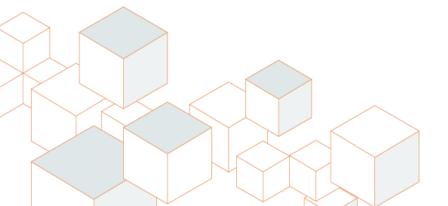# Assessment of the Economic and Social Impacts of the Failure of Congress to Extend the Compliance Deadline for Positive Train Control (PTC)

Given the recent understanding that much of the national rail network would be effectively shut down if the PTC deadline is not extended, this report presents the potential economic and social costs that could result.

Economics & Statistics Department
American Chemistry Council
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Summary of Findings and Important Points about the Potential Effects of a Shutdown of Freight Rail Service

Under the Rail Safety Improvement Act (RSIA) of 2008, railroads are required to implement Positive Train Control (PTC) on lines that ship certain hazardous materials and carry passengers by rail by December 31, 2015. Despite the efforts and investment that are ongoing to implement PTC, the Association of American Railroads (AAR), Government Accounting Office (GAO), and the Federal Railroad Administration (FRA) have clearly stated that the railroads will not be able to fully implement PTC by the deadline. Most railroads have publicly stated that they will be forced to shut down large portions of rail service unless the deadline is extended. Though the requirements for PTC under the RSIA are directed to passenger rail and the shipments of toxic inhalation hazard (TIH) chemicals, the rail shutdowns could extend to the shipments of all freight that would normally be transported on those lines. As a result, **an extensive proportion of the nation's rail network would effectively be shutdown or curtailed.**

Rail shippers depend on railroads to deliver coal, farm products, automobiles, chemicals, building materials, and many other essential products. **A major disruption of rail service would have direct and immediate as well as cascading impacts on the nation's food, energy, and water supplies. It would also impact transportation, construction, and nearly every sector of the U.S. economy. It would hit every point across our nation's supply chain.**

The costs of a major disruption of rail service would be felt immediately in terms of public health impacts, plant and business shutdowns, lost jobs and income, and a drop off in tax revenues for states and local governments. Should the disruption persist for an extended period of time the economic and social costs would be substantial and the harm caused, irreparable.

The recovery of the U.S. economy from the Great Recession has been slow and steady and lacking the robust pace to safeguard it from real vulnerability to a negative shock that could knock it off course. A negative supply shock arising from PTC regulation-induced rail service disruptions will most severely affect the industrial sector, resulting in less production and through various transmission channels would ripple through the U.S. economy fostering contractionary forces across wide spectrums of the economy. There would be ripple effects to associated industries and to production, employment, wage and salary income, and spending by consumers and business – inciting a vicious cycle. Consumer spending and business investment would falter. The ripple effects would be most manifested in manufacturing, mining and utilities, and industrial production would fall even further than the broader economy. The impact of a major rail service disruption would be crippling, pushing a modest pace of economic expansion into one of contraction during 1st quarter 2016. **Should the curtailment of rail service be prolonged, it would be truly catastrophic, likely resulting in a recession - the first regulatory-induced recession in American economic history.**

This report presents several assessments of how a rail service disruption would negatively impact the U.S. economy. There are four analytical components to the underlying analysis that are presented in this report. The first two provide an examination of the impacts related specifically to the inability to ship TIH chemicals, the latter two use different approaches to assess the impact of a broader disruption of all freight rail service to the economy. A brief description of each analytical approach follows here.

Qualitative assessment of the uses and applications of the TIH chemicals

This section of the report provides an explanation of the criticality of TIH materials to national commerce, public health and our modern way of living. Delivery of TIH chemicals is essential to clean water, agriculture and many other important segments of the economy.

Quantitative assessment of the economic footprint of TIH chemistry

The industries that consume TIH materials employ 2.4 million people (with an annual payroll of $155 billion). Together, the gross output of these industries is $2.1 trillion. The combined value added of these industries amounted to $735 billion (equivalent to 4.6% of U.S. GDP). These economic contributions are at risk if deliveries of TIH chemicals are disrupted.

Macroeconomic assessment of how the rail-induced supply disruptions will adversely affect the U.S. economy more broadly

Rail service disruptions lasting only one month will engender a 2.6 percentage point hit to U.S. real GDP growth during 1st quarter 2016 and could thrust the U.S. economy from one of modest expansion into one of contraction. The shock will generate ripple effects throughout the economy and put nearly 700,000 jobs at risk. Should the curtailment of rail service be prolonged, it would be truly catastrophic, likely resulting in a recession - the first regulatory-induced recession in American economic history.

Economic footprint of the sectors of the broader economy that rely on rail service to ship their products

Rail-shipping goods producers directly employ nearly 600,000 people and produce $345 billion annually of agricultural products, minerals, fuels, and manufactured goods. Inability to move their products by rail puts these jobs at risk. Additional jobs are at risk in the supply-chain and payroll-induced segments. All told, more than 3 million jobs are tied to the industries that ship their products by rail.

The economic and social costs resulting from a major rail service disruption would be long-lasting and widespread, hitting many sectors of the economy. This could include major losses in the chemical industry, including the 20,000 people that manufacture TIH chemicals and specifically, to households and the businesses who rely on TIH chemicals which employ nearly 2.4 million people. Clearly, the economic fallout due to the curtailment of TIH chemical shipments would be substantial. But, because TIH chemicals are critical inputs to goods and services that are essential to public health, the stability of our domestic food supply, clean water in our homes, schools, and hospitals, and the reliable provision of electric power, a rail shutdown would quickly and directly impact our everyday modern lives. Many shippers

choose to distribute TIH chemicals by rail considering both safety and efficiency for transporting these hazardous materials. The railroad industry is making steady progress and is committed to installing PTC to help ensure that shipping and travel by rail is as safe as possible. While installing PTC will yield important safety benefits, it is also very complex and must be installed on a realistic and workable timetable. Congress must act immediately to provide for a reasonable, workable extension for PTC to avoid this massive disruption to freight rail service and the potentially dire consequences for the U.S. economy that would come with such a shutdown.

Rail is Important to Our Economy

Every year, passengers and important freight move along America's railroads. Commodities that are essential to the economy are shipped to producers and consumers by rail. This economic activity depends on the stability of the national rail system. In 2014, nearly 2 billion tons of freight were transported by U.S. Class I railroads[1] generating $76.5 billion in revenues. This freight included a wide variety of goods: coal, food, crushed rock and sand, paper and lumber, chemicals, metal ores, primary metal products, motor vehicles, and other industrial products and commodities. Table 1 presents data for some of the top commodity categories in terms of rail carloads moved by Class I Railroads in the U.S. in 2014. The associated gross revenues and tons originated are also included. The operations of many domestic industries rely on rail transportation to distribute goods across the nation. There are many examples of how rail moves our economy and impacts our everyday lives. Rail transportation is essential to moving the coal that's used to make the electricity that powers our homes, rail moves the steel from the steel mills to the automobile assembly plants, rail moves fertilizers and the produce of American agriculture ensuring a stable domestic supply of food, and it moves crude oil fueling the manufacturing sector. There are countless examples of how an efficiently running railroad network is essential to the American economy.

Table 1
Class I Railroad Transportation: Carloads and Tons Originated and Revenues by Commodity, 2014
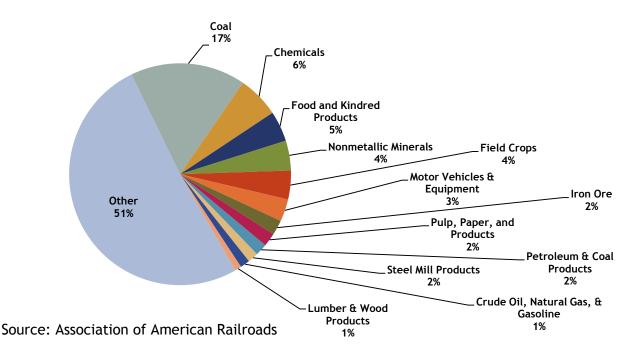
Commodity	Carloads Originated (thousands)	Tons Originated (million)	Gross Revenues (million)
Coal	6,110	713	$14,354
Chemicals	2,206	176	$10,347
Food and Kindred Products	1,614	101	$5,838
Nonmetallic Minerals	1,583	165	$4,015
Field Crops	1,524	142	$5,853
Motor Vehicles & Equipment	1,183	22	$5,530
Iron Ore	793	67	$582
Pulp, Paper, and Products	714	33	$2,342
Petroleum & Coal Products	635	49	$2,632
Steel Mill Products	554	47	$2,494
Crude Oil, Natural Gas, & Gasoline	508	49	$2,877
Lumber & Wood Products	353	28	$1,942
Other Commodities	18,554	961	32,057
Total	30,221	1,840	$76,509

Source: Association of American Railroads

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[1] AAR, https://www.aar.org/Pages/Freight-Rail-Traffic-Data.aspx#annualrailtraffic

More than 1.8 billion tons of agricultural products, minerals, fuels, and manufactured products were transported in 30.2 million carloads in 2014. Figure 1 shows railcar loadings by commodity class. Data from AAR shows that one in six (17%) of railcar loadings were coal traveling from mines to the nation's power producers. More than a third of the nation's electricity is generated from coal, making it the largest generation source. Chemical products make up the second largest category, representing 6% of rail car loadings. Food products producers originate 5% of loadings and nonmetallic minerals, and field crops (i.e., corn, wheat, etc.) each account for 4% of railcar loadings. In addition, motor vehicles, iron ore, petroleum products, steel mill products, crude oil, and lumber account for significant portions of rail car loadings.

Figure 1
Railcar Loadings by Commodity Class, 2014

Source: Association of American Railroads

Positive Train Control (PTC)

Positive train control (PTC) is a GPS-based system designed to monitor and control train movements to provide increased safety. It works to prevent train collisions and derailments caused by speeding. In 2008, Congress passed the Rail Safety Improvement Act (RSIA) which required railroads to implement PTC on lines that ship toxic inhalation hazard (TIH) chemicals and on passenger rail by December 31, 2015. However, the technology and expertise to implement and deploy a fully functional, interoperable PTC system across a broad and complex network of rail lines did not yet exist. Despite extensive investment and efforts to

meet the PTC requirements in time, the AAR, GAO, and the FRA have unequivocally confirmed that PTC will not be implemented by the deadline. Despite their common carrier obligation, at least one Class I railroad has stated publically it is considering shutting down rail lines that carry TIH products. The FRA has also made it clear that it will strictly enforce the PTC deadline.

Analysis Assumptions

The following analyses examine the economic effects arising from the rail-induced supply disruptions starting 1 January 2016. We assume that 80% of freight volume will be disrupted or stopped for one month. This is because TIH shipments are typically moved on the higher density, safer rail lines and the supply disruption to these lines would have a disproportionately large effect. It doesn't matter if the carloads are TIH or not, if it's a line that is supposed to have PTC (basically any line that could legally move the TIH) and doesn't have PTC we assume that no traffic is allowed to move on it. Our assumptions are based on statements from a Class I railroad on this matter.

To assess the economic and social impact of rail-induced supply disruptions, ACC examined the role of TIH chemicals in commerce. The approach is two-fold 1) a qualitative assessment of the primary, secondary, tertiary and further uses of these materials and their essentiality to the economy, and 2) a quantitative assessment of economic activity at risk.

ACC also examined the role of the supply disruption on the U.S. economy and the impact that would likely be observed on various measures of macroeconomic activity. The supply disruption is modeled as a brief supply shock to the U.S. economy. This approach employs two analytical methods: input-output analysis and econometrics.

Why TIH Materials are Important to Our Economy

Under the Hazardous Materials Regulations of the U.S. Department of Transportation (DOT), TIH materials are gases or liquids that are known or presumed on the basis of tests to be toxic to humans such that they pose a hazard to health in the event of a release during transportation.

ACC estimates that production of TIH chemicals likely amounted to 60 million short tons in 2014. The value of production was $29.6 billion and employed more than 20,000 people in their manufacture. Note that a portion of production is consumed internally within chemical industry facilities in which it is manufactured and does not move via rail.

According to an analysis of Surface Transportation Board (STB) Waybill data by the AAR, U.S. railroads moved about 75,000 carloads of TIH materials. Together, anhydrous ammonia and chlorine account for a combined 80% of TIH tank car shipments. Ethylene oxide is a distant third, accounting for about 10% of TIH shipments. Hydrogen fluoride is fourth in volume and

sulfur dioxide is fifth. ACC understands that the top five TIH materials account for about 95% of the total with all other TIH materials making up the balance. Although the TIH material volumes are modest, these materials are critical inputs for a wide variety of products and services.

Qualitative assessment of the Uses and Applications of TIH chemicals

The following list of TIH chemicals produced in the U.S. and shipped by rail also provides commentary of the uses and applications of the chemicals. This information illustrates the criticality of TIH materials to national commerce, public health and our modern way of living.

ANHYDROUS AMMONIA is one of the largest volume chemicals produced in the United States. Most ammonia produced in the United States is used to make fertilizer. Ammonia is applied directly as a fertilizer and it is used to make other nitrogenous fertilizers such as ammonium nitrate, urea, ammonium phosphates and ammonium sulfate. Nitrogen is essential for plant growth. Ammonia is thus essential for crops such as corn and wheat. It is the least costly and most effective source of nitrogen fertilizer for American farmers. **There is no viable substitute in maintaining the nation's food supply.** The largest consuming states are California, Illinois, Indiana, Iowa, Kansas, Minnesota, Nebraska, and North Dakota. Corn is the largest direct consumer of directly applied ammonia. One of the products of corn is ethanol, which is not only an important source of revenue for railroads, but also **an important part of our national energy policy**. Industrial uses for ammonia include the making of acrylonitrile (to make resins and acrylic fibers, which are used to make apparel, blankets, and upholstery), caprolactam (to make nylon 6 for use in such products as clothing, parachutes, and rope), and aniline (to make rubber processing chemicals). Ammonia is used in the continuous cycle cooling units found in large-scale commercial air conditioning and refrigeration at large, cold storage facilities. Other uses include Pharmaceuticals (sulfa drugs, vitamins, etc.), cosmetics, adhesives, feed supplements, home and industrial cleaners, pulp and paper production, metallurgy, and in the production of sodium azide propellants for air bags. Coal-burning electric power plants use ammonia for abatement of nitrogen oxides from power plants, thus **allowing these facilities to comply with the Clean Air Act emissions standards**. Minor uses include the making of explosives and the production of rocket fuel. **For most industrial users there is no substitute for ammonia.**

CHLORINE is a naturally-occurring element that is essential to life. It is a high volume chemical produced in the United States and **its use in American chemistry is pervasive, with the chlorine molecule involved in 60% of the industry's products**. Approximately 98% of public drinking water treatment systems use some form of chlorine-based disinfectant, according to a 2007 survey of water treatment facilities by the American Water Works Association. **Drinking water chlorination has been used for 100 years and is the major factor in preventing cholera and other waterborne disease. Chlorine disinfectants are also used extensively in food production and healthcare settings to guard against life-threatening germs.** Chlorine is used directly in paper manufacturing, and in the production of certain lightweight metals (titanium and magnesium) used in aircraft. Indirectly, it is used to make a variety of important building block chemicals, such as trichloroethylene, phosgene, chlorinated hydrocarbons, neoprene, polyvinyl chloride (PVC), hydrogen chloride, and ethylene dichloride. In turn, these are **used to ultimately produce thousands of industrial and consumer products.** According to the Chlorine Institute, chlorine chemistry is essential to 85% of all Pharmaceuticals, 25% of all medical plastics, 70% of all disposable medical applications, and 86% of crop protection chemicals. Some indirect applications include the production of wool, flame retardant materials, and special batteries (lithium and zinc). Chlorine is also used in the processing of fish, meat, vegetables, and fruit. The largest end uses of chlorine include the making of ethylene

dichloride, vinyl chloride monomer, and PVC resins (used to make a variety of products such as medical bags and tubing, adhesives, protective clothing, pipes, siding for homes, and raincoats).

ETHYLENE OXIDE is primarily used to make ethylene glycol (which is used to make polyester fibers/resins and antifreeze). The next largest application is in the making of surfactants and detergents. This chemical is also used to make other chemicals, such as ethanolamines (used for gas conditioning and soap production) and glycol ethers (used to make paint, brake fluids, aircraft fuel additives). Ethylene oxide is also used as a petroleum demulsifier, as a fumigant and humectant, in the making of rocket propellant, and as **a sterilizing agent for medical supplies** (bandages, sutures, and surgical implements) and industrial applications.

ANHYDROUS HYDROFLUORIC ACID is the source for virtually every product containing a fluorine molecule. Nearly 30% of all agricultural chemicals and 20% of Pharmaceuticals contain a fluorine molecule. **The agricultural and pharmaceutical industries depend on the timely shipments of this chemical.** Hydrofluoric acid is mainly used for the production of fluorocarbons, which are in turn used as refrigerants, foam-blowing agents, aerosol propellants, and solvents. While ammonia (also a TIH material) is a substitute for fluorocarbons used in refrigeration, there are few if any substitutes for fluorocarbons used in insulating foam applications. Fluorocarbons are also precursors to fluoropolymers and fluoroelastomers. Polytetrafluoroethylene is used in wire and cable insulation, aircraft/aerospace, electronics applications, and in non-stick coatings for cookware and bakeware. Fluoroelastomers exhibit high heat resistance and low permeability and are used in valves and seals for automotive and aircraft applications. Nearly 20% of hydrogen fluoride produced is used in primary aluminum production. Nearly 5% is used to make high-octane blending components for gasoline, where it is *critical in today's clean fuels*. Other uses include stainless steel pickling, treatment of titanium and zirconium, uranium fuel refining, semiconductor manufacture, glass etching, and as an additive in liquid rocket

propellants. Uranium is further processed to provide fuel rods for nuclear reactors and electric power generation.

About 40% of the SULFUR DIOXIDE produced in the United States is made into sodium hydrosulfite, which is used to bleach paper and textiles. Nearly a quarter is used by the pulp and paper industry to stabilize pulp. Agriculture and food production accounts for about 15% of production. It is used as a preservative and an antimicrobial in the production of corn syrup, wine, and beer. Sulfur dioxide is also used in water treatment to remove residual chlorine. It's used to treat water at chrome-plating facilities by converting chromate to less toxic compounds. Sulfur dioxide is also used in metal and ore refining, oil recovery, and as a catalyst in the production of phthalic anhydride used to make plasticizers (used in medical equipment, tarpaulins, cable jackets) and unsaturated polyester resins (plastics for use in construction, corrosion-resistant tanks/pipes, boats).

Two-thirds of SULFURIC ACID (hydrogen sulfate, battery acid, electrolyte acid) production is used to make phosphate fertilizer. A relatively small amount is used in copper refining and other metallurgical uses. Other uses include production of high-octane gasoline, methyl methacrylate, caprolactam, and in the production of lead-acid batteries. Methyl methacrylate is used to manufacture window glazing, lighting fixtures, taillights lenses, disposable medical equipment, laminates, polymeric optical fibers, and appliances and other consumer products. Caprolactam is used to manufacture nylon 6, used in tire cord and carpets.

The largest use for METHYL MERCAPTAN is as an intermediate for ammo acids (methionine) used in poultry and swine feed. **As an important component for animal feeds for the nation's poultry and pork industry, any disruption in the methyl mercaptan supply chain will have adverse effects on the price of animal products.** Methyl mercaptan is also used to produce jet fuel additives, fungicides and as a catalyst.

HYDROGEN CHLORIDE (or hydrochloric acid) is used to make vinyl chloride and alkyl chlorides, and used in polymerization, hydrochlorination,

isomerization, alkylation, and nitration reactions. It's also used in steel pickling (it is increasingly being used in place of sulfuric acid) and in food processing (in the making of high fructose com syrup and dextrose).

SULFUR TRIOXIDE (or sulfuric anhydride) is used to produce surface-active agents such as linear alkylbenzene sulfonates, alcohol sulfates and alcohol ether sulfates, that are used in detergents. Sulfur trioxide is also used in the production of explosives and solar energy collectors. Sulfuric acid is produced by the reaction of sulfur trioxide and water. Sulfuric acid is used to produce fertilizers, explosives, and lead-acid batteries, and is used in oil refining and metallurgy.

The largest use for ACETONE CYANOHYDRIN is as an intermediate for methyl methacrylate used in window glazing, lighting fixtures, etc. Acetone cyanohydrin is also used to produce methacrylic acid (a monomer for high-volume resins), fungicides and 2-ammo iso-butyronitrile.

About half of all HYDROGEN CYANIDE (hydrocyanic acid) produced goes into adiponitrile and is used in the manufacture of nylon 66 resin, an engineering thermoplastic. Because of nylon's high tensile strength, flame retardance and heat deflection properties, it is used in automotive and truck parts, electrical and electronic parts, industrial machinery parts, and in other consumer goods. About one-quarter of hydrogen cyanide produced is used to make acetone cyanohydrin, which is used to make methyl methacrylate. Methyl methacrylate is used to manufacture window glazing, lighting fixtures, taillight lenses, disposable medical equipment, laminates, polymeric optical fibers, and appliances. About 10% of hydrogen cyanide produced is used to make sodium cyanide, which is used by the mining industry for gold recovery. Some sodium cyanide is used in electroplating, caffeine synthesis, and pharmaceutical manufacture. Other products that are made using hydrogen cyanide include soaps, kidney dialysis products, herbicides, and coatings.

About two-thirds of PHOSPHOROUS TRICHLORIDE is used in glyphosphate herbicides and organophosphate insecticides. A small amount (13%) is converted to phosphorous oxychloride,

which is used in plastics and elastomers, functional fluids (fire resistant lubricants and hydraulic fluids for industrial machinery and aircraft), and pesticides. Another 12% is used to produce surfactants. Phosphorous trichloride is used in the textile, pulp and paper, photography, and electroplating industries. Other uses include plastics and elastomer additives (antioxidants, heat stabilizers, flame retardants) and oil additives.

A derivative of SULFUR TRIOXIDE, *chlorosulfonic acid* (sulfuric chlorohydrins) is used to make detergents, pharmaceuticals, dyes, pesticides, intermediates ion-exchange resins, anhydrous hydrogen chloride and smoke producing chemicals.

DIMETHYL SULFATE (methyl sulfate) is primarily used as a methylating agent for amines and phenols. End-use products derived from dimethyl sulfate include surfactants, fabric softeners, water treatment chemicals, pesticides, pharmaceuticals, dyes, and photographic chemicals. It is less often used as a sulfonation agent, catalyst, solvent, and stabilizer.

CHLOROPICRIN is a rodenticide used in grain elevators, bins, and other storage places. It's also applied to soil as pre-planting soil fumigant for control of fungi, verticillium wilt, nematodes, insects and weed seeds. Used in field bean crops and with fruits, tomatoes, tobacco, potatoes, other field crops (peanuts, sugar beets, etc.), lawns and turf, and as a fumigant for structural pest control. Chloropicrin is a possible alternative for methyl bromide. Other uses include organic synthesis and as crystal violet dye. It has also been used as a tear gas agent.

ALLYL ALCOHOL is used to make glycerol, herbicides (acrolein), and various resins and plasticizers. Used in the manufacture of flavorings and perfumes, it is also an intermediate for many pharmaceuticals. It is also used as a military poison.

BROMINE is primarily used as a chemical intermediate. It's used to make a wide spectrum of commercial products. These products include flame retardant additives, fire extinguishing agents, well completion fluids, water treatment chemicals, fumigants (methyl

bromide), dyes, Pharmaceuticals, photographic chemicals, and rubber products (automobile tires).

TITANIUM TETRACHLORIDE (or titanium chloride) is primarily used to make pure titanium metal (which is used to make aircraft parts, athletic equipment, and medical devices) and titanium dioxide (which is a pigment used in paints and foods and a whitening agent used in toothpaste). It's also used to make a variety of titanium catalysts, which, in turn are used to make various plastics, fibers, rubbers, and films. Minor uses include certain military uses (smoke screens).

HEXACHLOROCYCLOPENTADIENE is used to make fire-retardant chemicals. It's also used in the production of insecticides and as an intermediate for resins, dyes, and Pharmaceuticals. It's also an intermediate in shock-proof plastics.

HYDROGEN SULFIDE is used to make sulfuric acid (phosphate fertilizers, copper processing), sodium hydrosulfide (pulp processing for paper, copper mining, dye manufacturing, desulfurization of rayon and cellophane and leather tanning), sodium sulfide (leather tanning, polysulfide elastomers and plastics, dyes, pulp and paper, lubricating oils, wastewater treatment, photographic reagent, etc.), calcium polysulfide (a fungicide), sulfur chlorides and fluorides, and mercaptans (used in lubricating oils and cutting fluids).

ETHYL CHLOROFORMATE (ethyl chlorocarbonate) is used as an intermediate in making diethyl carbonate, floatation agents, polymers, and isocyanates. Diethyl carbonate is a solvent for nitrocellulose, and for synthetic and natural resins.

DINITROGEN TETROXIDE (nitrogen tetroxide, nitrogen dioxide) is used to produce nitric acid and as an oxidizer for spacecraft/rocket fuels, catalyst, oxidizing agent, nitrating agent, and a polymerization inhibitor for acrylates. Nitric acid is used in the manufacture of ammonium nitrate (a fertilizer providing nitrogen essential for plant growth), explosives, dyes, cellulose nitrate (used in automotive lacquers, rocket propellants, printing inks, flashless propellant powder, explosives), ore flotation, urethane polymers (used for sound and other insulation), rubber processing chemicals, and reprocessing spent nuclear fuel. Acrylates are used to manufacture acrylic polymers used in medical instruments, signs, headlight lenses, nonwoven fabrics, adhesives, and automotive coatings, and as ion exchange resins, absorbents in chromatography, among myriad uses.

The above summarizes the importance of TIH materials to our economy, public health and our modern way of living. These materials are essential to our nation.

Quantitative Assessment of the Economic Footprint of TIH chemistry

This section of the report presents the results of ACC's analysis which was concentrated on the value-added and employment associated with products and services ultimately dependent upon TIH materials and, in some cases, their derivatives. Many of the products and services are mentioned in the descriptions of the TIH chemicals listed in the qualitative assessment section of this report. The ultimate impact presented here is an underrepresentation as many of the derivative materials could not be included due to the unavailability of data. Lack of data also precluded inclusion of a number of distinct end-use applications (coatings, rocket fuel, parachutes, etc.). Furthermore, there are many downstream activities that could not be included. For example, primary magnesium and titanium are included but magnesium and titanium products are not included.

Table 2 presents estimates of the value-added and employment data for those industries and economic activities that are ultimately dependent upon TIH materials. The estimates, compiled using data from the Census Bureau and the Bureau of Labor Statistics, represent 2014 economic activity and employment for these industries. The data are adjusted to reflect the share of the economic activity of the sector that is dependent upon TIH materials. For example, ammonia is used in coal-burning electric power plants in selective catalytic reduction to comply with Clean Air Act emission standards. The value-added figure (and employment) reflects that electricity generated using coal accounts for only 38% of all electricity generated. The remaining share is from other fuels. Thus, the output and value-added (and estimated employment) of electricity generated by other sources is not included in the estimates in Table 2.

Table 2
Industries Dependent on TIH materials: Employment, Wages, Output, and Value-Added

	Employment (thousands)	Wages ($million)	Output ($million)	Value-Added ($million)
Agriculture & Food	821	29,848	415,602	185,073
Energy, Minerals & Water	200	20,590	1,014,073	212,101
Metals and Industrial Materials	233	17,363	190,012	86,992
Automotive, Electrical & Machinery	627	48,735	179,809	99,183
Building Materials & Other Industrial Products	153	6,983	51,716	21,152
Health Care & Other Consumer Products	338	31,557	204,059	130,638
Total	**2,372**	**155,077**	**2,055,271**	**735,139**

Source: American Chemistry Council, Bureau of Labor Statistics, Census Bureau

The data in Table 2 illustrate the criticality of TIH materials in a number of applications. The value-added provided by TIH material consuming industries amounted to $735 billion. This is equivalent to 4.2% of U.S. GDP. Employment in these industries totaled 2.4 million people. These figures do not include all economic activities where TIH materials are critical inputs.

Rail service disruptions would have a clearly negative impact on shippers of TIH chemicals and the industries that rely on their delivery to produce clean water, grow our food, and produce myriad materials and products essential to modern living. Based on the comments of a Class I railroad, however, the impact may expand well-beyond TIH chemicals. The potential exists for a widespread suspension of freight rail service to shippers of all classes of materials, including coal, agricultural products, metals, automotive equipment, non-TIH chemicals, fuels, wood products, etc. Thus, the broader economic impacts could be catastrophic.
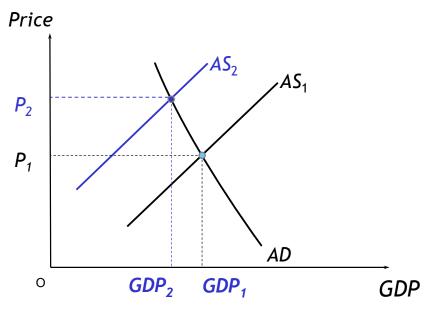
Broader Economic Impact of Rail-induced Supply Disruptions

The total supply of goods and services produced in an economy is referred to as the aggregate supply (AS). In an aggregate supply and demand graph, the AS curve illustrates the total quantity of goods and services that a nation can produce and sell at any given price level. In the short-run, the AS curve is upward-sloping as higher prices encourage increased production. In the long-run, however, the AS curve is vertical because changes in the price level do not affect output in the long run. In the long run, aggregate supply is determined by labor, capital, natural resources, and technology. Changes in any of these will shift the long-run AS curve.

Negative supply shocks to the economy are created by any unexpected event that constrains output or disrupts the supply chain, including spikes in energy prices, labor strikes, hurricanes, pandemics, and other natural disasters, and geopolitical developments such as acts of war or terrorism. Increases in business taxes and burdensome environmental and work place regulations can also cause negative supply shocks. As illustrated in Figure 2, negative supply shocks shift the aggregate supply curve inward (to the left) from AS_1 to AS_2, leading to a new equilibrium where prices are higher and output is lower.

Figure 2
Aggregate Supply (AS) and the Effect of a Negative Supply Shock on Economic Output (GDP)

Rail-induced supply disruptions to starting January 1, 2016 would have profound economic effects. Many associated (or satellite) businesses depend upon the railroad industry for service, sales, products and supplies. The combination of the losses that the railroad industry would incur, the losses of the associated business, along with other adverse ripple effects would engender a notable decline in real GDP growth. The supply disruptions would have a large ripple effect to many other industries that would see revenues and profits drop because

of the supply disruptions. This would include negative effects on the businesses dependent upon rail service for delivery of products (coal, other mining, chemicals, paper, etc.) and raw materials (steel, motor vehicles, etc.) as well as suppliers of products and services to the railroad industry (steel rail, diesel fuel, equipment, etc.). The shock due to a rail service disruption of this magnitude would lead to considerable supply and demand-side effects.

The negative effect of a supply disruption can be measured by the change in real GDP, the best indicator of economic growth. Obviously, when a nearly complete shutdown of a major industry occurs, GDP is significantly affected. A shock to supply in the U.S. economy is illustrated in Figure 2 above by an upward and inward shift of the AS curve. Holding all other factors (e.g., Federal Reserve monetary policy) constant, the supply shock would reduce GDP and raise the price level in the short-run.

Typically identified by a drop in GDP over the course of two consecutive quarters, recessions are periods of contractions in a nation's economic activity. The National Bureau of Economic Research (NBER) defines a recession as "a significant decline in economic activity spread across the economy, lasting more than a few months, normally visible in real GDP, real income, employment, industrial production, and wholesale-retail sales." Recessions may be triggered by various events, such as a financial crisis, an external trade shock, an adverse supply shock or the bursting of an economic bubble.

Historically, most negative supply shocks have resulted from sudden rises in the price of crude oil, a key input to most sectors of the economy. Energy -- and in particular, oil -- is ubiquitous, playing a large role in every sector of our economy. Considering U.S. recessions that have occurred Post-World War II, many have been associated with negative supply shocks due to oil price events. The information presented in Table 2 shows the close association between oil price related supply shocks and the timing of economic recessions. Recent econometric evidence suggests that this association has weakened as the effects of oil price shocks are not as extensive as 25 years ago, as the oil-intensity of the U.S. economy has dissipated.

Table 2
Energy Price Events and Post-World War II US Recessions

Energy Event	Recession
Over 35% Rise in Oil Prices During 1947	Nov. 1948 – Oct 1949
None	Jul. 1953 – May 1954
Suez Crisis	Aug. 1957 – Apr. 1958
Rise in Oil Prices (Texas Railroad Commission)	Apr. 1960 – Feb. 1961
Libyan Oil Industry Nationalized	Dec. 1969 – Nov. 1970
Yom Kippur War/OPEC Embargo	Nov. 1973 – Mar. 1975
Iranian Revolution	Jan. 1980 – Jul. 1980
Iran-Iraq War	Jul. 1981 – Nov. 1982
Iraq Invasion of Kuwait/Gulf War	Jul. 1990 – Mar. 1991
Over 35% Rise in Oil Prices During 1999-2000	Mar. 2001 – Nov. 2001
Rising Oil Demand and 145% Gain in Oil Prices	Dec. 2007 – Jun. 2009

Non-energy related supply shocks have also been associated with economic recessions. Most notable were the Steel Strike of 1959 and the US Postal Strike of 1970. And, more recently, a slowdown by West Coast longshoreman and adverse weather in the Northeast resulted in a decline in 1st quarter 2015 economic activity. This more recent example is directly related to transportation and distribution issues.

Table 3
Non-Energy Supply Shocks and Post-World War II US Recessions

Event	Annualized Effect on GDP (%)	Associated Recession or Slowdown?
1946 Bituminous Coal/Railroad Strikes	-0.5-2.3%	No
1959 Steel Strike	-3.0-5.5%	Yes
1970 US Postal Strike	-0.3-0.8%	Yes
1997 UPS Workers Strike	Minimal	No
2005 Hurricane Katrina	-2.0-2.5%	No, but slowdown
2012 Hurricane Sandy	-1.0-1.3%	No, but slowdown
2015 West Coast Dockworkers Labor Dispute/ Weather	-0.3%	No, but slowdown

The impact on the economy of a rail-induced disruption would be orders of magnitude larger than the West Coast longshoreman slowdown seen earlier this year. Due to the U.S. economy's broad and extensive dependence on rail transportation, if the PTC deadline is not extended and Class I railroads are forced to curtail rail service, a negative supply shock will be observed. This negative shock would come at a time when the U.S. economy is weak given the slowdown in China, slow growth in Europe and recessions in Canada, Brazil, and other emerging markets. This could potentially be the first U.S. recession induced by a regulation. The transmission of the supply shock would likely play out as follows.

- Starting January 1, 2016, Class I railroads curtail service on most lines.

- Those industries reliant upon the railroads for moving goods will then need to use alternative means of transporting goods (if possible) or draw down inventories of raw materials, intermediate goods, and finished product. In some cases (i.e., TIH Chemicals) alternative transportation modes are not possible. Supply chains are global and inventories are managed on a just-in-time basis. As a result, the effects will be immediately felt and will include not only impacts on domestic activity but also on international trade.

- As manufacturing companies draw down inventories of raw materials and intermediate goods, the inability to obtain new supply will result in curtailment of production. The inability to ship out products will result in curtailment of operations. Both will result in job losses. Industries that would be most affected include steel, paper and lumber, mining, chemicals, non-metallic mineral products, motor vehicles, and others. The economic impact of the curtailment of industrial activity will be manifested through several channels: directly (such as in the employment, output and fiscal contributions generated by the sector itself), indirectly (employment and output supported by the sector via purchases from its supply chain), and by induced impacts (employment and output supported by the spending of those employed directly or indirectly by the sector).

- The decline in aggregated economic activity will initiate cascading declines in the other economic activities. For example, when a drop in production causes a drop in employment, it triggers declines in income, which in turn feeds back into a fall in business sales which in turn feeds back into a further fall in production. A vicious cycle results and recessionary conditions ensue. This domino effect transmitting economic weakness from production to employment, to income, and to sales; and then feeding back into further weakness in all of these measures is what marks a supply shock.

- With the curtailment of business activity, loss of jobs and alarming news reports about water treatment issues and problems at coal-fired electric power plants, consumer confidence will fall sharply, further reinforcing a vicious cycle.

- The impacts will further migrate to upstream and downstream industries. For example, railroads will curtail orders for rail, diesel fuel and other supplies as well as for rolling stock and other capital investment. Steel companies will curtail orders for iron ore, limestone, coal and other raw materials and at the same time, consumers of steel mill products (fabricators of metal products, appliance manufacturers, automobile companies, etc.) will begin curtailing production and cutting employment. Chemical companies will be unable to ship plastic resins and other products, and manufacturers of plastic products, tire companies, and the downstream companies

that use these products will begin curtailing operations and cutting employment. All of this will further reinforce a vicious cycle.

Should Congress fail to act before the end of this year, the shipment of many critical products by rail could be brought to a stand-still. If railroads do follow through on their threat to refuse shipments, it would prevent the distribution of chlorine which is used in water treatment, in the manufacturing of PVC plastic that is used in essential medical equipment, and countless other essential goods. Shipments of anhydrous ammonia used in fertilizer could also be disrupted, which could lead to lost crops, increased food prices, and shortages. Even allowing the deadline to approach could be very damaging as companies make long-term transportation plans.

The devastating economic and social costs associated with this type of disruption have been observed before. **Unlike some other shocks in history, this one is preventable.** Congress can approve legislation that would provide railroads with a workable and reasonable extension to the deadline. The Senate included a three year PTC extension in the latest version of their long term highway bill. If approved by the House, the nation's railroads would have the time that they need to complete necessary testing and improvements to their PTC systems once they are deployed.

Supply Shock Impacts

Rail service disruptions will affect not only producers and shippers of goods transported by rail, but will have broader economic impacts, as well. This section focuses on the potential economic impact of these rail service disruptions to the broader macro-economy as the impact of a rail-induced supply shock expands to nearly all economic activities.

To assess the impact of supply shocks on the economy, ACC used the Oxford Economics Global Model, a quarterly international econometric model that provides an analyst with the ability to examine how economies react to changes in the economic environment, perform scenario analyses and produce forecasts. A review of the economic literature on the economics effects of strikes and other supply shocks was also important to assessing the impact of a rail-induced supply shock. Although the Oxford Economics Global Model provides global impacts, the emphasis of this analysis is on the effects of a supply shock to the U.S. economy. The effects of a supply shock were simulated by changing the confidence and input price assumptions and then comparing the results of the model solution with a baseline projection.

It was assumed that a severe rail disruption occurs starting the first week of 2016. The disruption would affect approximately 80% of rail volume and last for one month. The focus of ACC's analysis was on the first half of 2016. For the purpose of comparing to a baseline or "base case scenario," ACC considered the projections published in the September 2015 issue of *Consensus Forecasts® - USA* by Consensus Forecasts. A 2.5% seasonally-adjusted annual rate (SAAR) for U.S GDP in 1st quarter 2016 and a 2.8% pace for 2nd quarter 2016 were projected.

The results of ACC's modeling indicate that the effects of a one month rail service disruption would have a negative effect on the U.S. economy. Table 4 presents the deviation from the base case that would occur with the sustained supply disruption. Unless noted otherwise, the data are presented as a deviation from the baseline expressed as percentage points.

Table 4
Supply Shock Effects of Rail Service Disruptions on the pace of growth in the U.S. Economy
(Unless noted otherwise, % point deviation from base case - SAAR)

	1Q 2016	2Q 2016
Growth in Real GDP	-2.6	-1.3
Growth in Consumer Spending	-1.5	-0.8
Growth in Business Fixed Investment	-2.6	-2.7
Non-Farm Employment (thousands)	-358	-681
Unemployment Rate	+0.3	+0.6
Inflation – Consumer Prices	+0.3	-0.2
Long-Term Interest Rates (basis points)	-3	+15
Federal Deficit (billions)	-$29.1	-$33.2
Industrial Production	-2.9	-1.9
Light Vehicles Sales (millions)	-0.7	-0.3
Housing Starts (thousands)	-111	-113

A supply shock arising from PTC regulation-induced rail service disruptions will most severely affect the industrial sector, resulting in less production. Housing starts, for example, would fall below what they would be otherwise. For rail-dependent sectors such as coal and other mining, farming and food, motor vehicles, chemicals, steel and other primary metals, paper and lumber, and other manufacturing, the effects would be severe. In addition, curtailment of rail passenger service would adversely affect business travel and commerce (especially in the Northeast corridor) and will have supply-side labor effects as it will limit the ability of many workers to commute. The supply disruption would reduce employment, depressing disposable personal incomes and savings, and ultimately consumer spending, which accounts for two-thirds of the economy.

Thus, the shock to the supply-side along with demand side effects results in a much lower economic growth rate during 1st quarter 2016. The shock would reduce real GDP growth by about 2.6 percentage points. This would be enough to push a modest pace of economic

expansion into one of contraction. As a result, real GDP would likely decline during the 1st quarter and the adverse effects would linger into the 2nd quarter.

Inventory reductions would account for about three-tenths of the reduction to economic growth and would figure prominently at first but ripple effects to other sectors would soon dominate. Lower economic growth results in lessened job creation and a higher unemployment rate. ACC found that nearly 700,000 jobs will be at risk if the PTC deadline is not extended. There would be ripple effects to associated industries and to production, employment, wage and salary income, and spending by consumers and business – a vicious cycle. Consumer spending and business investment would falter. The ripple effects would be most manifested in manufacturing, mining and utilities, and industrial production would fall even further than the broader economy. The light vehicle industry and construction sectors would also be adversely affected.

At the same time, despite deflationary pressures from lower economic activity, inflation as measured by the consumer price index would likely accelerate as a result of the adverse supply shock. Economic theory and history suggest this will be the case. Interest rates present mixed results as the deflationary pressures from lower economic activity would be largely offset by premiums arising from inflationary expectations and from business (and credit market) uncertainty.

Finally, government financing would deteriorate. This occurs as the drop in employment (and income) and corporate profits engender lower tax receipts and in combination with higher unemployment claims, social welfare spending, and eventually higher borrowing costs results in a larger Federal deficit. The states with finances that depend more heavily on severance, fuel and related taxes will be disproportionately impacted.

Summary of Supply Shock Impacts: Economic theory and history suggest that supply shocks have profound effects on the U.S. economy and can be a potential factor in fostering recessionary conditions. The findings from ACC's analysis suggest that the **rail service disruptions lasting only one month would engender a 2.6 percentage point cut to U.S. real GDP growth during 1st quarter 2016 and would thrust the U.S. economy from one of modest expansion into one of contraction. With ripple effects throughout the economy, the service disruption could result in over 680,000 fewer jobs.**

Should the curtailment of rail service last longer than one month, the impact to the economy would be truly catastrophic, and would likely result in a recession; the first regulatory-induced recession in American economic history. Given the current fragile state of the economy, Congress must act immediately to provide for a reasonable, workable extension for PTC to avoid this massive disruption to freight rail service and the potentially dire consequences for the U.S. economy that would come with such a shutdown. The Administration should clearly and publicly support a reasonable PTC extension.

Economic Impact to Producers of Materials Shipped by Rail

The railroad industry supports numerous segments of the U.S. economy. According to the Census Bureau, more than 16.8% of goods that travel in the U.S. (based on tonnage) are on the rails at some point in their journey[2]. Geographically and economically, the United States is a large country. Rail is critical to the safe transportation of goods from one part of the country to another. The average distance per rail shipment is 805 miles, roughly the distance between Dallas and Chicago. Nearly $350 billion of goods are moved each year on the nation's rail network, representing 0.6% of U.S. GDP ($100 billion of value added). These shipments include raw materials, intermediate goods, and finished products traveling to domestic and international customers across all segments of the global economy. An estimated 590,000 people make a living working in industries that produce goods that are distributed by rail.

If freight rail service were suspended as a result of the failure to extend the PTC compliance deadline, industries that rely on rail would be faced with some tough decisions. In the short term, some businesses might be able to substitute truck transportation services for rail. However, **to move the 1.84 billion tons of goods hauled by rail would require the addition of 600,000 heavy-duty Class 8 trucks and certified truck drivers.** Even if there were that number of spare trucks available, the American Trucking Associations (ATA) reports that the truck transportation sector is already struggling to find enough truck drivers to fulfill its current obligations[3]. This severely reduces the likelihood that rail services could be substituted by truck. Thus, ACC assumes that if freight rail service were suspended, shippers would be unable to find substitute modes of transportation in the short-term. As a result, production would be suspended in most locations as inventory-building would be impractical or unfeasible.

ACC assumed that the industries that produce goods and materials shipped by rail would have to shut down until rail shipments were able to move again. The economic impact of the curtailment of industrial activity would be manifested through several channels:

- *Direct impacts* - such as the employment, output and fiscal contributions generated by the sector itself
- *Indirect impacts* - employment and output supported by the sector via purchases from its supply chain
- *Induced impacts* - employment and output supported by the spending of those employed directly or indirectly by the sector

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[2] Census Bureau, Commodity Flow Survey, Table 1a (http://www.census.gov/econ/cfs/)
[3] According to the ATA "The for-hire trucking industry is facing a shortage of drivers. Despite the national unemployment rate being over 7%, the industry struggles to find enough qualified drivers. The current shortage of roughly 25,000 is due to a multitude of reasons, including demographic, regulatory, and the fact that drivers are away from home for a period of time, among other factors." (http://www.trucking.org/News_and_Information_Reports_Driver_Shortage.aspx)

If freight rail service is disrupted, nearly $350 billion of annualized economic activity would be suspended. Depending on the length of the rail service suspension, the more than 590,000 employees of those industries would have to file for unemployment insurance at a substantial cost to taxpayers. Upstream, the businesses that supply materials and services to the affected industries would also be negatively impacted. An additional 1.26 million supply-chain jobs are supported by the industries that ship via rail. In local communities where these workers live, another 1.17 million jobs are supported by the household spending of workers of rail-shipping goods producers and their suppliers. Suspension of freight-rail service would negatively impact them as well. All told, more than 3 million jobs are linked to the economic activity generated by rail-producing goods shippers. The impact to the broader economy is much larger, however, because this estimate does *not* include jobs in industries that depend on the *delivery* of rail shipments themselves, likely an even higher number.

The downstream impacts are more difficult to quantify, but could be substantially higher as freight-rail suspension would prevent the delivery of raw materials to manufacturers, coal power plants, gasoline and other fuels businesses and households, parts to manufacturers, fertilizers to farms, farm products to food producers, manufactured products to retailers, etc. In addition, many rail shipments are sent to ports for export to markets around the world. In a globally competitive economy, disruptions to supply could result in a loss of market share that could ultimately impact our nation's trade deficit.

To estimate the upstream economic impacts from the rail-induced supply disruptions to the U.S. economy, the IMPLAN model was used. The IMPLAN model is an input-output model based on a social accounting matrix that incorporates all flows within an economy. The model uses industry spending patterns and output-to-labor ratios to calculate the employment impacts associated with a change in final demand in a particular industry (or set of industries). The IMPLAN model includes detailed flow information for 440 industries. As a result, it is possible to estimate the economic impact of a change in final demand for an industry at a relatively fine level of granularity. For a single change in final demand (i.e., change in industry spending), IMPLAN can generate estimates of the direct, indirect and induced economic impacts. Direct impacts refer to the response of the economy to the change in the final demand of a given industry to those directly involved in the activity. Indirect impacts (or supplier impacts) refer to the response of the economy to the change in the final demand of the industries that are dependent on the direct spending industries for their input. Induced impacts refer to the response of the economy to changes in household expenditure as a result of changes in labor income generated by the direct and indirect effects.

Using data on the value of shipments by mode from the 2012 Commodity Flow Survey prepared by the Census Bureau, ACC estimated the percentage of total modal shipments that use rail, either alone or in conjunction with water or truck transportation. We used this information to estimate the shipments of businesses in the industries that ship by rail. For example, 9.7% of the value of primary metals and basic forms (i.e., foundry products) is

moved by rail. Across all industries (including agriculture, mining, and manufactured products), the total shipments of industries that use rail was estimated to be $345.1 billion in 2014. This information was used with the IMPLAN model to generate an economic footprint of the contributions of rail-shipping goods producers in 2014. These contributions are presented in Table 5.

Table 5
The Economic Contributions of Rail-Shipping Goods Producers at Risk, 2014

Impact Type	Employment (thousands)	Labor Income ($ billion)	Value Added ($ billion)	Output ($ billion)
Direct Effect	592	$44.0	$99.7	$345.1
Indirect Effect	1,263	$89.8	$165.4	$394.8
Induced Effect	1,171	$57.5	$101.1	$182.7
Total Effect	**3,026**	**$191.3**	**$366.1**	**$922.7**

Industries that depend on rail shipments have a lot to lose from the failure to prevent a service disruption to the freight rail network. Even a small disruption could sever access these businesses have to customer markets, and production could halt. Such curtailment of production activity would lead to job losses in these industries. Upstream, their suppliers and businesses that serve the local communities where these businesses operate also stand to lose. The magnitude of the loss increases with every day the disruption persists. More than 3 million jobs are tied to the upstream economic activity generated by rail-shipping goods producers. Downstream, many more are linked to the businesses and households that count on those deliveries.

Summary of Economic Impact to Producers of Materials Shipped by Rail: Industries that depend on rail shipments have a lot to lose from the failure to prevent a service disruption to the freight rail network. Even a small disruption could sever access these businesses have to customer markets, and production could halt. Such curtailment of production activity would lead to job losses in these industries. Upstream, their suppliers and businesses that serve the local communities where these businesses operate also stand to lose. The magnitude of the loss increases with every day the disruption persists. Industries that produce materials shipped by rail produce $354.1 billion in output annually and directly employ nearly 600,000. In total, more than 3 million jobs are tied to the upstream economic activity generated by rail-shipping goods producers. Downstream, many more are linked to the businesses and households that count on those deliveries.

ACC's Economics and Statistics Department

The Economics & Statistics Department provides a full range of statistical and economic advice and services for ACC and its members and other partners. The group works to improve overall ACC advocacy impact by providing statistics on American Chemistry as well as preparing information about the economic value and contributions of American Chemistry to our economy and society. They function as an in-house consultant, providing survey, economic analysis and other statistical expertise, as well as monitoring business conditions and changing industry dynamics. The group also offers extensive industry knowledge, a network of leading academic organizations and think tanks, and a dedication to making analysis relevant and comprehensible to a wide audience.

Dr. Thomas Kevin Swift
Chief Economist and Managing Director
202.249.6180
kevin_swift@americanchemistry.com

Martha Gilchrist Moore
Senior Director – Policy Analysis and Economics
202.249.6182
martha_moore@americanchemistry.com

Heather R. Rose-Glowacki
Director, Chemical & Industry Dynamics
202.249.6184
heather_rose@americanchemistry.com

Emily Sanchez
Director, Surveys & Statistics
202.249.6183
emily_sanchez@americanchemistry.com