Externalities and Opportunities from Agricultural Transport in the U.S.

Neda Nazemi

Follow this and additional works at: https://digitalcommons.memphis.edu/etd

Recommended Citation
Nazemi, Neda, "Externalities and Opportunities from Agricultural Transport in the U.S." (2023). Electronic Theses and Dissertations. 2994.
https://digitalcommons.memphis.edu/etd/2994

This Thesis is brought to you for free and open access by University of Memphis Digital Commons. It has been accepted for inclusion in Electronic Theses and Dissertations by an authorized administrator of University of Memphis Digital Commons. For more information, please contact khgerry@memphis.edu.
EXTERNALITIES AND OPPORTUNITIES FROM THE AGRICULTURAL TRANSPORT IN THE U.S.

by

Neda Nazemi

A Thesis
Submitted in Partial Fulfillment of
the Requirements for the Degree of
Master of Science

Major: Civil Engineering

University of Memphis

August 2023
Abstract

One of the largest users of the transportation systems in United States is agriculture industry. The transportation networks and infrastructure play a vital role in food and distributions of agricultural commodities from farms to the final destinations. The growing population, increasing needs for agricultural products, and the competitive global market for agriculture products and food and related industries requires delicate transportation networks planning in order to move through the inland networks to the ports and deliver to the international markets via the international waterways. In this study, the challenges of transporting agricultural products are examined and the possible strategies, based on literature, are suggested.
## Table of Contents:

List of Figures ........................................ iii

List of Tables .......................................... iv

Introduction: Importance of Agricultural Products in the U.S. ........................................ 1

  Transporting Agricultural Products ................................................................. 6

  Externalities from Transporting Agricultural Products ........................................ 9

Tennessee Agricultural Commodities Flow and Data Review ....................................... 11

Agricultural Commodities Flow Data Disaggregation ................................................. 15

Results of Impacts Analysis and Solutions ............................................................. 17

Conclusion ........................................................................................................ 20

References .......................................................................................................... 22
List of Figures:

Figure 1, Total U.S. agricultural Trade and Trade Balance for 2000-2021 1

Figure 2, Total Planted and Harvested Corn, Wheat, Soybeans, and Cotton, from 1998 to 2022 4

Figure 3, Harvested Corn, Wheat, Soybeans, and Cotton per Harvested Acreage, from 1998 to 2022 4

Figure 4, The Amount of Produced, Exported, and Domestic Use Corn, Wheat, Soybeans, and Cotton and, from 1998 to 2022 4

Figure 5, 2012 Map of the Farmlands in Tennessee 12

Figure 6, 2012 Map of the Soybean Farmlands in Tennessee 12

Figure 7, 2012 Map of the Corn Farmlands in Tennessee 12

Figure 8, 2012 Map of the Cotton Farmlands in Tennessee 12

Figure 9, 2012 Map of the Wheat Farmlands in Tennessee 13

Figure 10, Barges and vessels Terminal in Tennessee 16

Figure 11, Freight Operating Airports in Tennessee 16

Figure 12, Freight Operating Rail Facilities in Tennessee 16
List of Tables:

Table 1. Total weight of transported products, in tons 14
Table 2. Total weight of transported products, in thousand dollars 14
Table 3, CO₂ emission estimation factors 18
Table 4, Exhaust emission estimation factors 18
Introduction: Importance of Agricultural Products in the U.S.

The growing population requires effective and efficient transportation systems to deliver agricultural products from farms to the factories, warehouses, distribution centers, elevators, and end customers. According to the Freight Analysis Framework (FAF) freight flow estimates, in 2018, more than 18 percent of the commodities, in ton-miles, transported in the United States, constitute of agriculture products. Consumption and production of crops and other agriculture-related products is increasing dramatically and the demand for exports in the international market is rising as well. World population is projected to grow slowly, 0.9 percent, during the 2022 to 2031, compared to the 1.1 percent growth in prior decade, U.S. Department of Commerce, Bureau of Census (2021), while high international trades of agricultural products are expected to satisfy the demands of world markets (1).

![Total Value of U.S. Agricultural Trade](image)

Figure 1, Total U.S. agricultural Trade and Trade Balance for 2000-2021

Source: USDA, Economic Research Service and USDA, Foreign Agricultural Service
Crops productions and performance in agriculture sectors significantly impacts the economics, in both the national market and international trades, and can contribute to economic growth. On average, the total agricultural exports in 2020 generated 2.03 USD per 1 USD exported products. Moreover, 150.4 billion of dollars of the related products are exported and the outputs supported exports is 304.4 billion dollars, figure 1 (2). The price pressure on the agricultural products, supply chain issues and challenges are the main impacting factors on the trade. According to the latest report by AgAmerica Lending, the real U.S. dollar value directly impacts the international trades. During the 2000s, the U.S. dollar significantly depreciated, and the demand increased sharply by 2014. Since 2014 the increasing U.S. dollar value lead in the drop in exports demand, and the trades balance experienced negative values in 2019. However, it is predicted that the total agriculture exports will reach their record with 192 billion dollars by 2025.

In 2019, agriculture sector, food, and related industries contribution in gross domestic productions (GDP) in the U.S. is 1.109 trillion dollars, 5.2 percent of the total GDP. Farm related activities directly account for 136.1 billion dollars, 0.6 percent. In 2020, the overall GDP contribution of agriculture and related industries decreased to 1.055 trillion dollars, 5.0 percent shares of the total GDP, and only farms shares of GDP is 134.7 billion dollars, 0.6 percent of the overall GDP, due to the start of the pandemic causing serious economic crisis. In addition, around 10.3 percent of the total U.S. employment is provided by the jobs related to the agriculture sector and the dependent industries in 2020. And 2.6 million jobs, 1.4 percent of the employment, are directly on-farm jobs (2), (3).

In addition, in 2020-2021, the major world economic crisis generated due to COVID-19 affecting the world agricultural exports and imports (2), (3). The crises targeted two major
microeconomic variables, in 2020, the global GDP and the dollar depreciation. The world’s GDP dropped by 3.5 percent, compared to the 4% decrease in the U.S. GDP, U.S. lead to declined agricultural exports. However, dollar depreciation against the Chinese yuan, Europe euro, and other global partners, as the actions of the U.S. Federal Reserve was to stimulate the agricultural exports. The results of these impacts raised the agricultural exports for 7 percent to $146 billion \((2),(3),(4)\). Regardless of the COVID-19 impacts, the increasing international trade partners’ demand for agricultural products boosted the sectors’ exports. For example, the agricultural exports from the U.S. to China raised from $13.9 billion to $26.4 billion in 2019-2020. Another factor affecting the agricultural trades is the weather conditions, which in 2020, the poor harvests in some competing countries, stimulated the U.S. exports to the trade partners, like China. Generally, dropped GDP due to COVID-19 was dominated the U.S. dollar depreciation and other export-enhancing economic developments of the world \((2),(3),(4)\).

The importance of agriculture sectors and related industries is becoming more and more evident to the local, statewide, national, and global, developing proper transportation networks and infrastructure help the countries thrive the global market. And by increasing in population, demand for the agricultural products as means of producing apparels, food and beverages, and other purposes increases as well as boosting the imports and exports of crops. The U.S. facing challenges due to its strong dollar value, and hence high commodities values in the international market. However, the U.S. remains competitive in the global international market with corn, soybean, wheat, cotton. Figure 2 shows the planted and harvested area for these four crops moved along the vast highway networks, railroads, and navigable inland and international waterways. The total corn production continues increasing despite the receding acreage. As can be seen in figure 3, the volume (bushels) per acreage for corn is increasing. According to USDA,
Economic research Service (USDA-ERS) the planted acreage for soybean is expected to slightly increase, after its peak price of $12.35 per bushels in 2021-22 declines to $10.50 per bushels in 2022-23 period, and production increases from 4.465 billion bushels to 4.885 billion bushels from 2022-23 to 2031-32 (1). The domestic use and exports for wheat are estimated to remain flat and hence the wheat acreage and productions are estimated to decline very slightly by 2031-32. However, the total production per acreage for these crops are projected to increase through the projection period. The demand for cotton in domestic use declines by 2022-23 and remains flat by 2031-32, figure 4.

Figure 2, Total Planted and Harvested Corn, Wheat, Soybeans, and Cotton, from 1998 to 2022
Source: USDA, National Agricultural Statistics Service (NASS)
Figure 3, Harvested Corn, Wheat, Soybeans, and Cotton per Harvested Acreage, from 1998 to 2022
Source: USDA, National Agricultural Statistics Service (NASS)

Figure 4, The Amount of Produced, Exported, and Domestic Use Corn, Wheat, Soybeans, and Cotton and, from 1998 to 2022.
Source: USDA, National Agricultural Statistics Service (NASS)
Agricultural sectors and related industries are important to the national and international economy, and for the international partners it is crucial to stay in this competitive market by delivering their products of the highest quality. Since the agricultural products are mostly perishables, it becomes a concern to the local to global level of planners and decision makers to provide effective transportation infrastructure moving the commodities and delivering them to the end destination. One of the main challenges is that transportation development cannot pace with increasing demand for transporting agricultural products, requiring concise planning.

**Transporting Agricultural Products**

An adequate transportation system is essential for the economy health and productivity of the agriculture industries, which the U.S. success in global market is highly dependent on the transportation network, to deliver the products to urban areas and coastal hubs. On the other hand, failure in transportation systems leads to job loss and unemployment, low quality of the products, lower income for the employees and farmers, loss in highly competitive international markets, and high shipping costs (5). Agriculture is highly dependent on the land. Planting and harvesting require high quality soil, favorable climate, access to watering systems, relocating them to the near manufacturers, milling, storages, and consumers in the regions are impossible (5), (6). Deficiency in the transportation networks affects the agricultural activities in the regions and the products quality while delivering to their destinations. Hence, new technologies and equipment have made it possible to move the perishable products to distant regions and beyond. The movement of crops from fields to markets and customers is facilitated by different types of transportation modes. These transportation methods include road transport, rail transport, water transport, and air transport. Road transportation is popular for short-distance travel offering
flexibility and easy access to isolated regions. Rail transportation is ideal for moving large volumes over the long haul since it is cost-effective and has lower toxic emissions from burning fuels. Inland and international waterways have provided this opportunity to move heavy-weight products, bulk or in containers, and compete in the international markets. Last but not least, air transportation is frequently employed to deliver high-value and perishable goods efficiently to distant markets. Each transportation mode offers unique opportunities and limitations, and based on various factors, such as distance, product type, market demand, and infrastructure, they can be used to maximize efficiency and productivity. In this study, the three most employed modes, trucks, railroad, and waterways, are summarized.

**Trucks**

Trucks are the most common mode of transportation for inland movements, transporting products through the highways crossing the several states. Trucking systems are critical in U.S. agricultural transportation. The demand for available trucks is seasonal, and for some commodities require specific equipment to pick up directly from farms and move them through the roads. The accessibility of the trucks, compared to other modes of transportation, made farmers to carry their crops by trucks. Over 70 percent of the forestry, fertilizers, agriculture products, and foods are carried with trucks (FAF5). The trucking industry is highly competitive in agriculture sectors keeping the rate low, which the operating costs of trucking in food sectors is 95 percent of the total revenue (5), (7). Another factor is that agricultural commodities are high in weight and volume, and low in raw value. Some local authorities suggested increasing the allowable weight of truckloads to bear with the high transportation costs, which on the other hand, will impose damage to the roadways, and the cost of maintenance become another issue.
By rising the volume of trucking agricultural products, congestion along the roads and crashes increases as well (5), (8), (9).

**Railroads**

Railroads are known for their low-cost services, especially for long-haul movements. They carry the most ton-mile of America’s freight compared to trucks. It is a cost-effective way to move agriculture and forestry products. Agricultural products are one of the essential sources of revenue for railroads (10). The east-west corridor, along with the west coast and Midwest corridors, are significant corridors for rail movements after the abandonment of the Class 1 rail, and high maintenance of these abandoned lines led to the starting of short-line railroads or regional railroads (5), (10). Short-line operations have been successful for regional hauling. In 2021, more than 28 percent of the tracking miles were traveled by regional railroads, according to American Association of Railroads (AAR) data. Railroads are the most favorable mode for long-haul shipments. The reason behind is that the main costs of the rail systems are the capital investments, and even these rates are advantageous for agricultural products, with the low value-to-volume ratio.

**Waterways**

Barges are an efficient method for inland waterways shipments, with low costs for transporting agricultural products. About 30 percent of the corn and 17 percent of the soybeans are moved through the Mississippi River and Illinois waterways (5). However, with the shrinking demand for barge movements and the sources of capital investments, along with the relatively high cost of maintaining the dams and locks, there is an imbalance between the generated revenue and total expenditure (14).
Container ships are another method for hauling agricultural products to deliver to international partners through the Gulf region. However, the growth of international trade leads in container availability crises and closure in maritime supply chains caused shipment delays, resulting in product spoilage, increasing transportation costs, and then losing global markets (5), (15).

**The Externalities from Transporting Agricultural Products**

With high pace growing domestic and global demand for the crops, meats, and aquacultural products have raised the concern of improving the transportation systems and infrastructure to deliver the products at the highest quality. However, the improvement rates lag behind the population growth and their immediate demand for food and apparel. Lack of efficient infrastructure and transportation systems causes long congestions and fatal crashes within the network, lacking container and vessels availability in the international market, increase in fuel consumptions and hence, more dangerous compounds emissions from the burning fuel, disrupt in human and animals sleep cycle, permanent health issues, etc.

**Environmental Impacts**

The increasing in the volume of moving agricultural commodities and the consumption of fuel increases causes in emitting undesired particles and greenhouse gas (GHG) to the air. Particles with diameter less than 2.5 of particulate matters (PM2.5), nitrogen oxides (NOx), and volatile organic compounds (VOC) are the considerable emissions from burning fuel, along with the carbon dioxide (CO<sub>2</sub>) (16). The emissions are absorbed from human breath and skin, causing low-birth rates, cognitive decline, diabetes, brain damage, premature births, respiratory and cardiovascular disease, and many other infections and diseases (17) - (21). Moreover, the CO<sub>2</sub> emissions from burning fossil fuels speeds up the polar glaciers melting and endangering the
habitats. Transportation accounts for around 19% of the total GHG emissions, and freight transportation is considered as one of the primary sources of the GHG and other dangerous emissions (22), (23).

Noise pollution and light pollution from freight-related activities in facilities, on roadways and railways causes disturbance to animals and human well-being (24). The persistence of noise pollution from rail and trucks activities in residential areas disturbs the sleep cycle-hours, and adverse annoyance reactions and social behaviors (25).

**Social Impacts**

Deficiency in roadways, long congestion, and fatal crashes due to rising freight volume raised the concern of the safety of the residents and the travelers using the same roads and highways, and disrupting their regular commuting and trips (26). The fatality rate of collisions involving freight trucks are 20 percent more compared to personal vehicles collisions (27).

**Economic and Land Use Impacts**

As mentioned previously, agriculture is highly dependent on the region, requiring efficient transportation network for the region, to access the warehouses, factories, millings, and storages, and providing water supplies for the farms. Moreover, the agriculture sectors and related industries contribute to the economic developments directly and impact the microeconomic factors (5), (6).

In order to mitigate these impacts effectively, it is important to methodically observe and analyze the issues at the local level. Recently, due to the increasing demand for cargo and resources, local, national, and international authorities, businesses, planners, and decision-makers are searching for the best way to an enduring sustainable approach.
To this end, this study is conducted to explore the patterns in the transportation of agricultural products in the state of Tennessee to understand the adverse impacts and potential solutions that can alleviate, or even mitigate, those impacts. Then, the total flow of agricultural products, inbound, outbound, and internal flow, is summarized and analyzed.

**Tennessee Agricultural Commodities Flow and Data Review**

Tennessee is one of the important states for transporting goods to other states. With access to the Mississippi River and barge ports, developing intermodal facilities, and connections with other states through the borders facilitate sufficient transportation network for agricultural transportation for intrastate and interstate market, moving commodities to ports connected to international waters, and domestic consumers. In Tennessee, farming dominated the state’s land acres, covering 41 percent of the 26.4 million acres of the total area of the state, 10.8 million acres, with 77,300 farms. Tennessee has the eighth rank for the number of farms in the U.S. and plays an important role in farming activities. In figure 5, the green color shows that the farms are mostly distributed in the west part of the state. Cotton, corn, soybean, wheat, and sorghum are the main products harvested in the “rich west farmland” (USDA-NASS). Figures from 6 to 9, show Tennessee’s farmlands for soybean, corn, cotton, and wheat, respectively. 78 percent of soybean and corn are harvested in the west of Tennessee, and around 21 percent of the farmland are in the middle state. 97 percent of the cotton is produced in the west lands. 96 percent of the wheat-lands is planted in double-cropped lands with soybean, 24 percent of the total area of planted soybean.
Figure 5, 2012 Map of the Farmlands in Tennessee
Source: USDA, National Agricultural Statistics Service (NASS), CropScape Query Tool.

Figure 6, 2012 Map of the Soybean Farmlands in Tennessee
Source: USDA, National Agricultural Statistics Service (NASS), CropScape Query Tool.

Figure 7, 2012 Map of the Corn Farmlands in Tennessee
Source: USDA, National Agricultural Statistics Service (NASS), CropScape Query Tool.

Figure 8, 2012 Map of the Cotton Farmlands in Tennessee
Source: USDA, National Agricultural Statistics Service (NASS), CropScape Query Tool.
Agricultural Flow data

To gain a better understanding of commodities flows, different organizations provided the origin-destination (OD) movements in the U.S., such as, Freight Analysis Framework (FAF) from partnerships between the Bureau of Transportation Statistics (BTS) and Federal Highway Administration (FHWA), Commodity Flow Survey (CFS) produced by BTS, and IHS Global Insight’s Transearch database. Transearch database is based on the estimations of commodity production with pairs of O-D at county-level, containing details about the equipment and conveyance types for transporting the products, and the types of commodities, categorized based on 3-digits Standard Classification Transport Goods (SCTG – 3digits) code. In this study, the agricultural commodities are categorized into SCTG codes with 2 digits from 1 to 5, 01: Live Animals and Fish, 02: Cereal Grains, 03: Agricultural Products, Except for Animal Feed, Cereal Grains, and Forage Products, 04: Animal Feed, Eggs, Honey, and Other Products of Animal Origin, and 05: Meat, Poultry, Fish, Seafood, and Their Preparations. Table 1 and 2 show the total produced and delivered agricultural products in 2012, by product types, in tons and value, in the state of Tennessee.
Table 1. Total weight of transported products, in tons

<table>
<thead>
<tr>
<th>Flow Type</th>
<th>Commodity Type</th>
<th>Outbound</th>
<th>Inbound</th>
<th>Internal</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCTG 01</td>
<td>6.42E+05</td>
<td>8.39E+05</td>
<td>9.34E+04</td>
<td></td>
</tr>
<tr>
<td>SCTG 02</td>
<td>3.39E+06</td>
<td>5.19E+06</td>
<td>5.51E+05</td>
<td></td>
</tr>
<tr>
<td>SCTG 03</td>
<td>6.94E+06</td>
<td>6.45E+06</td>
<td>5.12E+06</td>
<td></td>
</tr>
<tr>
<td>SCTG 04</td>
<td>1.57E+06</td>
<td>1.29E+06</td>
<td>2.08E+05</td>
<td></td>
</tr>
<tr>
<td>SCTG 05</td>
<td>7.21E+05</td>
<td>7.52E+05</td>
<td>4.89E+04</td>
<td></td>
</tr>
</tbody>
</table>

However, a comprehensive understanding of the impacts demands more localized information of the transportation flow of Agricultural products, compared to the county-level information provided by Transearch. Data gathering at the lower geographic levels, such as Zip code or transportation analysis zone (TAZ), requires effort and financial resources. Hence, data disaggregation enables optimal routing optimization, assists with the supply-chain management and decision-making, and provides more granular vision for organizations to obtain efficient risk-assessment analysis and identify the vulnerabilities within the network and the infrastructure (28) – (31).
Agricultural Commodities Flow Data Disaggregation

A wide range of literature have studied different methods of freight flow data disaggregation. Depending on the resolutions of disaggregate zones, commodity flow dataset, and provided variables for flow data disaggregation, a variety of methods are introduced. The most utilized method is proportional weighting, 60% of all the reviewed literature (32). Employment, population, farm acreage, are some socio-economic variable instances used proportional weighting method. In this method, basically, the commodity flow between the aggregate-level zones, county-level in this study, are broken down into flows through the smaller regions, TAZ-level, with the variables based on the industry and economic indicators.

In proportional weighting method, the ratio of the disaggregated-level of the origin-destination (OD) pair flow to the aggregate-level OD pair flow is calculated based on three major components, the socio-economic indicator, utilized area by InfoGroup InfoUSA (2013) and CropScape cropland by USDA-NASS, transport hubs obtained from InfoUSA, and National Transportation Atlas Database (NTAD) by BTS, and Input-Output (IO) Accounts Supply and Use conversion tool by Bureau of Economic Analysis (BEA) used in the analysis.

The indicator used for productions of commodities with SCTG 2-digit code of 02 to 04, which are identified as crops, is the area of total planted crops from the CropScape raster map by USDA. And for the productions of products with SCTG 2-digits of 01 and 05, and the attractions of all five product types, it is obtained from the InfoUSA (2013) data.

The Transport Hubs table indicates if the actual terminal, hubs, or facilities for trucks, rail, waterways, and airways exists in the disaggregation-level with binary values. Since the road network is vastly connecting every local area to urban area and freight activity facilities, the
value for all the TAZ regions with truck movements is 1, meaning that it is assumed that all the TAZ regions accommodate truck movements. For barges and airways, the NTAD database is used, figures 10 and 11. For rail facilities, records with ‘Railing’ or ‘Railroad’ Standard Industrial Classification (SIC) code description from InfoUSA data are selected, and checked with imagery map by Google Map, to only include the locations with rail facilities, figure 12.

Figure 10, Barges and vessels Terminal in Tennessee
Source: NTAD by BTS

Figure 11, Freight operating airports in Tennessee
Source: NTAD by BTS

Figure 12, Freight operating rail facilities in Tennessee
Source: InfoUSA database by InfoGroup
The IO Accounts Supply and Use tables show the production and consumption relationships between different industries, is also used to disaggregate the commodities production and attractions flows between the O-D pairs in TAZ-level.

Moreover, the industrial classification in the InfoUSA and IO Accounts tables are provided in North American Industry Classification System (NAICS) 3-digits. In order to identify the shares of each industry with NAICS 3-digit codes for the commodities with SCTG 2-digit codes, the crosswalk table from BEA is obtained for the relationship between the NAICS 3-digits and SCTG 2-digits codes. Then the proportional weighting equations provided by Pujats et. al. (32) are applied to the aggregated level.

**Results of Impacts Analysis and Solutions**

**Adverse Impacts**

The total VOC, CO, CO\(_2\), NOx emissions, in gram per traveled miles, congestion, in minutes, and crashes from ground movements are estimated from the available data.

**Exhaust Emissions**

- The total CO2 is the multiplication of the fuel efficiency of trucks, 2016 Freight Quick Facts Report by FHWA, net calories from burnt fuel, Heat Values of Various Fuels by World Nuclear Association, coal equivalent, from Carbon factors by U.S. Environmental Protection Agency, total traveled miles, from TDOT Statewide Travel Demand Model database, and the vehicle type (21), equation 1. The CEF factor is calculated based on the amount of hydrogen and carbon components in the fuel. Since other components in the fuel, for example water, may lower the heat produced and increase the CO emission (22), it is considered that 99% of the fuel is completely burnt (23).
• The total VOC, CO, NOx, and PM-10 emission factors are obtained from Freight Movement and Air Quality by FHWA.

Table 3 shows the CO\textsubscript{2} and table 4 shows VOC, CO, PM\textsubscript{10}, and NO\textsubscript{x} coefficients (grams per traveled miles) for gasoline and diesel single-unit truck and combination diesel truck.

<table>
<thead>
<tr>
<th>CO\textsubscript{2} Emission Estimation (f) (gram\textsubscript{ofFuel}/mile)</th>
<th>Fuel Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-Unit Truck</td>
<td>441.2</td>
</tr>
<tr>
<td>Combination Diesel Truck</td>
<td>545.8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>NCV (MJ/gal\textsubscript{Fuel})</th>
<th>Diesel</th>
<th>Gasoline</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.046</td>
<td>0.044</td>
</tr>
</tbody>
</table>

| CEF(galCO\textsubscript{2}/MJ) | 70.27 | 66.96 |

Table 3, CO\textsubscript{2} emission estimation factors


<table>
<thead>
<tr>
<th>Type of Truck and Fuel (gram/mile)</th>
<th>VOC</th>
<th>CO</th>
<th>NO\textsubscript{x}</th>
<th>PM-10 (Exhaust only)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-Unit Gasoline Truck</td>
<td>0.35</td>
<td>18.07</td>
<td>6.09</td>
<td>0.07</td>
</tr>
<tr>
<td>Single-Unit Diesel Truck</td>
<td>0.3</td>
<td>1.41</td>
<td>11.95</td>
<td>0.13</td>
</tr>
<tr>
<td>Combination Diesel Truck</td>
<td>0.27</td>
<td>1.44</td>
<td>12.39</td>
<td>0.13</td>
</tr>
</tbody>
</table>

Table 4, Exhaust emission estimation factors

Source: Freight Movement and Air Quality by Federal Highway Administration (FHWA), 2002, Table B-5, [36].
**Congestion and Crashes**

- The total crashes from freight ground movements are obtained from Tennessee’s Integrated Traffic Analysis Network (TITAN) database.
- The congestion is calculated based on the total delays within the road networks, in minutes, from Tennessee’s Statewide Travel Demand Model.

Table 3 lists the estimated externalities from trucks and rail movements in 2010 and 2040, based on the traveled miles, in Tennessee.

**Possible Mitigation Strategies**

There are numerous solutions offered to alleviate, or even mitigate, the impacts from freight and agricultural products’ movements. Alternative fuels, auxiliary engines, avoiding empty hauling, rerouting, intermodal shipping, and reducing the total traveled miles by each conveyance type helps addressing the impacts (17), (22), (37).

Methods for reduction of impacts are generally categorized into technology and operational strategies (37)-(41).

1. **Technology Strategies:**
   - Elimination of PM\textsubscript{x} from exhaust by using diesel particulate filters (DPF), NO\textsubscript{x} filters, or catalysts such as diesel oxidation to reduce the CO emissions by combining CO with oxygen to produce CO\textsubscript{2} and water.
   - Altering old engines with new ones or with hybrid/electric engines.
   - Alternative fuels such as biofuels, liquefied natural gas, emulsified diesel gas.
   - More energy efficient design for transporting equipment.

2. **Operational Strategies:**
• Reductions in idling time by auxiliary power units and limiting idling time devices.

• Improvements in bottlenecks on road and intersections, such as road-rail grade separation, more efficient signal coordination for trucks, and truck lanes separations.

• Providing signs, walls, and pedestrian pathways to avoid trespassing.

• Training for drivers, handlers, and workers in facilities and ports and more efficient planning by reducing the long hauls by trucks, empty hauls, intermodal transportation and switching from truck to rail, changing the ports, facilities and delivery operations hours are other operational practices to reduce the impacts.

Conclusion

Globally, transportation systems and networks are used significantly to deliver agricultural products. The global market competition for businesses is to deliver the commodities, especially the perishable products, at their best quality. Providing efficient networks for delivering agricultural products from farms to warehouses, distribution centers, mills, and then to ports and their destination is challenging. Moreover, agricultural products are seasonal, highly dependent on the location to plant, hence it is important to provide efficient road network and infrastructure near such areas during planting, delivering fertilizers to farms to harvesting and shipping them to the factories during this time. On the other hand, the ratio of the weight to value for these products is higher compared to electrical chips and other products, requiring building facilities near the harvesting areas, or providing more trucks to deliver the products. Increasing GHG emissions, long congestion along the roadways and fatal crashes, are some of the results of the rising demand for truck movements. However, switching ground
shipping from truck to rail for long hauls would help alleviate mentioned externalities. It is important for the planners, businesses, and local and national government to put their resources together in order to address the externalities with delicate planning at local jurisdictions.

References


27. Administration FM. pocket guide to large truck and bus statistics”, 2017


32. Pujats K., Golias M.M., Mishra S. Methods and tools for freight flow disaggregation, 2021. TRBAM-21-02480


36. Freight Movement and Air Quality by Federal Highway Administration (FHWA), 2002.


