian mines were estimated to spend more on transportation if they send coal to the Port of Baltimore, compared to sending coal to the Port of Virginia under current conditions. For this reason, experts expect that no or only small volumes of coal from this region are exported through Baltimore. Central Appalachian mines using the Port of Baltimore appear to always save on transportation costs by switching from Baltimore to coal terminals at Hampton Roads or Norfolk. Therefore, these mines would be the most likely to switch ports if a transportation fee is imposed. The cost savings per Central Appalachian mine range from $13.66 to $16.69 per ton delivered, with the fee.

Transportation costs for Northern Appalachian mines appear to increase substantially with the fee, which has some potential to reduce coal exports from Baltimore. Currently, the 10-year average cost to transport domestically used coal to Maryland is $25.36 per ton. With the new fee, this cost would rise to $38.36 per ton, representing a 51% increase. The actual freight cost is uncertain since it varies by volume shipped and distance and this average cost does not directly measure transport costs of coal for export. Nonetheless, a $13/ton increase is about 18% of the $70/ton selling price that experts estimate is likely the average current price of coal exported from Baltimore, which could cause mines to need to raise the price of coal. If Northern Appalachian mines cannot offer coal on the global marketplace at competitive prices, exports from the Port of Baltimore could decline.

Purpose and Scope

In this analysis we examine potential changes in rail freight costs for coal mines, if they were to alter their transportation routes and ports of export, in response to a proposed fee on coal transiting through Maryland. A fee of $13 per ton has been proposed in the Maryland Legislature (HB1088/SB882) for all coal transiting through Maryland for all uses except on farms. The analysis examines the change in rail freight distances and costs for Appalachian mines outside of Maryland that are currently exporting out of the Port of Baltimore, to the nearest alternative coal terminal in Norfolk or Hampton Roads. The alternative routes use rail lines that do not cross into Maryland, as would be needed to avoid the fee. This analysis only examines the cost of switching ports of export and does not examine costs to domestic coal users or quantify other economic outcomes that could result from increasing the transportation costs of coal.

Background

The Port of Baltimore exported an estimated 28.1 million short tons of coal in 2023 through its two coal-loading terminals and is projected to export around 20 million short tons in 2024 (US Energy Information Administration, 2024d). This 2024 projection is consistent with recent annual averages, and the higher volumes in 2023 represented a surge due to increased overseas demand. The majority of coal exported from Baltimore (70% by volume) is thermal (bituminous) coal destined for India (Utomi & Scott, 2024) and used in brick kilns (CoalNewswire, 2024). The Netherlands, Germany and Belgium are the second-largest market for North Appalachian coal (CoalNewswire, 2024) and multiple other countries receive modest volumes of coal exports.

The shutdown of the Port of Baltimore in 2024 due to the Key Bridge collapse provides insights into the ability of mines and ports to substitute coal export terminals. According to US International Trade Commission researchers who examined conditions during the Port of Baltimore shutdown (Utomi & Scott, 2024), "…much of the U.S. coal shipments that would have gone through Baltimore have been diverted to the port terminals in Norfolk, Virginia, significantly increasing (181 percent relative to March 2024) this district's exports of thermal coal." However, coal export volumes out of Baltimore recovered 2 months after the bridge collapse (US Energy Information Administration, 2024d), suggesting coal mines ultimately preferred to return to Baltimore, rather than switch ports. CONSOL Energy exports substantial coal out of Baltimore from its own and other companies' mines and owns one of the two main coal terminals at the port. A CONSOL official said that diverting shipments to the Port of Virginia, which has terminals in Norfolk and Hampton Roads, added about $10/ton to coal transportation costs and that the company was reducing capital expenditures and taking other measures to control costs during that time (Mining Connection, 2024).

The Port of Virginia was able to support a temporary increase in export capacity during the port closure and historic Hampton Roads export data (1993-2023) suggests that the coal piers are operating below historic maximum capacity (US Coal Exports, 2024). Further, the recent merger of Arch and CONSOL (to Core Natural Resources) increases the company's capacity since the merged group will own the CONSOL terminal in Baltimore and be a co-owner of the DTA terminal in Hampton Roads. In terms of global markets, the US is a major supplier of coal to India (35% in 2023) and during the port shutdown, India offset the lower coal imports from the U.S. with coal from South Africa (Utomi & Scott, 2024)**.** The Gulf coast ports may also be potential alternative ports since, according to a coal trade publication, some North Appalachian coal is barged south to the Port of New Orleans when the terminals at Baltimore and Hampton Roads become congested (CoalNewswire, 2024).

The coal that is exported from Baltimore largely originates from Northern Appalachia with the primary coal-producing states being Pennsylvania, West Virginia (northern), and Maryland (Utomi & Scott, 2024). Another state in Northern Appalachia, Ohio, has historically exported some coal through Baltimore (Campbell, 2017) but is not reported to be a major source of export coal moving through Baltimore at present. Central Pennsylvania mines produce anthracite coal that largely serves domestic uses (Burton, pers comm). Even though the Port of Virginia handles most of the Central Appalachian coal, some coal exported in Baltimore has historically originated from that region. Central Appalachia includes eastern Kentucky, Virginia, southern West Virginia, and multiple counties of Tennessee. Historically, coal production has been concentrated in southwestern Pennsylvania, southern West Virginia and eastern Kentucky but production in Northern Appalachia has exceeded that of Central Appalachia since 2014 (Appalachia Regional Commission, 2024).

Methods

Study Area

We identified two study areas for this analysis. The primary area of interest was the Northern Appalachian Coal Region, defined by the US Energy Information Administration (EIA) as Maryland, Ohio, Pennsylvania and northern West Virginia (US Energy Information Administration, 2025b) (Figure 1). Maryland mines were excluded from the analysis because they would not be able to avoid the fee and so would not have the opportunity to change transport routes. The anthracite region of Pennsylvania (Figure 1) was also excluded based on interviews conducted prior to the analysis that suggested that this coal was predominantly used domestically rather than exported (Burton, pers comm). The Ohio, western Pennsylvania and northern West Virginia mines identified for the analysis included 99 underground and surface mines that produced a total of about 86.8 million short-tons of coal in 2022.

The secondary study area was the Central Appalachian Coal Region which includes Eastern Kentucky, Virginia, southern West Virginia, and 11 counties in northern Tennessee (EIA 2025) (Figure 1). Coal transportation exports that were consulted for this project suggested that while some coal produced in this region may be exported through the Port of Baltimore, it is likely a very small volume compared to volumes from the Northern Appalachian region, due to the greater transport distance. However, to fully understand the potential implications of the effects of the transportation fee on the Port Baltimore, this region was included with a less detailed analysis. Although this region contained 283 mines, the total 2022 production was lower than the Northern Appalachian region at 60.3 million short-tons.

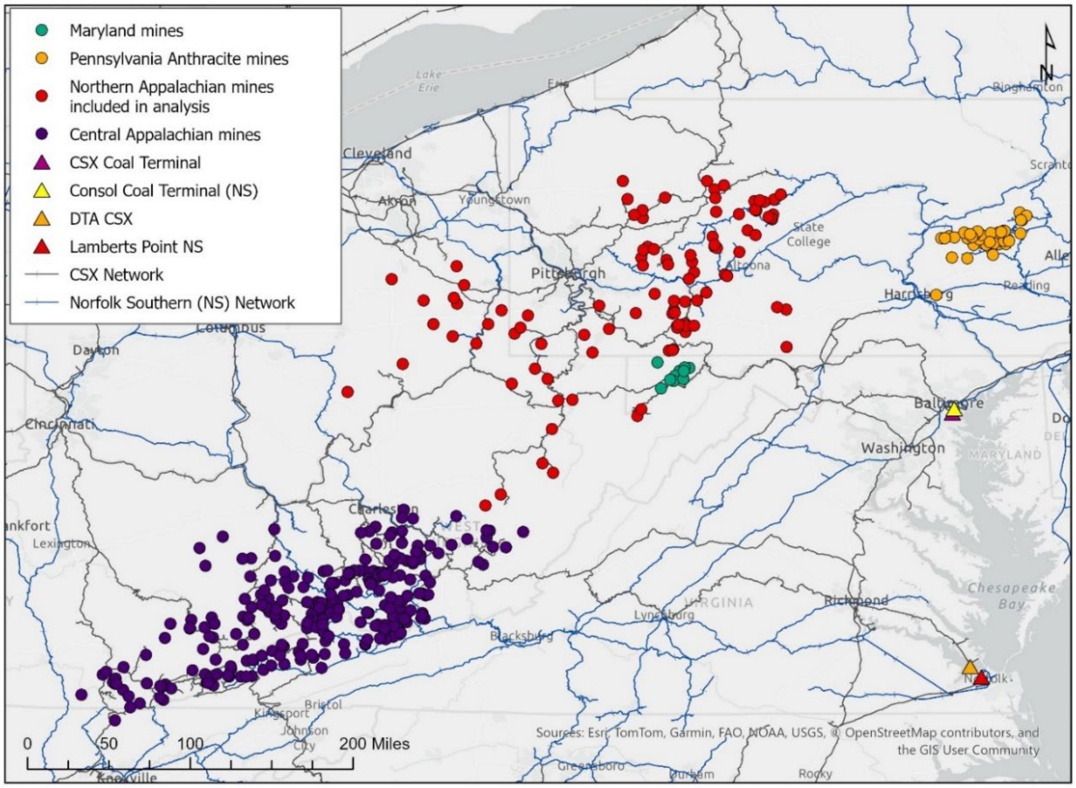

Figure 1. Study area map showing Northern and Central Appalachia mines, rail lines and coal terminal locations

Network Analysis

Northern Appalachian Region

We estimated the effects of the coal transport fee on coal exports through the Port of Baltimore by conducting a network analysis using ArcGIS Pro (version 3.4.2) Geographic Information System (GIS). The network analysis selects the shortest distance from mine origin sites to coal terminal destination points, along rail lines. We developed distinct rail networks for CSX and Norfolk Southern (NS) railroads because these rail lines are largely non-overlapping.

We estimated distances from mines to terminals for two scenarios to estimate a change in travel distance and rail freight costs, if mining companies avoid sending coal for export through Maryland. We ran each scenario two times: once for the CSX network and once for the NS network. In the first scenario, the analysis identified the shortest distance along the network from each mine to a coal export terminal in Baltimore. In the second scenario, the analysis identified the shortest distance along each network from each mine to an export terminal in Norfolk, when the rail lines in Maryland were not available for routing. The difference between the two scenarios was used to generate a change in shipping costs (per mine and in aggregate) to divert coal from Baltimore to Virginia terminals.

Many mines are directly on rail networks and which rail line services the mine generally determines the most cost-effective route to the export port. For Northern Appalachia, only mines that were within 10 km of a rail line were included in the network analysis so that we could identify the likely rail line used. Applying this filter resulted in 70 mines being added to the network analysis of 99 mines in the region. Distance and costs to move coal to the rail line were not included since these costs would apply to both scenarios and would not affect the change in cost from diverting coal.

Spatial (georeferenced) data on rail lines were available (US Department of Transportation Bureau of Transportation Statistics, 2025). The database attributes of rail segment ownership and trackage rights were used to distinguish rail used by CSX and NS. We also captured Class II, Class III and shortline railroad segments and appended them to each network by screening other lines in the region for affiliation with each company. For example, the Buffalo Pittsburgh RR is a Class II railroad with CSX and NS interchanges, so its segments were added to each rail network.[1]

Coal mines serve as the origins in the network analysis. Spatial coal mine data from the EIA contains information on mine location, whether each mine is underground or surface, and how much coal (short tons) it produced in 2022 (EIA 2024b).

Coal terminals at the Port of Baltimore and the Port of Virginia were the destinations in the network analysis. There are at least two coal terminals each at the Port of Baltimore and Port of Virginia, and CSX and NS serve one or both terminals at each port (Table 1). Coal terminal locations were identified through internet research and using aerial imagery base maps. A destination point for the network analysis was created near the coal loading operation. The CSX Coal Terminal in Baltimore is served by the CSX rail network. Both CSX and NS rail networks serve the CONSOL terminal in Baltimore, however, this terminal was used as the destination for the NS network analysis only because the CSX terminal already represented the destination for the CSX network.[2] At the Port of Virginia, the Dominion Terminal Associates (DTA) terminal in Hampton Roads is served by the CSX network, and the coal terminal at Lamberts Point in Norfolk is on the NS network.

Table 1. Origins (mines) and destinations (coal terminals) used in network analysis

Rail Network	Origins	Destination (Baltimore - baseline)	Destination (Port of VA – with legislation)
CSX	Coal mines in western PA and northern WV	CSX Terminal	DTA Terminal, Hampton Roads
NS		CONSOL Terminal	Lamberts Point, Norfolk

Using the GIS software, we created four Origin-Destination (O-D) Cost Matrices to analyze the 2 scenarios described above on each rail network (Table 2). When the destination was a terminal at the Port of Virginia, the state of Maryland was included as a barrier in the analysis, so all routes to that port avoided any rail lines within Maryland.

Table 2. Origins, destination and networks used in network analysis

Origin	Scenario	Rail Network	Travel Barrier	Destination
Coal mines in OH, western PA and northern WV	1a	CSX	None	CSX Terminal, Baltimore
	2a	CSX	Maryland	DTA Terminal, Hampton Roads
	1b	NS	None	CONSOL Terminal, Baltimore
	2b	NA	Maryland	Lamberts Point terminal, Norfolk

[1] We did not constrain the analysis to force the train routing through specific interchanges, so it is possible that measured distances could be underestimates in some cases.

[2] Some mines on the CSX network may transport coal to the CONSOL terminal rather than the CSX terminal. In the context of this analysis, using only the CSX terminal with the CSX network may slightly change the actual distance traveled to Baltimore from these mines, but this approach will have little effect on the overall analysis results.

The distance data calculated using the network analysis were exported to an Access database for further analysis. The sets of O-D distance measurements were used to calculate the difference in distance when Norfolk was the destination rather than Baltimore (Eqn 1). A subset of mines was served by both rail networks, and for those mines, the smaller increase in distance was used in analysis.

$$\begin{aligned} &Change\ in\ Distance\ (mi) \\ &\quad = Distance\ from\ mine\ to\ Port\ of\ Virginia\ (mi) \\ &\quad - Distance\ from\ mine\ to\ Port\ of\ Baltimore\ (mi) \end{aligned}$$

Equation 1

The increase in costs per short ton was calculated by applying an estimate of freight costs of $0.0459 per ton-mile (US Department of Transportation Bureau of Transportation Statistics, 2023) to the increased distance estimates (Eqn. 2). This value represents the average freight revenue per ton-mile for Class I rail for 2021, the most recent year for which data are available. Although the value represents revenue, interviews with coal experts suggested this is a reasonable estimate to use for coal transport costs (Burton, pers comm) although it is a national average across all freight types and will not reflect recent increases in costs (US Department of Transportation Bureau of Transportation Statistics, 2023).

$$Change\ in\ costs\ \left(\frac{\$}{short\ ton}\right) = Change\ in\ distance\ (mi) \times Freight\ costs\ \left(\frac{\$}{short\ ton\text{-}mile}\right)$$

Equation 2

To estimate how the per ton fee would affect mines with differing production levels, we first estimated the volume of coal that was likely to be exported from any given mine using a simple ratio. In 2022, about 20M short-tons of coal were exported through the Port of Baltimore (US Energy Information Administration, 2024e)and this volume is similar to projections for 2024. The Northern Appalachian mines included in the network analysis produced about 55.6M total short-tons in 2022 (US Energy Information Administration, 2024c). Assuming all exported coal came from this region, the proportion of mined coal that was exported through Baltimore was 36.5%. We applied this percentage to the production of each mine on the network to estimate the coal per mine transported for export (Eqn 3).

$$\begin{aligned} &Exported\ coal\ produced\ per\ mine\ in\ 2022\ (short\ tons) \\ &\quad = 2022\ production\ per\ mine\ (short\ tons)\ \times percent\ of\ production\ exported \end{aligned}$$

Equation 3

Finally, we estimated the total additional transportation costs per mine based on the increase in distance (from the Port of Baltimore to the Port of Virginia), weighted by the estimated production bound for export (Eqn 4).

$$\begin{aligned} &Total\ additional\ costs\ (\$) \\ &\quad = Change\ in\ costs\ \left(\frac{\$}{short\ ton}\right) \times Exported\ coal\ produced\ per\ mine\ (short\ tons) \end{aligned}$$

Equation 4

Central Appalachian Region

Findings from our research and interviews indicated that a small proportion of coal exported through the Port of Baltimore comes from the Central Appalachian coal-producing region. The mine origins of coal being exported in Baltimore are not publicly available but multiple sources suggest that the vast majority of coal exported through Baltimore comes from the Northern Appalachian region (US Energy Information Administration, 2024e; Utomi & Scott, 2024; Church, pers. comm.). Consequently, a limited detail network analysis was conducted for this region. Rather than calculating the distance from each of the 283 mines to each port on each network, a subset of mines was chosen to represent the distribution of distances from mines in this region to port and including at least two mines each from Kentucky, Virginia and southern West Virginia.

The same methods described for the Northern Appalachian region were applied in the Central Appalachian region. Two scenarios were run for each rail network. The first scenario calculated the shortest route from each mine to the Port of Baltimore along each rail network, and the second scenario calculated the shortest route from each mine to the Port of Virginia along each rail network. The rail networks in the state of Maryland were not available for routing when the destination was the Port of Virginia. For each mine, the difference in distance between the two scenarios was calculated according to Equation 1.

Results

Northern Appalachian Region

In the coal producing region that includes Ohio, western Pennsylvania and northern West Virginia, there were 99 mines in 2022. Using the 10 km search tolerance, the network analysis captured 70 of these mines near one or both rail networks (Table 3).

Table 3. Mines per rail line captured in the Northern Appalachian network analysis

Network	OH mines	Western PA mines	Northern WV mines	Total
CSX only	2	12	9	23
NS only	1	24	0	25
Both CSX and NS	0	17	5	22
Neither CSX nor NS	7	18	4	29
Total	*10*	*71*	*18*	*99*

Transporting coal from the Northern Appalachian region to Norfolk while avoiding the state of Maryland substantially increases the transport distances. To illustrate the difference in routes, we show the alternative routes selected by the network analysis for a representative coal mine in southwestern Pennsylvania that is near both rail networks (Figure 2 and Figure 3). The figures show the shortest routes from the same coal mine to the Port of Baltimore and to the Port of Virginia, when avoiding Maryland, for each rail network. These figures also demonstrate a finding that while the distance to the Port of Virginia is greater than the distance to the Port of Baltimore on both rail networks, the increase in distance on the NS rail network is greater than on the CSX network, due to the larger detour into Ohio (Figure 3). For the 22 mines in close proximity to both the CSX and the NS rail networks, the increase in miles was always smaller on the CSX network, so that network was chosen to create the aggregate analysis of transportation costs.

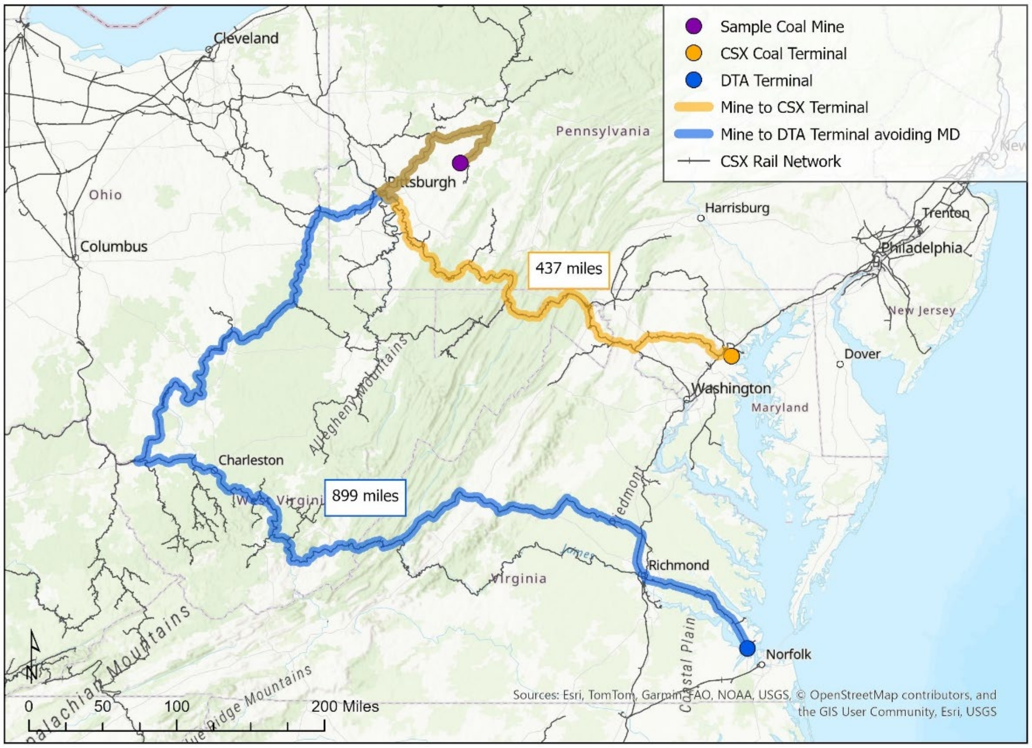

Figure 2. Routes from example Pennsylvania mine to the Port of Baltimore (orange line) and the Port of Virginia avoiding Maryland (blue line) on the CSX network. The route that avoids Maryland is 462 miles longer.

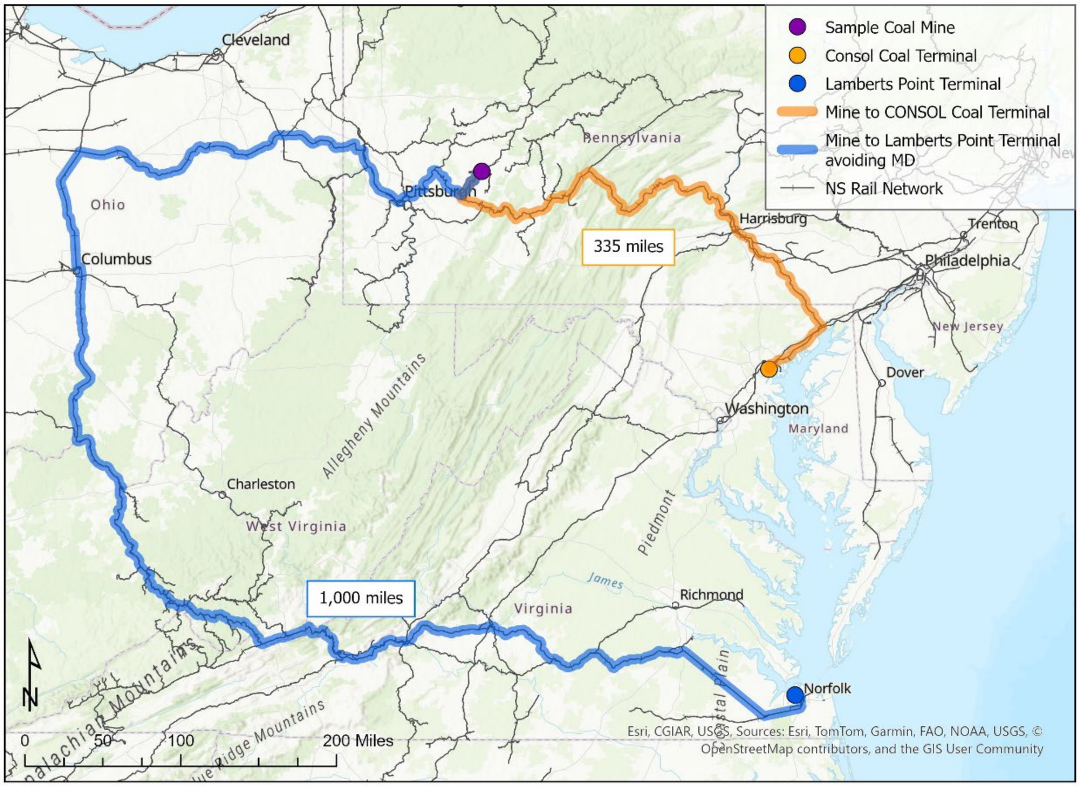

Figure 3. Routes from example coal mine to the Port of Baltimore (orange line) and the Port of Virginia avoiding Maryland (blue line) on the NS rail network. The route that avoids Maryland is 665 miles longer.

For the 70 mines in the Northern Appalachian network analysis, the increase in distance to the Port of Virginia relative to the Port of Baltimore (see Equation 1) ranged from 309 to 828 miles with an average of 597 miles (Figure 4). The increase in distance is most pronounced for mines along the eastern edge of the Northern Appalachian region (Figure 5). Some of these mines are just north of the Maryland-Pennsylvania border and are among the closest mines to the Port of Baltimore. For mines along the northern and western edges of the region, which are farthest from the Port of Baltimore, transport to the Port of Virginia still adds hundreds of additional miles, but represents a less dramatic increase than for mines closest to Baltimore via rail.

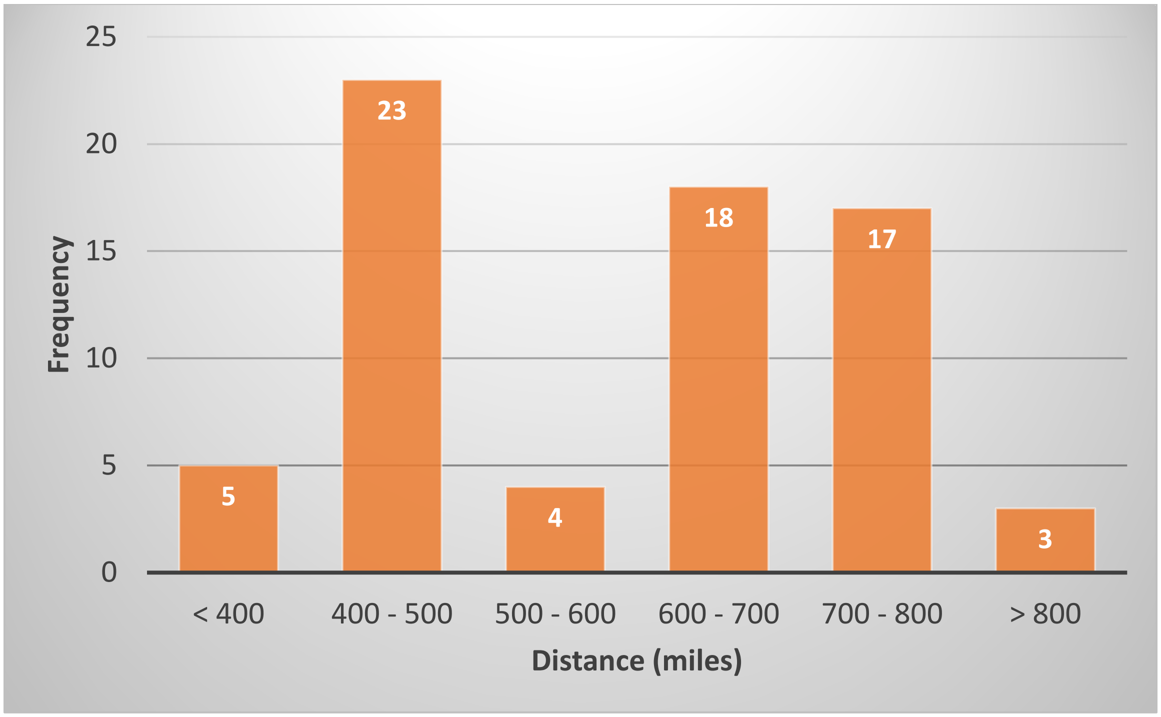

Figure 4. Frequency histogram of change in distance from mine (n = 70) to export terminal when the destination port is switched from Baltimore to Virginia

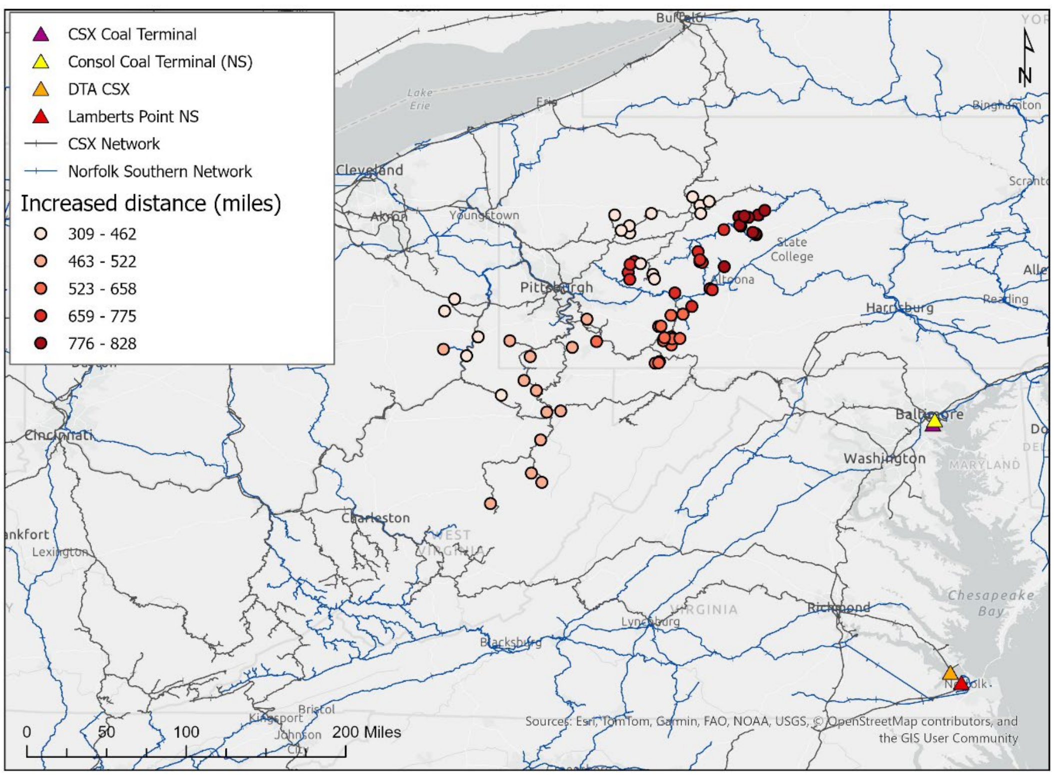

Figure 5. Geographic distribution of changes in transport distance from mine to export terminal when the destination port is switched from Baltimore to Virginia.

The subset of mines included in the network analysis are shown (n = 70) and data are displayed in quintiles.

Increased transport distance has a substantial impact on transport costs per ton. Applying the estimated cost per ton-mile (see Equation 2), increased transportation costs per mine range from $14.19 - $38.00 per ton, with an average increase of $27.41 (Figure 6). For every mine in the network analysis, the increased transport costs are greater than the proposed transport fee of $13 per ton. Since the same cost per ton-mile were applied to all mines, the increased cost per short ton follows the same geographic pattern as the increase in distance (Figure 7). The mines with the lowest increase in costs per short ton are located along the northern and western edges of the Northern Appalachian region, and the mines with the largest increase in costs per short ton are in the northeast portion of the region.

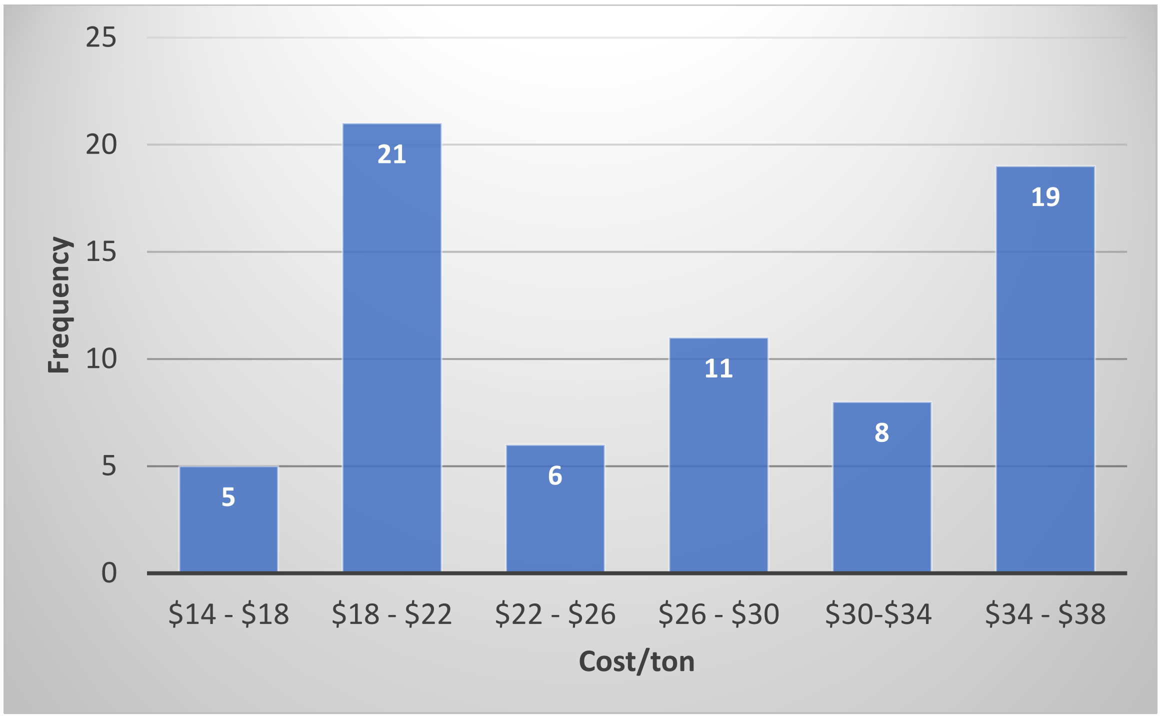

Figure 6. Frequency histogram of change in transport costs per ton per mine for Northern Appalachia (n = 70) due to increased distance when the destination port is switched from Baltimore to Virginia

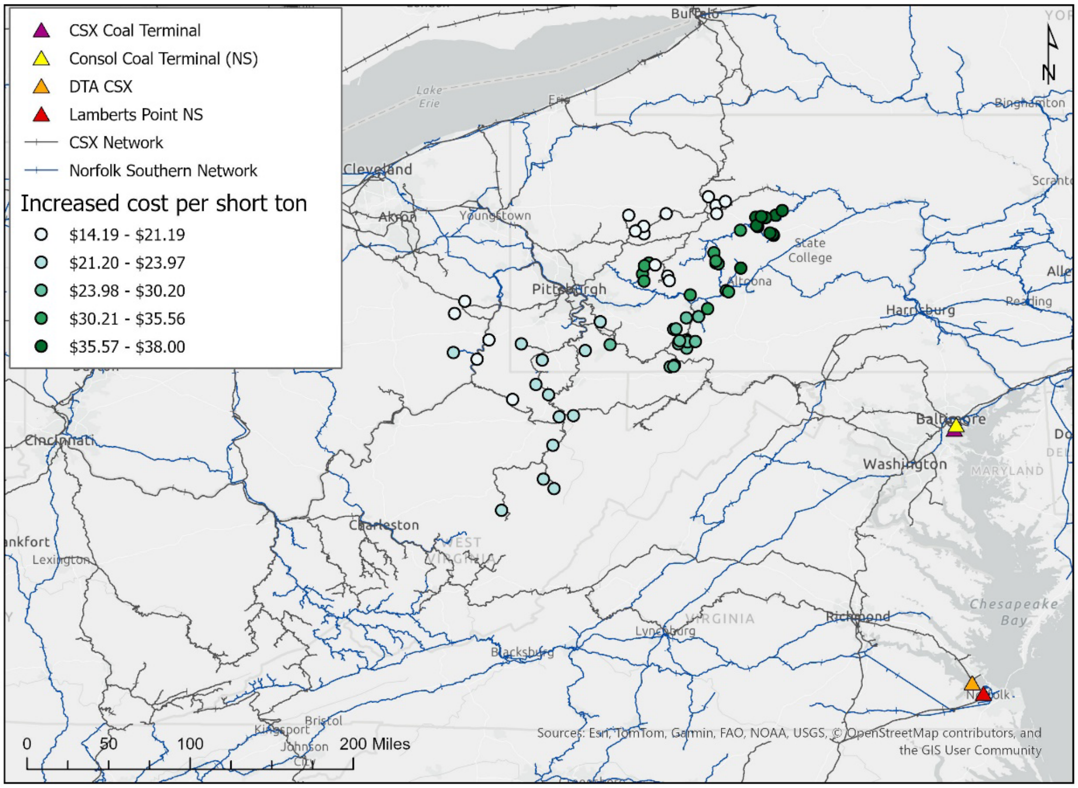

Figure 7. Geographic distribution of change in transport costs per ton per mine due to increased transport distance when the destination port is switched from Baltimore to Virginia.

The subset of mines included in the network analysis are shown (n = 70) and data are displayed in quintiles.

The 2022 coal production per mine is highly heterogeneous across the Northern Appalachian region. The mines with the greatest production were generally located in the region comprising the panhandle of West Virginia and the southwest corner of Pennsylvania (Figure 8). Using the amount of production for export to weight the transport costs per ton and per mine (Equations 3 and 4) generated a range of transportation cost increases of $1,600 - $53 Million from switching from Baltimore to Virginia ports (Figure 9). The $1,600 difference was for a mine with low production of a few hundred short tons of coal, while the $53 million applied to a mine with total production of 6.8 million short tons. The production-weighted cost data are quite skewed (Figure 9), so median value is reported. The median increase in production-weighted transportation costs was about $1.0 million. The 17 mines at the low end of the distribution have increased production-weighted transportation costs that range from $1,600 - $100,000 (Figure 9). At the high end of the distribution, 8 mines have increased transportation costs that range from $3.3 million - $53.0 million.

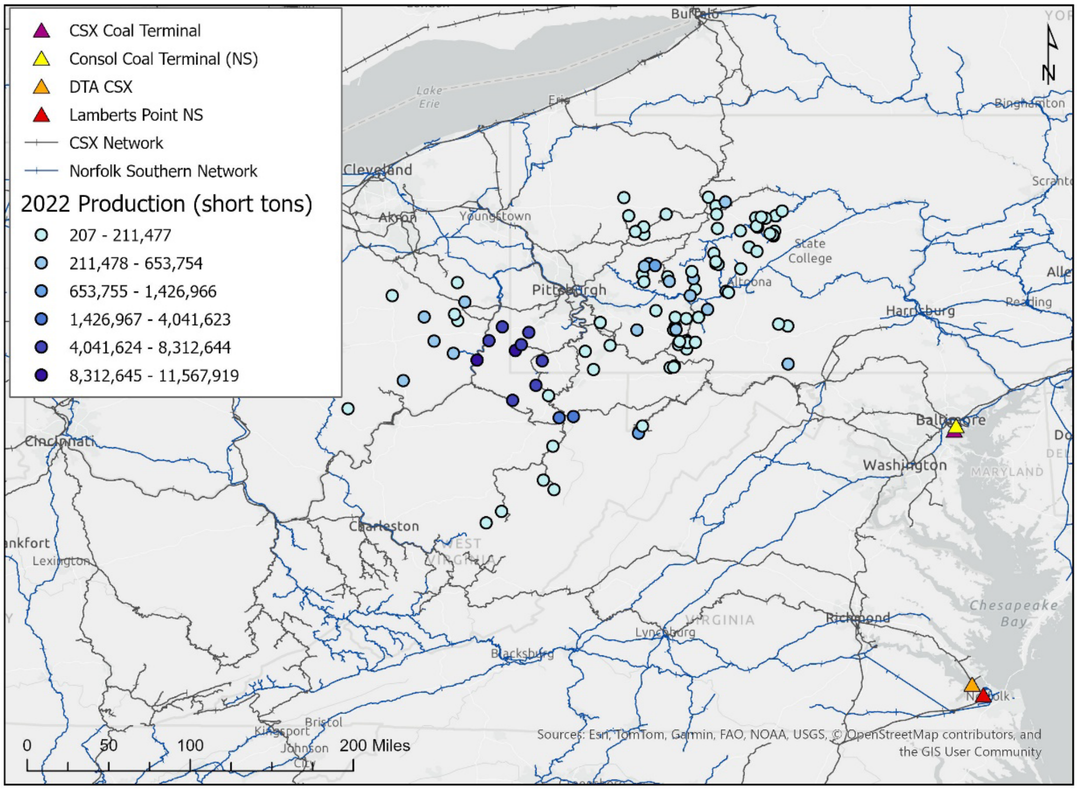

Figure 8. Coal production in 2022 (short tons) for mines in Northern Appalachian coal producing region. All mines in the region are shown (n = 99) and data are displayed using Jenks natural breaks.

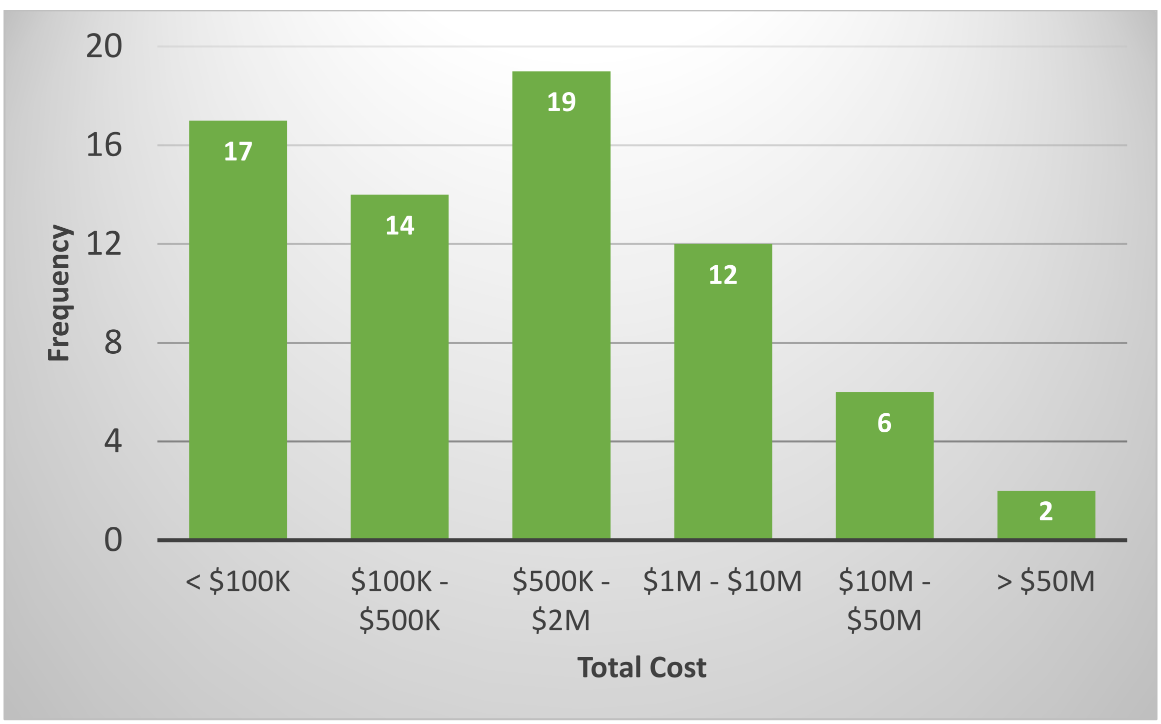

Figure 9. Increase in total estimated transportation costs per mine (n = 70) when the destination port is switched from Baltimore to Virginia.

As expected, the mines with the highest production had the largest additional transportation costs, due to moving a large volume of coal for export. The area northeast of Pittsburgh also had relatively high additional costs due to the combination of roughly average production and average to above average increases in transportation (Figure 10). For mines in this area that are near the NS network but not the CSX network, the increase in transport distance can be hundreds of miles greater than nearby mines that are on the CSX network because transporting coal to Virginia on the NS network requires a longer detour.

Actual rail transportation costs vary by volume and by distance. As a potential check on the cost estimate used in this analysis, we derived a cost per ton-mile estimate from statements made by CONSOL during the Port of Baltimore closure. They reported a $10/ton in additional transportation costs to divert coal to Norfolk, using all available rail lines. The distance from CONSOL's Pennsylvania Mine Complex to the export terminal at Hampton Roads is 169 miles longer than the route to the CONSOL terminal in Baltimore, suggesting that CONSOL's transportation rate was $0.059 per ton-mile. The transport of coal from the Pennsylvania Mine Complex to the Hampton Roads terminal on a route that avoids Maryland would be about 500 miles longer than transporting directly to the Port of Baltimore. Therefore, at this rate, transport costs would increase by about $30/ton for mines in southwestern Pennsylvania.

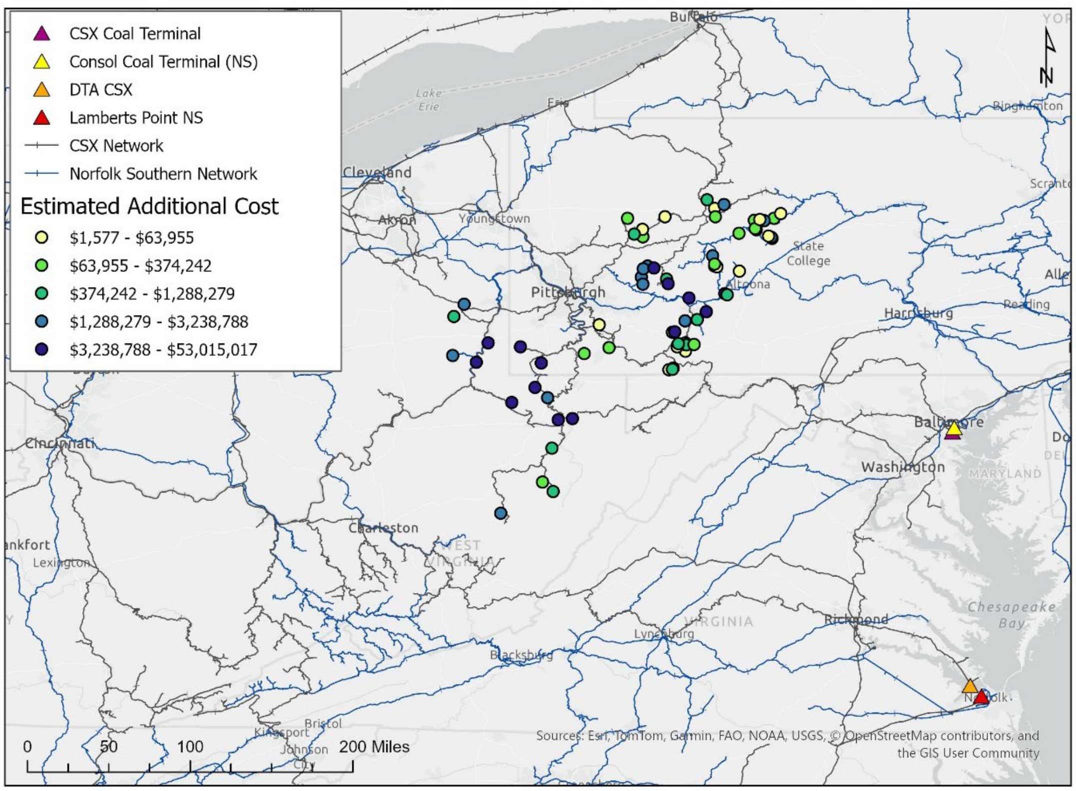

Figure 10. Estimated additional transportation costs where increase in distance is weighted by estimated coal production bound for export.

Mines included in network analysis shown (n = 70), and data are displayed in quintiles.

Central Appalachian Region

A total of 11 mines were selected for the Central Appalachian network analysis. The mines are distributed across the region in three states and along both rail networks (Table 4 and Figure 11).

Table 4. Mines per rail line captured in the Central Appalachian network analysis

Network	Eastern KY mines	VA mines	Southern WV mines	Total
CSX only	2	1	1	4
NS only	1	1	1	3
Both CSX and NS	1	1	2	4
Total	*4*	*3*	*4*	*11*

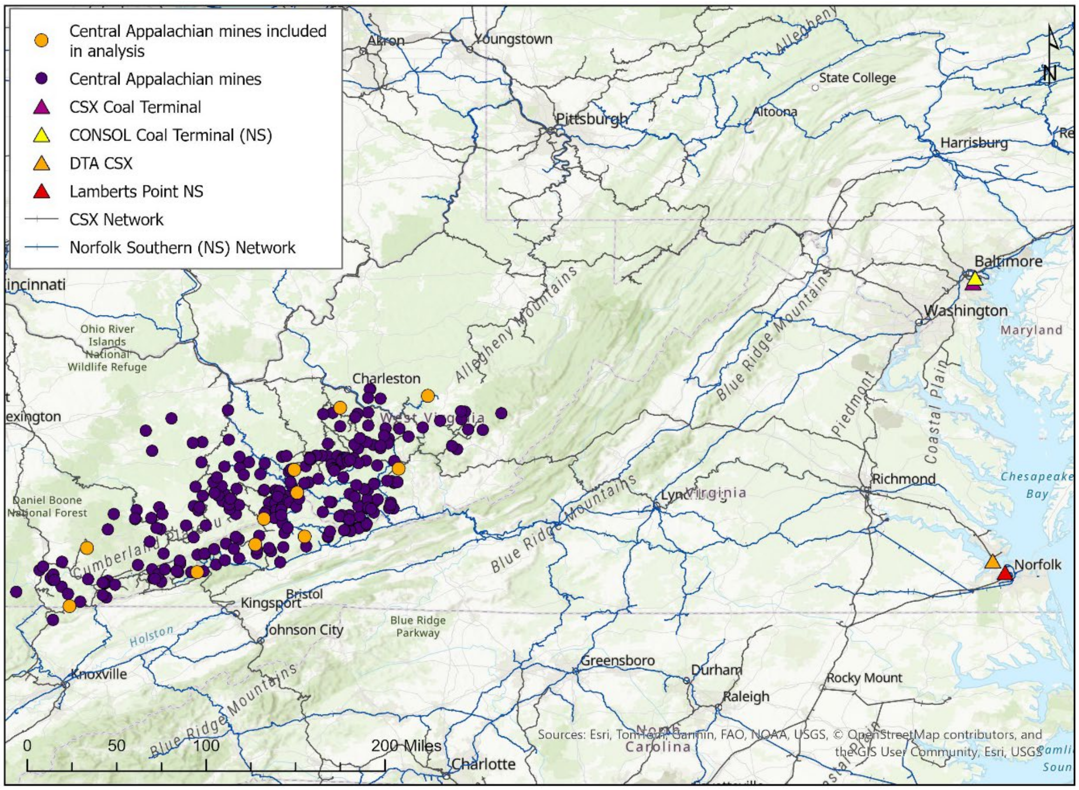

Figure 11. Mines included in the Central Appalachian network analysis

For all mines in the Central Appalachian analysis, the coal terminals at the Port of Virginia are always closer than the coal terminals at the Port of Baltimore, but the differences in distance are smaller than for Northern Appalachian mines. The seven mines near the NS network in this analysis are distributed throughout the Central Appalachian region, and the transportation of coal from these mines to the Lamberts Point terminal in Norfolk rather than the CONSOL terminal at the Port of Baltimore decreases travel distance by about 14 miles (Table 5). The difference in distance for all mine to switch is the same because of the limited routing options, even though total travel distance differs. For mines on the CSX network, transporting coal to the DTA terminal in Hampton Roads is about 33 to 80 miles shorter than transporting coal to the CSX terminal at the Port of Baltimore.

Mines that switch from the Port of Baltimore to the Port of Virginia would see modest transportation cost savings due to the relatively small reduction in transport distance. For the mines on the NS rail line in the Central Appalachian network analysis, transporting to Norfolk instead of Baltimore would result in freight transport costs that are $0.66 cheaper per short ton delivered without the fee or $13.66 with the fee (see Equation 2). For the Central Appalachian network analysis mines on the CSX network, the change from

Baltimore to Hampton Roads for export would result in transportation cost savings of $1.51 - $3.69 per short ton delivered, without the fee. With the $13 fee, the savings would be $14.51 - $16.69.

Table 5. Change in distance from Baltimore to Port of Virginia

Mine	CSX Network increased distance (mi)	NS Network increased distance (mi)
Eastern KY #1	-33	
Eastern KY #2	-76	
Eastern KY #3		-14
Eastern KY #4	-48	-14
Virginia #1	-33	
Virginia #2		-14
Virginia #3	-80	-14
Southern WV #1	-33	
Southern WV #2		-14
Southern WV #3	-33	-14
Southern WV #4	-33	-14

Discussion

The proposed fee on coal transportation in Maryland raises the cost of transportation by less than the additional transportation cost for Northern Appalachian mines to switch from Baltimore to coal terminals in Virginia. Therefore, the fee does not appear to be sufficient to directly divert substantial coal export volume from the Port of Baltimore, all else equal. CONSOL Energy, which produces much of the coal exported through Baltimore, owns and operates one of the two main coal terminals in Baltimore. This ownership provides an incentive to keep using the Port of Baltimore. Based on expert input (M. Burton, pers comm), we did not consider terminal fees in the calculation of changing costs, because these costs are modest compared to the transportation fee. Also, since CONSOL Energy has recently merged with Arch Resources, it was not clear that the terminal fee would increase if CONSOL mines switched to the Hampton Roads terminal since this CSX terminal is co-owned by Arch Resources.

Central Appalachian mines would always save transportation costs by switching from Baltimore to coal terminals at Hampton Roads or Norfolk. As a result, they would be the most likely to switch ports in the event of a transportation fee being imposed. We were unable to find data on the amount of coal moving from Central Appalachia to the Port of Baltimore for export, although the EIA reports that Kentucky supplies a small amount of coal to the electric power sector in Maryland (US Energy Information Administration, 2024a).

However, a factor that could still affect export volumes is that the proposed fee per-ton appears to roughly double the coal transport fee to Maryland. According to the most recent EIA data (US Energy Information Administration, 2025a), the average coal rail transport fee from origins in Northern Appalachia to electric power sector destinations in Maryland (2011-2021) is $25.36/ton (2022$).[3] After applying the $13/short ton fee, the new average cost per ton would be $38.36 (a 51% increase). Transportation costs used in this analysis are uncertain because freight cost data are not publicly available. Experts estimated current coal

[3] Transportation costs from Central Appalachia to Maryland were withheld in the same database, which occurs when 3 or fewer mine company respondents fill out the EIA information survey.

transportation costs for exported coal from Northern Appalachia at about $30/ton, which if accurate would mean that the $13/ton increase would represent a 43% increase in transport costs. Freight rates have been steadily increasing and rates per ton-mile have increased 15% over 5 years (2016-2021) and 22% over 10 years (2011-2021), measured in current dollars (US Department of Transportation Bureau of Transportation Statistics, 2023). Further, other sources suggest that the national average freight rate for rail transport is higher than the $0.0459 used in this analysis (e.g., Boleneus, 2024). Further, the costs to ship coal by rail to the Port of Baltimore will vary by distance and volume and this analysis does not include costs to transport coal by truck or barge when mines are not served directly by rail.

Coal exports volumes and selling prices at Baltimore have fluctuated over time and are subject to global changes in demand and supply. According to the EIA, exports increased from 2022 to 2023, but otherwise have been fairly steady for the past 5 years (EIA Annual Coal report 2023). The increased transportation costs could be a substantial proportion of the selling price of coal. The majority of the coal exported in Baltimore is bituminous coal, and the EIA (2024) reports that the average sales price of bituminous coal was $96.23 per short ton in 2023, a 1.8% decrease from 2022. However, bituminous price varies by qualities of the coal and all types of thermal coal (which includes most bituminous coal), had a national average selling price of $37.60 per short ton. Therefore, the price of most export coal from Baltimore is uncertain but subject matter experts said the price could be around $70/ton. The estimate of average coal sales price (of all coal types) in 2023 for Maryland was $101.89 and for Pennsylvania was $91.71. The West Virginia average sales price was a bit higher at $120.08 in 2023 (US Energy Information Administration, 2024b).

Mining companies in Northern Appalachia will face the challenge of either absorbing additional transport costs or passing these costs onto coal buyers. The ability to raise prices and pass along these costs depends on the state of the global coal market. If coal mines in other countries can maintain current global market prices while Baltimore coal prices rise, those countries would gain a comparative advantage and could capture market share from Appalachian mines. During the period when the Port of Baltimore was closed, CONSOL Mining stated that they were absorbing the added costs by reducing capital expenditures and taking other measures to control expenses (Mining Connection, 2024). However, if such cost-cutting measures are not sustainable in the long term, CONSOL may be forced to increase the selling price of coal, which could reduce their market share and exports from Baltimore.

Conclusions

This transportation cost analysis suggests that the coal that is currently being exported from the Port of Baltimore is unlikely to be diverted to the coal terminals at the Port of Virginia, since it would cost more than paying a $13/ton fee for all mines in Northern Appalachia. Taking into account the total amount of coal moving from each mine, the production-weighted increase in costs for Northern Appalachian coal mines from shifting export from the Port of Baltimore to the Port of Virginia has a median value of about $1.0 million per mine. The 17 mines at the low end of the cost distribution have increased production-weighted transportation costs that range from $1,600 - $100,000. At the high end of the distribution, 8 mines have increased costs that ranged from $3.3 million - $53.0 million. The average increase in transportation distance is 597 miles, with an associated average increase in cost of $27.41 per ton and a range of $14.19 - $38.00 per ton delivered. A small volume of coal coming from Central Appalachian mines to the Port of Baltimore has the potential to be diverted to Virginia by the fee since that route appears to already be more cost-effective with estimated transport savings of $0.66 - $3.69 per ton to use the Virginia coal terminals, even before adding the fee.

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