ABSTRACT

SHAN, YUE. Studies Exploring Impacts of Contemporary Policy and Regulation on U.S. and Global Supply Chains. (Under the direction of Dr. Kathryn A. Boys).

This dissertation comprises three essays that study global and U.S. domestic supply chain infrastructure and regulations, focusing on two key areas: the effects of China's Belt and Road Initiative (BRI) and U.S. truck detention on capital flows and products. Chapter 1 analyzes the extent to which China outward foreign direct investment (OFDI) and mergers and acquisitions (M&A) have affected the willingness of FDI and M&A donors to invest in BRI recipient countries, as well as identifies and examines country characteristics and other factors that may attract or dissuade FDI and M&A donors using a panel dataset for the period between 2003 and 2020. This analysis finds that China OFDI and M&A had a significant, and positive, impact on stimulating more FDI and M&A contributions from other than China for both BRI recipient countries and non-BRI countries. However, the result is not significant in the BRI countries subgroup. The BRI has a positive impact on attracting more FDI from countries other than China for recipient countries, but, for M&A, it has no significant impact. This study is the first to provide a broad, cross-sectional analysis of the impact of China OFDI on FDI inflows into recipient countries.

Chapter 2 examines the impact of the BRI on the global trade of aggregated and disaggregated sectors such as agriculture, forestry and fishing, mining and energy, manufacturing, and services, among BRI and non-BRI countries. We employ a structural gravity model with panel data covering the period 2006 to 2019 to address these questions. Our findings show that BRI membership has increased trade between BRI and non-BRI countries, particularly in the manufacturing sector, but has not positively impacted trade in the services sector. Excluding China, intra-regional trade among BRI countries is significantly higher across all sectors. This paper is one of the first to investigate the impacts of China's BRI on aggregated trade among BRI countries (excluding China). Additionally, it explores the previously unexamined effects of multilateral trade in disaggregated sectors on BRI and non-BRI countries. Furthermore, this is the first study to analyze the combined effects of BRI participation and a country's development status on trade in both aggregated and disaggregated sectors.

Chapter 3 applies confidential truck GPS data to analyze how detention is associated with driver behavior across slower, median, and faster speed groups, potentially leading to inefficiencies and safety risks, such as speeding to catch up with the next schedule, utilizing quantile regression analyses spanning the 0.25 to 0.75 quantiles. Detention refers to instances where a truck spends more than two hours loading or unloading at a facility. Unexpected detention can disrupt truck drivers' original schedules for subsequent deliveries and driving plans. Our findings reveal that detention is significantly correlated with truck speeds, with stronger positive correlations in the lower quantiles and diminishing effects in higher quantiles due to operational or physical constraints. Parking near facilities and cumulative parking duration hours are generally associated with reduced speeds, though positive effects emerge in specific contexts, such as when Parked Nearby aligns with drivers' resting schedule. Comparing speeds before and after facility visits, we find average speeds generally increase post-departure, particularly for aggregated samples and trucks visiting semiconductor and electric component facilities. These findings highlight the correlation between operational constraints and driver behavior, emphasizing the need for strategies to mitigate detention times and parking-related delays. Addressing these challenges can improve safety, efficiency, and supply chain performance in the trucking industry.

Studies Exploring Impacts of Contemporary Policy and Regulation on U.S. and Global Supply Chains

by
Yue Shan

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APPROVED BY:

Kathryn A. Boys Committee Chair	George List
Daniel Tregeagle	Heidi Schweizer

DEDICATION

To my parents.

BIOGRAPHY

Yue Shan was born in Urumqi, China. She earned a Bachelor of Science degree in Mathematics and Economics from the University of Delaware in 2015, and a Master of Science degree in Applied Mathematics from Northeastern University in 2017. Before starting her Ph.D. studies, she worked as a research assistant at the China Center for Agricultural Policy at Peking University. In 2019, Yue began pursuing a Doctor of Philosophy in Economics at North Carolina State University, where her research focused on international trade and agricultural economics.

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CHAPTER 1: The Unexamined Effects of China's Belt and Road Initiative Outward FDI for Recipient Countries

1.1 Introduction

In September 2013, Chinese President Xi Jinping proposed the Silk Road Economic Belt, a new economic corridor connecting Southeast Asia, Northeast Asia, landlocked regions of Asia and Europe, and European countries through cross-border infrastructure investment. The following month, in October 2013, President Xi proposed the 21st-Century Maritime Silk Road while visiting Indonesia (Wu & Zhang, 2013). This is an additional oceangoing version of the initial proposal through which China announced plans to invest in infrastructure projects of countries along the ancient Maritime Silk Road to develop and improve economic connections along the West Asia Sea, Indian Ocean, Eastern Africa, Red Sea, and the Mediterranean Sea.

Today, the Belt and Road Initiative (BRI) includes the land-based Silk Road Economic Belt and the oceangoing 21st-Century Maritime Silk Road. In the two years following the introduction of these initiatives, more than 20 countries signed a Memorandum of Understanding (MoU) with the Chinese government to join the BRI. Since 2015, the BRI has gradually become the most crucial part of China's foreign economic policies (Magnus, 2015). As of June 2023, China has signed more than 200 cooperation agreements with more than 150 countries and 30 international organizations in conjunction to the BRI (Qian, 2023). Between 2015 and June 2023, China contracted an average of 40 BRI projects annually, with a total committed investment of US $131 billion (Qian, 2023).

1.1.1 BRI and Economic Growth and Development

Foreign direct investment (FDI) and mergers and acquisitions (M&A) play an important role in promoting the economic development and trade development of countries and regions. For example, FDI can stimulate economic development in recipient countries by providing access to capital and new technology to developing industries (De Mello, 1997). It also improves productivity (De Mello, 1999), increases job opportunities, and transfers knowledge and skills from foreign investors to local workers (Marelli et al., 2014; Wang & Choi, 2021). Donors can also benefit from foreign investment by diversifying their investment portfolios, gaining access to new consumer markets, and broadening the scope of their business. When donors invest in companies overseas, they may also need to expand their domestic operations, which can lead to larger economies of scale and more employment opportunities globally.

Since 2013, China has launched BRI cooperation projects in numerous sectors such as transportation, energy, mining, IT and communications, tourism, and urban development. Through this growing number of BRI cooperation projects, large amounts of China outward FDI (OFDI), as well as M&A, flow to these BRI recipient countries. In addition, China has also set up specific financial institutions for foreign investment such as the Asian Infrastructure Investment Bank (AIIB) and the Silk Road Fund, both of which service BRI projects. Previous studies have found that the BRI is the main driver of China OFDI and foreign investment via M&A (Du & Zhang, 2018; Zhai, 2018; Zhang et al., 2018; Chen et al., 2019; Rehman & Ding, 2020; Zhang et al., 2022). During the last decade, China OFDI as a percentage of worldwide OFDI has increased spectacularly, climbing from less than 5% in 2010 to nearly 20% in 2020. Notably, between 2017 and 2020 when global OFDI experienced a downward trend, China OFDI remained comparatively stable.

1.1.2 Objectives and Contribution of this Study

According to the OECD Benchmark Definition of FDI (OECD, 2009), FDI refers to investment transactions including M&A, greenfield investment, extension of capital and investment for financial restructuring. M&A transactions are considered as a part of FDI and include both purchase and sale of existing shares by the direct investor (or direct investment enterprise), with the ownership stake representing 10% or more of the voting power of an enterprise. However, M&A collected by private sources usually only includes the purchase of existing shares. Cross-border M&A refers to the process by which a foreign firm either merges with a company in the target country or acquires shares of (or the entirety of) another firm. Greenfield investment refers to a foreign company establishing a new firm in a target country or expanding the existing operation of an already owned enterprise in the target country. Du & Zhang (2018) noted a significant rise in BRI countries being targeted for M&A by Chinese companies in 2014 and 2015, with little change in greenfield investments. Therefore, this study will focus on the aggregated FDI and M&A which only includes the purchase of existing shares.

To date, few studies have examined the impact of the BRI on FDI flows. Chang et al. (2021) and Shahriar et al. (2019) examined which factors, such as economic size, natural resources, political stability, and infrastructure condition, attract more China OFDI in BRI countries. Zhang et al. (2022) find that the BRI has a positive impact on the likelihood and value of transactions of China outward M&A. In specifically considering financial flows due to the BRI, findings of two recent studies reveal possibly contradictory OFDI outcomes for BRI recipients. Soussane & Mansouri (2022) found that China OFDI had attracted Moroccan OFDI to African countries. These authors found that joining the BRI led these countries to commit to improving the quality of institutions, property protection, and contract enforcement, and that China OFDI might serve as a signal to others that these countries are suitable for investment. However, Fotak et al. (2022) concluded that while receiving more imports, exports, and M&A flows from China, BRI countries reduced their economic dealings with third-party countries (those not in the BRI), and preferred to trade with countries that are politically aligned with China.

To our knowledge, no study has comprehensively explored the impact of China OFDI (and M&A) on the decision of countries other than China to direct their own FDI investment to BRI participants. Given the dominant role of China as an FDI and M&A contributor to many countries, and as this funding comes with many conditions which are not typical of FDI (i.e. requiring the use of Chinese-owned contractors for construction projects), the impact of this investment on the willingness of other countries to invest in BRI countries is an important and open question. It is possible that participation in the BRI may attract additional funding to BRI countries from investors who see this Chinese investment as a positive market signal and/or wish to build upon this initial Chinese investment. Alternatively, for several reasons, the significant flows of FDI and M&A from China may crowd-out FDI and M&A investors other than China who are less willing to invest in BRI countries. In addition, increased receipt of investment from China may be interpreted as a signal of close allegiance to China and may cause some other nations to decline to invest in BRI recipients for a variety of political considerations.

Broadly, this study has three objectives: (1) to analyze the extent to which China OFDI and the BRI have affected the willingness of FDI donors other than China to invest in the recipient countries; (2) to examine the extent of China M&A and the BRI effects on M&A donors other than China. And (3) to explore if and how these factors differ between BRI and non-BRI countries.

Aside from China's investment (or not) in an economy, previous research has identified a variety of other factors, such as characteristics of the recipient country's economy, and their size and natural resource base, that are correlated with country in- and outbound FDI flows and M&A transactions. As such, this study will also identify and examine country characteristics and other factors that may attract or deter FDI and M&A donors other than China to invest in BRI countries. Importantly, the extent to which these financial flows vary between BRI and non-BRI countries is also considered. In doing so, this study is the first to offer a holistic cross-sectional analysis of the impact of China OFDI on FDI inflows to recipient countries.

As a preview of our key findings, this analysis finds that the BRI has a positive effect on attracting more FDI from countries other than China to recipient countries. However, the BRI has no significant impact in attracting more M&A from investors other than China. Other than the BRI, China OFDI and China M&A have a significantly positive impact on the sources of countries to obtain more FDI and M&A from countries other than China for recipient countries in general, especially for the non-BRI countries subgroup. However, investment from China does not have a significant impact on attracting investment to the BRI countries subgroup. In addition, other characteristics such as GDP and communication infrastructure positively impacts FDI and M&A inflows sourced from countries other than China to BRI countries in different levels. Corruption and WTO has a negative effect on FDI and M&A inflows to BRI countries from countries other than China.

The remainder of this study is organized as follows. Section 1.2 provides a detailed introduction to the BRI, and Section 1.3 offers a review of the relevant literature. Section 1.4 describes the empirical models and dataset used in this analysis, followed by a discussion of the empirical results in Section 1.5. Section 1.6 presents the conclusion and limitations of this study.

1.2 Introduction to the Belt and Road Initiative

The BRI is the acronym for the Silk Road Economic Belt and 21st-Century Maritime Silk Road, proposed by Chinese President Xi Jinping in September and October 2013, respectively. In 2015, the National Development and Reform Commission, Ministry of Foreign Affairs, and Ministry of Commerce of the People's Republic of China, with State Council authorization, jointly released the Vision and Actions on Jointly Building the Silk Road Economic Belt and 21st-Century Maritime Silk Road. The BRI initiative became has become the most crucial component of China's foreign policy and international economic policy (Du, 2016 & Magnus, 2015). These public statements indicated that the primary purpose of developing the BRI is to jointly improve the economies of China and the recipient countries through infrastructure investment, industrial investment, resource development, economic and trade cooperation, financial cooperation, cultural exchange, maritime cooperation, and cooperation in other areas (Huang, 2016; Du, 2016; Du & Zhang, 2018). As of 2020, the BRI covers approximately 60% of the world's population and 38% of the world's GDP.

What, though, is the motivation for China to implement this policy? With its domestic economic growth continuing to slow,[1] China needs to find a novel approach to stimulate economic development. The BRI is an innovative attempt to promote China's development of new international partners, transfer China's excess production capacity (Du & Zhang, 2018) in steel, coal, and shipbuilding industries, and support the economic growth of BRI countries. Although China has undergone rapid economic development for three decades since the introduction of its Reform and Opening Up—a critical economic policy preceding the BRI that was introduced in 1978—it still lacks significant influence over many world economies. China aims to expand its influence on the global economy by developing the BRI and sharing its successful experience in infrastructure development, which has led to economic growth with other developing and underdeveloped countries. Through infrastructure linkages, China will build trade, financial, and cultural exchanges with its partner countries, as stated by The State Council of the People's Republic of China in 2013.

In its initial stage, the BRI was intended to create a corridor linking Asia and Europe to stimulate economic prosperity and regional cooperation with countries along the route. In addition, the BRI connects land and sea routes to integrate the European and Asian economies. As shown in **Figure 1.1**, the Silk Road Economic Belt connects three main paths by land: (1) China - Central Asia and Russia - Europe (Baltic Sea); (2) China - Central and West Asia - Persian Gulf and Mediterranean Sea; and (3) China - Southeast Asia, South Asia, and the Indian Ocean. The 21st-Century Maritime Silk Road has two key linkages by sea: (1) Chinese coastal ports - South China Sea - Indian Ocean - Europe; and (2) Chinese coastal ports - South China Sea - South Pacific.

[1] China's GDP annual growth rate was 8.5% in 2000. It increased to a peak of 14.2% in 2006 and then decreased to 7.8% in 2013. Before the COVID-19 pandemic, the growth rate was stable at around 7%, but dramatically dropped to 2.2% in 2020 and then recovered to 8% in 2021.

China has also established two domestic economic zones for the development of the BRI, centered on Xinjiang and Fujian. Xinjiang, a landlocked region in China, is one of the developing provinces in the country's northwestern area. However, Xinjiang province's geographic advantage lies in its border with eight Asian and European countries, including Mongolia, Russia, Kazakhstan, and Kyrgyzstan. China has established a road, railway, and flight logistics hub in Xinjiang to connect to other provinces within China, as well as the countries bordering Xinjiang, and further extending to European and Western Asian countries. China has also established the Kashgar development economic zone and a free trade zone in the city of Xinjiang province to boost trade and economic development in the developing northwestern area of China (Bhaya, 2021). China established the Fujian Free Trade Zone to facilitate and enhance cooperation between Fujian province and Taiwan, and to connect China with countries and regions along the 21st-Century Maritime Silk Road. The establishment of this free trade zone aims to enhance and facilitate the development of trade, investment, financial services, and legal systems among countries and regions involved in the BRI (HKTDC Research, 2019).

[Insert **Figure 1.1** here]

1.2.1 Current Status of the BRI

In recent years, the BRI has been expanded to include many countries in Africa, Oceania, and the Americas (**Figure 1.2**). As of March 2022, China has signed more than 200 cooperation documents with 149 countries and 32 international organizations to BRI (Liu, 2022). **Figure 1.3** represents countries that joined BRI between 2013 and March 2022, and **Figure 1.4** shows the annual cumulative number of countries that had signed a BRI MoU with China.

[Insert **Figure 1.2** here]

[Insert **Figure 1.3** here]

[Insert **Figure 1.4** here]

Among these recent additions, China has launched BRI cooperative projects with countries such as Peru, Italy, and Kazakhstan. China OFDI investment is commonly dedicated to infrastructure planning and development. China's funds have been used to build roads, railroads, ports, dams, oil pipelines, and communication facilities. Notable projects include the Yiwu–London railway line, Peshawar-Karachi Motorway, Israel's Haifa Port, and the Grand Ethiopian

Renaissance Dam. China has also established scientific and research networks with many countries through the BRI. As of 2021, China had established scientific and technological cooperation agreements with 84 BRI recipient countries, supported 1,118 joint research projects, and initiated the construction of 53 joint laboratories focused on agriculture, new energy, health and other fields (Huang, 2022). China has also set up special financial institutions for the BRI, such as the Asian Infrastructure Investment Bank (AIIB) and Silk Road Fund. These institutions act as investors or co-investors in BRI related projects. The Silk Road Fund mainly funded BRI-related infrastructure projects in energy sectors, such as the Karot Hydropower project in Pakistan (OECD, 2018). AIIB invests in both BRI-related infrastructure development projects and non-BRI projects, with China holding 26.6% of the voting power (AIIB, 2023). In 2015, for the first time, China OFDI ($145.7 billion) exceeded its inward FDI ($135.6 billion). Zhai (2018) predicted that China is expected to invest $1.4 trillion to $6 trillion in BRI projects. Overall, Chinese OFDI has been increasing since the BRI was proposed. Based on the aforementioned literature, we believe that the BRI has significantly stimulated the growth of China OFDI, representing a profound exogenous shock to the rest of the world.

1.2.2 The Future of the BRI

In the future, the BRI will continue to expand the scope of Chinese investment from traditional transportation infrastructure and energy sectors to high-tech, sustainable, and environmentally-friendly sectors, with planned projects including the 5G internet project, a solar power plant, and a wind power station (Bonner, 2022). Since 2019, Chinese investments through the BRI, especially for non-China countries, have been asked to comply with United Nations' sustainability standards (Larsen, 2021), ensuring that these projects apply the appropriate standards for environmental and social management to ensure the sustainability of these investments. Moreover, the BRI projects will strive to facilitate international cooperation, diversify sources of funding, and accelerate returns to reduce investment risk. China continues to welcome more countries and international organizations to join the BRI and stands ready to support any initiatives that can facilitate infrastructure development in developing countries, thereby fostering global connectivity (Qian, 2023).

In response to the COVID-19 pandemic, China recognized the lack and imbalance of medical resources faced by China and some BRI countries. Therefore, the Chinese government has continued investing in the Health Silk Road, a concept proposed in 2020 (Lancaster et al., 2020), to provide more medical necessities to BRI countries and the rest of the world (Baruzzi, 2021). The BRI projects that have been delayed due to the pandemic and other factors, such as global financial and political instability, are expected to be completed in the future. China will continue to increase its investments through the BRI and plans to invest $1.3 trillion globally by 2027 (Bonner, 2022).

1.3 Literature Reviews

Research on the BRI, FDI, and M&A is distributed in broad and various fields, including international trade, international politics, macroeconomics, environment, etc. However, as this study specifically examines the impact of China OFDI and M&A on recipient countries attracting OFDI and M&A sourced from countries other than China. This discussion will focus on literature related to China OFDI and M&A. Furthermore, given that the BRI is centered around infrastructure, countries participating in the initiative might attract more FDI—both from China and other countries—once they enhance their infrastructure. Consequently, this study's literature review will emphasize M&A over greenfield investments.

1.3.1 General Impact of FDI and M&A from BRI

Traditional investment theory favors investing in more economically developed areas or sectors that offer a relatively short payback period (Narayanan, 1985). Literature examining how the BRI affects the recipient countries and industrial sectors of China OFDI, has found that the geographic choices of China OFDI do not conform to this traditional theory. Razzaq et al. (2021) found that, in contrast to other countries that prioritize investments in developed countries, through the BRI China has made significant investments to both developed countries and to developing and least-developed countries. By examining the investment risks and natural resource potential of 63 BRI countries, Hussain et al. (2020) concluded that Chinese companies are well-positioned to invest in a majority of BRI countries, including Singapore, Malaysia, Nepal, Bhutan, Russia, Armenia, and the United Arab Emirates.

In recent years, the expansion of the BRI and the swift increase of China OFDI have sparked concerns regarding the potential negative effects of Chinese investments on recipient countries, particularly in increasing their debt burden. However, Jin & Shen (2020) contend that China's investments are not problematic for host nations. Moreover, they found no evidence to substantiate the “debt trap” theory, noting that in their subsample state-owned enterprises (SOEs) primarily invested in transportation, mainly through the M&A model.

China’s BRI investments in Africa have received particular scrutiny due to the uncertainty whether African countries can effectively integrate into and benefit from the BRI (Githaiga et al., 2019), as well as whether the investment is indeed promoting the economic growth of African nations. On this topic, Chen (2016) posited that while China’s investments in Africa have surged over the past decade, they are not proportionate to the increase in China’s overall OFDI. He further suggested that African nations should harness the benefits stemming from the BRI. Furthermore, China OFDI is heavily concentrated in sectors such as infrastructure, transportation and telecommunication (Du & Zhang, 2018; Huang, 2016; Zhang et al., 2018; Rehman & Noman, 2020), as well as energy and power (Du & Zhang, 2018 & Zhang et al., 2018).

The impact of the BRI has also been found to vary depending on the type of Chinese firm making the investment. Chinese SOEs continue to invest in infrastructure sectors, while private firms are more interested in non-infrastructure projects (Du & Zhang, 2018). Zhao & Lee (2021) argued that the BRI promotes OFDI by China’s central SOEs but not by local SOEs. Lv et al. (2018) stated that the BRI drives China OFDI through two different firm types: independent firms and business group affiliates, with the latter being more likely to make outward investments. Two previous studies examined the changes of investment motivation of Chinese firms through FDI (Shi et al., 2021) and M&A (Du, 2021) for BRI recipient countries.

There is some literature that finds that the BRI is the main driver behind the recent growth of China OFDI (Du & Zhang, 2018; Zhai, 2018; Zhang et al., 2018; Chen et al., 2019; Rehman & Ding, 2020). Zhang et al. (2022) concluded that the BRI increases the probability of Chinese firms acquiring foreign firms through M&As, as well as the value of these transactions. Fan et al. (2016) discussed the performance and determinants of China OFDI in BRI countries. They found that China OFDI has shown an overall growth trend, and there has been a consistently higher level of integration of China OFDI in countries such as Cambodia, Georgia, New Zealand, Germany, France, and Australia. However, the performance of China OFDI in the BRI countries is low and uneven when comparing their estimated efficiency scores, calculated by OFDI from China to target country divided by the frontier level of OFDI from China to that country. The actual China OFDI to these BRI countries is far below expectation. Despite this, the potential for China OFDI to flow into these countries remains high. Data from subsequent years also supports their conclusions, showing that China was continuously increasing the investment scale in BRI countries (Kang et al., 2018, Razzaq et al., 2021, Ma et al., 2019).

In addition to a country's participation in the BRI, several other factors that influence Chinese firms' OFDI and M&A decisions. There are positive determinants of China OFDI and M&A in BRI countries, including country size (Fan et al., 2016, Shahriar et al., 2019, Li et al., 2019), economic development status (Fan et al., 2016), natural resources endowment (Fan et al., 2016, Kamal et al., 2020, Jung et al., 2020), exchange rate (Zu & Liu 2018), bilateral trade (Li et al., 2019), the number of patent applications (Li et al., 2019), and infrastructure (Chen et al., 2020). In contrast, the quality of institutions (Kamal et al., 2020), and distance (Shahriar et al., 2019) negatively affect China OFDI. The institutional distance (Mohsin et al. 2021& Li et al., 2019, Jung et al., 2020), defined as the extent of regulatory similarity or dissimilarity between two countries, also had a negative impact on attracting China OFDI and M&A.

1.3.2 General Review of FDI and M&A: Encouraging FDI and M&A Investment Factors & Discouraging FDI and M&A Investment Factors

This study is intended to evaluate the extent to which China OFDI and M&A facilitated through the BRI and Chinese investment affect recipient countries. To avoid potential endogeneity, it is necessary to understand other important factors that would attract or deter FDI and M&A at the country level.

Previous literature has explored the determinants that encourage inward FDI from several perspectives. In their study of the relationship between multinational enterprises and FDI, Robock & Simmonds, (1983) stated that the companies considered factors such as local market conditions, market size, local policies, and local investment risks when investing overseas. Das (2020) concluded that the factors that determine FDI inflows evolve over time and differ across countries with various economic structures. For example, when comparing the Global Financial Crisis (2008-2009) and the Sovereign Debt Crisis (2010-2012) across different development status of countries, it becomes evident that no uniform explanatory variable, such as economic size, resource endowment, or openness, can adequately explain the increase in inward FDI.

Market size represented by gross domestic product (GDP) or GDP per person (GDPP) is a key determinant for evaluating the ability and capability of absorbing foreign investment. Based on previous literature (Balassa, 1966 & Robock & Simmonds, 1983, Graham, 1991, Hyun & Kim, 2010, Shen & Jin, 2018, Li et al., 2018, Xie et al., 2017, Jin & Shen, 2020, Erel et al., 2012, Zhang et al., 2022), countries with larger market sizes are associated with larger inward FDI and M&A activities. Both Robock & Simmonds (1983) and Fan et al. (2016) have highlighted that the size of the country is also important.

Production costs are a crucial consideration for many companies in their choices of recipient countries for OFDI. For labor-intensive industries, if the recipient country offers cheaper labor, more FDI will be attracted. Riedel (1975) posited that the main factor for Taiwan to attract export oriented FDI is cheap labor. When labor costs increase, recipient countries attract less FDI (Saunders, 1982; Schneider & Frey, 1985; Culem, 1988). However, for high-skilled labor, increasing wages do not undermine FDI inflows (Hale & Xu, 2016).

Government policy plays a pivotal role in attracting OFDI. Whether a host country encourages foreign firms to invest, or imposes restrictions on investments in certain sectors, significantly influences OFDI destination choices. Proactive government policies can promote FDI investment (Hayakawa et al., 2014). A robust environmental policy can also serve as a magnet for inward FDI (Cai et al., 2016). Moreover, Chen et al. (2019) highlighted that the quality of institutions, as shaped by laws and regulations, as positively impacting the facilitation of FDI inflows. Studies by Agarwal (1980) Moosa (2002), and Fan et al. (2016) found policy barriers, disadvantaged local police and high levels of government corruption, and geographical distance discourage inward FDI and M&A.

Infrastructure development (Coughlin et al., 1991, Cheng & Kwan, 2000, Wheeler & Mody, 1992; Asiedu, 2002, Deichmann et al., 2003, S. Li & Park, 2006, Bellak et al., 2009, Rehman et al. 2022), is also a key factor that can encourage FDI investment. The types of infrastructure included transportation, telecommunications, finance, and energy infrastructure. For resource-seeking oriented FDI, better natural resources endowment encourages more inward FDI (Musabeh & Zouaoui, 2020; Asiedu, 2004; Yang et al., 2017; Poelhekke & van der Ploeg, 2013).

Many other factors also impact inward FDI and M&A, such as macroeconomic factors including inflation (Abbott et al., 2012; Adebayo et al., 2020; Asiedu, 2002; Asiedu, 2006; Boateng et al., 2015; Hadi et al., 2018; Hailu, 2010; Mamytova & You, 2018; Musabeh & Zouaoui, 2020; Xie et al., 2017); exchange rates (Xing & Wan, 2006; Hyun & Kim, 2010; Abbott et al., 2012; Boateng et al., 2015; Choi et al., 2016; Hadi et al., 2018; Mamytova & You, 2018; Poelhekke & van der Ploeg, 2013; Zouaoui, 2020; Xie et al., 2017); and regional free trade agreements (Fan et al., 2016; Hyun & Kim, 2010,;Li et al., 2018). WTO accession also is an encouraging factor for attracting FDI (Chien et al., 2012) and M&A (Jin & Shen, 2020; Shen & Jin, 2018; Zhang et al., 2022).

1.3.3 Case Studies of China BRI Investment to Specific Countries and Regions

The existing literature has delved into the impact of both aggregate and disaggregate China OFDI, highlighting its significance on BRI host countries. Given that China OFDI spans multiple sectors across diverse settings, the impact of BRI investment is understandably varied across industries and countries. Through the BRI, China has invested in transportation infrastructure projects such as highways, railways, ports, bridges, dams, communication networks. China's investments has also established economic zones and industrial parks such as in in Ethiopia and Nigeria (Chen, 2018). Menhas et al. (2019) studied the China-Pakistan Economic Corridor investments under the BRI. They declared that such investments could bolster socio-economic conditions and reach the goal of sustainable development in Pakistan.

Studies examining the impact of China OFDI on African countries is mixed. On one hand, some economists view China OFDI in the African region as detrimental to its development. For instance, investments in infrastructure might result in increased debt, leading to exchange rate instability and limiting other investment opportunities for local governments (Chen, 2018). Megbowon et al. (2019) found that China OFDI does not significantly impact industrialization in sub-Saharan Africa. On the other hand, some studies conclude that China OFDI positively affects Africa's economic development. When examining FDI inflows to Africa from China and other developed countries, including the US, France, and the UK, it was found that China created more job opportunities with fewer projects between 2014 and 2018 (Zhang, 2021). Hu et al. (2021) determined that, based on data from 2006 to 2017, China OFDI significantly enhances the technological progress of African countries. In contrast, FDI from countries other than China does not have a noticeable impact. Chen (2018) argued that African countries should capitalize on the opportunity to foster local employment and enhance export capacity as China transitions its industrial overcapacity. O'Trakoun (2018) posited that increased China outward investment might enhance recipient countries' perceptions of China. The BRI could bolster business prospects in the

Asia-Pacific region and leverage existing regional economic and demographic trends. Chen & Lin (2018) projected a 5% increase in FDI flows to BRI countries, with regions like sub-Saharan Africa, East Asia, and the Pacific standing to gain the most.

China OFDI exhibits varying performance across regions worldwide, spanning multiple sectors. Hanemann et al. (2018) indicated that China OFDI was more uniformly distributed across European sectors. The industries that increased the most in investment were financial services, health and biotech, consumer products and services, and automotive industries in 2018. A portion of China OFDI is channeled into the agricultural sector, with private companies playing pivotal roles. Jiang et al., (2018) suggested that China OFDI not only introduces agricultural technology, labor requirements, and management expertise but also raises concerns such as food security and the volatility of farmers' livelihoods, especially in certain Asian developing nations. Mogilevskii (2019) highlighted the projects of Chinese investments in Kyrgyzstan through the BRI in the sectors of roads, energy, infrastructure, urban development, mining, and manufacturing. This research also delved into the economic impact of these projects and their potential future trends. Sun et al. (2021) investigated the influence of China OFDI on the comparative advantage of sectors in 62 BRI countries from 2003 to 2017. They inferred that China OFDI exerts varying degrees of positive impact on the comparative advantage of these nations, especially in natural resource-intensive and labor-intensive industries such as textiles, garments, and footwear. However, China OFDI has a detrimental effect on the comparative advantage in other labor-intensive sectors, as well as capital- and technology-intensive sectors in general. Yao et al. (2020) found that China agricultural OFDI directly or indirectly positively impacts food security in BRI countries, particularly when a nation consistently attracts agricultural OFDI.

1.4 Methodology and Data

1.4.1 Methodology

This study applies panel data regression models to estimate the determinants of inward FDI and M&A of all "countries other than China (COTC)". While previous literature such as Das (2020), Hadi et al. (2018) and Neto et al. (2009) have employed similar models to analyze the determinants of inward FDI and M&A across countries, this study distinguishes itself by examining the effect of China OFDI and M&A on foreign investment decisions by firms in other countries. Thus, this study uses country-level inward FDI flows and M&A transactions from COTC as dependent variables. This analysis uses a panel dataset which covers 184 countries and regions, between 2003 and 2020.

The baseline model used in this analysis is:

$$\text{COTC FDI}_{it} = \beta_0 + \beta_1 \text{ China OFDI}_{it} + \beta_2 \text{BRI}_{it} + \beta_3 \text{ GDP}_{\text{it}} + \beta_4 \text{Inflation}_{it} + \beta_5 \text{Exchange Rate}_{it} + \beta_6 \text{ Corruption}_{it} + \beta_7 \text{NR}_{it} + \beta_8 \text{Communication Infrastructure}_{it} + \beta_9 \text{Trade Openness}_{it} + \beta_{10} \text{WTO}_{it} + \beta_{11} \text{RTA with China}_{it} + \beta_{12} \text{Vote}_{it} \, (+\, \alpha_i + \gamma_t) + \epsilon_{it} \quad (1.1)$$

Where COTC FDI_{it} denotes inward FDI flows from all countries other than China to country i (1, …, 184) at time t (2003, …, 2020). China OFDI_{it} represents China OFDI flow to country *i* at time *t*; BRI_{it} is a dummy variable equal to 1 if the country *i* had an active BRI MOU in year *t*. Other independent variables were derived from previous literature. GDP_{it} denotes real GDP, and Inflation_{it} represents inflation of country *i* at time *t*. $\text{Exchange Rate}_{it}$ indicates exchange rate of country *i* at time *t* against US dollars. The Corruption_{it} represents country risk scores for corruption of country *i* at time *t* where higher scores indicate a higher corruption level. NR_{it} is a dummy variable which indicates if *i* has a significant endowment of economically valuable natural resources. NR is equal to 1 if total natural resources rents contribute at least 10% of country's GDP at time *t*. $\text{Communication Infrastruct}_{it}$ denotes the fixed telephone lines plus cellphone lines per 100 people. $\text{Trade Openness}_{it}$ denotes the trade openness, calculated by sum of experts and imports divided by population of country *i* at time *t*. WTO_{it} denotes a dummy variable equal to 1 if country *i* at time *t* is member of WTO. The final two variables are included to capture the extent of *i*'s economic linkages and political alignment with China. $\text{RTA with China}_{it}$ is a dummy variable equal to 1 if country *i* at time *t* has an active trade agreement (RTA) with China. Vote_{it} denotes the average percentage of the same vote as China in United Nation General Assembly resolution of country *i* over the three preceding years, and ϵ_{it} is the error term.

We utilize the traditional Ordinary Least Squares (OLS) with random effects, and country (α_i) and year (γ_t) fixed effects to estimate the baseline models by following the methodologies used in previous literature, such as Buckley et al. (2007), Hayakawa et al. (2014), Mamytova & You (2018), and Das (2020). To identify the most suitable specifications of random effects, and year and country fixed effects for our analyses, we will then apply the Hausman test.

Alternative model specifications explore the possibility of lagged policy effects and assess the influence of China OFDI on attracting FDI from countries other than China. We applied an ad-hoc lag approach, Akaike's information criterion (AIC) (Akaike, 1974) and Bayesian information criterion (BIC) (Stone, 1979) to identify the optimal lags selection. Additional analysis investigates and compares differences in outcomes between BRI and non-BRI recipient countries.

Furthermore, this study applied alternative equations to examine the determinants of COTC M&A transactions, where $\text{COTC M\&A}_{it}$ denotes the M&A annual transaction amount of country *i* at time *t*, which is calculated as the sum on annual M&A transaction deals of the target country from acquirer countries other than China; $\text{China M\&A}_{it}$ represents the M&A annual transaction amount of country *i* at time *t*, which is calculated as the aggregated annual M&A transaction deals of the country as target nation from China (acquirer nation). Other variables are defined as in equation (1).

To verify the robustness of our parameter estimates with regard to the effect of China OFDI, China M&A and BRI, we utilize an alternative source for BRI countries from the Green Finance and Development Center (Nedopil, 2022) instead of using the baseline model with BRI countries data from the Belt and Road portal.

1.4.2 Data Description

1.4.2.1 FDI, M&A and BRI

Using the United Nations Conference on Trade and Development (UNCTAD) database,[2] we sourced annual inward FDI flows data from 2003 to 2020. The data for China OFDI flow to all recipient countries was derived from the Statistical Bulletin of China's Outward Foreign Direct Investment. The dependent variable, 'COTC FDI', represents the inward FDI difference between recipient country's total annual FDI inflows and those obtained from China.

While the UNCTAD dataset includes 200 countries, several were excluded from this analysis. For example, Hong Kong was excluded due to its unique political relationship with mainland China. The Cayman Islands and the British Virgin Islands are significant destinations of FDI, but as they are considered to be tax havens (Fagetan, 2021)and are not the ultimate destinations for most of their FDI inflows and, as such, do not represent the kind of investment

[2] Table 1 provides more detailed information about data sources and links each dataset mentioned in this section.

relevant to this analysis. Lastly, we noted that certain small island countries,[3] along with Eritrea, Somalia, South Sudan and the Democratic People's Republic of Korea (North Korea), were missing a substantial amount of data. As these countries have relatively minor economies (collectively contributing to only about 1% of the world's total GDP), they were also excluded from this analysis. Thus, this dataset includes 184 countries and regions that collectively accounted for 99% of global GDP.

The dependent variable, 'COTC M&A', represents the total inward cross-border M&A value for all countries excluding China. As a result, the dependent variable reflects the annual aggregate amounts of cross-border M&A transactions from countries other than China. Similar procedures were applied to determine the independent variable, 'China M&A', which represents China outward M&A amount to each recipient country. The M&A transaction amounts between 2003 and 2020 were sourced from the Securities Data Corporation (SDC) Platinum. The M&A data from SDC Platinum are relatively accurate and complete over time, and they have been widely used in previous studies related to M&A in accounting and finance (Barnes et al., 2014). We retained all transaction deals where China acted as the acquiring nation and countries other than China were the target nations. We then remove the transactions that were either withdrawn[4] (36.44%) or have a missing transaction value (1.95%). After these steps, 285,258 observations remained, representing 33.39% of the original dataset. Aggregating the transaction data by country, we found that China invested in just six countries in 2003 and 41 countries in 2018 among all BRI and non-BRI countries. The latter figure marks the highest count between 2003 and 2020 (details in **Appendix C**).

A list of countries participating in the BRI, and the years of their entry into a BRI MoU, was constructed using data from the Belt and Road portal[5] and Nedopil (2022). [6] The BRI dummy variable equals 1 if the country had an active BRI MOU for at least a portion of the calendar year.

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[3] Small island countries included: Anguilla, Cook Islands, Curaçao, Guadeloupe, French Guiana, Marshall Islands, Montserrat, Martinique, Mayotte, New Caledonia, Palau, French Polynesia, Reunion, Saint Helena, Turks and Caicos Islands.

[4] It can be defined as an instance where the target or acquirer in the transaction has terminated its contract.

[5] https://www.yidaiyilu.gov.cn/

[6] These two datasets provide differing times for the signing of the BRI MoU for several countries, including Bangladesh, Cambodia, Kazakhstan, Laos, and others. In previous study (Qian et al., 2022, Lv et al., 2018, Jung et al., 2020, Zhang et al., 2022, Jin & Shen, 2020), the Belt and Road portal was used as the primary source for BRI data. We ran regressions with both BRI datasets and found that the results were not sensitive.

This data covers the period between 2013 to 2020. By the end of 2020, 131 countries had signed an MoU with China representing 27% of global GDP (in 2020). Of these, 74% were either developing or least developed countries. A detailed list of BRI country participants and the year that they signed an MoU with China is presented in **Appendix A**.

1.4.2.2 Other Independent Variables

Data for other independent variables were drawn from several sources. Data on real gross domestic product (GDP), population (POP), and inflation rate at the country level were sourced from the World Bank's World Development Indicators database. As this dataset did not include complete GDP and POP information for Taiwan (missing 2003-2019), and Venezuela (missing 2015-2019), this missing information was obtained from the Penn World Tables as in Feenstra et al. (2015). Total natural resource rents as a percent of GDP data and communication infrastructure were also obtained from the World Development Indicators database. A dummy variable was used to indicate whether natural resources are an important portion of the economy. Natural resources (NR) equal to 1 when the natural resource rents as a percent of GDP larger than 10%. As this data indicates that there is generally little change across time for a given country, missing values were completed using average data from preceding and subsequent years. The measure of communication infrastructure[7] is calculated as the sum of fixed telephone lines and cellphone lines per 100 people.

Country-level trade and exchange rate data was obtained from the UNCTAD. Trade openness is defined as the ratio of the sum of a country's exports and imports to its population, as described by Fujii (2017). The corruption variable, which evaluates the investment environment with respect to corruption in over 200 countries, was obtained from S&P Global - Country Risk Analyst. Information concerning whether the country has an active trade agreement with China was obtained from the Regional Trade Agreement database of World Trade Organization (WTO). The list of WTO members was obtained from the WTO.[8] The vote data is drawn from the United Nations General Assembly Voting Data compiled by Voeten et al. (2009). This metric is calculated

[7] Communication infrastructure was included rather than other forms of infrastructure such as transportation infrastructure (e.g. kilometer of highways, railroads, or paved roads) as to our knowledge, there is no available dataset that offers this information for all the countries and time span considered in this analysis. As previous literature (Bellak et al., 2009, Asiedu, 2002, Kang et al., 2018, Mamytova & You, 2018, Das, 2020, Asiedu, 2006, Hailu, 2010, Abbott et al., 2012, Jung et al., 2020, Xie et al., 2017), the communication infrastructure was used.

[8] https://www.wto.org/english/thewto_e/whatis_e/tif_e/org6_e.htm

as the average number of times, over the three preceding years, a country voted the same way as China in the United Nations, divided by the total number of votes. Further details concerning the definitions of these variables and associated literature are provided in **Table 1.1**.

[Insert **Table 1.1** here]

1.4.2.3 Descriptive Statistics

Table 1.2 presents the summary statistics for all countries as well as disaggregated by BRI and non-BRI countries. The negative values in COTC FDI arise from UNCTAD's method of calculating net inward FDI. This method involves subtracting debits from credits between direct investors and their foreign affiliates. These affiliates are defined as foreign business entities where the investor or acquiring organization has at least a 10% ownership stake. A negative value signifies a country's negative net incurrence of liabilities from the world, excluding China. Comparing the mean of COTC FDI inflows to BRI and non-BRI countries, non-BRI countries received five times more investment than BRI countries. The difference between these two groups is larger in the COTC M&A transaction amount for which non-BRI countries received nine times more than BRI countries. Regarding FDI and M&A investments from China, although higher in non-BRI countries, the disparity is smaller compared to investments from the rest of the world. Specifically, China invests twice as much FDI and 6.5 times more M&A in non-BRI nations than in BRI nations. The standard deviation of COTC FDI, COTC M&A, China OFDI, and China M&A of non-BRI countries is higher than BRI countries, indicating greater investment volatility in the non-BRI countries.

For other variables, on average non-BRI countries have larger market size, less natural resource endowment, less inflation rate, more WTO members, fewer free trade agreements with China, are rated as having less government corruption, a lower exchange rate relative to the USD, larger trade openness, less percentage of the same voting results as China (refers to less likelihood aligned with China), and better communication infrastructure development than BRI countries. Even though the means of these variables in BRI and non-BRI countries may not be similar, it does not necessarily indicate a statistical difference.

Potential correlation among independent variables was evaluated using Pearson correlation coefficients. These results, for all countries and BRI and non-BRI country subgroups are presented in **Appendix D**. As none of these pairwise correlations suggest problematic collinearity (maximum value 0.623), all of the described variables were included in the analysis.

[Insert **Table 1.2** here]

1.5 Results and Discussion

This section presents the results from the OLS random effects and country and year fixed effects estimations. First, we describe findings about the influence of China OFDI, the BRI, and other factors on COTC FDI in the entire countries sample, only BRI countries and non-BRI countries. Then, we present the effects of China M&A, BRI, and other factors on COTC M&A in the entire countries sample, BRI, and non-BRI countries. Following this, we explore lagged influences of China OFDI with baseline models' variables on COTC FDI within the entire sample of countries. Then, we explore the lagged effects of China M&A with baseline models' variables on COTC M&A using the same total sample of countries. Lastly, we incorporate interaction terms of lagged China FDI and BRI to the alternative models to explore their effects. Similarly, we also explore the interaction terms of lagged China M&A and BRI.

1.5.1 Empirical Results

Table 1.3 presents results examining the effect of FDI sourced from China and the BRI on FDI sourced from countries other than China for entire countries, BRI, and non-BRI participating countries. Results columns differ in their inclusion of random and fixed effects; odd numbered columns include random effects, while even numbered columns include country and year fixed effects. Equivalent results considering M&As are presented in **Table 1.4**.

Column (1) in **Table 1.3** illustrates the positive and statistically significant impact of China OFDI, GDP, and trade openness on COTC FDI. The remaining independent variables- inflation (%), exchange rate, corruption, natural resources, communication infrastructure, WTO, RTA with China, and vote have no significant impacts.

Compared with column (2), China OFDI and GDP results show a consistently positive and statistically significant effect on FDI of countries other than China. However, in column (2), BRI and communication infrastructure have positive and statistically significant effects on FDI of countries other than China, and trade openness has no statistically significant result. Because specifications with country and time fixed effects can control the unobserved time in-variant and country specified factors, we are more trust in the results from column (2). According to the results of the Hausman tests, most of the country and time fixed effects models are more appropriate, except for the subgroup analysis of FDI in BRI and non-BRI countries, as shown in **Table 1.3**. Thus, the rest of the discussion will focus on the results shown in columns (2), (3) and (5).

According to the coefficient results from column (2), when China invests an additional 1 million USD, it can attract approximately an average of 4.65 million USD more FDI from countries other than China within the entire countries group. When a country signs a BRI MOU with China, it obtains an additional 3.324 billion USD average FDI from countries other than China within the entire countries group. When the country's GDP increases by 1 billion USD, it will obtain an additional average of 11.56 million USD FDI from countries other than China within the entire countries group. The coefficient result of communication infrastructure indicates an additional phone line (per 100 people) would lead to an average increase of 34.66 million USD FDI from countries other than China within the entire countries group.

Column (3) shows the impact of variables on FDI of countries other than China for the group of BRI participating countries. It illustrates the no statistically significant impact of China OFDI, BRI inflation, and exchange rate on FDI from countries other than China. GDP, communication infrastructure, RTA with China, and vote have positive statistically significant effects on FDI from countries other than China. Corruption, natural resource endowment has negative statistically significant effects on FDI from countries other than China.

Column (5) shows the impact of variables on FDI from countries other than China for non-BRI participating countries. The results show that China OFDI and GDP positively and statistically significantly impact FDI from countries other than China. The rest of the independent variables have no significant effects.

Comparing the results from the BRI countries group and non-BRI countries group reveals that China OFDI can significantly incentivize more FDI from countries other than China to flow into non-BRI countries. It suggests that an additional million China OFDI inflows into a non-BRI country would promote, on average, 8 million USD FDI from countries other than China. GDP is the only variable that positively impacts both types of countries, but it has a larger scale of effect for BRI participant countries. An additional billion USD GDP would promote an average of 10.98 million USD FDI inflows from countries other than China into BRI countries and an average of

8.57 million USD FDI inflows from countries other than China into non-BRI countries. Variables other than China OFDI, BRI and GDP have a more significant impact on FDI from countries other than China for BRI countries. For BRI participating countries, lower corruption, better communication infrastructure, more considerable trade openness, an active regional trade agreement with China, and more political alignment with China would promote more FDI inflows sourced from countries other than China.

[Insert **Table 1.3** here]

According to the results of the Hausman tests, all of the country and time fixed effects models are more appropriate in **Table 1.4**. Thus, the rest of the discussion will focus on the results shown in the even columns.

Column (2) in **Table 1.4** represents the results of China M&A, BRI, and other critical variables on M&A sourced from countries other than China for the entire countries sample. China M&A, GDP, communication infrastructure, and trade openness positively affect M&A sourced from countries other than China. An additional million USD in China M&A would promote an average of 2.21 million USD more M&A from countries other than China. When a country’s GDP increases by 1 billion USD, the country can obtain average of 18.22 million USD more M&A from countries other than China. An additional phone line (per 100 people) would promote an average of 75.93 million USD more M&A from countries other than China. When a country’s trade openness increases by 1%, it can attract 0.254 million USD more M&A from countries other than China.

Column (4) in **Table 1.4** shows the impact of variables on M&A from countries other than China for the group of BRI participating countries. It illustrates no statistically significant impact of China M&A, BRI inflation, exchange rate, natural resources, communication infrastructure, trade openness, RTA with China, and vote on M&A from countries other than China. GDP has positive statistically significant effects on M&A from countries other than China. Corruption and WTO membership have negative statistically significant effects on M&A from countries other than China. Surprisingly, WTO membership shows a negative impact on M&A from countries other than China for BRI countries. This may be attributed to WTO members enforcing lower import taxes for commodities. Joining the WTO could replace opportunities for domestic production with imports, thereby impacting the attraction of foreign M&A. Thus, for BRI countries, WTO membership has a negative effect on M&A from countries other than China.

Column (6) in **Table 1.4** shows the impact of variables on M&A from countries other than China for non-BRI participating countries. The results show that China M&A, GDP, and communication infrastructure positively and statistically significantly impact M&A from countries other than China. The rest of the independent variables have no significant effects.

Comparing the BRI countries group and non-BRI countries group results reveals that China M&A can significantly incentivize more M&A inflows from countries other than China to non-BRI countries. It suggests that an additional million USD in China M&A inflow to a non-BRI country would promote, on average, 2.703 million USD M&A from countries other than China. GDP is the only variable that positively impacts both types of countries, but it has a larger scale of effect for BRI participant countries. An additional billion USD GDP would promote an average of 19.66 million USD M&A inflows from countries other than China for BRI countries and an average of 18.43 million USD M&A inflows from countries other than China for non-BRI countries. For BRI participating countries, an additional corruption score and becoming a member of WTO lead to an average of 595 million USD decrease and an average of 5.613 billion USD loss in M&A from countries other than China, respectively. For non-BRI participating countries, the coefficient of communication infrastructure indicates an additional phone line would promote 174 million USD M&A from countries other than China.

[Insert **Table 1.4** here]

Table 1.5 displays the results of the lagged effect of China OFDI on FDI from countries other than China. Based on the ad-hoc lag approach (details in **Appendix H**) and AIC and BIC values (details in **Appendix G**), we incorporated three lagged values of China OFDI[9] as independent variables. The results after three lags presented inconsistent in full sample groups and BRI countries, and the values of AIC and BIC are either the minimum or relatively small. Results columns differ in their inclusion of random and fixed effects; odd numbered columns include

[9] We also incorporated lagged values for BRI; however, they were not statistically significant. Thus, we omitted them from the analysis.

random effects, while even numbered columns include country and year fixed effects. Based on the Hausman test results, our discussion of **Table 1.5** will focus on columns (2), (4) and (5).

Columns (2) of **Table 1.5** display the lagged influence of China OFDI on FDI from countries other than China for the entire countries sample. The results indicate that China OFDI from the current year and previous year have significantly positive impacts on FDI from countries other than China in the current year. However, China OFDI from two years prior shows no significant effect on FDI from countries other than China in the current year. Notably, China OFDI from three years ago negatively influences FDI from countries other than China. This can be explained by the performance of China OFDI from three years ago is not good as other investors' expectation, thereby sending a negative signal. The cumulative lag effect (Tintin, 2012) for the average FDI from countries other than China is calculated as the sum of the coefficient of China OFDI and lagged of China OFDI, which is 4.882 million USD. This indicates that China OFDI has a positive cumulative lag effect on securing more FDI. BRI consistently shows a significant positive impact on FDI from other donors. Being a BRI participating country would promote an average of 3.324 billion USD FDI from countries other than China. The results for control variables are also consistent with those presented in column (2) of **Table 1.3**.

Column (4) of **Table 1.5** presents the lagged influence of China OFDI on FDI from countries other than China, specifically for the sample of BRI countries. The results show that China OFDI from the current year has a significantly negative impact on FDI from countries other than China. However, China OFDI with one to three years of lag all positively affect FDI from countries other than China in the current year. Our literature review indicated that China often invests in countries and regions where other investors are reluctant to enter. Thus, investment in the current year might crowd out other investors, or they may perceive Chinese investment negatively. However, the performance of Chinese investment over the next three years might surpass other investors' expectations, or the Chinese investment might contribute to creating a better investment environment in recipient countries through infrastructure development or other cooperation projects. Consequently, after the current year, China OFDI under the BRI facilitates these countries in attracting more FDI from other investors. The cumulative lag effect for the average FDI from countries other than China is 4.797 million USD, indicating a positive cumulative lag effect of China OFDI on attracting more FDI for BRI countries. The results for control variables are consistent with column (3) of **Table 1.3**.

Column (5) of **Table 1.5** displays the lagged influence of China OFDI on FDI from countries other than China, specifically for the sample of non-BRI countries. The results indicate that China OFDI from the current year and previous year have significantly positive impacts on FDI from countries other than China in the current year. In contrast, China OFDI from two and three years ago negatively influences attraction of more FDI from countries other than China. The cumulative lag effect for the average FDI form countries other than China is 4.11 million USD. The results for other variables are also consistent with those presented in column (5) of **Table 1.3**.

Comparing the BRI countries group and non-BRI countries group results reveals distinct patterns: current China OFDI has negative effect on FDI sourced investors other than China in the BRI countries, it consistently has a positive effect in non-BRI countries. However, China OFDI from the previous one to three years positively influences FDI from other donors in BRI countries. In contrast, China's OFDI from two and three years prior negatively impacts FDI in non-BRI countries. Notably, the cumulative lag effect is positive for both groups of countries. Taking into account the scale, sign, and trend of impact, it can be inferred that China's OFDI does not crowd out other investors in BRI countries and might, in fact, send positive signals to FDI investors.

[Insert **Table 1.5** here]

Table 1.6 presents the results of the lagged effect of China OFDI on FDI from countries other than China. Following the ad-hoc lag approach (details provided in **Appendix I**) and based on the AIC and BIC values (detailed in **Appendix G**), we incorporated two lagged values of China M&A[10] as independent variables. The results after including these two lags were not significant for both the full sample groups and the non-BRI countries group, with the AIC and BIC values being either the minimum or relatively small. Results columns differ in their inclusion of random and fixed effects; odd numbered columns include random effects, while even numbered columns include country and year fixed effects. Based on the results of the Hausman test, our discussion regarding **Table 1.6** will focus on columns (2), (4) and (6).

[10] We also incorporated lagged values for BRI; however, they were not statistically significant. Thus, we omitted them from the analysis.

Column (2) of **Table 1.6** displays the lagged influence of China M&A on M&A from countries other than China for the entire countries sample. The results show that China M&A in the current year significantly positively impacts M&A from other countries in the same year. However, China M&A from one and two years prior negatively influences the attraction of more M&A from other countries. The cumulative lag effect for the average M&A from countries other than China is -0.57 million USD, indicating a negative cumulative lag effect of China M&A on attracting more M&A from other countries. The BRI shows no significant impact on M&A from other donors. Other significant results align with those presented in column (2) of **Table 1.4**.

Column (4) of **Table 1.6** displays the lagged influence of China M&A on M&A from countries other than China for the BRI countries sample. The results indicate that China M&A from the current year, as well as one and two years prior, have no significant positive impact on M&A from countries other than China in the current year. This suggests that both current and lagged China M&A do not crowd out other investors. Other significant results are consistent with those presented in column (2) of **Table 1.4**.

Column (6) of **Table 1.6** displays the lagged influence of China M&A on M&A from countries other than China, specifically for the non-BRI countries. The results show that China M&A in the current year significantly positively impacts M&A from other countries in the same year for non-BRI countries. However, China M&A from one and two years prior negatively influences the attraction of more M&A from other countries in the non-BRI group. The cumulative lag effect for the average M&A from countries other than China is -0.471 million USD. This shows that China M&A has a negative cumulative lag effect on obtaining more M&A from countries other than China for non-BRI countries. BRI consistently shows no significant impact on M&A from other donors. Other significant results align with those presented in column (6) of **Table 1.4**.

Comparing the BRI countries group and non-BRI countries group results reveals different patterns: current China M&A has no significant effect on M&A from investors other than China in BRI countries but has positive effect in non-BRI countries. However, China M&A from previous one and two years shows no significant influence on FDI donors other than China in BRI countries. In contrast, China M&A from previous one and two years negatively impacts M&A in non-BRI countries. The size of cumulative lag effects is negative for non-BRI countries.

Considering the scale, sign and trend of impact, China M&A would not crowd out other investors in BRI countries.

[Insert **Table 1.6** here]

The results of robustness checks are presented in **Appendix E** and **F**. Comparing **Table 1.3** with **Appendix E**, the results of China OFDI and BRI across different groups of countries show consistency. Comparing the **Table 1.4** with **Appendix F**, the results of China M&A and BRI across different groups of countries also show consistency. The majority of the control variables demonstrate consistency as well. This is evidence that our results are robust.

1.5.2 Discussion

From previous results, we can summarize and discuss the impact of factors on FDI from countries other than China and M&A from countries other than China across types of countries.

According to **Table 1.3**, China OFDI has a significantly positive impact on FDI from countries other than China in the entire countries group, especially in non-BRI countries, but has no significant impact on BRI countries. This could be due to a lack of interest from other nations in the same sectors where China invests within BRI countries. Nonetheless, our findings confirm that China OFDI activities do not deter other nations from investing in BRI countries. For BRI participating countries, corruption, communication infrastructure, RTA with China, and vote are crucial to attracting more FDI from countries other than China. After more infrastructure projects in BRI countries are completed, they might be able to attract more FDI from countries other than China. However, the time span needed is too long to estimate this effect using current available data. However, for non-BRI countries, only China OFDI and GDP matters. Comparing those findings with results from lagged China OFDI effects, they are consistent with each other. China OFDI has a positive cumulative lag effect for BRI countries sourced FDI from countries other than China in general. For BRI countries, China OFDI from the previous one to three years positively affects the likelihood of receiving more FDI from countries other than China. However, in a contrasting finding, China OFDI shows no significant effect for BRI countries when considering the lag effect; specifically, the current year's China OFDI negatively impacts FDI from other countries. For non-BRI countries, China OFDI in the current and previous year positively influences FDI from other countries, but China OFDI from two and three years prior has a negative impact.

China M&A has a positive effect on M&A sourced from countries other than China in the entire countries group, especially non-BRI countries. China M&A has no significant positive impact on M&A from countries other than China in BRI participating countries. The results are consistent with previous FDI results. In the BRI countries, GDP, corruption, and WTO are critical in attracting more M&A from countries other than China. The investment environment is important when individuals or firms make foreign investment decisions via the M&A method in BRI countries. We find consistency between these findings with results from **Table 1.6**. Additionally, the cumulative lag effect of China M&A on average M&A from countries other than China is negative for all countries sample and the sample of non-BRI countries, but the scale of the effects is relatively small. Notably, China M&A shows no significant lagged effect on BRI countries. This further supports the evidence that China M&A does not crowd out M&A from other countries.

Contrary to our expectations, WTO membership negatively impacts M&A from countries other than China inflows into BRI countries. This deviates from the results of a previous study by Chien et al. (2012). One potential explanation is that upon joining the WTO and subsequently imposing reduced import tariffs, some products may become pricier to import compared to domestic production. Before joining the WTO, the prospect of domestic production presented opportunities to attract FDI and investment via M&A. However, with WTO membership, the emphasis might have shifted towards imports, diminishing domestic industries' attraction for foreign investment via M&A.

1.6 Conclusion

This study offers an analysis of the impact of China OFDI, China M&A, and BRI on other countries' investment decisions in recipient countries. Results of this analysis confirms that both China OFDI and M&A positively influence FDI and M&A inflows from countries other than China, especially in non-BRI countries. However, this pronounced impact is absent when solely assessing BRI countries. The cumulative lag effect of China OFDI on all types of countries are positive on average of FDI from countries other than China, but the cumulative lag effect of China M&A for all countries and non-BRI countries are negative, albeit on a relatively small scale. There is no statistically significant cumulative lag effect of China M&A on M&A from other donors for

BRI countries. Therefore, both China OFDI and M&A do not appear to crowd out other investors in recipient countries, particularly in those participating in the BRI.

Joining BRI is a positive factor in attracting more FDI from countries other than China for the all countries model, but it does not appear to significantly influence M&A from countries other than China and other subgroups. Several factors, such as GDP, trade openness, a regional trade agreement with China, and communication infrastructure, consistently promote FDI and M&A inflows from countries other than China across various country groups. Conversely, higher corruption levels tend to deter FDI from countries other than China for BRI countries and reduce M&A from countries other than China inflows across different country groups. BRI countries who are more aligned with China, can obtain more FDI from investors other than China. Unexpectedly, BRI countries that are WTO members seem less attractive for M&A from countries other than China.

Our findings highlight the importance of a country's characteristics in enhancing its ability to attract more FDI from abroad. These results also contribute to the ongoing debate on whether China's investments promote or inhibit investments from other countries. Evidently, China's investments serve as a positive external signal, bolstering confidence and encouraging other countries to increase their investments in recipient nations. Especially for BRI countries, there is no sign showing that China's investment crowds out other countries' investment opportunities. Furthermore, BRI countries that align more closely with China benefit from increased FDI from countries other than China. Thus, there is no supporting evidence to suggest that a rise in China OFDI and China M&A or alignment with China caused other nations to decline to invest in BRI recipients for various political, contract design, and other reasons.

Here are some implications from our analysis. For BRI countries, the investment from China does not seem to crowd out investments from other nations. This is crucial for countries forming development strategies, as they can be more confident about diversifying their investment sources without fearing displacement. Moreover, the diversified source of capital - both from China and other investors - may lead to a more resilient and varied supply chain of capital. Given global disruptions (like the COVID-19 pandemic) that affected supply chains, diversified capital flows can offer a buffer, allowing countries to rebuild or reinforce their supply chains faster with available capital. This diversification can act as a hedge against economic downturns in any particular investor country.

If Chinese investments can act as catalysts for investments from other countries, we could witness a redirection or reshaping of capital flows based on Chinese investment patterns, potentially turning BRI nations into more significant nodes in the global capital supply chain. The flows of capital impact the flows of goods. Furthermore, an increase in FDI might result in increased trade and consequently a need for innovative supply chain financing solutions, particularly in BRI countries that might see growth in infrastructure and trade.

1.6.1 Limitations and Suggestions for Future Research

We used aggregated FDI and M&A data in our analysis which limited our ability to estimate detailed results showing which sectors are most influenced by China OFDI and M&A activities. Given that the BRI was launched in 2013, the time span is too short to analyze its long-run effects.

Future studies could consider replicating the current analysis across countries with varying development statuses, as it might reveal differing outcomes. In the future, we plan to extend our study's timeframe, examining changes after intervals of five or ten years; by then, we should be able to identify long-term effects. Additionally, we will apply similar methodologies to analyze greenfield investments and then compare those findings with our current results

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Table 1.1 Definitions and Data Sources of the FDI, M&A and Other Key Variables

Variable	Short name	Definition	Data Source	Related Literature
Dependent Variables				
Countries Other than China Inward FDI Flows	COTC FDI	Individual country's annual total inward FDI flows from the world excluding China	UNCTAD (https://unctad.org/statistics); Statistical Bulletin of China's Outward Foreign Direct Investment (http://english.mofcom.gov.cn /article/statistic/)	[FDI]: Fan et al. (2016), Dunning (2002), Marino, (2000), Adebayo et al. (2020); Hailu (2010), Kang et al. (2018), Abbas & Mosallamy (2016); Mamytova & You (2018), Globerman & Shapiro (2004)
Countries Other than China M&A Amount	COTC M&A	Individual country's annual total M&A transaction amount from the world excluding China	Securities Data Corporation (SDC) Platinum (Refinitiv, 2022)	[M&A]: Globerman & Shapiro (2004), Zhang et al. (2022), Li et al. (2018), Kandilov et al. (2017), Fotak et al. (2022)
Independent Variables				
China FDI Outward Flows	China OFDI	China's annual OFDI flows to the individual country	Statistical Bulletin of China's Outward Foreign Direct Investment between 2004 to 2020	[FDI]: Chang et al. (2021); Qian et al. (2022), Shahriar et al. (2019), Li et al. (2019)
China M&A Amount	China M&A	China's annual M&A transaction amount to the individual country	Securities Data Corporation (SDC) Platinum	[M&A]: Globerman & Shapiro (2004), Zhang et al. (2022), Li et al. (2018), Kandilov et al. (2017), Fotak et al. (2022)
Belt and Road Initiative	BRI	Dummy variable and equal 1 if the country joined BRI in and after that year	Belt and Road portal (https://www.yidaiyilu.gov.cn/) and Nedopil (2022)	[FDI]: Qian et al. (2022), Lv et al. (2018), [M&A]: Jung et al. (2020), Zhang et al. (2022), Jin & Shen (2020)

Table 1.1 (continued)

Gross Domestic Product	GDP	Real gross domestic product of current USD	World Development Indicator of World Bank (https://datatopics.worldbank.org/world-development-indicators/)	[FDI]: Adebayo et al. (2020), Asiedu (2002), Asiedu (2006), Bellak et al. (2009), Boateng et al. (2015), Choi et al. (2016), Fan et al. (2016), Musabeh & Zouaoui (2020), [M&A]: Shen & Jin (2018), Li et al. (2018), Xie et al. (2017), Jin & Shen (2020), Erel et al. (2012), Xie et al. (2017), Li et al. (2018), Zhang et al. (2022), Fotak et al. (2022)
Inflation, consumer prices (annual %)	IR	Inflation as measured by the consumer price index reflects the annual percentage change in the cost to the average consumer of acquiring a basket of goods and services that may be fixed or changed at specified intervals, such as yearly.	World Development Indicator of World Bank	[FDI]: Abbott et al. (2012), Adebayo et al. (2020), Asiedu (2002), Asiedu (2006), Boateng et al. (2015), Hadi et al. (2018), Hailu (2010), Mamytova & You (2018), Musabeh & Zouaoui (2020), [M&A]: Xie et al. (2017)
Exchange Rate	ER	Each country's currency exchange rate against the U.S. dollar	UNCTAD	[FDI]: Abbott et al. (2012), Boateng et al. (2015), Choi et al. (2016), Hadi et al. (2018), Mamytova & You (2018), Poelhekke & van der Ploeg (2013), Zouaoui,(2020) [M&A]: Xie et al. (2017)

Table 1.1 (continued)

Country Risk Score of Corruption	Corruption	Measures the corruption level of the government of the country or region.	S&P Global (https://www.spglobal.com/ratings/en/research-insights/credit-conditions)	[FDI]: Fan et al. (2016), Li et al. (2019),
Natural Resources	NR	Dummy variables and equal 1 if Total natural resources rents (% of GDP) are more than 10%. Total natural resources rents (% of GDP) are the sum of oil rents, natural gas rents, coal rents (hard and soft), mineral rents, and forest rents.	World Development Indicator of World Bank	[FDI]: Fan et al. (2016), Abbott et al. (2012), Kang et al. (2018), Mamytova & You (2018), Musabeh & Zouaoui (2020), Poelhekke & van der Ploeg (2013), [M&A]: Jin & Shen (2020), Jung et al. (2020)
Communication Infrastructure	INF	Fixed telephone lines + cellphone lines (per 100 people)	World Development Indicator of World Bank	[FDI]: Bellak et al. (2009), Asiedu (2002), Kang et al. (2018), Mamytova & You (2018), Das (2020), Asiedu (2006), Hailu (2010), Abbott et al. (2012), [M&A]: Jung et al. (2020), Xie et al. (2017)
Trade Openness	TO	(Import + Export)/Population	UNCTAD and World Development Indicator of World Bank	[FDI]: Abbott et al. (2012), Adebayo et al. (2020), Asiedu (2002), Boateng et al. (2015), Das (2020), Hadi et al. (2018), Hailu (2010), Musabeh & Zouaoui (2020), [M&A]: Jung et al. (2020), Li et al. (2018), Xie et al. (2017),

Table 1.1 (continued)

Membership in the World Trade Organization	WTO	Dummy variable and equal 1 if the country joined WTO in and after that year	World Trade Organization (https://www.wto.org/english/thewto_e/whatis_e/tif_e/org6_e.htm)	[FDI]: Shahriar et al. (2019), [M&A]: Jin & Shen (2020), Shen & Jin (2018), Zhang et al. (2022)
Region Trade Agreement with China	RTA with China	Dummy variable and equal 1 if the country and China have RTA in force in and after that year	Reginal Trade Agreement database of World Trade Organization	[FDI]: Fan et al. (2016), [M&A]: Li et al. (2018), Zhang et al. (2022)
Vote	Vote	Measure the likelihood of the county political aligned with China, and calculated as the average number of three prior years of the same voting results as China in the United Nations divided total voting number	United Nations General Assembly Voting Data (Voeten et al., 2009)	[M&A]: Fotak et al. (2022)

Table 1.2 Descriptive Statistics

Variables	All Countries					BRI Countries					Non-BRI Countries				
	N	Mean	SD	Min	Max	N	Mean	SD	Min	Max	N	Mean	SD	Min	Max
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
COTC FDI (million USD)	3,312	6,368	23,620	-163,778	459,596	2,358	2,946	7,820	-29,684	101,568	954	14,825	41,068	-163,778	459,596
COTC M&A (million USD)	2,454	11,920	35,669	0.0150	439,847	1,777	3,615	11,384	0.0150	150,450	677	33,721	60,157	0.0980	439,847
China OFDI (million USD)	3,312	147.4	721.3	-11,453	16,981	2,358	106.3	520.4	-11,453	10,452	954	249.2	1,060	-3,212	16,981
China M&A (million USD)	3,312	153.5	1,092	0	43,782	2,358	57.33	426.0	0	13,883	954	391.1	1,901	0	43,782
BRI	3,312	0.149	0.356	0	1	2,358	0.209	0.407	0	1	954	0	0	0	0
GDP (billion USD)	3,307	326.9	1,357	0.0195	21,373	2,357	117.9	276.0	0.0902	2,409	950	845.5	2,418	0.0195	21,373
Inflation (%)	3,088	5.475	13.88	-18.11	557.2	2,258	6.116	15.96	-10.07	557.2	830	3.730	4.438	-18.11	36.70
Exchange Rate ($)	3,290	627.6	2,621	0.205	42,000	2,336	791.3	3,051	0.205	42,000	954	226.9	815.8	0.500	6,771
Corruption	3,026	2.783	1.491	0.100	9	2,178	2.990	1.383	0.100	9	848	2.251	1.623	0.100	6.930
Natural Resource	3,294	0.824	0.381	0	1	2,358	0.888	0.315	0	1	936	0.661	0.474	0	1
Communication Infrastructure	3,238	103.5	57.10	0.632	453.3	2,318	99.36	55.49	0.632	237.1	920	113.9	59.74	0.833	453.3
Trade Openness	2,839	9,837	16,389	30.47	152,195	2,021	8,205	15,936	30.47	152,195	818	13,869	16,802	40.07	87,595
WTO	3,312	0.817	0.387	0	1	2,358	0.811	0.391	0	1	954	0.830	0.376	0	1
RTA with China	3,312	0.0975	0.297	0	1	2,358	0.113	0.317	0	1	954	0.0587	0.235	0	1
Vote	3,204	0.651	0.165	0	0.911	2,337	0.672	0.156	0	0.911	867	0.593	0.173	0	0.874

Table 1.3 Impact of China OFDI and BRI on COTC FDI

	All Countries		BRI Countries		Non-BRI Countries	
	(RE)	(FE)	(RE)	(FE)	(RE)	(FE)
	(1)	(2)	(3)	(4)	(5)	(6)
China OFDI	4.982***	4.652***	0.408	0.0242	7.999***	8.007***
	(0.477)	(0.504)	(0.282)	(0.284)	(1.116)	(1.215)
BRI	-1,414	3,324**	-363.4	527.3		
	(958.7)	(1,378)	(374.4)	(702.2)		
GDP	11.45***	11.56***	10.83***	10.98***	10.04***	8.572***
	(0.410)	(1.226)	(0.924)	(1.896)	(0.937)	(2.424)
Inflation (%)	4.155	3.535	2.505	-0.766	111.5	-373.6
	(24.89)	(25.69)	(9.493)	(9.718)	(401.5)	(486.2)
Exchange Rate ($)	0.0208	-0.0801	0.0621	0.0378	-0.744	5.585
	(0.199)	(0.362)	(0.0832)	(0.137)	(2.481)	(6.663)
Corruption	-571.9	-589.4	-372.8**	-549.7**	-812.1	256.4
	(363.8)	(581.7)	(166.4)	(252.0)	(1,388)	(2,193)
Natural Resource	440.2	-3,815	-2,500***	-897.0	4,695	-11,449
	(1,444)	(2,539)	(783.1)	(1,228)	(4,571)	(7,324)
Communication Infrastructure	12.08	34.66**	5.978	18.12**	56.88	107.5
	(10.03)	(17.43)	(4.553)	(7.984)	(44.96)	(66.05)
Trade Openness	0.141***	-0.0380	0.179***	0.104**	0.0667	-0.291
	(0.0389)	(0.0907)	(0.0191)	(0.0410)	(0.151)	(0.299)
WTO	-142.8	-2,843	-1,001	-1,786*	3,738	
	(1,573)	(2,754)	(688.0)	(1,048)	(8,653)	
RTA with China	-1,911	-3,698	1,515**	2,304*	-9,605	-8,142
	(1,620)	(2,571)	(751.6)	(1,186)	(6,864)	(8,439)

Table 1.3 (continued)

Vote	-774.8	-1,553	3,259*	1,054	-3,173	-8,631
	(3,438)	(5,933)	(1,692)	(2,590)	(12,421)	(21,028)
Constant	1,710	4,761	1,451	1,299	-4,648	3,582
	(3,040)	(5,205)	(1,444)	(2,337)	(13,188)	(15,419)
Observations	2,442	2,442	1,785	1,785	657	657
R-squared	0.8549	0.8154	0.6362	0.5603	0.8607	0.7321
Number of Countries	168	168	126	126	42	42
Random Effect	Yes		Yes		Yes	
Country Fixed Effect		Yes		Yes		Yes
Year Fixed Effect		Yes		Yes		Yes
Hausman Test	32.572		15.85		12.82	
	0.0002		0.0702		0.1182	

Notes: Columns (3) & (4) represent only BRI countries in this subgroup. Columns (5) & (6) represent only non-BRI countries in this subgroup. Columns (1), (3) and (5) represent random effects. Columns (2), (4) and (6) represent country and time fixed effects. Standard errors are in parentheses *** p<0.01, ** p<0.05, * p<0.1. Results of Hausman Test are presented with the chi-squared test value in the upper row and the P-value in the lower row.

Table 1.4 Impact of China M&A and BRI on COTC M&A

	All Countries		BRI Countries		Non-BRI Countries	
	(RE)	(FE)	(RE)	(FE)	(RE)	(FE)
	(1)	(2)	(3)	(4)	(5)	(6)
China M&A	2.324***	2.209***	0.575	0.0994	2.618***	2.703***
	(0.314)	(0.312)	(0.399)	(0.398)	(0.591)	(0.582)
BRI	-982.7	295.8	-654.2	419.6		
	(1,123)	(1,541)	(511.6)	(967.8)		
GDP	16.66***	18.22***	27.43***	19.66***	15.25***	18.43***
	(0.619)	(1.250)	(0.653)	(2.475)	(1.294)	(2.312)
Inflation (%)	-4.039	-12.28	0.620	-4.606	43.02	-424.6
	(27.41)	(27.00)	(12.07)	(12.64)	(588.8)	(660.0)
Exchange Rate ($)	-0.181	-0.198	-0.289***	-0.145	-0.698	0.486
	(0.288)	(0.441)	(0.0687)	(0.208)	(3.871)	(7.457)
Corruption	-2,324***	226.9	-762.2***	-595.0*	-5,835***	1,471
	(488.2)	(672.3)	(189.7)	(359.9)	(1,890)	(2,572)
Natural Resource	1,212	2,178	-4,112***	-73.30	9,812	3,379
	(2,099)	(2,674)	(782.9)	(1,620)	(6,114)	(7,325)
Communication Infrastructure	20.56	75.93***	-7.758	11.36	79.78	174.0**
	(13.59)	(19.46)	(5.001)	(11.08)	(59.40)	(72.47)
Trade Openness	0.149***	0.254***	0.0588***	0.0325	0.255	0.462
	(0.0552)	(0.0970)	(0.0150)	(0.0544)	(0.199)	(0.308)
WTO	-1,992	-4,810	-1,846***	-5,613***	5,603	
	(2,472)	(3,275)	(705.5)	(1,546)	(18,960)	
RTA with China	216.6	-426.2	1,426**	1,319	-2,514	2,392
	(2,151)	(2,718)	(614.3)	(1,553)	(8,021)	(8,653)
Vote	-7,661	-6,883	-617.3	1,267	-7,587	-28,042
	(5,331)	(8,133)	(1,742)	(4,294)	(19,020)	(30,415)
Constant	12,321**	658.7	7,933***	5,374	4,674	-8,840
	(4,930)	(6,541)	(1,688)	(3,600)	(24,459)	(19,639)
Observations	2,016	2,016	1,475	1,475	541	541
R-squared	0.8004	0.7879	0.8940	0.8045	0.8022	0.7957

Table 1.4 (continued)

Number of Countries	157	157	119	119	38	38
Random Effect	Yes		Yes		Yes	
Country Fixed Effect		Yes		Yes		Yes
Year Fixed Effect		Yes		Yes		Yes
Hausman Test	36.88		34.16		39.30	
	0.0000		0.0001		0.0000	

Notes: Columns (3) & (4) represent only BRI countries in this subgroup. Columns (5) & (6) represent only non-BRI countries in this subgroup. Columns (1), (3) and (5) represent random effects. Columns (2), (4) and (6) represent country and time fixed effects. Standard errors are in parentheses *** p<0.01, ** p<0.05, * p<0.1. Results of Hausman Test are presented with the chi-squared test value in the upper row and the P-value in the lower row.

Table 1.5 Lagged Impact of China OFDI and BRI on COTC FDI

	All Countries		BRI Countries		Non-BRI Countries	
	(RE)	(FE)	(RE)	(FE)	(RE)	(FE)
	(1)	(2)	(3)	(4)	(5)	(6)
China OFDI	4.811***	4.502***	-0.728***	-0.894***	8.732***	7.951***
	(0.501)	(0.510)	(0.271)	(0.271)	(1.181)	(1.222)
China OFDI Lag 1	2.013***	1.886***	1.403***	1.348***	2.162*	1.540
	(0.501)	(0.506)	(0.264)	(0.263)	(1.221)	(1.251)
China OFDI Lag 2	-0.488	-0.440	2.934***	2.989***	-3.364***	-3.667***
	(0.496)	(0.506)	(0.258)	(0.258)	(1.229)	(1.288)
China OFDI Lag 3	-1.255***	-1.066**	1.258***	1.354***	-3.420***	-3.044**
	(0.480)	(0.495)	(0.256)	(0.256)	(1.206)	(1.301)
BRI	-1,324	3,324**	-997.5***	-20.25		
	(958.2)	(1,374)	(351.7)	(656.5)		
GDP	11.40***	11.54***	9.165***	6.206***	11.34***	14.29***
	(0.435)	(1.426)	(0.922)	(1.796)	(1.052)	(3.133)
Inflation (%)	3.190	2.477	4.735	2.081	76.94	-252.5
	(24.80)	(25.62)	(8.859)	(9.059)	(398.4)	(482.7)
Exchange Rate ($)	0.0158	-0.0905	0.0274	0.106	-0.577	3.686
	(0.199)	(0.361)	(0.0812)	(0.128)	(2.568)	(6.621)
Corruption	-635.6*	-572.2	-357.3**	-382.9	-864.9	-169.9
	(363.5)	(580.0)	(158.7)	(235.1)	(1,389)	(2,176)
Natural Resource	402.0	-3,762	-2,523***	-1,402	3,938	-11,810
	(1,445)	(2,531)	(761.0)	(1,145)	(4,647)	(7,252)
Communication Infrastructure	10.74	34.31**	9.657**	15.79**	45.65	88.86
	(10.05)	(17.40)	(4.363)	(7.443)	(45.18)	(65.65)
Trade Openness	0.136***	-0.0385	0.143***	0.0759**	0.0909	-0.255
	(0.0392)	(0.0905)	(0.0189)	(0.0383)	(0.153)	(0.297)
WTO	-108.2	-2,691	-1,014	-2,090**	3,386	
	(1,574)	(2,746)	(666.6)	(976.7)	(8,972)	
RTA with China	-2,034	-3,697	617.2	806.9	-6,728	-5,442
	(1,628)	(2,582)	(734.8)	(1,109)	(6,932)	(8,399)

Table 1.5 (continued)

Vote	-696.1	-1,666	3,111*	1,564	-1,819	-7,623
	(3,438)	(5,916)	(1,633)	(2,414)	(12,543)	(20,836)
Constant	2,028	4,569	1,399	510.0	-4,012	2,555
	(3,041)	(5,190)	(1,402)	(2,179)	(13,388)	(15,281)
Observations	2,442	2,442	1,785	1,785	657	657
R-squared	0.8557	0.8183	0.6815	0.6358	0.8565	0.7753
Number of countries	168	168	126	126	42	42
Random Effect	Yes		Yes		Yes	
Country Fixed Effect		Yes		Yes		Yes
Year Fixed Effect		Yes		Yes		Yes
Hausman Test	31.16		17.39		11.98	
	0.0003		0.0429		0.1523	

Notes: Columns (3) & (4) represent only BRI countries in this subgroup. Columns (5) & (6) represent only non-BRI countries in this subgroup. Columns (1), (3) & (5) represent random effects. Columns (2), (4) & (6) represent country and time fixed effects. Standard errors are in parentheses *** p<0.01, ** p<0.05, * p<0.1. Results of Hausman Test are presented with the chi-squared test value in the upper row and the P-value in the lower row.

Table 1.6 Lagged Impact of China M&A and BRI on COTC M&A

	All Countries		BRI Countries		Non-BRI Countries	
	(RE) (1)	(FE) (2)	(RE) (3)	(FE) (4)	(RE) (5)	(FE) (6)
China M&A	2.484***	2.193***	0.456	0.0701	2.860***	2.598***
	(0.315)	(0.309)	(0.405)	(0.399)	(0.598)	(0.577)
China M&A Lag 1	-1.205***	-1.574***	0.811**	0.537	-1.407**	-1.732***
	(0.318)	(0.318)	(0.408)	(0.400)	(0.607)	(0.596)
China M&A Lag 2	-0.833***	-1.189***	0.0423	-0.174	-0.933	-1.337**
	(0.316)	(0.321)	(0.403)	(0.395)	(0.608)	(0.603)
BRI	-859.4	-99.61	-705.1	419.4		
	(1,120)	(1,528)	(513.4)	(968.3)		
GDP	17.87***	22.59***	27.24***	19.51***	16.46***	23.14***
	(0.658)	(1.443)	(0.664)	(2.491)	(1.263)	(2.665)
Inflation (%)	-3.726	-10.59	0.694	-4.677	27.31	-387.3
	(27.34)	(26.75)	(12.06)	(12.64)	(582.6)	(653.0)
Exchange Rate ($)	-0.189	-0.240	-0.287***	-0.143	-0.812	-0.431
	(0.282)	(0.437)	(0.0686)	(0.208)	(3.329)	(7.383)
Corruption	-2,258***	103.4	-778.2***	-590.0	-5,642***	856.2
	(483.6)	(666.3)	(189.7)	(360.0)	(1,821)	(2,551)
Natural Resource	984.0	1,388	-4,068***	16.60	9,402*	2,218
	(2,068)	(2,652)	(782.7)	(1,622)	(5,705)	(7,255)
Communication Infrastructure	19.18	68.42***	-7.303	11.45	91.06	159.8**
	(13.47)	(19.33)	(5.005)	(11.08)	(57.44)	(71.87)
Trade Openness	0.164***	0.269***	0.0526***	0.0290	0.226	0.483
	(0.0542)	(0.0961)	(0.0154)	(0.0545)	(0.185)	(0.305)
WTO	365.5	-467.3	-1,805**	-5,526***	6,016	
	(2,118)	(2,693)	(705.3)	(1,548)	(15,903)	
RTA with China	-2,016	-5,306	1,390**	1,280	-1,232	531.0
	(2,431)	(3,245)	(614.1)	(1,555)	(7,784)	(8,578)
Vote	-6,757	-4,164	-775.5	1,274	-4,682	-16,115
	(5,258)	(8,070)	(1,744)	(4,294)	(17,987)	(30,282)

Table 1.6 (continued)

Constant	11,588**	-345.8	8,005***	5,233	1,212	-16,828
	(4,867)	(6,482)	(1,688)	(3,602)	(21,873)	(19,562)
Observations	2,016	2,016	1,475	1,475	541	541
R-squared	0.7925	0.7784	0.8958	0.8061	0.7951	0.7817
Number of Countries	157	157	119	119	38	38
Random Effect	Yes		Yes		Yes	
Country Fixed Effect		Yes		Yes		Yes
Year Fixed Effect		Yes		Yes		Yes
Hausman Test	44.99		33.95		36.63	
	0.0000		0.0001		0.0000	

Notes: Columns (3) & (4) represent only BRI countries in this subgroup. Columns (5) & (6) represent only non-BRI countries in this subgroup. Columns (1), (3) & (5) represent random effects. Columns (2), (4) & (6) represent country and time fixed effects. Standard errors are in parentheses *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Results of Hausman Test are presented with the chi-squared test value in the upper row and the P-value in the lower row.

Figure 1.1 The Silk Road Economic Belt and the 21st-Century Maritime Silk Road, 2021
Source: Baruzzi, 2021

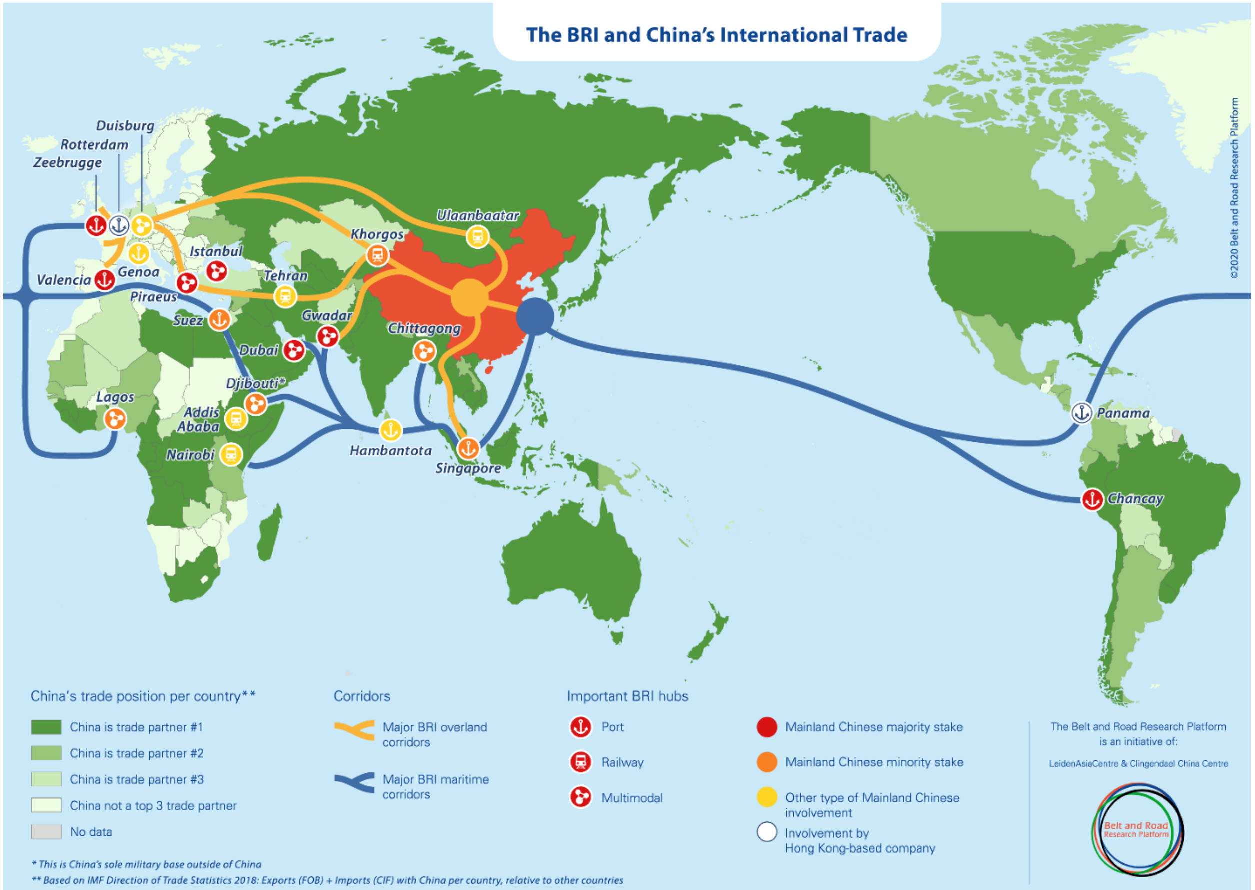

Figure 1.2 The Belt and Road Initiative and China's International Trade, 2021
Source: The Belt and Road Research Platform, 2021

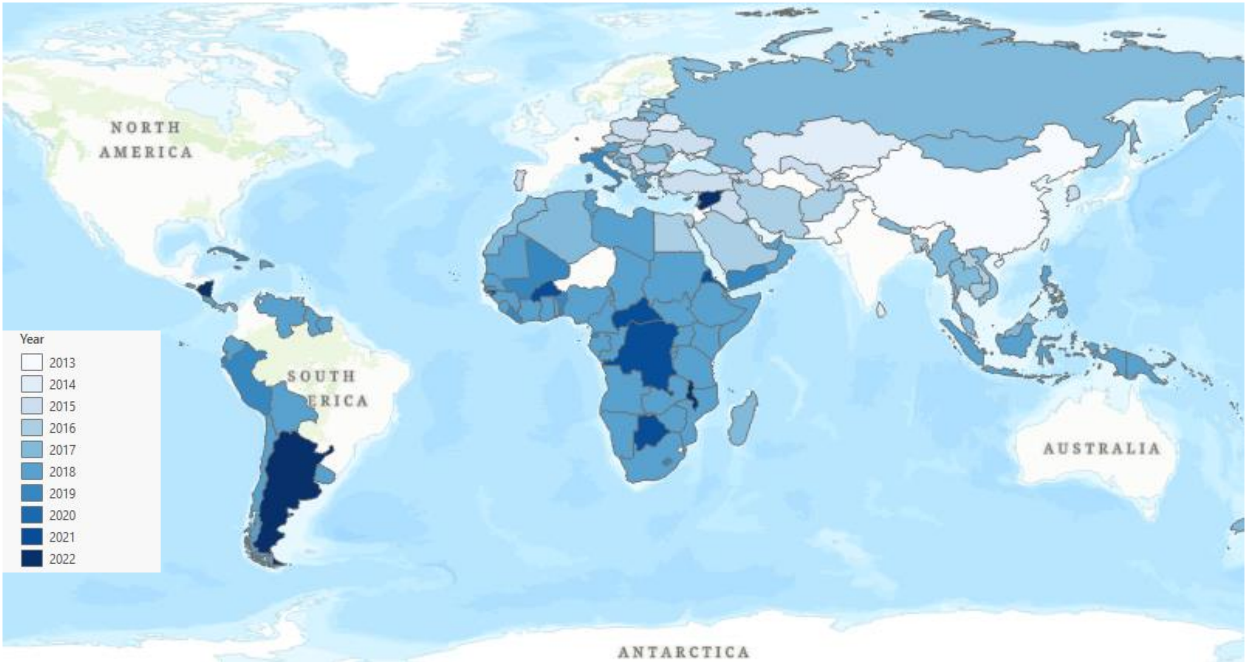

Figure 1.3 Geographical Development of BRI Countries, 2013-2022

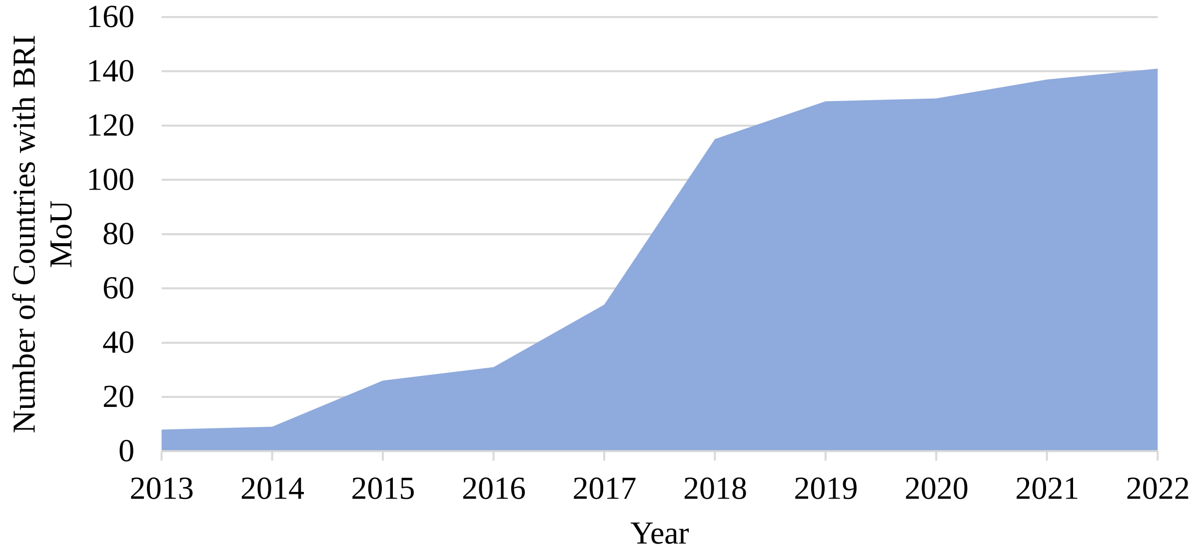

Figure 1.4 Number of BRI Countries, 2013-2022

CHAPTER 2: Examining the Impacts of The Belt and Road Initiative on Global Trade

2.1 Introduction

China's Belt and Road Initiative (BRI) was launched in 2013. China conceived the BRI to connect Europe and Asia through land infrastructure investment projects (Wu & Zhang, 2013). By 2022, China had invested $240 billion in BRI countries and engaged in over $1 trillion worth of BRI-related projects, underscoring the initiative's global reach and significance. As of June 2023, 152 countries and 32 international organizations have signed BRI Memorandum of Understandings (MoUs) with China, as detailed in **Figure 2.1**. As part of the BRI, China strategically established two free trade zones the provinces of Xinjiang (land route) and Fujian (ocean route) to facilitate BRI-related bilateral trade. These free trade zones have been instrumental in boosting China's trade with BRI and non-BRI countries (Devonshire-Ellis, 2019; HKTDC Research, 2019).

[Insert **Figure 2.1** here]

Other than established free trade zones, the BRI projects and investments in infrastructure sectors have led to improved infrastructure and reduced transport costs (Herrero & Xu, 2017; Yang et al., 2020). Enhanced infrastructure (i.e., roads, railroads, ports) coupled with transportation cost reductions stand to stimulate multilateral trade and open new trade possibilities, either on an intensive or extensive margin.[1] For example, the Yiwu–London Railway Line (see **Figure 2.2**) is one such linkage, connecting large swaths of China to central Asia, eastern Europe, and northwestern Europe. This railroad line has opened new trade opportunities and reduced transport costs for prospective trading countries along its route. Given the nature of the BRI projects China has invested in, the BRI may also encourage cooperation between China and BRI countries in sectors such as agriculture (Dang & Pang, 2020), financial services (AIIB, 2023), and natural resources (Hussain et al., 2020; OECD, 2018), potentially leading to the transfer of technology and capital between counties (Jiang et al., 2018; Yao et al., 2020), which can contribute to productivity gains. To the extent that the BRI increases opportunities for China's exports, this initiative may have positive externalities for China in putting to use some of its excess production

[1] The intensive margin represents the impact of trade among existing trade partners, while the extensive margin refers to expanding to new trade partners.

capacity (Du & Zhang, 2018), and is consistent with China's efforts to influence the international economic system and elevate the status of its currency, the Yuan (Uppal & Mudakkar, 2020).

[Insert **Figure 2.2** here]

China's exports increased from $1.48 trillion in 2007 to $3.35 trillion in 2021, while imports increased from $0.81 trillion in 2007 to $2.09 trillion in 2021 according to BACI: International Trade Database at the Product-Level (the 1994-2007 Version) (Gaulier & Zignago, 2010). **Figure 2.3** displays China's export and import values and their share of the world's exports and imports across agriculture, natural resources, and manufacturing sectors. This figure excludes the services sector because the BACI dataset does not cover this sector. China's imports of natural resources products as a share of the world total steadily increased from 7% in 2007 to 16% in 2021. Moreover, China's imports of agricultural products as a proportion of the world's imports increased from 3% in 2007 to 10% in 2021. In contrast to the significant growth in imports, China's agricultural and natural resources products exports have remained relatively stable over the same period. Additionally, China's exports of manufacturing goods as a share of the world increased from 13% in 2007 to 20% in 2021, but its import share of manufacturing goods increased slightly, from 6% in 2007 to 8% in 2021. The varied trends of China's imports and exports across sectors motivated us to explore the influence of the BRI on trade at the sector level.

[Insert **Figure 2.3** here]

To date, scholarly discourse on topics related to BRI and trade has been limited. Yu et al. (2020) and Fan (2023) found that the BRI significantly increased bilateral trade between China and BRI countries. Mao et al. (2019) focused only on analyzing the effects on exports of the BRI on BRI countries and China. Fotak et al. (2022) investigated the impact of BRI project investments on aggregated trade between China and BRI countries, and between BRI countries and third-party countries (other than China and BRI countries). While their study lightly examined aspects of the BRI's impact on trade, it does not comprehensively examine this topic. Before becoming BRI members, many countries may have faced limited communication channels, non-tariff trade barriers, and an absence of efficient channels for conducting trade with one another. To our knowledge, no prior research has discussed the implication of BRI on trade among BRI countries (excluding China) in aggregated terms and across different sectors. In doing so, this analysis considerably extends the scope of existing research and offers new and important implications and insights regarding both overall and sector-specific trade. It also examines the trade benefits for countries that join the BRI and the potential trade costs for those that choose not to participate in this initiative.

The objectives of this study are to examine the impact of the BRI on aggregated international trade and on goods of trade in key sectors such as agriculture, forestry and fishing, mining and energy, manufacturing, and services. Additionally, this study assesses the effects of the BRI on trade patterns among countries with different development statuses. Lastly, this study explores the intensive and extensive margin of trade, as well as trade creation and diversion effects between signatory and non-signatory members.

This paper is among the first to examine the impacts of China's BRI on aggregated trade among BRI countries (excluding China), and the first to explore the previously unexamined effects of multilateral trade in disaggregated sectors on both BRI and non-BRI countries. To our knowledge, this is also the first paper that analyzes the combined effect of BRI participation and a country's development status on trade in both aggregated and disaggregated sectors. Our findings provide valuable insights and practical implications for policymakers and stakeholders across various industries, enabling them to better understand and assess the BRI's impact on trade within their sectors of interest.

As a preview, the results of this analysis offer several new and important insights into the impact of the Belt and Road Initiative (BRI) on international trade flows. Our findings show that BRI membership has increased China's trade with both BRI and non-BRI countries, particularly in the manufacturing sector, but has not positively impacted trade in the services sector. Excluding China, intra-regional trade among BRI countries is significantly higher across all sectors, highlighting the BRI's role in facilitating regional trade. Moreover, this study detected net positive trade creation in the aggregated sector and agriculture, forestry and fishing, and manufacturing sectors between BRI and non-BRI countries. However, we found pure negative export and import diversions, indicating that BRI countries experience losses in exports and imports to non-BRI countries in the mining and energy sector. These findings emphasize the importance of targeted interventions to address sector-specific and income-level disparities, fostering broader and more equitable trade benefits under the BRI.

The remainder of this paper is organized as follows. Section 2.2 reviews the relevant literature, Section 2.3 describes empirical models and datasets used in this analysis, and Section 2.4 offers the empirical results and discussion. Section 2.5 presents the conclusion and limitations of this paper.

2.2 Literature Reviews

In this section, we first review studies most closely related to examining the impact of the BRI on trade. We then provide a broader overview of research exploring the relationship between the BRI and trade from various perspectives, including its influence on infrastructure development and specific sectors such as agriculture, mining and energy, manufacturing, and services.

2.2.1 BRI and Trade

Existing literature has examined the BRI across various economic fields, including politics, the environment, macroeconomics, development, finance, and international trade. Most relevant to our analysis is a study by Fotak et al. (2022), which uses a gravity model approach to investigate the impact of export, import, trade flows, and mergers and acquisition (M&A) between BRI countries and third-party countries (other than BRI and China) between 2013 to 2018. These authors observed that trade between China and BRI countries was substantial before the BRI launched but significantly increased afterward. However, they noted that bilateral trade between third-party countries (non-signatories) and BRI countries declined after the BRI's launch.

Foo et al. (2020) used a gravity model analysis to model the impact of the BRI on trade flows between ASEAN and BRI countries, as well as between ASEAN countries and a selected group of non-BRI countries, including Australia, Canada, Japan, the UK, and the US, between 2000 to 2016. They found a positive effect of the BRI on trade flows among these ASEAN and BRI countries using propensity score matching and difference in differences estimator. Li et al. (2019) analyzed the impact of infrastructure on the trade of Chinese inland provinces along with BRI. Some studies focused on the impact of BRI through other factors on the bilateral trade relationship between China and BRI countries.

2.2.2 Infrastructure, BRI, and Trade

There are some studies about the impact of infrastructure on trade among BRI countries. Rehman & Noman (2021) employed the two-step Generalized Method of Moment to estimate the effect of infrastructure on export along 66 BRI countries between 1970 and 2017, and examine the impact of BRI on the export of BRI countries by substituting the coefficient of the post-BRI period (2013-2017) and the pre-BRI period (2008-2012). The results showed that infrastructure development encourages BRI countries' exports. Herrero & Xu (2017) applied the gravity model to analyze the reduction of the railroad, air, and ocean trade cost impact on trade along 137 countries covering European Union (EU) and BRI countries (excluding the countries that are members of the EU) and third countries (other than member of EU and BRI) in 2013 and 2014. They found that reducing railroad, air, and ocean transportation costs positively impacts trade at different levels. Sternberg et al. (2020) stated that railroad lines expanded by over 20% during the BRI period in central Asian areas. China is not a major importer of agricultural products; thus, BRI and China's investment have no negative impact on food security in central Asia. Soyres et al. (2019) found that the BRI facilitated reducing global shipment times by an average of 1.1 to 1.2 percent and overall trade costs by 1.1 to 2.2 percent, and the reduction among BRI countries and countries along the BRI corridors benefited more.

Previous literature simulated different scenarios to predict the effects of BRI through infrastructure on trade. In general, based on their simulation results, the BRI has a positive impact on trade in various levels and geographic locations. Yang et al. (2020) applied the Global Trade Analysis Project model and data between 2010 and 2020 to forecast the effect of infrastructure investment along the BRI, driving increased total factor productivity and reduced trade costs on economic growth and welfare via three scenarios when BRI and other financing sources fulfilled different levels of infrastructure investment gap in Asia. They utilized data from 199 countries and regions between 1970 and 2014 and concluded that infrastructure investment positively impacts total factor productivity. Moreover, they estimated the relationship between trade cost and infrastructure investment by classified countries of landlock countries and coastal countries, and they found that increased infrastructure investment has a negative impact on trade cost. Then, their simulation analysis concluded that with three different levels of infrastructure investment along BRI, most countries and regions benefit from economic growth and welfare, especially those in Southeast Asia. Herrero & Xu (2017) also stimulated three scenarios: transportation costs were reduced to various degrees; free trade areas were established along BRI countries; and both previous scenarios happened together and identified top beneficial countries and regions under those scenarios. They concluded that the BRI would reduce transportation costs through the railroad and ocean and would benefit EU countries, especially landlocked countries. On the other hand, by establishing a free trade zone, Asian countries, not EU countries, obtain more trade benefits. However, they did not examine the direct impact of the BRI on trade. Lall & Lebrand (2020) applied the CGE model and found that BRI transportation investment benefits the development of larger urban areas near trade centers, while people in more distant areas tend to suffer in central Asia and China.

More generally, previous studies have shown that infrastructure development promotes trade. Francois & Manchin (2013) employed Heckman selection model-based gravity estimation and found that higher developed infrastructure and better institutional quality are determinants of both export level and the likelihood of export occurring, which has more impact than variations in tariffs. Thus, they implied that the impact of the development level of the facility of trade was underestimated in the past and might be more important than policies involved in developing market access. Celbis et al. (2014) examined the effects of infrastructure on trade, mainly focusing on transportation and communication, by applying quantified meta-analysis including 36 primary studies and 542 infrastructure elasticities of trade and found that every one percent increase in own infrastructure would increase exports by 0.6 percent and imports by 0.3 percent. Donaubauer et al. (2018) studied infrastructure's impact on trade among 150 countries and regions between 1992 and 2011 by utilizing a new measure of infrastructure. They concluded that improved infrastructure has a positive impact on bilateral trade relative to domestic trade and promotes multilateral trade. Vijil & Wagner (2012) found that infrastructure aid indeed encourages exports.

2.2.3 Sector-Level Trade and the BRI

After China launched the BRI, considerable literature has studied many dimensions of China's international trade patterns and relationships. Recognizing that the BRI may generate heterogeneous impacts across sectors, the following discussion considers literature that examined the impact of the BRI on sector-level trade.

2.2.3.1 BRI and Trade of Agricultural Products

Regarding agricultural products, China has primarily imported soybeans, corn, meat products, and cotton over the last two decades (FAO, 2022). Soybean and corn are used in food, animal feed, and edible oil, while meat products and cotton complement China's domestic production and consumption needs. On the other hand, China's major exports include animal products such as fish and seafood, beverages and oils, and vegetable commodities (Brodzicki, 2020). According to the International Trade and Production Database for Estimation (Borchert et al., 2021, 2022b), among BRI countries, Argentina[2], Russia, Thailand, Chile, Indonesia, Malaysia, South Korea, and Vietnam are significant agricultural trading partners with China. Major agricultural trade partners outside BRI countries include Brazil, the United States, Australia, Canada, Japan, and Germany.

Studies have examined several dimensions of the trade of agricultural products between China and BRI countries. Chen et al. (2021) estimated the agricultural environment among six BRI countries in the Black Sea region and ranked them from the most appropriate to the least appropriate for China to make investments. Dang & Pang (2020) applied CGE models and simulated several scenarios about border effects impact on agricultural trade between China and BRI countries and found that the BRI is one of the determinants of decreased trade barriers and promotes agricultural product trade between China and BRI countries. There are some event studies involving agricultural trade among BRI countries. Li et al. (2018) studied the spatial pattern of agricultural resources, the advantages and disadvantages of agricultural development in BRI countries such as Russia, Mongolia, Tajikistan, and Kyrgyzstan, and the trade between China and BRI countries. They found that countries in the BRI have significant agricultural bilateral trade with China, with Russia being the largest partner. Russia primarily exports aquatic and resource-intensive products to China while importing labor-intensive products like fruits and vegetables. Their findings also suggested that China and BRI countries should cooperate in the agricultural industry using different strategies, leveraging their respective advantages. Yang & Du (2023) used a gravity model to analyze the impact of national standards on agricultural trade between China and BRI countries. They found that both mandatory and voluntary standards, particularly country-specific ones, significantly boost trade. They suggested that China and BRI countries should enhance their cooperation and adopt international standards. Using computable general equilibrium models and estimation scenarios, Zhang et al. (2022) found that the BRI reduced tariff and non-tariff barriers between China and BRI countries and improved the position in global value chains of agriculture products for both China and BRI countries. Zhou et al. (2022) studied the fluctuations in agricultural product trade between China and BRI countries. They found that

[2] Argentina signed the BRI MoU with China in 2023.

demand effects are a major negative factor in the fluctuations of China's exports but a positive factor in BRI countries' overall agricultural exports.

The following literature focused on China and BRI countries' trade of virtual water and CO_2 emissions embedded in agricultural products. Qian et al. (2019) studied the agricultural products related to virtual water trade between China and BRI countries, revealing China's shift from net virtual water exporter to importer, with Southeastern and Southern Asia as key exporters. Key findings highlight the impact of trade structure and domestic production on virtual water exports, indicating inefficiencies in freshwater use and offering policy recommendations for sustainable trade practices. Wei et al. (2022) studied virtual water trade between China and BRI countries via analysis of crop trade. They found green virtual water dominated the trade among 64 countries, with China maintaining a trade surplus. Zhang et al. (2018) also studied virtual water trade between China and BRI countries. They found that more than 40 countries take advantage of agricultural trade with China and alleviate their water shortage issue. Hu et al. (2021) studied the impact of China's agricultural exports and imports as supply and demand shocks, respectively, on the CO_2 emissions of BRI countries and concluded that the shocks reduced the CO_2 emissions. Hafeez et al. (2020) noted that agriculture accounts for 21% of global CO_2 emissions, with BRI countries contributing 40% of their GDP from agriculture. They emphasized that agriculture and energy demand lead to environmental degradation, suggesting that using forests and environmentally friendly, sustainable renewable energy sources can effectively offset some environmental degradation caused by agricultural and resource demands

Other studies, such as He et al. (2016) and Wang et al. (2023), examined the complementarity and competition of agricultural products between China and BRI countries. These authors found that although there was competition, the complementarity was relatively significant, and the BRI promoted high-quality agricultural exports from BRI countries. Wang et al. (2018) studied agricultural product trade between China and BRI countries, identified the main determinants of the trade, and found both competitive and complementarity in agricultural trade between China and these countries. Strengthening trade cooperation and enriching agricultural collaboration within existing multilateral frameworks are recommended for mutual benefits and development. Zhou & Tong (2022) studied the competitiveness and other determinants of impact on agricultural trade between China and BRI countries and found significant regional disparities:

Central and Southeast Asia, South Asia, and Central and Eastern Europe exhibit high competitiveness, while China, Central Asia, Mongolia, Russia, and West Asia and the Middle East are less competitive. Zhang & Sun (2022) studied the comparative advantage of agriculture products of China and BRI countries and found that the present comparative advantage of most BRI countries is higher than that of China and suggested that BRI countries can play a more critical role in global food security.

2.2.3.2 BRI and Trade of Mining and Energy Sectors

China is one of the largest global mining and energy market importers. China imports crude petroleum, petroleum gas, iron, and copper from BRI countries - Russia, Angola, Iraq, Oman, and Iran, and countries outside the BRI - Australia, Saudi Arabia, and Brazil. China exports mineral fuels, mineral oils, iron, steel, and slag and ash ores to BRI countries - South Korea, Malaysia, Indonesia, Vietnam and countries outside of BRI - Japan, India, United States, Germany based on BACI: International Trade Database at the Product-Level (the 1994-2007 Version) (Gaulier & Zignago, 2010).

Two studies have explored aspects of the impact of the BRI on mining and energy sector trade and the BRI. Fu et al. (2021) applied a multi-region input-output model and network analysis to evaluate the intermediate and final energy trade flows among BRI countries between 2000 and 2015. They found that China is a leading net importer in intermediate energy trade but a net exporter in final energy trade, while Russia plays the opposite role. Li et al. (2021) studied the natural gas trade between 1992 and 2016 and forecast the future performance of the natural gas trade among BRI countries in 2030. They found that the development of liquefied natural gas trade is growing fast, and the pipeline natural gas trade is relatively stable in BRI countries. Furthermore, the liquefied and pipeline natural gas trade network has become more compact along BRI countries.

2.2.3.3 BRI and Trade of Manufacturing and Services Sectors

In the manufacturing sector, China imports manufactured goods such as integrated circuits and specialized machinery from South Korea, Japan, the United States, and Australia. It primarily exports broadcasting equipment and computers to the United States, Japan, and Germany (Gaulier & Zignago, 2010). In the services sector, China mainly imports intellectual property, education, financial services, and consultancy services from the United States, Japan, and Australia. Conversely, it exports IT and digital services and transport services to the United States and

European countries (ITPD-E-R02; Borchert et al., 2021, 2022b). Notably, the principal trade partners listed are all non-BRI countries.

Several studies have considered the impact of the BRI on the trade of manufactured products and services. Le et al. (2019) conducted interviews with 54 leaders and officials from Vietnam's public and private sectors. They identified that the BRI has had a positive impact on Vietnam's textile and garment industry and exports, as well as on the improvement of infrastructure. However, they also noted that Vietnam's textile and garment industry is not a strong competitive player in the global market. Luo et al. (2018) applied the export similarity index model to analyze the competition level between Guangzhou (a province in China) and 65 BRI countries. They found that Guangzhou, while a top-tier exporter, faces challenges due to its over-dependence on the manufacturing sector. It is gradually losing the low-cost manufacturing market to ASEAN and South Asian countries, suggesting a need to re-design its trade and investment policy. Pomfret (2019) found that the new railroads between China and Europe opened between 2011 and 2017 provided traders and exporters with a cheaper and more predictable shipping option along those routes, compared with air freight and ocean freight. The rail freight option attracted more traders, connected more shipping destinations, and incentivized the shipping service. Pechlaner et al. (2021) investigated the regional impact of the BRI on local service industry development in specified case studies in Georgia. They found that the key drivers or factors of the transfer of the BRI infrastructure investment to trade that are beneficial in the local service industry and tourism development are knowledge, business, and governance. Cieślik (2020) found that the BRI involved Chinese information and communication technology services' value-added transfer to and increased the manufacturing sector gross exports of BRI countries in Central Asia as well as Central and Eastern Europe.

2.3 Methodology and Data

This section provides a detailed overview of the structural gravity model, estimations, data sources, and data summary.

2.3.1 Methodology

Tinbergen (1962) was the first to apply the gravity model, adapted from Newton's Law of Universal Gravitation, to analyze international trade flows. The gravity model posits that trade flows between countries are positively related to the trading partners' economic size, usually measured by gross domestic product (GDP), and negatively related to their geographic distance. Larger economic size indicates greater resources, higher production capacity, and increased demand for goods and services, which in turn lead to a higher volume of trade. Conversely, geographic distance represents transportation costs and physical trade barriers. Greater distances are associated with higher trade costs, typically reducing trade volumes.

The first theoretical economics gravity equation was formulated by Anderson (1979). This model relied on two critical assumptions: product differentiation due to geographical origin and the application of the Constant Elasticity of Substitution (CES) expenditures model. Product differentiation by geographical origin refers to similar products not being perfectly substituted by each other because their country of origin influences their value. For example, coffee of the same grade might trade at different prices depending on whether it comes from Ethiopia or Colombia, reflecting consumer preferences based on origin. The CES expenditure model assumes that consumers derive utility from consuming a variety of goods, even if those goods are similar. This implies that even a small difference in price or quality between similar goods from different origins can lead to significant changes in trade flows. Building on Anderson's (1979) foundational work, which incorporated the CES framework, Anderson & Van Wincoop (2003) refined the structural gravity model, while Eaton & Kortum (2002) extended this approach within a Ricardian structure.

The current analysis employs the gravity equation described by many authors, including Anderson & Van Wincoop (2003) and Yotov et al. (2016), which is as follows:

$$X_{ij,t}^{k} = \frac{Y_{i,t}^{k} E_{j,t}^{k}}{Y_{t}^{k}} \left(\frac{t_{ij,t}^{k}}{\Pi_{i,t}^{k} \mathrm{P}_{j,t}^{k}} \right)^{1-\sigma_k} \tag{2.1}$$

Where $X_{ij,t}^{k}$ indicates the value of trade from the exporting (origin) country *i* to the importing (destination) country *j* at time *t* for industry *k* products. Y_{it}^{k} denotes the domestic production of exporting country *i* and E_{jt}^{k} indicates the domestic expenditure of importing country *j* for industry *k* at time *t*. Y_{t}^{k} indicates the world's total production of goods in industry *k* at time *t*, and t_{ijt}^{k} represents the trade cost between country *i* and country *j* at time *t* for industry *k*. Π_{it}^{k} and P_{jt}^{k} denote the outward and inward multilateral resistance terms, respectively; these measures capture transaction costs of country *i* (or *j*) to all trade partners *j* (or *i*) at time *t* for industry *k*.

In this analysis, equation (2.1) is operationalized using the following estimating equation:

$$X_{i,j,t}^{s} = \exp\left[\beta_1^s BRI_{(i),(j),t} + \beta_2^s International_{i,j,t} + \beta_3^s Distance_{i,j,t} + \beta_4^s International_{i,j,t} * Distance_{i,j,t} + \beta_5^s FTA_{i,j,t} + \sum_{n=6}^{8} \beta_n^s \, GRAV_{i,j,t} + \pi_{i,t}^{s} + \mu_{j,t}^{s} + \epsilon_{i,j,t}^{s}\right] \tag{2.2}$$

where t indicates the year between 2006 and 2019, and s represents sectors including aggregated sector and disaggregated sectors such as agriculture, forestry and fishing, mining and energy, manufacturing, and services. *BRI* reflects eight alternative dummy variables that denote importer and/or exporter participation in the BRI. Each analysis only includes one of these dummy variables to estimate the effects of BRI under different membership statuses. The examples of dummy variables are defined as follows: *BRI (At Least One)* denotes at least one trade partners signed BRI MoUs with China. *One BRI (Only)* indicates that only one of the trade partners has signed BRI MoUs with China. Since both the exporter and importer are crucial, we utilize various dummy variables and their combination to identify the BRI status for exporting and importing countries in our analysis. Two dummy variables, *EXBRI* and *IMBRI*, identify the BRI participants of exporting and importing countries. *BOTHBRI* indicates that both trade partners have signed the BRI MoUs with China.

To address the identification issue regarding the potential effect of trade policy on both international and domestic trade, we follow the approach of previous literature: Beverelli et al. (2023), Borchert et al. (2022), Heid et al. (2021) and Yotov et al. (2016) by including trade flows covering both international and intra-national trade in our analysis. $International$ is a dummy variable equal to 1 if the trade partners differ, indicating international trade flows. Otherwise, it equals 0, denoting domestic (intra-national) flows. This allows us to examine the BRI's effects on international and domestic trade, which is consistent with previous research.

Furthermore, importer-time and exporter-time fixed effects ($\pi_{i,t,}$, $\mu_{j,t}$) represents the unobserved multilateral resistance terms $\Pi_{i,t}^{s}$ and $P_{j,t}^{s}$ (Olivero & Yotov, 2012). These fixed effects address identification issues related to country-specific heterogeneity, such as economic size and production variables ($Y_{i,t}^{s}, E_{j,t}^{s}$) in the gravity equation, as well as other country-specific characteristic variables including exchange rate, inflation rate, national policies, quality of institutions, and more. For aggregated sectors, we employed importer-time-sector and exporter-time-sector fixed effects to capture the unobserved country- and sector- characteristics, such as impact of country-specific policies on particular industries. Additionally, applying country-paired fixed effects in the baseline analysis would prevent the estimation of traditional gravity variables. Therefore, we have decided not to include country-pair fixed effects in this analysis.

$Distance$ is the logarithm of the distance between the exporting country and the importing country, $International * Distance$ represents the interaction term between international and logarithm of the distance between the exporting country and the importing country. FTA indicates a dummy variable equal to 1 if the exporting country and the importing country has an active free trade agreement. $\sum_{n=6}^{8} \beta_n^s \, GRAV_{ijt}$ indicates a set of traditional gravity model variables, including: (1) A dummy variable, *Contiguity*, equals to 1 if the exporting country *i* and the importing country *j* shares border; (2) A dummy variable, *Common Language*, equals to 1 if the exporting country *i* and the importing country *j* shared at least a same language; and (3) A dummy variable, *Colonial Relationship*, equals to 1 if the exporting country *i* and the importing country *j* ever in a colonial relationship.

Alternative model specifications, based on Equation (2.3), explore the combined impact of development status and BRI membership on international trade. This approach is inspired by the framework of Grant & Boys (2012), which analyzed the effects of development status and WTO membership on trade flows.

$$X_{i,j,t}^s = \exp\left[\beta_1^s Exporter(Importer)DevelopmentStatus_{(i),(j),t} * International_{i,j,t} + \beta_2^s FTA_{i,j,t} + \pi_{(i),(j),t}^s + \mu_{i,j}^s + \epsilon_{i,j,t}^s\right] \tag{2.3}$$

To estimate the impact of development status and BRI membership on trade, we applied four sets of combinations of dummy variables for exporters and importers. The first set focuses on development status. Exporters and importers are categorized as high-income countries (HIC), middle-income countries (MIC), or low-income countries (LIC). The second set incorporates the development status of one side of the trading partners' BRI membership. Exporters (or importers) are classified as HIC and BRI, MIC and BRI, or LICs and BRI. The third set includes the development status of one side of the trade partners with an interaction term based on the BRI or non-BRI membership of the other side. For example, the exporter is an HIC, and the importer is either a BRI or non-BRI country. Lastly, the fourth set represents both trading partners' development status and BRI membership. For instance, the exporter is an HIC and a BRI member, and the importer is either an HIC and a BRI member or an HIC and a non-BRI member.

To address the identification issue regarding country-specific characteristic variables, we the same employed exporter-time and importer-time fixed effects in estimations, as in baseline models. Additionally, we apply country-pair fixed effects in our analysis to control time-invariant variables, such as, geographical distance, shared borders, historical trade relationships, as well as to mitigate the endogeneity issues associated with bilateral trade policies, following Agnosteva et al. (2014). Consequently, only the Free Trade Agreement (FTA) variable remains interpretable in this context. Given that our objective is to estimate the combined effects of BRI membership and a country's development status on international trade, we included interaction terms between development status variables and international trade. This allows us to assess the impact of both development status and BRI membership on international, rather than intra-national, trade.

Alternative models consider the BRI membership of trading partners to analyze the effect of the BRI on trade creation and diversion. This approach follows a methodology similar to that used by Yang & Martinez-Zarzoso (2014), who applied a comparable model to estimate the effects of the ASEAN–China Free Trade Area on trade creation and diversion.

$$X_{i,j,t}^{s} = \exp\big[\beta_1^s BothBRI_{i,j,t} * International_{i,j,t} + \beta_2^s OnlyExporterBRI_{i,j,t} * International_{i,j,t} + \beta_3^s OnlyImporterBRI_{i,j,t} * International_{i,j,t} + \pi_{i,t}^s + \tau_{i,t}^s + \mu_{i,j}^s + \epsilon_{i,j,t}^s\big] \quad (2.4)$$

where *BothBRI* is a dummy variable equal to 1 if both the exporter and importer signed BRI MoUs with China. *OnlyExporterBRI*, the dummy variable, is equal to 1 if only the exporting country has BRI membership. The dummy variable, *OnlyImporterBRI*, is equal to 1 if only the importing country is a BRI member. The interaction terms of those variables with international trade were included to examine trade creation and diversion in international trade rather than intra-national trade.

Trade creation and diversion involve both export and import effects, which may differ in sign and magnitude. For instance, when $\beta_1 > 0$ and $\beta_2 > 0$, indicates pure trade creation, where exports from BRI countries to non-BRI countries increase. when $\beta_1 > 0$, $\beta_2 < 0$, and $\beta_1 > \beta_2$, trade creation exists despite negative export diversion. Conversely, when $\beta_1 > 0$, $\beta_2 < 0$, and $\beta_1 < \beta_2$, BRI countries experience a net loss in exports. Similarly, when $\beta_1 > 0$ and $\beta_3 < 0$, it denotes reduced import diversion, meaning BRI countries import less from non-BRI countries despite trade creation. These interpretations align with the frameworks established by Yang &

Martinez-Zarzoso (2014), Martínez-Zarzoso et al. (2009) and Soloaga & Alan Wintersb (2001), which offer methods for understanding trade creation and diversion effects under regional agreements.

We employ the Poisson pseudo maximum likelihood (PPML) to estimate the gravity equations (2), (3), and (4). For several reasons, we prefer the PPML estimator over the Ordinary Least-Squares (OLS) estimator. First, PPML effectively addresses the zero trade flow problem without necessitating modifications to the trade data. Second, the PPML estimator can also handle the heteroscedasticity issue that arises from log-linear OLS estimations (Silva & Tenreyro, 2006). In contrast to OLS, which assumes homoscedasticity (constant variance of residuals), the PPML estimator relaxes this assumption, making it more robust to non-constant variance in residuals.

2.3.2 Data Description

This study analyzes the impact of the BRI using trade using data from 2006 to 2019. This timeframe includes several years leading up to the launch of the BRI in 2013. Furthermore, to avoid any disruptions caused by the COVID-19 pandemic in 2020, the analysis will conclude in 2019.

This study investigates four sectors, including agriculture, forestry and fishing, mining and energy, manufacturing and services. We chose to use aggregated sectors instead of more disaggregated ones due to the scale of BRI. The introduction mentions that the BRI is a macroeconomic and geopolitical initiative aimed at large-scale infrastructure and investment across nations. By focusing on broader sectors, we can better capture the spillover effects induced by the BRI. Additionally, this study covers most countries globally, which poses challenges in obtaining accurate data on international and intra-national trade flows across more disaggregated sectors. To avoid underestimating or overestimating the effects of the BRI, we decided to work with more aggregated sectors.

International trade data

Trade flows data is obtained from the International Trade and Production Database for Estimation - Release 2 (ITPD-E-R02; Borchert et al., 2021, 2022b). This dataset covers over 265 countries across 170 industries, classified by ITPD-E industry codes[3] between 1986 and 2019. It was selected over more commonly used trade data sources, such as BACI (Gaulier & Zignago, 2010), because it incorporates additional intra-national trade flows and provides data for the services sector. A detailed comparison of these datasets is presented in **Appendix J**. Detailed ITPD-E industry classifications used in this paper are provided in **Appendix K**. The trade data from the International Monetary Fund's Direction of Trade Statistics (as used by Fotak et al. (2022)), was not selected for this study because it only contains aggregated national-level data. This limitation prevents the examination of the Belt and Road Initiative's (BRI) effects on disaggregated sectors, which is a key focus of this research.

Trade flows data from the ITPD-E-R02 dataset (2006-2019) reveals a significant presence of zero trade flows across sectors, shown as **Table 2.1**, with 28.9% in aggregated industries, 43.5% in agriculture, forestry, and fishing, 50.1% in mining and energy, 29.6% in manufacturing, and 28.6% in services. To address the estimation challenges posed by these zeros, we applied the PPML estimator. However, distinguishing between "true" zeros (countries that occasionally trade) and "false" zeros (countries that never trade) is crucial to avoid biased results. We established a 15% threshold over 14 years to filter out "false" zeros, retaining only zeros deemed "true." More detailed processes are presented in **Appendix L**. After this adjustment, the proportion of zeros decreased across sectors, with aggregated industries at 21.5%, agriculture, forestry, and fishing at 28.7%, mining and energy at 33.5%, manufacturing at 22.2%, and services at 24.6%.

[Insert **Table 2.1** here]

Other data

Information regarding country participation in the BRI was sourced from the Belt and Road portal (Belt and Road Portal, n.d.).[4] The BRI was launched in 2013, and as of 2019, 136 countries have signed the BRI MoUs with China.

[3] There are concordances between ITPD-E industry codes and other industry classification systems, such as the FAOSTAT Commodity List (FCL) and the International Standard Industrial Classification of All Economic Activities (ISIC). Both ITPD-E industry codes and Harmonized System (HS) codes are used to classify products for international trade. While ITPD-E industry codes represent broader industry categories, such as agriculture and manufacturing, HS codes classify products at a more detailed, disaggregated level within these broader categories. Despite this difference in granularity, ITPD-E industry codes can be mapped to HS codes at a broader, aggregated industry level.
[4] The Green Finance and Development Center (Nedopil, 2022) provides an alternative source for tracking BRI participation. However, previous studies, such as Zhang et al. (2022), have primarily utilized data from the Belt and Road Portal. Therefore, our analysis aligns with the same data source.

Traditional gravity model variables, including *Distance, Contiguity, Common Language, Colonial Relationship*, and *Free Trade Agreement*, are sourced from the Dynamic Gravity Dataset (DGD) (Gurevich & Herman, 2018), which covers over 280 countries between 1948 and 2019.

Distance, measured in kilometers, represents the population-weighted distance between exporting and importing countries. The same method was applied to calculate domestic distances. For countries with only one major city, such as Andorra and Qatar, the intra-national trade distance is set to 1. Gurevich & Herman (2018) compared this approach to the distance metrics provided by the CEPII dataset and found that the mean difference in distance between country pairs was only 4.4 kilometers.

The development status of countries is classified into high-income, upper middle-income, lower middle-income, and low-income categories, based on the World Bank (2024) classification. For this analysis, upper and lower middle-income countries are grouped together as middle-income countries. It is important to note that a country's income level is dynamic, with classifications potentially varying over the analyzed time period.

2.3.3 Descriptive Statistics

The dataset developed for this analysis covers the period from 2006 to 2029 and reflects the trade flows of 242 importing and 243 exporting countries. The number of countries signed BRI MoUs with China between 2013 and 2022 fluctuated (see **Figure 2.1**). In 2018, 65 countries joined BRI membership, while only one joined BRI in 2020. From 2013, the exports and imports between China and BRI countries increased along with the number of BRI countries, but they have a similar growth trend to the trade between China and the world (see **Figure 2.4**). Then, we want to see the trade flows trend without the increasing number of BRI countries. Therefore, in Figure 5, we selected 17 countries that joined BRI in 2015 as a sample of BRI countries to show the difference in trade flows pre- and post-joining the BRI. These countries were compared with non-BRI countries that did not join BRI until 2023. Based on Panels A and B in **Figure 2.5**, the trade value between BRI countries is smaller than between BRI countries and non-BRI countries. However, exports and imports among BRI countries exhibited a more substantial percentage change (increase rate) after 2017 compared to trade between BRI countries and non-BRI countries. Although China's overall exports and imports value of both types of countries increased from 2011 to 2019, Panels C and D show an opposite lower percentage change (increase rate) of export and import between China and BRI countries than between China and non-BRI countries after 2015.

[Insert **Figure 2.4** here]

[Insert **Figure 2.5** here]

Table 2.2 summarizes the statistics for the aggregated industries sector and four disaggregated sectors over 14 years. The average aggregated trade is 1.1 billion USD, with a standard deviation of approximately 72.3 billion USD, suggesting significant variability and potential outliers due to countries with exceptionally high or low trade flows.

[Insert **Table 2.2** here]

Among the four disaggregated sectors, the agriculture, forestry, and fishing sector has the lowest average trade flows, while the services sector has the highest. All sectors exhibit large standard deviations, indicating considerable variation in trade flows across partners. The number of observations shows that more countries participate in the manufacturing sector while fewer engage in the services sector.

In the aggregated sector, the mean of *Both BRI* is 0.068, indicating that 6.8% of trade occurs between BRI countries. The mean of *BRI (At Least One)* is 0.209, showing that 20.9% of trade involves at least one BRI participation.

The mean of *International* is around 0.99, indicating that most trade data represent international transactions. The services and mining and energy sectors have relatively lower mean *Distances* (5,949 km and 6,511 km, respectively), suggesting these sectors are more geographically constrained. The *Common Language* variable has a lower mean of 0.276 in the service sector, meaning only 27.6% of trade occurs between countries with a common language. The mining and energy sector (0.24) and services sector (0.35) also show relatively higher means for the *Free Trade Agreement* variable, indicating a higher percentage of trade under free trade agreements.

Table 2.3 presents the development status of countries and their BRI participation as exporters and importers across sectors. Fewer countries participate in the services sector, with particularly low participation among middle-income and low-income countries compared to other sectors. Among high-income countries, non-BRI countries outnumber BRI countries by 6 to 8 in all sectors, except in the services sector, where non-BRI countries are two fewer than BRI countries. For middle-income countries, approximately 80% of participants are BRI countries across all sectors. Among low-income countries, 65% of participants are BRI countries in all sectors, except in the services sector, where only 1 out of 3 participating countries is a BRI member.

[Insert **Table 2.3** here]

Lastly, we assessed the potential issue of multicollinearity using the Pearson correlation coefficient. The coefficients for the aggregated industries and the four disaggregated sectors, detailed in **Appendix M**, are not close to 1 or -1, suggesting that multicollinearity is unlikely to confound our model.

2.4 Results and Discussion

This section presents our empirical results. Subsection 2.4.1.1 examines the results of the PPML estimation of Equation (2), focusing on the impact of various BRI combinations on trade across both aggregated and disaggregated sectors. Subsection 2.4.1.2 presents the results of the PPML estimation of Equation (3), analyzing the effects of a country's development status and BRI participation on international trade for aggregated and disaggregated sectors. Subsection 2.4.1.3 discusses the intensive and extensive margin of trade. Subsection 2.4.1.4 explores the results of the PPML estimation of Equation (4), evaluating the BRI's role in international trade creation and diversion across both aggregated and disaggregated sectors.

2.4.1 Empirical Results

2.4.1.1 Baseline Results

This subsection examines the results of the PPML estimation of Equation (2), which assesses the impact of various BRI combinations on trade flows. The analysis spans both aggregated and disaggregated sectors, such as agriculture, forestry and fishing, mining and energy, manufacturing, and services.

Table 2.4 highlights the baseline results of BRI's impacts on both aggregated and disaggregated sectors, focusing only on statistically significant results with either positive or negative signs. In general, the effects of BRI vary across sectors depending on the roles of countries, such as whether they are exporters or importers, and whether they are BRI members or non-members. Briefly, the BRI positively impacts trade between BRI countries and non-BRI countries, as well as trade among BRI countries other than China, across all sectors. In the agriculture, forestry, and fishing sector, BRI has a positive impact on BRI countries' imports from non-BRI countries and trade among BRI countries other than China. Similarly, in the mining and energy sector, BRI positively affects BRI countries' imports from non-BRI countries and trade among BRI countries other than China. In the manufacturing sector, BRI promotes trade between BRI and non-BRI countries, as well as trade between BRI countries. However, in the service sector, BRI negatively impacts trade between BRI and non-BRI countries while having a positive effect on trade among BRI countries. The detailed magnitudes of the impacts of BRI and traditional gravity variables can be found in the following five tables.

[Insert **Table 2.4** here]

The results in **Table 2.5** demonstrate the effect of various BRI combinations and other variables on trade. The variable *BRI (At Least One)* in column (1) indicates that at least one of the trade partners is a BRI member. The coefficient, 0.36, is positive and statistically significant, suggesting that trade involving at least one BRI member is, on average, 43.3% higher than trade among non-BRI countries. This increase is calculated using the formula (exp (0.36) - 1) * 100). *One BRI (Only)* variable in column (2) indicates that only one country in the paired trade partners has signed the BRI MoU with China. The result of *One BRI (Only)* represents the average impact of trade exclusively between BRI countries and non-BRI countries, compared to trade between non-BRI countries and trade only between BRI countries. The coefficient of 0.18 is both positive and statistically significant. This suggests that trade between BRI and non-BRI countries is, on average, 19.7% higher compared to trade only between BRI countries and only between non-BRI countries.

[Insert **Table 2.5** here]

Importer BRI indicates that the importer has signed the BRI MoUs with China and trades with all types of countries. Therefore, it specifically analyzes the effects of the BRI on importers. Since the coefficient result in column (4) is statistically significant and negative, it indicates that when BRI countries act as importers, it has a negative impact on trade flows. On average, BRI countries, when acting as importers, experience trade flows that are 18.9% lower compared to non-BRI countries when they act as importers in the aggregated industries sector.

The *Both BRI* variable denotes that both paired trade partners have signed the BRI MoUs with China. The coefficient in Column (5) is significantly negative, indicating that aggregated trade among BRI countries is 30.2% lower compared to trade among non-BRI countries or trade where only one of the trade partners is a BRI country.

Both BRI (China is Excluded) denote cases where BRI countries, excluding China, serve as importers and exporters. The variables Both BRI (China is Exporter) represent case where China is the sole exporter to BRI countries. The coefficient in columns (6) and (7) show a positive statistically significant effect, indicating that trade among BRI countries (China excluded) is 39.1% larger than trade between non-BRI countries and BRI countries, between China and other countries, and among non-BRI countries and China export 134.0% more to BRI countries than non-BRI countries.

The results for the international variable across all columns are statistically significant and negative, consistent with the findings of Beverelli et al. (2023). This suggests that international trade is more challenging than intra-national trade due to the presence of both tariff and non-tariff barriers, which can hinder the movement of goods and services across borders. While WTO membership variables were included in the initial analysis, they were omitted from the final results due to collinearity issues.

Half of the results for the *Distance* variable are statistically significant and exhibit a negative sign, which aligns with our expectations. However, columns (3), (4), (7), and (8) show statistically significant positive results, likely due to intra-national trade within large countries, such as China and the United States. To specifically assess the impact of distance on international trade, we introduced the *Distance* and *International* interaction term. In this case, all results are consistently negative and statistically significant, confirming our initial expectations. Additionally, the results for the *Free Trade Agreement*, *Contiguity*, *Common Language*, and *Colonial Relationship* are consistent with our expectations, as all these factors positively impact trade flows.

The results in **Table 2.6** show the effects of various BRI combinations and other control variables on trade in the agriculture, forestry, and fishing sector between paired countries. In column (4), the coefficient for *Importer BRI* is significant and positive, indicating that the BRI countries, as importers, on average import 122.6% more products in the agriculture, forestry and fishing sector than non-BRI importers. The coefficient of *Both BRI* (China is excluded) is positive and significant, denoting that agricultural, forestry and fishing trade among BRI countries other than China is 82.2% higher than trade between non-BRI countries, between BRI and non-BRI countries, and between China and other countries. The coefficient for *Both BRI (China is exporter)* and *Both BRI (China is importer)* in columns (7) and (8) shows positively significant results indicating that China exports 101.4% more agricultural products to BRI countries than outside BRI countries and imports 927.8% more products from BRI countries than non-BRI countries, respectively. Other BRI combination variables did not yield significant results. The results in control variables are either consistent with the previous aggregated trade flows results or insignificant.

[Insert **Table 2.6** here]

Table 2.7 presents the results of the impact of BRI combinations and control variables on trade in the mining and energy sector. The coefficients for *Importer BRI* in column (4), *Both BRI (China is Excluded)* in column (6), and *Both BRI (China is Importer)* in column (8) show significant and positive effects on trade flows. When a BRI country is an importer, it imports 52.2% more mining and energy products, on average, than non-BRI countries. Trade among BRI countries, excluding China, is 107.5% higher than between non-BRI countries and between BRI and non-BRI countries. Additionally, China imports 3,244.8% more mining and energy products from BRI countries than non-BRI countries.

The results for the other BRI-related variables are not significant. The control variables either show results consistent with the previous two tables or are insignificant. Notably, the coefficients for *Common Language* in columns (4) and (8) show a negative effect on mining and energy trade, which can be explained by the fact that China does not share a common language with most other countries.

[Insert **Table 2.7** here]

As shown in **Table 2.8**, the results demonstrate the impact of BRI combinations and control variables on trade flows in the manufacturing sector. The coefficients for *One BRI (Only)* in column (2), *Both BRI* in column (5), and *Both BRI (China is exporter)* in column (7) show significant and positive effects on trade flows. On average, trade between BRI and non-BRI countries is 76.8% higher than trade only among BRI countries and only within non-BRI countries.

Trade among BRI countries is 390.4% more than between non-BRI countries and between BRI countries and non-BRI countries. Additionally, China exports 31.0% more manufacturing products to BRI countries than non-BRI countries.

The remaining BRI combination variables do not show significant results. Except for the International variable, the control variables' results are consistent with those observed in the previous sectors, suggesting that, on average, more manufacturing goods are exported than consumed domestically. However, the interaction term between International and Distance is negative and significant, aligning with our expectations.

[Insert **Table 2.8** here]

For the service sector, the results in **Table 2.9** show the impact of BRI combinations and control variables on trade. The coefficients for *BRI (At Least One)* in column (1), *One BRI (Only)* in column (2), *Exporter BRI* in column (3), and *Importer BRI* in column (4) are significant and negative. Trade involving BRI countries is 60.9% less than trade solely between non-BRI countries. When BRI countries serve as only one of the trade partners in the service sector, trade flows are 37.5% lower than when both partners are either BRI or non-BRI countries. Trade flows with BRI countries as exporters and importers are 56.4% and 58.1% lower, respectively, compared to non-BRI countries.

Conversely, the coefficients for *Both BRI* in column (5), *Both BRI (China is Excluded)* in column (6), *Both BRI (China is Exporter)* in column (7), and *Both BRI (China is Importer)* in column (8) are significant and positive. On average, trade among BRI countries is 156.0% higher than trade only between non-BRI countries or between BRI and non-BRI countries. Additionally, trade between BRI countries, excluding China, is 209.6% higher than the average trade between non-BRI countries or between BRI and non-BRI countries. BRI countries import 278.1% more and export 313.7% more to and from China than other countries. The results for the control variables align with our expectations.

[Insert **Table 2.9** here]

2.4.1.2 Impact of Development Status and BRI on International Trade for Aggregated and Disaggregated Sectors

This subsection explores the results of the PPML estimation of Equation (3), focusing on the combined effects of a country's development status and BRI participation on international trade. The analysis examines aggregated and disaggregated sectors.

Table 2.10 presents the impact of development status and BRI participation on international trade for aggregated sectors. In column (1), *Exp. is HIC and Exp. is MIC* indicate that the exporter is a high-income and middle-income country, respectively. Both coefficients are positive and significant, showing that high-income and middle-income countries export 87.8% and 61.6% more, respectively.

From column (2), for aggregated sectors, the development status of BRI countries does not differ significantly from that of non-BRI countries. In column (3), BRI countries with high-income, middle-income, and low-income statuses export 29.7%, 43.3%, and 39.1% more to other BRI countries. Column (4) reveals that middle-income BRI countries export more to both middle-income BRI and non-BRI countries, while high-income BRI countries export 8.3% more to high-income non-BRI countries. However, low-income BRI countries export 37.5% and 66.0% less to low-income BRI and non-BRI countries, respectively. Column (5) shows that high-income and middle-income countries import 71.6% and 50.7% more than low-income countries. In column (6), middle-income and low-income BRI countries are observed to import more overall. Column (7) indicates that BRI countries import more from other BRI countries across all income levels. Finally, column (8) reveals that middle-income BRI countries import more from both BRI and non-BRI countries.

[Insert **Table 2.10** here]

Table 2.11 presents the results of the development status and BRI effects on trade in the agriculture, forestry and fishing sector. From columns (1) to (3), BRI countries across all income levels export more agricultural products to both BRI and non-BRI countries. Column (4) shows that high-income and middle-income BRI countries export more to countries of the same development status, whether BRI or non-BRI. However, low-income BRI countries export less to other low-income BRI countries. The results for importers mirror these findings, with similar patterns observed across income levels and trade partnerships.

[Insert **Table 2.11** here]

Table 2.12 presents the results of development status and BRI effects on trade in the mining and energy sector. In column (2), high-income and middle-income BRI countries export less than their non-BRI counterparts. Column (3) shows that middle-income BRI countries export more to other BRI countries, while all income levels of BRI countries export less to non-BRI countries. Column (5) indicates that high-income and middle-income countries import more mining and energy products. Based on columns (6) and (7), middle-income and low-income BRI countries import more mining and energy products from both BRI and non-BRI countries. In column (8), high-income BRI countries import less from other high-income BRI countries and non-BRI countries. The coefficient for *Free Trade Agreement* is negative and significant in columns (4) and (8).

[Insert **Table 2.12** here]

Table 2.13 presents the results of development status and BRI effects on trade in the manufacturing sector. From columns (1) to (3), high-income and middle-income BRI countries export more to BRI and non-BRI countries, while low-income BRI countries export more manufacturing goods to BRI countries. Column (4) shows that middle-income BRI countries export more manufacturing goods to both middle-income BRI and non-BRI countries, but low-income BRI countries export less to low-income non-BRI countries. From columns (5) to (7), high-income and middle-income BRI countries import more from BRI and non-BRI countries of the same income level, whereas low-income BRI countries import more exclusively from other BRI countries. Column (8) indicates that middle-income BRI countries import more from both BRI and non-BRI countries.

[Insert **Table 2.13** here]

Table 2.14 presents the results of the development status and the BRI effects on services sector trade. From column (1), high-income countries export more services, while low-income BRI countries export fewer services products, as shown in column (2). Column (3) reveals that low-income BRI countries export fewer services to BRI countries. In column (4), high-income BRI countries export less to other high-income BRI countries, whereas middle-income BRI countries export more to middle-income non-BRI countries. From column (6), middle-income BRI countries import more services, but low-income BRI countries import fewer services than non-BRI countries. Column (7) indicates that middle-income BRI countries import more from both BRI and non-BRI countries, whereas low-income BRI countries import less from both groups. Finally, column (8) shows that high-income BRI countries import less from other high-income BRI countries but more from non-BRI countries of the same status, while middle-income BRI countries import less from middle-income non-BRI countries.

[Insert **Table 2.14** here]

2.4.1.3 Intensive / Extensive Margin

The intensive margin of trade refers to the value or volume of goods or services already being traded. It measures the increase or decrease in trade for existing trading relationships or products. On the other hand, the extensive margin of trade pertains to the changes in the number or variety of traded goods or services and new trade relationships. It measures how many new products are introduced into trade or how many new trading partners are established.

We used data for four aggregated sectors, which makes it impossible to examine the impact of extensive margin of trade through new varieties of goods or services. In order to measure the extensive margin of trade through new trading partners, we counted the number of existing trade partners before the launch of the BRI in 2013, as well as the number of new trade partners established afterwards as well as the BRI membership status of these new trade partners.

Table 2.15 displays the unique pairs of trade partners before and after the BRI launch for aggregated trade and across sectors, as well as the BRI membership status of the new trade partners. The number reveals that fewer than 30 new trade partners were established in the agriculture, forestry and fishing, mining and energy, and services sectors. In contrast, the manufacturing sector added 752 new trade partners. However, this only represents about 3% of the existing trade partners. Furthermore, less than 50% of these new trade partners involve BRI countries. Therefore, due to the limited number of new trade partners, we are unable to thoroughly analyze the extensive margin of trade. Our prior baseline results reflect the estimates of the intensive margin of trade.

[Insert **Table 2.15** here]

2.4.1.4 Trade Creation and Trade Diversion

This subsection evaluates the results of the PPML estimation of Equation (3) to analyze the impact of the BRI on trade creation and trade diversion for both aggregated and disaggregated sectors. The analysis investigates how the BRI has influenced trade flows within and between BRI and non-BRI countries, providing insights into the extent of trade expansion facilitated by the initiative.

For aggregated sectors, as shown in **Table 2.16**, the positive and significant coefficients indicate that BRI countries experience both trade creation and positive export and import diversion, resulting in a net trade creation of 149.7% in exports and 101.8% in imports to non-BRI countries. Similar patterns are observed in the agriculture, forestry and fishing sectors, with a total net trade creation of 136.6% exports and 100.2% imports to non-BRI countries. However, in the mining and energy sector, pure negative export and import diversions indicate that BRI countries experience a 24.0% loss in exports and a 15.4% loss in imports to non-BRI countries. In the manufacturing sector, BRI countries show significant trade creation and positive export and import diversion, leading to a total net trade creation of 218.7% in exports and 140.4% in imports to non-BRI countries.

[Insert **Table 2.16** here]

2.4.2 Discussion

Based on the previous results, we can summarize and discuss the impact of the BRI across sectors and types of trade partners, the combined effects of BRI participation and countries' development statuses on international trade, and the influence of the BRI on trade creation and diversion.

The results of *BRI (At Least One)* indicate that BRI countries, on average, trade 43.3% more in aggregated sectors but 60.9% less in the services sector than trade between only non-BRI countries. The results of *One BRI (Only)* indicate that BRI countries trade 19.7% more overall and 76.8% more in the manufacturing sector but 37.5% less in the services sector with non-BRI countries than with other BRI countries. These findings suggest that the BRI has successfully facilitated trade between BRI and non-BRI countries in the aggregate and manufacturing sectors but has had no positive impact on trade in the services sector. BRI countries trade less in the services sector than non-BRI countries. This divergence may be due to the inherently different characteristics of the services sector compared to other sectors. The BRI's focus on infrastructure investments and logistics development has benefited goods trade by reducing transportation costs (Rehman & Noman, 2021; Herrero & Xu, 2017). At the same time, the services sector continues to face distinct regulatory and infrastructural barriers that are less affected by such investments. Our findings also contrast with Fotak et al. (2022), who found that trade between BRI countries and third-party countries (neither BRI nor China) decreased.

The results of *Exporter BRI* indicate that BRI countries export 76.8% more than non-BRI countries in the manufacturing sector, aligning with research done by Li et al. (2022) showing that the BRI would enhance manufacturing export capacity in BRI countries, but less in the service sector. The results of *Importer BRI* indicate that BRI countries import 30.2% less overall than non-BRI countries and 58.1% less in the service sector, but 122.6% more in agriculture, forestry and fishing, and 52.2% more in the mining and energy sector. These findings suggest that the BRI has promoted increased exports of manufacturing goods and higher imports of agricultural, forestry and fishing, and mining and energy products among BRI countries.

The results of *Both BRI* indicate that trade only between BRI countries is 38.7% lower in aggregated compared to trade between non-BRI countries or between BRI and non-BRI countries, but 156.0% higher in the services sector. The results of *Both BRI (China is excluded)* indicate that when China is excluded from the list of BRI countries list, trade between the remaining BRI countries is 82.2% higher in agriculture, forestry and fishing sector, 107.5% more in mining and energy sector, 31.0 more in manufacturing sector, and 209.6 more in service sector than trade between non-BRI countries, between BRI countries and non-BRI countries, or between China and other countries. Overall, our findings suggest that the BRI positively impacts trade among BRI countries (excluding China) across all disaggregated sectors, indicating that the BRI provides a platform for increased interaction among these countries. However, aggregate trade exclusively within BRI countries remains lower than trade between BRI countries and non-BRI countries and only between non-BRI countries.

The results of *Both BRI (China is exporter)* indicate that China trades significantly more with BRI countries compared to non-BRI countries: 101.4% more exports in the agriculture, forestry and fishing sectors, 390.4% more exports in the manufacturing sector, and 278.1% more exports in the services sector. The results of *Both BRI (China is importer)* indicate that China's imports are also substantially higher, with 927.8% more in the agriculture, forestry and fishing sector, 3244.8% more in the mining and energy sector, and 313.7% more in the services sector from BRI countries than from non-BRI countries. Our findings align with previous studies that have identified the BRI's positive impact on trade between China and BRI countries (Fotak et al., 2022) and on the export performance of BRI countries to China (Mao et al., 2019). However, we found that the BRI has a more pronounced positive effect on exports from China to BRI countries in the agriculture, forestry and fishing, and services sectors, and a significant positive effect on China's imports from BRI countries in the agriculture, forestry and fishing, mining and energy, and services sectors.

The results from development status and BRI membership highlight significant disparities in trade performance across income levels and sectors, reflecting the dual influences of economic development and BRI participation. For aggregated sectors, agriculture, forestry and fishing, and manufacturing sectors, BRI countries across three different development statuses export and import more to other BRI countries regardless of a trade partner's development status. Furthermore, when we specified the trade partner's development status, middle-income trading partners generally benefited regardless of their BRI participation. For the mining and energy sector, high-income and middle-income BRI countries export significantly less than non-BRI countries. However, middle-income BRI countries export more to other BRI countries than non-BRI countries. BRI countries across three different development statuses import more mining and energy goods from other BRI countries regardless of trade partners' development status. For the services sector, only middle-income BRI countries trade more with both BRI and non-BRI countries. High-income BRI and low-income BRI countries trade less with BRI countries. These findings underline the role of middle-income BRI countries as critical nodes in trade networks, showcasing their ability to connect both BRI and non-BRI partners. High-income BRI countries exhibit strong trade engagement but may prioritize interactions with non-BRI countries, especially in the services sector.

The findings from trade creation and diversion reveal substantial effects under the BRI framework, but these impacts vary considerably across sectors. For aggregated sectors, the substantial net trade creation of 149.7% in exports and 101.8% in imports to non-BRI countries highlights the BRI's role in fostering broader international trade links. This positive impact is particularly evident in the agriculture, forestry, and fishing sector, which shows net trade creation of 136.6% in exports and 100.2% in imports. These results suggest that infrastructure and logistical improvements under the BRI have facilitated greater market access and reduced trade costs in these sectors. Conversely, the mining and energy sector exhibits negative trade diversion effects, with a 24.0% loss in exports and a 15.4% loss in imports to and from non-BRI countries. In contrast, the manufacturing sector displays the strongest trade creation effects, with net trade creation of 218.7% in exports and 140.4% in imports.

2.5 Conclusion

This study examined the impact of the Belt and Road Initiative (BRI) on trade flows across various sectors, such as agriculture, forestry and fishing, mining and energy, manufacturing, and services, using the structural gravity model with PPML regressions. Additionally, we examined the combined effects of BRI participation and development status on trade, as well as the trade creation and diversion dynamics between BRI and non-BRI countries. Our findings offer valuable insights into how the BRI influences international trade patterns.

This is the first to examine the impact of BRI on aggregate trade, including in BRI countries (excluding China). This is the first analysis of BRI's impact on trade in disaggregated sectors among BRI and non-BRI countries. Our findings also address gaps in understanding how a country's participation in the BRI and its level of development influence trade across various sectors, as well as the trade creation and diversion between BRI and non-BRI countries.

The first objective of this study was to examine the impact of the BRI on aggregated international trade and on goods of trade in key sectors such as agriculture, forestry and fishing, mining and energy, manufacturing, and services. Through analysis, we found that impact of the BRI on trade flows varies significantly depending on the roles of the countries involved—exporters or importers—and their trading relationships, whether between BRI countries, between BRI and non-BRI countries, or involving China. The effects of the BRI also differ considerably across sectors, with both positive and negative impacts observed. Firstly, the BRI has facilitated more trade between BRI and non-BRI countries, particularly in the manufacturing sector, where BRI countries export significantly more than their non-BRI counterparts. However, the BRI has a mixed impact on trade in the services sector, where BRI countries trade less with non-BRI countries than with other BRI countries. This divergence likely reflects the distinct characteristics of the services sector, which faces regulatory and infrastructural barriers that are less responsive to infrastructure-focused investments promoted by the BRI. Secondly, the BRI has also promoted higher exports of manufacturing goods and increased imports of agricultural, forestry and fishing, and mining and energy products among BRI countries. However, the BRI's benefits are not evenly distributed, with aggregate trade among BRI countries still lower than between BRI and non-BRI countries, indicating that the BRI's most significant benefits may be realized when engaging with a broader range of international partners. Thirdly, China's central role in the BRI framework is evident from the substantial increase in its trade with BRI countries compared to non-BRI countries. Our findings indicate that China exports significantly more to BRI countries in sectors such as agriculture, forestry and fishing, and services, while also importing considerably more from BRI countries across various sectors. This suggests that the BRI has strengthened China's trade relationships with the initiative. While our findings align with previous studies highlighting the BRI's positive impact on trade between China and BRI countries, we also uncover effects across different sectors and trade relationships that previous research, such as Fotak et al. (2022) and Mao et al. (2019), may not have fully captured.

The second objective of this study was to assess the effects of the BRI on trade patterns among countries with different development statuses. Through analysis, the findings reveal significant disparities in trade performance across income levels and sectors, shaped by the interplay of development status and BRI participation. Manufacturing and agriculture, forestry and fishing sectors show strong trade creation effects, while mining and energy faces persistent challenges. The services sector remains underdeveloped within the BRI framework, particularly for low-income countries. Middle-income BRI countries act as critical connectors between BRI and non-BRI partners, while low-income BRI countries face structural limitations, leading to weaker trade performance.

The third objective of this study was to explores trade creation and diversion effects between signatory and non-signatory members. The analysis reveals trade creation and diversion effects under the BRI vary significantly by sector. Aggregated sectors show substantial net trade creation of 149.7% in exports and 101.8% in imports to non-BRI countries, with similar trends in agriculture. In contrast, the mining and energy sector suffers from trade diversion, losing 24.0% in exports and 15.4% in imports to non-BRI countries. Manufacturing displays the most substantial trade creation effects, with 218.7% in exports and 140.4% in imports, underscoring the BRI's success in integrating manufacturing industries into global supply chains.

In conclusion, the BRI has shown a broadly positive impact on trade flows and trade creation, particularly in manufacturing trade, while its effects on the services sector remain more mixed. Middle-income BRI countries act as critical connectors between BRI and non-BRI partners, while low-income BRI countries experience weaker trade performance. These findings underscore the complexity of the BRI's impact and suggest that future policy interventions may need to address sector-specific challenges, particularly in services, to realize BRI's potential benefits fully.

The findings of this study hold several critical implications for policymakers, businesses, and stakeholders in global trade. Notably, the BRI is not a trade agreement in the traditional sense. Compared to existing free trade agreements, such as the ASEAN–China FTA, which increased exports by 117% (Yang & Martinez-Zarzoso, 2014), the TPP, which boosted exports among members by 11.5% (Petri and Plummer, 2016), and CETA, which raised the extensive margin of exports by 14.5% from France to Canada in 2017 (Fontagné et al., 2024), this study finds that BRI positively impacts exports (149.7%) and imports (101.8%) of BRI member countries. Unlike traditional trade agreements that primarily reduce tariff and non-tariff barriers, the BRI promotes trade by improving infrastructure, reducing transport costs (Yang et al., 2020; Herrero & Xu, 2017), and transferring technology and capital (Jiang et al., 2018; Yao et al., 2020). As such, the BRI represents a new model of international collaboration that facilitates trade liberalization and may act as a substitute for traditional free trade agreements.

Additionally, because the BRI shows mixed outcomes for trade between BRI and non-BRI countries across sectors, policymakers in non-BRI countries should consider joining the BRI to gain trade benefits stemming from infrastructure improvements, reduced transport costs, and capital transfer.

For businesses, the BRI presents significant opportunities, particularly in sectors where trade with China and other BRI countries has grown substantially. Firms in BRI member countries benefit from enhanced market access and lower transport costs, particularly in the manufacturing and agriculture, forestry, and fishing sectors. For instance, businesses in Southeast Asia engaged in agriculture, as well as firms in Central Asia and Europe operating in the manufacturing sector, should strategically leverage these advantages to maximize their trade potential.

2.5.1 Limitations and Suggestions for Future Research

This study has several limitations, including that the dataset used does not fully capture intra-national trade flows. In the ITPD-E dataset (Borchert et al., 2021), intra-national trade flows are calculated as the difference between production and export levels. However, both Borchert et al. (2021) and other studies, such as Campos et al. (2021), have noted that intra-national trade data only partially covers certain countries and years due to incomplete administrative data on production output. Furthermore, this dataset does not separate export and re-export. For example, Borchert et al. (2021) indicated that they removed negative international trade flows at the sector-country-year level, as seen in Singapore's agriculture sector. This adjustment was necessary because Singapore functions as an entrepot for trade, particularly for re-export activities.

To estimate BRI effects with countries exporters or importer's role, we are unable to apply both exporter-time and importer-time fixed effects. For example, when analyzing the impact of BRI membership on exporters, we applied only importer-time fixed effects instead of both exporter-time and importer-time fixed effects, as including both would lead to collinearity issues. As a consequence, our estimations focus on capturing the variations associated with importer characteristics while potentially omitting some unobservable exporter-specific effects, which could slightly bias the interpretation of exporter-side results.

Moreover, this study is designed to not consider the period after 2019, thereby excluding the potential impacts of the COVID-19 pandemic on international trade. Future research could extend the analysis to include the post-2019 period, providing insights into how the pandemic and subsequent global economic shifts influenced trade patterns within the BRI framework. Incorporating these temporal elements would enable a more comprehensive assessment of the BRI's long-term effects on global trade dynamics, including potential shifts between BRI and non-BRI countries.

This study could be extended to analyze the lead and lag effects of BRI on trade. The initiative's impact is not only instantaneous. Some firms may have already been in business before their host country joined the BRI, thereby experiencing the BRI's influence long before newer firms that started afterward. Similarly, lagged effects could arise from the delayed completion of BRI infrastructure projects, which often occur years after the signing of the MoUs. These factors suggest that the BRI’s impact on trade likely unfolds over an extended period, requiring further investigation into both lead and lag effects.

Furthermore, this study also could explore the relationship between China’s FDI and trade performance within the BRI framework, focusing on whether they are complementary or substitutes. FDI can be a substitute for trade when companies decide to produce goods and services directly in foreign markets, rather than exporting from their home country. Conversely, FDI can also complement trade by enhancing the firm’s ability to trade internationally, such as establishing factories abroad and producing intermediate goods from these facilities back to the home country to optimize firms’ supply chain.

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Table 2.1 Percentage of Zeros in the Initial and Final Dataset

Industry	Full (Initial) Dataset			Final Dataset with "False" Zeros Removed		
	Zeros Obs.	Total Obs.	%	Zeros Obs.	Total Obs.	%
All Trade	515,751	1,365,648	37.55	301,320	1,151,217	26.17
Agriculture, Forestry, and Fishing	166,457	382,426	43.53	86,834	302,803	28.68
Mining and Energy	144,755	289,243	50.05	72,891	217,379	33.53
Manufacturing	183,714	621,129	29.58	124,593	562,008	22.17
Services	20,825	72,850	28.59	17,002	69,027	24.63

Table 2.2 Descriptive Statistics

Variables	All Industries		Agriculture, Forestry, and Fishing		Mining and Energy		Manufacturing		Services	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Trade Flows (million USD)	1,093	72,264	121.7	5,628	362.1	12,270	766.1	43,380	10,323	266,586
BRI (At Least One)	0.209	0.407	0.216	0.412	0.215	0.411	0.198	0.399	0.250	0.433
One BRI (Only)	0.142	0.349	0.141	0.348	0.143	0.350	0.137	0.344	0.174	0.379
Exporter is BRI	0.138	0.344	0.145	0.352	0.146	0.353	0.127	0.333	0.162	0.369
Importer is BRI	0.139	0.346	0.146	0.353	0.141	0.348	0.132	0.338	0.163	0.369
Both BRI	0.068	0.251	0.075	0.263	0.072	0.258	0.061	0.239	0.076	0.265
Both BRI (Excluding China)	0.065	0.247	0.073	0.259	0.0682	0.252	0.060	0.237	0.072	0.259
Both BRI (Exporter is China)	0.001	0.033	0.001	0.035	0.002	0.041	0.001	0.026	0.002	0.041
Both BRI (Importer is China)	0.001	0.033	0.001	0.035	0.002	0.041	0.001	0.026	0.002	0.041
International	0.995	0.069	0.993	0.083	0.995	0.067	0.998	0.049	0.983	0.128
Distance (km)	7,325	4,552	7,018	4,442	6,511	4,370	7,974	4,587	5,949	4,449
Contiguity	0.024	0.153	0.027	0.162	0.037	0.190	0.015	0.123	0.041	0.197
Common Language	0.368	0.482	0.374	0.484	0.394	0.489	0.367	0.482	0.276	0.447
Colonial Relationship	0.018	0.134	0.020	0.141	0.028	0.164	0.013	0.112	0.027	0.161

Table 2.2 (continued)

Free Trade Agreement (RTA)	0.188	0.391	0.192	0.394	0.240	0.427	0.144	0.351	0.369	0.483
Observations (n)	1,151,217		302,803		217,379		562,008		69,027	

Notes: BRI (At Least One) is a dummy variable that indicates that at least one of the trade partners is BRI country. One BRI (Only) is a dummy variable that indicates that only one of the trade partners is BRI country. This table presents the statistical descriptive of the final dataset. All variables have a constant number of observations, as shown in the bottom row, except for distance. The number of distance observations is as follows: 1,149,589 across all industries, 302,421 in Agriculture, Forestry, and Fishing, 216,867 in Mining and Energy, and 561,274 in Manufacturing. These numbers are lower due to missing distance data for certain trade partners.

Table 2.3 Development Status of Countries Across Sectors in 2019

		Exporters			Importers		
Sector	Development Status	ALL	BRI	Non-BRI	ALL	BRI	Non-BRI
Agriculture, Forest and Fishing	HIC	74	34	40	76	34	42
	MIC	104	82	22	105	82	23
	LIC	29	19	10	29	19	10
Mining and Energy	HIC	75	34	41	76	34	42
	MIC	102	81	21	105	82	23
	LIC	29	19	10	29	19	10
Manufacturing	HIC	76	34	42	76	34	42
	MIC	105	82	23	105	82	23
	LIC	29	19	10	29	19	10
Services	HIC	54	28	26	54	28	26
	MIC	55	43	12	55	43	12
	LIC	3	1	2	3	1	2
All Trade	HIC	76	34	42	76	34	42
	MIC	105	82	23	105	82	23
	LIC	29	19	10	29	19	10

Data source: World Bank (2024b).

Notes: HIC, MIC, and LIC refer to high-income, middle-income, and low-income countries, respectively. This table presents the number of classified countries' development statuses and BRI participation across sectors in 2019. Country income status is dynamic and may fluctuate based on changes in national income level.

Table 2.4 Conclusion on BRI's Effects on Exporters, Importers, and Non-Members

	Exporter	**Importer**	**All**	**AG.**	**M&E**	**Mfg.**	**Ser.**	**Compared against**
(1)	At least One Trading partner is BRI		+ (**)	NS	NS	NS	- (***)	Both non-BRI
(2)	BRI (Non-BRI)	Non- BRI (BRI)	+ (**)	NS	NS	+ (***)	- (***)	Both BRI, and Both non-BRI
(3)	BRI	All	NS	NS	NS	NS	- (***)	Exporters are not BRI
(4)	ALL	BRI	- (**)	+ (***)	+ (**)	NS	- (***)	Importers are not BRI
(5)	BRI	BRI	- (**)	NS	NS	+ (***)	+ (***)	Both non-BRI, and BRI & non-BRI
(6)	BRI (other than China)	BRI (other than China)	+ (***)	+ (***)	+ (***)	NS	+ (***)	BRI (other than China) & China, BRI(other than China)& non-BRI, and China &non-BRI
(7)	China	BRI(other than China)	+ (***)	+ (***)	NS	+ (***)	+ (***)	Countries other than China & China and non-BRI countries
(8)	BRI (other than China)	China	NS	+ (***)	+ (***)	NS	+ (***)	China and non-BRI countries & countries other than China

Notes: AG. represents the agriculture, forestry, and fishing sector. M&E represents the mining and energy sector. Mfg. represents the manufacturing sector. Ser. represents the services sector. NS denotes results that are not statistically significant. "+" and "-" indicate positive and negative results, respectively. *** p < 0.01, ** p < 0.05, * p < 0.1.

Table 2.5 Impact of BRI on Trade, All Sectors

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
BRI (At Least One)	0.36**							
	(0.15)							
One BRI (Only)		0.18**						
		(0.07)						
Exporter BRI			0.07					
			(0.10)					
Importer BRI				-0.21**				
				(0.10)				
Both BRI					-0.36**			
					(0.15)			
Both BRI (China is Excluded)						0.33***		
						(0.10)		
Both BRI (China is Exporter)							0.85***	
							(0.31)	
Both BRI (China is Importer)								0.33
								(0.36)
International	-1.71***	-1.71***	-1.07***	-0.86***	-1.71***	-1.70***	-1.25***	-1.02***
	(0.56)	(0.56)	(0.38)	(0.29)	(0.56)	(0.56)	(0.37)	(0.29)
Distance (Ln)	-0.38***	-0.38***	0.27***	0.31***	-0.38***	-0.37***	0.25***	0.29***
	(0.08)	(0.08)	(0.03)	(0.02)	(0.08)	(0.08)	(0.03)	(0.02)
Distance*International	-0.26***	-0.26***	-0.71***	-0.74***	-0.26***	-0.26***	-0.68***	-0.72***
	(0.08)	(0.08)	(0.05)	(0.04)	(0.08)	(0.08)	(0.05)	(0.04)
Free Trade Agreement (RTA)	0.04	0.04	0.42***	0.42***	0.04	0.05	0.40***	0.40***
	(0.09)	(0.09)	(0.04)	(0.04)	(0.09)	(0.09)	(0.04)	(0.04)
Contiguity	0.43***	0.43***	1.15***	1.07***	0.43***	0.43***	1.21***	1.12***
	(0.12)	(0.12)	(0.10)	(0.07)	(0.12)	(0.12)	(0.10)	(0.07)
Common Language	0.32***	0.32***	0.03	0.07**	0.32***	0.30***	-0.00	0.05*
	(0.07)	(0.07)	(0.04)	(0.03)	(0.07)	(0.07)	(0.0361)	(0.03)
Colonial Relationship	0.29**	0.29**	0.59***	0.62***	0.29**	0.28**	0.60***	0.62***
	(0.12)	(0.12)	(0.05)	(0.05)	(0.12)	(0.12)	(0.05)	(0.05)

Table 2.5 (continued)

Constant	16.36***	16.40***	12.51***	12.27***	16.43***	16.38***	12.63***	12.32***
	(0.49)	(0.49)	(0.17)	(0.15)	(0.50)	(0.49)	(0.17)	(0.14)
Observations	1,149,358	1,149,358	1,149,469	1,149,465	1,149,358	1,149,358	1,149,469	1,149,465
FEs	its,jts	its,jts	jts	its	its,jts	its,jts	jts	its
Pseudo R2	0.97	0.97	0.93	0.93	0.97	0.97	0.93	0.93

Notes: BRI (At Least One) is a dummy variable that indicates that at least one of the trade partners is BRI country. One BRI (Only) is a dummy variable that indicates that only one of the trade partners is BRI country. Robust standard errors are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 2.6 Impact of BRI on Trade of Agriculture, Forestry and Fishing Sector Products

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
BRI (At Least One)	-0.12							
	(0.16)							
One BRI (Only)		-0.06						
		(0.08)						
Exporter BRI			-0.06					
			(0.08)					
Importer BRI				0.80***				
				(0.13)				
Both BRI					0.12			
					(0.16)			
Both BRI (China is Excluded)						0.60***		
						(0.15)		
Both BRI (China is Exporter)							0.70***	
							(0.11)	
Both BRI (China is Importer)								2.33***
								(0.10)
International	-2.43***	-2.43***	-0.61*	-1.38**	-2.43***	-2.43***	-1.21***	-2.20***
	(0.82)	(0.82)	(0.34)	(0.66)	(0.82)	(0.81)	(0.38)	(0.68)
Distance (Ln)	-0.74***	-0.74***	0.70***	0.40***	-0.74***	-0.73***	0.62***	0.28***
	(0.13)	(0.13)	(0.05)	(0.06)	(0.13)	(0.13)	(0.05)	(0.07)
Distance*International	-0.21	-0.21	-0.89***	-0.74***	-0.21	-0.21	-0.80***	-0.60***
	(0.13)	(0.13)	(0.05)	(0.10)	(0.13)	(0.13)	(0.06)	(0.10)
Free Trade Agreement (RTA)	0.85***	0.85***	1.10***	1.18***	0.85***	0.87***	1.12***	1.23***
	(0.09)	(0.09)	(0.03)	(0.04)	(0.09)	(0.09)	(0.03)	(0.04)
Contiguity	0.51***	0.51***	1.22***	1.06***	0.51***	0.51***	1.31***	1.15***
	(0.16)	(0.16)	(0.08)	(0.09)	(0.16)	(0.16)	(0.09)	(0.10)
Common Language	0.17	0.17	0.32***	0.19***	0.17	0.16	0.27***	0.08
	(0.11)	(0.10)	(0.05)	(0.06)	(0.11)	(0.11)	(0.04)	(0.06)
Colonial Relationship	0.00	0.00	-0.01	-0.04	0.00	0.01	-0.02	-0.05
	(0.18)	(0.18)	(0.06)	(0.06)	(0.18)	(0.18)	(0.06)	(0.06)

Table 2.6 (continued)

Constant	16.09***	16.06***	6.45***	8.28***	16.03***	15.96***	6.84***	8.96***
	(0.84)	(0.85)	(0.29)	(0.43)	(0.85)	(0.83)	(0.29)	(0.44)
Observations	302,335	302,335	302,377	302,366	302,335	302,335	302,377	302,366
FEs	it,jt	it,jt	jt	it	it,jt	it,jt	jt	it
Pseudo R2	0.97	0.97	0.92	0.92	0.97	0.97	0.92	0.92

Notes: BRI (At Least One) is a dummy variable that indicates that at least one of the trade partners is BRI country. One BRI (Only) is a dummy variable that indicates that only one of the trade partners is BRI country. Robust standard errors are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 2.7 Impact of BRI on Trade for Mining and Energy Sector Products

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
BRI (At Least One)	-0.19							
	(0.16)							
One BRI (Only)		-0.09						
		(0.08)						
Exporter BRI			0.08					
			(0.10)					
Importer BRI				0.42**				
				(0.19)				
Both BRI					0.19			
					(0.16)			
Both BRI (China is Excluded)						0.73***		
						(0.14)		
Both BRI (China is Exporter)							0.32	
							(0.21)	
Both BRI (China is Importer)								3.51***
								(0.10)
International	-2.37*	-2.37*	-1.30***	-4.03***	-2.37*	-2.36*	-1.44***	-4.26***
	(1.40)	(1.40)	(0.44)	(0.47)	(1.40)	(1.39)	(0.45)	(0.48)
Distance (Ln)	-0.88***	-0.88***	0.22***	0.44***	-0.88***	-0.87***	0.20***	0.37***
	(0.18)	(0.18)	(0.05)	(0.05)	(0.18)	(0.18)	(0.05)	(0.05)
Distance*International	-0.23	-0.23	-0.60***	-0.44***	-0.23	-0.23	-0.57***	-0.38***
	(0.21)	(0.21)	(0.06)	(0.07)	(0.21)	(0.21)	(0.06)	(0.07)
Free Trade Agreement (RTA)	0.39***	0.39***	-0.07	0.46***	0.39***	0.40***	-0.07	0.47***
	(0.12)	(0.12)	(0.08)	(0.10)	(0.12)	(0.13)	(0.08)	(0.10)
Contiguity	0.37*	0.37*	1.11***	1.39***	0.37*	0.38*	1.14***	1.41***
	(0.20)	(0.20)	(0.14)	(0.13)	(0.20)	(0.20)	(0.15)	(0.14)
Common Language	0.45***	0.45***	0.29***	-0.19**	0.45***	0.44***	0.27***	-0.19**
	(0.13)	(0.133)	(0.06	(0.08)	(0.13)	(0.13)	(0.06)	(0.08)
Colonial Relationship	0.47**	0.47**	0.17	0.56***	0.47**	0.46**	0.17	0.53***
	(0.23)	(0.23)	(0.11)	(0.10)	(0.23)	(0.23)	(0.11)	(0.09)

Table 2.7 (continued)

Constant	18.32***	18.28***	10.61***	9.58***	18.25***	18.19***	10.70***	9.71***
	(1.13)	(1.13)	(0.32)	(0.34)	(1.13)	(1.12)	(0.32)	(0.33)
Observations	216,820	216,820	216,852	216,835	216,820	216,820	216,852	216,835
FEs	it,jt	it,jt	jt	it	it,jt	it,jt	jt	it
Pseudo R2	0.95	0.95	0.84	0.81	0.95	0.95	0.84	0.82

Notes: BRI (At Least One) is a dummy variable that indicates that at least one of the trade partners is BRI country. One BRI (Only) is a dummy variable that indicates that only one of the trade partners is BRI country. Robust standard errors are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 2.8 Impact of BRI on Trade for Manufacturing Sector Products

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
BRI (At Least One)	0.18							
	(0.13)							
One BRI (Only)		0.57***						
		(0.13)						
Exporter BRI			0.07					
			(0.15)					
Importer BRI				-0.18				
				(0.13)				
Both BRI					1.59***			
					(0.40)			
Both BRI (China is Excluded)						0.49		
						(0.38)		
Both BRI (China is Exporter)							0.27***	
							(0.10)	
Both BRI (China is Importer)								0.18
								(0.13)
International	0.97*	0.97*	1.72***	2.87***	0.97*	0.98*	1.32**	2.63***
	(0.52)	(0.52)	(0.52)	(0.40)	(0.52)	(0.51)	(0.52)	(0.38)
Distance (Ln)	-0.22***	-0.22***	0.36***	0.44***	-0.22***	-0.22***	0.30***	0.41***
	(0.08)	(0.08)	(0.04)	(0.04)	(0.08)	(0.08)	(0.04)	(0.03)
Distance*International	-0.48***	-0.48***	-1.01***	-1.15***	-0.48***	-0.47***	-0.94***	-1.11***
	(0.08)	(0.08)	(0.07)	(0.05)	(0.08)	(0.08)	(0.07)	(0.05)
Free Trade Agreement (RTA)	0.27***	0.27***	0.83***	0.73***	0.27***	0.27***	0.84***	0.73***
	(0.07)	(0.07)	(0.04)	(0.05)	(0.07)	(0.07)	(0.04)	(0.05)
Contiguity	0.38***	0.38***	1.00***	0.82***	0.38***	0.38***	1.07***	0.86***
	(0.09)	(0.09)	(0.15)	(0.11)	(0.09)	(0.09)	(0.15)	(0.11)
Common Language	0.33***	0.33***	-0.09*	0.06	0.33***	0.32***	-0.16***	0.03
	(0.07)	(0.07)	(0.05)	(0.04)	(0.07)	(0.07)	(0.05)	(0.04)
Colonial Relationship	0.15	0.15	0.47***	0.48***	0.15	0.15	0.47***	0.49***
	(0.10)	(0.10)	(0.07)	(0.06)	(0.10)	(0.10)	(0.07)	(0.06)

Table 2.8 (continued)

Constant	14.55***	14.59***	11.26***	10.77***	14.62***	14.57***	11.64***	11.00***
	(0.54)	(0.55)	(0.28)	(0.28)	(0.55)	(0.54)	(0.27)	(0.21)
Observations	561,274	561,274	561,274	561,274	561,274	561,274	561,274	561,274
FEs	it,jt	it,jt	jt	it	it,jt	it,jt	jt	it
Pseudo R2	0.97	0.97	0.85	0.87	0.97	0.97	0.85	0.87

Notes: BRI (At Least One) is a dummy variable that indicates that at least one of the trade partners is BRI country. One BRI (Only) is a dummy variable that indicates that only one of the trade partners is BRI country. Robust standard errors are reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 2.9 Impact of BRI on Trade of Services

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
BRI (At Least One)	-0.94***							
	(0.12)							
One BRI (Only)		-0.47***						
		(0.06)						
Exporter BRI			-0.83***					
			(0.05)					
Importer BRI				-0.87***				
				(0.04)				
Both BRI					0.94***			
					(0.12)			
Both BRI (China is Excluded)						1.13***		
						(0.11)		
Both BRI (China is Exporter)							1.33***	
							(0.14)	
Both BRI (China is Importer)								1.42***
								(0.14)
International	-1.89***	-1.89***	-1.83***	-1.95***	-1.89***	-1.90***	-1.81***	-1.94***
	(0.40)	(0.40)	(0.21)	(0.19)	(0.40)	(0.40)	(0.21)	(0.19)
Distance (Ln)	-0.17***	-0.17***	0.33***	0.34***	-0.17***	-0.17***	0.33***	0.34***
	(0.05)	(0.05)	(0.02)	(0.02)	(0.05)	(0.05)	(0.02)	(0.02)
Distance*International	-0.42***	-0.42***	-0.71***	-0.69***	-0.42***	-0.42***	-0.71***	-0.70***
	(0.05)	(0.05)	(0.03)	(0.02)	(0.05)	(0.05)	(0.03)	(0.02)
Free Trade Agreement (RTA)	-0.08	-0.08	0.07	0.06	-0.08	-0.07	0.09**	0.08*
	(0.10)	(0.10)	(0.05)	(0.04)	(0.10)	(0.10)	(0.05)	(0.04)
Contiguity	0.30***	0.30***	0.98***	1.02***	0.30***	0.29***	0.97***	1.01***
	(0.11)	(0.11)	(0.06)	(0.05)	(0.11)	(0.11)	(0.05)	(0.05)
Common Language	0.40***	0.40***	0.17***	0.17***	0.40***	0.40***	0.20***	0.21***
	(0.09)	(0.09)	(0.04)	(0.03)	(0.09)	(0.09)	(0.04)	(0.03)
Colonial Relationship	0.60***	0.60***	0.83***	0.82***	0.60***	0.60***	0.83***	0.82***
	(0.15)	(0.15)	(0.06)	(0.05)	(0.153)	(0.15)	(0.07)	(0.06)

Table 2.9 (continued)

Constant	15.69***	15.66***	12.74***	12.64***	15.63***	15.63***	12.68***	12.58***
	(0.37)	(0.37)	(0.12)	(0.14)	(0.37)	(0.36)	(0.13)	(0.14)
Observations	68,929	68,929	68,966	68,990	68,929	68,929	68,966	68,990
FEs	it,jt	it,jt	jt	it	it,jt	it,jt	jt	it
Pseudo R2	0.99	0.99	0.98	0.98	0.99	0.99	0.98	0.98

Notes: BRI (At Least One) is a dummy variable that indicates that at least one of the trade partners is BRI country. One BRI (Only) is a dummy variable that indicates that only one of the trade partners is BRI country. Robust standard errors are reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 2.10 Impact of Development Status and BRI Status on Trade for Aggregated Sectors

	Exporter				Importer			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
EXP. is HIC	0.63***							
	(0.23)							
EXP. is MIC	0.48***							
	(0.15)							
EXP. is HIC and BRI		0.08						
		(0.10)						
EXP. is MIC and BRI		0.17						
		(0.19)						
EXP. is LIC and BRI		0.10						
		(0.16)						
Exp. is HIC and BRI; Imp. is BRI			0.21**					
			(0.10)					
Exp. is MIC and BRI; Imp. is BRI			0.36***					
			(0.13)					
Exp. is LIC and BRI; Imp. is BRI			0.33*					
			(0.18)					
Exp. is HIC and BRI; Imp. is not BRI			0.03					
			(0.11)					
Exp. is MIC and BRI; Imp. is not BRI			0.11					
			(0.23)					
Exp. is LIC and BRI; Imp. is not BRI			-0.13					
			(0.16)					
Exp. is HIC and BRI; Imp. is HIC and BRI				0.02				
				(0.05)				

Table 2.10 (continued)

Exp. is MIC and BRI; Imp. is MIC and BRI	0.56***			
	(0.08)			
Exp. is LIC and BRI; Imp. is LIC and BRI	-0.47*			
	(0.28)			
Exp. is HIC and BRI; Imp. is HIC and not BRI	0.08*			
	(0.05)			
Exp. is MIC and BRI; Imp. is MIC and not BRI	0.24***			
	(0.05)			
Exp. is LIC and BRI; Imp. is LIC and not BRI	-1.08***			
	(0.27)			
Imp. is HIC		0.54***		
		(0.15)		
Imp. is MIC		0.41***		
		(0.07)		
Imp. is HIC and BRI			0.13	
			(0.08)	
Imp. is MIC and BRI			0.27**	
			(0.11)	
Imp. is LIC and BRI			0.14*	
			(0.08)	
Imp. is HIC and BRI; Exp. is BRI				0.28***
				(0.07)
Imp. is MIC and BRI; Exp. is BRI				0.43***
				(0.08)
Imp. is LIC and BRI; Exp. is BRI				0.33***
				(0.09)

Table 2.10 (continued)

Imp. is HIC and BRI; Exp. is not BRI							0.05	
							(0.10)	
Imp. is MIC and BRI; Exp. is not BRI							0.19	
							(0.14)	
Imp. is LIC and BRI; Exp. is not BRI							-0.08	
							(0.11)	
Imp. is HIC and BRI; Exp. is HIC and BRI								0.02
								(0.04)
Imp. is MIC and BRI; Exp. is MIC and BRI								0.55***
								(0.07)
Imp. is LIC and BRI; Exp. is LIC and BRI								-0.42
								(0.28)
Imp. is HIC and BRI; Exp. is HIC and not BRI								0.07
								(0.04)
Imp. is MIC and BRI; Exp. is MIC and not BRI								0.16***
								(0.05)
Imp. is LIC and BRI; Exp. is LIC and not BRI								-0.11
								(0.57)
Free Trade Agreement (RTA)	0.21**	0.19**	0.18**	0.23***	0.19***	0.16**	0.14**	0.23***
	(0.09)	(0.09)	(0.09)	(0.05)	(0.07)	(0.06)	(0.06)	(0.05)

Table 2.10 (continued)

Constant	13.14***	13.27***	13.27***	13.33***	13.20***	13.30***	13.31***	13.33***
	(0.04)	(0.01)	(0.01)	(0.02)	(0.03)	(0.01)	(0.01)	(0.02)
Observations	1,112,852	1,147,865	1,147,865	1,147,747	1,121,717	1,147,857	1,147,857	1,147,747
FEs	jts, ij	jts, ij	jts, ij	its,jts,ij	its,ij	its,ij	its,ij	its,jts,ij
Pseudo R^2	0.98	0.98	0.98	0.99	0.98	0.98	0.98	0.99

Notes: Flows of internationally traded products (only) are included in this analysis. Case where EXP. is LIC and IMP. is LIC omitted due to collinearity. Robust standard errors are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 2.11 Impact of Development Status and BRI Participation on Trade of Agriculture, Foresty, and Fishing Sector Products

	Exporter				Importer			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
EXP. is HIC	0.23***							
	(0.07)							
EXP. is MIC	0.19***							
	(0.05)							
EXP. is HIC and BRI		0.28***						
		(0.03)						
EXP. is MIC and BRI		0.21***						
		(0.03)						
EXP. is LIC and BRI		0.26***						
		(0.07)						
Exp. is HIC and BRI; Imp. is BRI			0.39***					
			(0.04)					
Exp. is MIC and BRI; Imp. is BRI			0.32***					
			(0.03)					
Exp. is LIC and BRI; Imp. is BRI			0.19**					
			(0.08)					
Exp. is HIC and BRI; Imp. is not BRI			0.20***					
			(0.03)					
Exp. is MIC and BRI; Imp. is not BRI			0.11***					
			(0.03)					
Exp. is LIC and BRI; Imp. is not BRI			0.35***					
			(0.09)					
Exp. is HIC and BRI; Imp. is HIC and BRI				0.28***				
				(0.06)				

Table 2.11 (continued)

Exp. is MIC and BRI; Imp. is MIC and BRI	0.37***			
	(0.05)			
Exp. is LIC and BRI; Imp. is LIC and BRI	-0.90**			
	(0.42)			
Exp. is HIC and BRI; Imp. is HIC and not BRI	0.22***			
	(0.08)			
Exp. is MIC and BRI; Imp. is MIC and not BRI	0.21***			
	(0.05)			
Exp. is LIC and BRI; Imp. is LIC and not BRI	-0.11			
	(0.39)			
Imp. is HIC		0.59***		
		(0.09)		
Imp. is MIC		0.46***		
		(0.09)		
Imp. is HIC and BRI			0.14***	
			(0.02)	
Imp. is MIC and BRI			0.34***	
			(0.04)	
Imp. is LIC and BRI			0.26***	
			(0.07)	
Imp. is HIC and BRI; Exp. is BRI				0.19***
				(0.03)
Imp. is MIC and BRI; Exp. is BRI				0.42***
				(0.04)
Imp. is LIC and BRI; Exp. is BRI				0.36***
				(0.08)

Table 2.11 (continued)

Imp. is HIC and BRI; Exp. is not BRI							0.12***	
							(0.02)	
Imp. is MIC and BRI; Exp. is not BRI							0.31***	
							(0.04)	
Imp. is LIC and BRI; Exp. is not BRI							0.16	
							(0.12)	
Imp. is HIC and BRI; Exp. is HIC and BRI								0.28***
								(0.05)
Imp. is MIC and BRI; Exp. is MIC and BRI								0.38***
								(0.05)
Imp. is LIC and BRI; Exp. is LIC and BRI								-0.90**
								(0.42)
Imp. is HIC and BRI; Exp. is HIC and not BRI								0.23***
								(0.05)
Imp. is MIC and BRI; Exp. is MIC and not BRI								0.23***
								(0.06)
Imp. is LIC and BRI; Exp. is LIC and not BRI								-0.34
								(0.26)
Free Trade Agreement (RTA)	0.13***	0.12***	0.12***	0.08**	0.03	0.02	0.02	0.08**
	(0.03)	(0.02)	(0.02)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)

Table 2.11 (continued)

Constant	10.43***	10.47***	10.47***	10.48***	10.38***	10.48***	10.48***	10.48***
	(0.01)	(0.00)	(0.00)	(0.00)	(0.02)	(0.00)	(0.00)	(0.00)
Observations	297,804	299,006	299,006	298,878	296,726	298,918	298,918	298,878
FEs	jt, ij	jt, ij	jt, ij	jt, it, ij	it, ij	it, ij	it, ij	jt, it, ij
Pseudo R^2	0.99	0.99	0.995	0.99	0.99	0.99	0.99	0.99

Notes: Flows of internationally traded products (only) are included in this analysis. Case where EXP. is LIC and IMP. is LIC omitted due to collinearity. Robust standard errors are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 2.12 Impact of Development Status and BRI Participation on Trade of Mining and Energy Sector Products

	Exporter				Importer			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
EXP. is HIC	0.12							
	(0.19)							
EXP. is MIC	0.01							
	(0.16)							
EXP. is HIC and BRI		-0.20***						
		(0.06)						
EXP. is MIC and BRI		-0.23***						
		(0.06)						
EXP. is LIC and BRI		-0.36						
		(0.29)						
Exp. is HIC and BRI; Imp. is BRI			0.07					
			(0.08)					
Exp. is MIC and BRI; Imp. is BRI			0.16**					
			(0.07)					
Exp. is LIC and BRI; Imp. is BRI			-0.12					
			(0.36)					
Exp. is HIC and BRI; Imp. is not BRI			-0.33***					
			(0.07)					
Exp. is MIC and BRI; Imp. is not BRI			-0.50***					
			(0.08)					
Exp. is LIC and BRI; Imp. is not BRI			-0.53**					
			(0.23)					
Exp. is HIC and BRI; Imp. is HIC and BRI				-0.03				
				(0.09)				

Table 2.12 (continued)

Exp. is MIC and BRI; Imp. is MIC and BRI	0.04			
	(0.09)			
Exp. is LIC and BRI; Imp. is LIC and BRI	-0.60			
	(0.42)			
Exp. is HIC and BRI; Imp. is HIC and not BRI	0.12			
	(0.09)			
Exp. is MIC and BRI; Imp. is MIC and not BRI	-0.05			
	(0.11)			
Exp. is LIC and BRI; Imp. is LIC and not BRI	0.19			
	(0.52)			
Imp. is HIC		0.53***		
		(0.15)		
Imp. is MIC		0.60***		
		(0.13)		
Imp. is HIC and BRI			0.05	
			(0.05)	
Imp. is MIC and BRI			0.38***	
			(0.07)	
Imp. is LIC and BRI			0.92***	
			(0.25)	
Imp. is HIC and BRI; Exp. is BRI				0.06
				(0.06)
Imp. is MIC and BRI; Exp. is BRI				0.46***
				(0.11)
Imp. is LIC and BRI; Exp. is BRI				0.91***
				(0.28)

Table 2.12 (continued)

Imp. is HIC and BRI; Exp. is not BRI							0.04	
							(0.05)	
Imp. is MIC and BRI; Exp. is not BRI							0.34***	
							(0.06)	
Imp. is LIC and BRI; Exp. is not BRI							1.00***	
							(0.32)	
Imp. is HIC and BRI; Exp. is HIC and BRI								-0.18*
								(0.10)
Imp. is MIC and BRI; Exp. is MIC and BRI								0.05
								(0.10)
Imp. is LIC and BRI; Exp. is LIC and BRI								-0.61
								(0.42)
Imp. is HIC and BRI; Exp. is HIC and not BRI								-0.22*
								(0.12)
Imp. is MIC and BRI; Exp. is MIC and not BRI								-0.07
								(0.13)
Imp. is LIC and BRI; Exp. is LIC and not BRI								0.27
								(0.46)
Free Trade Agreement (RTA)	0.18	0.13	0.15**	-0.22***	-0.02	-0.07**	-0.06*	-0.22***
	(0.11)	(0.08)	(0.08)	(0.06)	(0.04)	(0.03)	(0.03)	(0.06)

Table 2.12 (continued)

Constant	11.10***	11.14***	11.13***	11.19***	10.97***	11.14***	11.14***	11.19***
	(0.06)	(0.01)	(0.01)	(0.01)	(0.05)	(0.01)	(0.01)	(0.01)
Observations	212,139	213,508	213,508	213,243	210,732	213,275	213,275	213,243
FEs	jt, ij	jt, ij	jt, ij	jt, it, ij	it, ij	it, ij	it, ij	jt, it, ij
Pseudo R^2	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99

Notes: Flows of internationally traded products (only) are included in this analysis. Case where EXP. is LIC and IMP. is LIC omitted due to collinearity. Robust standard errors are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 2.13 Impact of Development Status and BRI Participation on Trade of Manufacturing Sector Products

	Exporter					Importer		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
EXP. is HIC	0.93***							
	(0.08)							
EXP. is MIC	0.76***							
	(0.07)							
EXP. is HIC and BRI		0.24***						
		(0.04)						
EXP. is MIC and BRI		0.34***						
		(0.04)						
EXP. is LIC and BRI		0.39***						
		(0.10)						
Exp. is HIC and BRI; Imp. is BRI			0.31***					
			(0.09)					
Exp. is MIC and BRI; Imp. is BRI			0.47***					
			(0.06)					
Exp. is LIC and BRI; Imp. is BRI			0.63***					
			(0.12)					
Exp. is HIC and BRI; Imp. is not BRI			0.20***					
			(0.02)					
Exp. is MIC and BRI; Imp. is not BRI			0.31***					
			(0.04)					
Exp. is LIC and BRI; Imp. is not BRI			0.12					
			(0.08)					
Exp. is HIC and BRI; Imp. is HIC and BRI				-0.10				
				(0.07)				

Table 2.13 (continued)

Exp. is MIC and BRI; Imp. is MIC and BRI	0.61***			
	(0.11)			
Exp. is LIC and BRI; Imp. is LIC and BRI	-0.50			
	(0.39)			
Exp. is HIC and BRI; Imp. is HIC and not BRI	0.02			
	(0.08)			
Exp. is MIC and BRI; Imp. is MIC and not BRI	0.25***			
	(0.06)			
Exp. is LIC and BRI; Imp. is LIC and not BRI	-1.38***			
	(0.30)			
Imp. is HIC		0.63***		
		(0.06)		
Imp. is MIC		0.46***		
		(0.05)		
Imp. is HIC and BRI			0.23***	
			(0.03)	
Imp. is MIC and BRI			0.36***	
			(0.04)	
Imp. is LIC and BRI			0.20***	
			(0.06)	
Imp. is HIC and BRI; Exp. is BRI				0.35***
				(0.07)
Imp. is MIC and BRI; Exp. is BRI				0.44***
				(0.06)
Imp. is LIC and BRI; Exp. is BRI				0.29***
				(0.08)

Table 2.13 (continued)

Imp. is HIC and BRI; Exp. is not BRI							0.17**	
							(0.02)	
Imp. is MIC and BRI; Exp. is not BRI							0.32***	
							(0.05)	
Imp. is LIC and BRI; Exp. is not BRI							0.10	
							(0.07)	
Imp. is HIC and BRI; Exp. is HIC and BRI								-0.10
								(0.06)
Imp. is MIC and BRI; Exp. is MIC and BRI								0.57***
								(0.11)
Imp. is LIC and BRI; Exp. is LIC and BRI								-0.40
								(0.39)
Imp. is HIC and BRI; Exp. is HIC and not BRI								0.02
								(0.06)
Imp. is MIC and BRI; Exp. is MIC and not BRI								0.12*
								(0.06)
Imp. is LIC and BRI; Exp. is LIC and not BRI								-0.11
								(0.65)
Free Trade Agreement (RTA)	0.24***	0.19***	0.17***	0.24***	0.21***	0.17***	0.16***	0.24***
	(0.07)	(0.06)	(0.06)	(0.07)	(0.04)	(0.04)	(0.04)	(0.07)

Table 2.13 (continued)

Constant	11.78***	12.15***	12.15***	12.16***	11.90***	12.15***	12.15***	12.16***
	(0.04)	(0.02)	(0.01)	(0.01)	(0.03)	(0.02)	(0.01)	(0.01)
Observations	526,643	558,643	558,643	558,643	537,685	558,643	558,643	558,643
FEs	jt, ij	jt, ij	jt, ij	jt, it, ij	it, ij	it, ij	it, ij	jt, it, ij
Pseudo R^2	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99

Notes: Flows of internationally traded products (only) are included in this analysis. Case where EXP. is LIC and IMP. is LIC omitted due to collinearity. Robust standard errors are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 2.14 Impact of Development Status and BRI Participation on Trade of Services

	Exporter				Importer			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
EXP. is HIC	0.35*							
	(0.21)							
EXP. is MIC	0.24							
	(0.20)							
EXP. is HIC and BRI		-0.00						
		(0.05)						
EXP. is MIC and BRI		-0.04						
		(0.06)						
EXP. is LIC and BRI		-0.51**						
		(0.2)						
Exp. is HIC and BRI; Imp. is BRI			-0.00					
			(0.06)					
Exp. is MIC and BRI; Imp. is BRI			-0.02					
			(0.10)					
Exp. is LIC and BRI; Imp. is BRI			-0.21**					
			(0.11)					
Exp. is HIC and BRI; Imp. is not BRI			-0.00					
			(0.05)					
Exp. is MIC and BRI; Imp. is not BRI			-0.05					
			(0.06)					
Exp. is HIC and BRI; Imp. is HIC and BRI				-0.10**				
				(0.04)				
Exp. is MIC and BRI; Imp. is MIC and BRI				0.18				
				(0.15)				

Table 2.14 (continued)

Exp. is HIC and BRI; Imp. is HIC and not BRI	-0.06			
	(0.04)			
Exp. is MIC and BRI; Imp. is MIC and not BRI	0.24*			
	(0.13)			
Imp. is HIC		0.05		
		(0.16)		
Imp. is MIC		-0.09		
		(0.15)		
Imp. is HIC and BRI			0.04	
			(0.05)	
Imp. is MIC and BRI			0.13**	
			(0.05)	
Imp. is LIC and BRI			-0.48***	
			(0.17)	
Imp. is HIC and BRI; Exp. is BRI				0.01
				(0.05)
Imp. is MIC and BRI; Exp. is BRI				0.19*
				(0.10)
Imp. is LIC and BRI; Exp. is BRI				-0.31***
				(0.10)
Imp. is HIC and BRI; Exp. is not BRI				0.05
				(0.05)
Imp. is MIC and BRI; Exp. is not BRI				0.11**
				(0.05)
Imp. is LIC and BRI; Exp. is not BRI				-3.46***
				(0.80)

Table 2.14 (continued)

Imp. is HIC and BRI; Exp. is HIC and BRI								-0.09**
								(0.04)
Imp. is MIC and BRI; Exp. is MIC and BRI								0.21
								(0.16)
Imp. is LIC and BRI; Exp. is LIC and BRI								-0.05
								(0.04)
Imp. is HIC and BRI; Exp. is HIC and not BRI								0.57***
								(0.18)
Imp. is MIC and BRI; Exp. is MIC and not BRI								-0.09**
								(0.04)
Imp. is LIC and BRI; Exp. is LIC and not BRI								0.21
								(0.16)
Free Trade Agreement (RTA)	-0.08	-0.08*	-0.08*	-0.00	-0.01	-0.03	-0.03	-0.00
	(0.08)	(0.04)	(0.04)	(0.06)	(0.04)	(0.04)	(0.04)	(0.06)
Constant	14.55***	14.57***	14.57***	14.57***	14.57***	14.57***	14.57***	14.57***
	(0.02)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)
Observations	68,604	68,687	68,687	68,615	68,590	68,697	68,697	68,615
FEs	jt, ij	jt, ij	jt, ij	jt, it, ij	it, ij	it, ij	it, ij	jt, it, ij
Pseudo R^2	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99

Notes: Flows of internationally traded products (only) are included in this analysis. Case where EXP. is LIC, Exp. is LIC and BRI; Imp. is not BRI, Exp. is LIC and BRI; Imp. is LIC and BRI, Exp. is LIC and BRI; Imp. is LIC and not BRI, and IMP. is LIC omitted due to collinearity. Robust standard errors are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 2.15 Number of Trade Partners

Sector	Existing Trade Partners 2006-2012	New Trade Partners between 2013-2019	Either Exporter or Importer is BRI between 2013-2019	Neither Exporter or Importer is BRI between 2013-2019
Agriculture, Foresty and Fishing	15,219	27	8	19
Mining and Energy	11,949	16	3	13
Manufacturing	23,923	752	252	500
Services	2,883	3	1	2

Note: Values count (only) unique pairs of trading countries; exporter-importer pairs that are identical to importer-exporter pairs are counted only once.

Table 2.16 Trade Creation and Trade Deviation

	(1) All Sectors	(2) Agriculture, Forest and Fishing	(3) Mining and Energy	(4) Manufacturing	(5) Services
Both Exporter and Importer are BRI	0.546***	0.447***	-0.125	0.664***	-0.0157
	(0.068)	(0.034)	(0.079)	(0.100)	(0.042)
Only Exporter is BRI	0.369***	0.414***	-0.275***	0.495***	-0.060
	(0.051)	(0.038)	(0.098)	(0.080)	(0.039)
Only Importer is BRI	0.156***	0.247***	-0.167**	0.213***	-0.054
	(0.049)	(0.035)	(0.076)	(0.070)	(0.041)
Constant	13.35***	10.48***	11.18***	12.18***	14.57***
	(0.017)	(0.001)	(0.004)	(0.006)	(0.000)
Observations	1,147,747	298,878	213,243	558,643	68,615
FE	its,jts,ij	it,jt,ij	it,jt,ij	it,jt,ij	it,jt,ij
Pseudo R2	0.986	0.996	0.993	0.995	0.999

Notes: All variables interact with International. The results are obtained from two separate regressions: the first includes all variables, but Only Importer is BRI was omitted due to collinearity. To estimate the importer effect, a second regression was conducted including the Only Importer is BRI variable. Robust standard errors are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

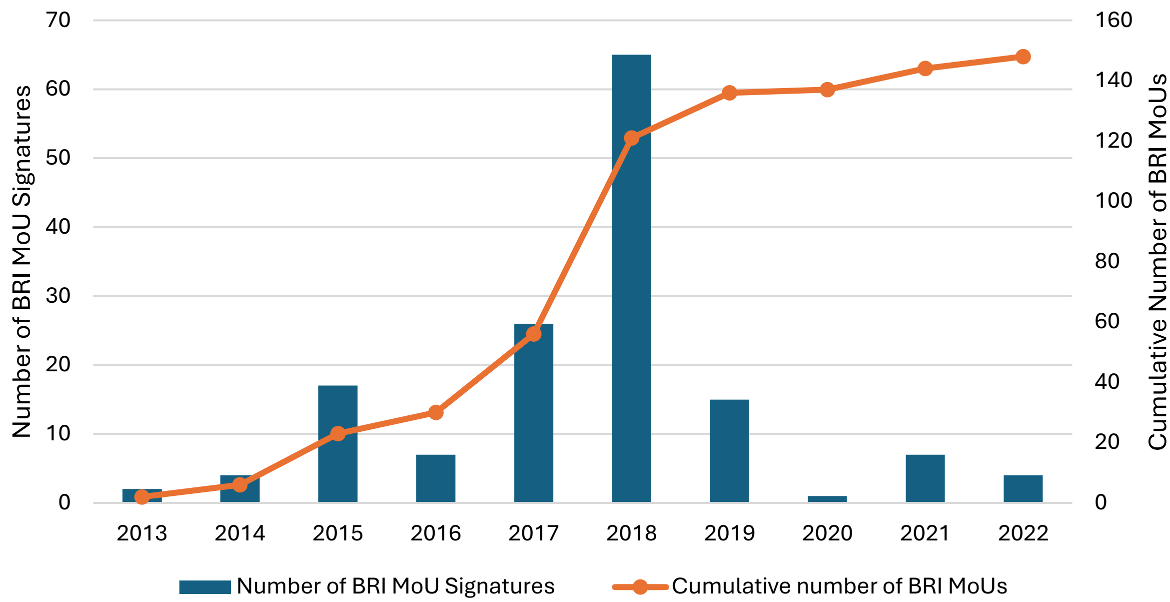
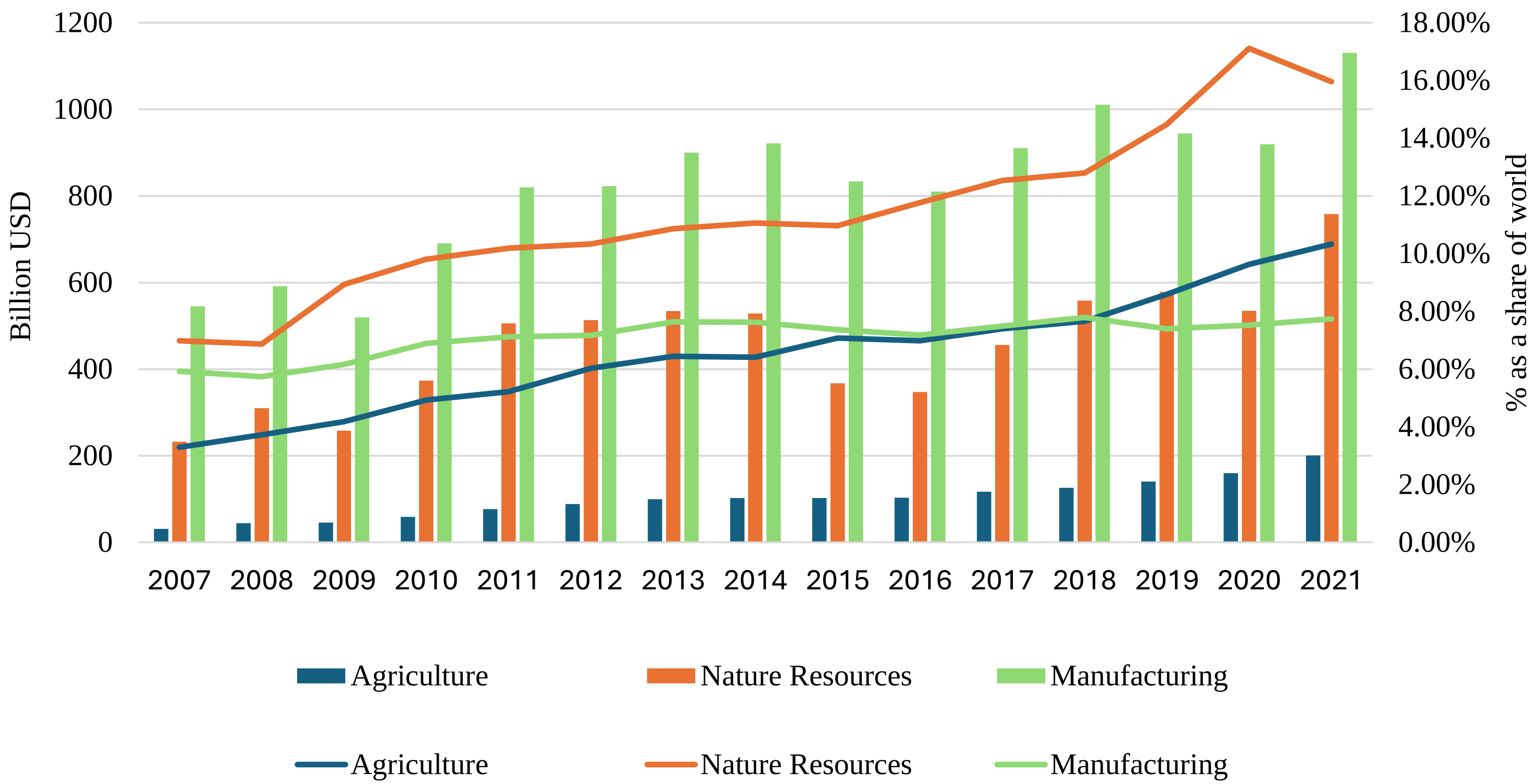


Figure 2.1 The Number of Countries Signed BRI MoUs with China between 2013 and 2022
Data Source: Belt and Road Portal, n.d.

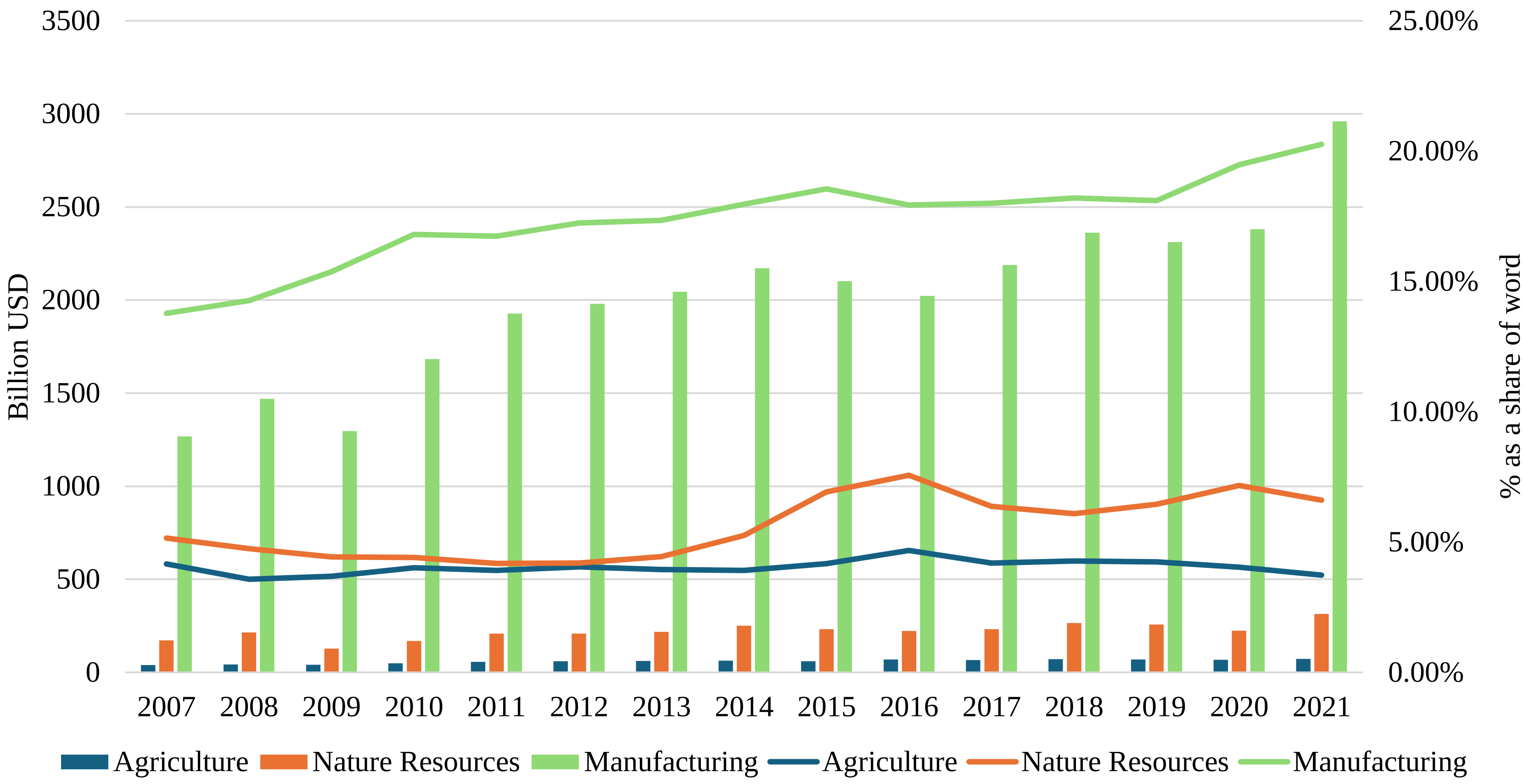
Figure 2.2 Yiwu–London Railway Line, 2017
Source: Silk Road Briefing, 2017

Figure 2.3 China Trade Flows and Their Share of World Across Three Sectors, 2007–2021
Data Source: BACI: International Trade Database at the Product-Level (the 1994-2007 Version) (Gaulier & Zignago, 2010)

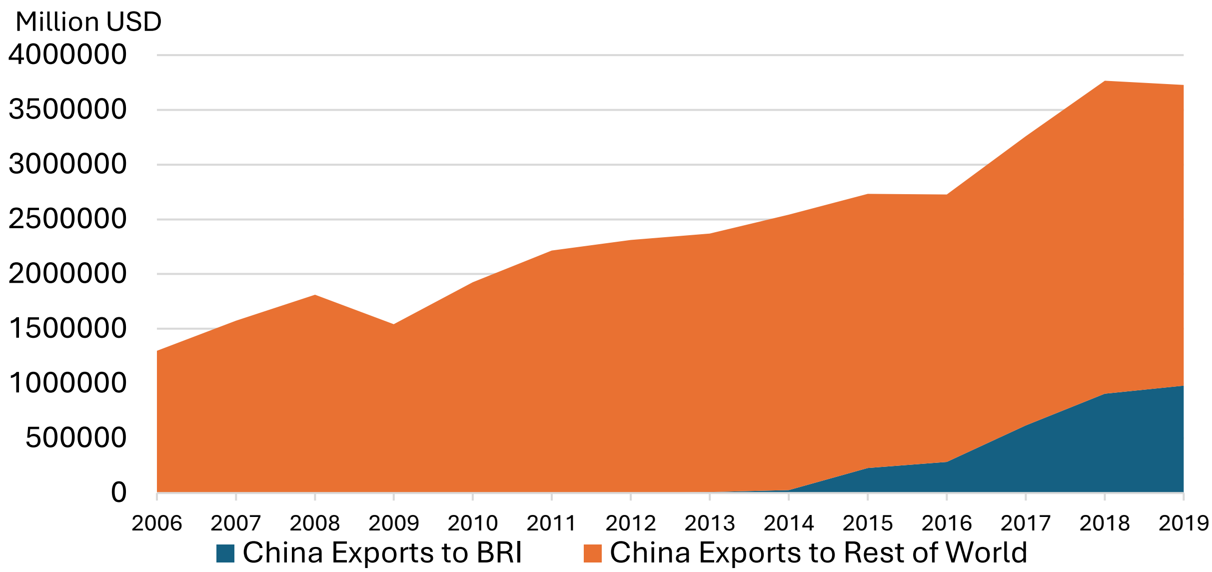
Panel A. China Import and Their Share of World Imports Across Three Sectors



Panel B. China Export and Their Share of World Exports Across Three Sectors



Panel A. China Exports to BRI Countries and Rest of World



Panel B. China Imports from BRI Countries and Rest of World

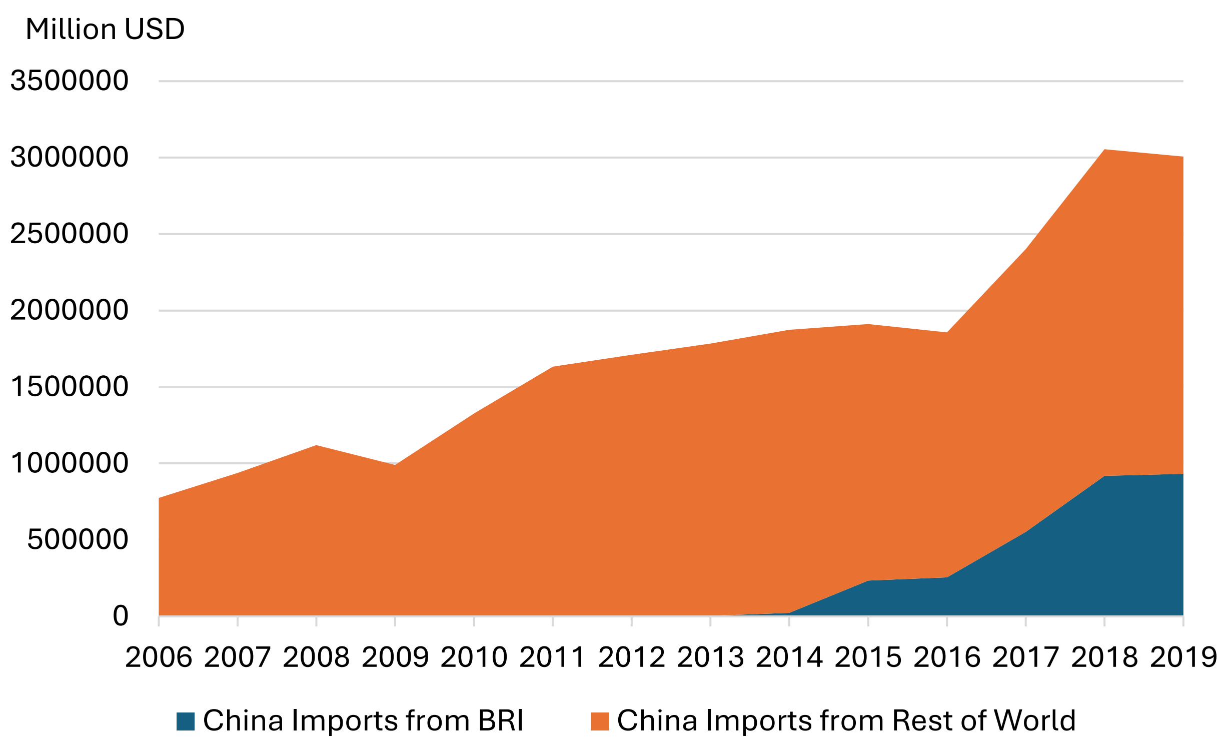
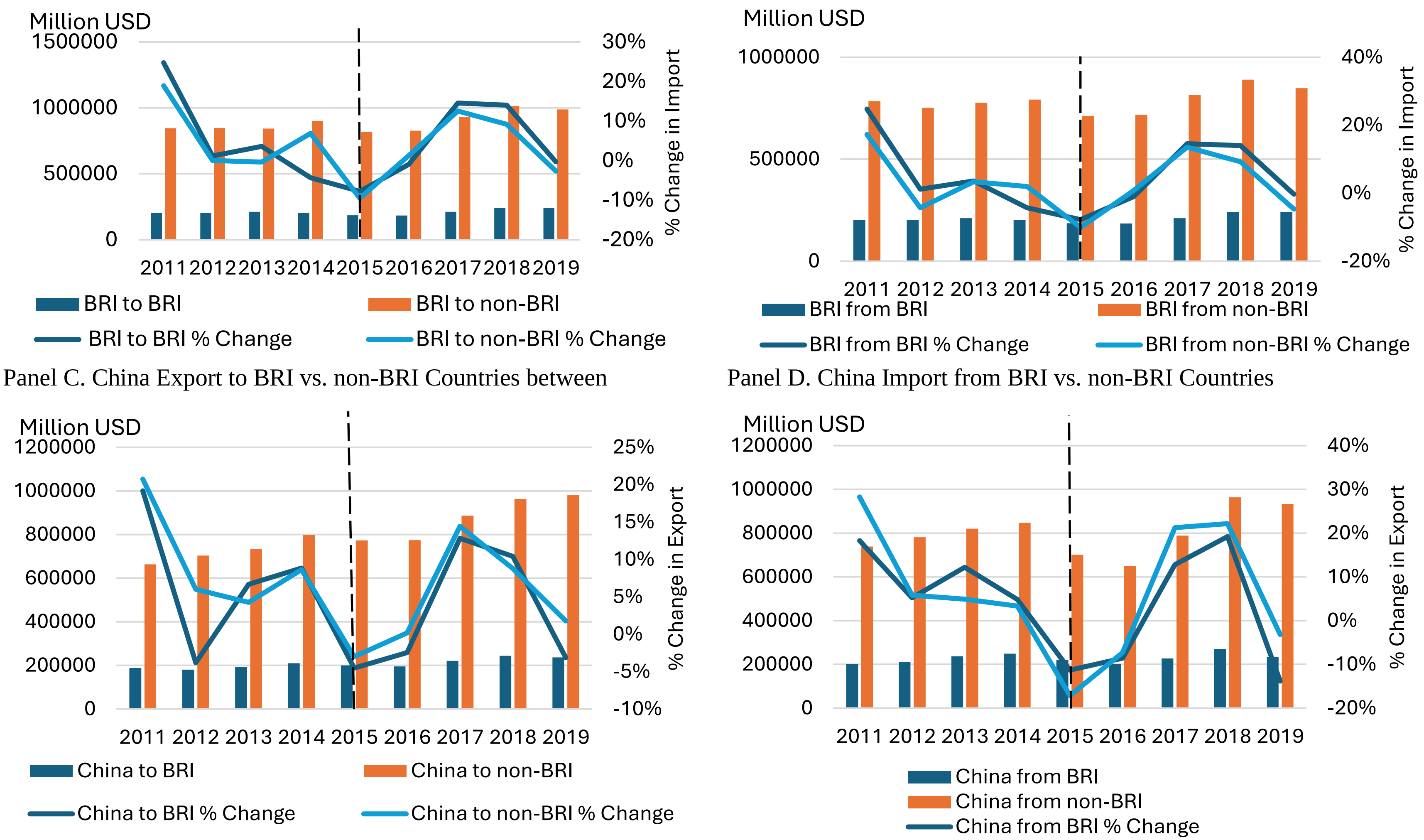


Figure 2.4 China's Trade Flows between BRI Countries and the Rest of the World (RoW), 2013 - 2019

Panel A. BRI Countries Export to BRI vs. non-BRI Countries

Panel B. BRI Countries Import from BRI vs. non-BRI Countries



Note: To observe the trend of trade with consistent trade partners, the presented data reflects the 17 countries that China had signed MoUs with in 2015.

Figure 2.5 Trade Flows among BRI Countries (17), China, and non-BRI Countries between 2011 and 2019

CHAPTER 3: Driving Under Pressure: Examining the Relationship Between Facility Detention and Truck Speed Patterns

3.1 Introduction

Truck detention has emerged as a growing concern among industry stakeholders and policymakers. According to American Transportation Research Institute (ATRI)'s *Critical Issues in the Truck Industry* reports from 2019 to 2022 (McReynolds et al., 2021, 2022; McReynolds & McLean, 2019, 2020), detention consistently ranked among the top ten challenges impacting the trucking industry. Reflecting the continued relevance of this issue, ATRI's 2023 research priorities included a dedicated focus on driver detention.

Despite increased awareness among industry stakeholders, truck detention still lacks a standardized definition. In this study, detention refers to any time a truck dwelling (is stopped at a facility) in a facility area for more than two hours while loading or unloading cargo (U.S. GAO, 2011). Several factors contribute to the probability and length of detention, including inadequate communication channels between drivers and facility sites, overscheduling or overbooking by the facility, insufficiently trained staff, and issues with the cargo itself (Mera & Sirikande, 2022; Speltz & Murray, 2019).

According to the most recent report from ATRI (Leslie & Murray, 2024), when trucks are detained, they may need to stay parked at the facility. However, if the facility's parking lot is full, drivers may have to use additional fuel and time to find parking elsewhere, potentially in unsafe areas. The report states that although 94.5% of carriers charged detention fees to their customers in 2023, only a portion of these fees was paid by customers, which varied based on the contracts between carriers and their customers. Smal fleets, defined as having fewer than 50 trucks, were found to be less likely to charge detention fees to customers they consider critical, compared to larger fleets with more than 50 trucks. Importantly, however, the fees collected for detention do not fully offset the revenue loss for truck drivers. For example, in the case of refrigerated trucks, the median loss amounts to $51.32 per hour, which amounts to a loss of $18,786 per truck annually. Therefore, even if the detained truck receives some compensation from their customers for this detention, it will still result in a net revenue loss. The prevalence of detention is also important. On the basis of an industry survey, Leslie & Murray (2024) found that truck drivers respondents experienced 39.3% detention of stops in 2023. This has important implications. To help make up for this lost time and income, truck drivers may adjust their speed or other aspects of their behavior in an effort to catch up with their original schedule.

Policies and compliance requirements surrounding new technologies may impact the effects of detention on truck driver behavior. The Hours of Service (HOS) regulations permit a maximum of 11 driving hours within a 14-hour workday. Additionally, the mandatory use of Electronic Logging Devices (ELDs) raises concerns about how detention impacts driver speeds. HOS rules strictly limit driving hours, and ELDs enforce compliance by monitoring adherence to these restrictions. Unanticipated driver detention disrupts driving and rest schedules, potentially leading drivers to increase their speed to meet original delivery timelines or avoid late deliveries. Consequently, detention could influence driver behaviors, such as increasing average driving speeds or even exceeding speed limits on highways. Truck drivers driving faster than the posted speed limit is one of the factors that increases the rate of injury/fatal single and multiple vehicle crashes (Mashhadi et al., 2018). Moreover, Khattak et al. (2003) found that speeding is one of the factors of truck rollovers and occupant injuries in single vehicle crashes by using crash data in North Carolina. Crucially, it has been found that speeding accounts for approximately 28% of fatal crashes annually (The Law Firm for Truck Safety, 2024).

A report by Speltz & Murray (2019) examined the effect of HOS compliance and the ELD mandate on detention rates. Using survey data from two periods (March 2014 to January 2015 and August to November 2018), this report concluded that drivers experience varying levels of impact due to detention. They found 37% of refrigerated trailers experienced more than 4 hours of delay and 19% dry van and tanker trucks experience the same level detention in the respondents. Further evidence from an Federal Motor Carrier Safety Administration (FMCSA)'s report (U.S. Department of Transportation Office of Inspector General, 2018), found that an additional 15 minutes of average monthly dwell time (the total time a truck is stopped at a facility) is associated with a 6.2% increase in average crash rates for that carrier. Using a descriptive analysis, this report also estimated an annual loss of $1.1 to $1.3 billion in earnings for for-hire drivers due to detention, along with a $250.6 to $302.9 million reduction in annual net income for motor carriers in the truckload sector. Therefore, this paper aims to apply economic models alongside GPS data to estimate the correlation between detention and truck driver speeds.

Using a novel research methodology, this study explores several important questions. First, the question of whether trucking service providers adjust their behavior in response to detention and if so, in what specific ways does driver behavior change, is examined. In considering these questions we explore whether there is a correlation between driver detention and speeds, and what factors might contribute to this outcome. Of particular interest is whether this correlation varies based shipment characteristics such as load type or type of destination facility, given that contract norms differ across industry sectors (Nickerson & Silverman, 2003). More specifically, we employ quantile regression analyses based on truck speed to analyze the relationship between detention and trucks' speed across aggregated and disaggregated data across various truck types (i.e., dry van truck, refrigerated truck, tanker truck) and facilities (i.e., food processors, distribution centers, semiconductors and electric components, chemicals, and petroleum refineries). In doing so, this study offers several unique contributions. This is the first study on detention to integrate traditional transportation GPS data and algorithms with economic insights and methodologies. Unlike previous transportation studies on safety issues that focused on optimization models, this research shifts the emphasis from "optimal" responses to actual driver behavior outcomes.

Several key findings emerge from this analysis. First it is found that detention significantly influences truck speeds, with a stronger positive association in the lower speed quantiles, where slower drivers compensate for delays by driving faster, and a diminishing effect in the higher quantiles due to speed limiters. Secondly, parking in a 10-mile radius of the facility and cumulative parking duration hours near the facility are predominantly associated with reduced speeds, though positive correlations are observed in specific contexts. For example, parking in a 10-mile radius of the facility for trucks visiting food processors positively correlates with maximum speed in the median groups, reflecting situational compensatory responses. Finally, in comparing speeds approaching and leaving the facility, we found generally increased average speeds post-departure, but interaction effects between post and key variables exhibit context-specific patterns, which vary by truck and facility types. These findings highlight the need for sector-specific targeted strategies to address detention and reduce risky driving behaviors.

The remainder of this study is organized as follows: Section 3.2 provides a comprehensive literature review, examining key reports and prior research relevant to detention, trucking policies, and broader issues concerning driver safety. Section 3.3 describes the methodologies and data used in the analysis, detailing the data algorithms and econometric models applied. Section 3.4 presents the results of the analysis followed by a discussion that contextualizes these findings within the existing literature and explores their broader implications. Finally, Section 3.5 concludes the study by summarizing the main insights, outlining research limitations, and offering suggestions for future research directions.

3.2 Literature Review

This section presents the literature most relevant to the issue of U.S. truck detention. We first summarize key studies on detention in the trucking industry, focusing on the interests of policymakers and industry stakeholders. Next, we review topics within the truck industry that are of interest to economists, including income, safety, and related regulatory issues. Finally, we discuss broader transportation methodologies and algorithms pertinent to truck driver behavior studies.

3.2.1 Detention

Policymakers and industry stakeholders have been at the forefront of discussions and studies on detention issues. However, research on detention-related topics is limited, with only several reports (U.S. GAO, 2011; Dunn et al. 2014; U.S. Department of Transportation Office of Inspector General, 2018; Speltz & Murray, 2019; Owner-Operator Independent Driver Association Foundation, 2024; Leslie & Murray 2024), and one master's thesis (Mera & Sirikande, 2022) available.

U.S. GAO (2011) first examined truck detention as an issue by analyzing data from interviews with 300 truck drivers. The report found that drivers experienced significant detention, which reduced their driving hours and potentially led to an income loss. Since then, several other studies have examined aspects of the causes and consequences of truck driver detention. Several factors contributing to detention were identified, including limited facility equipment and staff, products not being ready for shipping, poor scheduling services, and incorrect information provided by drivers. Dunn et al. (2014) analyzed the distribution of stops across different operation types, truck types, and carrier sizes. Using logistic regression and datasets from two third-party vendors over two six-month periods (January to June 2013 and December 2012 to May 2013), they found that refrigerated trucks experienced the longest average detention times.

Three studies have focused on the extent of detention across various truck and driver characteristics, such as truck types, fleet size, length of haul, gender, age, employment status, and business information. U.S. Department of Transportation Office of Inspector General (2018) examined the impact of detention on crash rates and drivers' income using regression models with variables like estimated detention probabilities, average dwell time, and monthly crash rates. This analysis made use of stopping data of 31 carriers from two third-party vendors and crash rate data from FMCSA's Motor Carrier Management Information System in 2013. The study applied a truncated lognormal distribution to measure the likelihood of detention and found that a 5-percent increase in detention probability was associated with a 4.7 percent increase in crash rates. Additionally, for every 15-minute increase in average dwell time, the expected crash rate increased by 6.2 percent, potentially reducing truck drivers' annual income by around $1 billion due to truck drivers always paying by mileage rather than driving hours. Speltz & Murray (2019) studied the impact of detention on truck driver productivity and compliance using surveys and descriptive statistical analysis. These authors found that truck drivers experienced longer detention in 2018 than in 2014, with smaller carriers being more adversely affected due to lower compensation compared to larger carriers. They also found that the average charge for detention fees from customers was slightly lower than the average per hour operating cost. Mera & Sirikande (2022) examined the correlation between detention time and truck driver shortages using six months of ELD log data from a mid-sized U.S. trucking carrier company. They observed that, compared to weekdays, there were higher average detention times on weekends due to several factors such as lack of communication, inexperienced personnel, and the schedule of trucks.

Two recent surveys by industry organizations have sought to understand the extent of detention and its costs for various types of trucks. Owner-Operator Independent Driver Association Foundation (2024) conducted a detention survey in 2023 with 253 respondents. In summarizing the survey results they found that the average weekly waiting time for loading and unloading was 14.3 hours per truck. Additionally, 17 percent of drivers reported never receiving any detention compensation, and 50 percent stated that they lost one to two loads a week due to detention. The survey estimated that drivers paid by mileage could potentially lose $106.2 per hour if detained at a facility.

Building on Speltz & Murray (2019), Leslie & Murray (2024) conducted a follow-up survey with 587 respondents to analyze detention trends from 2014, 2018, and 2023 for three types of trucks: refrigerated (reefers), dry van, and other specialized trucks. They found that while the overall duration of detention decreased by 11.4 percent between 2014 and 2023, 39.3% of drivers experienced detention in 2023. The study revealed that reefers experienced the most detention, followed by dry van trucks. Most detained trucks were held for an extended period of 0-2 hours, while fewer instances lasted between 2-4 hours or longer. Additionally, they found that 67% of trucks imposed a detention fee starting after 2 hours waiting at facilities, with an average of 41.8 percent of these fees being reimbursed across all truck types. The study estimated that the unreimbursed losses due to detention for U.S.-based reefer drivers amounted to over $670 million in 2023.

3.2.2 Hours-of-Service

One of the motivations for studying detention is its relationship to Hours-of-Service (HOS) regulations. To comply with these regulations, truck drivers may choose to drive faster when they encounter detention or anticipate delays at subsequent facilities. Therefore, this part of review focuses on the HOS regulations in transportation and logistics studies, summarizing the commonly used methods and data sources.

Several researchers have studied the changes in HOS regulations (Goel, 2014; Saltzman & Belzer, 2002), the decisions truck drivers make to comply with the new HOS regulations (Goel & Vidal, 2014; Min & Melachrinoudis, 2016; Sartori et al., 2022; Vital & Ioannou, 2020, 2021; Xu et al., 2022) and the impact of HOS regulations on safety outcomes (Apostolopoulos et al., 2014; Chen & Xie, 2014; Chen et al., 2021; Dick et al., 2006; Golias, 2013; Hall & Mukherjee, 2008; Hammond et al., 2021; Hanowski et al., 2009; Heaton, 2005; Lemke et al., 2021; Min, 2009; Pilz et al., 2022). Commonly used methodologies include logistic regression (Chen et al., 2021; Hanowski et al., 2009; Lemke et al., 2021), descriptive statistics analysis (Dick et al., 2006; Speltz & Murray, 2019), bounding methods (Hall & Mukherjee, 2008), and regression model (U.S. Department of Transportation Office of Inspector General, 2018). The typical data sources for these studies are surveys with drivers (Chen et al., 2021; Dick et al., 2006; Lemke et al., 2021;

Speltz & Murray, 2019), focus group interviews with drivers, carrier safety managers and other carrier personnel who completed survey (Dick et al., 2006), field operation tests (Hanowski et al., 2009), census data (Hall & Mukherjee, 2008), FMCSA's Motor Carrier Management Information System (U.S. Department of Transportation Office of Inspector General, 2018).

Among recent studies examining HOS regulations, Pilz et al. (2022) explored how a centralized platform can improve truck drivers' rest schedules and parking assignments, aiming to address the issues of parking scarcity and compliance with HOS regulations. Their computational results indicated that a booking platform reduces organizational overhead performs almost as effectively as a centralized system that has complete knowledge of schedules. Hammond et al. (2021) examined the effects of driver distraction and drowsiness on heavy vehicle drivers. Their research revealed that longer driving hours are positively correlated with an increase in crashes, near crashes, crash-related conflicts, and unintentional lane deviations. Notably, they found that the risk of incidents during the eighth hour of driving is two to three times higher than during the first hour. Lemke et al. (2021) examined the factors that influence compliance with HOS regulations and how this compliance is related to sleep-related safety risks. It finds that lower compliance is associated with longer working hours, a faster work pace, and inadequate sleep. Furthermore, safety risks are more significantly impacted by the level of supervisor support than by HOS compliance itself. The study suggests reducing work hours, improving the relationships between drivers and supervisors, and revisiting HOS policies to enhance overall safety outcomes.

3.2.3 Economics Studies in Truck Industry

To date, no economic studies have focused on detention, rather, this literature focusses on income, safety, and the methods and data used in analysis. For instance, Monaco et al. (2006) concluded that truck driver wages decreased after industry deregulation through policy changes enacted by the Motor Carrier Act of 1980 which significantly reducing federal control over the trucking industry. Belman & Monaco (2005) found that truck drivers earn most of their wages by working longer hours per week, but found there is no advantage in hourly wages compared to other blue-collar occupations. The relationship between truck driver compensation and safety is also a key focus in this literature. For example, Kudo & Belzer (2019) stated that paying truck drivers for non-driving work hours reduces the total number of hours truck drivers work and may reduce driver's safety and health risks. Belzer & Sedo (2018) found that the truck driver's supply curve matches the classic backward-bending labor supply curve meaning that drivers are willing to work fewer hours after receiving their target wages, resulting in safer driving. Savage (2011) proposed targeted policy improvements using a structural model to address market failures associated with the costs of truck crashes. He concluded that the truck safety market needs these minimum standards and mandatory third-party insurance to tackle safety issues effectively

3.3 Data and Methodology

This section includes three main components. First, we develop an algorithm to identify truck dwell times, upper percentile speeds (99^{th} and 95^{th} percentile), median speeds, and average speeds before and after visiting a facility from confidential GPS data provided by ATRI. Second, we summarize the limitations and assumptions of the data. Third, we introduce the model and estimations to explore the correlation between detention and truck speeds.

The American Transportation Research Institute (ATRI) is a nonprofit research organization, primarily conduct transportation research. Since 2002, ATRI has partnered with the trucking industry to continuously collect GPS data on key national corridors (Pinjari et al., 2014). Since 2013, ATRI has been permitted to collected GPS data in Canada (Croken et al., 2024). ATRI possesses extensive experience in commercial vehicle operations, demonstrating leadership or active participation in national freight analyses, technology research initiatives, and field operational tests. The data primarily comes from extensive trucking fleets, which mainly consist of tractor-semitrailer combinations used for long-haul freight transportation (Zanjani et al., 2015). ATRI’s GPS dataset offers nationwide coverage, enabling a detailed analysis of truck movement patterns. With no other GPS datasets matching its detail and scope as ATRI’s GPS dataset, it is an essential asset for our research.

This study utilizes an 8-week period of confidential GPS data provided by ATRI, which includes anonymous truck ID, timestamp, latitude and longitude coordinates (ping locations), and truck instant speed. The data covers two periods, May 1 to May 30 and October 1 to October 31, 2022, and includes GPS pings of trucks visiting one of 15 facilities which are the focus of this study. These facilities were selected to include sites based in different industries, geographic areas, and which receive visits from different types of trucks. These sites are five food processing facilities, five distribution centers, three semiconductor and electric component facilities, one chemical facility, and one crude oil-petroleum refinery based in 12 different states. Three truck types included in the study include reefers, dry van and tanker truck. The raw dataset includes 7,448 unique truck IDs and over 51 million GPS ping observations.

3.3.1 Identify Truck Dwell Time and Speeds

We adopt and refine the algorithms and methods from previous transportation research (Kamali et al., 2016; Thakur et al., 2015; Zanjani et al., 2015) and other related studies (Akter et al., 2018; Camargo et al., 2017; Corro et al., 2019) to identify and develop variables relevant to our research question. This approach enables us to identify truck stops and to calculate dwell durations in facilities while filtering out unqualified data, such as duplicate or short-duration records. Additionally, it allows us to detect truck visits and generate key variables – median speeds, average speeds, and upper percentile speeds for each individual truck visit.

Figure 3.1 outlines the key steps in our algorithms, which are explained in detail later. ArcGIS Pro and Python are applied to analyze the large GPS dataset. For each facility, we first input raw GPS data and use the geocoded address of the facility into ArcGIS. Examples of raw GPS data are presented in **Table 3.1**, including anonymous truck ID, timestamp, latitude and longitude coordinates (ping locations), and truck instant speed. Then, we create a facility bounding box that includes the facility building and its parking lot. In addition, we create a 10-mile geofencing area. **Figure 3.2** presents a simplified depiction of the facility's bounding box area and a 10-mile radius geofenced area in ArcGIS. Based on these two geofencing areas, two dummy variables are created– an in-facility-area and an in-nearby-area. In-facility-area is equal to 1 if the truck GPS pings are located within the facility bounding box, and in-nearby-area is equal to 1 if the pings are located within a 10-mile radius but not in the facility area. This step is unique from previous algorithms (Akter et al., 2018; Camargo et al., 2017; Corro et al., 2019) as it specifically calculates the time trucks spend in the facility or nearby areas in subsequent steps.

[Insert **Figure 3.1** here]

[Insert **Figure 3.2** here]

[Insert **Table 3.1** here]

Next, using Python, duplicate records and short records (those with less than 10 pings) are removed. This data cleaning step is common and has been adopted by several authors including Akter et al. (2018), Camargo et al. (2017), and Corro et al. (2019). Observations which reported that the truck was driving at a speed exceeding 95 mph were also removed.[1] The number of observations excluded from the dataset at each facility due to these three data cleaning steps are reported in **Appendix N**.

Next truck visits to a given facility were identified. To do so, the dataset was sorted by truck ID and timestamp. To extract key variables, such as entry time, exit time, duration hours in facility area, truck speeds (upper percentile speed, median speed and average speed), we employed a two-step iteration. The first loop iterated through each truck ID, and the second loop focused on visits where trucks are identified as being in the facility (in-facility-area variable equal to 1). This two-step iteration approach is a unique innovation of this study as it enables us to capture all truck visits.[2]

Next, GPS data is used to identify whether truck visits were subject to detention and to calculate pre- and post-visit speeds during specified hours for each truck visit. To do so, for each visit, we obtain the entry time into, and the exit time from, the facility. The first key variable, duration time (of truck visit in the facility), is calculated as the difference between the entry and exit time. In addition, we calculate- *Speed* variables- the upper percentile speeds and average moving speed (average speed) within 24 hours pre- and post-visiting the facility using the entry and exit time. A 24-hour period is used in the baseline analysis; this time period was chosen based on ATRI recommendation, as this timeframe captures both drivers' driving and resting hours. Speeds during an alternative 4-hour pre- and post- visit time period is explored through later robustness analysis. We then identified whether the truck stopped in a nearby area (*Parked Nearby*) using the in-nearby-area variable (from ArcGIS process) and the speed data within 24-hour period, and calculated the maximum and cumulative time (*Max Hours Parked Nearby; Cumulative Hours*

[1] ATRI notes that trucks rarely exceed speeds of 85 MPH. As such observations are likely caused by telematics device errors, ATRI removes such observations from its own analyses. Additionally, companies using speed limiters typically set maximum speeds between 62 and 72 MPH. For isolated outliers within a series of pings, ATRI deletes only the specific ping. However, for trucks that consistently generated errors, such as pings in unrealistic locations like the ocean, they removed the entire truck ID from the dataset. Following ATRI's recommendations and accounting for trucks without speed limiters or those potentially driving downhill, we set a higher maximum speed threshold to identify outliers. To this end, we classified instant speeds exceeding 95 MPH as GPS signal errors. Since no consistent extreme speed pings were detected, there was only a need to remove individual pings exceeding this threshold (n=5); no trucks were removed from this dataset. We removed 34 pings across all facilities.

[2] In other detention studies, they identify duration time either through a survey (Leslie & Murray, 2024) or truck drivers' logs (Mera & Sirikande, 2022).

Parked Nearby) a truck was parked in the nearby area before and after visiting the facility. Samples of data after the processing steps are presented in **Table 3.2**.

[Insert **Table 3.2** here]

3.3.2 Data Assumptions and Limitations

The GPS data in this study provides only spatial and temporal information for the truck's head, as the GPS tracker is mounted on the truck's cab rather than the trailer. As a result, certain operational details are unavailable, creating heterogeneity that the GPS data alone cannot capture:

1. Truck Types: GPS data does not provide information on truck types. We identify truck types based on the facility type, with confirmation from ATRI. For instance, the dataset includes five food processors: two are visited exclusively by reefers, one is served solely by dry van trucks, another is accessed only by tanker trucks, and a mix of reefers and dry van trucks visits the remaining facility. Accordingly, our analysis assumes that only the specified types of trucks visit these facilities. We may either overestimate or underestimate the correlation between detention and speeds for refrigerated trucks due to the presence of other types of trucks.
2. Number of Truck Drivers: GPS data does not indicate whether a truck is operated by a single driver or a team of drivers sharing the responsibilities of a single truck. Team drivers typically drive longer hours, which may reduce the impact of detention on their driving behavior compared to solo drivers.
3. Trailer Continuity: It is unclear whether the truck retains the same trailer before and after visiting a facility. If a truck switches trailers, it is likely to spend less time at the facility and may experience detention less frequently.
4. Parking Location and Pre-Arrival Communication: GPS data does not reveal whether a truck waits in the facility's parking lot or in a nearby location, nor does it show if drivers can call ahead to check in to the facility's queue via phone. Two possible scenarios exist: drivers may be instructed to wait nearby until their loading time, or they may first arrive at the facility and then be asked to park nearby until loading. To identify these situations, we rely on a binary variable, *Parked Nearby*, and the recorded duration of stops before and after facility visits.

Due to these data limitations, we assume each truck visit to a facility is an independent event, with detention events occurring independently across visits. We also consider facility type, truck type, state, and month fixed effects in our regressions to control for any systematic but unobserved variance in speed stemming from these characteristics.

3.3.3 Model and Estimation Approach

We apply a unique Equation (3.1) to estimate the correlation between detained status and speed:

$$\begin{aligned} Speed_{ijkts} = {} & \beta_0 + \beta_1 Detained_{ijkts} + \beta_2 Post_{ijkts} + \beta_3 Detained_{ijkts} * Post_{ijkts} + \\ & \beta_4 Parked\ Nearby_{ijkts} + \beta_5 Parked\ Nearby_{ijts} * Post_{ijts} + \\ & \beta_6 Cumulative(or\ Max)\ Hours\ Parked\ Nearby\ _{ijkts} + \\ & \beta_7 Cumulative(or\ Max)\ Hours\ Parked\ Nearby_{ijkts} * Post_{ijkts} + \lambda_{(j)(k)ts} + \varepsilon_{ijkts} \end{aligned} \tag{3.1}$$

where *i* represents truck arriving or leaving the facility, *j* denotes facility type (food processors, distribution centers, semiconductor and electric components, chemicals, petroleum refineries), *k* indicates truck type (reefers, dry van trucks, tanker trucks), *t* represents the month of the observation (May or October). To account for possible differences in speed limits in different states, a fixed effect *s* is also included to denote the state the facility is located in. Depending on the model specification, $Speed$ represents the truck's average or an upper percentile speed. Average speed is calculated as the average moving speed 24 hours before or after visiting the facility. Upper percentile speed is *i*'s 95th or 99th percentile speed during the same two time periods. Median speed is *i*'s 50th percentile speed during the same two time periods. *Detained* is dummy variable equal to 1 if the duration hours in facility area is longer than 2 hours. *Post* is the time indicator for a truck leaving the facility. *Parked Nearby* is dummy variable equal to 1 if a truck parked within a 10-mile radius of the facility's GPS coordinates. The mileage radio was recommended by ATRI experts, who noted that most truck drivers tend to park within this range while waiting for their loading/unloading schedules. A truck parked within a 10-mile radius of the facility's GPS coordinates is referred to as near the facility. *Max Hours Parked Nearby* is the maximum truck stopping hours near the facility. *Cumulative Hours Parked Nearby* is cumulative stopping hours near the facility. The fixed effects terms $\lambda_{(j)(k)ts}$ represent the interaction between facility type, truck type, month, and state, capturing unobserved heterogeneity specific to these dimensions. ε_{ijtks} is an idiosyncratic error term.

Our dataset includes only one chemical facility and one petroleum refinery, with limited observations of 150 and 518 visits, respectively. Due to the small number of visits, these facilities were excluded from facility-specific analyses.

As shown in **Appendix O**, the correlation between the variables duration and detention exceeds 0.5, while the correlation between *Max Hours Parked Nearby* and *Cumulative Hours Parked Nearby* is as high as 0.99. As such, due to the potential of multicollinearity, only one or the other (but not both) of the variables in these sets is included in a given estimation.

In regression analysis, ensuring the validity of model assumptions is crucial for obtaining reliable estimates. One key assumption is homoscedasticity, where the variance of residuals is constant across all levels of the independent variables. To assess the existence of heteroscedasticity in residuals across all levels of the independent variables, we apply the Breusch-Pagan and White tests. Results of these tests are summarized in **Appendix P**. These results indicate the presence of heteroscedasticity, which undermines the reliability of OLS estimates and their associated standard errors.

Given these findings, this analysis instead employs a quantile regression approach. Quantile regression is a statistical method that models the relationship between independent variables and specific percentiles (quantiles) of the dependent variable, rather than just its mean. This approach allows for a detailed analysis of how predictors influence the entire distribution of the outcome, capturing effects that may vary across different levels of the dependent variable. Quantile regression relaxes the restrictive assumptions of homoscedasticity and normality of residuals, and enables us to analyze the impact of detention on driver speed at various conditional quantiles of the speed distribution. Although there are additional alternative estimation methods, such as generalized least squares to address heteroscedasticity, they lack the distributional insights that quantile regression offers. By focusing on different points in the conditional distribution of driver speeds, quantile regression allows us to examine the impact of detention at various speed levels. As such, this approach captures a broader range of speeds effects, thereby offering deeper insights into driver behavior across the distribution of speeds rather than focusing solely on the mean speed.

3.4 Results and Discussion

The section discusses the descriptive results of truck speeds. Then, results of estimated correlations between detention and truck drivers' speeds, analyzed both in aggregate and segmented by truck and facility types is presented. Lastly, we summarize and discuss our findings, providing practical implications and recommendations based on the observed results.

3.4.1 Descriptive Results

In this section, we provide a brief comparison of driving speed across time, various truck types, and facility types when detained and not-detained. Visits to 15 diverse facilities[3] and three types of trucks[4] are considered.

Combining observations across the two examined periods (October and May), our dataset contains 21,424 truck visits. In an average month, 714.13 trucks visited each of the 15 facilities, and 89.03 truck visits were detained. As shown in **Table 3.3**, trucks visiting chemical facilities experience high average monthly detention rates (41.3%), indicating more severe detention conditions compared to other types of facilities. Trucks experience average monthly detention rates of 14.6% at semiconductor and electric component facilities, 14.3% at distribution centers, and 9.5% at food processing facilities. Following this, among the considered sites, distribution centers, food processors, and facilities making semiconductors and electric components, have the highest average monthly visits. Interestingly, however, detention rates vary considerably across time; for all facility types except distribution centers and petroleum refineries, the rates of detention are much higher in October than in May.

[Insert **Table 3.3** here]

In examining driver behavior after being detained, we compared the 99th and 95th percentile speeds and average moving speed separately across three types of trucks. As shown in **Figure 3.3**, standard error bars on the bar figures indicate the range of values within which the true population mean is expected to lie, with a 95% confidence level. For most types of trucks, detention is correlated with trucks having statistically significant differences in their upper and average speeds, including both pre- and post-visit. The upper and average speeds of tanker trucks, in particular, are

[3] Fifteen facilities include food processors, distribution centers, semiconductor and electric components, chemicals, and petroleum refineries.
[4] Three truck types are reefers, dry van trucks, and tanker trucks.

higher when they are detained compared to other types of truck drivers. This can be explained by the observation, as shown in the figure, that tanker truck drivers generally drive slower than other types of truck drivers, providing them with greater potential to increase their speed after being detained. It is also worth noting that the speed of tanker trucks has a relatively large 95% confidence interval, suggesting there is more variability in their speed than other types of trucks.

[Insert **Figure 3.3** here]

The upper percentile and average speeds of detained and not-detained vehicles visiting each type of facility are also examined. Several truck types visited food processors (reefer, dry van, and tanker truck) and semiconductor and electric component facilities (reefer and dry van), while only one truck type visited chemical facilities (tanker truck), petroleum refineries (tanker truck), and distribution centers (dry van). As shown in **Figure 3.4**, there is no significant difference in the upper percentile and average speeds of detained or not-detained vehicles visiting semiconductor and electric component, chemical, or refinery facilities. However, detained vehicles at distribution centers exhibited slightly higher speeds, and those at food processing facilities showed significantly higher speeds than vehicles which are not-detained.

[Insert **Figure 3.4** here]

We then separate the dataset into detained and not-detained subgroups, which allows for a comparison of the driving speed between these groups. We compare the 99th percentile speed, 95th percentile speed and average speed across three periods: (1) both before and after facility visits (24 hours before a visit until 24 hours after a facility visit); (2) the 24-hour period before a visit; and (3) the 24-hour period after a visit. As shown in **Figure 3.5**, detained trucks drove statistically significantly faster than not-detained trucks across all periods, with more pronounced speed differences in average speeds. For example, the average speed of detained trucks is approximately eight mph faster than that of not-detained trucks across all periods. Highway speed limits generally range from 60 to 75 mph across states, with the minimum set at 55 mph and the maximum reaching 85 mph in some areas. Detained trucks, however, drive at speeds around 65 mph in the 95th percentile, which may exceed the speed limits in certain areas.

[Insert **Figure 3.5** here]

The cumulative distribution function (CDF) can be used to depict and compare upper percentile speeds and average speed distributions during the 24-hour periods before and after a visit for detained and non-detained trucks across various facility types (**Figure 3.6**). Trucks arriving at most facilities did not show significantly higher upper percentile speeds compared to not-detained trucks; this is reflected by cases where trends were consistent both 24 hours before and after facility visits. The exception to this was distribution centers where trucks that are detained exhibit higher upper percentile speeds compared to those that are not-detained. However, detained trucks at food processors, distribution centers, and chemical facilities exhibited higher average speeds than not-detained trucks. Detained trucks seemed to drive faster even before arriving at the facility. No significant speed difference was observed between detained and not-detained trucks visiting semiconductor and electric component, and refinery facilities.

[Insert **Figure 3.6** here]

CDF graphs across different truck types are presented in **Figure 3.7**. It is demonstrated here that reefer and tanker trucks had significantly higher upper percentile and average speeds when detained. Detained dry van trucks drive faster than not-detained dry van trucks only in average speed, but there is no significant difference in their upper percentile speeds. In most situations, the findings are consistent with previous observations that detained trucks drive faster even before arriving at the facilities.

[Insert **Figure 3.7** here]

Lastly, before conducting a deeper analysis of the dataset, we applied an 8-hour time frame to calculate truck speeds during the 4 hours before and after visiting a facility. This approach was used to check the robustness of the 48-hour dataset. Analyzing shorter time periods when trucks approach and leave a facility may better capture drivers' immediate behaviors. For instance, truck drivers may drive faster in the final 4 hours before reaching a facility, especially if they are running behind schedule. After being detained at the facility, drivers may initially speed up when leaving to make up for lost time. However, once they feel they are back on schedule, they may adjust to lower, more consistent speeds. This shorter time frame allows us to better capture instances of faster driving behaviors. Additionally, if the pattern of speeds observed in the shorter 8-hour period is consistent with the 48-hour dataset, it provides greater confidence in the robustness and reliability of the 48-hour results.

The CDF can be used to compare 95th percentile, median, and average speed distributions during the 4-hour periods before and after a visit for detained and non-detained trucks across the various truck types, as shown in **Figure 3.8**. Compared to the CDF graphs for 48 hours periods, it shows similar patterns that detained trucks drive faster than not-detained trucks across all types of trucks. In this graph, we display the median speed instead of the 99th percentile speed and observe that its trend is similar to the average speed. Additionally, the difference between pre- and post-speed is slightly larger than between 48 hours in **Figure 3.7**. This aligns with our expectation that shorter time frames are better at capturing faster driving behaviors around the time they stopped at a facility.

CDF graphs across facility types during the 4-hour periods before and after a visit for detained and non-detained trucks are displayed in **Appendix Q**. The trends are similar to **Figure 3.6**. Detained trucks visiting distribution centers are significantly faster than not-detained trucks for all types of speeds. Detained trucks visiting food processors and semiconductor and electric component facilities are significantly faster than not-detained trucks in median speed and average speed. Since the trends in speed over both short and long time periods are consistent, the remainder of this analysis is focused on the baseline time period of 24-hours before and after facility visits.

[Insert **Figure 3.8** here]

The differences found between upper percentile speeds and average speed may be partially explained by different speed limits in different areas and installment of the speed limiter on some of the trucks. Upper percentile speeds most likely reflect driver behavior on highways, while average speeds provide insights into driver behavior across both highways and local roads. Speed limiters are installed directly on the engine and automatically limit a vehicle's speed. As a result, their impact on speed does not necessarily reflect driver behavior. On interstate highways with higher speed limits (65 mph or above), truck drivers are at most able to drive 10 to 15 mph faster due to the constraints imposed by speed limiters.[5] However, for vehicles with adjustable speed limiters, on roads with a 45 mph speed limit, trucks might be able to drive 20 mph (+) faster than

[5] There are typically two types of truck speed limiters. Adjustable speed limiters allow drivers or trucking companies to manually set the speed limit based on regulations and their preferences. Intelligent speed limiters, on the other hand, use GPS and road sign recognition to identify the posted speed limit on the road and dynamically adjust the truck's speed. If the driver exceeds the posted speed limit, the system alerts the driver and automatically reduces the vehicle's speed (Hurt Trucker Attorneys, n.d.).

the speed limit. Thus, detention may result in an increase in the average speed more than the upper percentile speeds. Also important is the finding that detained truck drivers drive faster, on average, even 24 hours before visiting the facility, compared to not-detained drivers. Two scenarios may explain this finding: (1) Through experience (their own or that of others) drivers might anticipate that they may be detained before arriving at the facility and may try to get an earlier spot in queue, or (2) they were already behind schedule.

Finally, detailed descriptive statistics can be found in **Tables 3.4** to **3.6**. Merging pre- and post-visit data, we have a total of 42,848 observations for the next steps in our empirical analysis.[6] As shown in **Table 3.4**, across all facilities and truck types, on average, detained trucks exhibit about 2 mph higher upper percentile speeds, 12 mph higher median speed, and 8 mph higher in average speeds. Interestingly, the standard deviation of speeds for not-detained trucks is 3 to 5 mph larger than that for detained trucks, indicating more varied driving behavior among drivers when not encountering detention. The average maximum speed of detained trucks is 66.21 mph, exceeding highway speed limits in some states, which range from 55 to 65 mph. Similarly, the average median speed of detained trucks is 55.79 mph, surpassing the 55 mph limit on certain highways and the 45 mph limit on local roads. **Table 3.5** shows that detained trucks visiting food processors, distribution centers, and petroleum refineries have higher means across all speed measures than not-detained trucks, aligning with our previous observations. Specifically, the average maximum speed of detained trucks visiting food processors, distribution centers, and semiconductor and electric component facilities is approximately 66 mph, again exceeding highway speed limits in some states. Similarly, the average median speed of detained trucks visiting distribution centers is about 57.7 mph, surpassing the 55 mph highway limit and the 45 mph limit on local roads. **Table 3.6** reveals that detained trucks generally drive faster than not-detained trucks across truck types, with dry van trucks, in particular, showing higher speeds compared to other truck types. The average maximum speed of detained dry van and tanker trucks is around 66.5 mph, exceeding highway speed limits of 55 to 65 mph. Similarly, the average median speed of detained dry van and tanker trucks is 56.5 mph and 62.2 mph, respectively, exceeding both the 55 mph highway limit and the 45 mph local road limit.

[6] Observations are truck visits approaching or leaving the facility. Our dataset includes only one chemical facility and one petroleum refinery facility, with very limited observations—150 and 518, respectively. Due to the relatively small number of visits to these facilities, they were excluded in these further analyses.

[Insert **Table 3.4** here]

[Insert **Table 3.5** here]

[Insert **Table 3.6** here]

In summary, these figures and tables offer important insights into driving behavior under detention conditions. Detained trucks generally drive faster than not-detained trucks, especially in terms of median and average speeds. Intuition might suggest that detention only affects vehicle speed after visiting the facility. However, this analysis finds that drivers may also choose riskier driving behavior before they are detained if, for example, if they believe they are behind or at risk of missing their scheduled loading/unloading time. Tanker trucks, reefers and trucks visiting food processor facilities were more impacted by detention than other types of trucks and facilities. Drivers visiting semiconductor and chemical facilities exhibited the highest maximum speed regardless of detention with large 95% confidential interval, but they drove faster on average when detained. Detention is positively correlated with speed, but the magnitude of this relationship varies across different industry segments.

As mentioned earlier in this section, while the findings are largely consistent, the 99^{th} percentile speed reflects more extreme scenarios compared to the 95^{th} percentile speed. Therefore, our discussion primarily focusses on the results from the 95^{th} percentile speed. To enhance readability and interpretation, we have continued naming the 95^{th} percentile speed as the maximum speed in the rest context of this discussion.

3.4.2 Empirical Analyses

This section presents results examining the relationship between detention and truck drivers' speeds. Utilizing quantile regressions from the 0.25 to 0.75 quantiles, the analysis provides a comprehensive understanding of how characteristics of a truck's detention (or not-detention) is correlated with driver speeds overall, and by truck and facility types. The 0.25 quantile focuses on the lower end of the speed distribution, representing drivers who are driving slower than 75% of their peers. The 0.5 quantile, also known as the median, reflects the typical driver speed and gives insights into the central tendency of the data. The 0.75 quantile examines the upper end of the distribution, highlighting drivers who exceed the speeds of 75% of their fellow drivers. By focusing on specific quantiles, this approach captures variations in speed behaviors among slower, median, and faster drivers, offering a perspective on the relationship between detention and speed across different truck and facility types. We present the main results from quantile regressions between 0.25 to 0.75 of Equation (1) across all truck visits in **Table 3.7**. Subsequent analyses explore if there are any systematic differences in these results for trucks of different types, or visits to different types of facilities.

[Insert **Table 3.7** here]

As shown in **Table 3.7**, there are similar relationships among the truck's maximum (95^{th} percentile), median, and average speeds, and key variables between the 0.25, 0.5, and 0.75 quantiles. The coefficient of *Detained* in Column (1) is 1.80 and statistically significant, indicating that for drivers in the lower quartile (0.25 quantile group), being detained is associated with an increase of 1.8 mph in their maximum speed,[7] compared to those who were not-detained. We observed that the *Post* variable which indicates the truck leaving the facility and the interaction term of *Detained* and *Post* are not statistically significant. This indicates that the maximum speed in the lower quartile during the 24 hours before visiting the facility does not differ significantly from the speed observed in the 24 hours after leaving the facility. These results suggest that detention does not appear to influence maximum speed behavior for drivers in the lower quartile when comparing pre-visit and post-visit periods. The coefficients for *Cumulative Hours Parked Nearby* (-0.18) and its interaction term with *Post* (-0.04) are both statistically significant and negative indicating that one hour longer cumulative parking near the facility is associated with a decrease of 0.18 mph in the maximum speed. This suggests that extended parking duration in nearby areas tends to reduce the highest observed speeds. Furthermore, the interaction term indicates an additional decrease of 0.04 mph in the maximum speed in the 24 hours after leaving the facility, which further underscores the trend that extended parking duration near the facility has a small but sustained effect in reducing higher end driving speeds among the group of slower moving vehicles.

Columns (2) and (3) present the results of the maximum speed of trucks travelling in the median and 0.75 quantile groups. Most of the coefficients in these columns are of a smaller magnitude, but of the same sign and statistical significance compared to those reported in Column

[7] Here the 95^{th} percentile speed is assumed to be the truck's maximum speed.

(1). The exception to this is the *Detained* variable which is not statistically significant for 0.75 quartile drivers (Column (3)). This indicates that detention has a stronger correlation with maximum speeds for drivers in the lower quantile than those in the higher quantile – perhaps because the higher quartile drivers are already typically travelling at speeds closer to speed limits or restricted by speed limiters. For median quantile drivers, if the truck encounters detained, averagely the truck will drive 0.46 mph in maximum speed. Similarly, the coefficients for *Cumulative Hours Parked Nearby* and its interaction term with *Post* are more negatively correlated with maximum speed in the lower quantile than in the higher quantile. This indicates that extended parking duration and its post-visit effects reduce speeds more significantly for slower drivers than for faster ones.

Columns (4) to (6) present the results of the median speed (50^{th} percentile speed) for the highest to lowest groups. Results in Column (4), are similar to those in Column (1), but with a large magnitude. This suggests that while detention and other variables continue to influence the median speed, their effects are more pronounced than the 95^{th} percentile. Compared to Column (4), *Detained* is statistically significant in Column (5) and Column (6) but of a lower magnitude indicating that the median speed in the higher quantile group is slightly more associated with detention compared to the lower quantile group. This reflects that drivers with lower average speeds respond by driving faster when they encounter detention. *Post* and its interaction term with *Detained* are not statistically significant. The coefficients of *Parked Nearby* from vehicle median speeds are all negative and statistically significant, indicating that if the truck parks in a nearby area, truck drivers drive slower than if it does not park in the nearby area. The coefficients of *Cumulative Hours Parked Nearby* from columns (4) to (6) are all small, negative, and statistically significant indicating that for an additional hour of parked time, trucks travel at 0.13 to 0.26 mph slower at median speeds. The interaction terms of *Parked Nearby* and *Cumulative Hours Parked Nearby* with *Post are* not statistically significant. This indicates that trucks parked nearby or parked for an additional hour upon leaving the facility do not show a significant difference in median speeds compared to trucks that are not parked nearby or do not park for an additional hour.

Columns (7) to (9) present the results for average speed across quantiles, ranging from lower to higher percentiles. Compared to Column (1), which represents the results of maximum speed, there are more significant results for *Post*, *Parked Nearby*, and their interaction term. From

Columns (7) to (9) the coefficients for *Detained* are all statistically significant and positive, indicating that detention consistently increases average speeds across all quantile groups. However, the magnitude of the effect decreases from 5.04 mph to 2.37 mph as the quantile increases from 0.25 to 0.75, suggesting that detention is more strongly correlated with average speeds for drivers in the lower than in the higher quantile. This pattern implies that slower drivers respond to detention more in terms of their average speed, while faster drivers exhibit relatively smaller changes in response to detention. This decreasing magnitude highlights the diminishing sensitivity of higher-speed drivers to the effects of detention on their average speed. The coefficient for *Post* is statistically significant and positive, indicating that average truck speeds are higher after leaving the facility compared to when approaching the facility. For median quantile drivers, their average speed increases by 0.51 mph when leaving the facility. The coefficients for *Parked Nearby* and its interaction with *Post* are both negatively statistically significant. This indicates that the presence of parking in nearby areas is associated with a decrease of about 4 mph for lower and median group drivers and 3 mph for higher group drivers in average speed. Furthermore, the negative coefficient of its interaction with Post indicates that trucks drive even slower when parked near the facility after leaving. The coefficients for *Cumulative Hours Parked Nearby* are statistically significant and negative, indicating that longer cumulative parking durations near the facility are associated with lower speeds. Additionally, the interaction term between *Cumulative Hours Parked Nearby* and *Post* in the median quantile drivers is also negative and statistically significant. This implies that the slowing effect of extended parking duration is even more pronounced after trucks leave the facility for drivers in the median speed group.

In addition to these findings, results from several additional analyses are presented in **Appendix R**. For instance, detailed analyses of average speed using *Max Hours Parked Nearby* and its interaction with *Post* instead of cumulative variables, spanning from the lower to higher percentiles. The results align with those obtained from the *Cumulative* variables. We chose to present the *Cumulative* results as they effectively capture all stopping behavior near the facility. These analyses offer a comprehensive illustration of the methods employed and the insights derived, showcasing the broader scope of our approach. By exploring patterns across the speed groups, it reinforces the robustness and depth of our findings.

Table 3.8 presents the results assessing differences in the maximum speed across different truck types. Columns (1) to (3) show the results for reefer trucks, spanning from the lower to higher quantiles. It is found here that the coefficient for *Detained* is 0.94, statistically significant and positive only in the higher quantile indicating that faster-driving reefer trucks are more likely to further increase their maximum speeds when detained. Specifically, if high-quantile reefer truck drivers encounter detention, their maximum speed increases by 0.94 mph. The coefficients for *Parked Nearby* are -0.87 and -1.6, statistically significant and negative in the median and higher quantiles, respectively. This indicates that if reefer trucks park nearby, their maximum speeds decrease by 0.87 MPH and 1.6 MPH for each group of drivers, respectively. This suggests that drivers operating at moderate or high speeds may reduce their speed if they have had to park in a nearby area. However, the interaction term between *Parked Nearby* and *Post* is statistically significant and positive in the median quantile. This indicates that, for the group of refer drivers who travel at median speeds, parked nearby led to an increase of 0.76 mph in their maximum speed during the 24 hours after leaving the facility. The *Cumulative Parked* variable and its interaction with *Post* are consistent with the previous findings, showing a negative correlation with maximum speed. For instance, among median quantile reefer truck drivers, parking nearby results in an average reduction of 0.24 mph in maximum speed. Additionally, when leaving the facility, these drivers reduce their speed further by 0.05 mph on average.

[Insert **Table 3.8** here]

In columns (4) to (6), we observe that detention is positively associated with maximum speed in the lower and median quantiles for dry vans Specifically, if lower quantile dry van truck drivers encounter detention, their maximum speed increases by 1.77 mph. Similarly, median quantile dry van truck drivers increase their maximum speed by 0.87 mph when detained. Additionally, in the median quantile of maximum speed, the coefficient for *Parked Nearby* is positive, indicating that *Parked Nearby* is associated with an increase in maximum speeds for drivers in this group. Specifically, median quantile dry van truck drivers increase their maximum speed by 0.38 mph when parked nearby. The *Cumulative Parked* variable and its interaction with *Post* are consistent with the previous findings, showing a negative correlation with maximum speed. For example, among median quantile dry van truck drivers, parking nearby results in an average reduction of 0.03 mph in maximum speed. Additionally, when leaving the facility, these drivers reduce their maximum speed further by 0.02 mph on average.

For tanker trucks detention is not significantly related to maximum speed at any quantiles, that encountering detention is not correlated with the maximum speed of tanker trucks. In the lower quantile analysis, the coefficient for *Post* is statistically significant and negative, indicating that tanker truck drivers tend to drive slower after leaving the facility compared to when they are approaching it. Specifically, lower quantile tanker truck drivers reduce their maximum speed by 1.19 mph after leaving the facility. The *Cumulative* variables are consistent with previous findings, showing a negative correlation with maximum speed, meaning that longer cumulative parking durations near the facility are associated with lower maximum speeds. For example, median quantile tanker truck drivers reduce their maximum speed by 0.73 mph after parking an additional hour nearby. However, the interaction term between *Cumulative* variables and *Post* is statistically significant and positive in both the lower quantile and higher quantile. This suggests that longer parking durations are generally associated with an increase of 0.29 mph in maximum speeds when leaving the facility.

Table 3.9 presents the results of the correlation between detention and other variables on median speed across different truck types. Columns (1) to (3) show the results for reefers, spanning from the lower to higher quantiles. The coefficient for *Detained* is statistically significant and positive only in the median quantile. This suggests that median-driving reefer trucks are more likely to increase their median speeds by 1.05 mph when detained. The coefficient for *Parked Nearby* is statistically significant and negative in the lower and median quantiles. This suggests that drivers operating at low or moderate speeds may reduce their speed by 5.47 mph and 3.03 mph, respectively, when parked nearby. The interaction term between *Parked Nearby* and *Post* is not statistically significant, indicating no correlation between trucks parked nearby after visiting the facility and their median speed. The coefficients of *Cumulative Hours Parked Nearby* are statistically significant and negative, indicating that each additional hour of cumulative parking reduces reefer drivers' median speeds by 0.19 mph to 0.53 mph, with a greater impact observed among higher-quantile drivers. However, the coefficients of its interaction with *Post* are positive and statistically significant, suggesting that reefer drivers tend to drive faster at median speeds by

0.11 mph to 0.28 mph, with the effect increasing from lower quantile to higher quantile drivers, if they spend more time parked in nearby areas after visiting facilities.

[Insert **Table 3.9** here]

From Columns (4) to (6), we observe that detention is positively associated with median speed across all quantiles for dry vans. Specifically, lower quantile dry van drivers increase their median speed by 9 mph when detained, while median quantile drivers increase their median speed by 6 mph. Higher-quantile drivers show a smaller increase, raising their median speed by 2.51 mph when detained. These results highlight a decreasing impact of detention on speed as driver quantiles increase. The coefficient for *Post* is negative and statistically significant for lower quantile dry van drivers, indicating that only lower quantile drivers reduce their median speed by 0.98 mph when leaving facilities. Additionally, for all quantiles of median speed, the coefficient for *Parked Nearby* is negative and statistically significant, indicating that the presence of *Parked Nearby* is associated with a decrease in median speeds, ranging from 11.97 mph for lower-quantile drivers to 2 mph for higher-quantile drivers. The *Cumulative* variable and its interaction with *Post* show negatively correlate with median speed. For example, among median quantile dry van truck drivers, parking nearby results in an average reduction of 0.2 mph in median speed. Additionally, when leaving the facility, these drivers reduce their median speed further by 0.02 mph on average.

For tanker trucks, from Columns (7) to (9), detention is positively and statistically significantly correlated to median speed for lower and median speed drivers. Specifically, lower quantile tanker truck drivers increase their median speed by 8 mph when detained, while median quantile drivers increase their median speed by 2.75 mph. In the lower quantile analysis, the coefficient for *Post* is statistically significant and negative, indicating that tanker truck drivers tend to drive 7 mph slower after leaving the facility compared to when they are approaching it. The *Cumulative* variables align with previous findings, showing a negative correlation with median speed. This indicates that longer cumulative parking durations near the facility are associated with a 0.3 mph decrease in median speeds. However, the interaction term between *Cumulative* variables and *Post* is statistically significant and positive in the lower quantile. This suggests that longer parking durations are generally associated with a 0.12 mph increase in median speeds after leaving the facility.

As shown in **Table 3.10**, the results present the correlations between detention and other variables on average speed across truck types, spanning from lower to higher quantiles. From Columns (1) to (3), the coefficient for *Detained* is positive and statistically significant in the lower and median quantiles. This indicates that detention is associated with increases in average speed of 1.03 mph and 1.59 mph, respectively, for reefer trucks in these quantiles. The coefficient for *Parked Nearby* is significant and negative in the lower and median quantiles, indicating that the presence of nearby parking areas is associated with decreases in average speed of 3.11 mph and 3.40 mph, respectively, for reefer trucks in these groups. The coefficient for *Cumulative Hours Parked Nearby* is negative and significant across all quantiles, suggesting that longer cumulative parking durations are generally associated with decreases in reefer trucks' average speeds, ranging from 0.16 mph to 0.48 mph. However, the interaction term between *Cumulative Hours Parked Nearby* and *Post* is positive and significant in the median and higher quantiles. This indicates that when leaving the facility, reefers in these quantiles tend to increase their average speeds by 0.03 mph and 0.22 mph, respectively, after spending extended durations in parking areas.

[Insert **Table 3.10** here]

From Columns (4) to (6), the results indicate that the average speed of dry vans is positively correlated with detention, with a larger increase observed in the lower quantile (6.19 mph) compared to the higher quantile (2.69 mph). This suggests that detention has a stronger impact on increasing average speed for slower dry vans than for faster ones. Both *Parked Nearby* and *Cumulative Hours Parked Nearby* are negatively correlated with average speed across all quantiles. The presence of parked vehicles nearby is associated with a reduction of approximately 4 mph in average speed, while extended parking durations are associated with a smaller decrease of less than 0.5 mph in average speed for dry vans. The *Post* variable is positively correlated with average speed in the higher quantile, suggesting that faster dry vans tend to increase 0.61 mph their speeds after leaving the facility compared to when approaching it. *Parked Nearby* interaction with *Post* shows a negative relationship with average speed in the lower and higher percentiles. Dry van trucks reduce their average speed by 0.59 mph and 0.73 mph in these quantiles, respectively, when parked nearby upon leaving the facility. *Cumulative Hours Parked Nearby* interaction with *Post* is negatively correlated with average speed in the median quantile. This suggests that when leaving the facility, dry vans in the median quantile tend to decrease their average speed by 0.02 mph after spending extended durations in parking areas.

From columns (7) – (9), detention is positively correlated with the average speed of tanker trucks in the lower and median quantiles. This suggests that for slower and median speed tanker truck drivers, detention is associated with increases in their average speed by 7.37 mph and 4.71 mph, respectively. Both *Post* and *Parked Nearby* are negatively correlated with average speed in the lower quantile. This indicates that lower quantile tanker truck drivers reduce their average speed by 4.9 mph when leaving the facility. Additionally, these drivers reduce their average speed by 5.62 mph when parked nearby. The interaction between *Detained* and *Post* is positively correlated with average speed in the lower quantile. Lower quantile tanker truck drivers increase their average speed by 6.22 mph when they experience detention and leave the facility. The interaction between *Parked Nearby* and *Post* is also positively correlated with average speed in the lower quantile. Lower quantile tanker truck drivers increase their average speed by 3.84 mph when they park nearby after visiting the facility. *Cumulative Hours Parked Nearby* is negatively correlated with average speed across all quantiles, suggesting that longer cumulative parking durations are generally associated with decreases in tanker trucks' average speeds, ranging from 0.36 mph to 0.48 mph.

Table 3.11 presents the results of correlations between *Detained* and other variables on maximum speed across facility types, spanning from lower to higher quantiles. From Columns (1) to (3), for trucks visiting food processors, detention is negatively correlated with maximum speed. Trucks reduce their maximum speed when experiencing detention, with decreases ranging from 0.48 mph in the lower quantile to 1 mph in the higher quantile. Interaction between *Detained* and *Post* is positively correlated with maximum speed in the lower quantile. This indicates that trucks visiting food processors increase their maximum speed by 0.41 mph when they experience detention and leave the facility. *Parked Nearby* also is positively correlated with maximum speed in the median quantile, implying that the presence of parked vehicles nearby increases the maximum speed by 1 mph for trucks with median quantile speeds. *Cumulative Hours Parked Nearby* negatively correlated with maximum speed, consistent across quantiles, suggesting that longer cumulative parking durations are generally associated with decreases in trucks' maximum speeds, ranging from 0.03 mph to 0.01 mph.

[Insert **Table 3.11** here]

For trucks visiting distribution center, Columns (4) – (6), detention is positively correlated with maximum speed, indicating that detained trucks tend to drive faster, with increases ranging from 1.94 mph in the lower quantile to 0.37 mph in the higher quantile. In contrast, *Cumulative Hours Parked Nearby* and its interaction with *Post* are negatively correlated with maximum speed, suggesting that longer cumulative parking durations are associated with decreases in maximum speeds, ranging from 0.3 mph to 0.05 mph.

For trucks visiting semiconductors and electric components facilities, Columns (7) - (9), detention negatively correlated with maximum speed. Trucks reduce their maximum speed when experiencing detention, with decreases of 0.98 mph in the lower quantile and 0.6 mph in the higher quantile. *Parked Nearby* is negatively correlated with maximum speed across all quantiles, indicating that the presence of parked vehicles nearby decreases maximum speed, with reductions ranging from 2.94 mph in the lower quantile to 0.97 mph in the higher quantile. Interaction between *Parked Nearby* and *Post* negatively correlated with maximum speed in the higher quantile. For higher quantile drivers, the presence of parked vehicles nearby after visiting a facility reduces maximum speed by 0.64 mph. *Cumulative Hours Parked Nearby* negatively correlated with maximum speed but its interaction with *Post* is negatively correlated with maximum speed, but its interaction with *Post* is negative in the lower quantile and switches to positive in the median quantile. Longer cumulative parking durations after visiting a facility are associated with a 0.06 mph decrease in maximum speed in the lower quantile but a 0.05 mph increase in the median quantile.

Table 3.12 presents the results of correlations between detention and other variables on median speed across facility types, spanning from lower to higher quantiles. For trucks visiting food processors, from Columns (1) - (3), detention is positively correlated with median speed in the median and higher quantiles, indicating increases of 3.95 mph and 4 mph, respectively. The coefficients of variable *Post* and its interaction with *Detained* are not statistically significant, suggesting no significant difference in median speed when trucks leave the facility or when they experience detention before leaving. Additionally, the coefficients of *Parked Nearby*, *Cumulative Hours Parked Nearby*, and its interaction with *Post* are all negatively correlated with median speed, indicating that trucks parked nearby, longer stopped nearby, and longer parked nearby after visiting the food processing facility drive slower than in contrary situations. For example, for lower quantile trucks visiting food processors, the presence of parked vehicles nearby decreases median speed by 6.35 mph, while each additional hour of cumulative parking nearby contributes to a further reduction of 0.09 mph in median speed.

[Insert **Table 3.12** here]

From Columns (4) - (6) for trucks visiting distribution centers, detention shows a similar positive correlation with median speed as observed for food processors. However, the magnitude of this association is more pronounced in the lower quantile and diminishes in the higher quantile. Trucks experiencing detention show an increase in median speed ranging from 10.5 mph in the lower quantile to 1.98 mph in the higher quantile. *Parked Nearby* and *Cumulative Hours Parked Nearby* also exhibit a similar negative correlation with median speed. For example, for lower quantile trucks visiting food processors, the presence of parked vehicles nearby decreases median speed by 12.33 mph, while each additional hour of cumulative parking nearby contributes to a further reduction of 0.15 mph in median speed. There are no significant effects of *Post* or its interaction with other variables, suggesting that post-visit speed adjustments are not as pronounced for trucks visiting distribution centers.

From Columns (7) - (9) for trucks visiting semiconductor and electric component facilities, detention is positively correlated with median speed in the slower and median quantile groups. Trucks experiencing detention exhibit an increase in median speed of 7.06 mph in the lower quantile and 5 mph in the median quantile. *Post* positively correlated with median speed across all quantiles, indicating that trucks visiting semiconductor and electric component facilities drive faster, with increases ranging from 5.27 mph in the lower quantile to 1.5 mph in the higher quantile. However, the interaction between *Detained* and *Post* negatively correlated with median speed in the median quantile, suggesting that trucks reduce their median speed by 5 mph when experiencing detention and leaving the facility. *Parked Nearby* negatively correlated with median speed in lower and median quantiles. For example, for lower quantile trucks visiting semiconductor and electric component facilities, the presence of parked vehicles nearby decreases median speed by 6.08 mph. In addition, its interaction with *Post* negatively correlated with median speed in all quantiles, , suggesting that the presence of parked vehicles nearby after visiting a facility reduces median speed, ranging from 6.19 mph in the lower quantile to 3.91 mph in the higher quantile. *Cumulative*

Hours Parked Nearby also shows a negative association with median speed in low and median quantiles, consistent with previous findings. For instance, an additional hour of cumulative parking nearby reduces median speed by 0.22 mph in the higher quantile truck group.

Table 3.13 presents the results of correlations between detention and other variables on average speed across facility types, spanning from lower to higher quantiles. For trucks visiting food processors, from Columns (1) - (3), detention is positively correlated with average speed in the median and higher quantiles, suggesting increases of 3.35 mph and 5.06 mph, respectively. The variable *Post* and its interaction with *Detained* are positively correlated with average speed in the median quantile only. Trucks drive 0.66 mph faster when leaving the facility, while trucks experiencing detention and leaving the facility increase their average speed by 0.92 mph. In contrast, *Parked Nearby* and its interaction with *Post*, as well as *Cumulative Hours Parked Nearby* and its interaction with *Post*, are all negatively correlated with average speed. For example, the presence of parked vehicles nearby decreases average speed by 3.01 mph in lower quantiles, while each additional hour of cumulative parking nearby contributes to a further reduction of 0.06 mph in average speed.

[Insert **Table 3.13** here]

For trucks visiting distribution centers, from Columns (4) - (6), detention shows a similar positive association with average speed as observed for food processors. However, the magnitude of the association is larger in the lower quantile and smaller in the higher quantile compared to trucks visiting food processors. Trucks experiencing detention show an increase in average speed ranging from 7.53 mph in the lower quantile to 1.53 mph in the higher quantile. *Parked Nearby* also exhibits a similar negative correlation with average speed. For example, the presence of parked vehicles nearby decreases average speed by 4.75 mph in lower quantiles. Unlike food processors, however, there are no significant effects of *Post* or its interaction with other variables, suggesting that post-visit speed adjustments are not as pronounced for trucks visiting distribution centers.

For trucks visiting semiconductor and electric component facilities, from Columns (7) - (9), detention is positively correlated with average speed in the lower and median quantiles. This suggests that detained trucks, at average speed, drive 3.22 mph and 1.68 mph faster in lower quantile and median quantile. *Post* is positively correlated with average speed across all quantiles, suggesting that trucks increase their average speed when leaving the facility, with increases ranging from 2.38 mph in the lower quantile to 2.58 mph in the higher quantile. However, the interaction between *Detained* and *Post* is negatively correlated with average speed in the lower quantile. This suggests that trucks reduce their average speed by 2.24 mph when experiencing detention and leaving the facility. *Parked Nearby* negatively correlated with average speed in lower and median quantile, but it shows a positive association with average speed in high quantile. This indicates that trucks reduce their average speed by 3.66 mph and 1.76 mph in the lower and median quantiles, respectively, when parked vehicles are nearby, but increase their average speed by 3.09 mph in the higher quantile under similar conditions. *Cumulative Hours Parked Nearby* also shows a negative association with average speed across all quantiles, consistent with previous findings. For instance, an additional hour of cumulative parked vehicles nearby decreases average speed by 0.13 mph in the lower quantiles. However, its interaction with *Post* is positively correlated with average speed in the higher quantile, suggesting that an additional hour of cumulative parking nearby, combined with leaving the facility, increases average speed by 0.17 mph.

3.4.3 Discussion

This analysis finds that detention plays a significant role in truck drivers' speeds, with the correlation between detention and speed varying across facility types, truck types, and speed quantiles. In general, detention is positively correlated with speeds in the lower quantiles, particularly for slower drivers (i.e. those in the 0.25 quantile), suggesting compensatory behavior to recover lost time. However, this association diminishes in higher quantiles, reflecting the limited capacity of faster drivers to further increase their speeds, potentially due to posted speed limits and/or speed limiter constraints. Detention generally has a stronger correlation with median and average speeds than with maximum speeds across truck types and facility types.

As this is the first study to examine the relationship between truck detention and speed, these findings help fill gaps in the understanding of how truck detention is correlated with driver behavior. These findings are particularly relevant in light of data on speeding-related crashes. According to *The Critical Impact of Speeding on Trucking Safety: A Data-Driven Analysis* (The Law Firm for Truck Safety, 2024), on average, speeding account for approximately 28% of fatal crashes annually. Department of Transportation (2016) estimated that setting a speed limit of 60 mph for heavy vehicles could save between 162 and 498 lives annually, while a 65 mph limit could save 63 to 214 lives annually, and a 68 mph limit could save 27 to 96 lives annually. The descriptive results show that the 99th percentile speed mean for detained trucks is 67.71 mph, which exceeds the typical truck speed limit on highways. This, combined with our findings that detention has a statistically significant positive correlation with maximum speed, suggests a concerning relationship: detention may encourage drivers to exceed speed limits to compensate for lost time. Such behavior not only violates regulations but also heightens the risk of crashes, further underscoring the link between detention and safety concerns.

In addition, *Traffic Safety Facts 2022 Data: Speeding* (U.S. Department of Transportation, 2024) reported that 87% of those speeding related fatal crashes are occurred on non-interstate roads with lower speed limits than interstates. Our findings show that detention has a larger magnitude correlation with median and average speeds than maximum speeds, indicating that detention may also be associated with crashes on roads with relatively lower speed limits. The mean median speed of detained trucks in this dataset is 55.75 mph, significantly exceeding the typical 45 mph speed limit on local roads. Moreover, an additional 15 minutes of average monthly dwell time (the total time a truck is stopped at a facility) is associated with a 6.2% increase in average crash rates for that carrier(U.S. Department of Transportation Office of Inspector General, 2018). This underscores the critical safety risks associated with detention-induced speeding and the importance of addressing operational inefficiencies to mitigate such behaviors and improve trucking safety.

Other than the generally positive correlations between detention and speed, for trucks visiting food processors and semiconductor and electric component facilities, detention is negatively correlated with maximum speed. These results may stem from the nature of the products handled at these facilities, which are often more time-sensitive than those at other facility types. The mean maximum speeds of not detained trucks visiting food processors and semiconductor and electric component facilities are 64.9 mph and 66.9 mph, respectively, which are close to or exceed the typical posted speed limit of 65 mph on highways. As a result, regardless of whether detention occurs, drivers may already be driving as fast as operational or physical constraints allow.

In general, *Post* is positively correlated with average speed across the aggregated dataset at all quantile levels, as well as with both median and average speeds for semiconductor and electric component facilities across all quantiles. This indicates that, on average, truck speeds tend to increase after leaving the facility. However, for tanker trucks, the *Post* variable is negatively correlated with median and average speeds in the lower quantile, suggesting that slower tanker truck drivers tend to reduce their median and average speeds after leaving the facility. This may reflect cautious driving behavior, operational adjustments, or specific conditions affecting tanker truck drivers in this speed group. Interestingly, the interaction between *Detained* and *Post* is positively correlated with both median and average speeds for tanker trucks in the lower quantile. This suggests that for slower tanker truck drivers, the combined effect of detention and post-departure conditions leads to an increase in median speed and average speed, likely reflecting compensatory behavior to recover lost time after delays.

Parked-related variables, particularly *Parked Nearby*, are predominantly negatively correlated with average speed in the aggregated data, and across different truck types and facility types. This suggests that the presence of nearby parking areas is generally associated with reduced driving speeds well the trucks are moving. The slowdown is likely due to compliance with HOS regulations, which mandate drivers to rest during designated hours. For maximum speed, reefers and trucks visiting semiconductor and electric component facilities exhibit a consistent negative correlation with *Parked Nearby*, underscoring the broader slowing effect of parking proximity for these types. However, there are some notable exceptions. For instance, *Parked Nearby* shows an unexpected positive correlation with average speed in the higher quantile for semiconductor and electric component facilities, suggesting that faster drivers may accelerate when they parked near the facility. Similarly, maximum speed for trucks visiting food processors in the lower quantile and for dry vans in the median quantile also show positive correlations, possibly reflecting compensatory behaviors or situational conditions that lead to increased speeds in these specific cases.

The interaction between *Parked Nearby* and *Post* is negatively correlated with average speed in the aggregated data, as well as for dry vans and trucks visiting semiconductor and electric component facilities. The interaction terms are negatively correlated with median speed for trucks visiting semiconductor and electric component facilities across all groups of drivers. This suggests that the presence of parking areas near facilities, combined with post-departure conditions, tends to reduce average speeds for these truck types. However, a few exceptions to this trend are observed. For instance, the interaction shows a positive association with maximum speed for reefers in the median quantile, indicating that reefer trucks operating at median speeds may increase their speeds under these conditions. This could reflect efforts to compensate for delays or navigate efficiently through parking-related congestion, such as detention in nearby areas, which prompts drivers to accelerate after departure.

The other parking-related variable, *Cumulative Hours Parked Nearby*, consistently exhibits a negative correlation with speed across the aggregated dataset, as well as for different truck types and facility types. This finding suggests that longer cumulative parking durations near facilities tend to reduce truck speeds. If a truck decides to stay longer in the vicinity of a facility, it is possibly scheduling rest periods in nearby areas either before or after visiting the facility. This behavior reflects that drivers are operating in alignment with their delivery schedules and do not feel the need to rush.

The interaction between *Cumulative Hours Parked Nearby* and *Post* is predominantly negatively correlated with speed across the aggregated dataset, truck types, and facility types. This consistent trend suggests that prolonged parking durations near the facility, combined with post-facility driving, generally result in slower speeds. This behavior likely reflects longer dwell times in the vicinity of a facility, possibly due to scheduling rest periods in nearby areas after visiting the facility. It also indicates that drivers are operating in alignment with their delivery schedules and do not feel the need to rush, promoting a more measured and deliberate approach to driving. However, exceptions to this general pattern emerge in specific contexts, where the interaction term is positively correlated with speed. For trucks visiting semiconductor and electric component facilities, the interaction term is positively linked to average speed in the higher quantile, indicating that faster drivers visiting semiconductor and electric component facilities tend to accelerate after leaving the facility when they have spent extended time in parking near the facility. Similarly, for reefers, the interaction is positively correlated with average speed in the median and higher quantiles, reflecting compensatory behavior among reefer drivers to recover time lost during prolonged parking durations.

3.5 Conclusion

Stakeholders and policymakers in the trucking industry are increasingly recognizing detention as an emerging issue linked to truck drivers' safety and supply chain resilience. Detention refers to instances where a truck spends more than two hours waiting or loading or unloading at a facility.

Unexpected detention can disrupt truck drivers' original schedules for subsequent deliveries and driving plans, potentially leading to inefficiencies and safety risks, such as speeding to catch up with the next schedule (U.S. GAO, 2011). This study investigates the correlation between vehicle detention and other variables such as *Parked Nearby*, *Cumulative Hours Parked Nearby* and post-facility driving behaviors on truck drivers' speed. These relationships are explored across facility types, truck types, utilizing quantile regression analyses spanning from the 0.25 to the 0.75 quantiles. By analyzing aggregated and disaggregated data of various type of trucks and facilities, we provide a comprehensive understanding of how detention influences driver speeds, offering insights into behavioral patterns among slower, median, and faster drivers. The inclusion of fixed effects (facility type, truck type, state, and month) ensures robustness by accounting for unobserved heterogeneity. In doing so, this study is the first to examine the correlation between detention and truck drivers' behavior across different types of trucks and facility sites. Additionally, our analysis bridges traditional transportation GPS data with economic methodologies, offering a novel approach and filling gaps in understanding the behavioral adjustment and safety concerns associated with detention.

The first objective of this study was to explore the role of detention in shaping truck speeds across upper percentile, median, and average speeds, considering various truck and facility types. Through the analysis, it was found that detention is generally positively correlated with speeds in the lower quantiles, particularly for slower drivers, suggesting compensatory behavior to recover lost time. However, this association diminishes in the higher quantiles, reflecting the limited capacity for faster drivers to further increase speeds, likely due to operational or physical constraints. Notably, trucks visiting food processors and semiconductor and electric component facilities exhibit a negative correlation with maximum speed, likely because the time-sensitive nature of their products leads drivers to consistently drive as fast as possible, regardless of detention, leaving little room for speed adjustments.

The second objective of this study was to examine the correlation between factors other than detention and truck speeds across various types of trucks and facilities. The analysis reveals that factors other than detention exhibit different signs of correlation with speed variables under varying conditions. *Post* is generally positively correlated with average speed across the aggregated dataset at all quantile levels, as well as for trucks visiting semiconductor and electric component facilities across all quantiles. However, a notable exception is observed with tanker truck drivers, who typically prefer to drive at slower median and average speeds after leaving the facility. Interestingly, when tanker truck drivers experience detention, they exhibit compensatory behavior by driving faster after leaving the facility, suggesting an effort to recover lost time despite their usual preference for slower speeds.

Parking-related variables, such as *Parked Nearby* and *Cumulative Hours Parked Nearby*, as well as their interactions with *Post*, are predominantly negatively correlated with speeds. These findings suggest that most truck drivers who choose to park near a facility, either before or after visiting, are pre-planning to comply with HOS regulations, such as taking a 30-minute rest or meeting required sleeping hours. This alignment between parking behavior and delivery schedules reflects a deliberate effort to ensure compliance and manage operational timing. As a result, these drivers are less likely to speed. However, positive associations emerge in specific contexts, such as higher quantile drivers for semiconductor and electric component facilities and mid-quantile maximum speeds for trucks visiting food processors and dry vans, reflecting situational compensatory behaviors. In these cases, drivers may not have willingly chosen to park in nearby areas but were instead required to wait due to facility-related constraints or operational delays. This forced waiting could lead to adjustments in driving speeds, particularly among drivers aiming to compensate for lost time or meet subsequent schedules. These mixed results highlight the context-specific nature of post-facility driving behaviors, influenced by operational dynamics, truck types, and facility conditions. Understanding these interactions is critical for designing tailored strategies to address the unique challenges faced by different segments of the trucking industry.

These findings underscore the critical need for industry stakeholders to address detention issues to enhance both safety and efficiency within the trucking sector. The positive correlation between detention and increased speeds—particularly among slower drivers—points to a potential rise in risky driving behavior as drivers attempt to compensate for lost time. This highlights the urgency of implementing strategies to mitigate detention times and improve scheduling practices. By reducing operational delays, stakeholders can not only support safer driving behaviors but also improve overall supply chain performance, benefiting drivers, logistics companies, and end consumers alike.

We can also offer actionable recommendations for industry policymakers and facility operators to address detention issues. First, detention is a critical concern that requires attention. Policymakers could require detention compensation for truck drivers, ensuring that drivers are fairly compensated for lost revenue during delays. Facility operators, on the other hand, can focus on addressing key factors contributing to detention, such as poor communication, inexperienced staff, and overbooking (Mera & Sirikande, 2022). By mitigating these issues, operators can reduce detention times and alleviate the pressure placed on drivers. Furthermore, a public sector action could be established to mandate those facilities responsible for causing detention cover detention fees as an accountability measure. This approach would incentivize improved operational efficiency. A similar approach is seen in the U.S. airline industry, where passengers are entitled to compensation for delays caused by overbooking. For instance, U.S. airlines must provide financial compensation or rebooking options to affected passengers, ensuring accountability and encouraging better planning. Adopting such an action in the trucking industry would not only provide fair compensation for drivers but also promote efficiency and responsibility among facility operators.

3.5.1 Limitations and Future Studies

ATRI's GPS dataset provides nationwide coverage, allowing for a detailed analysis of truck movement patterns. It is widely used in research related to transportation and logistics. With no other GPS dataset matching its level of detail and scope, it serves as an essential resource for our study. In spite of these benefits, using GPS data for this type of analysis has some limitations. Since truck IDs are associated with the tractor rather than the trailer, we cannot definitively identify the type of trailer being used. For instance, even when analyzing trucks entering and exiting refrigerated facilities, we cannot confirm that they are equipped with refrigerated trailers. Additionally, as previously mentioned, GPS data does not provide information on truck types. To address this, we identify truck types based on facility types and recommendations from ATRI, assuming that only the specified types of trucks visit these facilities. However, this assumption may lead to either an overestimation or underestimation of the correlation between detention and speeds for refrigerated trucks due to the potential presence of other types of trucks in the dataset. In addition, the GPS data does not offer any information about the vehicle driver(s). For the purposes of this analysis, it would have been useful to know whether a single driver or a team operates a truck. Due to the stricter limitations imposed by their driving hours, single drivers may be more impacted by detention. As a result, our analysis cannot account for the potential heterogeneity in how detention affects single versus team drivers.

While this study offers some important and novel contributions in both its findings and methodological approach, there are several ways in which it could be usefully extended. In future analyses, it would be helpful to conduct robustness checks of key results, such as considering alternative parking distances from the facility location (e.g., a 5-mile radius instead of a 10-mile radius) and to explore alternative time periods prior to and after facility visits such as adjusting the time period from 24 hours to 12 hours intervals.

This analysis could also be extended to estimate the correlation between speed and detention across different types of roads, such as highways and local roads, to compare variations in truck speeds relative to speed limits. Further, additional factors, such as weather conditions (e.g., rain or snow) or road conditions (e.g., construction or closures) could also be incorporated into the analysis as these can impact truck driving speed both during the disruption and potentially afterward if it causes them to be behind in their schedules. Adding such control variables could help prevent underestimating the effects of detention on driver behavior. Additionally, we can analyze how frequently and how long trucks are delayed at previous stops, which may also affect truck speed and lead to late arrivals (and possible detainment) at their subsequent stops.

Furthermore, we can continue to explore the relationship between safety and detention in the future. For example, we can use accident rate data to explore the correlation between accident rates and detention would provide additional valuable insights for enhancing driver safety and reducing road incidents.

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Table 3.1 Sample of Raw GPS Data

Truck ID	Read date	Latitude	Longitude	Speed
12345	2022/10/01-10:00:02	35.788399	-78.674126	65
12345	2022/10/01-10:02:08	35.790372	-78.673983	55
12345	2022/10/01-10:04:20	35.788166	-78.673983	58
12345	2022/10/01-10:06:48	35.788665	-78.673335	23
12345	2022/10/01-10:07:15	35.788399	-78.668393	0
12345	2022/10/01-10:09:03	35.791460	-78.674004	38
78901	2022/10/03-00:10:02	35.788368	-78.669648	0
78901	2022/10/03-00:11:57	35.792323	-78.672394	23
78901	2022/10/03-00:14:23	35.788692	-78.672277	55
78901	2022/10/03-00:15:55	35.791137	-78.673211	47
78901	2022/10/03-00:17:26	35.783762	-78.676483	66

Note: The numbers in the table are only examples and do not represent the actual dataset.

Table 3.2 Sample of Data after Data Processing

Truck ID	Entry time	Exit time	Duration time	Upper percentile speed pre entry facility	Upper percentile speed post exit facility	Average speed pre entry facility	Average speed post exit facility	Parked nearby pre entry facility	Parked nearby post exit facility	Max duration time parked nearby pre entry facility	Max duration time parked nearby post exit facility
12345	2022/10/01 - 10:00:02	2022/10/01 - 10:09:03	9 minutes 1 second	75	68	55	65	0	1	0	30 minutes
78901	2022/10/03 - 00:10:02	2022/10/03 - 00:17:26	7 minutes 24 seconds	69	68	58	55	1	0	48 minutes	0

Note: The numbers in the table are only examples and do not represent the actual dataset.

Table 3.3 Detention Rate across Facilities

Type of Facility	Number of Facilities	Truck Types	Region	Number of Average Monthly Visits	Average Monthly Detentions		Average Detentions by Month (%)	
					% (Min, Max)	Number	May	October
Food Processors	5	Reefer, Dry Van, Tanker Truck	East, Midwest, South, West	796.8	9.5% (3.8, 69.4)	75.6	8.0%	11.1%
Distribution Centers	5	Dry Van	East, Midwest, West	1130.6	14.2% (0.3, 32.9)	161.1	14.5%	14.0%
Semiconductor and Electric Component Facilities	3	Reefer, Dry Van	East, South, West	302.7	14.6% (2.9, 20.8)	44.3	13.5%	15.7%
Chemical Facilities	1	Tanker Truck	Midwest	37.5	41.3% (17.2, 56.5)	15.5	17.2%	56.5%
Petroleum Refineries	1	Tanker Truck	South	129.5	2.7% (2.0, 3.0)	3.5	3.7%	2.0%

Notes: Regions are categorized as States in the analyses. Average monthly value represents the simple average across facilities for both May and October.

Table 3.4 Descriptive Statistics, All Vehicles

	All					Detained					Not-Detained				
	Obs.	Mean	SD	Min	Max	Obs.	Mean	SD	Min	Max	Obs.	Mean	SD	Min	Max
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
95th Percentile Speed	42,848	63.90	10.03	6	87.75	5,342	66.21	6.99	7	81	37,506	63.57	10.35	6	87.75
99th Percentile Speed	42,848	65.94	9.28	6	91.30	5,342	67.71	6.91	7	82	37,506	65.69	9.55	6	91.30
50th Percentile Speed	42,848	44.97	18.84	6	78	5,342	55.79	13.92	7	77	37,506	43.43	18.94	6	78
Average Speed	42,848	41.43	13.03	6	72.41	5,342	48.72	10.11	7	72.26	37,506	40.39	13.07	6	72.41
Duration in Facility (hour)	42,848	2.31	9.65	0	353.00	5,342	15.65	23.28	2.000	353.0	37,506	0.41	0.46	0	2
Post	42,848	0.50	0.50	0	1	5,342	0.50	0.50	0	1	37,506	0.50	0.50	0	1
Cumulative Hours Parked Nearby	42,848	9.15	19.50	0	641.50	5,342	2.83	13.78	0	556.70	37,506	10.05	20.02	0	641.50

Table 3.5 Descriptive Statistics by Facility Type

	All					Detained					Not-Detained				
	Obs. (1)	Mean (2)	SD (3)	Min (4)	Max (5)	Obs. (6)	Mean (7)	SD (8)	Min (9)	Max (10)	Obs. (11)	Mean (12)	SD (13)	Min (14)	Max (15)
Food Processors															
95th Percentile Speed	15,936	65.0	10.3	6	82.9	1,512	66.1	6.6	9.9	81	14,424	64.9	10.6	6	82.9
99th Percentile Speed	15,936	67.2	9.2	6	86.4	1,512	67.8	6.3	10.0	82	14,424	67.1	9.5	6	86.4
50th Percentile Speed	15,936	45.6	17.8	6	78	1,512	54.1	17.1	7.5	77	14,424	44.8	17.6	6	78
Average Speed	15,936	42.2	13.2	6	72.3	1,512	49.4	12.9	8.5	72.3	14,424	41.5	13.0	6	72.3
Duration in Facility (h)	15,936	0.9	4.1	0	164.8	1,512	7.4	11.2	2.0	164.8	14,424	0.2	0.5	0	2.0
Post	15,936	0.5	0.5	0	1	1,512	0.5	0.5	0	1	14,424	0.5	0.5	0	1
Cumulative Hours Parked Nearby	15,936	10.0	20.2	0	632.9	1,512	3.7	20.2	0	556.7	14,424	10.7	20.1	0	632.9
Distribution Centers															
95th Percentile Speed	22,612	63.3	8.6	6	87.8	3,222	66.4	6.4	8.9	79	19,390	62.8	8.8	6	87.8
99th Percentile Speed	22,612	65.4	7.9	6	91.3	3,222	67.9	6.3	9.0	81.4	19,390	65.0	8.1	6	91.3
50th Percentile Speed	22,612	44.5	19.6	6	78	3,222	57.7	11.2	7.5	77	19,390	42.4	19.9	6	78
Average Speed	22,612	40.9	12.8	6	72.4	3,222	49.0	8.1	7.9	72.2	19,390	39.5	13.0	6	72.4
Duration in Facility (h)	22,612	3.4	12.2	0	353.0	3,222	21.0	26.0	2.0	353.0	19,390	0.5	0.3	0	2.0
Post	22,612	0.5	0.5	0	1	3,222	0.5	0.5	0	1	19,390	0.5	0.5	0	1
Cumulative Hours Parked Nearby	22,612	9.7	20.2	0	641.5	3,222	2.7	10.9	0	196.1	19,390	10.9	21.2	0	641.5
Semiconductor and Electric Components															
95th Percentile Speed	3,632	66.8	6.9	6	81	532	65.9	9.1	9.9	80	3,100	66.9	6.5	6	81
99th Percentile Speed	3,632	68.0	6.7	6	84	532	67.2	9.2	10.0	81	3,100	68.2	6.2	6	84
50th Percentile Speed	3,632	47.3	16.1	6	78	532	49.5	15.2	7	77	3,100	46.9	16.2	6	78
Average Speed	3,632	43.7	10.3	6	71.4	532	44.9	10.6	8	71.1	3,100	43.5	10.3	6	71.4
Duration in Facility (h)	3,632	2.1	9.4	0	167.4	532	8.4	23.5	2.0	167.4	3,100	1.1	0.5	0	2
Post	3,632	0.5	0.5	0	1	532	0.5	0.5	0	1	3,100	0.5	0.5	0	1
Cumulative Hours Parked Nearby	3,632	1.0	5.4	0	89.0	532	0.7	3.2	0	40.5	3,100	1.1	5.7	0	89.0

Table 3.5 (continued)

Chemicals															
95th Percentile Speed	150	66.6	6.7	7	75.3	62	65.8	9.3	7	73	88	67.2	3.9	41.25	75.3
99th Percentile Speed	150	67.7	6.8	7	78.9	62	66.7	9.5	7	75.0	88	68.4	3.9	43.45	78.9
50th Percentile Speed	150	58.0	13.7	7	71	62	61.6	11.8	7	71	88	55.5	14.5	11	71
Average Speed	150	52.9	10.6	7	66.2	62	56.1	9.9	7	66.2	88	50.6	10.5	19.17	65.6
Duration in Facility (h)	150	1.5	1.1	0	4.6	62	2.6	0.6	2.0	4.6	88	0.8	0.7	0	1.8
Cumulative Duration Nearby Facility	150	1.7	4.6	0	33.7	62	3.2	6.7	0	33.7	88	0.6	1.6	0	14.0
Petroleum Refineries															
95th Percentile Speed	518	35.7	23.1	6	77.2	14	42.4	24.9	15	74	504	35.5	23.1	6	77.2
99th Percentile Speed	518	37.4	23.0	6	83	14	43.3	24.6	16.4	74	504	37.3	23.0	6	83
50th Percentile Speed	518	23.9	20.0	6	73	14	30.3	24.2	9	69	504	23.7	19.8	6	73
Average Speed	518	23.1	16.6	6	66.0	14	28.1	17.9	9.6	52.5	504	22.9	16.6	6	66.0
Duration in Facility (h)	518	0.3	1.8	0	25.8	14	7.8	7.8	2.1	25.8	504	0.1	0.3	0	1.8
Post	518	0.5	0.5	0	1	14	0.5	0.5	0	1	504	0.5	0.5	0	1
Cumulative Hours Parked Nearby	518	16.8	14.7	0	67.5	14	9.6	8.9	0	25.2	504	17.0	14.8	0	67.5

Table 3.6 Descriptive Statistics by Truck Type

	All					Detained					Not-detained				
	Obs. (1)	Mean (2)	SD (3)	Min (4)	Max (5)	Obs. (6)	Mean (7)	SD (8)	Min (9)	Max (10)	Obs. (11)	Mean (12)	SD (13)	Min (14)	Max (15)
Reefer															
95th Percentile Speed	4,748	59.3	11.1	7	78.8	650	64.3	6.3	37.3	78	4,098	58.5	11.5	7	78.8
99th Percentile Speed	4,748	62.8	9.1	7	82.2	650	66.6	6.1	41.8	81	4,098	62.2	9.3	7	82.2
50th Percentile Speed	4,748	42.4	22.1	6.5	73	650	54.1	13.1	8	72	4,098	40.6	22.6	6.5	73
Average Speed	4,748	39.6	17.1	7	67.1	650	48.5	10.7	12.0	65.7	4,098	38.1	17.5	7	67.1
Duration in Facility (h)	4,748	1.7	6.4	0	164.8	650	9.2	15.4	2.0	164.8	4,098	0.6	0.5	0	2
Post	4,748	0.5	0.5	0	1	650	0.5	0.5	0	1	4,098	0.5	0.5	0	1
Cumulative Hours Parked Nearby	4,748	5.1	14.2	0	632.9	650	2.2	9.1	0	104.8	4,098	5.5	14.8	0	632.9
Dry Van															
95th Percentile Speed	34,062	64.7	8.9	6	87.8	3,972	66.5	6.2	8.9	80	30,090	64.4	9.1	6	87.8
99th Percentile Speed	34,062	66.6	8.3	6	91.3	3,972	68.0	6.1	9.0	81.4	30,090	66.4	8.5	6	91.3
50th Percentile Speed	34,062	45.3	18.3	6	78	3,972	56.5	13.4	7.5	77	30,090	43.8	18.3	6	78
Average Speed	34,062	41.6	12.2	6	72.4	3,972	48.7	9.3	7.9	72.2	30,090	40.7	12.2	6	72.4
Duration in Facility (h)	34,062	2.4	10.1	0	353.0	3,972	17.9	24.4	2.0	353.0	30,090	0.3	0.4	0	2.0
Post	34,062	0.5	0.5	0	1	3,972	0.5	0.5	0	1	30,090	0.5	0.5	0	1
Cumulative Hours Parked Nearby	34,062	10.4	20.6	0	641.5	3,972	3.1	15.3	0	556.7	30,090	11.3	21.0	0	641.5
Tanker Truck															
95th Percentile Speed	1,054	51.6	23.4	6	81	306	66.7	11.0	7	81	748	45.4	24.3	6	79
99th Percentile Speed	1,054	53.0	23.1	6	83	306	67.6	11.0	7	82	748	47.0	24.0	6	83
50th Percentile Speed	1,054	42.1	25.2	6	77	306	62.2	13.9	7	77	748	33.8	24.0	6	75
Average Speed	1,054	39.1	21.5	6	72.3	306	57.1	12.3	7	72.3	748	31.7	20.1	6	72.3
Duration in Facility (h)	1,054	2.6	5.4	0	45.9	306	8.1	7.6	2.0	45.9	748	0.3	0.5	0	2.0
Post	1,054	0.5	0.5	0	1	306	0.5	0.5	0	1	748	0.5	0.5	0	1
Cumulative Hours Parked Nearby	1,054	10.8	20.2	0	474.7	306	3.4	7.9	0	66.7	748	13.7	22.8	0	474.7

Table 3.7 Factors Affecting the 95th Percentile (Maximum), 50th Percentile (Median), and Average Truck Speeds

	Maximum Speed			Median Speed			Average Speed		
	0.25_QR	0.5_QR	0.75_QR	0.25_QR	0. 5_QR	0.75_QR	0.25_QR	0.5_QR	0.75_QR
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Detained	1.80***	0.46***	0.02	7.54***	5.00***	2.01***	5.04***	3.97***	2.37***
	(0.21)	(0.16)	(0.07)	(0.40)	(0.51)	(0.45)	(0.26)	(0.28)	(0.36)
Post	0.00	-0.00	-0.00	0.54	0.51	0.00	0.87***	0.51**	0.82**
	(0.19)	(0.15)	(0.07)	(0.38)	(0.48)	(0.43)	(0.24)	(0.25)	(0.32)
Detained*Post	0.07	0.00	-0.00	0.38	-0.01	0.09	-0.14	0.08	0.05
	(0.29)	(0.23)	(0.10)	(0.55)	(0.70)	(0.62)	(0.36)	(0.39)	(0.49)
Parked Nearby	0.20	-0.06	0.00	-9.98***	-5.70***	-1.93***	-4.14***	-4.07***	-3.06***
	(0.16)	(0.13)	(0.06)	(0.32)	(0.40)	(0.36)	(0.21)	(0.22)	(0.28)
Parked Nearby*Post	-0.07	-0.00	0.01	-0.46	-0.59	-0.07	-1.00***	-0.58*	-0.99***
	(0.22)	(0.17)	(0.08)	(0.44)	(0.56)	(0.49)	(0.28)	(0.30)	(0.38)
Cumulative Hours Parked Nearby	-0.18***	-0.07***	-0.04***	-0.13***	-0.20***	-0.26***	-0.13***	-0.13***	-0.15***
	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)
Cumulative Hours Parked Nearby*Post	-0.04***	-0.02***	-0.01***	-0.02*	-0.01	-0.01	-0.01	-0.01**	0.01
	(0.01)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Constant	64.87***	66.08***	69.00***	57.46***	62.00***	64.00***	51.83***	55.34***	58.18***
	(0.53)	(0.42)	0.02	(1.02)	(1.30)	(1.15)	(0.67)	(0.72)	(0.91)
Observations	42,848	42,848	42,848	42,848	42,848	42,848	42,848	42,848	42,848
Fixed Effects: j, k, t, s	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pseudo R^2	0.271	0.173	0.147	0.300	0.233	0.089	0.307	0.221	0.122

Notes: Post is a dummy variable that equals 1 if the truck's speed is calculated during the time period after leaving the facility, and 0 otherwise. Parked Nearby is a dummy variable that equals 1 if the truck is parked within 10-mile radius of the facility, either before or after visiting, and 0 otherwise. Cumulative Hours Parked Nearby represents the cumulative hours of the truck spends parked near the facility, either before or after visiting. Fixed effects for facility type (*j*), truck type (*k*), month (*t*), and state (*s*) are incorporated into the analyses.

Table 3.8 Factors Affecting Truck Maximum Speed by Truck Types

	Reefer			Dry van			Tanker Truck		
	0.25_QR	0.5_QR	0.75_QR	0.25_QR	0. 5_QR	0.75_QR	0.25_QR	0.5_QR	0.75_QR
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Detained	0.00	0.38	0.94*	1.77***	0.87***	0.01	0.85	-0.90	1.29
	(0.25)	(0.33)	(0.53)	(0.25)	(0.16)	(0.07)	(0.55)	(2.33)	(2.46)
Post	0.00	0.00	-0.60	0.00	0.05	0.00	-1.19*	-0.73	0.29
	(0.23)	(0.30)	(0.48)	(0.23)	(0.15)	(0.07)	(0.71)	(3.00)	(3.17)
Detained*Post	0.00	-0.27	0.06	0.14	-0.05	-0.01	1.19*	0.63	-1.71
	(0.35)	(0.46)	(0.75)	(0.34)	(0.23)	(0.10)	(0.71)	(2.99)	(3.16)
Parked Nearby	0.00	-0.87***	-1.60***	0.25	0.38***	0.00	-0.64	0.17	1.00
	(0.20)	(0.26)	(0.42)	(0.20)	(0.13)	(0.06)	(0.58)	(2.45)	(2.59)
Parked Nearby*Post	0.26	0.76**	0.85	-0.14	-0.06	0.01	0.46	1.19	-0.91
	(0.27)	(0.35)	(0.57)	(0.27)	(0.18)	(0.08)	(0.77)	(3.24)	(3.43)
Cumulative Hours Parked Nearby	-0.25***	-0.24***	-0.32***	-0.17***	-0.07***	-0.03***	-0.46***	-0.73***	-0.43***
	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.02)	(0.07)	(0.07)
Cumulative Hours Parked Nearby*Post	-0.06***	-0.05***	0.17***	-0.05***	-0.03***	-0.02***	0.07***	0.05	0.29***
	(0.01)	(0.01)	(0.02)	(0.01)	(0.00)	(0.00)	(0.02)	(0.08)	(0.08)
Constant	65.00***	66.97***	69.81***	66.15***	69.70***	73.09***	67.15***	70.00***	71.71***
	(0.25)	(0.34)	(0.54)	(0.21)	(0.14)	(0.06)	(0.59)	(2.49)	(2.64)
Observations	4,748	4,748	4,748	34,062	34,062	34,062	1,054	1,054	1,054
Fixed Effects: j, t, s	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pseudo R^2	0.509	0.339	0.0835	0.119	0.106	0.165	0.607	0.425	0.153

Notes: Post is a dummy variable that equals 1 if the truck's speed is calculated during the time period after leaving the facility, and 0 otherwise. Parked Nearby is a dummy variable that equals 1 if the truck is parked within 10-mile radius of the facility, either before or after visiting, and 0 otherwise. Cumulative Hours Parked Nearby represents the cumulative hours of the truck spends parked near the facility, either before or after visiting. Fixed effects for facility type (*j*), month (*t*), and state (*s*) are incorporated into the analyses.

Table 3.9 Factors affecting Detained and Average Speed by Truck Types

	Reefer			Dry van			Tanker Truck		
	0.25_QR	0.5_QR	0.75_QR	0.25_QR	0. 5_QR	0.75_QR	0.25_QR	0.5_QR	0.75_QR
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Detained	1.00	1.05*	0.62	9.00***	6.00***	2.51***	8.00***	2.75*	1.88
	(0.85)	(0.57)	(2.65)	(0.45)	(0.65)	(0.49)	(1.50)	(1.44)	(2.98)
Post	-0.72	0.01	-0.00	-0.98**	-0.00	0.00	-7.00***	0.00	-0.12
	(0.78)	(0.53)	(2.43)	(0.45)	(0.65)	(0.49)	(1.94)	(1.86)	(3.84)
Detained*Post	0.29	0.55	0.38	0.98	0.18	0.19	7.00***	0.25	0.12
	(1.21)	(0.82)	(3.78)	(0.62)	(0.89)	(0.67)	(1.93)	(1.85)	(3.83)
Parked Nearby	-5.47***	-3.03***	-0.99	-11.97***	-6.91***	-2.00***	-5.41***	-0.90	-0.83
	(0.68)	(0.46)	(2.11)	(0.36)	(0.52)	(0.39)	(1.58)	(1.52)	(3.13)
Parked Nearby*Post	0.23	-0.92	-0.79	0.99*	-0.23	-0.21	5.41***	1.23	1.45
	(0.92)	(0.62)	(2.88)	(0.51)	(0.73)	(0.55)	(2.09)	(2.01)	(4.14)
Cumulative Hours Parked Nearby	-0.19***	-0.17***	-0.53***	-0.12***	-0.20***	-0.24***	-0.34***	-0.31***	-0.32***
	(0.02)	(0.02)	(0.07)	(0.01)	(0.01)	(0.01)	(0.05)	(0.04)	(0.09)
Cumulative Hours Parked Nearby*Post	0.11***	0.13***	0.28***	-0.02**	-0.02	-0.02**	0.12**	-0.00	0.08
	(0.03)	(0.02)	(0.09)	(0.01)	(0.01)	(0.01)	(0.05)	(0.05)	(0.10)
Constant	59.72***	61.99***	64.00***	51.28***	57.50***	63.50***	57.00***	64.25***	68.50***
	(0.87)	(0.59)	(2.73)	(0.39)	(0.57)	(0.43)	(1.61)	(1.54)	(3.19)
Observations	4,748	4,748	4,748	34,062	34,062	34,062	1,054	1,054	1,054
Fixed Effects: j, t, s	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pseudo R^2	0.526	0.420	0.077	0.260	0.205	0.086	0.499	0.556	0.329

Notes: Post is a dummy variable that equals 1 if the truck's speed is calculated during the time period after leaving the facility, and 0 otherwise. Parked Nearby is a dummy variable that equals 1 if the truck is parked within 10-mile radius of the facility, either before or after visiting, and 0 otherwise. Cumulative Hours Parked Nearby represents the cumulative hours of the truck spends parked near the facility, either before or after visiting. Fixed effects for facility type (*j*), month (*t*), and state (*s*) are incorporated into the analyses.

Table 3.10 Factors affecting Detained and Average Speed by Truck Types

	Reefer			Dry van			Tanker Truck		
	0.25_QR	0.5_QR	0.75_QR	0.25_QR	0. 5_QR	0.75_QR	0.25_QR	0.5_QR	0.75_QR
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Detained	1.03*	1.59***	1.48	6.19***	4.47***	2.69***	7.37***	4.71***	2.20
	(0.55)	(0.54)	(1.85)	(0.32)	(0.34)	(0.37)	(1.18)	(1.58)	(2.54)
Post	0.00	0.39	0.44	0.32	-0.10	0.61*	-4.90***	-0.88	0.80
	(0.50)	(0.50)	(1.70)	(0.29)	(0.31)	(0.35)	(1.52)	(2.03)	(3.27)
Detained*Post	-0.15	0.65	0.62	-0.07	0.23	-0.02	6.22***	1.73	-0.15
	(0.78)	(0.77)	(2.63)	(0.44)	(0.47)	(0.52)	(1.52)	(2.03)	(3.26)
Parked Nearby	-3.11***	-3.40***	-1.94	-4.34***	-4.72***	-3.79***	-5.62***	-1.48	-0.98
	(0.44)	(0.43)	(1.47)	(0.25)	(0.27)	(0.30)	(1.24)	(1.66)	(2.67)
Parked Nearby*Post	0.15	-0.44	-0.75	-0.59*	-0.08	-0.73*	3.84**	0.96	1.76
	(0.59)	(0.59)	(2.01)	(0.34)	(0.36)	(0.40)	(1.64)	(2.19)	(3.53)
Cumulative Hours Parked Nearby	-0.16***	-0.18***	-0.48***	-0.12***	-0.12***	-0.13***	-0.36***	-0.48***	-0.44***
	(0.02)	(0.02)	(0.05)	(0.01)	(0.01)	(0.01)	(0.04)	(0.05)	(0.08)
Cumulative Hours Parked Nearby*Post	-0.01	0.03*	0.22***	-0.01	-0.02***	-0.01	0.06	0.07	0.12
	(0.02)	(0.02)	(0.07)	(0.01)	(0.01)	(0.01)	(0.04)	(0.05)	(0.09)
Constant	52.89***	55.61***	57.87***	43.93***	49.16***	54.10***	51.36***	57.57***	62.14***
	(0.56)	(0.56)	(1.90)	(0.28)	(0.29)	(0.32)	(1.26)	(1.69)	(2.72)
Observations	4,748	4,748	4,748	34,062	34,062	34,062	1,054	1,054	1,054
Fixed Effects: j, t, s	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pseudo R^2	0.514	0.392	0.0977	0.247	0.182	0.112	0.523	0.533	0.368

Notes: Post is a dummy variable that equals 1 if the truck's speed is calculated during the time period after leaving the facility, and 0 otherwise. Parked Nearby is a dummy variable that equals 1 if the truck is parked within 10-mile radius of the facility, either before or after visiting, and 0 otherwise. Cumulative Hours Parked Nearby represents the cumulative hours of the truck spends parked near the facility, either before or after visiting. Fixed effects for facility type (*j*), month (*t*), and state (*s*) are incorporated into the analyses.

Table 3.11 Correlation between Detained and Maximum Speed by Facility Type

	Food Processors			Distribution Centers			Semiconductors		
	0.25_QR	0.5_QR	0.75_QR	0.25_QR	0. 5_QR	0.75_QR	0.25_QR	0.5_QR	0.75_QR
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Detained	-0.48***	-0.74**	-1.01***	1.94***	1.29***	0.37***	-0.98***	-0.07	-0.60**
	(0.16)	(0.32)	(0.19)	(0.21)	(0.13)	(0.11)	(0.34)	(0.17)	(0.29)
Post	0.00	-0.00	-0.01	0.00	-0.00	0.00	0.00	0.00	-0.00
	(0.17)	(0.33)	(0.20)	(0.19)	(0.12)	(0.09)	(0.23)	(0.11)	(0.19)
Detained*Post	0.41*	0.72	0.07	0.06	0.01	0.08	0.10	0.07	0.60
	(0.23)	(0.45)	(0.27)	(0.29)	(0.18)	(0.143)	(0.48)	(0.24)	(0.40)
Parked Nearby	0.02	1.00***	0.08	0.12	0.02	0.00	-2.94***	-1.00***	-0.97***
	(0.13)	(0.25)	(0.15)	(0.17)	(0.11)	(0.09)	(0.25)	(0.12)	(0.21)
Parked Nearby*Post	0.14	0.02	0.03	-0.07	-0.01	0.00	0.06	-0.07	-0.64**
	(0.18)	(0.36)	(0.22)	(0.23)	(0.15)	(0.11)	(0.36)	(0.18)	(0.30)
Cumulative Hours Parked Nearby	-0.03***	-0.03***	-0.01***	-0.30***	-0.11***	-0.05***	-0.10***	-0.06***	-0.03
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.02)	(0.01)	(0.02)
Cumulative Hours Parked Nearby*Post	-0.04***	-0.02***	-0.01**	-0.02***	-0.03***	-0.02***	-0.06*	0.05***	0.03
	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)	(0.00)	(0.03)	(0.02)	(0.03)
Constant	65.00***	66.00***	69.01***	65.00***	68.01***	71.00***	65.98***	66.07***	67.60***
	(0.23)	(0.46)	(0.28)	(0.59)	(0.37)	(0.29)	(0.31)	(0.15)	(0.26)
Observations	15,936	15,936	15,936	22,612	22,612	22,612	3,632	3,632	3,632
Fixed Effects: k, t, s	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pseudo R^2	0.308	0.177	0.093	0.189	0.124	0.082	0.121	0.125	0.101

Notes: Post is a dummy variable that equals 1 if the truck's speed is calculated during the time period after leaving the facility, and 0 otherwise. Parked Nearby is a dummy variable that equals 1 if the truck is parked within 10-mile radius of the facility, either before or after visiting, and 0 otherwise. Cumulative Hours Parked Nearby represents the cumulative hours of the truck spends parked near the facility, either before or after visiting. Fixed effects for truck type (*k*), month (*t*), and state (*s*) are incorporated into the analyses.

Table 3.12 Correlation between Detained and Median Speed by Facility Type

	Food Processors			Distribution Centers			Semiconductors		
	0.25_QR	0.5_QR	0.75_QR	0.25_QR	0. 5_QR	0.75_QR	0.25_QR	0.5_QR	0.75_QR
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Detained	-0.50	3.95***	4.00***	10.50***	5.00***	1.98***	7.06***	5.00***	0.50
	(0.77)	(0.68)	(1.07)	(0.51)	(0.86)	(0.50)	(1.67)	(1.86)	(1.20)
Post	-0.99	0.00	-0.00	-1.00**	-0.00	0.00	5.27***	5.00***	1.50*
	(0.80)	(0.70)	(1.11)	(0.50)	(0.85)	(0.49)	(1.12)	(1.25)	(0.80)
Detained* Post	1.49	0.76	0.00	1.00	0.01	0.02	-2.84	-5.00*	-1.00
	(1.08)	(0.95)	(1.50)	(0.70)	(1.19)	(0.68)	(2.37)	(2.63)	(1.69)
Parked Nearby	-6.35***	-8.68***	-4.93***	-12.33***	-4.97***	-0.97**	-6.08***	-3.77***	1.01
	(0.61)	(0.53)	(0.84)	(0.42)	(0.71)	(0.41)	(1.23)	(1.37)	(0.88)
Parked Nearby*Post	1.36	-0.01	0.00	0.92	-0.01	-0.46	-6.19***	-6.73***	-3.51***
	(0.86)	(0.76)	(1.20)	(0.59)	(0.99)	(0.57)	(1.78)	(1.98)	(1.27)
Cumulative Hours Parked Nearby	-0.09***	-0.09***	-0.15***	-0.15***	-0.29***	-0.32***	-0.14	-0.21*	-0.22***
	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.11)	(0.12)	(0.08)
Cumulative Hours Parked Nearby*Post	-0.07***	-0.03**	0.01	0.00	-0.00	0.00	0.02	0.13	0.14
	(0.02)	(0.01)	(0.02)	(0.01)	(0.02)	(0.01)	(0.17)	(0.19)	(0.12)
Constant	60.00***	63.00***	65.00***	60.00***	64.00***	65.51***	42.08***	53.50***	62.50***
	(1.11)	(0.98)	(1.54)	(1.43)	(2.42)	(1.39)	(1.53)	(1.70)	(1.09)
Observations	15,936	15,936	15,936	22,612	22,612	22,612	3,632	3,632	3,632
Fixed Effects: k, t, s	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pseudo R^2	0.273	0.207	0.078	0.303	0.255	0.103	0.076	0.058	0.015

Notes: Post is a dummy variable that equals 1 if the truck's speed is calculated during the time period after leaving the facility, and 0 otherwise. Parked Nearby is a dummy variable that equals 1 if the truck is parked within 10-mile radius of the facility, either before or after visiting, and 0 otherwise. Cumulative Hours Parked Nearby represents the cumulative hours of the truck spends parked near the facility, either before or after visiting. Fixed effects for truck type (*k*), month (*t*), and state (*s*) are incorporated into the analyses.

Table 3.13 The Results of Correlation between Detained and Average Speed for Various Facility Types

	Food Processors			Distribution Centers			Semiconductors		
	0.25_QR	0.5_QR	0.75_QR	0.25_QR	0. 5_QR	0.75_QR	0.25_QR	0.5_QR	0.75_QR
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Detained	-0.48	3.35***	5.06***	7.53***	3.95***	1.53***	3.22***	1.68**	1.28
	(0.50)	(0.35)	(0.83)	(0.35)	(0.45)	(0.36)	(0.82)	(0.77)	(0.99)
Post	0.10	0.66*	0.58	0.33	-0.32	0.41	2.38***	2.03***	2.58***
	(0.51)	(0.36)	(0.86)	(0.31)	(0.40)	(0.32)	(0.55)	(0.52)	(0.67)
Detained*Post	0.92	0.92*	-0.56	-0.33	0.17	0.05	-2.24*	-0.95	-0.81
	(0.70)	(0.49)	(1.17)	(0.48)	(0.61)	(0.49)	(1.16)	(1.09)	(1.40)
Parked Nearby	-3.01***	-6.16***	-6.98***	-4.75***	-3.67***	-2.14***	-3.66***	-1.76***	3.09***
	(0.39)	(0.27)	(0.65)	(0.28)	(0.36)	(0.29)	(0.60)	(0.57)	(0.73)
Parked Nearby*Post	0.07	-0.67*	-0.21	-0.54	0.18	-0.66*	-2.87***	-3.51***	-6.54***
	(0.56)	(0.39)	(0.93)	(0.38)	(0.49)	(0.39)	(0.87)	(0.82)	(1.06)
Cumulative Hours Parked Nearby	-0.06***	-0.05***	-0.08***	-0.16***	-0.20***	-0.19***	-0.13**	-0.10**	-0.17**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.05)	(0.05)	(0.07)
Cumulative Hours Parked Nearby*Post	-0.04***	-0.02**	0.00	0.00	-0.01	-0.01	0.01	0.07	0.17*
	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.08)	(0.08)	(0.10)
Constant	52.89***	56.15***	60.16***	51.45***	55.86***	59.13***	39.70***	45.67***	52.31***
	(0.72)	(0.50)	(1.20)	(0.97)	(1.25)	(1.00)	(0.75)	(0.70)	(0.91)
Observations	15,936	15,936	15,936	22,612	22,612	22,612	3,632	3,632	3,632
Fixed Effects: k, t, s	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pseudo R^2	0.293	0.211	0.125	0.298	0.240	0.133	0.069	0.058	0.051

Notes: Post is a dummy variable that equals 1 if the truck's speed is calculated during the time period after leaving the facility, and 0 otherwise. Parked Nearby is a dummy variable that equals 1 if the truck is parked within 10-mile radius of the facility, either before or after visiting, and 0 otherwise. Cumulative Hours Parked Nearby represents the cumulative hours of the truck spends parked near the facility, either before or after visiting. Fixed effects for truck type (*k*), month (*t*), and state (*s*) are incorporated into the analyses.

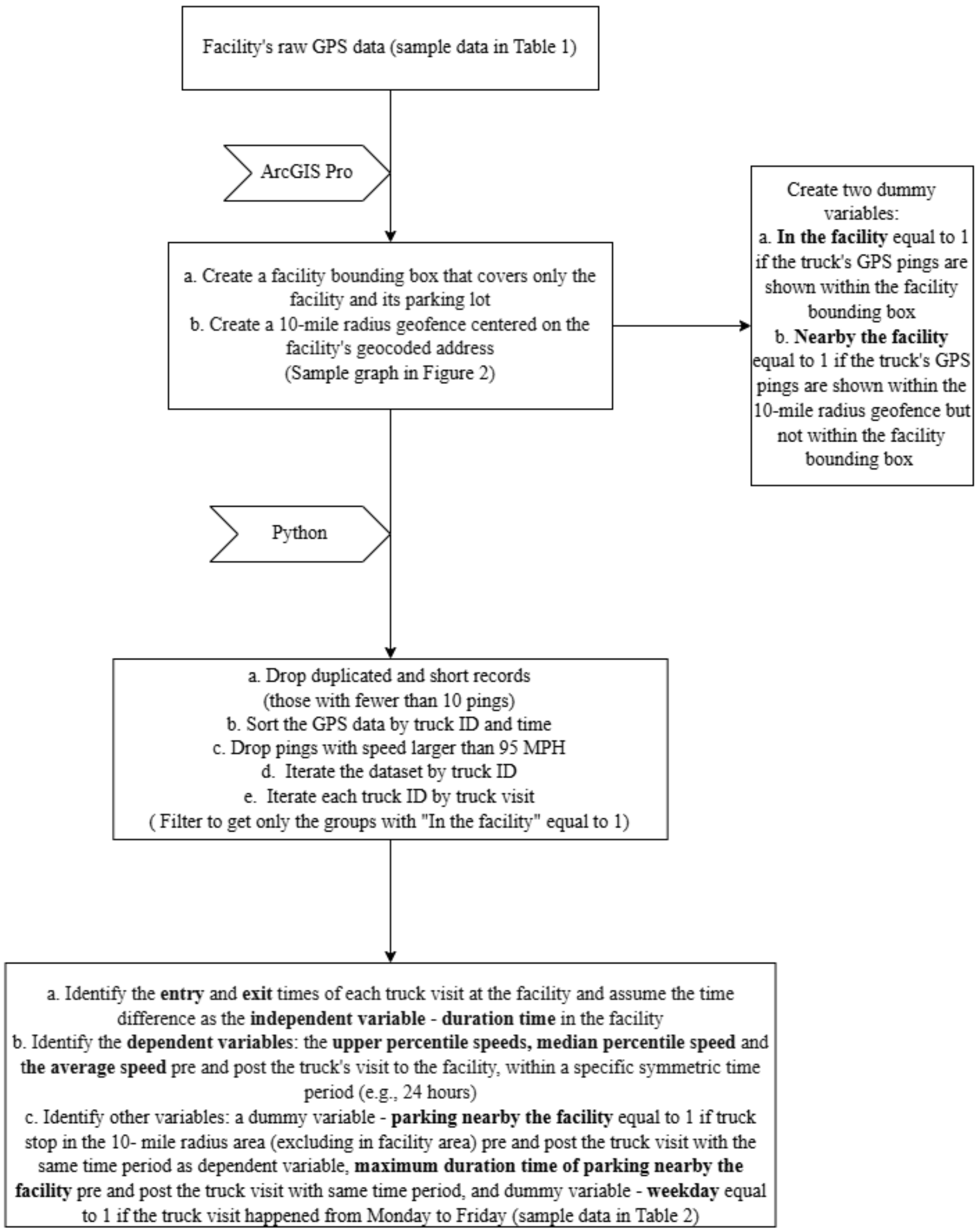


Figure 3.1 The Algorithm of the GPS Data Processing for Each Facility

Figure 3.2 Example of Facility Boundary Box and 10-mile Geofence Area

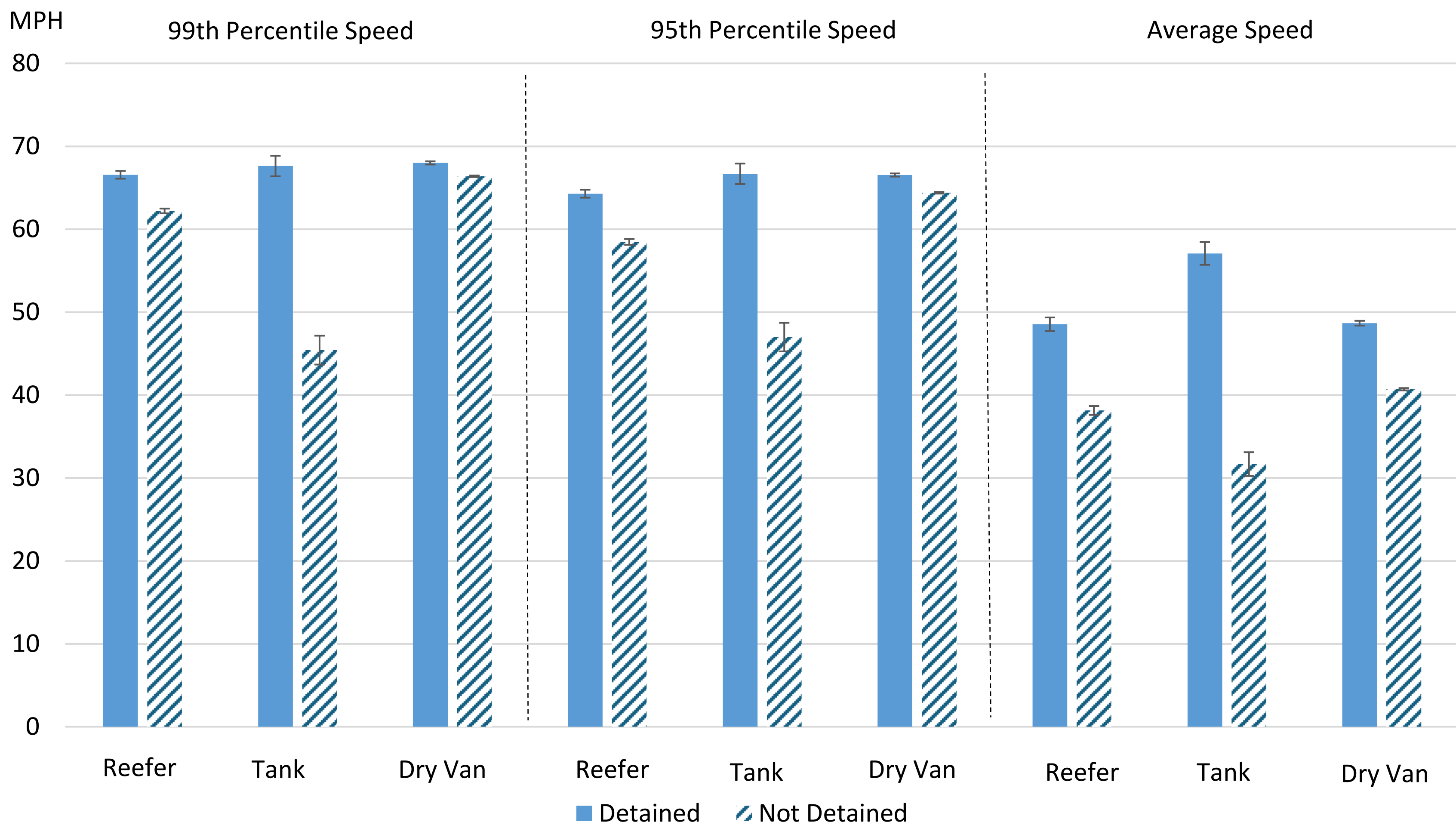


Figure 3.3 Upper Percentile Speed and Average Speed Comparison Between Detained and Not-Detained for Different Types of Trucks

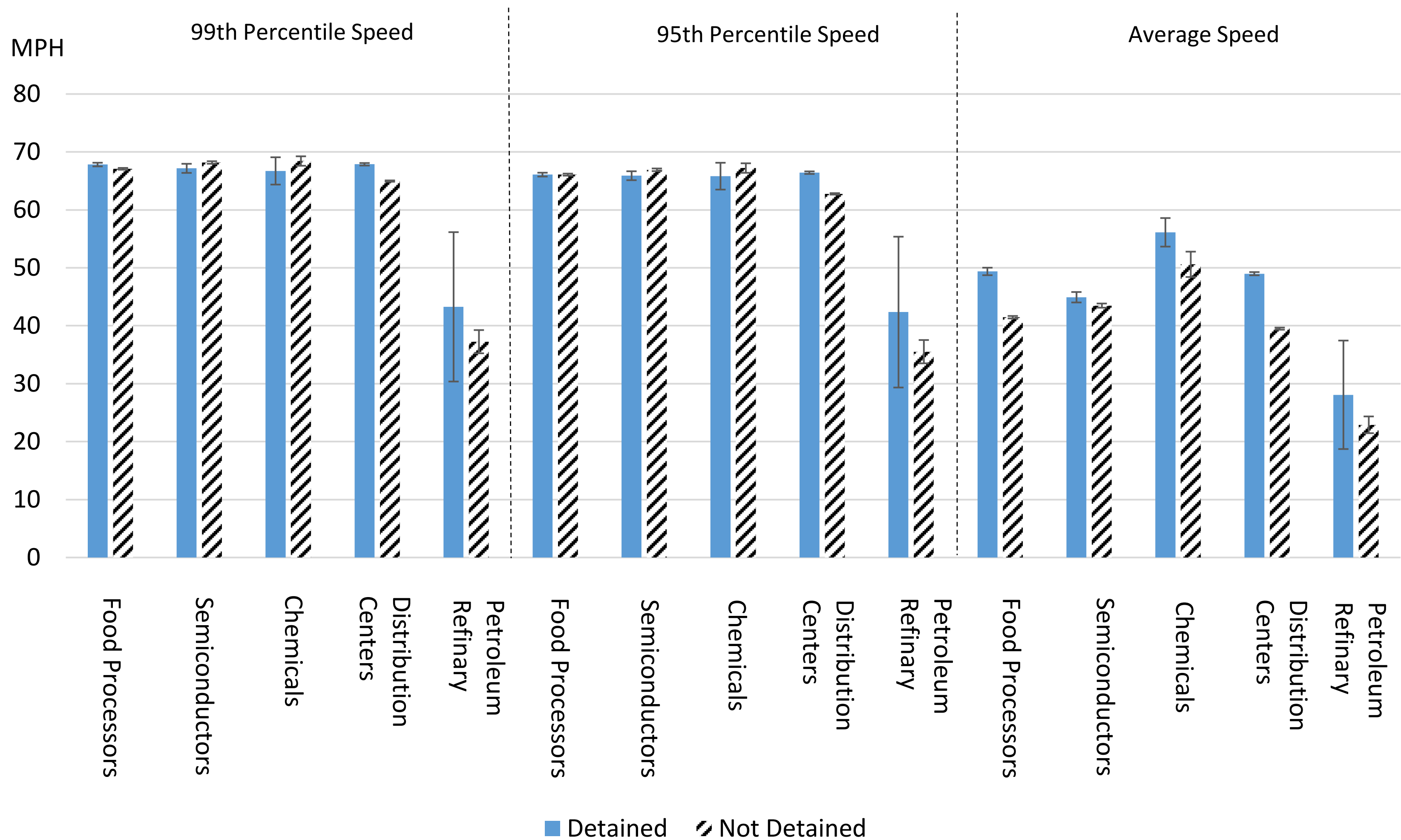


Figure 3.4 Upper Percentile Speed and Average Speed Comparison Between Detained and Not-Detained in Different Types of Facilities

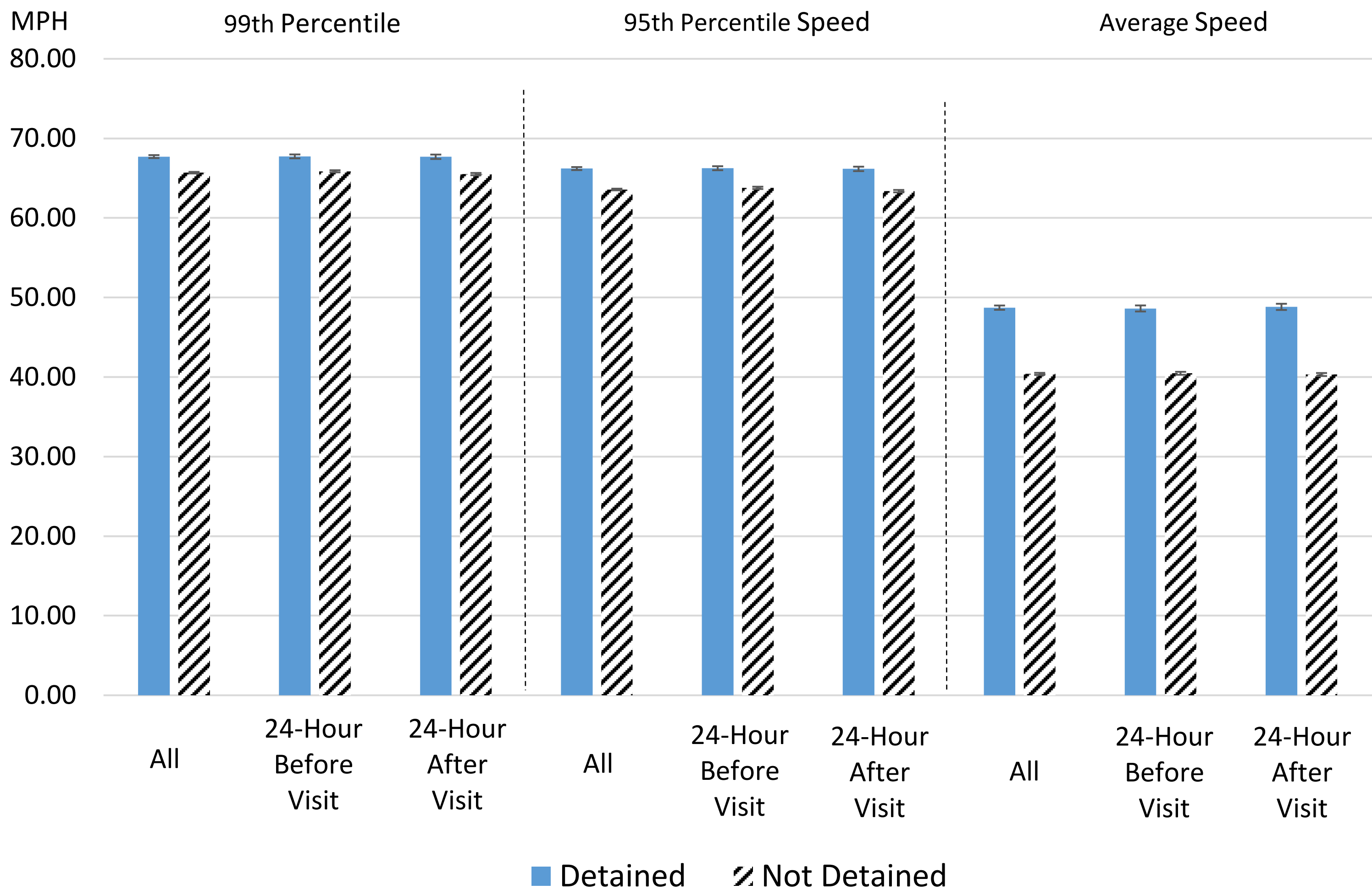
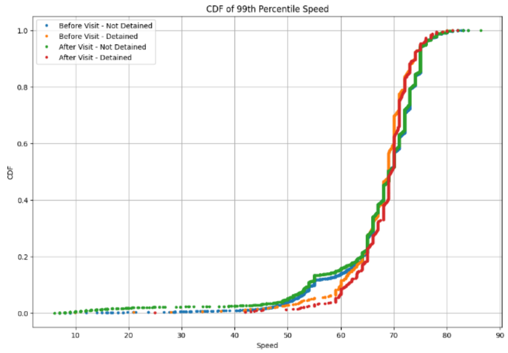


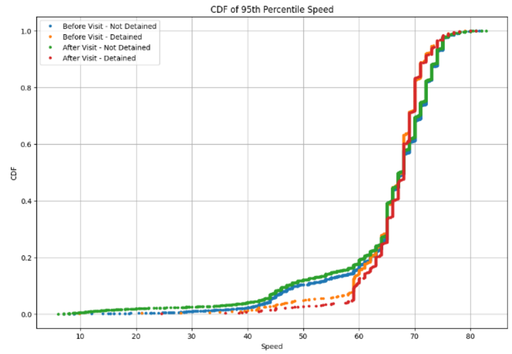
Figure 3.5 Upper Percentile Speed and Average Speed Comparison Between Detained and Not-Detained in All 48-hour Periods, 24-hours Before Visit, and 24-hours After Visit

Figure 3.6 CDF of Upper Percentile Speed and Average Speed Comparison Between Detained and Not-Detained in Different Types of Facilities in All 48-hour Periods, 24-hours Before Visit, and 24-hours After Visit

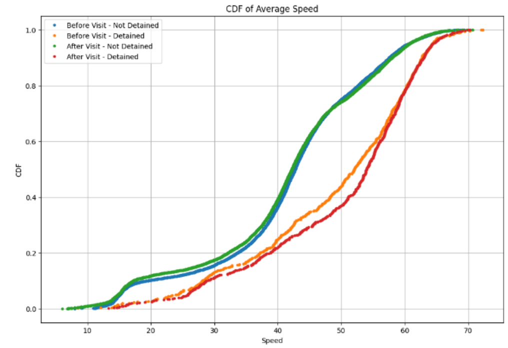
Food Processors 99th Percentile Speed



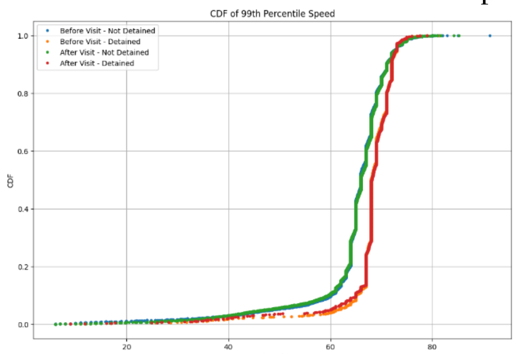
Food Processors 95th Percentile Speed



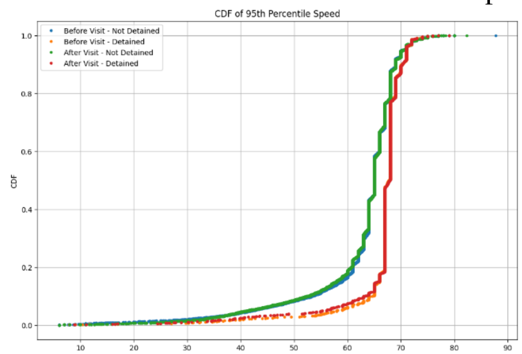
Food Processors Average Speed



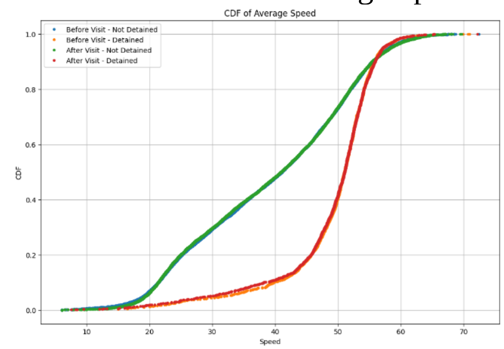
Distribution Centers 99th Percentile Speed



Distribution Centers 95th Percentile Speed



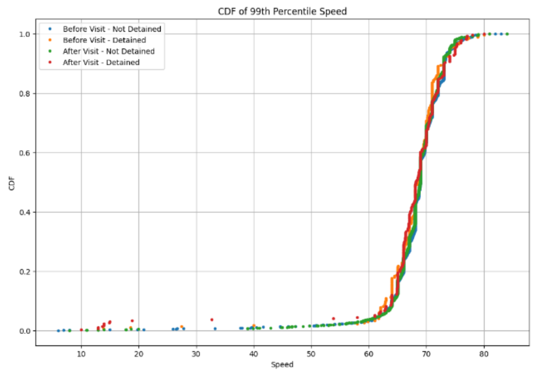
Distribution Centers Average Speed



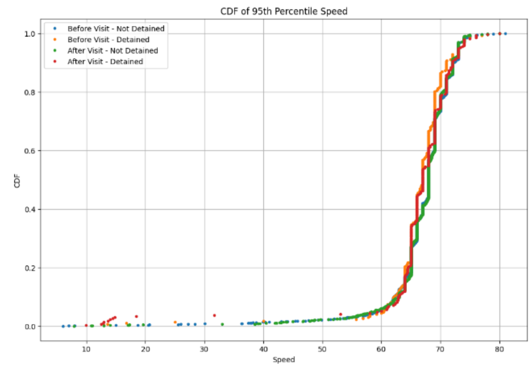
Semiconductor and Electric Components 99th Percentile Speed

Semiconductor and Electric Components 95th Percentile Speed

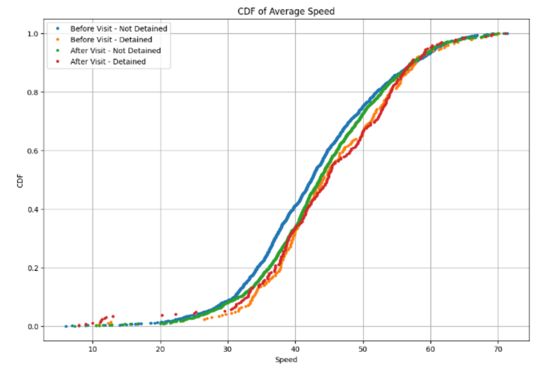
Semiconductor and Electric Components Average Speed



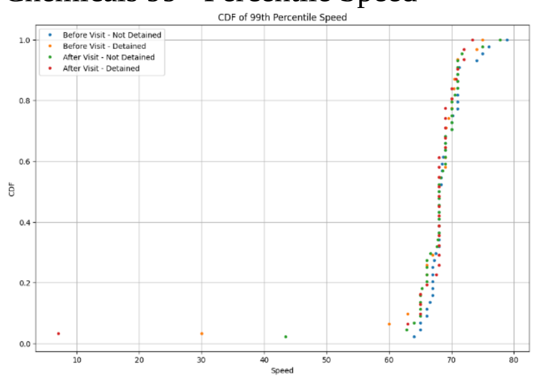
Chemicals 99th Percentile Speed



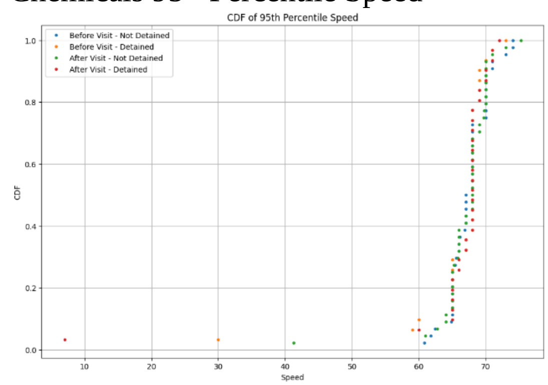
Chemicals 95th Percentile Speed



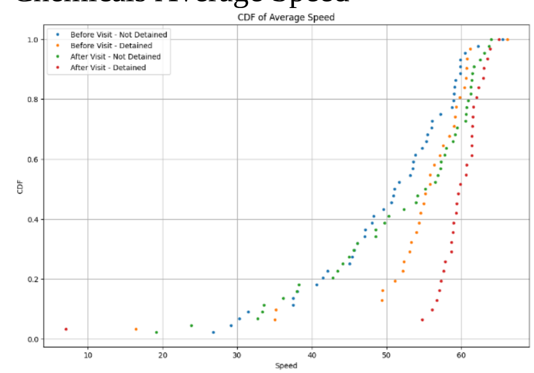
Chemicals Average Speed



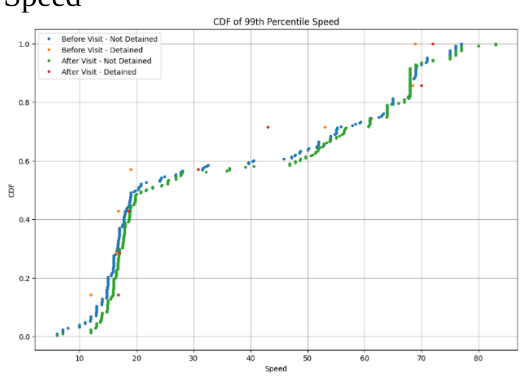
Petroleum Refineries 99th Percentile Speed

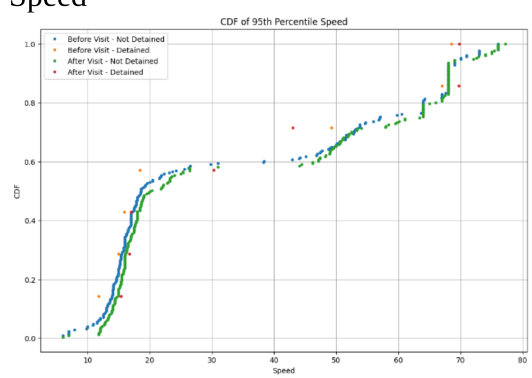


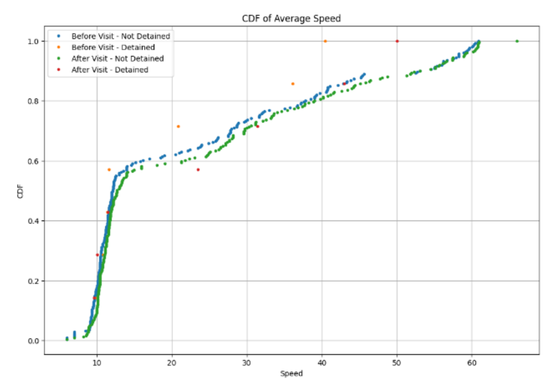
Petroleum Refineries 95th Percentile Speed



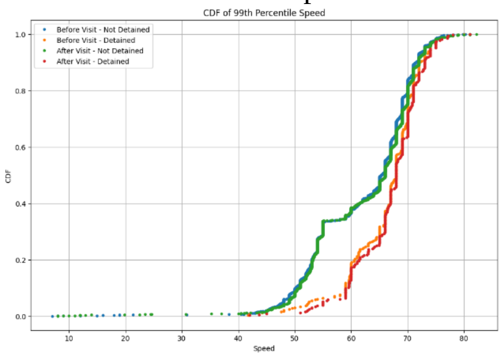
Petroleum Refineries Average Speed



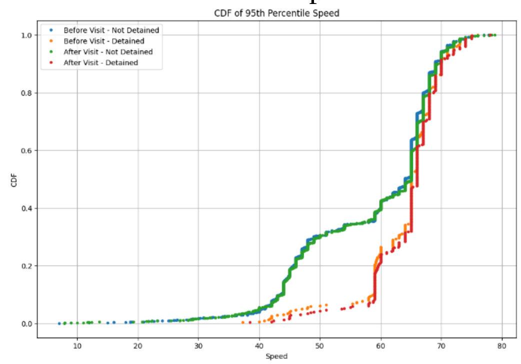




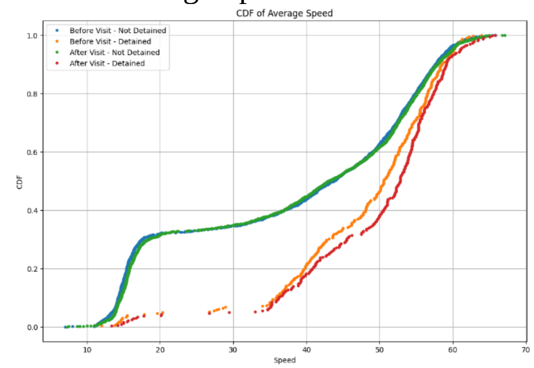
Reefer 99th Percentile Speed



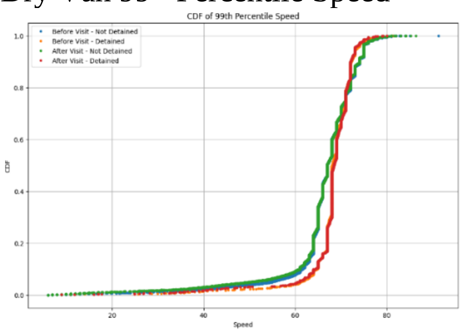
Reefer 95th Percentile Speed



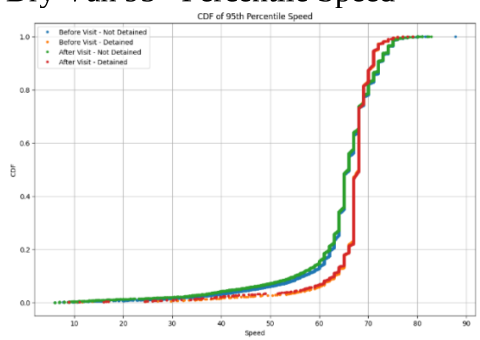
Reefer Average Speed



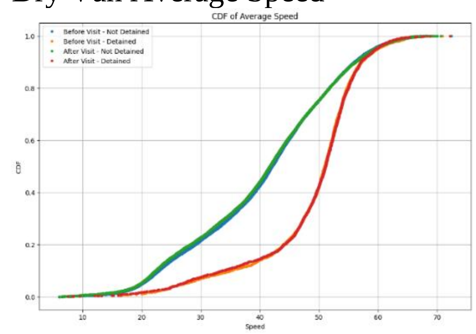
Dry Van 99th Percentile Speed



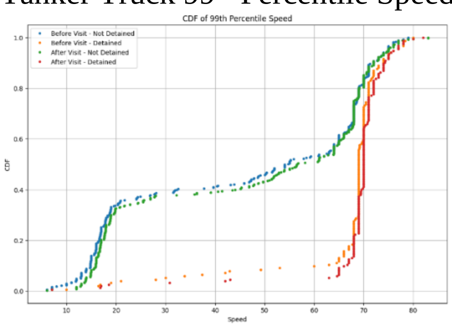
Dry Van 95th Percentile Speed



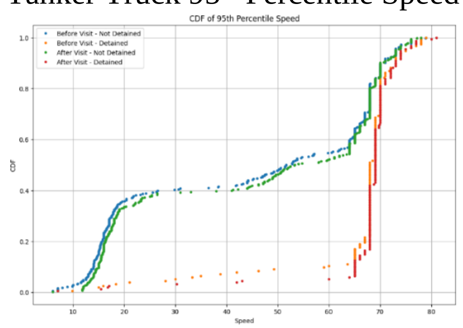
Dry Van Average Speed



Tanker Truck 99th Percentile Speed



Tanker Truck 95th Percentile Speed



Tanker Truck Average Speed

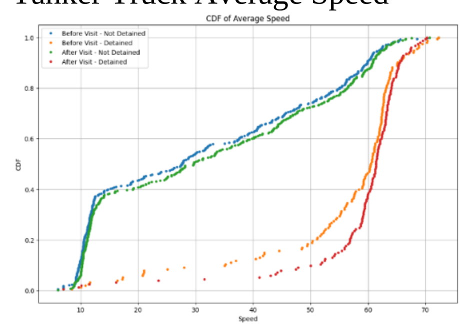


Figure 3.7 CDF of Upper Percentile Speed and Average Speed Comparison Between Detained and Not-Detained in Different Types of Trucks in All 48-hour Periods, 24-hours Before Visit, and 24-hours After Visit

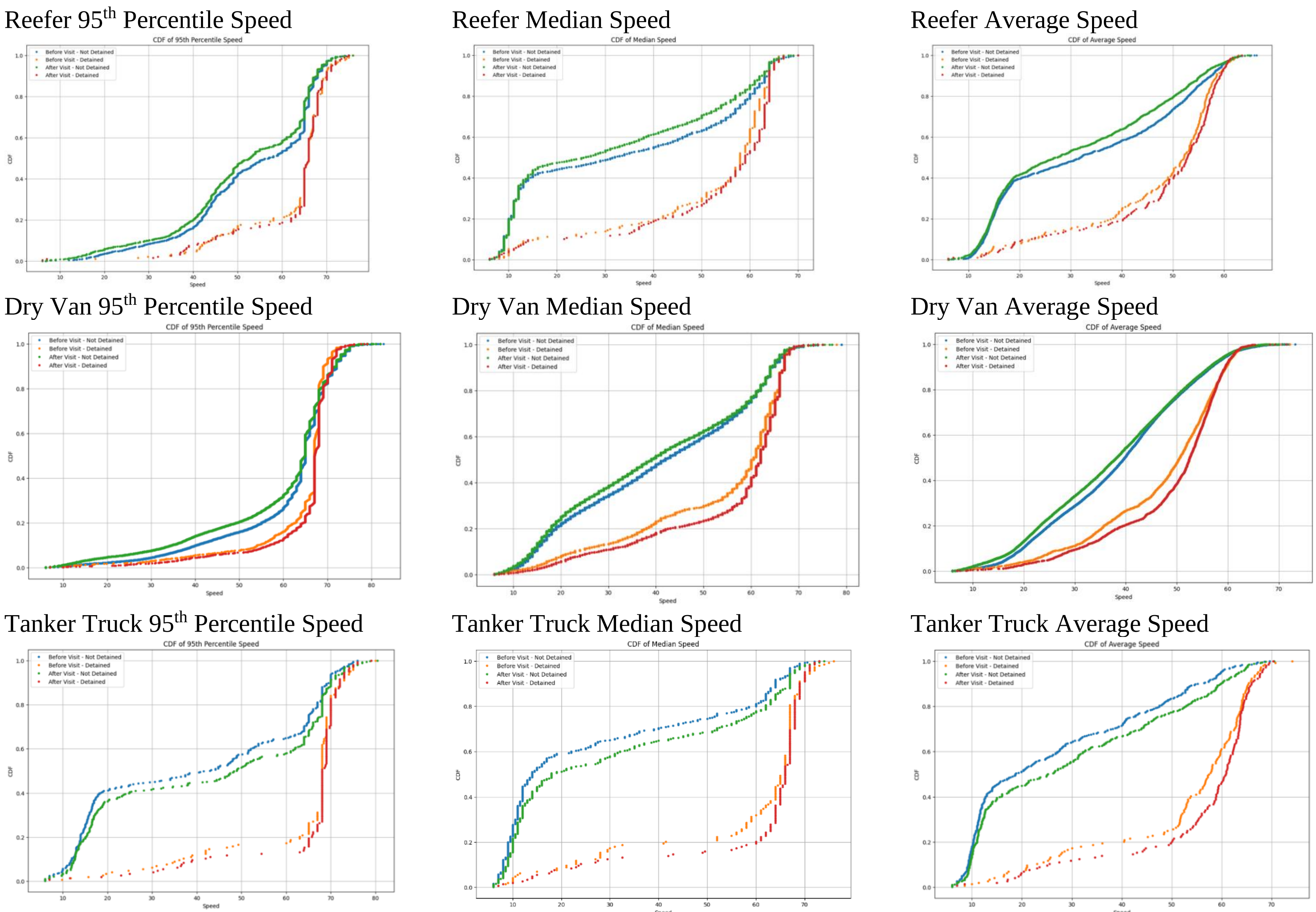


Figure 3.8 CDF of 95th Percentile Speed, Median Speed and Average Speed Comparison Between Detained and Not-Detained in Different Types of Trucks in All 8-hour Periods, 4-hours Before Visit, and 4-hours After Visit

APPENDICES

Appendix A BRI Country List, the Year of MoU, and WTO Member Status, 2013-2022

Year	**Belt and Road Portal**	**Nedopil (2022)**
2013	Kyrgyzstan*	Afghanistan**
	Pakistan*	Belarus
		Cambodia*
		Kyrgyzstan*
		Macedonia*
		Moldova*
		Mongolia*
		Pakistan*
2014	Belarus	Thailand*
	Kazakhstan**	
	Qatar*	
	Sri Lanka*	
2015	Armenia*	Armenia*
	Azerbaijan	Azerbaijan
	Bulgaria*	Bulgaria*
	Czech Republic*	Cameroon*
	Georgia*	Czech Republic*
	Hungary*	Hungary*
	Iraq	Indonesia*
	Macedonia*	Iraq
	Poland*	Kazakhstan*
	Portugal*	Poland*
	Serbia	Romania*
	Slovakia*	Serbia
	South Korea*	Slovakia*
	Tajikistan*	Somalia
	Turkey*	South Africa*
	Ukraine*	Turkey*
	Uzbekistan	Uzbekistan
2016	Afghanistan*	Egypt*
	Bangladesh*	Georgia*
	Cambodia*	Latvia*
	Egypt*	Myanmar*
	Iran	Papua New Guinea*
	Laos*	
	Saudi Arabia*	
2017	Albania*	Albania*
	Bosnia and Herzegovina	Bosnia and Herzegovina
	Brunei*	Croatia*
	Croatia*	East Timor
	East Timor	Estonia*
	Estonia*	Ivory Coast (Côte d'Ivoire)*
	Latvia*	Kenya*
	Lebanon	Lebanon
	Lithuania*	Lithuania*
	Madagascar*	Madagascar*
	Malaysia*	Malaysia*
	Maldives*	Maldives*

Appendix A (continued)

	Moldova*	Montenegro*
	Mongolia*	Morocco*
	Montenegro*	Nepal*
	Morocco*	New Zealand*
	Myanmar*	Panama*
	Nepal*	Philippines*
	New Zealand*	Slovenia*
	Panama*	Sri Lanka*
	Romania*	Ukraine*
	Russia*	Vietnam*
	Singapore*	Yemen*
	Slovenia*	
	Thailand*	
	Vietnam*	
2018	Algeria	Algeria
	Angola*	Angola*
	Antigua and Barbuda*	Antigua and Barbuda*
	Austria*	Bahrain*
	Bahrain*	Bolivia*
	Bolivia*	Brunei*
	Burundi*	Burundi*
	Cameroon*	Cape Verde*
	Cape Verde*	Chad*
	Chad*	Chile*
	Chile*	Cook Islands
	Congo*	Costa Rica*
	Cook Islands	Djibouti*
	Costa Rica*	Ecuador*
	Djibouti*	El Salvador*
	Dominica*	Ethiopia
	Ecuador*	Fiji*
	El Salvador*	Gabon*
	Ethiopia	Gambia*
	Fiji*	Ghana*
	Gabon*	Greece*
	Gambia*	Grenada*
	Ghana*	Guinea*
	Greece*	Guyana*
	Grenada*	Iran
	Guinea*	Kuwait*
	Guyana*	Laos*
	Indonesia*	Libya
	Ivory Coast (Côte d'Ivoire)*	Malta*
	Kenya*	Mauritania*
	Kuwait*	Micronesia
	Libya	Mozambique*
	Malta*	Namibia*
	Mauritania*	Nigeria*
	Micronesia	Niue

Appendix A (continued)

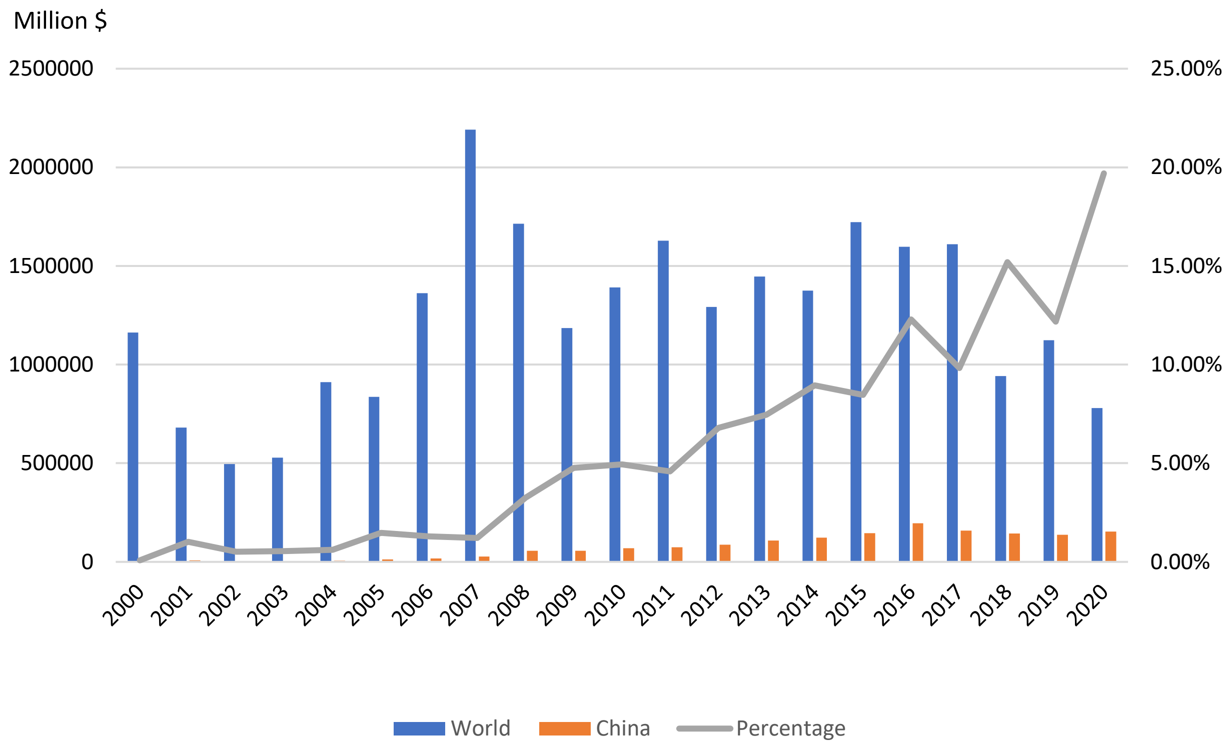
	Mozambique*	Oman*
	Namibia*	Portugal*
	Nigeria*	Rwanda*
	Niue	Samoa*
	Oman*	Saudi Arabia*
	Papua New Guinea*	Senegal*
	Philippines*	Seychelles*
	Rwanda*	Sierra Leone*
	Samoa*	Singapore*
	Senegal*	South Korea*
	Seychelles*	South Sudan
	Sierra Leone*	Sudan
	Somalia*	Suriname*
	South Africa*	Tajikistan*
	South Sudan	Tanzania*
	Sudan	Togo*
	Suriname*	Tonga*
	Tanzania*	Trinidad and Tobago*
	The Dominican Republic*	Tunisia*
	Togo*	Uganda*
	Tonga*	United Arab Emirates*
	Trinidad and Tobago*	Uruguay*
	Tunisia*	Vanuatu*
	Uganda*	Venezuela*
	United Arab Emirates*	Zambia*
	Uruguay*	Zimbabwe*
	Vanuatu*	
	Venezuela*	
	Zambia*	
	Zimbabwe*	
2019	Barbados*	Bangladesh*
	Benin*	Barbados*
	Comoros	Cuba*
	Cuba*	Cyprus*
	Cyprus*	Equatorial Guinea
	Equatorial Guinea	Italy*
	Italy*	Jamaica*
	Jamaica*	Lesotho*
	Lesotho*	Liberia*
	Liberia*	Luxembourg*
	Luxembourg*	Mali*
	Mali*	Peru*
	Peru*	Qatar*
	Solomon Islands*	Solomon Islands*
	Yemen*	
2020	Kiribati	Kiribati
2021	Botswana*	Democratic Republic of Congo*
	Burkina Faso*	
	Central African Republic*	

Appendix A (continued)

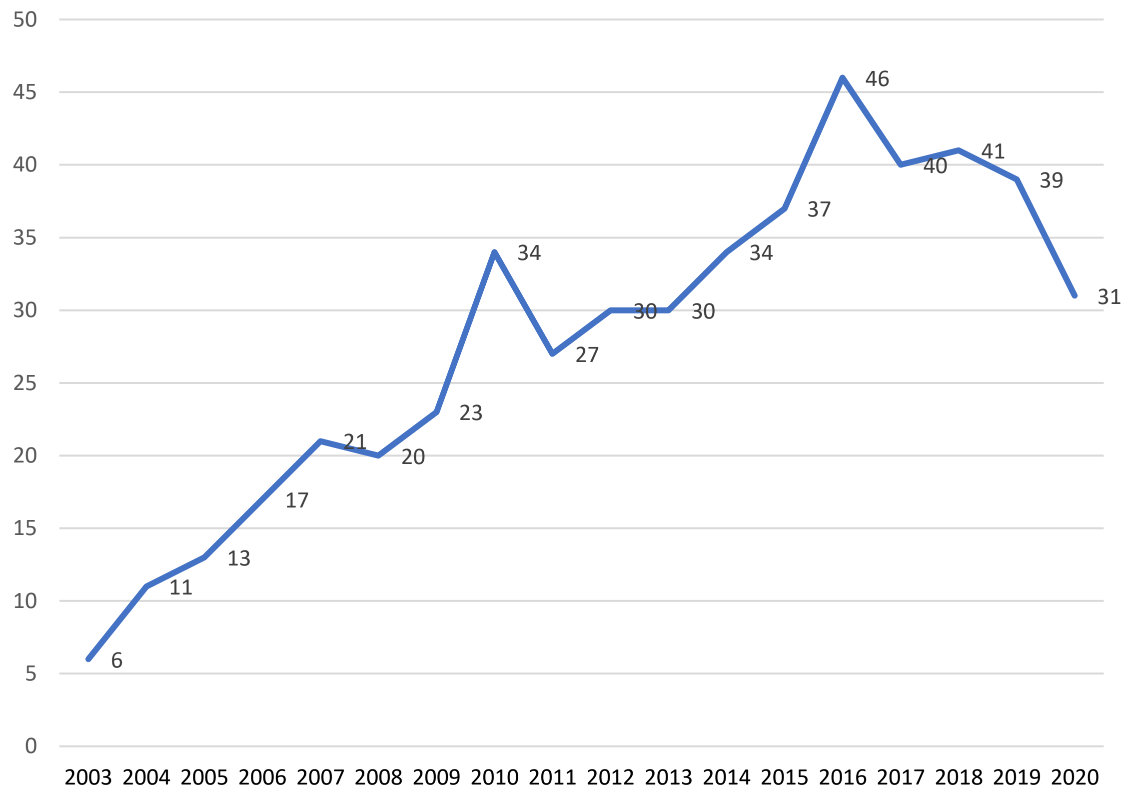
	Democratic Republic of Congo* Eritrea* Guinea-Bissau* São Tomé and Príncipe	
2022	Argentina* Malawi* Nicaragua* Syria*	Not updated
Unknown	Niger*	Austria* Benin* Comoros Congo* Dominica* Niger* Russia*

Notes: *: the country had been a WTO member before the year; **: the country had not been a WTO member this year but became a WTO member after some years; without * or **: the country is not a WTO member; countries who signed MOU after 2021 and unknown and Chile, Cook Island, Niue, Somalia, South Sudan, Cuba are not included in the empirical analysis; our analysis based on country list from Belt and Road Portal.

Appendix B OFDI Flows from World and China, 2000-2020



Appendix C Number of Countries that Received FDI from China via M&A, 2003-2020



Appendix D Pairwise Correlation of Independent Variables

D.1 All Countries

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
(1) China OFDI	1.000												
(2) China M&A	0.585	1.000											
(3) BRI	0.029	-0.032	1.000										
(4) GDP	0.465	0.483	-0.053	1.000									
(5) Communication Infrastructure	0.159	0.112	0.165	0.168	1.000								
(6) Natural Resource	-0.027	-0.008	0.085	-0.042	-0.248	1.000							
(7) Inflation (%)	-0.030	-0.030	0.022	-0.046	-0.129	0.100	1.000						
(8) Exchange Rate ($)	0.047	-0.022	0.093	-0.021	-0.046	0.093	0.065	1.000					
(9) Trade Openness	0.259	0.122	-0.008	0.083	0.481	-0.279	-0.115	-0.113	1.000				
(10) WTO	0.068	0.053	0.047	0.093	0.195	0.091	-0.079	-0.087	0.150	1.000			
(11) RTA with China	0.176	0.023	0.085	0.008	0.104	-0.049	-0.026	0.223	0.118	0.124	1.000		
(12) Corruption	-0.114	-0.124	0.167	-0.190	-0.297	0.259	0.161	0.107	-0.493	-0.173	-0.043	1.000	
(13) Vote	-0.094	-0.135	-0.034	-0.252	-0.128	0.199	0.100	0.123	-0.177	0.041	0.181	0.258	1.000

D.2 BRI Countries

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
(1) China OFDI	1.000												
(2) China M&A	0.359	1.000											
(3) BRI	0.090	0.015	1.000										
(4) GDP	0.211	0.196	0.070	1.000									
(5) Communication Infrastructure	0.152	0.113	0.247	0.314	1.000								
(6) Natural Resource	-0.104	-0.081	0.020	-0.061	-0.134	1.000							
(7) Inflation (%)	-0.014	-0.017	0.003	-0.024	-0.102	0.071	1.000						
(8) Exchange Rate ($)	0.105	-0.003	0.071	0.094	-0.027	0.067	0.058	1.000					
(9) Trade Openness	0.379	0.256	0.043	0.140	0.457	-0.268	-0.090	-0.099	1.000				
(10) WTO	0.048	0.024	0.065	0.073	0.208	0.039	-0.075	-0.114	0.138	1.000			
(11) RTA with China	0.288	0.112	0.073	0.194	0.083	-0.056	-0.035	0.248	0.146	0.131	1.000		
(12) Corruption	-0.034	-0.052	0.139	-0.029	-0.197	0.194	0.153	0.082	-0.400	-0.172	-0.058	1.000	
(13) Vote	0.088	0.042	-0.113	0.006	-0.063	0.222	0.085	0.116	-0.051	0.103	0.210	0.175	1.000

D.3 Non-BRI Countries

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1) China OFDI	1.000											
(2) China M&A	0.680	1.000										
(3) GDP	0.559	0.492	1.000									
(4) Communication Infrastructure	0.164	0.126	0.180	1.000								
(5) Natural Resource	0.081	0.079	0.048	-0.380	1.000							
(6) Inflation (%)	-0.109	-0.088	-0.139	-0.404	0.277	1.000						
(7) Exchange Rate ($)	-0.056	-0.051	-0.082	-0.146	0.187	0.086	1.000					
(8) Trade Openness	0.126	0.058	0.045	0.504	-0.229	-0.346	-0.190	1.000				
(9) WTO	0.100	0.090	0.154	0.159	0.210	-0.111	0.108	0.164	1.000			
(10) RTA with China	0.077	0.002	-0.004	0.215	-0.124	-0.002	-0.059	0.096	0.113	1.000		
(11) Corruption	-0.169	-0.144	-0.234	-0.465	0.261	0.266	0.237	-0.623	-0.154	-0.102	1.000	
(12) Vote	-0.275	-0.225	-0.382	-0.239	0.064	0.171	0.128	-0.335	-0.072	0.006	0.311	1.000

Appendix E Impact of China OFDI and BRI on COTC FDI

	All Countries		BRI Countries		Non-BRI Countries	
	(RE)	(FE)	(RE)	(FE)	(RE)	(FE)
	(1)	(2)	(3)	(4)	(5)	(6)
China OFDI	4.979***	4.647***	0.486*	0.165	7.798***	7.826***
	(0.477)	(0.504)	(0.276)	(0.281)	(1.044)	(1.136)
BRI	-1,245	3,113**	-219.4	221.3		
	(974.0)	(1,347)	(369.4)	(665.3)		
GDP	11.46***	11.56***	8.386***	8.348***	10.29***	8.980***
	(0.411)	(1.226)	(1.042)	(2.465)	(0.847)	(2.258)
Inflation (%)	3.969	3.291	1.987	-0.926	88.09	-178.8
	(24.89)	(25.70)	(9.215)	(9.483)	(301.1)	(343.0)
Exchange Rate ($)	0.0124	-0.0467	0.0998	0.0517	-0.503	4.964
	(0.199)	(0.361)	(0.0806)	(0.134)	(2.243)	(6.245)
Corruption	-587.1	-581.4	-386.8**	-648.6**	-778.6	466.7
	(363.6)	(581.8)	(166.4)	(253.3)	(1,183)	(1,861)
Natural Resource	438.9	-3,833	-3,112***	-1,475	4,989	-10,351
	(1,446)	(2,539)	(778.1)	(1,228)	(4,033)	(6,686)
Communication Infrastructure	11.98	32.79*	5.308	12.35	53.59	110.7*
	(10.07)	(17.54)	(4.502)	(7.884)	(38.22)	(58.68)
Trade Openness	0.140***	-0.0387	0.187***	0.108***	0.0860	-0.282
	(0.0390)	(0.0907)	(0.0188)	(0.0403)	(0.134)	(0.276)
WTO	-207.4	-2,404	189.6	157.5	-2,723	-18,256
	(1,572)	(2,743)	(699.7)	(1,084)	(6,167)	(12,142)
RTA with China	-1,908	-3,840	1,710**	2,367**	-8,811	-7,710
	(1,623)	(2,568)	(734.5)	(1,160)	(6,386)	(7,908)

Appendix E (continued)

Vote	-567.4	-2,132	2,332	138.3	-1,979	-10,142
	(3,430)	(5,931)	(1,666)	(2,589)	(10,870)	(18,507)
Constant	1,666	4,845	1,785	1,271	-328.7	19,251
	(3,042)	(5,208)	(1,430)	(2,340)	(10,781)	(17,175)
Observations	2,442	2,442	1,692	1,692	750	750
R-squared	0.8546	0. 8165	0. 6478	0.5792	0.8611	0.7145
Number of Countries	168	168	119	119	49	49
Random Effect	Yes		Yes		Yes	
Country Fixed Effect		Yes		Yes		Yes
Year Fixed Effect		Yes		Yes		Yes

Notes: Columns (3) & (4) represent only BRI countries in this subgroup. Columns (5) & (6) represent only non-BRI countries in this subgroup. Columns (1), (3) and (5) represent random effects. Columns (2), (4) and (6) represent country and time fixed effects. Standard errors are in parentheses *** p<0.01, ** p<0.05, * p<0.1.

Appendix F Impact of China M&A and BRI on COTC M&A

	All Countries		BRI Countries		Non-BRI Countries	
	(RE)	(FE)	(RE)	(FE)	(RE)	(FE)
	(1)	(2)	(3)	(4)	(5)	(6)
China M&A	2.322***	2.210***	0.372	0.152	2.615***	2.611***
	(0.314)	(0.312)	(0.365)	(0.369)	(0.568)	(0.558)
BRI	-660.9	900.6	-339.0	49.77		
	(1,143)	(1,514)	(464.4)	(858.6)		
GDP	16.67***	18.27***	26.06***	19.70***	15.44***	18.74***
	(0.618)	(1.250)	(0.745)	(3.005)	(1.195)	(2.209)
Inflation (%)	-4.418	-12.66	0.526	-3.167	-47.87	-274.4
	(27.42)	(27.00)	(10.85)	(11.43)	(402.3)	(416.0)
Exchange Rate ($)	-0.192	-0.198	-0.247***	-0.185	-0.537	0.396
	(0.287)	(0.441)	(0.0671)	(0.188)	(3.554)	(7.134)
Corruption	-2,349***	236.9	-800.8***	-535.6	-5,151***	1,238
	(487.0)	(672.5)	(181.7)	(336.0)	(1,617)	(2,198)
Natural Resource	1,207	2,152	-4,124***	51.53	9,408*	3,230
	(2,098)	(2,674)	(768.9)	(1,504)	(5,548)	(6,847)
Communication Infrastructure	20.16	74.54***	-8.011*	7.194	70.60	171.2***
	(13.65)	(19.59)	(4.758)	(10.14)	(52.26)	(65.70)
Trade Openness	0.148***	0.252***	0.0653***	0.0324	0.243	0.469
	(0.0552)	(0.0970)	(0.0149)	(0.0495)	(0.182)	(0.292)
WTO	-2,071	-4,812	-153.7	-1,027	-13,573	-23,109*
	(2,467)	(3,264)	(698.1)	(1,522)	(10,323)	(12,400)
RTA with China	206.1	-389.1	1,444**	1,187	-2,116	2,536
	(2,151)	(2,715)	(606.7)	(1,410)	(7,638)	(8,296)
Vote	-7,214	-6,970	-1,415	663.4	-9,165	-26,096
	(5,297)	(8,127)	(1,703)	(3,972)	(16,572)	(27,072)

Appendix F (continued)

Constant	12,167**	808.5	7,090***	1,612	23,612	13,090
	(4,922)	(6,545)	(1,639)	(3,350)	(16,965)	(20,680)
Observations	2,016	2,016	1,409	1,409	607	607
R-squared	0.8000	0.7875	0.8885	0.8560	0.7959	0.7867
Number of Countries	157	157	113	113	44	44
Random Effect	Yes		Yes		Yes	
Country Fixed Effect		Yes		Yes		Yes
Year Fixed Effect		Yes		Yes		Yes

Notes: Columns (3) & (4) represent only BRI countries in this subgroup. Columns (5) & (6) represent only non-BRI countries in this subgroup. Columns (1), (3) and (5) represent random effects. Columns (2), (4) and (6) represent country and time fixed effects. Standard errors are in parentheses *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Results of Hausman Test are presented with the chi-squared test value in the upper row and the P-value in the lower row

Appendix G Lag Length Selection

G.1 China OFDI

	All Countries		BRI Countries		Non-BRI Countries	
Number of Lags	AIC	BIC	AIC	BIC	AIC	BIC
0	53790.56	53964.58	35827.86	35992.47	15241.84	15367.49
1	53780.82	53960.63	35766.14	35936.24	15243.14	15373.28
2	53781.24	53966.86	35607.47	35783.06	15234.94	15369.57
3	53778.18	53969.6	35579.04	35760.12	15230.82	15369.94
4	53758.71	53955.93	35577.8	35764.36	15212.39	15355.99

G.2 China M&A

	All Countries		BRI Countries		Non-BRI Countries	
Number of Lags	AIC	BIC	AIC	BIC	AIC	BIC
0	44536.41	44704.67	30333.83	30492.73	12540.21	12660.43
1	44513.4	44687.28	30333.92	30498.11	12533.91	12658.42
2	44500.37	44679.85	30335.7	30505.18	12530.34	12659.14
3	44501.53	44686.62	30337.49	30512.27	12531.69	12664.78
4	44501.72	44692.42	30338.74	30518.81	12531.71	12669.1

Appendix H Ad-hoc Lag Approach- China OFDI

H.1 All Countries

	(RE) (1)	(FE) (2)	(RE) (3)	(FE) (4)	(RE) (5)	(FE) (6)	(RE) (7)	(FE) (8)	(RE) (9)	(FE) (10)
China OFDI	4.982***	4.652***	4.591***	4.440***	4.759***	4.516***	4.811***	4.502***	5.016***	4.653***
	(0.477)	(0.504)	(0.491)	(0.507)	(0.501)	(0.510)	(0.501)	(0.510)	(0.501)	(0.509)
China OFDI Lag 1			1.527***	1.628***	1.711***	1.704***	2.013***	1.886***	2.140***	1.944***
			(0.475)	(0.495)	(0.488)	(0.499)	(0.501)	(0.506)	(0.500)	(0.504)
China OFDI Lag 2					-0.800*	-0.603	-0.488	-0.440	0.0423	-0.0141
					(0.482)	(0.501)	(0.496)	(0.506)	(0.508)	(0.513)
China OFDI Lag 3							-1.255***	-1.066**	-0.701	-0.647
							(0.480)	(0.495)	(0.493)	(0.501)
China OFDI Lag 4									-2.146***	-2.136***
									(0.474)	(0.480)
BRI	-1,414	3,324**	-1,527	3,365**	-1,435	3,367**	-1,324	3,324**	-1,355	2,943**
	(958.7)	(1,378)	(957.5)	(1,375)	(958.5)	(1,375)	(958.2)	(1,374)	(954.3)	(1,371)
GDP	11.45***	11.56***	11.12***	10.15***	11.25***	10.68***	11.40***	11.54***	11.51***	12.62***
	(0.410)	(1.226)	(0.422)	(1.297)	(0.430)	(1.371)	(0.435)	(1.426)	(0.435)	(1.441)
Inflation (%)	4.155	3.535	4.057	3.050	3.696	2.951	3.190	2.477	3.124	2.237
	(24.89)	(25.69)	(24.84)	(25.64)	(24.83)	(25.64)	(24.80)	(25.62)	(24.70)	(25.51)
Exchange Rate ($)	0.0208	-0.0801	0.0103	-0.0679	0.0142	-0.0724	0.0158	-0.0905	0.0262	-0.106
	(0.199)	(0.362)	(0.198)	(0.361)	(0.199)	(0.361)	(0.199)	(0.361)	(0.199)	(0.359)
Corruption	-571.9	-589.4	-604.5*	-555.2	-611.5*	-566.2	-635.6*	-572.2	-712.1**	-572.5
	(363.8)	(581.7)	(363.2)	(580.5)	(363.4)	(580.5)	(363.5)	(580.0)	(362.9)	(577.6)
Natural Resource	440.2	-3,815	397.3	-3,778	414.9	-3,744	402.0	-3,762	438.5	-3,692
	(1,444)	(2,539)	(1,440)	(2,533)	(1,443)	(2,533)	(1,445)	(2,531)	(1,443)	(2,521)
Communication Infrastructure	12.08	34.66**	12.78	36.02**	12.10	35.43**	10.74	34.31**	9.168	34.47**
	(10.03)	(17.43)	(10.01)	(17.40)	(10.03)	(17.40)	(10.05)	(17.40)	(10.03)	(17.33)
Trade Openness	0.141***	-0.0380	0.130***	-0.0455	0.133***	-0.0434	0.136***	-0.0385	0.133***	-0.0470
	(0.0389)	(0.0907)	(0.0390)	(0.0905)	(0.0391)	(0.0905)	(0.0392)	(0.0905)	(0.0391)	(0.0901)

H.1 (continued)

WTO	-142.8	-2,843	-98.77	-2,867	-122.4	-2,831	-108.2	-2,691	-82.30	-2,390
	(1,573)	(2,754)	(1,569)	(2,748)	(1,572)	(2,748)	(1,574)	(2,746)	(1,571)	(2,735)
RTA with China	-1,911	-3,698	-2,299	-4,301*	-2,179	-4,075	-2,034	-3,697	-2,099	-3,578
	(1,620)	(2,571)	(1,621)	(2,572)	(1,626)	(2,578)	(1,628)	(2,582)	(1,626)	(2,571)
Vote	-774.8	-1,553	-812.4	-1,581	-789.9	-1,669	-696.1	-1,666	-610.2	-1,447
	(3,438)	(5,933)	(3,430)	(5,920)	(3,435)	(5,920)	(3,438)	(5,916)	(3,432)	(5,891)
Constant	1,710	4,761	1,850	4,463	1,900	4,545	2,028	4,569	2,405	4,589
	(3,040)	(5,205)	(3,033)	(5,194)	(3,038)	(5,194)	(3,041)	(5,190)	(3,037)	(5,168)
Observations	2,442	2,442	2,442	2,442	2,442	2,442	2,442	2,442	2,442	2,442
R-squared	0.8549	0.8154	0.8578	0.8189	0.8568	0.8185	0.8557	0.8183	0.8546	0.8159
Number of countries	168	168	168	168	168	168	168	168	168	168
Random Effect	Yes		Yes		Yes		Yes		Yes	
Country Fixed Effect		Yes		Yes		Yes		Yes		Yes
Year Fixed Effect		Yes		Yes		Yes		Yes		Yes

H.2 BRI Countries

	(RE) (1)	(FE) (2)	(RE) (3)	(FE) (4)	(RE) (5)	(FE) (6)	(RE) (7)	(FE) (8)	(RE) (9)	(FE) (10)
China OFDI	0.408	0.0242	0.0768	-0.185	-0.600**	-0.773***	-0.728***	-0.894***	-0.767***	-0.946***
	(0.282)	(0.284)	(0.279)	(0.280)	(0.272)	(0.272)	(0.271)	(0.271)	(0.273)	(0.273)
China OFDI Lag 1			2.223***	2.066***	1.695***	1.640***	1.403***	1.348***	1.368***	1.305***
			(0.267)	(0.269)	(0.259)	(0.259)	(0.264)	(0.263)	(0.265)	(0.264)
China OFDI Lag 2					3.149***	3.184***	2.934***	2.989***	2.858***	2.894***
					(0.257)	(0.257)	(0.258)	(0.258)	(0.265)	(0.263)
China OFDI Lag 3							1.258***	1.354***	1.204***	1.292***
							(0.256)	(0.256)	(0.259)	(0.259)
China OFDI Lag 4									0.336	0.444*
									(0.258)	(0.258)
BRI	-363.4	527.3	-537.6	596.9	-890.1**	194.5	-997.5***	-20.25	-993.6***	23.92
	(374.4)	(702.2)	(367.6)	(690.0)	(353.5)	(660.6)	(351.7)	(656.5)	(351.7)	(656.6)
GDP	10.83***	10.98***	10.17***	9.183***	9.400***	6.980***	9.165***	6.206***	9.135***	6.034***
	(0.924)	(1.896)	(0.923)	(1.878)	(0.919)	(1.805)	(0.922)	(1.796)	(0.921)	(1.797)
Inflation (%)	2.505	-0.766	2.632	-0.553	4.153	1.217	4.735	2.081	4.760	2.135
	(9.493)	(9.718)	(9.306)	(9.549)	(8.920)	(9.133)	(8.859)	(9.059)	(8.858)	(9.054)
Exchange Rate ($)	0.0621	0.0378	0.0429	0.0525	0.0265	0.0776	0.0274	0.106	0.0263	0.111
	(0.0832)	(0.137)	(0.0825)	(0.135)	(0.0813)	(0.129)	(0.0812)	(0.128)	(0.0811)	(0.128)
Corruption	-372.8**	-549.7**	-417.5**	-514.9**	-385.8**	-418.2*	-357.3**	-382.9	-345.0**	-370.5
	(166.4)	(252.0)	(164.0)	(247.6)	(159.2)	(236.9)	(158.7)	(235.1)	(158.8)	(235.1)
Natural Resource	-2,500***	-897.0	-2,444***	-956.5	-2,524***	-1,386	-2,523***	-1,402	-2,534***	-1,415
	(783.1)	(1,228)	(775.7)	(1,207)	(761.8)	(1,155)	(761.0)	(1,145)	(760.1)	(1,145)
Communication Infrastructure	5.978	18.12**	6.837	17.62**	8.862**	16.46**	9.657**	15.79**	9.758**	15.47**
	(4.553)	(7.984)	(4.494)	(7.845)	(4.375)	(7.503)	(4.363)	(7.443)	(4.360)	(7.441)
Trade Openness	0.179***	0.104**	0.160***	0.0903**	0.144***	0.0752*	0.143***	0.0759**	0.144***	0.0786**
	(0.0191)	(0.0410)	(0.0191)	(0.0403)	(0.0189)	(0.0386)	(0.0189)	(0.0383)	(0.0189)	(0.0383)

H.2 (continued)

WTO	-1,001	-1,786*	-998.1	-1,821*	-991.8	-1,962**	-1,014	-2,090**	-1,018	-2,125**
	(688.0)	(1,048)	(681.0)	(1,029)	(667.6)	(984.5)	(666.6)	(976.7)	(665.9)	(976.3)
RTA with China	1,515**	2,304*	1,008	1,708	676.2	966.3	617.2	806.9	613.0	778.0
	(751.6)	(1,186)	(747.5)	(1,168)	(735.3)	(1,118)	(734.8)	(1,109)	(733.9)	(1,109)
Vote	3,259*	1,054	3,218*	1,206	3,128*	1,449	3,111*	1,564	3,131*	1,545
	(1,692)	(2,590)	(1,673)	(2,545)	(1,636)	(2,434)	(1,633)	(2,414)	(1,632)	(2,413)
Constant	1,451	1,299	1,603	939.6	1,541	714.2	1,399	510.0	1,337	470.6
	(1,444)	(2,337)	(1,430)	(2,297)	(1,403)	(2,197)	(1,402)	(2,179)	(1,401)	(2,178)
Observations	1,785	1,785	1,785	1,785	1,785	1,785	1,785	1,785	1,785	1,785
R-squared	0.6362	0.5603	0.6662	0.6093	0.6821	0.6423	0.6815	0.6358	0.6805	0.6319
Number of countries	126	126	126	126	126	126	126	126	126	126
Random Effect	Yes		Yes		Yes		Yes		Yes	
Country Fixed Effect		Yes		Yes		Yes		Yes		Yes
Year Fixed Effect		Yes		Yes		Yes		Yes		Yes

H.3 Non-BRI Countries

	(RE) (1)	(FE) (2)	(RE) (3)	(FE) (4)	(RE) (5)	(FE) (6)	(RE) (7)	(FE) (8)	(RE) (9)	(FE) (10)
China OFDI	7.999***	8.007***	7.856***	7.874***	8.694***	8.187***	8.732***	7.951***	9.265***	8.142***
	(1.116)	(1.215)	(1.175)	(1.227)	(1.188)	(1.223)	(1.181)	(1.222)	(1.171)	(1.205)
China OFDI Lag 1			0.451	0.994	1.490	1.296	2.162*	1.540	2.251*	1.288
			(1.180)	(1.256)	(1.205)	(1.251)	(1.221)	(1.251)	(1.205)	(1.234)
China OFDI Lag 2					-4.229***	-3.903***	-3.364***	-3.667***	-2.291*	-3.072**
					(1.197)	(1.289)	(1.229)	(1.288)	(1.237)	(1.277)
China OFDI Lag 3							-3.420***	-3.044**	-2.072*	-2.391*
							(1.206)	(1.301)	(1.229)	(1.291)
China OFDI Lag 4									-5.263***	-5.312***
									(1.195)	(1.237)
GDP	10.04***	8.572***	9.923***	7.741***	10.73***	11.38***	11.34***	14.29***	11.85***	17.96***
	(0.937)	(2.424)	(0.986)	(2.643)	(1.023)	(2.887)	(1.052)	(3.133)	(1.030)	(3.203)
Inflation (%)	111.5	-373.6	110.7	-384.9	94.66	-319.6	76.94	-252.5	38.41	-176.1
	(401.5)	(486.2)	(402.4)	(486.6)	(399.9)	(483.7)	(398.4)	(482.7)	(392.2)	(476.0)
Exchange Rate ($)	-0.744	5.585	-0.744	5.764	-0.681	4.700	-0.577	3.686	-0.679	1.381
	(2.481)	(6.663)	(2.516)	(6.669)	(2.548)	(6.632)	(2.568)	(6.621)	(2.494)	(6.547)
Corruption	-812.1	256.4	-846.6	322.8	-836.8	96.81	-864.9	-169.9	-1,023	-613.4
	(1,388)	(2,193)	(1,395)	(2,196)	(1,391)	(2,182)	(1,389)	(2,176)	(1,364)	(2,147)
Natural Resource	4,695	-11,449	4,595	-11,329	4,216	-11,712	3,938	-11,810	4,102	-11,160
	(4,571)	(7,324)	(4,613)	(7,328)	(4,634)	(7,279)	(4,647)	(7,252)	(4,540)	(7,147)
Communication Infrastructure	56.88	107.5	57.85	109.7*	51.72	97.25	45.65	88.86	34.37	77.66
	(44.96)	(66.05)	(45.19)	(66.13)	(45.16)	(65.80)	(45.18)	(65.65)	(44.39)	(64.74)
Trade Openness	0.0667	-0.291	0.0611	-0.293	0.0705	-0.292	0.0909	-0.255	0.0943	-0.231
	(0.151)	(0.299)	(0.152)	(0.299)	(0.153)	(0.297)	(0.153)	(0.297)	(0.150)	(0.292)
WTO	3,738		3,811		3,389		3,386		2,764	
	(8,653)		(8,781)		(8,898)		(8,972)		(8,710)	

H.3 (continued)

RTA with China	-9,605	-8,142	-9,909	-8,437	-8,369	-6,966	-6,728	-5,442	-6,098	-4,837
	(6,864)	(8,439)	(6,918)	(8,450)	(6,917)	(8,406)	(6,932)	(8,399)	(6,806)	(8,278)
Vote	-3,173	-8,631	-3,224	-9,101	-3,211	-9,529	-1,819	-7,623	-869.0	-4,549
	(12,421)	(21,028)	(12,510)	(21,043)	(12,525)	(20,899)	(12,543)	(20,836)	(12,284)	(20,544)
Constant	-4,648	3,582	-4,523	3,761	-3,601	4,323	-4,012	2,555	-2,425	2,622
	(13,188)	(15,419)	(13,301)	(15,426)	(13,354)	(15,321)	(13,388)	(15,281)	(13,088)	(15,058)
Observations	657	657	657	657	657	657	657	657	657	657
R-squared	0.8607	0.7321	0.8605	0.7231	0.8582	0.7753	0.8565	0.7753	0.8545	0.7874
Number of countries	42	42	42	42	42	42	42	42	42	42
Random Effect	Yes		Yes		Yes		Yes		Yes	
Country Fixed Effect		Yes		Yes		Yes		Yes		Yes
Year Fixed Effect		Yes		Yes		Yes		Yes		Yes

Appendix I Ad-hoc Lag Approach- China M&A

I.1 All Countries

	(RE)	(FE)	(RE)	(FE)	(RE)	(FE)	(RE)	(FE)	(RE)	(FE)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
China M&A	2.324***	2.209***	2.428***	2.199***	2.484***	2.193***	2.482***	2.174***	2.477***	2.127***
	(0.314)	(0.312)	(0.315)	(0.310)	(0.315)	(0.309)	(0.315)	(0.310)	(0.315)	(0.312)
China M&A Lag 1			-1.261***	-1.523***	-1.205***	-1.574***	-1.213***	-1.580***	-1.208***	-1.601***
			(0.318)	(0.319)	(0.318)	(0.318)	(0.319)	(0.318)	(0.319)	(0.318)
China M&A Lag 2					-0.833***	-1.189***	-0.842***	-1.202***	-0.828***	-1.202***
					(0.316)	(0.321)	(0.317)	(0.322)	(0.319)	(0.322)
China M&A Lag 3							0.0745	-0.284	0.0909	-0.284
							(0.317)	(0.326)	(0.320)	(0.326)
China M&A Lag 4									-0.118	-0.423
									(0.324)	(0.330)
BRI	-982.7	295.8	-958.1	174.1	-859.4	-99.61	-863.8	-163.7	-868.3	-300.5
	(1,123)	(1,541)	(1,122)	(1,532)	(1,120)	(1,528)	(1,122)	(1,530)	(1,122)	(1,534)
GDP	16.66***	18.22***	17.38***	20.49***	17.87***	22.59***	17.84***	23.14***	17.89***	23.94***
	(0.619)	(1.250)	(0.632)	(1.331)	(0.658)	(1.443)	(0.682)	(1.575)	(0.696)	(1.694)
Inflation (%)	-4.039	-12.28	-3.623	-11.33	-3.726	-10.59	-3.747	-10.38	-3.695	-10.14
	(27.41)	(27.00)	(27.38)	(26.84)	(27.34)	(26.75)	(27.34)	(26.75)	(27.35)	(26.75)
Exchange Rate ($)	-0.181	-0.198	-0.185	-0.222	-0.189	-0.240	-0.188	-0.243	-0.189	-0.252
	(0.288)	(0.441)	(0.283)	(0.439)	(0.282)	(0.437)	(0.283)	(0.437)	(0.283)	(0.437)
Corruption	-2,324***	226.9	-2,295***	132.5	-2,258***	103.4	-2,258***	95.19	-2,258***	81.38
	(488.2)	(672.3)	(484.2)	(668.6)	(483.6)	(666.3)	(484.0)	(666.5)	(484.0)	(666.4)
Natural Resource	1,212	2,178	1,025	1,663	984.0	1,388	995.8	1,353	999.1	1,379
	(2,099)	(2,674)	(2,071)	(2,661)	(2,068)	(2,652)	(2,071)	(2,653)	(2,070)	(2,653)
Communication Infrastructure	20.56	75.93***	20.44	72.97***	19.18	68.42***	19.26	67.08***	19.07	65.43***
	(13.59)	(19.46)	(13.48)	(19.36)	(13.47)	(19.33)	(13.48)	(19.39)	(13.50)	(19.43)

I.1 (continued)

Trade Openness	0.149***	0.254***	0.157***	0.264***	0.164***	0.269***	0.164***	0.268***	0.164***	0.265***
	(0.0552)	(0.0970)	(0.0542)	(0.0964)	(0.0542)	(0.0961)	(0.0543)	(0.0961)	(0.0543)	(0.0961)
WTO	216.6	-426.2	299.3	-537.4	365.5	-467.3	353.8	-421.9	373.4	-325.7
	(2,151)	(2,718)	(2,121)	(2,702)	(2,118)	(2,693)	(2,121)	(2,694)	(2,121)	(2,694)
RTA with China	-1,992	-4,810	-2,032	-5,253	-2,016	-5,306	-2,030	-5,321	-2,019	-5,279
	(2,472)	(3,275)	(2,435)	(3,257)	(2,431)	(3,245)	(2,435)	(3,246)	(2,434)	(3,245)
Vote	-7,661	-6,883	-7,224	-5,236	-6,757	-4,164	-6,795	-3,585	-6,850	-3,835
	(5,331)	(8,133)	(5,263)	(8,093)	(5,258)	(8,070)	(5,275)	(8,098)	(5,275)	(8,099)
Constant	12,321**	658.7	11,988**	145.2	11,588**	-345.8	11,611**	-648.3	11,657**	-410.6
	(4,930)	(6,541)	(4,873)	(6,503)	(4,867)	(6,482)	(4,878)	(6,492)	(4,878)	(6,493)
Observations	2,016	2,016	2,016	2,016	2,016	2,016	2,016	2,016	2,016	2,016
R-squared	0.8004	0.7879	0.7956	0.7823	0.7925	0.7784	0.7927	0.7772	0.7925	0.7764
Number of countries	157	157	157	157	157	157	157	157	157	157
Random Effect	Yes		Yes		Yes		Yes		Yes	
Country Fixed Effect		Yes		Yes		Yes		Yes		Yes
Year Fixed Effect		Yes		Yes		Yes		Yes		Yes

I.2 BRI Countries

	(RE) (1)	(FE) (2)	(RE) (3)	(FE) (4)	(RE) (5)	(FE) (6)	(RE) (7)	(FE) (8)	(RE) (9)	(FE) (10)
China M&A	0.575	0.0994	0.460	0.0640	0.456	0.0701	0.436	0.0693	0.430	0.0705
	(0.399)	(0.398)	(0.403)	(0.399)	(0.405)	(0.399)	(0.405)	(0.400)	(0.405)	(0.400)
China M&A Lag 1			0.817**	0.524	0.811**	0.537	0.776*	0.528	0.743*	0.503
			(0.404)	(0.399)	(0.408)	(0.400)	(0.410)	(0.401)	(0.411)	(0.402)
China M&A Lag 2					0.0423	-0.174	-0.0105	-0.192	-0.0597	-0.228
					(0.403)	(0.395)	(0.407)	(0.397)	(0.411)	(0.399)
China M&A Lag 3							0.366	0.169	0.303	0.125
							(0.400)	(0.391)	(0.406)	(0.395)
China M&A Lag 4									0.372	0.328
									(0.400)	(0.398)
BRI	-654.2	419.6	-700.9	406.9	-705.1	419.4	-741.5	409.0	-740.8	450.8
	(511.6)	(967.8)	(511.6)	(967.5)	(513.4)	(968.3)	(514.9)	(968.9)	(514.9)	(970.3)
GDP	27.43***	19.66***	27.24***	19.41***	27.24***	19.51***	27.18***	19.48***	27.14***	19.40***
	(0.653)	(2.475)	(0.658)	(2.481)	(0.664)	(2.491)	(0.667)	(2.494)	(0.668)	(2.496)
Inflation (%)	0.620	-4.606	0.688	-4.670	0.694	-4.677	0.654	-4.691	0.542	-4.856
	(12.07)	(12.64)	(12.05)	(12.63)	(12.06)	(12.64)	(12.06)	(12.64)	(12.06)	(12.65)
Exchange Rate ($)	-0.289***	-0.145	-0.287***	-0.142	-0.287***	-0.143	-0.286***	-0.142	-0.286***	-0.138
	(0.0687)	(0.208)	(0.0686)	(0.208)	(0.0686)	(0.208)	(0.0686)	(0.208)	(0.0686)	(0.208)
Corruption	-762.2***	-595.0*	-777.8***	-587.7	-778.2***	-590.0	-778.1***	-585.3	-774.0***	-586.9
	(189.7)	(359.9)	(189.6)	(359.9)	(189.7)	(360.0)	(189.8)	(360.3)	(189.8)	(360.4)
Natural Resource	-4,112***	-73.30	-4,069***	33.42	-4,068***	16.60	-4,046***	44.31	-4,065***	9.908
	(782.9)	(1,620)	(782.3)	(1,621)	(782.7)	(1,622)	(783.1)	(1,624)	(783.4)	(1,625)
Communication Infrastructure	-7.758	11.36	-7.320	11.55	-7.303	11.45	-7.186	11.57	-7.194	11.36
	(5.001)	(11.08)	(5.001)	(11.08)	(5.005)	(11.08)	(5.007)	(11.09)	(5.008)	(11.09)

I.2 (continued)

Trade Openness	0.0588***	0.0325	0.0528***	0.0284	0.0526***	0.0290	0.0513***	0.0296	0.0516***	0.0320
	(0.0150)	(0.0544)	(0.0153)	(0.0545)	(0.0154)	(0.0545)	(0.0155)	(0.0546)	(0.0155)	(0.0546)
WTO	-1,846***	-5,613***	-1,805**	-5,534***	-1,805**	-5,526***	-1,807**	-5,538***	-1,812**	-5,584***
	(705.5)	(1,546)	(705.0)	(1,547)	(705.3)	(1,548)	(705.3)	(1,549)	(705.4)	(1,550)
RTA with China	1,426**	1,319	1,391**	1,258	1,390**	1,280	1,389**	1,258	1,399**	1,246
	(614.3)	(1,553)	(613.8)	(1,553)	(614.1)	(1,555)	(614.1)	(1,556)	(614.3)	(1,556)
Vote	-617.3	1,267	-766.6	1,256	-775.5	1,274	-843.7	1,220	-829.9	1,170
	(1,742)	(4,294)	(1,741)	(4,293)	(1,744)	(4,294)	(1,746)	(4,298)	(1,746)	(4,299)
Constant	7,933***	5,374	7,999***	5,231	8,005***	5,233	8,029***	5,233	8,017***	5,242
	(1,688)	(3,600)	(1,686)	(3,601)	(1,688)	(3,602)	(1,688)	(3,603)	(1,688)	(3,604)
Observations	1,475	1,475	1,475	1,475	1,475	1,475	1,475	1,475	1,475	1,475
R-squared	0.8940	0.8045	0.8957	0.8061	0.8958	0.8061	0.8965	0.8065	0.8967	0.8061
Number of countries	119	119	119	119	119	119	119	119	119	119
Random Effect										
Country Fixed Effect		Yes		Yes		Yes		Yes		Yes
Year Fixed Effect		Yes		Yes		Yes		Yes		Yes

I.3 Non-BRI Countries

	(RE) (1)	(FE) (2)	(RE) (3)	(FE) (4)	(RE) (5)	(FE) (6)	(RE) (7)	(FE) (8)	(RE) (9)	(FE) (10)
China M&A	2.618***	2.703***	2.704***	2.635***	2.860***	2.598***	2.876***	2.555***	2.929***	2.445***
	(0.591)	(0.582)	(0.588)	(0.579)	(0.598)	(0.577)	(0.601)	(0.580)	(0.616)	(0.585)
China M&A Lag 1			-1.569***	-1.615***	-1.407**	-1.732***	-1.389**	-1.769***	-1.260**	-1.826***
			(0.599)	(0.596)	(0.607)	(0.596)	(0.610)	(0.598)	(0.623)	(0.599)
China M&A Lag 2					-0.933	-1.337**	-0.914	-1.393**	-0.732	-1.409**
					(0.608)	(0.603)	(0.612)	(0.608)	(0.627)	(0.608)
China M&A Lag 3							0.00112	-0.477	0.185	-0.517
							(0.621)	(0.631)	(0.636)	(0.631)
China M&A Lag 4									-0.651	-0.775
									(0.622)	(0.589)
GDP	15.25***	18.43***	16.39***	20.80***	16.46***	23.14***	16.36***	24.07***	15.95***	25.36***
	(1.294)	(2.312)	(1.358)	(2.458)	(1.263)	(2.665)	(1.301)	(2.937)	(1.192)	(3.093)
Inflation (%)	43.02	-424.6	53.63	-404.1	27.31	-387.3	26.59	-370.8	21.60	-308.5
	(588.8)	(660.0)	(585.6)	(655.6)	(582.6)	(653.0)	(583.3)	(653.7)	(582.4)	(654.9)
Exchange Rate ($)	-0.698	0.486	-0.551	0.102	-0.812	-0.431	-0.855	-0.629	-1.079	-1.252
	(3.871)	(7.457)	(3.845)	(7.410)	(3.329)	(7.383)	(3.267)	(7.391)	(2.892)	(7.401)
Corruption	-5,835***	1,471	-5,708***	1,038	-5,642***	856.2	-5,662***	765.6	-5,864***	407.6
	(1,890)	(2,572)	(1,880)	(2,560)	(1,821)	(2,551)	(1,816)	(2,555)	(1,777)	(2,567)
Natural Resource	9,812	3,379	9,553	2,665	9,402*	2,218	9,402*	2,237	9,444*	2,709
	(6,114)	(7,325)	(6,078)	(7,282)	(5,705)	(7,255)	(5,658)	(7,258)	(5,334)	(7,262)
Communication Infrastructure	79.78	174.0**	83.25	170.4**	91.06	159.8**	92.74	156.2**	101.8*	153.2**
	(59.40)	(72.47)	(59.07)	(72.00)	(57.44)	(71.87)	(57.29)	(72.06)	(56.11)	(72.04)
Trade Openness	0.255	0.462	0.282	0.476	0.226	0.483	0.215	0.479	0.137	0.491
	(0.199)	(0.308)	(0.198)	(0.306)	(0.185)	(0.305)	(0.183)	(0.305)	(0.172)	(0.305)
WTO	5,603		5,518		6,016		6,068		6,055	
	(18,960)		(18,826)		(15,903)		(15,578)		(13,756)	

I.3 (continued)

RTA with China	-2,514	2,392	-2,495	1,108	-1,232	531.0	-1,087	448.3	139.0	265.7
	(8,021)	(8,653)	(7,975)	(8,609)	(7,784)	(8,578)	(7,770)	(8,582)	(7,591)	(8,577)
Vote	-7,587	-28,042	-4,061	-21,187	-4,682	-16,115	-5,172	-11,525	-9,698	-12,910
	(19,020)	(30,415)	(18,954)	(30,320)	(17,987)	(30,282)	(18,019)	(30,899)	(17,186)	(30,893)
Constant	4,674	-8,840	1,066	-13,690	1,212	-16,828	1,574	-19,635	5,338	-18,945
	(24,459)	(19,639)	(24,337)	(19,591)	(21,873)	(19,562)	(21,688)	(19,921)	(20,150)	(19,912)
Observations	541	541	541	541	541	541	541	541	541	541
R-squared	0.8022	0.7957	0.7950	0.7885	0.7951	0.7817	0.7959	0.7785	0.8004	0.7776
Number of countries	38	38	38	38	38	38	38	38	38	38
Random Effect	Yes		Yes		Yes		Yes		Yes	
Country Fixed Effect		Yes		Yes		Yes		Yes		Yes
Year Fixed Effect		Yes		Yes		Yes		Yes		Yes

Appendix J Trade Flows Data Sources Comparison

Dataset	The International Trade and Production Database for Estimation - Release 2 (ITPD-E-R02)	Tradition Trade Dataset: BACI
Descriptives	Includes international and intra-national trade flows for 265 countries and 170 industries, and covers 1986-2019	covers over 5000 products and 200 countries crossing 11 sections in 6 digital Harmonized System (HS) codes between 2007 and 2021.
Time Period	Agriculture, Forestry and Fishing: 1986-2019 Mining and Energy & Manufacturing: 1988-2019 Services: 2000-2019	1995-2021
Number of Counties	265	200
Contained Variables	Exporter (iso 3-digital country code, name), importer (iso 3-digital country code, name), year, industry category (ITPDE industry code, ITPDE industry description, broad sector), value of the trade flows (trade flows in millions of current US dollars), and flag indicators (mirror and zero)	Exporter (iso 3-digital country code), importer (iso 3-digital country code), year, product category (6 digital HS code), value of the trade flows, Quantity
International Trade Flows	Yes	Yes
Intra-national Trade Flows	Yes	No (need to calculate by domestic output - export)
Industry Codes	ITPD-E industry codes	6-digital HS codes
Concordances with Other Industry Classification Systems	Yes	Yes
Original Trade Data Source	Agriculture: FAO Other sectors: the United Nations Comtrade Database (COMTRADE)	COMTRADE
Original Production Data Source	Agriculture: FAOSTAT Forestry and Fishing: UN National Accounts database (UNSNA) Manufacturing: The United Nations Industrial Statistics (INDSTAT) database Mining and Energy: “Mining and Utilities Statistics Database” dataset of the United Nations Industrial Development Organization (UNIDO) (both rev.3 & rev.4)	None

Appendix J (continued)

	Services: WTO-UNCTAD-ITC Annual Trade & UN Trade in Services (UN-TSD) Database	
Details	1) Using reported administrative data which is not estimated by statistical techniques. 2) In the Agriculture sector, it dropped industries could not match any ISIC and HS code, and FCL item codes above 1296	
Pros	Cover international and intra-national trade flows	Data updates to 2021
Cons	The data was updated only up to 2019	Need to merge data from following sources and then to calculate the intra-national trade flows: Agriculture: FAOSTAT -2021 Forestry and Fishing: UNSNA - 2020 Manufacturing: the United Nations Industrial Statistics (INDSTAT) database, cover 174 countries (111 in the most recent year) between 1963-2020 Mining and Energy: UNIDO - 2020 Services: WTO-UNCTAD-ITC Annual Trade & UN Trade in Services (UN-TSD) Database (2000- 2020)

Notes: In the agriculture sector of ITPD-E dataset, industries not matching FCL items were dropped. These industries included 10(Total Merchandise Trade), 30(Rice, paddy (rice milled equivalent), 464, 944(Meat of cattle with the bone, fresh or chilled (indigenous)), 972(Meat of buffalo, fresh or chilled (indigenous)), 1012(Meat of sheep, fresh or chilled (indigenous)), 1032(Meat of goat, fresh or chilled (indigenous)), 1055(Meat of pig with the bone, fresh or chilled (indigenous)), 1070(Meat of ducks, fresh or chilled (indigenous)), 1077(Meat of geese, fresh or chilled (indigenous)), 1084(Meat of pigeons and other birds n.e.c., fresh, chilled or frozen (indigenous)), 1087(Meat of turkeys, fresh or chilled (indigenous)), 1094(Meat of chickens, fresh or chilled (indigenous)), 1120(Horse meat, fresh or chilled (indigenous)), 1122(Meat of asses, fresh or chilled (indigenous)), 1124(Meat of mules, fresh or chilled (indigenous)), 1137 (Meat of camels, fresh or chilled (indigenous)), 1144(Meat of rabbits and hares, fresh or chilled (indigenous)), 1154(Meat of other domestic rodents, fresh or chilled (indigenous)), 1159, and 1161(Meat of other domestic camelids, fresh or chilled (indigenous)). FCL item codes above 1296 correspond to non-agricultural sectors, such as machinery, services, and other industries.

Appendix K Industry Classification by ITPD-E (version 2) Codes

Broader Industry	Code	Industry Category
		Agriculture, Forestry, and Fishing (1-28)
Agriculture	1	Wheat
Agriculture	2	Rice (raw)
Agriculture	3	Corn
Agriculture	4	Other cereals
Agriculture	5	Cereal products
Agriculture	6	Soybeans
Agriculture	7	Other oilseeds (excluding peanuts)
Agriculture	8	Animal feed ingredients and pet foods
Agriculture	9	Raw and refined sugar and sugar crops
Agriculture	10	Other sweeteners
Agriculture	11	Pulses and legumes, dried, preserved
Agriculture	12	Fresh fruit
Agriculture	13	Fresh vegetables
Agriculture	14	Prepared fruits and fruit juices
Agriculture	15	Prepared vegetables
Agriculture	16	Nuts
Agriculture	17	Live Cattle
Agriculture	18	Live Swine
Agriculture	19	Eggs
Agriculture	20	Other meats, livestock products, and
Agriculture	21	Cocoa and cocoa products
Agriculture	22	Beverages, nec
Agriculture	23	Cotton
Agriculture	24	Tobacco leaves and cigarettes
Agriculture	25	Spices
Agriculture	26	Other agricultural products, nec
Forestry	27	Forestry
Fishing	28	Fishing
		Mining and Energy (29-35)
Mining and Energy	29	Mining of hard coal
Mining and Energy	30	Mining of lignite
Mining and Energy	31	Extraction crude petroleum and natural gas
Mining and Energy	32	Mining of iron ores
Mining and Energy	33	Other mining and quarrying
Mining and Energy	34	Electricity production, collection,
Mining and Energy	35	Gas production and distribution

Appendix K (continued)

Manufacturing (36-153)		
Manufacturing	36	Processing/preserving of meat
Manufacturing	37	Processing/preserving of fish
Manufacturing	38	Processing/preserving of fruit & veg
Manufacturing	39	Vegetable and animal oils and fats
Manufacturing	40	Dairy products
Manufacturing	41	Grain mill products
Manufacturing	42	Starches and starch products
Manufacturing	43	Prepared animal feeds
Manufacturing	44	Bakery products
Manufacturing	45	Sugar
Manufacturing	46	Cocoa chocolate and sugar confection
Manufacturing	47	Macaroni noodles & similar products
Manufacturing	48	Other food products n.e.c.
Manufacturing	49	Distilling rectifying & blending of
Manufacturing	50	Wines
Manufacturing	51	Malt liquors and malt
Manufacturing	52	Soft drinks; mineral waters
Manufacturing	53	Tobacco products
Manufacturing	54	Textile fiber preparation; textile w
Manufacturing	55	Made-up textile articles except apparel
Manufacturing	56	Carpets and rugs
Manufacturing	57	Cordage rope twine and netting
Manufacturing	58	Other textiles n.e.c.
Manufacturing	59	Knitted and crocheted fabrics and articles
Manufacturing	60	Wearing apparel except fur apparel
Manufacturing	61	Dressing & dyeing of fur; processing
Manufacturing	62	Tanning and dressing of leather
Manufacturing	63	Luggage handbags etc.; saddlery & ha
Manufacturing	64	Footwear
Manufacturing	65	Sawmilling and planning of wood
Manufacturing	66	Veneer sheets plywood particle board
Manufacturing	67	Builders' carpentry and joinery
Manufacturing	68	Wooden containers
Manufacturing	69	Other wood products; articles of cork/straw
Manufacturing	70	Pulp paper and paperboard
Manufacturing	71	Corrugated paper and paperboard
Manufacturing	72	Other articles of paper and paperboard
Manufacturing	73	Publishing of books and other public
Manufacturing	74	Publishing of newspapers journals et
Manufacturing	75	Publishing of recorded media
Manufacturing	76	Other publishing

Appendix K (continued)

Manufacturing	77	Printing
Manufacturing	78	Service activities related to printing
Manufacturing	79	Coke oven products
Manufacturing	80	Refined petroleum products
Manufacturing	81	Processing of nuclear fuel
Manufacturing	82	Basic chemicals except fertilizers
Manufacturing	83	Fertilizers and nitrogen compounds
Manufacturing	84	Plastics in primary forms; synthetic
Manufacturing	85	Pesticides and other agrochemical products
Manufacturing	86	Paints varnishes printing ink and ma
Manufacturing	87	Pharmaceuticals medicinal chemicals
Manufacturing	88	Soap cleaning & cosmetic preparation
Manufacturing	89	Other chemical products n.e.c.
Manufacturing	90	Man-made fibers
Manufacturing	91	Rubber tyres and tubes
Manufacturing	92	Other rubber products
Manufacturing	93	Plastic products
Manufacturing	94	Glass and glass products
Manufacturing	95	Pottery china and earthenware
Manufacturing	96	Refractory ceramic products
Manufacturing	97	Struct. non-refractory clay; ceramic
Manufacturing	98	Cement lime and plaster
Manufacturing	99	Articles of concrete cement and plaster
Manufacturing	100	Cutting shaping & finishing of stone
Manufacturing	101	Other non-metallic mineral products n.e.c.
Manufacturing	102	Basic iron and steel
Manufacturing	103	Basic precious and non-ferrous metals
Manufacturing	104	Structural metal products
Manufacturing	105	Tanks reservoirs and containers of metal
Manufacturing	106	Steam generators
Manufacturing	107	Cutlery hand tools and general hardware
Manufacturing	108	Other fabricated metal products n.e.c.
Manufacturing	109	Engines & turbines (not for transport equipment)
Manufacturing	110	Pumps compressors taps and valves
Manufacturing	111	Bearings gears gearing & driving elements
Manufacturing	112	Ovens furnaces and furnace burners
Manufacturing	113	Lifting and handling equipment
Manufacturing	114	Other general purpose machinery
Manufacturing	115	Agricultural and forestry machinery
Manufacturing	116	Machine tools
Manufacturing	117	Machinery for metallurgy
Manufacturing	118	Machinery for mining & construction

Appendix K (continued)

Manufacturing	119	Food/beverage/tobacco processing machinery
Manufacturing	120	Machinery for textile apparel and leather
Manufacturing	121	Weapons and ammunition
Manufacturing	122	Other special purpose machinery
Manufacturing	123	Domestic appliances n.e.c.
Manufacturing	124	Office accounting and computing machinery
Manufacturing	125	Electric motors generators and transformers
Manufacturing	126	Electricity distribution & control apparatus
Manufacturing	127	Insulated wire and cable
Manufacturing	128	Accumulators' primary cells and batteries
Manufacturing	129	Lighting equipment and electric lamps
Manufacturing	130	Other electrical equipment n.e.c.
Manufacturing	131	Electronic valves tubes etc.
Manufacturing	132	TV/radio transmitters; line comm. apparatus
Manufacturing	133	TV and radio receivers and associated goods
Manufacturing	134	Medical surgical and orthopedic equipment
Manufacturing	135	Measuring/testing/navigating appliances etc.
Manufacturing	136	Optical instruments & photographic equipment
Manufacturing	137	Watches and clocks
Manufacturing	138	Motor vehicles
Manufacturing	139	Automobile bodies trailers & semi-trailers
Manufacturing	140	Parts/accessories for automobiles
Manufacturing	141	Building and repairing of ships
Manufacturing	142	Building/repairing of pleasure/sport. boats
Manufacturing	143	Railway/tramway locomotives & rolling stock
Manufacturing	144	Aircraft and spacecraft
Manufacturing	145	Motorcycles
Manufacturing	146	Bicycles and invalid carriages
Manufacturing	147	Other transport equipment n.e.c.
Manufacturing	148	Furniture
Manufacturing	149	Jewelry and related articles
Manufacturing	150	Musical instruments
Manufacturing	151	Sports goods
Manufacturing	152	Games and toys
Manufacturing	153	Other manufacturing n.e.c.
	Services (154-170)	
Services	154	Manufacturing services on physical inputs
Services	155	Maintenance and repair services n.i.e.
Services	156	Transport
Services	157	Travel
Services	158	Construction
Services	159	Insurance and pension services

Appendix K (continued)

Services	160	Financial services
Services	161	Charges for use of intellectual property
Services	162	Telecom, computer, information services
Services	163	Other business services
Services	164	Heritage and recreational services
Services	165	Health services
Services	166	Education services
Services	167	Government goods and services n.i.e.
Services	168	Services not allocated
Services	169	Trade-related services
Services	170	Other personal services

Appendix L Procedures for Addressing Zero Trade Flows

We apply the PPML estimation to address estimation problems which may be created by the high frequency zero trade flows. However, an unsolved problem still exists- ‘true’ zero trade flows versus ‘false’ zero. ‘True’ zero trade flows refer to pairs of countries that may not trade with each other for several years within a certain period but do engage in trade in other years. ‘False’ zero trade flows refer to pairs of trade partners who either never trade or only trade once during a specific period, possibly due to some trade barriers such as political issues. If we directly input the raw data into the analysis, it might lead to biased results. For example, consider a pair of trade partners that never engage in trade, representing a 'false' zero situation. In such cases, signing a BRI MoUs with China is irrelevant because they will never trade with each other due to other reasons. Consequently, retaining these zeros in the analysis would underestimate the impact of the BRI.

To tackle the ‘false’ zeros issue, we have established a 15% threshold over 14 years spans. In other words, we set thresholds based on three instances- two times positive trade flows, one-time positive trade flows and zero times positive trade flows. If the paired trade partners record at least two positive trade flows over 14 years, we retain positive and zero trade flows data. In this case, the zeros are considered 'true', so we retain them. We also retain the positive trade flows data when the paired trade partners have just one positive trade flow over 14 years, but we eliminate all zero trade flows. These single positive trade flows from paired countries represent that they have the potential to trade with each other. However, the zeros in these cases are considered 'false' zeros. Lastly, suppose the paired trade partners record no positive trade flows during the period. In that case, we discard the 'false' zeros, as they appear unlikely to trade with each other under any circumstance.

Appendix M Pairwise Correlation of Independent Variables

M.1 Aggregated Industries

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
(1) BRI (At Least One)	1.00													
(2) One BRI (Only)	0.79	1.00												
(3) Exporter BRI	0.78	0.42	1.00											
(4) Importer BRI	0.78	0.43	0.41	1.00										
(5) Both BRI	0.52	-0.11	0.67	0.67	1.00									
(6) Both BRI (China is excluded)	0.51	-0.11	0.66	0.66	0.98	1.00								
(7) Both BRI (China is Exporter)	0.06	-0.01	0.08	0.08	0.12	-0.01	1.00							
(8) Both BRI (China is Importer)	0.06	-0.01	0.08	0.08	0.12	-0.01	0.01	1.00						
(9) International	0.01	0.03	-0.00	-0.00	-0.02	-0.02	-0.01	-0.01	1.00					
(10) Distance (Ln)	-0.03	0.01	-0.05	-0.04	-0.07	-0.07	0.00	0.00	0.11	1.00				
(11) Contiguity	0.01	-0.02	0.02	0.02	0.04	0.03	0.02	0.02	0.01	-0.22	1.000			
(12) Common Language	-0.06	-0.06	-0.04	-0.04	-0.01	-0.01	-0.02	-0.02	-0.09	-0.04	0.14	1.000		
(13) Colonial Relationship	-0.02	-0.01	-0.02	-0.02	-0.01	-0.01	-0.00	-0.00	0.01	-0.06	0.12	0.13	1.00	
(14) Free Trade Agreement (RTA)	0.04	0.03	0.03	0.03	0.02	0.02	-0.00	-0.00	0.03	-0.30	0.14	0.01	0.08	1.00

M.2 Agriculture, Forestry, and Fishing Sector

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
(1) BRI (At Least One)	1.00													
(2) One BRI (Only)	0.77	1.00												
(3) Exporter BRI	0.78	0.40	1.00											
(4) Importer BRI	0.79	0.41	0.43	1.00										
(5) Both BRI	0.54	-0.12	0.69	0.69	1.00									
(6) Both BRI (China is excluded)	0.53	-0.11	0.68	0.68	0.98	1.00								
(7) Both BRI (China is Exporter)	0.07	-0.01	0.09	0.09	0.12	-0.01	1.00							
(8) Both BRI (China is Importer)	0.07	-0.01	0.09	0.08	0.12	-0.01	0.02	1.00						
(9) International	0.02	0.03	0.00	0.00	-0.02	-0.02	-0.01	-0.01	1.00					
(10) Distance (Ln)	-0.03	0.02	-0.04	-0.04	-0.07	-0.07	0.01	0.01	0.13	1.00				
(11) Contiguity	0.00	-0.02	0.01	0.01	0.03	0.02	0.02	0.02	0.01	-0.22	1.00			
(12) Common Language	-0.06	-0.06	-0.03	-0.05	-0.01	-0.01	-0.02	-0.02	-0.11	-0.08	0.14	1.00		
(13) Colonial Relationship	-0.02	-0.01	-0.02	-0.02	-0.02	-0.02	-0.00	-0.00	0.01	-0.06	0.12	0.14	1.00	
(14) Free Trade Agreement (RTA)	0.04	0.03	0.03	0.03	0.02	0.02	-0.01	-0.01	0.04	-0.30	0.14	0.02	0.08	1.00

M.3 Mining and Energy Sector

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
(1) BRI (At Least One)	1.00													
(2) One BRI (Only)	0.78	1.00												
(3) Exporter BRI	0.79	0.43	1.00											
(4) Importer BRI	0.77	0.40	0.42	1.00										
(5) Both BRI	0.53	-0.11	0.67	0.69	1.00									
(6) Both BRI (China is excluded)	0.52	-0.11	0.66	0.67	0.97	1.00								
(7) Both BRI (China is Exporter)	0.08	-0.02	0.10	0.10	0.15	-0.01	1.00							
(8) Both BRI (China is Importer)	0.08	-0.02	0.10	0.10	0.15	-0.01	0.02	1.00						
(9) International	0.01	0.03	-0.00	-0.01	-0.03	-0.03	-0.01	-0.01	1.00					
(10) Distance (Ln)	-0.03	0.02	-0.04	-0.04	-0.07	-0.07	0.01	0.01	0.10	1.00				
(11) Contiguity	0.00	-0.03	0.02	0.02	0.04	0.03	0.02	0.02	0.01	-0.24	1.00			
(12) Common Language	-0.07	-0.07	-0.04	-0.04	-0.01	-0.00	-0.03	-0.03	-0.08	-0.08	0.16	1.00		
(13) Colonial Relationship	-0.03	-0.01	-0.02	-0.02	-0.02	-0.02	-0.01	-0.01	0.01	-0.05	0.11	0.16	1.00	
(14) Free Trade Agreement (RTA)	0.04	0.03	0.03	0.03	0.02	0.03	-0.01	-0.01	0.04	-0.32	0.13	0.01	0.07	1.00

M.4 Manufacturing Sector

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
(1) BRI (At Least One)	1.00													
(2) One BRI (Only)	0.80	1.00												
(3) Exporter BRI	0.77	0.43	1.00											
(4) Importer BRI	0.78	0.45	0.39	1.00										
(5) Both BRI	0.51	-0.10	0.67	0.65	1.00									
(6) Both BRI (China is excluded)	0.51	-0.10	0.66	0.65	0.99	1.00								
(7) Both BRI (China is Exporter)	0.05	-0.01	0.07	0.07	0.10	-0.01	1.00							
(8) Both BRI (China is Importer)	0.05	-0.01	0.07	0.07	0.10	-0.01	0.02	1.00						
(9) International	0.01	0.02	-0.00	-0.00	-0.02	-0.02	-0.01	-0.01	1.00					
(10) Distance (Ln)	-0.03	0.01	-0.04	-0.03	-0.06	-0.06	-0.00	-0.00	0.08	1.00				
(11) Contiguity	0.01	-0.01	0.02	0.01	0.03	0.03	0.02	0.02	0.01	-0.19	1.00			
(12) Common Language	-0.06	-0.06	-0.04	-0.04	-0.02	-0.01	-0.02	-0.02	-0.06	-0.02	0.11	1.00		
(13) Colonial Relationship	-0.02	-0.01	-0.01	-0.01	-0.01	-0.01	-0.00	-0.00	0.01	-0.06	0.12	0.11	1.00	
(14) Free Trade Agreement (RTA)	0.04	0.03	0.03	0.02	0.02	0.02	0.00	0.00	0.02	-0.23	0.13	0.00	0.08	1.00

M.5 Services Sector

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
(1) BRI (At Least One)	1.00													
(2) One BRI (Only)	0.80	1.00												
(3) Exporter BRI	0.76	0.42	1.00											
(4) Importer BRI	0.77	0.42	0.36	1.00										
(5) Both BRI	0.50	-0.13	0.65	0.65	1.00									
(6) Both BRI (China is excluded)	0.48	-0.13	0.64	0.63	0.98	1.00								
(7) Both BRI (China is Exporter)	0.07	-0.02	0.09	0.09	0.14	-0.01	1.00							
(8) Both BRI (China is Importer)	0.07	-0.02	0.09	0.09	0.14	-0.01	-0.00	1.00						
(9) International	0.03	0.06	0.01	0.01	-0.04	-0.04	0.01	0.01	1.00					
(10) Distance (Ln)	-0.02	0.02	-0.04	-0.04	-0.07	-0.07	0.01	0.01	0.17	1.00				
(11) Contiguity	0.01	-0.04	0.02	0.02	0.06	0.05	0.02	0.02	0.03	-0.23	1.00			
(12) Common Language	-0.07	-0.07	-0.05	-0.04	-0.01	-0.01	-0.02	-0.02	-0.21	-0.02	0.24	1.00		
(13) Colonial Relationship	-0.02	-0.02	-0.01	-0.01	-0.00	0.00	-0.01	-0.01	0.02	-0.06	0.22	0.20	1.00	
(14) Free Trade Agreement (RTA)	-0.01	-0.02	-0.01	-0.01	0.00	0.01	-0.0	-0.01	0.10	-0.48	0.15	0.05	0.05	1.00

Appendix N Number of GPS Pings after Filtering Steps

	May				October			
Facility Number	Raw	After dropping duplicated records	After dropping short records (fewer than 10)	After drop speeds larger than 95 MPH	Raw	After dropping duplicated records	After dropping short records (fewer than 10)	After drop speeds larger than 95 MPH
1	2243572	2128509	2128509	2128509	3056975	2879474	2879474	2879472
2	1794976	1752662	1752662	1752660	923676	903756	903756	903755
3	2743964	2655722	2655722	2655720	2815191	2730380	2730378	2730371
4	3059798	2887455	2887455	2887455	2407842	2272905	2272905	2272905
5	3003933	2900283	2900283	2900283	1924128	1863312	1863312	1863311
6	472072	454652	454652	454652	607944	582728	582728	582728
7	372321	360909	360909	360909	526286	510796	510796	510796
8	133780	127802	127802	127802	503563	482401	482401	482401
9	1775166	1693376	1693376	1693372	1851825	1754175	1754175	1754164
10	7271218	6986927	6986927	6986926	7239709	6996492	6996492	6996488
11	152732	145862	145862	145862	23175	22543	22510	22510
12	126890	124282	124282	124282	100592	97884	97884	97884
13	1812811	1773211	1773211	1773210	1917015	1869764	1869764	1869761
14	932746	909081	909079	909076	1094454	1068188	1068188	1068186
15	122850	118408	118388	118388	747729	727941	727941	727939

Appendix O Pairwise Correlation of Independent Variables

Variables	(1)	(2)	(3)	(4)	(5)	(6)
(1) Detained	1.000					
(2) Post	0.000	1.000				
(3) Duration (hour)	0.522	0.000	1.000			
(4) Parked Nearby	-0.095	0.018	-0.044	1.000		
(5) Max Duration Hours Parked Nearby	-0.106	-0.005	-0.069	0.258	1.000	
(6) Cumulative Hours Parked Nearby	-0.122	0.001	-0.079	0.290	0.991	1.000

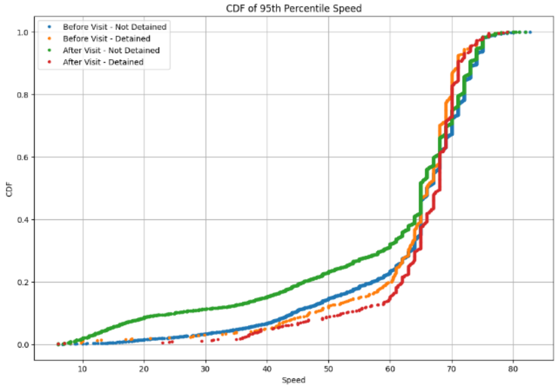
Appendix P Results of Breusch-Pagan Test and White Test

	Breusch-Pagan Test: H0: Constant Variance		White Test: H0: Homoskedasticity		
Aggregated Data	Chi^2	P-value	Chi^2	Degree of Freedom	P-value
95^{th} Percentile Speed	16608.36	0.0000	7077.68	260	0.0000
99^{th} Percentile Speed	19212.26	0.0000	6465.20	260	0.0000
Average Speed	2413.34	0.0000	13713.55	260	0.0000
Reefer					
95^{th} Percentile Speed	1088.22	0.0000	1602.82	66	0.0000
99^{th} Percentile Speed	820.40	0.0000	1277.31	66	0.0000
Average Speed	1473.12	0.0000	3663.47	66	0.0000
Dry Van					
95^{th} Percentile Speed	2629.64	0.0000	3857.01	98	0.0000
99^{th} Percentile Speed	9452.81	0.0000	3568.90	98	0.0000
Average Speed	939.87	0.0000	6588.02	98	0.0000
Tanker Truck					
95^{th} Percentile Speed	299.33	0.0000	1028.81	66	0.0000
99^{th} Percentile Speed	307.21	0.0000	1043.70	66	0.0000
Average Speed	49.59	0.0000	750.98	66	0.0000
Food Processors					
95^{th} Percentile Speed	1816.49	0.0000	1989.25	102	0.0000
99^{th} Percentile Speed	1403.38	0.0000	1842.30	102	0.0000
Average Speed	987.33	0.0000	4929.63	102	0.0000
Distribution Centers					
95^{th} Percentile Speed	13111.13	0.0000	3820.34	80	0.0000
99^{th} Percentile Speed	15795.31	0.0000	3316.04	80	0.0000
Average Speed	1291.26	0.0000	8649.29	80	0.0000
Semiconductors					
95^{th} Percentile Speed	1489.45	0.0000	352.26	66	0.0000
99^{th} Percentile Speed	1499.20	0.0000	347.81	66	0.0000
Average Speed	86.30	0.0000	448.95	66	0.0000

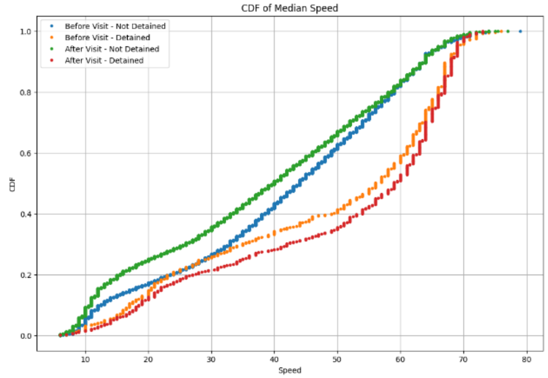
Note: The values in the White Test section represent the aggregate results from the heteroskedasticity, skewness, and kurtosis.

Appendix Q CDF of 95th Percentile Speed, Median Speed and Average Speed Comparison Between Detained and Not-Detained in Different Types of facilities in All 8-hour Periods, 4-hours Before Visit, and 4-hours After Visit

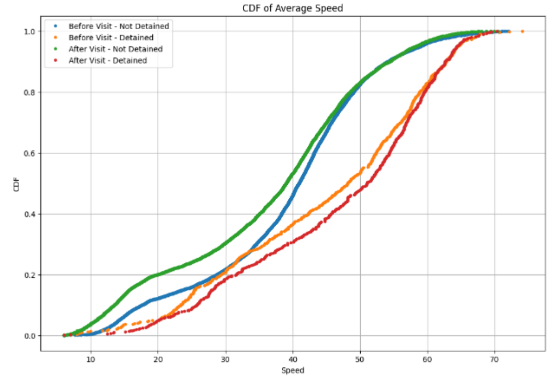
Food Processors 95th Percentile Speed



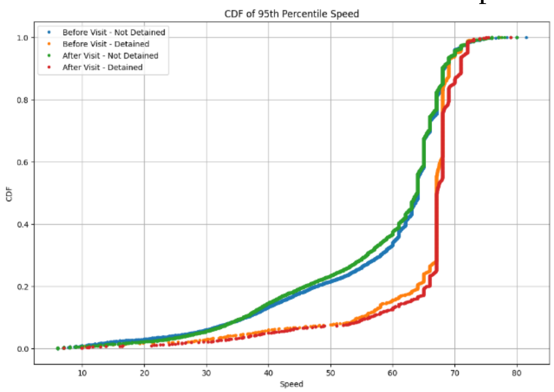
Food Processors Median Speed



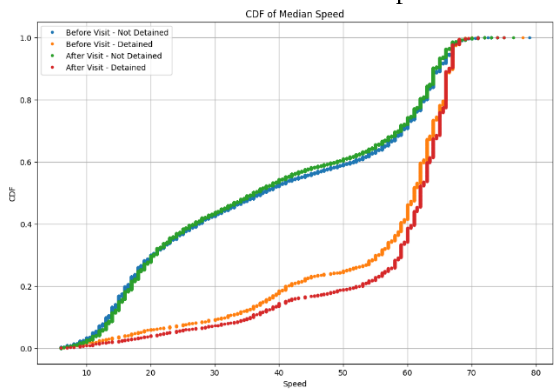
Food Processors Average Speed



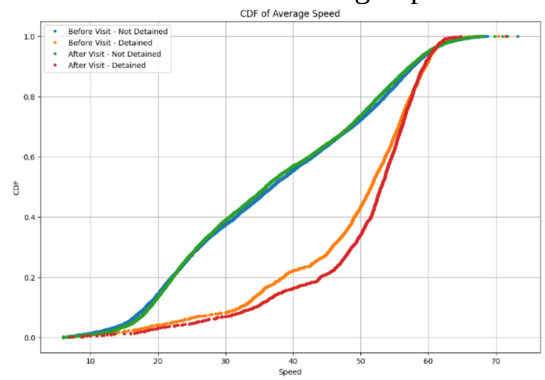
Distribution Centers 95th Percentile Speed



Distribution Centers Median Speed

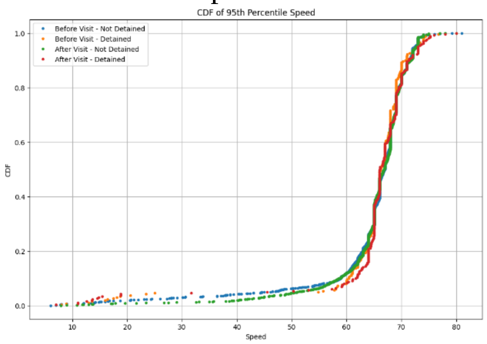


Distribution Centers Average Speed

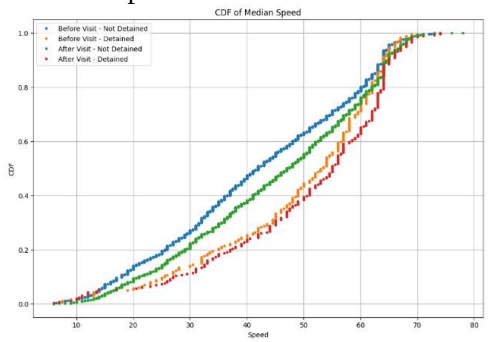


Appendix Q (continued)

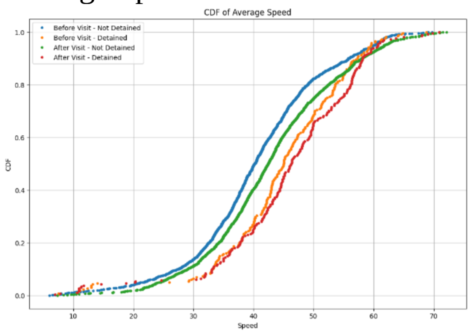
Semiconductor and Electric Components 95th Percentile Speed



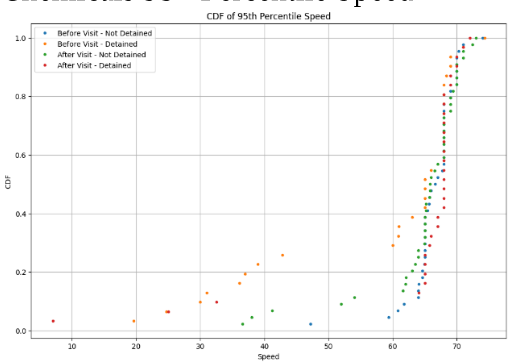
Semiconductor and Electric Components Median Speed



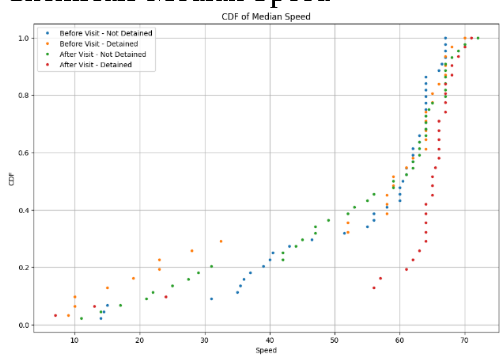
Semiconductor and Electric Components Average Speed



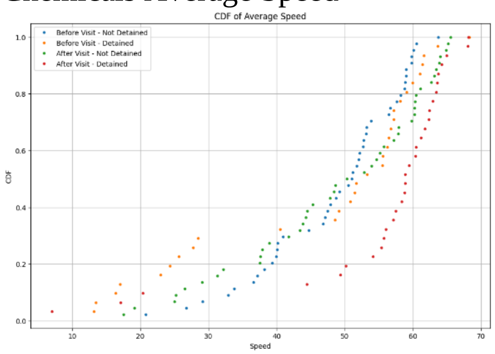
Chemicals 95th Percentile Speed



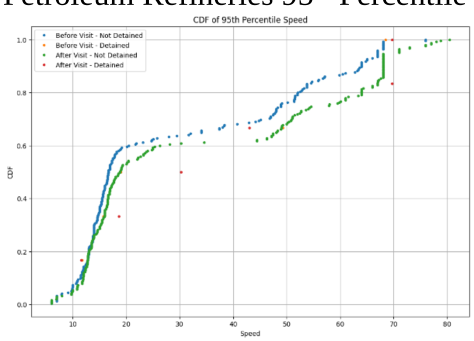
Chemicals Median Speed



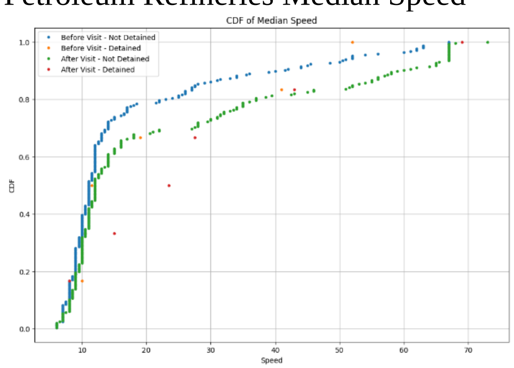
Chemicals Average Speed



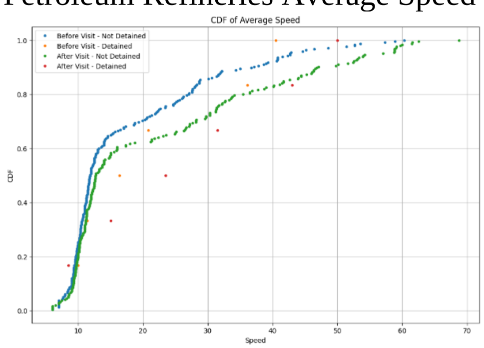
Petroleum Refineries 95th Percentile Speed



Petroleum Refineries Median Speed



Petroleum Refineries Average Speed



Appendix R Results of Average Speed for Aggregated Data

R.1 Results of Average Speed in the 0.25 Quantile Regression for Aggregated Data

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Detained	5.97***	5.53***	5.82***	5.34***	5.93***	5.42***	5.66***	5.13***	5.48***	5.04***
	(0.19)	(0.19)	(0.27)	(0.26)	(0.26)	(0.25)	(0.27)	(0.27)	(0.26)	(0.26)
Post			-0.09	-0.06	0.83***	0.94***	0.81***	0.86***	0.79***	0.87***
			(0.13)	(0.12)	(0.23)	(0.23)	(0.24)	(0.24)	(0.23)	(0.24)
Detained*Post			0.32	0.32	-0.31	-0.34	-0.09	-0.18	-0.02	-0.14
			(0.37)	(0.35)	(0.36)	(0.35)	(0.37)	(0.37)	(0.36)	(0.36)
Parked Nearby					-4.89***	-5.08***	-4.20***	-4.46***	-3.89***	-4.14***
					(0.20)	(0.19)	(0.21)	(0.21)	(0.20)	(0.21)
Parked Nearby*Post					-0.97***	-1.03***	-0.99***	-0.96***	-0.95***	-1.00***
					(0.27)	(0.26)	(0.28)	(0.28)	(0.28)	(0.28)
Max Hours Parked Nearby							-0.10***	-0.10***		
							(0.00)	(0.00)		
Max Hours Parked Nearby*Post							-0.01	-0.01**		
							(0.01)	(0.01)		
Cumulative Hours Parked Nearby									-0.12***	-0.13***
									(0.00)	(0.00)
Cumulative Hours Parked Nearby*Post									-0.00	-0.01
									(0.01)	(0.01)

R.1 (continued)

Constant	42.08***	50.38***	42.13***	50.43***	43.92***	52.04***	43.80***	51.98***	43.74***	51.83***
	(0.34)	(0.64)	(0.35)	(0.64)	(0.36)	(0.64)	(0.36)	(0.68)	(0.36)	(0.67)
Observations	42,848	42,848	42,848	42,848	42,848	42,848	42,848	42,848	42,848	42,848
Fixed Effects: *j*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fixed Effects: *k*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fixed Effects: *t*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fixed Effects: *s*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fixed Effects: *j*, *k*, *t*, *s*		Yes		Yes		Yes		Yes		Yes
Pseudo R^2	0.262	0.283	0.262	0.283	0.274	0.295	0.283	0.304	0.286	0.307

Notes: Post is a dummy variable that equals 1 if the truck's speed is calculated during the time period after leaving the facility, and 0 otherwise. Parked Nearby is a dummy variable that equals 1 if the truck is parked within 10-mile radius of the facility, either before or after visiting, and 0 otherwise. Max Duration Hours Parked Nearby denotes maximum parking hours of the truck parked near the facility, either before or after visiting. Cumulative Hours Parked Nearby represents the cumulative hours of the truck spends parked near the facility, either before or after visiting. Fixed effects for facility type (*j*), truck type (*k*), month (*t*), and state (*s*) are incorporated into the analyses.

R.2 Results of Average Speed in the 0.5 Quantile Regression for Aggregated Data

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Detained	3.93***	3.78***	3.65***	3.55***	4.62***	4.32***	4.34***	4.04***	4.13***	3.97***
	(0.23)	(0.22)	(0.32)	(0.29)	(0.32)	(0.28)	(0.34)	(0.28)	(0.35)	(0.28)
Post			-0.24	-0.18	0.54*	0.57**	0.60**	0.53**	0.61**	0.51**
			(0.15)	(0.14)	(0.29)	(0.25)	(0.30)	(0.25)	(0.31)	(0.25)
Detained*Post			0.49	0.42	0.12	0.07	0.13	0.16	0.13	0.08
			(0.44)	(0.40)	(0.44)	(0.39)	(0.47)	(0.39)	(0.48)	(0.39)
Parked Nearby					-5.00***	-4.78***	-4.41***	-4.23***	-4.13***	-4.07***
					(0.24)	(0.23)	(0.26)	(0.22)	(0.27)	(0.22)
Parked Nearby*Post					-0.82**	-0.72**	-0.75**	-0.67**	-0.72*	-0.58*
					(0.33)	(0.29)	(0.36)	(0.30)	(0.37)	(0.30)
Max Hours Parked Nearby							-0.10***	-0.10***		
							(0.01)	(0.01)		
Max Hours Parked Nearby*Post							-0.02**	-0.01**		
							(0.01)	(0.01)		
Cumulative Hours Parked Nearby									-0.13***	-0.13***
									(0.01)	(0.01)
Cumulative Hours Parked Nearby*Post									-0.01*	-0.01**
									(0.01)	(0.01)

R.2 (continued)

Constant	51.17***	53.76***	51.23***	53.90***	52.44***	55.61***	52.56***	55.38***	52.47***	55.34***
	(0.40)	(0.74)	(0.41)	(0.74)	(0.44)	(0.72)	(0.46)	(0.72)	(0.47)	(0.72)
Observations	42,848	42,848	42,848	42,848	42,848	42,848	42,848	42,848	42,848	42,848
Fixed Effects: *j*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fixed Effects: *k*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fixed Effects: *t*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fixed Effects: *s*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fixed Effects: *j*, *k*, *t*, *s*		Yes		Yes		Yes		Yes		Yes
Pseudo R^2	0.153	0.192	0.153	0.192	0.169	0.205	0.180	0.216	0.185	0.221

Notes: Post is a dummy variable that equals 1 if the truck's speed is calculated during the time period after leaving the facility, and 0 otherwise. Parked Nearby is a dummy variable that equals 1 if the truck is parked within 10-mile radius of the facility, either before or after visiting, and 0 otherwise. Max Duration Hours Parked Nearby denotes maximum parking hours of the truck parked near the facility, either before or after visiting. Cumulative Hours Parked Nearby represents the cumulative hours of the truck spends parked near the facility, either before or after visiting. Fixed effects for facility type (*j*), truck type (*k*), month (*t*), and state (*s*) are incorporated into the analyses.

R.3 Results of Average Speed in the 0.75 Quantile Regression for Aggregated Data

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Detained	2.51***	2.48***	2.27***	2.37***	2.83***	2.85***	2.49***	2.39***	2.42***	2.37***
	(0.25)	(0.29)	(0.34)	(0.40)	(0.31)	(0.36)	(0.32)	(0.36)	(0.32)	(0.36)
Post			-0.06	0.00	0.79***	0.86***	0.75***	0.87***	0.72**	0.82**
			(0.17)	(0.19)	(0.28)	(0.32)	(0.28)	(0.32)	(0.29)	(0.32)
Detained*Post			0.52	0.30	-0.00	-0.02	0.06	0.20	-0.05	0.05
			(0.47)	(0.55)	(0.43)	(0.50)	(0.44)	(0.50)	(0.44)	(0.49)
Parked Nearby					-4.12***	-4.21***	-3.27***	-3.21***	-3.08***	-3.06***
					(0.23)	(0.28)	(0.24)	(0.28)	(0.25)	(0.28)
Parked Nearby*Post					-0.92***	-0.95***	-0.91***	-1.17***	-0.78**	-0.99***
					(0.32)	(0.37)	(0.33)	(0.38)	(0.34)	(0.38)
Max Hours Parked Nearby							-0.13***	-0.133***		
							(0.01)	(0.01)		
Max Hours Parked Nearby*Post							0.01	0.01		
							(0.01)	(0.01)		
Cumulative Hours Parked Nearby									-0.15***	-0.15***
									(0.01)	(0.01)
Cumulative Hours Parked Nearby*Post									0.00	0.01
									(0.01)	(0.01)

R.3 (continued)

Constant	55.67***	56.56***	55.70***	56.56***	57.08***	58.72***	56.86***	58.22***	56.83***	58.18***
	(0.44)	(1.00)	(0.45)	(1.01)	(0.42)	(0.92)	(0.43)	(0.92)	(0.44)	(0.91)
Observations	42,848	42,848	42,848	42,848	42,848	42,848	42,848	42,848	42,848	42,848
Fixed Effects: *j*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fixed Effects: *k*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fixed Effects: *t*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fixed Effects: *s*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fixed Effects: *j*, *k*, *t*, *s*		Yes		Yes		Yes		Yes		Yes
Pseudo R^2	0.071	0.082	0.071	0.082	0.090	0.100	0.105	0.116	0.112	0.122

Notes: Post is a dummy variable that equals 1 if the truck's speed is calculated during the time period after leaving the facility, and 0 otherwise. Parked Nearby is a dummy variable that equals 1 if the truck is parked within 10-mile radius of the facility, either before or after visiting, and 0 otherwise. Max Duration Hours Parked Nearby denotes maximum parking hours of the truck parked near the facility, either before or after visiting. Cumulative Hours Parked Nearby represents the cumulative hours of the truck spends parked near the facility, either before or after visiting. Fixed effects for facility type (*j*), truck type (*k*), month (*t*), and state (*s*) are incorporated into the analyses.