Decoding Socio-Demographic Dynamics within Logistics Clusters: A Roadmap to Fairer Supply Chains

Background and Motivation: The economy of metropolitan areas and nations hinges on the operational efficiency of their logistics sector and the resiliency of their supply chains. The logistics sector in the United States (US) is responsible for 8% of the GDP, translating to approximately 1.64 trillion dollars annually (Smith, 2019). The direct impacts of logistics and supply chains on society are critical for economic development and growth. However, at the same time, they also produce negative externalities to societies, including but not limited to noise and environmental pollution, road safety incidents, and health impacts, to name a few. To complicate things further, for socio-demographic, political, and historical reasons, low-income populations and marginalized communities are more likely to be exposed to poor air quality due to their proximity to transportation corridors and facilities (Pickett & Wilkinson, 2015; Vaz et al., 2017). Hence, it is vital to holistically understand supply chains and the logistics sector to shed light on the disparities that different socio-demographic groups face. Ultimately, the goal should be greener, efficient, and fair supply chains.

Supply chains can be conceptualized as a series of operational stages that facilitate the movement of goods from manufacturing sites to consumption points. In a broader sense, supply chain management, which includes transportation and inventory control, seeks to establish efficient and robust links between goods' production and consumption stages. For typical commercial supply chains, there are four primary stakeholders: 1) producers or manufacturers, 2) carriers, 3) retail outlets, and 4) end consumers. Throughout the supply chain, logistics facilities play a crucial role as transshipment points where the cargo is transferred between different modes of transportation or stored goods closer to the final consumers than their production sites. The most frequent types of logistics facilities include warehouses or distribution centers (DCs).

The location of logistic facilities within metropolitan areas can determine if there are logistics clusters—defined as the concentration and accumulation of logistic activities (Sheffi, 2012). The concentration of logistic facilities in a specific area can result in operational advantages when transporting goods and sharing assets between firms. Logistics clusters, in particular, allow for economies of scope, scale, and density (Sheffi, 2012). Typically, two frameworks exist to identify logistics clusters (Liu et al., 2022). The first one is based on quantitative indexes such as the number of logistics establishments (Rivera et al., 2014), employment, population, and proportion of workers (Chhetri et al., 2014), and location entropy (Liu et al., 2018). The second is a qualitative analysis of well-developed logistics bases, logistics parks, and logistics industrial zones as case studies for the logistics clusters (Lyu et al., 2019). Despite extensive research on logistics clusters:

There is a significant knowledge gap in analyzing the socio-demographic characteristics of the population where logistics clusters are located. Specifically, there has not been a comparison between the population that lives in logistics clusters and those that do not. This analysis is vital to determine if a particular income group, ethnicity, gender, or race suffers disproportionally from negative externalities from their proximity to DCs.

Research Goals: This project seeks to **understand the impacts of the DCs location's externalities on socially vulnerable populations**. As part of this research effort, the team aims to answer the following questions: (i) Do specific socio-demographic groups experience systematic burdens from the location where logistics clusters happen? (ii) Is there a mismatch between where logistics and transportation facilities are located and where the goods are delivered? (iii) If there is a mismatch, what policies could help to balance those inequalities? These research questions align with the environmental justice strategy of the U.S. Department of Transportation (2016), which mentions how transportation projects must: "*avoid, minimize, or mitigate disproportionally high and adverse health and environmental effects, including social and economic effects, on communities of color and low-income population.*" Therefore, it is critical to holistically understand supply chain equity concerns to have more informed policies on how to distribute better both the benefits and burdens produced on the local populations.

Data and Methods: The project will use the Albuquerque Metropolitan Statistical Area (MSA) in New Mexico as a case study to perform the analysis. This metro area was selected for several reasons. First, New Mexico is ranked among the states with the highest poverty rates (Friends Committee on National Legislation, 2023). Second, nearly 50% of Albuquerque's population MSA is Hispanic, and almost 4% is Native American—both historically

marginalized populations. Third, it is the largest metropolitan area in New Mexico, with over half a million people. Fourth, two major highways (I-40 and I-25) pass through the MSA. Fifth, the first phase of the I-40 TradePort Corridor—a freight corridor connecting the large logistic facilities in the west to the central part of the U.S. through the sunbelt states (California, Arizona, and New Mexico)—will connect Albuquerque to the Los Angeles seaports complex (I-40 TradePort Corridor, 2024). Sixth, 16,5 % of Albuquerque's population lived in poverty in 2021 (United States Census Bureau, 2023).

Figure 1 shows the different databases, inputs, and processes that encompass this research. The first database is establishment data to obtain the total number of transportation and warehousing facilities in the Albuquerque MSA at the Zip code level. The selection of establishments is based on NAICS codes 48 and 49 "Transportation and Warehousing". Once the data input is ready, a Local Indicator of Spatial Association (LISA) Statistic (the Gettis Ord*) will be used to identify the location logistics clusters. The second database is the Census Tract data and the American Community Survey data, which have various socio-demographic characteristics at the county and zip-code levels. The third database is the Social Vulnerability Index (SVI), which measures the potential negative effects on communities caused by external stresses on human health (Centers for Disease Control and Prevention & Agency for Toxic Substances and Disease Registry, 2024). The SVI has an overall metric and four specific metrics for different themes (socio-economic status, household characteristics, racial and ethnic minority, and housing type and transportation) that would allow the team to understand existing vulnerabilities in the area. The fourth database is freight trip generation data. Specifically, this database contains information at the zip code level of Freight Trip Attraction, i.e., the number of deliveries made by different industry sectors. For the second, third, and fourth databases, there will be a comparison between the zones identified as logistics clusters and those that do not.

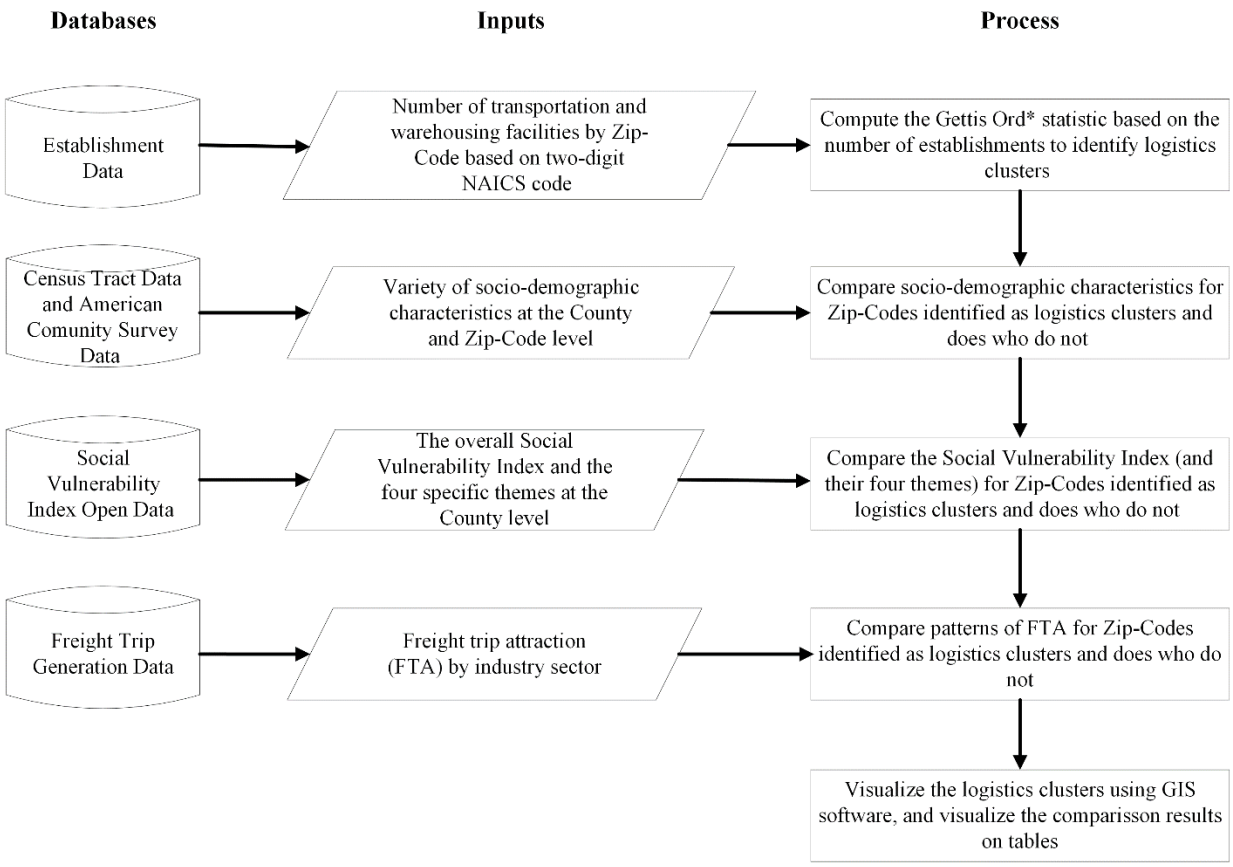


Figure 1 Databases, Inputs, and Process for Proposed Research

Research or Policy Issues of Interest to DOT: State-of-the-art literature on transportation equity and freight transportation points out how there has been a systematic failure to adequately consider urban freight in prevailing

transport and mobility justice discussions (Fried et al., 2024). Therefore, it is vital to conduct research that helps to develop evidence-based policies, especially on how to have greener, more efficient, and fairer supply chains. The research outcome can shed light on whether there are systematic inequalities in a particular income group, ethnicity, gender, or race that suffer disproportionally from logistic facilities—using as a case study of a vulnerable state. This research is of interest to the DOT as it could lead to the discussion of proposing a Pigouvian tax where the cargo receivers that order more frequently have to pay an extra, considering the negative externalities the local population on logistics clusters faces. The change in shipping rates (due to the Pigouvian tax) could lead to e-commerce retailers proposing incentives to their customers to consolidate their packages or delay the delivery date, among other strategies. Changing the behavior of cargo receivers is the goal, as their decisions significantly impact the entire supply chain. For example, suppose cargo receivers consolidate their packages or delay the delivery date. In that case, carriers can have better operational delivery strategies by having longer delivery tours and reducing the number of freight vehicles making deliveries, ultimately reducing the externalities. The findings from this research have the potential to spark policy initiatives that extend beyond the scope of the included case study.

Task Workflow:

The project will encompass four different tasks within seven months, as shown in **Figure 2**. Task 1 focuses on gathering all the necessary data for identifying logistics clusters and socio-demographic characteristics of Albuquerque MSA. Task 2 uses spatial statistics to identify logistics clusters, as the data and methods section explains. Task 3 focuses on doing a comparative analysis between populations that live in logistics clusters and those that do not to identify spatial mismatches between where cargo facilities are located and where cargo is being consumed. Taks 4 refers to documenting all the insights from the research, highlighting the policy recommendations, and a plan for a peer-reviewed publication.

TIMELINE	1	3	4	5	6	7
MONTH	May	June	July	August	September	October
Task 1: Assemble all required data	100%					
Task 2: Logistics Cluster identification		100%				
Task 3: Comparative analysis		40%	70%	100%		
Task 4: Documentation of findings and presentation				30%	60%	☆ 100%

☆ :National Bureau of Economic Research Conference

Figure 2 Research Project Schedule

Research Team: One assistant professor, key personnel, and a grad research assistant form the research team.

Dr. Lisa L. Losada-Rojas is an Assistant Professor at the Civil, Construction, and Environmental Engineering Department at the University of New Mexico. Her research has approached transportation from three primary lenses: social justice, public health, and the economic impacts of transportation systems. In recent years, Dr. Losada-Rojas has studied the adoption and changes of transportation innovations, such as autonomous vehicles, using a combination of geographic information systems, econometric models, spatial analysis, and theories from social and behavioral sciences. From her past experiences, she will bring her skills and knowledge in data acquisition and spatial data analysis and her commitment to creating healthier transportation systems, especially for disadvantaged communities. Dr. Losada-Rojas will lead all tasks of this project and receive key support from Dr. Rivera-Gonzalez.

Dr. Carlos Rivera-Gonzalez is a postdoctoral fellow in the Civil and Mineral Engineering Department at the University of Toronto. His line of research aims to foster transportation systems and supply chains in which efficiency, livability, and environmental objectives are achieved. To do so, he researches the interconnections among urban economies, land-use and transportation systems, and supply chains, to identify ways to foster economic efficiency, sustainability,

quality of life, and environmental justice. In his research, Dr. Rivera-Gonzalez uses different quantitative (econometrics, operations research methods, machine learning models, among others) and qualitative (content and thematic analysis) methods to produce research that impacts the real world. Dr. Rivera-Gonzalez will bring his experience modeling freight transportation and supply chain analysis.

The graduate research assistant (TBD) will work on all project tasks and be trained to conduct logistics clusters analysis and statistical descriptive analysis to compare zones identified as logistics clusters and those that do not.

Conflict of Interest Statement

I, Lisa L. Losada-Rojas, hereby declare that I have no conflict of interest in relation to the National Bureau of Economic Research's (NBER) research initiative on Transportation Economics in the 21st Century, which is being carried out with support from the US Department of Transportation (DOT). I am not involved in the administration or funding of the initiative, nor do I have any financial or personal interests in the research outcome. My involvement in this proposal is solely based on my expertise and interest in the field of transportation economics, and my goal is to contribute to advancing knowledge and developing policy in this important area.

I, Carlos Rivera-Gonzalez, hereby declare that I have no conflict of interest in relation to the National Bureau of Economic Research's (NBER) research initiative on Transportation Economics in the 21st Century, which is being carried out with support from the US Department of Transportation (DOT). I am not involved in the administration or funding of the initiative, nor do I have any financial or personal interests in the research outcome. My involvement in this proposal is solely based on my expertise and interest in the field of transportation economics, and my goal is to contribute to advancing knowledge and developing policy in this important area.

Budget: PI and Key Personnel salaries, $38,000 | Graduate Student salaries, $10,000 | Materials and supplies (equipment, books, journal subscriptions, office supplies, and incidentals), $3,000

References:

Centers for Disease Control and Prevention, & Agency for Toxic Substances and Disease Registry. (2024). *CDC/ATSDR Social Vulnerability Index*. Retrieved 31 March 2024 from https://www.atsdr.cdc.gov/placeandhealth/svi/index.html

Chhetri, P., Butcher, T., & Corbitt, B. (2014). Characterising Spatial Logistics Employment Clusters. *International Journal of Physical Distribution & Logistics Management, 44*(3), 221-241. https://www.emerald.com/insight/content/doi/10.1108/IJPDLM-03-2012-0086/full/html?casa_token=yLCDL9rRNn8AAAAA:XGqN51q-vzXkZz6FzlLuehz0p4iMH8DVFMLfgQT-z-vxU0IU-LPd5gqqQsFktfVBXBwUo7zagZ_YN-5cq7rb9ydTvWdVj0Ohby62tsfoBMc_m549qVY

Fried, T., Goodchild, A., Browne, M., & Sanchez-Diaz, I. (2024). Seeking Equity and Justice in Urban Freight: Where to Look? *Transport Reviews, 44*, 191-212. https://www.tandfonline.com/doi/epdf/10.1080/01441647.2023.2247165?needAccess=true

Friends Committee on National Legislation. (2023). *Top 10 Poorest States in the U.S.* Retrieved 4 April 2024 from https://www.fcnl.org/updates/2023-11/top-10-poorest-states-us#:~:text=According%20to%20the%20U.S.%20Census,%2C%20Texas%2C%20and%20New%20York.

I-40 TradePort Corridor. (2024). *Home*. Retrieved 3 April 2024 from https://i40tradeportcorridor.com/

Liu, S., He, N., Cao, X., Li, G., & Jian, M. (2022). Logistics Cluster and its Future Development: A Comprehensive Research Review. *Transportation Research Part E: Logistics and Transportation Review, 168*. https://www.sciencedirect.com/science/article/pii/S1366554522003519#b0290

Liu, S., Li, G., & Jin, F. (2018). Quantitative Measurement and Development Evaluation of Logistics Clusters in China. *Dili Xuebao/Acta Geographica Sinica, 73*(8), 1540-1555.

Lyu, G., Chen, L., & Huo, B. (2019). The Impact of Logistics Platforms and Location on Logistics Resource Integration and Operational Performance. *The International Journal of Logistics Management, 30*(2), 549-568. https://www.emerald.com/insight/content/doi/10.1108/IJLM-02-2018-0048/full/html

Pickett, K., & Wilkinson, R. (2015). Income Inequality and Health: A Causal Review. *Social Science & Medicine, 128*, 316-326. https://www.sciencedirect.com/science/article/pii/S0277953614008399

Rivera, L., Sheffi, Y., & Welsch, R. (2014). Logistics Agglomeration in the US. *Transportation Research Part A: Policy and Practice, 59*, 222-238. https://www.sciencedirect.com/science/article/pii/S0965856413002358?ref=cra_js_challenge&fr=RR-1

Sheffi, Y. (2012). *Logistics Clusters: Delivering Value and Driving Growth*. MIT press.
Smith, J. (2019). Logistics Spending Jumped 11.4% on Strong Economic Growth. *The Wall Street Journal*. https://www.wsj.com/articles/logistics-spending-jumped-11-4-on-strong-economic-growth-11560862800
U.S. Department of Transportation. (2016). *Environmental Justice Strategy*. Retrieved December 29, 2020 from https://www.transportation.gov/transportation-policy/environmental-justice/environmental-justice-strategy
United States Census Bureau. (2023). *QuickFacts: Albuquerque City, New Mexico*. Retrieved 3 April 2024 from https://www.census.gov/quickfacts/fact/table/albuquerquecitynewmexico/IPE120222#IPE120222
Vaz, E., Anthony, A., & McHenry, M. (2017). The Geography of Environmental Injustice. *Habitat International, 59*, 118-125. https://www.sciencedirect.com/science/article/abs/pii/S0197397516310591?casa_token=VHDgKQBu0CAAAAAA:I_-tNNGoSgdDKg89REByuyvr-ny_cZoyZ7lAWAwuuPGArgMQvk4p9ARemPtWZZLBRMrAnkrexw