IMPROVING PUBLIC TRANSIT SERVICES:

DOES COLLABORATIVE TRANSIT SERVICES AMONG PUBLIC TRANSIT PROVIDERS MAKE THEM MORE EFFICIENT?

by

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Presented to the Faculty of the Graduate School of

The University of Texas at Arlington in Partial Fulfillment

of the Requirements

for the Degree of

DOCTOR OF PHILOSOPHY

THE UNIVERSITY OF TEXAS AT ARLINGTON

May 2017

Acknowledgements

This intellectual odyssey began years ago for me. Ironically, it does not end with this milestone rather it is a moment in time on the never-ending education continuum. I will be remiss if I fail to thank the individuals in academia who have contributed immensely to this academic accomplishment. The list is littered with accomplished academic professionals. For lack of space, I will limit the names to my supervisory committee members, Dr. Ard. Anjomani, Dr. Rod Hissong, and Dr. Ivonne Audirac, headed by Dr. Anjomani. It would have been easier for me to say that I chose them based on my knowledge of their respective academic areas of interest, which is part of the strategy. However, the truth is that I serendipitously picked the best dissertation committee one could have chosen. I simply lucked out. They allowed me unlimited access to their wealth of knowledge. I owe them a debt of gratitude for EVERYTHING. Also, I would like to thank Dr. John Connolly who has provided me with some statistical direction for this research. Last but not the least, I will like to thank my colleague, Mr. Gary Hufstedler, who has provided me a clear insight into the true calculus of transit performance measurements, the kinds you do not glean from theories and literatures.

April 7, 2017

Dedication

I must thank the good Lord that has given me the intellectual capacity to navigate through some of these rough patches of my learning journey. To my family whose unending support provided the fuel that sustained this academic quest, thank you. To my mother who constantly kept me in her prayers, thank you. To my wife whose commitment to my kids gave me the free pass, thank you. To my children who have endured my unintended neglects, thanks a lot. To my brothers and sisters who will frequently ask how much longer, Thanks.

Abstract

IMPROVING PUBLIC TRANSIT SERVICES: DOES COLLABORATIVE TRANSIT SERVICES AMONG PUBLIC TRANSIT PROVIDERS MAKE THEM MORE EFFICIENT***?***

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The network effect is the postulation that the utility of a product to a consumer increases as its consumption increases (Clement, 2004). If a parallel is drawn in transit service usage, the utility for transit services will increase to users as transit ridership increases. Different public transit providers within a metropolitan region can expand their area of transit services which would improve the utilization of their services through collaboration of transit services with other public transit providers within their service regions. Does such added utilization result in the increase of productive or technical efficiency levels for participating public transit providers?

The answer is the focus of this study, which is the empirical comparative analysis of the productive efficiency measurements of public transit providers who collaboratively provide regional transit services against non-collaborative ones. These transit agencies serve as proxies for measuring the relationship between collaborative transit services and productive transit efficiency. It verifies that the transit providers participating in coordinated transit services with other transit providers in their service region are different than those that operate alone judging from a key performance indicator (KPI) – passenger trips per revenue hour.

In doing that, an explanatory cross sectional study was conducted using data from Federal Transit Administration's (FTA) transit data clearinghouse called National Transit Database (NTD) and the United States Census Bureau. The study examined the factors contributing to the improvement of transit productive efficiency levels in US metropolitan areas. This empirical verification was designed to show how the KPI of efficiency could be improved through collaborative services. The result from this effort has shown that there is correlation between collaborativeness of transit services and productive or technical transit efficiency.

Keywords: *network effect, key performance indicators, productive or technical efficiency, coordinated collaborative services, explanatory cross sectional study, and correlation.*

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Chapter 1

Introduction

The idea of this dissertation topic grew out of professional experience and intellectual uncertainties two of the three events (current events, life experiences and intellectual puzzles) that usually lead to research topics (Nachmias et al, 2000). The interest in this topic arose from years in the public transit industry where there is the constant clamor by municipalities or jurisdictions to leave their transit agencies in order to foster separate transit systems for better services. As well as the inquisition of seeing if economies of scale type efficiency improvement could be achieved if different transit providers collaboratively operate their services as a system.

This makes the closing remarks of Edward Glaeser's "Triumph of the City" an opening setting for this research. He concluded that:

> "*… Building cities is difficult, and density creates costs as well as benefits. But those costs are well worth bearing, because whether in London's ornate arcades or Rio's fractious favelas, whether in the high-rises of Hong Kong or the dusty workspaces of Dharavi, our culture, our prosperity, and our freedom are all ultimately gifts of people living, working, and*

*thinking **together** – the ultimate triumph of the city"*

(Glaeser, 2012 p. 269-270).

If public transit is part of what helps to harness and expand those linkages amongst and within our cities, then can it be made better? Is having a seamless collaborative transit service amongst different transit service providers within a travel region make them more efficient in delivering their services? In order to answer these questions, it is appropriate to first clarify the concept "*efficiency*" as used in this research. Generically, economic efficiency is broken down into two key components: technical efficiency and price efficiency. A system is said to be technically efficient if it produces more output with a given input (Yotopoulos et al., 1973). While price efficiency level is determined by the marginal output that optimizes revenue (Yotopoulos et al., 1973). Let us focus on technical efficiency for this research.

The term efficiency, technical or productive efficiency will be used interchangeably to mean the same. Economic efficiency is achieved when businesses maximize their profit with a given output at the point where the marginal cost of production is equal to the marginal revenue (Brueckner, 2011) while productive or technical efficiency if correctly measured is defined as the most output from a given input (Farrell, 1957 p. 254). Now, if outputs were to yield market-valued revenue, then both concepts are not mutually exclusive. Since the early 20th century, transit systems are no longer privately operated (Bay et al., 2011). This has forced them to depend on government subsidies. This dependency makes market or price efficiency measurement not applicable to this research and it makes the use of technical or productive efficiency the better efficiency proxy. Therefore, public transit service providers work in technically efficient ways to maximize their ridership as their way of increasing efficiency or performance (Brons et al., 2005) even though it does not yield them profit (marginal cost less than marginal revenue). This backdrop provides the theme of this dissertation research.

This research looks at different transit agencies in the United States who have coordinated collaborative service arrangements to determine if there is correlation between their type of service arrangements and their productive efficiency levels. In order to do that, the productive services of collaborative public transit providers will be compared to non-collaborative ones. There are three kinds of collaboration in urban transit systems: consolidation, alliance, and contracting (Ugboro et al., 2000). The concept as used in this research effort refers to the alliance typology, which is an agreement that combines transit services while the involved agencies maintain their respective autonomies (Ugboro et al., 2000). So, transit systems are said to be involved in **collaborative services** if their riders do not notice service boundaries. The measure of the presence of such service arrangement is a **unit or regional fare system**. If a public transit rider can purchase a fare ticket and use it to ride multiple transit systems within its service area, then it would constitute a unit or regional fare system. The transit providers who participate in these types of service arrangements are said to be in collaborative services or in collaborations.

This research idea can be illustrated using the three hypothetical scenarios shown in figures 1-1, 1-2 and 1-3. In these representations, there are three possible transit operation arrangements. The first, scenario in figure “1-1”, indicates a travel region with three transit operators serving different transit service areas that are collaboratively linked to each other. The second scenario, in figure “1-2”, is the same area with three different transit operators that operate in their unlinked respective service areas. The third scenario, in figure “1-3”, is the same travel region being operated by a single transit provider. This third scenario is included in the research to isolate or control for the effects of service area size on transit productive efficiency to allay the concerns of those who would argue that collaborativeness should make transit operations more productively efficient because it increases the operators’ service areas hence the demand for their product (transit services).

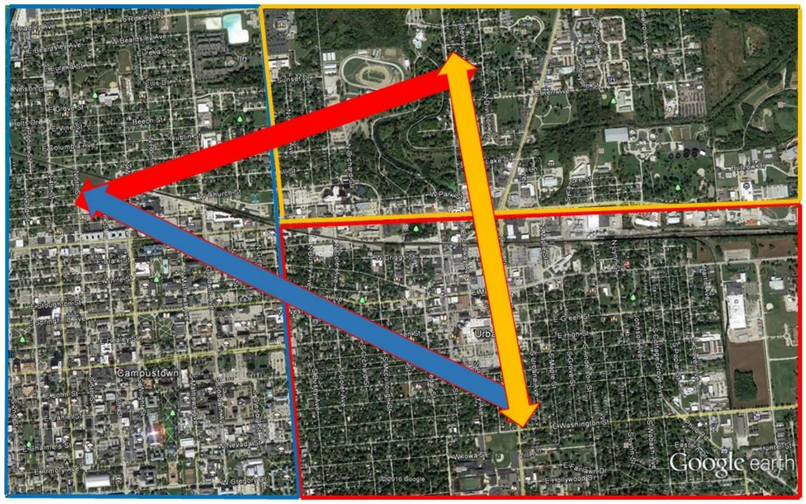

Figure 1-1: Three Collaborative Transit Providers: Triangle indicates collaborations.

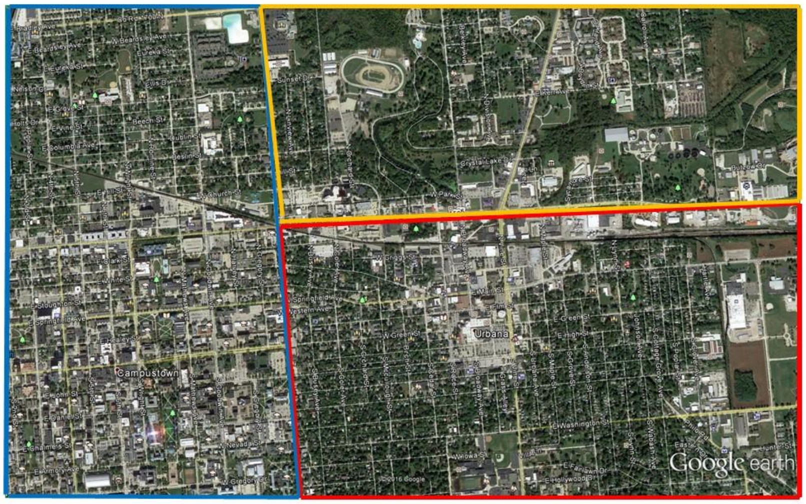

Figure 1-2: Three Non-Collaborative Transit Providers

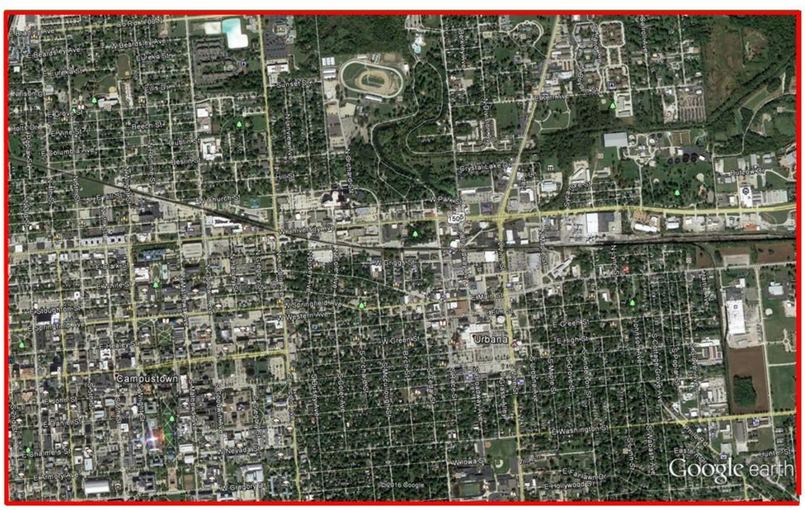

Figure 1-3: One Regional Transit Operator

As mentioned earlier, this research effort will help shed light on the constant clamoring of certain municipalities or segments of transit agencies wanting to operate independent services believing that they could provide better services if they run their independent transit systems. It would also help clarify the intellectual curiosity of the applicability of the concept of economies of scale in terms of whether transit operating systems within a metropolitan region could be better off operating as one system in their productive efficiency or not. It will also enhance the achievement of the performance objectives of the recent US transportation policies. The differences in the productive efficiency levels of the collaborative systems and non-collaborative ones from the analyzed sample of transit service providers, *ceteris paribus* should be attributable to the differences in their collaborative service arrangements (collaborative vs. non-collaborative).

Statement of Problem

Historically, public transit operators work in technically efficient ways to maximize their ridership as a strategy to improve productive transit efficiencies (Brons et al., 2005). They usually do this by increasing or improving their services. Such approach implies that the more or the better the transit services, the greater its usage or the demand for it. Given that the demand for transit services are not ubiquitous and the limited nature of transit resources, the question becomes: how to optimize the transit demand given limited resources? Could collaborative transit services amongst different transit operators within a metropolitan service area make a difference? If so, does such arrangement have direct or indirect effects in terms of transit system productive efficiency?

The difference in the levels of transit productivity (output) is due to changes in the transit services (input). However, the changes will be decreasing marginally based on the economic return to scale as shown in Figure 1-4 (Brueckner, 2011). One would argue that increasing services would increase ridership for both systems but at decreasing rates (Brueckner, 2011). For transit providers that operate independently, productivity would increase as resources are increased at a faster decreasing rate than the collaborative systems (Brueckner, 2011; Farrell, 1957) as shown in figure 1-5.

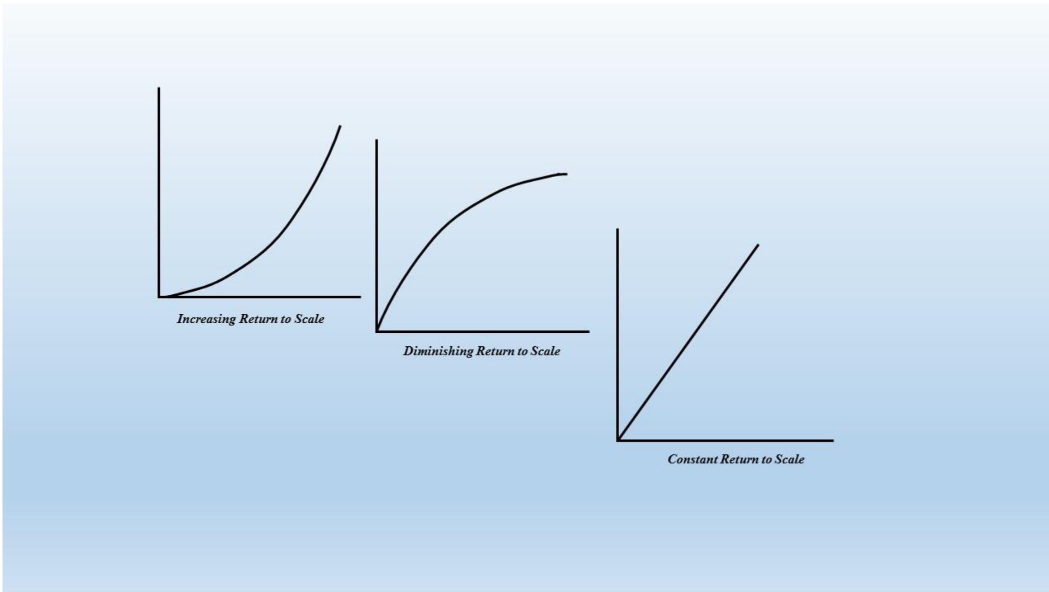

Figure 1-4 Return to Scale

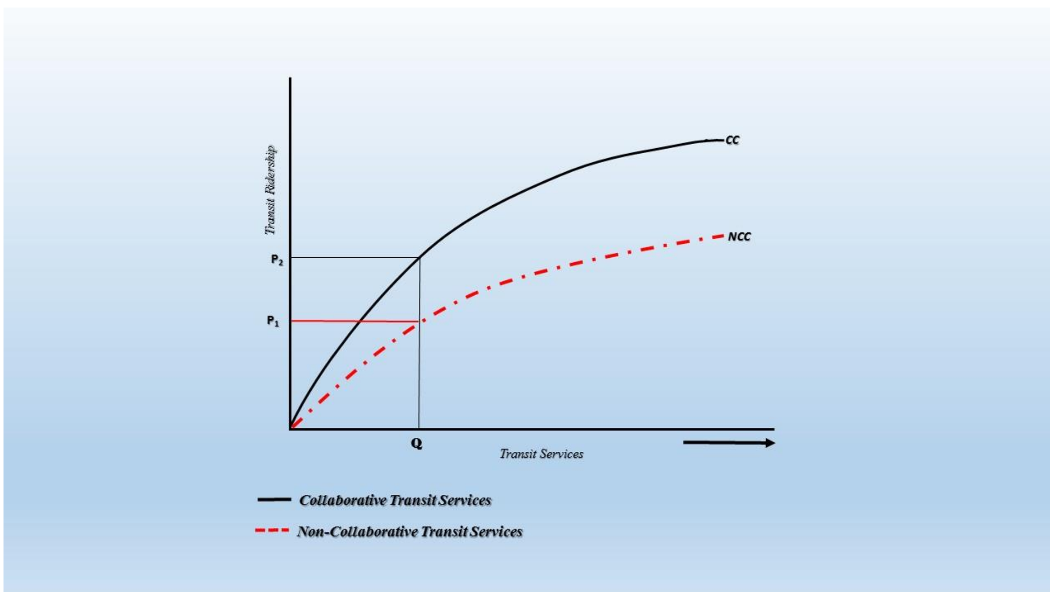

Figure 1-5 Service increase leads to more collaborative than non-collaborative riders

This economic theoretical underpinning is the basis of this intellectual inquisition, which is trying to see if such collaborations in transit services by different transit providers within a metropolitan travel area will help increase their collective productive efficiency levels. This research topic is intended to explore the differences between transit service providers that have seamless coordinated service collaborations with those that operate alone. The result from this study should elucidate the efficacy of collaborations vs. non-collaborations of transit providers on their productive efficiency levels.

Research Questions

This dissertation's research question(s) is an attempt to operationalize the above research concept, which states that **there are differences between collaborative and non-collaborative transit systems in their productive efficiency levels**. This will entail transforming the concept into a researchable question (Nachmias et al, 2000). This research will use the key performance indicators (KPI) of public transit service providers to operationalize their efficiencies. The KPIs are gathered annually by the subsidiary of Federal Transit Administration (FTA) called National Transit Database (NTD) from each transit agency. Using explanatory cross sectional datasets from NTD and US Census, this study will compare the differences between the productive efficiencies of these two transit operating systems (collaborative vs. non-collaborative) (Babbie et al, 1997). This will help answer these specific questions:

1. ***Does seamless coordination of services by different public transit agencies within a metropolitan region make a difference?*** This question differs from the ones that have been previously posited in transit efficiency because it does not seek to know if regional transit services are more efficient than local ones or whether increasing transit services make them more efficient (Brons et al., 2005). Rather, it is trying to determine if seamless collaborations amongst different transit providers within a travel region make them relatively different in productive efficiency when compared to non-collaborative ones.
2. ***If it makes a difference, are their differences directly or indirectly related to productive efficiency levels?*** The answer to this question should explain whether collaborations with other public transit providers within a transit travel region enhance their relative productivity propensities. The initial literature reviews have shown that transit ridership from the public transit industry's perspective would be an ideal efficiency proxy because it is what the services of transit provider produces (Gleason et al., 1982). In short, it is the output of a public transit operator. However, using pure ridership as the efficiency index does not lend it to a comparable measure thus requiring some type of standardization or weighting to permit comparison. The best-standardized indicator of ridership or marginal transit productivity would be ***Unlinked passenger trips per vehicle***

revenue hour, *or for short* ***passenger trips per revenue hour.*** Any action that will lead to increases in passenger trips per revenue hour should be deemed as an efficiency improvement factor. That is the rationale for the selection of ***Passenger trips per revenue hour*** as the index for productive efficiency in this research.

Performance Measures

For introductory purposes, let us examine some of the measures, or KPIs, of effectiveness and efficiency in the transit industry and their appropriate usage to elucidate their different usages from agency to agency. There are several transit performance measures, depending at what level (e.g., point, segment, route, or system) one is measuring (Bertini et al., 2003). Since this research will comparatively analyze different transit agencies, the KPIs used here will be system-level ones. Some of those measures that the KPI of this research will be selected from and their performance types in parentheses include:

- Operating expense per vehicle revenue mile (efficiency) is the ratio of total operating cost of a transit agency and its corresponding total vehicle revenue miles. *Vehicle revenue miles* are the total miles operated by vehicles available for passenger service. For instance, if a bus route is 10 miles long and has eight daily round trips, then the route would have 160 daily revenue vehicle miles. Revenue miles do not include any deadhead miles (Fielding et al., 1978). The deadhead miles refer to those public transit vehicle miles traveled when they are out of revenue services (Office of Budget and Policy, 2016).

- Operating expense per vehicle revenue hour (efficiency) is the ratio of the total operating cost of a transit agency and its corresponding total vehicle revenue hours. *Vehicle revenue hours* are the total hours that vehicles operate passenger service schedules, excluding time spent traveling to and from garages. For instance, if a vehicle leaves the garage in the morning at 5:00 a.m., but begins its service schedule at 6:00 a.m., then ends service at 9:00 p.m., but gets back to the garage at 10:00 p.m., then that vehicle's revenue hour total is 15 hours, not 17 hours.

- Passenger trips per capita (effectiveness): the ratio of the total unlinked trips taken by transit riders in the service area, divided by the population of that area.

- Passenger trips per revenue mile (efficiency): the ratio of the total passenger trips of a transit system and the system's corresponding total revenue miles. This measure captures the efficiency of the transit system.

- Passenger trips per revenue hour (efficiency): the ratio of total passenger trips to total vehicle revenue hours. The *revenue hour* is the resource component of this measure, which makes it an efficiency indicator. This is an important performance indicator, because the revenue hour is significant in transit agencies' operating resources, yet it does not have a traditional cost component. Some authors have therefore considered it an effectiveness measure of system patronage (Fielding et al., 1978), and for this reason it is the preferred indicator of technical efficiency for this research. One vehicle revenue hour is the same in all parts of the United States of America.

- Operating expense per passenger trip (efficiency) is the ratio of the total operating budget of a transit agency divided by its corresponding total passenger trips. This measure is not always accurate because the fare rate is not usually flat for most transits due to certain fare discounts.

- Revenue vehicle hours per employee (efficiency) are the ratio of total revenue vehicle hours to total employees of that agency; it is an efficiency measure of labor productivity. This indicator will be affected by the size of the administrative staff of a property. The use of *total* employees in this measure introduces some error because as workday and work week lengths may differ significantly between properties, and yet appear the same in this measure. Total employee hours would be a better denominator, but this statistic is not generally available (Fielding et al., 1978).

- Total passengers per vehicle (effectiveness): an effectiveness measure of system patronage and capacity utilization, indexed to an average transit vehicle. This indicator is affected by average trip length, rate of transfers in the system, and the daily-service vehicle or the total fleet ratio (Fielding et al., 1978).

As will be detailed out in the performance measures section of this dissertation, each of these productivity measures captures different aspects of the public transit productivity and they vary according to the size and locational of the transit system. They also capture either the demand-side or supply-side of public transit productivity. Effectiveness and efficiency of a product are measuring its goodness from a relatively different perspective (consumer and producer). However, technical efficiency, passenger trips per revenue hour, the theme of this research, captures a little of both, thus justifying its selection as the efficiency index for this dissertation research effort (Gleason et al., 1982).

Chapter 2

Literature Review

This is a look at the research of previous works done in related and contributing areas to the topic of this dissertation such as planning theory, public transit performance, network effect, the economics of coordinated services, and public policy relevant to this research effort. The written intellectual conversations on these topics were found through searches in academic and professional sources through electronic and non-electronic media as well as the Library of University of Texas at Arlington. In addition, relevant readings and textbooks from courses in Urban Planning and Public Policy (UPPP) classes helped in informing this research effort.

Planning Theory

This section chronicles previous works on the applicability of planning theories to the subject area of this dissertation research effort, but more specifically how a collaborative planning approach might provide a better lens to the rationality of a collaborative public transit services. Thomas Kuhn, states the significance of theories and paradigms in pure and social sciences as the view of scientific continuum based on verifiable assumptions. This continuum is not linear, but cyclical. The theories/paradigms explain our practices and our actions, and in turn help to shape or reshape our theories/paradigms (Kuhn, 1970). There are several other descriptions of theory, but the one by Babbie et al, sums it up. They described it as a tested, systematic way of describing how things work (Babbie et al., 1997 p. 47). So, planning theories are the lens that provides planners clarity in how planning activities work. The current planning theories can be classified into a five-part that Hudson et al termed SITAR, which covers the Synoptic, Incremental, Transactive, Advocacy, and Radical schools of planning thought (Hudson et al., 1979).

Based on the above description of the significance of theory, one could then see how all the different planning perspectives can be rationalized or justified. This shows that to objectively criticize any planning philosophy (physical, social, economic, or political), one should look at the underlying theory. This means that one should defend only those planning outcomes that match their corresponding planning theories and criticize those that don't. In other words, an outcome is either right or wrong in so far as it adheres or diverges from its theoretical underpinnings.

Planning theories such as the ones by Altshuler, 1965; Healey, 1991; Healey, 2003; Kerlinger, 1979; Innes et al, 1999; Archibugi, 2008; Faludi, 1973; Salet, 1982; Healey, 2006; Brand et al, 2007; Margerum, 2011; kanovich et al, 2007; Cheng et al, 2006; Friedmann, 1973; Helling, 1998; Hendler, 1995; Fainstein et al., 2015; Lindblom, 2009; Galloway et al., 1977; and Tewdwr-Jones et al, 1998; etc., will help in providing the relevant background information needed for this research effort.

This dissertation, like others, is a participation in an already started scholarly conversation (PSU.edu source, p. 8) on improving public transit productive efficiency. These theories bring clarity to represent one listening or paying attention to previous discussions with the intent to contribute. **Collaborative Planning Approach,** an institutional theory (Margerum, 2011 p. 23), is the preferred theoretical approach for this dissertation research. There have been many works done in different planning theories in general and collaborative planning approach. Let us first look at some of the criticisms of the planning theories and the paradigm shifts that have led to the emergence of consensus building or collaborative planning approach.

Criticisms of Planning Theory

Some of these works indicate that planning theories/paradigms are interdisciplinary in nature because they are drawn from different disciplines (social, political, economic and environmental). That explains why the evolutions of planning paradigms have corresponded with changes in societal values (Fainstein et al., 2015; Galloway et al., 1977; Healey, 1997). The protagonists of these planning theories opined that the efficacy of each type of planning (comprehensive vs. incremental, physical vs. normative, rational vs. advocacy) should be measured on how close their processes parallel the underlying theory rather than their effectiveness in goal achievements (Fainstein et al., 2015; Galloway et al., 1977; Healey, 1997).

Critics of the different planning paradigms (pluralistic and neoclassic) concede the fact that some level of planning is required for the orderliness of society, but the forms and levels have always been their divergent points. They accept that some form of the fundamental principles of historic planning theories/ paradigms are still at work today, but in different forms. For instance, the guiding principles of the traditional advocacy planning has since morphed into equity planning which is the governments' way of giving voice to the voiceless in modern society (Fainstein et al., 2015).

The criticisms of the theories of physical planning were because planners have limited knowledge of the physical and sociological makeup of society. Thus, any decision made on this limited knowledge is bound to be wrong (Taylor, 1998). Others tried to justify those decisions because they follow rational actor theory (Faludi, 2013).

Taylor's philosophical criticism on planning is centered on physical aspects of the cities while ignoring its social features. He stated that the criticism was not directed to the planning process, rather the planning theory because they were grounded on "physical determinism" (Taylor, 1998). He maintained that physical aesthetics of our urban areas are necessary, but not sufficient. He maintained that their sociological makeups are even more significant. He opined that though planners try to do it right, their lack of complete sociological knowledge of society makes it difficult (Taylor, N. 1998). His argument was that the people should determine what is good for them and not the planners. According to him, it is even difficult for the people because there is no one social norm (Taylor, 1998). His solution is to involve the consumers of the planning product in the planning process (Taylor, 1998).

Comprehensive planning, based on rational actor theory, states that if one follows a rational process (means) that the result (ends) will be satisfactory (Faludi, 2013). This theory is rooted in Adam Smith's rational choice theory. This theory postulates that individuals are going to act rationally in ways that benefit them most. Its crux is the assumption that actors possess the adequate knowledge necessary to choose between their preferences (Resnick et al., 1987). It is understood that in order to have the right result, one must have complete knowledge. This necessitates the incremental approach (Muddling Through) or a mixture of both (mixed-scanning) (Lindblom, 2009) as the preferred options to the comprehensive plan.

Rise of Collaborative Planning Approach

Alan Altshuler argued against the effectiveness of comprehensive planning because it requires complete knowledge of the society's goals and planners lack such level of physical and social knowledge (Altshuler, 1965). He recommended more operational middle range plans as substitute for the comprehensive plans (Altshuler, 1965). Judith Innes agreed with his criticism, but she insists that the comprehensiveness of plans are still viable to planners through the consensus building approach of planning (Innes, 1996). She argued that consensus building with stakeholders is a better substitute and would address Altshuler's concerns. Her consensus building approach is built on the assumption that acquiring complete knowledge of the society needs to be fostered through interactions with the public via public participation in the planning process (Innes, 1996).

This leads to more pragmatic action planning paradigms (Transactive and communicative). These theories see planning in its political economy context where plans and their implementations are intertwined. These paradigms postulate the need for planners and their clients to collaboratively produce plans that would facilitate implementation. Taylor's book explains the communicative planning paradigm as an offshoot of Habermas' communicative action theory. His theory was centered on the fact that communication is a two-way street between the communicator and his/her audience. This means that the communicator (planner) is not simply presenting their plan to the politician and public, but he/she also actively listens. This helps in resolving any differences to reach an acceptable resolution. According to Taylor, Habermas' paradigm was based on four fundamental conditions: the object of the communication must be *comprehensible, true, sincere and legitimate* (Taylor, 1998. 124). If any of the four criteria is missing, then the communicative action as defined by Habermas has been violated. Taylor argued that planners should not steer away from politics, but they should embrace it themselves and understand that plan implementation involves a great deal of compromising, even if the ultimate plan falls short of the planner's desired results (Taylor, 1998).

John Friedman argues that planning should get away from Euclidean type planning and focus on a more Transactive Planning. He argues that the goal of a planner is seeing that his/her plan gets implemented. To do that in his perspective, planning should be normative, innovative, political, and Transactive (Friedman, 1993). That does not necessarily mean the planner gets their wish, but it would lead to an acceptable solution. He indicated that planners should engage both public and private participants from the beginning of the problem definition phase of their plan. According to him, that would allow the public to assume ownership of the plan thus making its implementation easier (Friedman, 1993). This brings the planning theory conversation in full to the communicative planning theory, which advocates for the ultimate consensus-building platform.

Communicative planning theory is based on the role information plays on the planners' actions, which is rooted on Habermas's views of communicative action and rationality (Innes, 1998). It dissuades planners from the notion of reliance on technically accurate information because that is never enough to influence actions; rather they should rely on communicative and interactive activities with the private and public stakeholders and do away with purported value-neutral expertise role, as that would be an exercise in futility (Innes, 1998). The communicative planning approach does not minimize or marginalize the importance of information in planning. Rather, it emphasizes how information should be gathered and its appropriate usage. A communicative planner is one whose role still involves finding and presenting formal information as background, or answered questions, which is still an expert role, but it is a shift from the traditional elitist role (Innes, 1998).

This planning school of thought believes that useful and important information must be a part of its social construct. Meaning that the information is gathered when the experts (planners) participate directly with the other players (public and private stakeholders) to discuss what information becomes pertinent in their policy implications. This process entails a lot of meaningful dialogues that lead to modified information that might be different from the results of information had they been arrived at through the traditional method of the planner as the expert. The usefulness of such information is because it would have been gleaned through the communicative process among experts and stakeholders through genuine interactions, which will lead to meaningful executable actions (Innes, 1998).

This is a shift from the traditional planning theories that subscribe to the fact that the planner’s job is mainly to deliver unbiased, professional advice and analysis to decision makers who implement the plans, programs or policies (Innes, 1998). This new direction in planning emphasizes the types of information rather than the formal analytic reports or quantitative tools (Innes, 1998). The consensus building or collaborative planning approach, which is an offshoot of communicative rationality, will be rational to the degree that these conditions are met (Innes, 1998).

Collaborative Planning Lens for Collaborative Public Transit Services

The argument is that the most important consequences of consensus building through collaborative approach may be the changing direction of a complex, uncertain, evolving situation, it can move communities toward higher level of social and environmental performance because its leadership has learned how to work together better and develop viable, flexible, long-term strategies for action (Innes et al., 1999). The collaborative planning approach is based on the theoretical framework as developed by Judith Innes and her colleagues, which is centered on the principles of consensus building (Innes, J. E. et al, 1999). This is the offshoot of the communicative planning theory (Healey, 2003). Collaborative planning approach encapsulates the way that the socioeconomic and environmental dynamics of a society can be translated into institutionalized governance processes (Healey, 2003). The choice of this theoretical approach is because nothing requires the building of consensus more than the subject of this dissertation - the *creation of a collaborative, seamless, coordinated service* *between two or more public transit providers within a metropolitan area to improve efficiency levels.*

If one categorizes planning into three traditions: economic, physical development, and public administration (Healey, 2006 p. 10), then the collaborative planning theoretical approach deals with the third category. This is needed for the implementation of collaborative arrangements amongst different transit providers within a metropolitan area. This theoretical approach explains the method that leads to an implementable effective or efficient plan (Healey, 2006) through the building of consensus by the stakeholders and the public (Margerum, 2011 p. 7). It emphasizes the fact that the collaborative planning approach allows the introduction of effective co-existence of diverse ideals, a necessary condition for the successful implementation of collaborative public transit services by public transit providers within a metropolitan region (Healey, 2006). This approach aids in solving complex problems of a diverse group of autonomous stakeholders striving to build consensus that would lead to acceptable results (Margerum, 2011 p. 6). Its allure also stems from the fact that collaborative services are better if participants clearly understand all potential issues associated with such creation before investing the necessary time and money (Helling, 1998). That intrinsically is the bedrock of successful collaborative public transit operations.

This dissertation uses collaborative planning approach as the lens that allows planners see the effectiveness of consensus building in coalescing conflicting perspectives, especially but not limited to environmental related issues in the implementation of a centralized administrative policy. In its initial form, it also allows participants in environmental related policy issues to co-exist (Innes, J. E. et al, 1999). As Richard Margerum describes, it allows inter-jurisdictional governance and policy implementations (Margerum, 2011 p. 12), which is crucial for the successful implementation of collaborative transit services amongst different transit operators. This is an example of the role of theories in explaining planning-related research; they allow clear insights into what planners do and why they do it (Snyder et al., J. C., 1979). The collaborative planning approach clarifies the planning processes necessary for the selection and implementation (Archibugi, 2008) of collaborative transit services.

The inquisition of this dissertation is to investigate public transit collaborative arrangements like "game theory" where there is no dichotomy of winners vs. losers, rather all participating players are considered winners (Innes, J. E. et al, 1999). This theoretical approach will explain the rationale for productive efficiency of collaborative arrangements between different public transit service providers operating within a metropolitan area. Basically, testing to see if all participating public transit service providers (players) are winners or losers.

Studies have shown that the collaborative planning or consensus building approach discourages participants from taking positions, and encourages them to be part of a common course, usually for the greater good (Innes et al, J. E., 1999). That means that participants will depend on each other for attaining their collective goals of improved efficiencies of productive services. This draws from Habermas's conditions of authenticity in the dialogue that leads to consensus (Deyle et al, 2014). Such authenticity is built on trust, a key element of a thriving collaborative arrangement. It outlines the necessary blue print for coordinated collaborative transit services amongst different transit services providers in the United States.

The applicability of collaborative planning approach to the research effort of this dissertation is in the administration of coordinated services amongst different transit service providers. It explains why the collaborativeness of different transit service providers would result in wins for all participating public transit providers. To that effect, it shows the anticipated result of collaboration in transit services not only in its administration through information sharing and consensus building, but also in sustaining this service arrangement (Margerum, 2011 p. 32).

The levels or type of collaborations varies depending on the involved group or issues they are trying to address. Regardless of the modality of the collaboration, the results are consensus driven (Margerum, 2011 p. 51). Different public transit agencies involved in collaborative services focus on different aspects of collaboration based on motivating factors and expected outcome (Margerum, 2011 p. 21), which Margerum refers as typologies. They also result in operational arrangements born out of consensus built planning efforts (Margerum, 2011).

Although the focus of this desertion is on public transit collaborative efforts as related to the productive efficiency of public transit services, the real issue in creating these service arrangements amongst public transit agencies is in the distribution of revenue amongst the participating agencies (Margerum, 2011 p. 20). This issue arises because the agencies involved are usually not equal participants. Given that useful and important information is part of the social construct of collaborative planning approach, during the gathering of information, the experts participating directly with the key players will discuss relevant information (revenue sharing). This process involves a lot of meaningful dialogues that will lead to modify information from communicative process among experts and stakeholders through genuine interactions (Innes, 1998). That is the beauty of consensus building or the collaborative planning approach. As Willson characterizes it: “communicative” form of transportation planning is a rational paradigm that puts a premium on interactions between planners and stakeholders in attaining the desired transportation ends (goals). He argues that this interactive planning process trumps the traditional planning process in terms of effectiveness in achieving the goal of every plan – implementation (Willson, 2001).

Network Effect

Network effect as used in this research does not refer to transit network effect on ridership, but on the postulation that the utility of a product to a consumer increases as its consumption increases (Clement, 2004). While the direct evaluation of network effect on collaborative transit services and transit service efficiencies is beyond the scope of this research, due to lack of data on transit rider's utility measurement, the idea behind the concept of network effect is germane to this research topic. Its use in this research will be purely anecdotal to illustrate that by improving the public transit productive efficiency (increased ridership) through transit collaborations, will be a positive network effect for transit riders.

Although there are other impacts of network effect, this research efforts focus is on "*utility*" improvement attributes. So for the purpose of this research, the term network effects are almost exclusively associated with positive and direct effects. It states that each user's utility increases with expansion in the number of users (Liebowitz et al., 2005). To clarify the differences between direct and indirect network effects, Clements cites examples of a telephone becoming more valuable to an individual as the total number of telephone users increases as a direct network effect. An example of an indirect network effect is a DVD player becoming more valuable as the variety of available DVDs increases, and this variety increases as the total number of DVD users increases (Clements, 2004).

The non-transit related consumer behaviors studies by Clements, 2004; Liebowitz et al., 1994; Varga et al., 2010; Varga et al., 2009; Ter et al., 2009; etc. show that expansion of the demand of products or services results in network effects. This is analogous to the increase in transit productivity through collaborative arrangements, which will have positive network effect. Weitzel et al., describes network effect the way it will be used in this dissertation, as the value of network increases as the number of its users increases (Weitzel et al., T., 2000). The collaboration of transit services would lead to an increase in transit ridership or productivity, and this will increase the value or utility of transit services to transit users. This network effect in transit is what Frank Goetzke referred to as social spillover (Goetzke, 2008). He described the network effect to be positive when people prefer to use transit *together* with other people (Goetzke, 2008).

The non-transit examples would have argued that collaborative transit service arrangements would increase the utility or value that a transit user derives from using transit services due to the increase of transit service consumptions resulting from transit collaborations (Liebowitz et al., 1994). Weitzel et al., developed a model showing that the dynamics of network effects does not only depend on individual decisions but also on the collaborative behavior patterns

(Weitzel et al., T., 2000). They framed it using their interdisciplinary theory of network effects (Weitzel et al., T., 2000), which aligns with transit collaborativeness.

The parallel being drawn between the network effects and the subject of this dissertation lies in the fact that it would increase the consumption of transit services. If the consumers' utility of certain products increase as the number of its users increases (Weitzel et al., T., 2000), then public transit passengers would gain increases in their utility for transit usage if their transit provider participates in transit service collaborations with other transit providers. The essence of this conjecture is the fact that when transit providers collaborate with other transit providers, they expand their service areas. This will result in the increase in demand for their services. Such increases would result in positive network effect. This implies that the utility or value of transit services to transit user will increase due to collaborative transit services amongst transit service providers within a metropolitan transit region.

Public Transit Performance

This portion of the dissertation is focused on studies that have been done in economic performances in general and public transit performances in particular and on how to best measure them. Performance measurements are economic gauges of the level of progress being made towards reaching a desired economic outcome (Gleason et al., 1982). In public sectors, it is usually made up of efficiency or effectiveness. Neither of these two performance proxies are operational or quantifiable measurements (Karlaftis, 2004). One cannot observe efficiency or effectiveness. In order to guide against possible confusions, different indices or indicators for these measures have been identified, sometimes called key performance indicators (KPIs) (Gleason et al., 1982).

Effectiveness is the accuracy and completeness with which systems achieve their goals or objectives. While efficiency is relating the accuracy and completeness with which systems achieve those goals or objectives and the resources expended in achieving them (Frøkjær et al., 2000, April). There are different KPIs for efficiency and effectiveness.

It was Adam Smith who made economic efficiency an economic performance measure when he argued about the role of the invisible hand of competition in the market place. He made the case for profit-maximization and utility-maximization by producers and consumers respectively (Gregory et al., 1997; Arnott et al., 1994).

Given that this research effort is an inquiry of the possible correlation between collaborative transit services amongst public transit providers within a transit service region and improvement in transit productive efficiency, accurate performance measurements become crucial. Thus, making the clarifications of the different measures of transit performance (effectiveness and efficiency), which are sometimes referred to as indicators, an important aspect of this study. Before delving specifically into the transit key performance indicators (KPI) of effectiveness and efficiency, it will be germane to describe clearly each performance concept in relation to public transit industry.

Effectiveness measures whether a public transit provider is meeting its goals or objectives of moving transit riders from their origins to their destinations (Gleason et al., 1982). Efficiency measures how resources are used to move the transit riders from their origins to their destinations (Frøkjær et al., 2000, April). In other words, effectiveness and efficiency will imply that the transit provider has met its goals and objectives in a resourceful manner (Gleason et al., 1982). Several studies have been done in this subject area. The authors of such studies have come from both the transportation and academia professions. They include, but are not limited to Viton, 1997; Chu et al., 1992; Kaparias et al., 2011; Karlaftis, 2004; Farrell, 1957; Fielding et al., 1978; Glauthier et al., 1978; Falcocchio, 2004; Brons et al., 2005; De Borger et al., 2002; Barnum et al., 1979; Talley et al., 1982; etc.

The description below by Kaparias, Bell, and Tomassini is a good encapsulation of performance measurement as a tool for the evaluation of plans, projects, programs, and implementations necessary for the distribution or redistribution of resources especially in transit.

> “Performance measurement and monitoring significantly impact the development, implementation, and management of existing transport plans and programs, and largely contribute to the identification and assessment of successful alternative programs and projects. Moreover, performance measurement and monitoring enable obtaining the data necessary to compare the performance of different projects and programs in future scenarios and to evaluate the performance of the same project and system at different time points. Accordingly, data obtained from performance measures are elaborated to construct composite indices for these comparison and evaluation purposes. …….” (Kaparias et al., 2011).

The above description of performance measures implies that the success of transportation plans, programs, and implementations are based on goals and objectives that can only be assessed through effectiveness measures. This is done through the gathering of data of key performance indicators (KPI) needed for alternatives evaluation, decision-making support, and monitoring (Kaparias et al., 2011). So one of the concepts of transit performance (effectiveness) measures how well public transit systems are able to meet the transit or community goals or objectives (Gleason et al., 1982; Farrell, 1957). Goals can be as general as economic development, environmental sustainability, decreased traffic congestion, and provision of equitable mobility opportunities, or more specific objectives of moving number of riders per capita (Volinski, 2014). Efficiency, on the other hand, is designed to capture how well public transit systems are able to economize the resources needed to meet those goals or objectives (Gleason et al., 1982). It normally shows the unit cost of transit services provided (Volinski, 2014). In other words, effectiveness measures efforts of the transit operators in attracting passengers, while efficiency measures the cost per rider of the attracted ridership (Gleason et al., 1982; Volinski, 2014).

In public transit, performance measures are useful tools that help decision makers in setting priorities, generating financial resources, and allocating funds (Falcocchio, 2004). They are also used in the distribution and redistribution of resources. It is important to note that identifying the right performance measure is vital when assessing the efficiency and effectiveness of any transit system, so they can be better managed (Falcocchio, 2004). This is important in transportation planning and operations, especially due to growing transportation budgetary constraints; those budget limitations have created the need to require performance-based planning and programming (PBPP) when securing transportation funding for transit projects (Falcocchio, 2004; Bertini et al., 2003; Neumann, 2004).

PBPP provides transportation agencies the tools to measure the efficiency and effectiveness of their plans (Neumann, 2004). PBPP is data-driven, meaning that transportation organizations can use it to track and predict their projects' financial recovery rates. This provides alternative transportation funding sources other than those from the government (Neumann, 2004; Cambridge Systematic, …… 2000).

Effectiveness indices are usually ratios of some input and output (Gleason et al., 1982; Farrell, 1957). Therefore, transit effectiveness KPIs is not rule of thumb; rather, they are actual ratios of transit service factors (e.g., *labor, vehicle, operating network and fuel*) and transit output (i.e., ridership) (Chiou et al., 2010), which is cost free. In comparison, efficiency is the ratio of input and output with some cost or resource component (Gleason et al., 1982). These are better gauges of transit operators' performance, which is why Michael James Farrell argued that "it is far better to compare performances with the best actually achieved than with some unattainable ideal" (Farrell, 1957 p. 255). This statement is true especially in analyzing studies like this one, which examines the correlation between public transit collaborative services and the levels of improvement in transit productive or technical efficiency.

KPIs also help operationally measure the absolute level of the desired effectiveness or efficiency outcome that has been achieved for both service consumption and service production, respectively (Bertini et al., 2003). Effectiveness is a demand-side measure, while efficiency is the supply-side measure. This clarification is necessary because the definition of performance measurements in public sectors, such as public transit, have always been nebulous

(Gleason et al., 1982 p. 379). This helps to prevent the misuse of these measures (Gleason et al., 1982; Bertini et al., 2003; Farrell, 1957); KPIs are used in operationalizing transit performances. This includes not only the providers of transportation, but also the customers and the communities where the transportation infrastructure is located. That is why these performance measures must include metrics that address the interests of all stakeholders (Falcocchio, 2004).

Against this backdrop, let us examine some of the measures, or KPIs, of effectiveness and efficiency in the transit industry and their appropriate usage. There are several transit performance measures, depending on what level (e.g., point, segment, route, or system) is being measured (Bertini et al., 2003). This research will involve comparatively analyzing different transit agencies; therefore, the KPIs used here will be system-level transit performance measures. Some of those measures, with their performance types in parentheses, include:

- Operating expense per vehicle revenue mile (*efficiency*): the ratio of the total operating cost of a transit agency and its corresponding total vehicle revenue miles. *Vehicle revenue miles* are the total miles operated by vehicles available for passenger service. For instance, if a bus route is 10 miles long and has eight daily round trips, the route would have 160 daily revenue vehicle miles. Revenue miles do not include any deadhead miles (Fielding et al., 1978). Since it has a cost component, it is an efficiency measure. If the goal or objective of this provider had been to operate at less than 160 daily revenue miles, then this measure will be considered an effectiveness measure.

- Operating expense per vehicle revenue hour (*efficiency*): the ratio of the total operating cost of a transit agency and its corresponding total vehicle revenue hours. *Vehicle revenue hours* are the total hours that vehicles operate passenger service schedules, excluding time spent traveling to and from garages. If a vehicle leaves the garage in the morning at 5:00 a.m., but begins its service schedule at 6:00 a.m., then ends service at 9:00 p.m., but gets back to the garage at 10:00 p.m., that vehicle's revenue hour total is 15 hours, not 17 hours.

- Passenger trips per capita (*effectiveness*): the ratio of the total unlinked trips taken by transit riders in the service area, divided by the population of that area.

- Passenger trips per revenue mile (*efficiency*): the ratio of the total passenger trips of a transit system and the system's corresponding total revenue miles. This measure captures the efficiency of the transit system.

- Passenger trips per revenue hour (*efficiency*): the ratio of total passenger trips to total vehicle revenue hours. The *revenue hour* is the resource component of this measure, which makes it an efficiency indicator. This is an important performance indicator, because the revenue hour is significant in transit agencies' operating resources, yet does not have a traditional cost component. Some authors have therefore considered it an effectiveness measure of system patronage (Fielding et al., 1978), and for this reason it is the preferred indicator of technical efficiency for this research. One vehicle revenue hour is the same across the entire US.

- Operating expense per passenger trip (*efficiency*): the ratio of the total operating budget of a transit agency divided by its corresponding total passenger trips. This measure is not always accurate because the fare rate is not usually flat for most transits due to certain fare discounts.

- Revenue vehicle hours per employee (*efficiency*): the ratio of total revenue vehicle hours to total employees of that agency; it is an efficiency measure of labor productivity. This indicator will be affected by the size of the administrative staff of a property. The use of *total* employees in this measure introduces some error, as work day workday and work week lengths may differ significantly between properties, and yet appear the same in this measure. Total employee hours would be a better denominator, but this statistic is not generally available (Fielding et al., 1978).

- Total passenger per vehicle *(effectiveness*): an effectiveness measure of system patronage and capacity utilization, indexed to an average transit vehicle. This indicator is affected by average trip length, rate of transfers in the system, and the daily-service vehicle or the total fleet ratio (Fielding et al., 1978).

These KPIs are not an exhaustive listing of effectiveness and efficiency measures, but rather have summarized theoretically the operational attributes of the measures commonly used. These descriptions reveal standard indicators, but others could be customized or created for different studies as needed. If these measures bring some sense of homogeneity to the factors of production (i.e., input and output), especially in studies like this where a standard measure of efficiency devoid of price (technical efficiency) is needed (Farrell, 1957). The use of ratio measurements will always be desirable. The attraction of these measures is not limited to their simplicity, but is tied to the fact that they allow for easy comparisons in this case—different transit agencies from different geographic locations (Farrell, 1957).

It is important to note that identifying the right performance measure is vital when assessing the efficiency and effectiveness of any transit system, so they can be better managed. This is important in transportation planning and operations, especially due to growing transportation budgetary constraints; those budget limitations have created the need to require performance-based planning and programming that would help in securing alternative implementation funding.

Performance indicators are quantitative measures that enable managers and policymakers to monitor the ranking of any agency to determine if strategies are required to improve performance. This process involves the use of many different KPIs (Fielding et al., 1983). To begin the examination of the evaluation strengths of the two performance measures, the question that needs to be answered is what is being measured and from whose perspective? Is it the consumer or producer? If the answer is the former, then effectiveness would be the right evaluation tool; otherwise, efficiency would be the preferred evaluation instrument. If on the other hand the evaluation is for ranking purposes, then some combination of both measures is necessary because there is the need to show that the system will accomplish its goals in a more fiducially responsible way. Most internal and external evaluation of systems is done for ranking purposes (Karlaftis, 2004).

Internally, the rankings help the system assess whose performance, evaluate the systems' progress towards achieving service and community objectives, and provide the basis for a transit management system that monitors and facilitates improved personnel performance (Karlaftis, 2004; Kaparias et al., 2011). This effort identifies transit routes that are not performing well and slate them for elimination or improvement. It also identifies the ones that are not meeting demand and requires increase of service levels. This process is used also to assess the level of staffing (administrative and operational) needs to efficiently run each system.

Externally, the rankings are the basis for the transit agencies' funding (Karlaftis, 2004). The rankings are usually based on systems' efficiency and effectiveness performance criteria, making it a necessity for agencies to evaluate their systems' performances on both criteria.

Public Policy

This dissertation is not about public policy; the reason for the review of the works and literatures on public policy is due to the possible implications or ramifications of the outcome of this dissertation research effort on public policies in general and transportation policies in particular. Public policy is the government's hallmark decisions that orderly guide the society to avoid or minimize conflicts (Dye, 1992; Smith, 2010). This is manifested in different ways such as regulating behavior, organizing bureaucracies, distributing benefits or extracting taxes (Dye, 1992).

Here are some of the applicable public policy based literatures that explain how the possible outcome of this research effort could have public policy implications. Information from works by authors like Cochran et al., 2005; Kraft et al., 2012; Stone, 2012; Radin, 2013; Smith, 2010; Dye, 1992; Anderson, 2014; etc. will help in assessing its possible implications in the public policy realm, especially the transportation performance based public policies.

The academic, professional, and technical works are some of the public policy relevant intellectual conversations that have occurred, which this research effort could draw from in determining the implication of this dissertation's outcome on the transit productive or service efficiencies and collaborative transit services. This research effort would be an attempt to use knowledge gleaned from those works in making any possible linkages.

Public Policy Theory

Public policies are laws, executive orders, bureaucratic regulations, local ordinances, and judicial decisions designed to address socioeconomic, political, or environmental public problems by policymakers through public policies (Seekins et al., 1986; Kraft et al., 2012). Gaining a better understanding of public policy begins with the five major public policy theories: elite, group, institutional, rational choice, and political (Kraft et al., 2012). If theories are the lens of how things work, then the aforementioned theories are the typologies of public policy theories, which inform how public policies work (Kraft et al., 2012).

The Pros and Cons of Public Policy Theories

Elite theory stresses the values and preferences of governing elites, which differ from the preferences of the public at large. It tells us that this segment of the society is very influential in creating public policy. The primary assumption of elite theory is that the values and preferences of the public are less influential in shaping public policy. The policy actors in this theory are economic, political, and cultural elites who create public policies that guide the public. They sometimes create the illusion that their opinions belong to the public to get the public to buy into their agenda. It is a top – down policy flow rather than bottom – up (Kraft et al., 2012; Dye, 1992). The unit of analysis here is not individual or organized interest group as it should be, rather it is a small group that control society’s institutions (Cochran et al., 2005). The policy outcome of this school of thought turns pluralistic only by accident not by design. For example, Dye argues that the Civil Rights Act of 1964, happened not necessarily because African Americans wanted it. Their pressure helped, but the political elites demanded it (Dye, 1992). Political elites needed the Act to prevent the disruptions to satisfy their political goals (Anderson, 2014; Kraft et al., 2012; Dye, 1992). The strength of elite theory is that they are effective in getting their issues on the public policy agenda quicker and the weakness is that the policy outcomes of this school of thought are not always pluralistic or representative of the interest of the public at large.

Pluralism or Group theory is a public policy school of thought which results from true democratic forces, – where citizens or group interactions of self-interests lead to state of equilibrium that is normally satisfactory to everyone. The outcome may not be to certain individuals or group preference, but they are usually the collective preference. This is what makes it democratic. The outcome of the group theory is what Anderson calls public policy in the equilibrium (Anderson, 2014). The pluralists argue that, in the group theory, power is shared rather than concentrated on a few as in the elitist theory. They maintain that this makes it more democratic (Anderson, 2014; Kraft et al., 2012). However, critics of group theory argue that individuals do not participate equally; they posit that affluent people participate more than less affluent ones (Anderson, 2014). One of the strengths of group theory is that the competing groups tend to counterbalance one another thereby creating policies that are more representative. The weakness is that the disenfranchised are not represented because they lack organizing power.

Institutional theory or institutionalism provide the vivid lens of seeing the closeness of the legitimacy of public policy emanating from governmental institutions – legislatures, executives, judiciary or political parties (Anderson, 2014; Dye, 1992). The political system in the United States gives the institution more influence in setting public policy agenda (Doh et al., 2006). It is the institution that legitimizes public policies, makes it universal rule, and has the power to enforce it by penalizing violators of the public policy (Dye, 1992). This theory also categorizes the different levels of government with public policy capacities: local, regional, state and federal.

Institutional theory points to the fact that the policy capacity at the regional level depends on the governance arrangements in general, and of metropolitan planning organizations (MPO) in particular, which is shaped by two main factors: the preferences of the policy actors and the rules that aggregate those preferences into outcomes (Gerber et al., 2009). The preferences of the policy actors are, in turn, affected by their formal positions—whether they are elected officials or public managers (Gerber et al., 2009). One of the strengths of institutional theory is the fact it provides us the lens to understand how the two types of institutions can empower or obstruct policy outcomes, but its weakness is that it obfuscates the influence of non-institutional actors.

Rational choice theory is borrowed from the economic marketplace rational actor model. This theory postulates that individuals make collective decisions by acting in ways that maximize their self-interest (Cochran et al., 2005). This school of thought argues that individuals or groups coalesce around issues of self-interest and help to force it to become public agenda, which then attract solution in the form of public policy. It is also argued that rational choice theory explains the reason for the effectiveness of public policies because individuals make choices between actions on the grounds of their cost-benefit assessments. They normally pick the ones that benefit them most, thus forcing them to adhere to public policies (Cochran et al., 2005).

This has made the rational choice models, lately, the preferred tool for public policy experts in their development and evaluation of the efficacy of public policies (Neimun et al., 1998). Neimun and Stambough also argue that it has added to the public distrust of the government, accusing it of intrusion in their lives and has increased skepticism about government's ability to guarantee effective public policies (Neimun et al., 1998). This ambivalence has created an outright questioning of the government's policy capacity. This has raised an increased emphasis on market solutions for a wide variety of issues (Painter et al., 2005). Thus, public policies, like cap-and-trade (CAT) emissions pollution control policy. The one obvious strength of the rational choice theory is that it sees policy actors as being in quest for policy outcomes that would maximize their self-interest. Its weakness is that the theory assumes that all actors have complete information. They do not have all the necessary information required to make those choices that would maximize their self-interest.

Political systems theory is more comprehensive, but also more general, than the other ones because it stresses the way political systems respond to public demands (Kraft et al., 2012). Systems theory emphasizes the larger social, economic, and cultural context in which political decisions and policy choices are made (Kraft et al., 2012). It is the formal way of thinking about the interrelationship of institutions and policy actors and the role of the larger environment. This theory shows how the government responds to the public's demands (Kraft et al., 2012). This theory's major strength is that it is a holistic picture of the public policy process as an ecological one where the government responds to environmental demand to produce public policy. The weakness of it is that the system can adapt to the environment. When that happens, there is no pressure on the government to change.

Public Policymaking Process

With this summary of public policy theories, it is now appropriate to visit the policymaking process to see at what stage of the process the possible outcome of this dissertation effort might come to play. Public policymaking process is a series of steps sequentially followed in the development and implementation of public policies (Kraft et al., 2012). This process is universal in the sense that it is not "culturally bounded", meaning that policy making in the United States is the same as policymaking in Europe. The terms used might differ, but the steps are identical (Anderson, 2014). It is important to understand how these steps are interrelated to each other.

Public Policy Making Process

Problem definition and Agenda Setting is the first stage of the policymaking process. The invocation of the term "policy" implies that there is a problem. Using the health treatment metaphor, it means that there is an illness that needs to be cured. The problem is the illness and the policy is the cure. In order to cure the illness, one must understand its root cause(s). So in order to craft or develop an appropriate policy to address a problem, it is absolutely necessary that the root cause(s) must be identified. Once that is done, the problem has to be defined in a way that encompasses all the detailed causes of the problem. It begins with issue framing, which refers to how an issue gets defined so that they can be measured. They are usually framed so that they can garner public support enough to push it into the public agenda. It then gets defined in ways that elicit the right solution or policy implementation. In other words, how the issue is framed determines how it is linked to causes or what to blame for the problem base on certain indicators. That is how policy actors construct or reconstruct reality to elicit the appropriate problem definition that would lead to the right public policy outcome or solution (Rochefort et al., 1994 p. 5).

Issues are raised to the level that the government determines. Sometimes governments are forced to admit that issue(s) have risen to the level that calls for action (Kraft et al., 2012; Anderson, 2014; Dye, 1992). Issue(s) that were unnoticed or private become public problems that demand government action. It is at this stage that the examiner (policy practitioner(s)) will invoke any method that will galvanize the public interest. Once the public recognizes this problem as an issue that deserves fixing, it is then propelled to the public issue status that warrants public discourse. There are different actors (public, special interest groups, or government officials) that can facilitate pushing an issue into the political agenda. Once it gets on the agenda, then the public debate, which will eventually lead to the policy creation, will ensue. As soon as this is accomplished, the formulation of the policy begins both by proponents and opponents.

P**olicy formulation** is the next step in the creation, identification, of alternative courses of action that would address a public problem. The policymakers will create several options that would address the identified problem and begin to analyze their efficiency and effectiveness of each option. The evaluation criteria are based on evaluation norms such as economic cost, social and political acceptability, and its effectiveness in addressing the problem (Kraft et al., 2012; Anderson, 2014; Dye, 1992). Based on these evaluation techniques, a preferred alternative gets recommended as the proposed policy option. The actors strive to draw up policies that mirror strategic interests rather than the collective neutral societal interest based on the causes and consequences of their problem demands (Schmidt et al., 2004).

Policy Legitimization or is policy acceptance is usually garnered through public involvement at the earlier phases of the policy making process. The legitimation of a policy option could be achieved through several different ways. It could come from legislative, executive, or judiciary actions. It is when the policymakers take the action to legitimize the policy (Kraft et al., 2012; Anderson, 2014; Dye, 1992). Although all three branches of the government have powers to legitimize policies, the Supreme Court can produce significant shifts in policy evaluations. (Mondak, 1994), making it very unpopular. The legitimacy may be questioned when it is perceived to have been gotten in ways that are not broadly acceptable by the larger population. For instance, if legislation (policy) is buried in a budget leaden bill and it gets passed into law, its legitimacy comes to question because it did not stand the test of legislative scrutiny on its own (Kraft et al., 2015 p. 95).

Policy Implementation is the next step once the scrutinizing policymaking body has accepted policy recommendation; it becomes a public policy that needs to be implemented. There is an implicit assumption that once a policy has been formulated and receives legislative approval, the policy will be implemented. Interest groups and opposition parties must accept it. Affected individuals and groups may attempt to influence the implementation of policy rather than its formulation (Smith, 1973). Here is where there is the most tension in the policy making process because both the opponent and proponents understand that the failure or success of their respective agenda rest here. A lot of the tensions come from the use or misuse of the policy's transaction patterns, which may or may not match the intended outcome of the policy (Smith, 1973). It becomes an enforceable law or policy or the policy that gets implemented.

Policy Evaluation happens once the policy has been implemented. Policy analysts will begin the assessment or evaluation of the policy in terms of meeting its intended goals. The results of some of the policies are long term and for those it is critical that appropriate time is allowed so that the right results will be captured (Kraft et al., 2012; Anderson, 2014; Dye, 1992). However, opponents are usually quick to point to the failure of such policies prematurely just to make their point. A successful policy remains a policy, but a failed one will either get changed or terminated based on the policy analytical results.

Public Policy Change: Dissertation Relevance

If it is determined that the policy outcome is effective in addressing the public problem, it is left alone; otherwise it could lead to **policy change** or **termination.** It is at this stage in the process that the outcome of this dissertation might have a policy implication. Once the outcome of the policy implementation has been fully vetted by policy analysts and determined to be either ineffective or inefficient in meeting the policy's goals and or objectives, it will be termed a failed policy. The next action will be to change parts or all of the policy to a new one. This step usually starts with discussion and debate between the different policy actors to identify potential obstacles, propose alternative solutions, and to set clearer goals (Kraft et al., 2012; Anderson, 2014). This phase of the process is usually odious and frequently requires compromises from proponents and opponents before a new policy outcome is reached. Studies have shown that most of the time such compromises lead to weaker policies meaning that the success of the results of such policy could be in jeopardy (Schmidt et al., 2004).

The outcome of this dissertation will apply elite theory to slightly modify existing transportation performance policy to include seamless collaborative service arrangements between public transit providers within a region as part of the performance measures. The policy change is not one that needs to put the policy through the complete policy cycle of the policymaking process. The problem that led to the creation of PBPP policy was appropriately defined, but the policy instituted a measurement matrix (implementation tool) that included coordination and collaborations between different modes of transportation and not between different transit providers in the same region.

Based on this theory, it is anticipated that once the Federal Transit Administration (FTA) gets the results of this research, which show that collaborative services between transit providers does increase their productive efficiency levels, they will recommend to the United States Department of Transportation (US DOT) to include it in the policy implementation tool of PBPP. US DOT will include it during the rule making session of the annual transportation appropriations. The actors would be FTA, DOT, and the transportation committee in the federal legislative body. The factor and elements that need to be included are the proof of the correlation between collaborative transit services and different transit operators with a services region and the improvement of transit productive efficiency.

Summary of Literature Review

It is believed that improving public transit performances (efficiency and effectiveness) could be gleaned through the principles of performance-based planning and programming (PBPP) (Neumann, 2004; Fielding et al., 1983). Improving transit performance is usually due to increased transit ridership (Neumann, 2004; Fielding et al., 1983), which has made public transit service providers work in technically efficient ways to maximize their ridership (Brons et al., 2005). However, there is the need for research to determine whether collaborative transit services amongst public transit providers within a metropolitan transit region can improve the transit efficiency levels measured by ridership.

The applicability of planning theories or more specifically collaborative planning approach to this research effort should provide a better lens to the rationality of collaborative public transit services. As Thomas Kuhn stated, the significance of theories in social sciences is the view of scientific continuum based on verifiable assumptions. The continuum is not linear, but cyclical. Theories that explain our practices and our actions in turn help to shape or reshape our theories (Kuhn, 1970). Babbie et al describe it as a tested systematic way of describing how things work (Babbie et al., 1997 p. 47). If this is correct, the collaborative planning approach, which is an offshoot of communicative planning theory, is the lens that provides planners clarity of how collaborative planning works. This is in line with Willson's characterization of "communicative" form of transportation planning as a rational paradigm that put a premium on interactions between planners and stakeholders in attaining the desired transportation goals (Willson, 2001).

Network effect as used in this research is the act of individual consumer having his/her utility for a product increased with increase in the demand for such product (Clements, 2004). Collaboration of transit services by transit providers lead to increase transit ridership, which would in turn increase the value, or utility, of transit services to transit users. While the evaluation of network effect is beyond the scope of this research due to lack of data on transit consumers' utilities, the idea behind the concept of network effect is reviewed because it is germane to this research topic. Its use in this research will be purely anecdotal to illustrate the relation of collaborative transit service operations and the improvement of transit productive.

In order to appropriately research public transit performances (efficiency & effectiveness) and how best to measure them, it is necessary to revisit previous studies completed on economic performance, transit performance, and performance measurements. Efficiency as performance measure better conceptualizes the intent of this research effort because in its simplest form it can illustrate how to get the most bang for one's buck. In transit, it is getting the most ridership for the least transit service resources. This research is seeking to see if public transit service arrangements (collaborative vs. non-collaborative) make a difference in technical or productive efficiency levels. Technical efficiency is a way of standardizing efficiency for easier comparison. Standardizing public transit efficiency measure will permit comparison of improvements in public transit efficiency of collaborative transit operators vs. non-collaborative ones. This restrictiveness in efficiency measure is crucial because it creates homogeneity in the factors of production in any given industry, thereby simplifying technical efficiency as an index or proxy in the industry's performance (Farrell, 1957 p. 260).

The literature review in public policy area will allow for the possible use of the outcome of this research effort in determining the possible public policy implications or ramifications. Public policy is the government's hallmark decision that orderly guides the society to avoid or minimize conflicts (Dye, 1992; Smith, 2010). This is manifested in different ways such as regulating behavior, organizing bureaucracies, distributing benefits, or extracting taxes (Dye, 1992). The goal of all transit related policies are to make transit operations more efficient and effective. If the outcome of this research effort shows the makings of improved public transit efficiency, the next step is to change parts of the transportation policy to incorporate policy statement(s) to address this research outcome. This step usually starts with discussion and debate between the different policy actors to identify potential obstacles, propose alternative solutions, and to set clearer goals (Kraft et al., 2012; Anderson, 2014).

Chapter 3:

Performance Measures

This research is about measuring the correlation between collaborativeness of public transit providers and their performance levels through productive efficiency measure. In order to do that, it is important to have in-depth discussion of the different performance measures to highlight how they are used as evaluation tools. Both efficiency and effectiveness are performance measures from the perspectives of producers and consumers respectively (Gleason et al., 1982). Effectiveness is a performance measure used to determine how well systems can meet their goals or objectives (Gleason et al., 1982; Farrell, 1957). It is usually cost free, except when the goal or objective has a cost component, and then efficiency type measure becomes a good proxy for an effectiveness index.

Efficiency, on the other hand, is the performance instrument that determines how prudent the system can use its resources in meeting those goals or objectives (Gleason et al., 1982). It is normally a ratio of some input and output of production function (Gleason et al., 1982). It also shows the unit cost of the system's output (Volinski, 2014). In public transit, effectiveness measures how well a public transit agency is able to meet its goal of attracting riders, while efficiency measures the cost for providing services to the attracted ridership (Gleason et al, 1982; Volinski, 2014).

Origin of Performance Measures

In order to differentiate between efficiency and effectiveness, it is necessary to briefly explain the origin of each performance typology. Since Adam Smith argued that the invisible hand of competition would force profit-maximizing producers and utilitymaximizing consumers to reach an efficient allocation of society’s resources, economists have been enamored by that concept (Gregory et al., 1997). Basically, economic efficiency is the state of things where no resources are being wasted. It is the maximization of resource allocations in society (Gregory et al., 1997). In its theoretical form, society’s resources are allocated optimally in the form where no one could be made better off without make someone worse off. It is sometimes referred to as Pareto-efficient or Pareto-optimality level (Arnott et al., 1994).

If all outputs in the market place had been ordinary commodities that are produced and then stored for sale, then the only performance measure would have been efficiency. However, service outputs like transportation or transit services are not storable (Karlaftis, 2004). This means that once they are produced, the service must be consumed right away, or it will go to waste or be ineffectively utilized (Lawrence et al., 2003).

In transit, as soon as services are produced, they cease to exist, regardless of whether they are consumed or not (Karlaftis, 2004, p. 358). For instance, a bus seats 30 passengers and operates a 20-mile route, and carries 10 passengers on a trip. There are 20 extra passenger seats that are being produced on that trip that will not be consumed, so that bus services are ineffectively utilized. This is the clear the differences between the storable output and the services that cannot be stored (Lawrence et al., 2003). This has led economists to devise different ways of measuring performances (efficiency and effectiveness) (Lawrence et al., 2003). Both are methods of monitoring the performance of two distinct dimensions of society or a system. However, a joint measurement of both is necessary to fully capture the overall performance of society or a system (Chiou et al., 2010). This research effort uses an indicator (passenger trips per revenue hour), which merges both measures. It is more a productivity measure than effectiveness or efficiency measures. Hence, it is referred to as "productive efficiency" in this study. This quality makes it comparable across the nation, and that is its allure to this research effort.

The efficiency measurement is the ratio of service outputs to service inputs; it shows the resourcefulness with which systems produce outputs that get consumed (Lawrence et al., 2003). In the case of public transit, it depicts how well service providers manage their resources in transporting the riders in their service area (McCrosson, 1978). If it costs transit agency **"A"** $10 per passenger trip, and it costs transit agency **"B"** $6 per passenger trip, then transit agency **"B"** is more efficient, regardless of their respective ridership. This is so because if transit trips were market priced, transit agency "**B**" would be more profitable than "**A"**.

Service effectiveness is the measure of the level of accessibility of services to area residents (McCrosson, 1978). It measures the ratio of service consumption (passenger-miles, passenger-hours, etc.). If you have two transit providers, **A** and **B**, operating in two areas with populations of 1 million and 0.5 million, respectively; and if operator "**A**" provides services to 200,000 transit riders, and operator "**B**" provides services to 80,000 transit riders, then in this scenario, operator "**B**" is more effective than operator "**A**" because their riders per capita (effectiveness measure), which are computed by dividing the population of the area by the total riders, comes out to be 6.5 and 5 respectively.

In public sectors like the public transit industry, the norm is that for systems to be successful, they should be effective and efficient (Talley et al., 1981; Karlaftis, 2004). In other words, each measure is necessary, yet not sufficient; but in combination, you have necessary and sufficient conditions for a successful transit operation. This statement does not mean that every efficient system is effective and vice versa; but it does say that to be considered a successful transit provider, the transit agency should have some level of both (Karlaftis, 2004). Studies have shown that due to some operational and administrative reasons, efficient systems also tend to be effective ones (Karlaftis, 2004). What this tells us is that evaluating any system with either of the performance measures would likely produce different results. On this backdrop, let us examine both as evaluation tools.

Performance Measures as Evaluation Criteria

To begin the examination of the evaluation strengths of the two performance measures, the question that needs to be answered is: What is being measured and from whose perspective? Is it the consumer or producer? If the answer were the former, then effectiveness would be the right evaluation tool; otherwise, efficiency would be the preferred evaluation instrument (Karlaftis, 2004). If, on the other hand, the evaluation is for ranking purposes, then some combination of both measures is necessary because there is the need to show that the system will accomplish its goals or objectives and fulfills its fiduciary responsibilities since we are speaking of public agencies (Karlaftis, 2004). Systems are usually evaluated for internal or external reasons. Most internal and external systems evaluations are done for ranking purposes (Karlaftis, 2004). The ranking of transportation projects and services has never been more important than now given the growing transportation budgetary constraints, which have created the need for performance-based planning and programming as a requirement for securing transportation infrastructural and service related improvement funds (Bertini et al., 2003).

Internally, the rankings help the system assess its performance and evaluate progress toward achieving service goals and objectives. It allows systems the ability to monitor and facilitate their personnel performance improvements (Karlaftis, 2004). In public transit, this effort identifies transit routes according to their performance levels. Such results enable systems to modify their services through addition, elimination, or simply improvement of route service levels to meet current or projected demands (Karlaftis, 2004). This process is also used to assess the level of staffing (administrative and operational) needed to efficiently run each system.

Externally, the rankings are the basis for the transit agencies' funding (Karlaftis, 2004). Those are not provided because an agency is efficient or effective, but rather on both criteria, making it necessary for agencies to evaluate their systems' performances on both criteria. When public transit agencies are seeking funds from the government for transit projects or services, given the limited nature of transit budgets, those resources are given out based on these ranking systems. In other words, performance rankings offer a practical tool for allocating funds or subsidies among competing transit properties based on relative system performances, which are determined by how efficient and effective each system operates (Karlaftis, 2004). The calculation usually involves several effectiveness and efficiency measures.

This research is seeking to discover if public transit service arrangements (collaborative vs. non-collaborative) make a difference in technical or productive efficiency levels. As has been outlined in the introductory and literature review sections of this dissertation, technical efficiency is a way of standardizing efficiency for easier comparison. Standardizing public transit efficiency measures will permit comparison of improvements in public transit efficiency of collaborative transit operators vs. non-collaborative ones.

This restrictiveness in efficiency measure is crucial because it creates homogeneity in the factors of production in the public transit industry, thereby simplifying technical efficiency as an index or proxy of transit service performance (Farrell, 1957, p. 260). Its attraction is not limited to the simplicity of the index. It also allows easy comparison of similar production factors at different geographic locations given its price neutrality, which makes it preferable (Farrell, 1957 p. 260).

There has been a preponderance of evidence that systems performing well in efficiency also perform well in effectiveness (Karlaftis, 2004, p. 363). There is also an indication that efficiency is better for evaluation of large transit systems, while effectiveness tends to be better for smaller transit properties (Karlaftis, 2004, p. 363). This justifies the choice of an indicator of productive efficiency (Passenger Trips per Revenue Hour) as the dependent variable of a regression model for this research effort. Now let us look at how they relate to subsidies.

Relation of Subsidies and Performance Measures

Subsidies are categorized as either operational or capital subsidies. Operational subsidies are used to reduce the total operation and maintenance costs burden on a transit system; capital subsidies are devoted to reducing their total costs for replacement or extension of transit infrastructures (Bly et al., 1980). Most of the supports for transit service subsidies have been based on the non-economic reasons that transit would play a key role in achieving a lot of social objectives, such as preserving and revitalizing cities, creating a better urban environment, and satisfying the transport needs of the underprivileged (Karlaftis et al., 1998). This means that systems that are able to show that they are more productive through their performance measures will most likely be subsidized.

Given the fact that public transit is no longer operated on a market system, public transit is no longer privately operated (Bay et al., 2011), and knowing that subsidies now constitute over half of transit revenues, it is important to determine the correlation between subsidies and transit performance (Gleason et al., 1982) by looking at their relative effects on different performance indicators. That implies that in order to be subsidized, the system has to show a relatively better performance based on the efficiency measurement. Thus, begging for ways of improving each system's productivity level. Hence, one of the reasons for this research topic – investigating the relationship between public transit service collaborativeness and productive efficiency. Confirmation of a direct relationship of public transit services arrangements will enhance the chances of those collaborative transit agencies in getting funds and subsidies faster than non-collaborative ones (Gleason et al., 1982).

Studies done pertaining to public transit subsidies and their effects on transit performance have had conflicting results (Karlaftis et al., 1998). Those conflicts arise from studies looking at the sources (federal, state, or local) of the subsidies or the size of the transit systems. The one implication from these results is that predicting the effects of subsidies may be misleading if the analysis does not differentiate them by system sizes and funding sources (Karlaftis et al., 1998). Overall studies have shown that subsidies have a direct effect on patronage and cost, but an indirect effect on transit fare and productivity (Karlaftis et al., 1998). In other words, transit subsidies do reduce fares, thereby increasing the amount of service operated, which results in some increase in ridership. It has also identified a correlation between increases in subsidies and increases in unit costs, which has led to reductions in output per employee, resulting in inefficiency (Bly et al., 1986). In summary, transit subsidies improve effectiveness, while making the system less efficient. These findings have caused critics of subsidies to transit industry to opine that the subsidies are being provided without close monitoring of its usage, causing abuse of the system (Bly et al., 1986).

Chapter 4:

Methodology

Since this is quantitative social science research, a great deal of effort is focused in developing a good methodological approach because of the significance of selecting the appropriate measurements (Nachmias et al, 2000 p. 486). This section of this dissertation explains the methodological approach that was utilized in researching the correlation of collaborative transit services of different transit agencies within metropolitan travel region and improvements in their productive efficiencies. It details out the statistical analytical tools necessary for the evaluations, the analysis and interpretations of the results from this research. In short this section is used to empirically answer the research question of this effort or clearly communicate the quantitative reasoning and the objectivity of this dissertation research (Nachmias et al, 2000).

This is the crux of this research effort. It allows for the use of necessary analytical tools on cross-sectional datasets from NTD and US Census to measure the relationship between the research independent and dependent variables. It is pseudo control mechanism of this nonexperimental social research effort. The preference of cross-section data over time series was due to the lack of enough data for the before and after conditions of the coordination of regional transit services for the transit agencies in this study group.

Given that this dissertation is seeking to measure the inquisition of whether the improvement of transit productive efficiency has a reasonable relation with collaboration of transit services amongst different transit operations within a travel region, it is necessary to employ a quantifiable tool. That tool is a multiple regression equation system on a public transit efficiency production function. This function will model the parameter (beta) of collaborative transit services, rail fare-transit mode, population density, total operating funds, regional operation, sprawl index, minority ratio, median income, employment density, and zero-car households.

The dependent (passenger trips per revenue hour) and the above ten independent variables are the analytical variables. The choice of passenger trips per revenue hour as the efficiency measure (dependent variable) among the key performance indicators (KPI) identified in the previous section is because it is the one variable that is comparable across the board nationally. In other words, passenger trips per revenue hour are the standardized or weighted efficiency measure for all transit providers. It allows one to compare all transit agencies regardless of their size or location. Before discussing this tool in detail, let us examine this study’s research design.

Research Design

This study, like most social science researches, uses nonexperimental quantitative design approach in detailing out the study structure (Spector, 1981). The research design was selected due to knowledge/experience in quantitative research methods coupled with advices from this dissertation supervisory committee (Creswell, 2013). In doing so, this dissertation followed systematically the research design process of problem formulation, study design, data collection, data processing, data analysis, and interpretation of findings arrive at the research conclusions (Babbie et al., 2008). The snap shot of this process is shown on table 4-1: *The methodology approach.* This table encapsulates the synopsis of the research process: from the conceptual level of the research questions, through the operationalization, to the empirical deduction of the presumptive relationship (Babbie et al., 2008).

This process has adequately provided the correlation measurements of public transit productive type efficiency and public transit service arrangements (collaborative vs. non-collaborative) in way that minimizes the subjectivity biases that would have impacted the qualitative type research approach (Spector, 1981 p. 7). Quantitative methodology is also the better predictor of the magnitude of the relationship between seamless coordinated services by different public transit agencies within a metropolitan service area and productive efficiency improvement levels (Spector, 1981).

In addition to the quantitative research method, the dissertation research questions have added more specificity to the conceptual purpose of this research effort (Babbie et al., 2008). Since public transit operators are constantly working to maximize their efficiencies through increased ridership (Brons et al., 2005), this dissertation seeks to know if collaborative transit services contribute to such efficiency improvement. This research effort will provide an answer to more specific research questions: are there differences between collaborative and non-collaborative transit service types? If so, how do they relate to transit efficiency improvement?

Once the above research problem has been operationalized, the next step becomes the logical arrangements of the data collection methods (Babbie et al., 2008). Since this research is designed to focus on analyzing cross-sectional secondary data collected mainly from FTA's, National Transit Database, and the United States Bureau Census for the study subjects (transit agencies in the U.S), it is crucial that the method of extracting data of the eleven variables (a dependent and ten independent) of this research effort is valid. The data of five variables *(passenger trips per revenue hour, regional fare, regional fare-transit mode, population density, and total operating funds)* were gathered at the unit of analysis level -- transit service area of operations. The data of the other six variables *(regional operation, sprawl index, minority ratio, median income, employment density and zero-car households)* were collected at metropolitan statistical area (MSA) level. Given that these data are collected from secondary sources, the usual problems with the internal and external validity of social science researches will not be of major concern (Spector, 1981).

The next phase of this process is the establishment of statistical theory that will guide the eventual inferential research conclusions of this dissertation. It will then be followed by the quantitative empirical analysis (Creswell, 2013) of controlled data gathered from NTD and US Census to verify the study's hypotheses. This process included testing for multicollinearity between the independent variables to ensure that there are no perfect linear relationships among them (Gujarati, 2008). This is crucial because its presence will diminish the reliability of the interpretive coefficients of the variables in this research due to the potential of inaccurately estimations (Blalock, 1979 p. 493). Next, it is important to cover this study's guiding statistical theory.

Table 4-1 Methodological Approach

Research Question(s)	**Inputs**	**Data Collection**	**Expected data**	**Expected Outcomes**
• Does seamless coordination of services by different public transit agencies within a metropolitan region make a difference? • What type of differences does it make in productive efficiency levels?	• Ridership of Transit Agencies in U.S • Transit Key Performance Indicators (KPI) • Transit Agencies Service Arrangements (Collaborative Vs. Non-collaborative) • Demographic and Geographic data	• Cross sectional data of Public Transit Providers from National Transit Database (NTD) and Census • Stratified by transit mode/technology and size of area of operations	• Passenger Trips per Revenue Hour • Rail Transit Mode • Population Density • Total Operating Funds • Recovery Ratio • Regional Operation • Sprawl Index • Minority Ratio • Median Income • Zero-Car Households • Employment Density	• Direct relation between transit service levels and productive efficiency • Direct relation between service arrangements and change in productive efficiency

Theory

This describes the **theoretical framework** of this work, not the planning theory (***Collaborative Planning Approach***), which will be the foundation of the quantitative analysis of this study. It draws on the research question(s) that this dissertation is seeking to answer (Creswell, 2013). The "economic theory of production function" is this theoretical assumption because it is based on the maximum output that can be achieved given different levels of inputs (Greene, 1980). It is used to explain marginal productivity of public transit (Garegnani, 1970), which is the crux of this dissertation research (efficiency). The estimation strength of economic production function approach has been well studied especially in the areas of applied econometrics (Greene, 1980). Cobb-Douglas popularized production function as an economic performance theory (Douglas, 1967, Gujarati, 1988).

This theory can be used to explain production function and demonstrate correlation between collaborative transit services amongst transit service providers and the level of improvement in their productive efficiencies. Statistically, this theory will allow making inferences about the productivities of public transit providers in the United States based on the sampling of transit agencies gathered from NTD (Schroeder et al., 1986). It is understood that the inferential statement of this study is based on nonexperimental research and as such will never be 100 percent guaranteed to produce similar results at the population level always. However, since the cost of studying all the public transit agencies in the United States would have been prohibitive, this approach tolerates some chances that an incorrect conclusion could be drawn (Schroeder et al., 1986).

Statistical theory of hypothesis testing allows for identification of the likelihood of making possible incorrect inferences (Schroeder et al., 1986 p. 37). It sets inferences about public transit providers in the United States from the analyzed study group of public transit agencies (Schroeder et al., 1986 p. 37) at 95%. This implies that there is a 95% chance of the result from this study being representative of the population (public transit operators in the U.S.) and a 5% chance of making incorrect statements of public transit operations in the United States based on this sample studied.

This research involves measuring transit productive efficiency: the production function, or some approximation of public transit efficiency slope, or elasticity of the marginal productivity curve of input (transit services), and the output (transit ridership) (Douglas, 1967). This theory is grounded on the assumption that a percentage increase in input would cause an increase in total output (Douglas, 1967). Applying this to the subject of this research effort, the percentage increase in the transit services would lead to an increase in the total transit ridership. It is ideal for this research because it works for either time series or cross-section study (Shaikh, 1974). The coefficients of the independent variables from this model, according to the Cobb-Douglas production function, represent the returns to scale (Gujarati, 1988). If the return to scale is one, this would represent a constant return to scale, when less than one, is a diminishing return to scale exists, while greater than one is increasing return to scale (Gujarati, 1988, p. 190).

Cobb-Douglas production function has been used in explaining or comparing marginal productivity (Garegnani, 1970). Based on Babbie et al's description of the theory as the tested systematic way of how things work (Babbie et al., 1997 p. 47), the topic of this dissertation will authenticate the Cobb-Douglas production function underpinnings in the sense that the marginal change in input (transit services) leads to increase in output (transit ridership) (Garegnani, 1970). To avoid the complications encountered in comparing the efficiency outputs derived through different production methods (Robinson, 1953), this research has been designed to use a similar production method for all public transit providers in the study group to avoid confounding the results.

Given that theory is the lens that shows how things work (Babbie et al., 1997), and knowing that collaborative and non-collaborative transit service types mirror the diminishing return to scale (Berry Jr., 1967), one would argue that the production functions as shown by collaborative curve (CC) and non-collaborative curve (NCC) in Figure 4-1 would mean that an increase in transit services to "Q" will lead to an increase in ridership for collaborative and non-collaborative systems to P_2 and P_1 respectively. This means that their productivity would increase at different rate. More importantly, the hypothesis is that an increase in transit services of the collaborative transit providers will increase their ridership at a higher decreasing rate when compare to those of non-collaborative ones until the point of diminishing returns (Robinson, 1953).

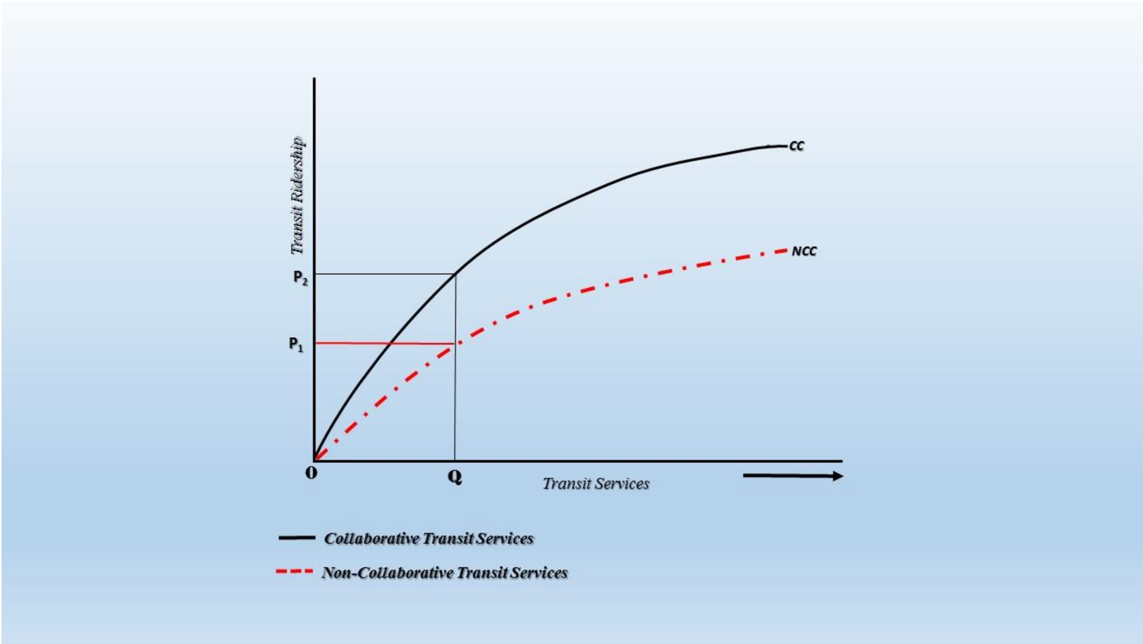

Figure 4-1: Service increase leads to more collaborative than non-collaborative riders

Variables

The variable section briefly outlines the research variables of this dissertation and the underlying theoretical framework for their selections. Those rationales are based on public transit related performance theories and studies that identified these variables as having meaningful contributions to transit operational efficiencies. Their desirability is the fact that they can be converted into empirical events (Nachmias et al, 2000) and they are quantitative entities that will take different values during the hypotheses testing (Spector, 1981). They will also aid in the operationalization of this study into measureable values for analysis necessary for statistical inferences. Each of the variables (dependent and independent) will remain the same for each data point regardless of who gathers them; their variation will only happen when the study is seeking a different measurement (Nachmias et al, 2000).

In addition to the characteristics, *Passenger Trips Per Revenue Hour* was chosen as the dependent variable because it is the best-standardized variable of all the transit key performance indicators (KPI) in measuring transit productive efficiency. It also allows for better comparison of the services of transit operators in the United States because it is a marginal transit productivity index. The independent variables (*Regional Fare, Rail Fare-Transit Mode, Population Density, Total Operating Funds, Regional Operation, Sprawl Index, Minority Ratio, Median Income, Employment Density and Zero-car Households*) will help explain the changes in the dependent variable – transit ridership *(Passenger Trips Per Revenue Hour)*. The total operating funds, which is an independent variable determines each transit agency's input level (labor and capital) in transit production function, produces transit output in this research model, *ceteris paribus*. This means that each independent variable in this model as shown in figure 4-2 would explain only a certain portion of the variation in the dependent variable holding other independent variables constant (Nachmias et al, 2000 p. 50). Together they explain much more of the variation in passenger trips per revenue hour.

Research Model & Variables

The research model can be represented in functional or graphical forms as follows:

Transit Productive Efficiency = f (*Rail fair-transit mode, population density, total operating funds, recovery ratio, regional operation, sprawl index, minority ratio, median income, zero-car households, employment density****)***

OR

$$Y = a + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + B_5X + B_6X_6 + B_7X_7 + B_8X_8 + B_9X_9 + B_{10}X_{10}$$

Where:

1. Y = ***Passenger trips per revenue hour (PTPRH)***.
2. X_1 = ***Rail fare-transit modes*** *(measure of collaborative transit service)* ***(RFTM)***.
3. X_2= ***Population Density (PD)***
4. X_3= ***Total Operating Funds (TOF)***
5. X_4 = ***Recovery Ration (RR)***
6. X_5= ***Regional Operation (RO)***
7. X_6= ***Sprawl Index (SI)***.
8. X_7= ***Minority Ratio (MR)***
9. X_8= ***Median Income (MI)***
10. X_9= ***Zero-Car Households (ZCH)***
11. X_{10}= ***Employment Density***.

OR

Figure 4-2: Dependent & Independent Variables

Dependent Variable

The focal point of this analysis is to determine the relationships between variations in public transit production efficiency and the various factors of public transit productivities (Gabler, 1969). The use of passenger trips per revenue hours as an index of public transit production efficiency will help to eliminate variations in different transit agencies (Gabler, 1969).

Independent Variables

In order to explain variations in the public transit productive efficiency (transit ridership), ten independent variables, as outlined above, were used as the factors of transit efficiency production. Some of the data of these variables were collected at the unit of analysis level (public transit agencies) and the rest were gathered at their metropolitan statistical area (MSA) levels.

Building the right prediction model or equation is critical to social science research. More importantly, identifying the right independent variables that can be shown to explain lots of the changes in the dependent variable. In this research, it was contingent on theories and previous studies done in public transit performance or efficiency. The brief descriptions of all the variables of this dissertation and the rationale for their selection:

Variables and Rationale for Selection

1. **Passenger Trips Per Revenue Vehicle Hour (PTPRH)** is a variable is a ratio of total passenger trips and total vehicle revenue hours. Revenue vehicle hours are the hours that passenger vehicles operate while in revenue service. The revenue hour is the resource component of this measure, which makes it an efficiency indicator. This is an important performance indicator because the revenue hour is significant in transit agencies operating resources, yet it does not have traditional cost component. That is why some authors have considered it an effectiveness measure of system patronage (Fielding et al., 1978). For this reason, it is the preferred indicator of technical efficiency for this research, since one vehicle

revenue hour is the same nationwide in the United States. It does not vary with variation in geographical area or size. It is a marginal productivity index.

2. **Rail Fare-Transit Mode (RFTM)** is the rail collaborative measure, which is an offshoot of a breakdown of public transit rail mode. Rail mode is a system for carrying transit passengers described by specific right-of-way (ROW), technology, and operational features (Office of Budget and Policy, 2016). It identifies collaborative systems with rail transit mode. There are several transit modes that contribute to collaborativeness such as the feeder bus systems; however, in this research, this variable is divided into two nominal groups. All collaborative systems with transit rail modes are categorized as "1" and the rest without transit rail modes are classified as "0". This variable assumes that the level of transit service collaborations differs between rail transit mode and other transit modes (Hardy, 1993). Since rail transit modes provide more direct links to multiple transit jurisdictions, it is more likely to enhance the collaborations of transit providers. This variable is a proxy for isolating the effects of rail transit modes on productive efficiency levels.

3. **Regional Fare** (**RF**) is the transit collaborative measure that is used to measure the fare system of multiple transit agencies operating within a service region as used in this study. It determines if transit agencies have collaborative or non-collaborative arrangements. This variable assumes that the level of transit service collaborations differs by the presence or absence of regional transit fare (Hardy, 1993). A system of multiple transit operators with "1" regional fare is collaborative. Those without regional fare are non-collaborative transit operators.

This is a nominal or dichotomous (dummy) variable where "1" represents the presence of collaboration and "0" represents a lack of it.

4. **Population Density (PD)** is the variable measures the degree of the concentration or dispersion of people living in each transit service area. It is the ratio of the population and service area in square miles. Densely populated areas generate more transit riders (Anjomani et al., 1982). Studies have shown that population density is positively correlated with improved transit efficiency (Giuliano, 1995).
5. **Recovery Ratio (RR):** Fare revenues are funds earned through carrying passengers in regularly scheduled service. It includes the base fare, zone premiums, express service premiums, extra cost transfers and quantity purchase discounts applicable to the passenger's ride (Office of Budget and Policy, 2016). All these costs are used to determine the cost of providing a passenger trip but the actual fare that the transit passenger pays is a fraction of the total cost of his/her trip. The fare box recovery ratio is the percent recovered of a trip's operating costs through passenger fares, and varies by mode and each transit operator (Office of Budget and Policy, 2016). Recovery ratio is the proportion of the amount of revenue generated through fares by paying customers as a percentage of the cost of total operating expenses. Since that cost is what the passenger perceives at the travel cost, the higher the out-of-pocket cost the less likely they will use the system.
6. **Sprawl Index (SI)** is the variable that measures the degree to which the MSA of each transit agency is sprawled out. Certain areas in the United States are sprawling out while other areas are compact. To capture this measure, Ewing et

al. used four factors: 1) residential and employment density, 2) neighborhood mix of homes, jobs and services, 3) strength of activity centers and downtowns, and 4) accessibility of the street network. They have score to determine if an area is “compact” or “sprawl” (Ewing et al., 2014). The average sprawl index is 100. This means that an area scored higher than 100 is considered a “compact” area. Those less than 100 are considered “sprawling” (Ewing et al., 2014). Such score is called Sprawl Index score (Ewing et al., 2014). Studies have shown that there is a correlation between sprawl index and transit service usage (Habib et al., 2011; Holtzclaw, 1994 & Ewing et al., 2014).

7. **Minority Ratio (MR)** is the variable that measures minority percentage makeup of each transit system service area’s metropolitan statistical area (MSA). The selection of this variable is because research has shown that a higher percentage of minorities use the public transit system as a major means of transportation over non-minorities (Taylor et al., 1999).
8. **Median Income (MI)** is the variable that captures the average annual income of each transit system service area’s MSA. The selection of this variable is based on the fact that research has shown that the lower the average income level of residents of an area, the higher their dependence on the public transit system as their major means of transportation (Cervero, 1981).
9. **Regional Operation (RO)** is the variable that measures the influence of regional service on productive efficiency. It isolates the effects of expansion of service due to the collaboration of services by transit agencies. In other words, this variable will help differentiate the impacts of size of service area with those of

collaborativeness of transit service operations. Like collaboration (regional fare and rail fare transit mode), this is a dummy variable. "1" will indicate if a transit agency is the only transit operator in a service area (MSA) and "0" otherwise.

10. **Zero-Car Households (ZCH)** variable represents the proportion of the households in each transit service area's MSA that does not have drivable vehicles, or a person licensed to drive. In other words, it represents the number of transit dependent trips. They are sometimes called captive transit riders. Studies have shown that as density increases households with one or more vehicles produce fewer trips; whereas, zero-car household trip production increases (Deutschman et al., 1968).

11. **Total Operation Funds (TOF)** is the variable that indicates the total fund available annually for each transit agency to cover the cost of systems operations. Those funds are gained from transit riders, as well as local, state, and federal government sources. These funds are used to better the transit services and aid in the improvement of their productive efficiency. Given that this research involves measurement of public transit production function, TOF is the proxy for the transit input (services), which determines the output (ridership measure).

12. **Employment Density (ED)** is the variable used to measure the concentration of jobs or employees within the MSA of transit agency's service area. The employment density is computed as the total employment in each transit service MSA divided by the size of that MSA in square miles. Transit riders are attracted to areas with high employment density (Anjomani et al., 1982). This variable has been found to be associated with trips that originate from homes and end at work

places (home based work trips) or trips that are non-work related (nonwork based trips) (Frank et al., 1994).

Data

Sources

There are two data sources for this dissertation research: levels 1 and 2, and both are secondary data. The source of the first level data gathered at the "unit of analysis level" (public transit agencies' service area) is the FTA subsidiary, the NTD. The public transit external data were not available at the unit of analysis level. As a result they were identified as level 2 data sets and collected at the MSA level from America Community Survey (ACS). All data were for the year 2014. NTD is the primary source of information and statistics on US transportation systems including all public transportation modes. The United States Congress established NTD in 1974, to ensure that the information collected from transit providers are standardized since it is the basis of federal funding. The Congress requires FTA to maintain NTD for the purpose of recording public transportation's financial, operating, and asset condition of transit systems using best accounting procedures. It began collecting data in 1979. This data source has helped the appropriation of over $7 billion FTA funds to transit agencies in the urbanized areas (NTD website, 2014). The ACS is a survey conducted by the United States Census Bureau.

Over 500 transit agencies provide data annually to NTD, as required by the Urban Mass Transportation (UMT) Act to receive federal funding (Ryus, 2010). The data which will be subsequently referred to as internal, includes information on transit organization characteristics, fleet size and types, revenues and subsidies, operating and maintenance costs, safety and security, vehicle fleet reliability and inventory, and services consumed and supplied (Ryus, 2010). Since these data have been fully vetted, NTD has become the sole source of standardized and comprehensive data for all public transit industry related studies (Ryus, 2010).

Collection

The goal of a good research data collection effort is to produce datasets that are valid, reliable, generalizable, and ethical (Mills, 2000). All these attributes are characteristics of NTD and Census data sets collected for this research. The data were compiled individually for each of the 221 sampled transit agencies. The data used for this analysis were assembled from the above two sources. The primary source for the transit-related data was the National Transit Database (NTD), which is compiled annually by the Federal Transit Administration. The required data for this research were gathered at the above two levels for a sample of public transit agencies from the database kept by the NTD of all the public transit agencies in the United States and the Census for the demographic data, see *table A* in Appendix A for listings. The sample is made up of public transit agencies serving urbanized areas (UZA) with a population of 200, 000 or more. As earlier stated, all variables (transit and demographic) listed in this research are from the year 2014.

Since this dissertation research hypothesized that public transit productive efficiency levels are explained in part due to collaborativeness of transit services of different transit providers within a transit travel region, it made sense to include the collaborativeness nominal variable so that analysis of productive transit efficiency could be done at the regional level. Thus, one of the key data that needed to be collected in this research effort is each transit agency's service arrangement typology (collaborative vs. Non-collaborative). NTD does not keep this record. In order to gather this information, all the public transit agencies in the selected sample had to be contacted to ascertain whether they have collaborative arrangement with any other transit agency or agencies in their travel region. That effort led to adding two new variables (regional fare and regional operations) that categorized them into three groups (*collaborative transit agencies within a metropolitan area vs. none collaborative ones within a metropolitan area as well as individual transit agency operating in a metropolitan area alone*).

All the demographic or transit external variables were compiled from the ACS 2014 US Census and aggregated for each MSA. To do that, each of the sampled transit agency's physical address zip code was geocoded to identify their respective MSA code. Using those MSA codes, the ACS Census information was collected for each transit agency's MSA. Examples of the ACS variables include minority ratio, median household income, regional operation, zero-car households and employment density. All these variables are shown in Table A in Appendix A with 2 stars (**).

Measurement

This research as any other social science, nonexperimental study involves assigning measurement numbers to the variables in order for analyses to be conducted and conclusions drawn on them (Nachmias et al, 2000 p. 138-139). This identification of the measures of association between the dependent and independent variables begins with quantifications of such relationship (Liebetrau, 1983), operationalizing the research process of the concepts in this dissertation.

This section is devoted to identifying and quantifying statistically standard numerical values that will be used to differentiate the productive efficiency levels of collaborative vs. none collaborative public transit service providers (Nachmias et al, 2000 p. 139) within metropolitan areas in the United States. This research began with the selection of the study population public transit agencies or providers in the United States (Liebetrau, 1983). Since it will be virtually impossible to study all the transit agencies, a representative sample was selected that would produce the right descriptive and inferential statistics for this study (Liebetrau, 1983).

These numerical measurements are necessary to identify indicator of transit efficiency for statistical inferences because collaborations are not observable (Nachmias et al, 2000 p. 142). These measurements serve as attributes or properties of this research subject (Spector, 1981). For clarifications, the levels of measurement ranging from the lowest to the highest are nominal, ordinal, interval, and ratio (Nachmias et al, 2000 p. 147). Since this research is about measuring or quantifying the technical or productive efficiency levels of public transit systems in the United States, it will involve measuring public transit production functions. Since transit efficiency is a production function or ratio of transit input (transit services) and output (transit ridership), most of the measures are *ratio* type. However, the variables, regional fare, regional operation and rail fare-transit mode are nominal measures. Table 4-2 shown below identifies the research variables of this dissertation according to their measurement types.

Table 4-2 Scale of Variables

Variable	***Indicator***	***Measurement Type***
Passenger trips/revenue hour (PTPRH)	Productive Efficiency	Ratio
Rail Fare-Transit Mode (RFTM)	Collaborativeness of systems with rail	Nominal
Population density (PD)	Population per square mile	Ratio
Total Operating Funds (TOF)	Transit system service capacity	Ratio
Recovery Ratio (RR)	Ratio of operating cost paid by rider	Ratio
Sprawl indeX (SI)	Compactness or congestion	Ratio
Regional operation (RO)	Transit operators in metropolitan area	Nominal
Median Income (MI)	Poverty Level	Ratio
Zero-Car Households(ZCH)	Level of Transit Dependency	Ratio
Minority ratio (MR)	Percentage of minority	Ratio
Employment Density (ED)	Employment per square mile	Ratio

Hypotheses

The research and null hypotheses are used to predict or explain the research direction of this dissertation (Creswell, 2013 p. 109). As previously stated, the quantitative nature of this research calls for a great deal of emphasis in this section because the strength of social science research like this is contingent on testing the hypotheses. In order to have a good test of hypotheses, it is crucial that this research effort follow the traditional systematic steps chronologically. Sequentially, these steps include: obtaining the right sampling distribution, selecting the right significant level, and computing the test statistic. This leads to making the right inferences or deductions in this dissertation (Blalock et al., 1972 p. 154). Here is the breakdown of these dissertation hypotheses.

Research hypotheses

The research hypotheses of this dissertation are those research concept(s) that this study is seeking not rejected. They are usually represented by ($\mathcal{H}_1$ and $\mathcal{H}_2$) symbols (Nachmias et al, 2000 p. 438). Formulating these concepts into researchable format is necessary for testing these hypotheses (Nachmias et al, 2000 p. 437). The process involves showing that:

- **Transit Key performance indicators (KPI) are the good measures or indices of transit productive efficiency levels**. This is designed to show that KPIs are efficient measures of the public transit operations; so, if the evaluations from this research effort validate the improvement of these measures, then that would imply improvement in the transit efficient system.
- **Coordinated regional services of different public transit service providers within a metropolitan region are related to improved productive efficiency levels**. This research is geared towards testing whether the seamless coordination of public transit services of different transit providers would result in improved efficiency levels. To verify that transit operators participating in collaborative transit services will be compared to non-collaborative ones. Their efficiency differences will be attributable to transit service collaborations since they are relatively similar in all other aspects.

Null hypothesis

The null hypothesis of this dissertation unlike the research hypotheses, is the event that this study is seeking to reject, which is normally represented by ($\mathcal{H}_o$) symbol (Nachmias et al, 2000 p. 438). This research is seeking to find out if regional transit service collaborations among different transit agencies do have effect on improving public transit service efficiency levels in the United States. In other words, are the efficiency levels of collaborative public transit properties the same as the non-collaborative ones? In this research, we are saying that $\mathcal{H}_o$: $\mathcal{B} = \mathcal{O}$, or more specifically,

$B1=B2=B3=B4=B5=B6=B7=B8=B9=B10=0$, where $B_1 \ldots B_k$ represent the coefficient of the independent variables in this research model. This research effort will directly test this. Its rejection will amount to failing to reject the research hypotheses.

Sampling distribution

The validity of the inferences coming out of this research will be based on the soundness of the sampling distribution of public transit agencies in the United States (Liebetrau, 1983). Since this study will not examine all transit agencies in the United States, it is crucial that the "mean" of the sapling distribution approximates the "mean" of all transit agencies in the United States. In order to achieve that, the sampling distribution has to be approximately "normal". It is also important that the dependent and independent variables sampled are selected from those that theoretically contribute to the productive efficiency of public transit operations (Liebetrau, 1983). This section is devoted to ensuring that there is a high probability that the result from the sampling of collaborative and non-collaborative public transit service properties fully represent public transit operations in the United States (the population mean μ) (Nachmias et al, 2000 p. 453). This probability is sometimes referred to as the level of significance. So the goal here is to find the value from the samples of the public transit agencies whose expected probability of μ is within the range of $1 - \alpha$, where α is equal to .05, which produces $100(1 - \alpha)$ % confidence interval (Gibbons et al., 2011). The sample will approximate the true parameters of the United States public transit agencies 95% of the time (Gibbons et al., 2011).

Like all events that involve probability, the expectation in this research is that these processes will lead to a correct decision 95% of the time, but we should understand that there is no total certainty in these decisions (Blalock et al., 1972 p. 157). It is essential that the public transit agencies sampled in this study accurately represent public transit operations in the United States because all the inferences that would be made about this research effort will be based on those sampled public transit agencies.

This study comprises 221 public transit agencies or providers serving urbanized areas (UZAs) as defined by 2010 US Census Bureau (Office of Budget and Policy, 2016), stratified by population size of their service areas. These are non-rural areas with population greater than two hundred thousand people. The reason for choosing non-rural public transit properties is the fact that while UZAs makes up 2.5 percent of United States land area; the populations of UZAs make up 71.5 percent of United States population (Office of Budget and Policy, 2015), thus the bulk of transit production. Sampling distribution in this research is using the statistics from these UZAs public transit systems to measure the relationship between collaborative transit services and productive efficiency, which assumes (95%) theoretical probability (Lipson, 2002). The results from the regression analysis model will show the t-scores and significance levels of each independent variable. This statistic will inform this research of the confidence level that the inferences made out these results of this sample of public transit systems represent the public transit agencies in the United States (population). That is the essence of normalizing the sampling distribution of this study at the model-building phase.

Level of significance

Now that we have constructed the sampling distribution of this research effort, let us evaluate the likelihood of no differences between collaborative and non-collaborative transit services in the United States (the assumption of the null hypothesis). The decision as to what result is sufficiently unlikely to justify the rejection of the null hypothesis as in most research efforts is quite arbitrary (Nachmias et al, 2000 p. 440). The level of significance in this study is set at .05. This result would represent the rejection of the null hypothesis of this study based on the outcome of the public transit agencies surveyed by a chance no more than 5 percent of the time (Nachmias et al, 2000 p. 440). The result from the sample of collaborative public transit services falls within the region of rejection; thus, the null hypothesis can be rejected at the 5 percent significance level (Nachmias et al, 2000). The rejection of null hypothesis lends support to the research hypotheses that there is a difference between the productive efficiency of collaborative public transit agencies and non-collaborative ones in the United States (Nachmias et al, 2000 p. 441). This simply tells us that there is a 5 percent chance of rejecting that there is no difference between collaborative and non-collaborative system when that is true (type 1 error) (Barnard, G. A. 1947). This level of uncertainty is acceptable in this research effort.

Statistical Test

Statistical testing entails describing the methodological assembling and analysis of this research data. These data will aid the decision-making or inferences about this study, hence it is called descriptive and inferential statistics respectively (Nachmias et al, 2000 p. 320). The former enables researchers to summarize and organize data in an effective and meaningful manner (Nachmias et al, 2000 p. 321). The descriptive statistics provide the tools that were used in the gathering of public transit related statistical data and operationalizing them so that they can be understandable (Nachmias et al, 2000 p. 440). On the other hand, inferential statistics permit the decision-making or inferences through the interpretation of the results of empirical analysis of the data from public transit agencies in the United States. The second phase of statistics will be used to determine whether the hypothesized relationship between the public transit collaborative services and level of transit productive efficiencies (Nachmias et al, 2000 p. 321) exist or not.

Descriptive Statistics

The statistical analysis and results used in the determination or interpretation of the outcome of this study are based on secondary data related to 221 of the top public transit agencies serving UZAs in the United States as shown in Table A in the Appendix. Data on eleven dependent and independent variables from these transit agencies were collected at two data levels. The first level data tagged with an asterisk (*) represent those gathered at the unit of analysis level (public transit agency or their service areas). It also includes the second data level tagged with two asterisks (**). These were collected at the metropolitan statistical area (MSA) level. The addresses of each transit agency were used to identify their service area MSA code numbers, which was then used to collect the second level or census data. The description of each variable has been detailed out in the variable section of this research.

Table 4-3, below summarizes the statistical sample of the observations, range, mean, and standard deviation for each variable used in this Dissertation research. Given that the sampling distribution has been established at a 95% confidence interval, there is a 95% chance that these statistics are representative of public transit agencies in the United States. The Passenger trips per revenue hour averaged 21.91 and ranges from 4.96 to 93.57 (Unlinked passenger trips per revenue hour). The Rail fare transit mode – the collaborative rail measure is a nominal (dummy) variable. It averaged .24 and is either 1 or 0, which means that there are more non-collaborative rail systems than collaborative ones. The Transit mode variable is also a nominal scale measure of systems with rail transit mode vs. those without. It averaged .38 and is either 1 or 0, which means that there are more non-rail transit systems than rail transit systems. The Regional fare is the system wide collaborative measure, a nominal (dummy) variable as well. It averaged .53 and is either 1 or 0, which means that there are more collaborative transit systems than non-collaborative ones. The Population density averaged 3802 residents per square mile and ranges from 130 to 146239 (Residents per square mile). The Total operating funds averaged 142.31 million dollars and ranges from 670,000 to 2.2 billion dollars (Annual operating funds). The Recovery rate averaged 24% and ranges from 0% to 119% (Transit riders' contribution to total system operating costs). The Regional operation measure is a nominal (dummy) variable. It averaged .19 and it is either 1 or 0, which means that there are very few regional operating systems in the United States. The Sprawl index averaged 105.70 and ranges from 40.99 to 203.36 (Rate of compactness of US urbanized areas). The Minority ratio of urbanized areas served by public transit systems averaged 26% of nonwhite population with a minimum of 3% (Nonwhite) and a maximum of 51% (Nonwhite). The size of the measure of the wealth in urbanized areas served by transit services averaged 59.30 thousand dollars with a minimum of 38.31 (Median income) and a maximum of 96.48 (Median income). The Zero-car households – the measure of transit dependents or captive riders averaged 4% of the population with a minimum of 1% (Population) and a maximum of 23% (Population). The Employment density averaged 591 employees per square mile and ranges from 39 to 2121 (workers per square mile).

Table 4-3 Descriptive Statistics

Variables	Minimum	Maximum	Mean	Std. Deviation	N
Passenger trips per revenue hour (PTPRH) *	4.96	93.57	21.91	13.47	221
Rail fare -transit mode R(FTM) *	0.00	1.00	0.24	0.43	221
Transit mode (TM) *	0.00	1.00	0.38	0.49	221
Regional fare (RF) *	0.00	1.00	0.53	0.50	221
Population density (PD) *	129.52	146239.43	3802.76	10263.31	221
Total operation funds (TOF) *	0.67	2199.35	142.31	316.30	221
Recovery ratio (RR) *	0.00	1.19	0.24	0.16	221
Regional operation (RO)**	0.00	1.00	0.19	0.40	221
Prawl Index (SI) **	40.99	203.36	105.70	31.04	221
Minority ratio (MR) **	0.03	0.51	0.26	0.11	221
Median Income (MI) **	38.31	96.48	59.29	11.96	221
Zero-car households (ZCH) **	0.01	0.23	0.04	0.04	221
Employment density (ED) **	39.34	2121.07	641.04	590.56	221

Inferential Statistics

The inferential statistical test of this research identifies the sampling distribution necessary to test the research hypotheses. It is used to compute with a 95% confidence that the quantity and direction of variation in the data from the sample of public transit agencies represents the public transit agencies in the United States. This implies that the value of the sampled public transit agencies in this research will be compared with the above sampling distribution to estimate the probability of its occurrence (Blalock et al., 1972 p. 165).

The inferences about the average public transit productive efficiency differences need to be based on a comparison of arithmetic means of the productive efficiency for different transit agencies in the sample in the sample surveyed (Barber et al., 1998). All these statistics are produced by SPSS software, version 24.

Chapter 5:

Procedures and Analysis

The procedures and analysis section describes the application of empirical tools outlined previously in the methodological section to the research effort of this dissertation. Since this is quantitative social science research, a great deal of effort is devoted to the application of these empirical tools to this research to operationalize the appropriate research measurements (Nachmias et al, 2000 p. 486). The methodological approach necessary for the evaluations, analysis, and interpretations of the results of this study is summarized in Table 5-1. It shows the empirical process necessary to answer the research question of this study beginning from the research question(s) to the anticipated interpretation of the results. The collection and empirical analysis of quantitative data from NTD and US Census Bureau was done to provide a better understanding of the results of this research effort to address the research questions (Creswell, 2005). Basically, this section is the application of the empirical tools outlined in the previous methodological section to this dissertation research effort.

This section will also allow the use of necessary analytical tools on cross-sectional datasets from NTD to measure the relationship between the research dependent and independent variables. The preference of cross-section data over time series was due to the lack of enough data for the before and after conditions of the collaboration of regional transit services for the transit agencies in this study group.

These dependent and ten independent variables are the analytical variables of this research. The choice of passenger trips per revenue hour as this research efficiency measure (dependent variable) among the key performance indicators (KPI) is because it is the one variable that is comparable across the board nationally. For instance, this research could not use operating expense because it is a function of the operating cost of the transit agency or transit modes, which are not the same across the nation. For example, buses are cheaper to operate than light rail transit (LRT), and LRTs are cheaper than heavy rail. An agency with a higher operating cost will seem inefficient when compared to one with lower operating cost. Let us start with how the research model of public transit production function was constructed.

Table 5-1 Methodological Approach

Research Question(s)	**Inputs**	**Data Collection**	**Expected data**	**Expected Outcomes**
• Does seamless coordination of services by different public transit agencies within a metropolitan region make a difference? • What type of differences does it make in productive efficiency levels?	• Ridership of Transit Agencies in U.S • Transit Key Performance Indicators (KPI) • Transit Agencies Service Arrangements (Collaborative Vs. Non-collaborative) • Demographic and Geographic data	• Cross sectional data of Public Transit Providers from National Transit Database (NTD) and Census • Stratified by transit mode/technology and size of area of operations	• *Passenger trips per revenue hour* • *Rail Fare-Transit Mode* • *Population Density* • *Total Operating Funds* • *Recovery Ratio* • *Regional Operation* • *Sprawl index* • *Minority Ratio* • *Median Income* • *Zero-Car Households* • *Employment Density*	• Direct relation between transit service levels and productive efficiency • Direct relation between service arrangements and change in productive efficiency

Model Building

Once the passenger trips per revenue hour and this research explanatory variables were selected through theories and previous studies, the process of determining what combination(s) of the explanatory variables will best explain or predict the changes in the dependent variable started with the model building process (Anjomani, 2016). The process was intended to ensure that the best model was selected, which will include ensuring the absence of multicollinearity amongst the independent variables (Mac Nally, 2000). Given that this research like most nonexperimental researches has no control group, this process serves as its pseudo control. That makes the specifics and thoroughness of this step very crucial. In other words, it is this dissertation diagnostic and elimination of possible confounding inferential statistical factors (Zucchini, 2000).

Once the variables have been selected based on their relation to the research questions, then data were collected on them to start the model building process (Anjomani, 2016). This process started with the use of the statistical package for the social sciences (SPSS) software version 24. This software iteratively and automatically compared each pairing of the variables in the model. The result from this process is displayed using the Pearson correlation output shown in Table 5-2 bellow. Let us spend a little time detailing the steps involved in the model building process.

Model Building Process

1. Correlation Analysis

The correlation analysis process is done using Pearson correlation. This includes the checking dependent variable data for normality (Anjomani, 2016). It helped ensure that a set of variables with appropriate and robust coefficient estimates is identified (Nesse, 2012). As a rule of thumb, multicollinearity should be suspected when the correlation coefficients of the paring of two variables is 0.7 or higher (Kennedy, 2003). Judging from Table 5-2, none of the pairing of the independent variables displays high correlations and as such there is no multicollinearity problem (Charumathi, 2012).

The results shown on this Pearson correlation table below indicate the statistics that identify the strength and direction (positive or negative) of relation between variables. This research effort selected robust diagnostic methods because it produces the most commonly used statistic in correlational analysis of research variables (Nachmias et al, 2000). It shows the presence of relations, the direction and magnitude of such relationships between the public transit productive efficiency measure and the other variables, which include regional transit service collaborativeness (regional fare and rail fare-transit mode). The importance of displaying the lack of multicollinearity in Pearson Correlation table cannot be overstated; it has allowed the focus of the model building process to create a predictive robust model (Padachi, 2006).

Key to this research is to ensure that the inferential outcomes of this effort are representative of the larger population (public transit agencies in the United States). This is achieved through a normal distributed sample, hence making this next an important focus of this research effort. That step is called “normality test” in SPSS. The normality diagnostic test for this research model was done by graphing the histogram of the model, as well as those of the standardized residual of the model as shown in Figures 5-1 and 5-2 respectively. As can been seen in Figure 5-1, the sampling distribution is slightly skewed to the left, which indicates the difference between the means of sample and the population. This is a sign that the sample is not representative of public transit agencies in the United States. To avoid that, the model was normalized; see Figures on the right side of figures 5-1 and 5-2.

The software program was used to normalize the dependent variable (PTPRH) (Anjomani, 2016). Once it was transformed, the histogram and the normal Q-Q plot of the PTPRH, showed more normal distribution and linear correlation respectively. This transformation of the dependent variable got the research model ready for the multiple regression analysis.

Theoretical analysis suggests that it is quite advantageous to know what these relationships will look like in advance because such knowledge can help inform the screening process and thereby improve the overall performance of this research model. However, in practice, one can hardly predict what the relation will look like, hence the need to normalize it at the model building phase of the research (Maciak et al., 2016).

2. Selecting Best Research Model

Once it has been determined that none of the paring of independent variables showed any sign of multicollinearity through the first regression model run shown in the Pearson Correlation Matrix on Table 5-2, the next step was to perform the model building analysis shown on Table 5-3, to select the best model for this research effort. This process began with making a hierarchy of the independent variables based on literature or theories (Anjomani, 2016). It involved running an iterative regression analysis starting with the dependent variable and the main independent variables according to the hierarchy (effect of collaborative transit services on efficiency) (Anjomani, 2016).

Subsequently, one independent variable is added at a time. The results are compared to the previous one to determine whether to keep the variable or discard it from the research model. The criteria are based on the adjusted R^2 and CP. In this instance, if adding the next variable increases the adjusted R^2, such variable is kept in the model. If the adjusted R^2 decreases, it is dropped. According to the CP criteria at the end of the model building process, the model with the value of CP close to K+1 should be selected. Where K is the number of independent variables (Anjomani, 2016). The process is continued until all the independent variables have been tested see Table 5.3. The process started with R^2 and adjusted R^2 at .145 and .141 respectively. It continued until the highest mark of .408 and .380.

However, if theories or previous studies indicate that certain variable(s) would be crucial to this research, then they are left in the model, regardless of their performance on the criteria test (Anjomani, 2016). For instance, the regional operation variable did not pass the adjusted R^2 test, but it was left in the model because it was used to control for the size of public transit service areas. Also, the zero-car household variable did not pass the criteria test, but it was left in the research model because it is the determinant of the transit dependent riders or captive riders; it is the building block of transit production.

Starting from Model 1, the next variable (regional fare) was dropped because it reduced the subsequent adjusted R^2 to .140 from .141. After that every subsequent model had its adjusted R^2 increasing until model 6 when the addition of regional operation variable deceased adjusted R^2 from .356 to .354, that would have forced the variable to be dropped from subsequent models but due to its aforementioned significance, it left. The same happened in model 10, but the zero-car household variable was not dropped because it is perceived as a needed variable because it plays a major role in the production of transit trips. Model 11 was the last model for the "model building" exercise. Based on both criteria (adjusted R^2 and CP), model 11 is selected. At the end of this process, the selected model (*rail fare-transit mode, population density, total operating funds, recovery* *ratio, regional operation, sprawl index, minority ratio, median income, zero-car households and employment density*) is then normalized.

3. Normalizing Selected Research Model

Once the model building process was complete, the model that resulted was then normalized with the help of SPSS software, version 24. The final research multiple regression modeling was done on the selected model to test the hypotheses, and come up with the decision for this dissertation. This is laid out in detail in the regression analysis in the next section.

Table 5-2 Pearson Correlation

		PTPRH *	RFTM *	PD *	TOF *	RO **	SI **	MR **	MI **	ZCH **	ED **	RR *
Pearson Correlation	PTPRH *	1.000	0.381	0.238	0.518	-0.181	0.295	0.297	0.320	0.264	0.319	0.287
	RFTM *	0.381	1.000	0.151	0.292	-0.279	0.004	0.251	0.283	-0.003	0.144	0.228
	PD *	0.238	0.151	1.000	0.067	-0.086	0.159	0.188	0.015	0.071	0.122	0.108
	TOF *	0.518	0.292	0.067	1.000	-0.143	0.249	0.218	0.248	0.381	0.284	0.255
	RO **	-0.181	-0.279	-0.086	-0.143	1.000	-0.068	-0.292	-0.325	-0.156	-0.310	-0.169
	SI **	0.295	0.004	0.159	0.249	-0.068	1.000	0.183	0.391	0.566	0.498	0.129
	MR **	0.297	0.251	0.188	0.218	-0.292	0.183	1.000	0.416	0.341	0.474	0.122
	MI **	0.320	0.283	0.015	0.248	-0.325	0.391	0.416	1.000	0.330	0.374	0.227
	ZCH **	0.264	-0.003	0.071	0.381	-0.156	0.566	0.341	0.330	1.000	0.488	0.151
	ED **	0.319	0.144	0.122	0.284	-0.310	0.498	0.474	0.374	0.488	1.000	0.122
	RR *	0.287	0.228	0.108	0.255	-0.169	0.129	0.122	0.227	0.151	0.122	1.000

Table 5-3 Model Building

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10	Final Model
PTPRH *	X	X	X	X	X	X	X	X	X	X	X
RFTM *	X	X	X	X	X	X	X	X	X	X	X
RF *		X	O	O	O	O	O	O	O	O	O
PD *			X	X	X	X	X	X	X	X	X
TOF *				X	X	X	X	X	X	X	X
RR *					X	X	X	X	X	X	X
RO **						X	X	X	X	X	X
SI **							X	X	X	X	X
MR **								X	X	X	X
MI **									X	X	X
ZCH **										X	X
ED **											X
R^2	0.145	0.147	0.178	0.356	0.367	0.368	0.393	0.401	0.405	0.405	0.408
Adj-R^2	0.141	0.140	0.171	0.347	0.356	0.354	0.376	0.382	0.382	0.380	0.380
Cp	86	88	77	15	14	15	8	7	8	10	11

**** Unit of Analysis Level (Public Transit Agency)***

***** Public Transit Agency's Metropolitan Statistical Area (MSA) Level***

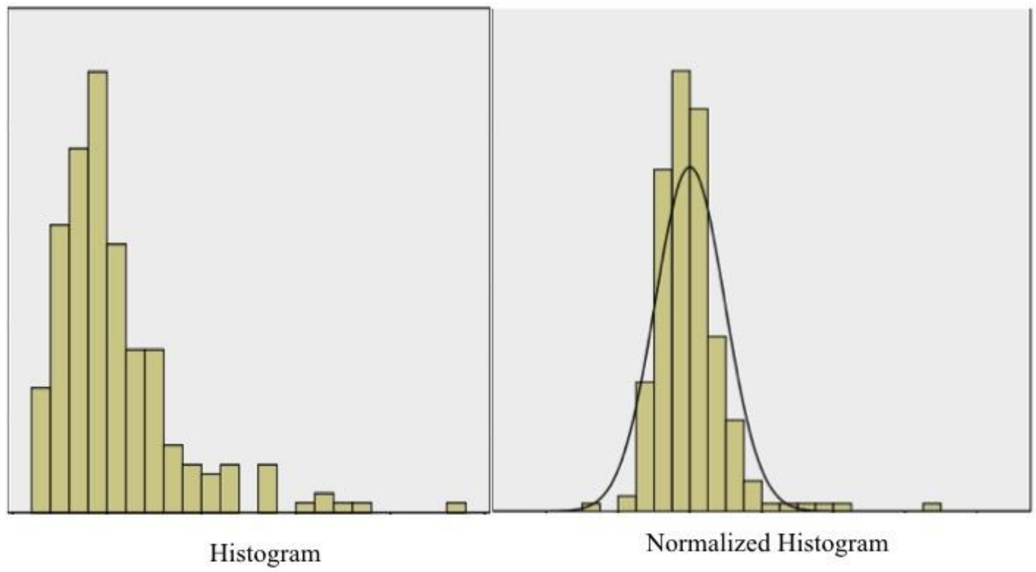

Figure 5-1: Histograms

The standardized residual *(zresid) histograms* in Figure 5-1 above depict both the residual histogram on the left and the normalized residual histogram on the right, as a way to modify or normalize the research dataset (Osborne, 2010). These graphs are the visual depictions of normalizing this research model through the sophistication of SPSS software. This process involves the use of Kolmorogov-Smirnov inferential tests of normality (Osborne, 2010). At first, the histogram is slightly positively skewed, but through the SPSS normality test, the result shows this research distribution is not significantly different from standard normal distribution (Osborne, 2010), SPSS software assumed 95% confidence interval and trimmed the mean statistic of the dependent variable by 5%. That process created the normalized histogram shown in Figure: 5-1. That shows that the assumption of normally distributed residual error has been met. These two graphs are intended to show that the robustness of this regression model was not compromised, thus its result is representative of the population (public transit agencies in the United States).

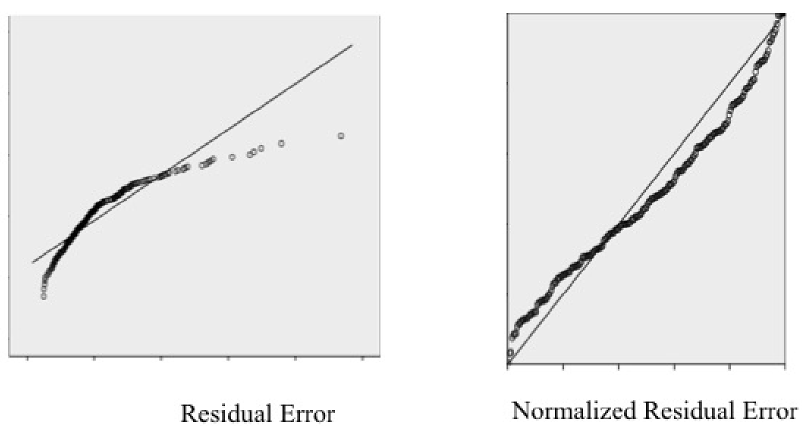

Figure 5-2: Residual Error

The *normal probability plot* (zresid normal p-p plot) above is another depiction of the normal distribution of the residual error. The initial residual error plot on the left did not show the normal distribution of the residual error plot. A perfect normal distribution of the residual error plot would have followed a 45-degree on the diagonal, however, once the software normalized the model as we see on the right graph in Figure 5-2, it shows normal residual distribution. Since

SPSS software was asked to normalize the model, the residual plot on the right is the normalized residual plot. It exhibits normality. With these two graphical exhibits (histogram and residual plots), this research effort is ready for the interpretation of the rest of the regression model results.

Multiple Regression Analysis

Multiple regression analysis is used to analyze the correlation between the independent variables (*rail fare-transit mode, regional fare, population density, total operating funds, regional operation, sprawl index, minority ratio, median income, zero-car households and employment density*) and the dependent variable – public transit productive efficiency (*passenger trips per revenue hour*). The choice of regression analysis as the preferred statistical tool is because it is clearly one of the most important tools available for the functional relationships (Armstrong, 2011). This research is based on a functional model whose correlations will be derived through the estimation of the coefficients of the above variables (Schroeder et al, 1986 p. 29).

The specification of this model's functional form is based on transit efficiency parametric measures, which have been used in previous transit efficiency studies (Sampaio et al., 2008). Each independent variable's coefficient shows the relative influence on the dependent variable, holding other independent variables constant *ceteris paribus* (Schroeder et al, 1986). Although choosing these variables is based on theories and previous studies on transit efficiencies, there is always the possibility of model misspecification. This is due to omission of relevant variables, inclusion of irrelevant variables, or an incorrect functional form (Schroeder et al, 1986). For instance, some studies have shown that weather (level of precipitation) has impact on transit ridership (Nesse, 2012), however, due to lack of available matching data at either the unit of analysis level or the MSA levels for 2014, this independent variable was excluded in this study.

These types of error usually lead to inaccuracy in the estimations of the relevant coefficients and will result in wrong inferential deductions (Schroeder et al, 1986 p. 68). Thus, it has become crucial to this research effort. The anticipated relation type (positive or negative) of each independent variable with the dependent variable has been established previously in the literature reviews and theories.

The presentation of the assessment of this study's multiple regression analysis results will include sufficient information to address:

- An overall evaluation of the regression model (Regression Summary)
- Statistical tests of the explanatory variables (Regression Coefficients)
- Goodness-of-fit statistics (Peng et al., 2002)

This above information, in Tables 4-4 and 4-5, encapsulated the regression output of this research, produced from SPSS software version 24. These indicators included an overall test of all the statistical parameters necessary to make reasonably informed inferences about the relationships between the dependent variable and the independent variables to enable decisions on the null and research hypotheses. They also provided a statistical significance test of each explanatory variable, as well as the variance inflation factors (VIF), which evaluates the significance of the explanatory variables correlations (Peng et al., 2002).

The linear multiple regression model developed for this study is universally represented as:

$$Y = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + B_5X_5 + B_6X_6 + B_7X_7 + B_8X_8 + B_9X_9 + B_{10}X_{10} + B_{11}X_{11},$$

Or

Specifically, for this study as:

$$PTPRH = 2.680 + 5.881RFTM + .0002PD + .016TOF + .601RO + .053SI + 8.187MR + .081MI + .002ED - 14.819ZCH + 8.039RR$$

Table 5-4 shows how well the above model can explain the changes in public transit productive efficiency measure (passenger trips per revenue hour). Since this research is centered on available secondary data gathered from the unit of analysis and MSA levels, it can predict or explain 40.8% of the changes in passenger trips per revenue hour of public transit systems in the United State. Table 5-5 shows the magnitude and the type impacts of each independent variables has on the dependent variable in the research model.

Table 5-4 Regression Model Summary

Model Summary[b]					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	
1	.639[a]	0.408	0.380	10.613	
a. Predictors: (Constant), RR *, ED **, RFTM *, PD *, RO **, TOF *, MI **, MR **, ZCH **, SI **					
b. Dependent Variable: PTPRH *					

Table 5-5 Regression Coefficients

Model	Variables	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics		Level of Importance		
		B	Std. Error	Beta			Tolerance	VIF	Mean	Mean * B	Ranking
1	(Constant)	2.680	4.412		0.607	0.544					
	RFTM *	5.881	1.913	0.188	3.074	0.002	0.754	1.326	0.244	1.437	6
	PD *	0.000	0.000	0.137	2.457	0.015	0.902	1.109	3802.764	0.686	8
	TOF *	0.016	0.003	0.367	5.967	0.000	0.745	1.342	142.307	2.225	3
	RO *	0.601	2.030	0.018	0.296	0.767	0.789	1.267	0.195	0.117	9
	SI **	0.053	0.032	0.122	1.678	0.095	0.530	1.886	105.697	5.616	1
	MR **	8.187	7.816	0.070	1.047	0.296	0.634	1.578	0.260	2.130	4
	MI **	0.081	0.075	0.071	1.069	0.286	0.630	1.587	59.290	4.775	2
	ZCH **	-14.819	22.929	-0.047	-0.646	0.519	0.542	1.844	0.043	-0.639	10
	ED **	0.002	0.002	0.067	0.933	0.352	0.550	1.819	641.036	0.977	7
	RR *	8.039	4.722	0.097	1.703	0.090	0.878	1.139	0.237	1.903	5

a. Dependent Variable: PTPRH *

Model Interpretations

Rail Fare – Transit Mode (RFTM) variable in Table 5-5 indicates that there is a significant positive relationship between rail fare-transit mode and passenger trips per revenue hour. The coefficient of this variable is positive, and significant at 5% and 1% levels. Its t-test value is 3.074, the second highest beside TOF. This is greater than the critical value thus will lead to *the inferences in this sampling of public transit agencies being representative of public transit agencies with 95% and 99% confidence level. The 5.881* coefficient *leads to the null hypothesis that there is no relationship between rail fare-transit mode and the dependent variable being rejected.* It also means that keeping all other independent variables constant, changing the rail fare-transit mode from non-collaborative systems with rail to collaborative systems with rail results in passenger trips per revenue hour increasing by 5.881. Thus, it can be concluded that the collaborative public transit providers that have rail are productively more efficient than rail transit mode in non-collaborative systems.

Population Density (PD) variable in Table 5-5 indicates that there is a positive relationship between the service area population density and passenger trips per revenue hour. The coefficient for population density is positive and significant at 5% level. Its t-test value is 2.457, which is greater than the critical value. *The null hypothesis that there is no relationship between population density and the dependent variable is rejected and this inference is true of public transit* *providers in the United States. Thus, there is a positive relationship between the population density and passenger trips per revenue hour.* The unstandardized coefficient of population density is 0.0002. Using the unstandardized coefficient and keeping all the other variables constant, if the population density grows by 1 unit, then passenger trips per revenue hour will increase by .0002. Thus, it can be concluded that the transit service areas with higher population density will have better productive efficiency (passenger trips per revenue hour).

Total Operating Funds (TOF) variable in Table 5-5, shows a positive significant relationship between the total operating funds and passenger trips per revenue hour. The coefficient of total operating funds is positive and significant at 5% and 1% levels. Its t-test value is 5.967, which implies that the inferences of the sample of public transit systems is a representation of United States transit systems regarding total operating funds at a 95% and 99% confidence level. Hence, *the null hypothesis that the* total operating funds *variable has no relationship to the passenger trips per revenue hour is rejected. Thus, there is a positive relationship between total operating funds and passenger trips per revenue hour.* The unstandardized coefficient of total operating funds is equal to 0.016, and its standardized coefficient value is 0.367. Using the unstandardized coefficient and keeping all the other variables constant: if the value of total operating funds of a transit system increases by 1 unit, then passenger trips per revenue hour will increase by .016. This signifies that a change in the percentage of total operating funds of a system will increase the passenger trips per revenue hour.

Recovery Ratio (RF) variable result in Table 5-5 indicates that there is a positive relationship between recovery ratio and passenger trips per revenue hour. The coefficient for this variable is positive. Its t-test value is 1.703, which is less than the critical value. The coefficient of 8.039 means that keeping all other independent variables constant, changing the recovery ratio variable by 1 unit will result in passenger trips per revenue hour increasing by 8.039. This implies that increasing the recovery ratio of public transit agencies would make them more productive.

Regional Operation (RO) variable in Table 5-5, shows a positive relationship between a transit system being the sole operator in a transit service area and passenger trips per revenue hour. The coefficient of regional operation is positive but not significant at 5% level. Its t-test value is .296, indicates nonzero relationship of regional operation and passenger trips per revenue hour for public transit systems in US.

Sprawl Index (SI) The regression result in Table 5-5 shows there is positive relationship between the sprawl index of a transit service area and the passenger trips per revenue hour. The coefficient for this variable is positive, but not significant at t-test value of 1.678.

Minority Ratio (MR) is Table 5-5 shows that there is a positive relationship between the minority rate and passenger trips per revenue hour. The coefficient of minority rate is positive, but not significant at 5% level. Its t-test value is 1.047, which is less than the critical value. *Thus, there is a* positive *relationship between the minority rate of a transit agency's service area and passenger trips per revenue hour.* The unstandardized coefficient of minority rate is equal to 8.187 and its standardized coefficient Beta value is 0.070. Using the unstandardized coefficient and keeping all the other variables constant, if the value of minority rate increases by 1 unit, passenger trips per revenue hour will increase by 8.187. Thus, it can be concluded that areas with higher minority percentage produce more transit trips than areas with less minority population.

Median Income (MI) Table 5-5, there is a positive relationship between the median income of a transit system service area and passenger trips per revenue hour. The coefficient of median income is positive, but not significant at 5% level. Its t-test value is 1.069. The unstandardized coefficient of median income is equal to 0.081 and its standardized coefficient value is 0.071. Using the unstandardized coefficient and keeping all the other variables constant, if the value of median income increases by 1 unit, then passenger trips per revenue hour will increase by 0.081.

Zero-Car Households (ZCH) variable in Table 5-5, shows there is a negative relationship between the zero-car household and passenger trips per revenue hour. Again, this result is counterintuitive at the first glance because increasing the proportion of with zero-car households seems to be reducing the public transit productivity, which explains the inverse of the anticipated relation. The coefficient of zero-car households is negative but not significant at 5% level. Its t-test value is -0.646. *Thus, there is a negative relationship between the zero-car households and passenger trips per revenue hour.* The unstandardized coefficient of zero-car households is equal to – 14.819 and its standardized coefficient Beta value is -0.047. Using the unstandardized coefficient and keeping all the other variables constant, if the value of zero-car household in a service area increases by 1 unit, passenger trips per revenue hour will decrease by 10.209. This signifies that a change in the percentage of zero-car households in a transit service area will reduce the passenger trips per revenue hour, but not necessarily decreasing the ridership. It might increase it in an inefficient manner.

Employment Density (ED) variable in Table 5-5, shows that there is a positive relationship between the employments density and passenger trips per revenue hour. The coefficient of employment density is positive, but not significant at 5% level. *Thus, there is a positive relationship between employment density and passenger trips per revenue hour.* The unstandardized coefficient of total operating funds is equal to 0.002 and its standardized coefficient Beta value is 0.067. Using the unstandardized coefficient and keeping all the other variables constant, if the value of employment density of a transit system increases by 1 unit, passenger trips per revenue hour will increase by .002. This signifies that a change in the employment density of area served by a system will increase the passenger trips per revenue hour.

Results

The previous section identified the effect of each independent variable on the transit productive efficiency. Now let us explain the significance of those effects on the overall descriptive and inferential statistical relations in the public transit production function empirical analysis, so that meaningful research conclusions can be drawn on this dissertation effort.

Table 5-6 Descriptive Statistics

Variables	Minimum	Maximum	Mean	Std. Deviation	N
PTPRH *	4.96	93.57	21.91	13.47	221
RFTM *	0.00	1.00	0.24	0.43	221
TM *	0.00	1.00	0.38	0.49	221
RF *	0.00	1.00	0.53	0.50	221
PD *	129.52	146239.43	3802.76	10263.31	221
TOF *	0.67	2199.35	142.31	316.30	221
RR *	0.00	1.19	0.24	0.16	221
RO **	0.00	1.00	0.19	0.40	221
SI **	40.99	203.36	105.70	31.04	221
MR **	0.03	0.51	0.26	0.11	221
MI **	38.31	96.48	59.29	11.96	221
ZCH **	0.01	0.23	0.04	0.04	221
ED **	39.34	2121.07	641.04	590.56	221

Note: Results Obtained using SPSS 24
** Level 1: Data at unit of analysis level (transit agency)*
*** Level 2: Data at metropolitan statistical area (MSA) level*

Table 5-6 above depicts a brief summation of the descriptive statistics of the variables used in this study. The dependent variable (unlinked passenger trips per revenue hour) on the average is 21.91 and ranges from 4.96 to 93.57, for public transit systems in the United States with standard deviation of 13.47 based on the 221 transit agencies surveyed. Over 1/3 (.376) of the public transit providers in the United States have some form of rail transit mode in their transit operations (based on the 221 transit systems surveyed). Slightly over half (.529) of the public transit systems in the nation have some form of collaborative transit service arrangements with other transit providers in their travel areas based on the 221 public transit systems surveyed. The areas served by public transit on the average have 3,802 residents per square mile, according to the 221 sampled public transit agencies. The total operating funds of public transit providers in the United States averages $142,307,000 annually, based on the 221 transit agencies surveyed. However, this figure ranges from $674,287, for the smallest transit operator to $2,199,349,867, for the largest transit operator in the United States see Table 5-6. This is the main indicator of the level of transit services provided by each operator. Less than 20% (.195) of the public transit providers in the United States are single-transit service providers in their respective regions of operation, based on the 221 sampled transit providers. The sprawl index variable, which captures the rate of commuting in an area, averaged 105.697, with a minimum of 40.99, and a maximum of 203.36. On the average, the transit providers surveyed operate in less sprawled areas. This is because any score higher than 100, is considered “compact” while those less than 100 are considered sprawling (Ewing et al., 2014). On average, the areas served by the 221 public transit agencies surveyed had 26%, nonwhite resident in each MSA of each transit agency travel region. That percentage ranged from the lowest of 3.2% to the highest of 51.2% minority ratio of areas serves by public transit operators. The average median household income, the measure of how wealthy the residents of the 221 transit service areas surveyed, is $59,290. The median income ranged from $38,312 to $96,481 as shown in Table 5-6. The percentage of households in areas served by public transit according to the 221 transit agencies surveyed that have no cars in their households is 4.3% on the average. This variable captures transit dependent residents ranges from 1.3% to 22.6%. Based on the 221 transit agencies surveyed, on the average, there are about 641 employments per square miles of the MSA that each transit agency operates. Employment density variable ranges from 39 to 2121, employments per square miles (see Table 5-6). Now that we have outlined the descriptions of the data that were used for the empirical analysis of this research effort, let us look at how they inform this research outcome.

Table 5-7 Regression Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	
1	***.639[a]***	***0.408***	***0.380***	***10.613***	
a. Predictors: (Constant), RR *, PD *, ZCH **, RO **, RFTM *, MR **, TOF *, MI **, ED **, SI *					
b. Dependent Variable: PTPRH *					

Note: Results Obtained using SPSS 24
** Level 1: Data at unit of analysis level (transit agency)*
*** Level 2: Data at metropolitan statistical area (MSA) level*

Table 5-7 above displays the model summary of the regression for the sampled public transit agencies in the United States and is normally distributed, which implies that it is a representation of public transit agencies in the United States. The value of R is equal to 64% and R-Square (R^2) of the model is 40.9%. This implies that about a 41% change in the dependent variable, passenger trips per revenue hours (PTPRH), is explained by the variations in the ten independent variables used in this model.

Table 5-8 ANOVA

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	16282.672	10	1628.267	14.457	.000[b]
	Residual	23651.896	210	112.628		
	Total	39934.568	220			
a. Dependent Variable: PTPRH *						
b. Predictors: (Constant), ED **, RFTM *, RR *, PD *, RO **, TOF *, MI **, MR **, ZCH **, SI **						

Note: Results Obtained using SPSS 24

Table 5-8 shows the result of analysis of variance (ANOVA) of this research production function. The key columns that are critical from the above table are the first and the last. The others are for calculation purposes as part of the SPSS, version 24-model output (Stockburger, 1998). Since the number in the last column is less than the critical value (.05), it shows that the model effects are significant.

Since these effects are shown to be significant using the above procedure, it means that the effects of independent variables on the dependent variable in this research model are more than would have been caused by simple chance (Stockburger, 1998). In terms of this research, what this means is that the ten explanatory variables have unequal effects on public transit efficiency levels. This is not due to chance.

Table 5-9 Regression Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics		Level of Importance		
		B	Std. Error	Beta	T	Sig.	Tolerance	VIF	Mean	Mean * B	Ranking
	(Constant)	2.270	4.375		0.519	0.604					
	*Rail Fare-Transit Mode (RFTM *)*	5.921	1.631	0.213	3.629	0.000	0.815	1.228	0.376	2.224	3
	*Rail Fare (RF *)*	1.055	1.814	0.039	0.581	0.562	0.620	1.613	0.529	0.558	8
	*Population Density (PD *)*	0.0002	0.000	0.149	2.686	0.008	0.913	1.096	3802.764	0.744	7
	*Total Operating Funds (TOF *)*	0.016	0.003	0.366	5.924	0.000	0.736	1.359	142.307	2.221	4
1	*Regional Operation (RO **)*	-0.133	2.183	-0.004	-0.061	0.951	0.681	1.469	0.195	-0.026	9
	*Sprawl Index (SI **)*	0.055	0.032	0.127	1.743	0.083	0.530	1.887	105.697	5.825	1
	*Minority Ratio (MR **)*	8.094	7.804	0.069	1.037	0.301	0.634	1.577	0.260	2.106	5
	*Median Income (MI **)*	0.092	0.076	0.082	1.214	0.226	0.616	1.624	59.290	5.483	2
	*Zero-Car Households (ZCH **)*	-10.209	22.952	-0.032	-0.445	0.657	0.540	1.852	0.043	-0.440	10
	*Employment Density (ED **)*	0.001	0.002	0.064	0.898	0.370	0.546	1.831	641.036	0.943	6

Note: Results Obtained using SPSS 24
** Level 1: Data at unit of analysis level (transit agency)*
*** Level 2: Data at metropolitan statistical area (MSA) level*

Results and Discussion

Rail Fare – Transit Mode (RFTM) is a measure of public transit collaborativeness, captured in rail transit modes. Although the measure of collaborativeness is regional fare, transit riders who are using local services would not purchase regional fare. So, ascribing the impacts of regional services to non-regional productivity measure cofounds the true measure of its impact. However, RFTM confines collaborativeness of public transit services to the rail transit modes only. To do this, the research effort identified all collaborative transit systems that have rail transit modes and those non-collaborative systems with rail transit modes through the process of interaction effects. Given the restriction to transit rail modes, the relationship between collaborative public transit systems and improvements on the productive efficiency levels becomes obvious. Not only does it show the positive relationship, but it also provides us with a statistical evidence of the relationship being significant. This is a resounding validation of the subsequent inference from the regional fare that is unconstrained. Thus, it provides the validity that collaborative public transit systems are productively **more** efficient than none collaborative ones. This conclusion validates the postulation of the Cobb-Douglas Production Function, which states that a percentage increase in input would cause an increase in total output (Douglas, 1967). Since the public transit productivity levels increase more for collaborative public transit services with rail than non-collaborative systems with rail.

The fare that transit riders pay to use transit services make up the public transit fare revenues. Its percentage of the total operating cost is called recovery rate or ratio. It is assumed that the higher this variable, the more efficient the transit system. On the other hand, the lower the recovery rate the higher its ridership or effectiveness (Cervero, 1990). However, this research's productivity measure is not ridership rather passenger trips per revenue hour. The positive correlation between them confirms the fact that when a system's recovery rate is higher, it results in improves services. This leads to improvement in productivity levels (Cervero, 1990).

Regardless of the trip production format (origin to destination (O-D) or production to attraction (P-A)), population density plays a major role in determining transit ridership and this research validates that. The result on Table 5-9 confirms the direct relation between population density and productive efficiency of public transit systems in the United States, which implies that increase in the population density of an area will increase the transit productive efficiency level in that area. Thus, the conclusion is that transit service areas with higher population density will have better productive efficiency (passenger trips per revenue hour). This result is in line with public transit proponents that argue against the increasing growth rate of the United States suburbanization patterns. This leads us into the next variable – sprawl index.

The Sprawl Index (SI) shows that there is a direct correlation between the changes in the sprawl index of an area and change in public transit productive efficiency measure. It is quite germane to clarify this measure now. The average sprawl index score is 100, which signifies that areas with a score higher than 100 are “compact” and those with scores lower than 100 are “sprawled” (Ewing et al., 2014). This result corresponds with prevailing urban theories and previous studies. The reasoning for this relationship is because the greater an area sprawl index, the more compact such an area, and the greater the need for alternative means of transportation. Hence, the increase in public transit productive efficiency levels (Anjomani et al., 1982, Ewing et al., 2014).

The minority ratio (proportion of the residents of public transit agency’s service area that are non-white residents) is used in this study because it is one of the determinants of the usage of public transit services. Its inclusion stems from previous studies that show the influence of minority population, as defined by US Census, on transit ridership. Minorities (non-white) make up a high percentage usage of transit services when compared to whites (Taylor et al., 1999). The result of this study, shown on Table 5-9, confirms the postulation that there is direct relationship between the minority ratio and passenger trips per revenue hour (Taylor et al., 1999). That result leads to the conclusion that areas with higher minority ratio produce more transit trips than areas with less minority population, thus contributing to the improvement of transit productive efficiency.

The average income of the population of each transit agency's service area is the Median Income (MI). It is an indicator of household car ownership, which determines the dependence in transit services as major transportation mode. The result in Table 5-9 corroborates the previous assertion of a direct relation between median income and public transit productive efficiency levels (Giuliano, 2005). The conclusion is that areas with lower median income produce more transit trips than areas with higher median income population.

The Regional Operation (RO) is included in this research model to control for the impact of service area size to transit productive efficiency. The theme of this research effort is to measure the impact of collaborativeness of public transit services, which usually leads to the enlargement of the coverage areas of the collaborative participants. It would isolate the effects of expansion of service due to collaboration of services by transit agencies. In other words, this variable would help differentiate the impacts of service area size with those that result due to collaborativeness of transit service operations. What this variable shows is that increasing the size of transit agency's service area slightly increases this productive efficiency measure because this productivity measure is weighted. If the dependent variable in this model had been unlinked passenger trips, rather than passenger trips per revenue hours, the correlation might have been greater. To control this variability, due to service area size, passenger trips per revenue hour variable was used in this research as the productive index. Intuitively, the larger the service area of each transit agency, the greater the demand for its product. However, the productivity measure in this research is passenger trips per revenue hour (weighted average of transit ridership), which made it to lessen the direct relationship. If the measure had been unlinked passenger trips, the result could have been different. Transit riders will tend to ride for a longer distance, which implies a longer time span. Thus, leading to the conclusion that simply increasing the service area of a transit provider does not necessarily make their productivity more efficient.

The proportion of the households in each transit service area's MSA that do not have drivable vehicles or licensed individuals to drive automobile in a household is Zero-Car Households (ZCH). This segment of the population constitutes those referred to as transit dependents or captive riders (Office of Budget and Policy, 2016). They ride the public transit services longer distances and longer time periods because it is their only means of transportation. However, the productive efficiency measure in this research is not unlinked trips or riders, rather passenger trips per revenues hour, which is a weighted average. To increase the zero-car households will result in the reduction of non-zero-car households. This aids in the improvement of the public transit productive efficiency levels because they have alternative transportation and are more likely to ride transit for a shorter time span than transit dependents. This signifies that an increase in the percentage of zero-car households in a transit service area will reduce the passenger trips per revenue hour, but not necessarily decreasing the ridership. It **might** increase it at an inefficient manner.

The total operating funds (TOF) variable encapsulates the input in the input-output model of public transit production function. The total input (transit services) of each transit agency is determined by their total operating funds. That is why it is a significant variable in this model because it determines the level of services of each transit agency. The source of these funds is gained from transit riders, local, state and federal government. They are used to improve or increase the transit services, thus aid in the improvement of their productive efficiency. The result from this research shows that the percentage of total operating funds of a system will increase the passenger trips per revenue hour. This confirms the production function relationship, which indicates that increasing the input (transit services) would increase the output (ridership).

The measure of the concentration of jobs or employees within the MSA of transit agency's service area is considered their Employment Density (ED). The employment density is computed by the total employment in each transit service MSA divided by the size of that MSA in square miles. This variable has been found to be associated with work trips and shopping trips as origins and destinations (Frank et al., 1994). This research indicates that an increase in the employment density of areas served by public transit systems will increase their respective average passenger trips per revenue hour.

Implications

The objective of this dissertation research is to examine the possible correlation between collaborative transit services amongst multiple transit providers within a travel region and improvement in their productive efficiency levels. Given the statistical inferential evidence in this research result. What are the possible implications of such positive results? Or why does it matter? Although, the answers to these questions are beyond the scope of this dissertation, speculatively, one can postulate that this result could have certain policy and planning implications to transit providers, municipalities, regional planning agencies, and state and federal government agencies.

Transit agencies that are not currently engaged with other transit providers in their regions might see the outcomes of this research as an indication of the need to begin exploring such service arrangements because all public transit agencies strive to maximize their ridership (Brons et al., 2005). Public transit providers should begin to pay more attention to those services or transit modes that would enhance their abilities to engage collaboratively with other transit providers. Unfortunately, some cities threaten to leave their transit agencies to forge a separate identity with their own transit operations. The rationale is that they can do better in providing their residents better transit services than if they collaborate. This result might have them think otherwise. In fact, leaving their current providers does not guarantee improvement in their service efficiency levels, ultimately forcing them to work on improving their level of services while staying with their respective partners in the collaborations.

Even municipalities that are in the process of forming new public transit services need to explore the idea of joining existing transit providers in their area or region to improve their service efficiency levels. The results of this research show that certain transit modes (light rail or commuter rail) are more likely to facilitate collaborative services. Transit agencies should invest more in those types of transit projects to make them more attractive to collaborative transit services with other transit providers in their regions.

Metropolitan planning organizations (MPOs) should start to encourage different transit agencies in their respective regions to foster more collaboration in their service provisions. One of the key roles of MPOs is to foster regionalism amongst municipalities in their jurisdiction, especially in their transportation planning; this will enhance that role (Lewis, 1998). Given that MPOs are charged with the disbursement of certain funds to transit providers in their regions, the collaborative criteria could service as incentive to get more transit agencies to participate in transit service collaborations.

In view of the untapped large number of public transit providers operating non-collaboratively according to this research, policy makers should focus in this area since it will require minimum resource investments. Improving transportation performance has been the hallmark of all transportation related policies in the last few decades. To include public transit service collaborativeness as one of the implementing tools of transportation related policies would enhance the improvement of transit efficiency levels, thus complimenting the goal of most of United States transportation policies.

Including the collaborative services as part of the index of performance evaluation criteria would show a better return on investments in public transit projects. This is crucial because a lot of the recent public transit funding is through public-private partnerships (P3) (Yescombe, E. R. (2011). Federal transportation funding agencies, like FTA, should add this variable (transit collaborative services) as one of their criteria for rating transit related projects.

More specifically, a look at the most recent transportation policy – **FAST Act**, that states "*... It is in the interest of the United States, including the economic interest of the United States, to foster the development and revitalization of public transportation systems with the cooperation of both public transportation companies and private companies engaged in public transportation*" (FTA Website). The result of this dissertation research (***presence of correlation between transit collaborations and improved efficiency levels***) speaks to three (4, 5 & 7) of the eight outlined purposes of this policy:

1. Provide funding to support public transportation;
2. Improve the development and delivery of capital projects;

3. Establish standards for the state of good repair of public transportation infrastructure and vehicles;
4. ***Promote continuing, cooperative, and comprehensive planning that improves the performance of the transportation network;***
5. ***Establish a technical assistance program to assist recipients under this chapter to more effectively and efficiently provide public transportation service;***
6. Continue Federal support for public transportation providers to deliver high quality service to all users, including individuals with disabilities, seniors, and individuals who depend on public transportation;
7. ***Support research, development, demonstration, and deployment projects dedicated to assisting in the delivery of efficient and effective public transportation service;*** and
8. Promote the development of the public transportation workforce.

The fact that FAST Act has become law should not discourage any plan to add the result of this research into its implementation tool. That could be done by simply modifying the FAST Act to include seamless collaborative service arrangements between public transit providers within a region as part of the performance measures. This change will not need to put the FAST Act through the complete policy cycle of the policymaking process. It is believed that the problem that led to the creation of the FAST Act policy was appropriately defined, but the policy instituted a measurement matrix (implementation tool) that included coordination and collaborations between different modes of transportation and not between different transit providers in the same region. That is what this effort will be seeking to add to the FAST Act.

It should be anticipated that if FTA accepts the results of this research, showing that collaborative services between transit providers does increase their productive efficiency levels, they should recommend to the United States Department of Transportation (US DOT) for its inclusion in the policy implementation tool of FAST Act. US DOT will then include it during the rule making session for the next transportation appropriations.

The policy actors would be FTA, DOT, and the transportation committee in the federal legislative body. The factor and elements that need to be included are the proof of the correlation between collaborative transit services between different transit operators within a service region and the improvement of transit productive efficiency levels. The result of this dissertation research should serve as such proof.

Given the result of this research effort, it should be anticipated that transit collaboration as an efficiency measure will be included in the FAST Act implementation tool for the next transportation appropriation. However, if it does find detractors, then members of the transportation committee of the legislative body might add it as omnibus bill in the transportation appropriations for the next fiscal year.

This suggested inclusion to the policy implementation tool does not override any of the previous performance measures, but will enhance them. The previous compendium of measurement matrix includes a range of activities and products undertaken by a transportation agency together with other agencies, stakeholders, and the public as part of a 3C (cooperative, continuing, and comprehensive) process (FTA Guidebook, 2013). There are no conflicts in including public transit collaborative services as public transit efficiency index to the existing performance management transportation tools rather it will be COMPLIMENTARY.

Before summing up the findings of this research effort, it is important to state that like all other researches, there were certain limitations. Those limitations did not necessarily undermine the outcome of this study.

Limitations of study

The end of every research (academia or non-academia) leads to the beginning of another one. This sequencing of learning process signals that each study has its limitations and this dissertation research will not be an exception to that rule. Those limitations are based on one's perspective or expectations of each study. It is common that several people can look at the same study and identify different limitations.

Perceived Limitations

- The study would be enhanced with the ability to gather all the data of all the variables at the unit of analysis level. NTD should keep the geographical layout or map of the service areas of each transit provider. This information is available because all transit agencies have the map of their service areas. This would have made it possible to geocode census data to match the transit agency's internal data. For instance, this study would have preferred to use activity density (*population and employment divided by size of area in square miles*) at the service area level, unfortunately, NTD keeps only the population density information. Consequently, population densities were gathered at the unit of analysis level while employment densities were collected at the MSA level. It does not necessarily change the outcome of the study, but it would have made it easier and more accurate if these were aligned.
- There is little or no study done on transit related network effects beside the one done on social spillover of transit users, which did not measure the individual transit rider's utility of transit services (Goetzke, 2008). Studies have been done on the network effect on non-public transit ridership related areas (Clements, 2004; Liebowitz et al., 1994; Varga et al., 2010; Varga et al., 2009; Ter et al., 2009; etc.). The question remains if such parallel can be drawn in public transit. Secondary data of this variable are

not available at any of this research data sources. Again, NTD should gather this information through ridership surveys because all the performance indicators do not have to be interval measures. The fix could be easy if they added some additional attitudinal questions that inquire if passengers would ride transit due to other users. This could have had a direct relation to the productivity of public transit providers, but would not have changed the outcome of the inquisition of this dissertation – the effect of collaborativeness of transit services on productive efficiency.

Future Research

The aforementioned research limitations underscore the direction of a possible future research needed. Some studies had been done on the network effect on non-public transit service related consumptions (Clements, 2004; Liebowitz et al., 1994; Varga et al., 2010; Varga et al., 2009; Ter et al., 2009; etc.). The question remains if such parallel can be drawn in the public transit service arena. In other words, would increasing or attracting more consumers of public transit services increase the utility or value of transit services to its users? The results of this dissertation have shown that collaborativeness of transit services does increase public transit productive efficiency.

The outcome of this dissertation research envisages a continued inquiry. If the attitudinal data on transit riders' behavior toward increase, or attraction of more riders, indicates network effect, then an investigation into the decomposition of the total effects of collaborativeness of transit services on productive efficiency levels is intriguing. Finding the type (direct or indirect) of network effects is intriguing (Alwin et al., 1975). Statistical tools such as "*path analysis*" can be used in the decomposition of the total effects on public transit productive efficiency through collaborations (Alwin et al., 1975). Unfortunately, the lack of transit type network effect data that can be collected through survey has not allowed it. This might lend it to additional research.

Chapter 6:

Conclusion

The research effort of this dissertation has conclusively determined that the variable rail fare - transit mode as the index of collaborativeness, shows unquestionably: there is a direct relationship or correlation between public transit service collaborations and public transit productive efficiency levels. Again, as a nonexperimental research, correlation is clearly not causation. In other words, making a nonproductive public transit system a participant in public transit collaboration service arrangements does not automatically guarantee that they will become efficient, but it would not make them worse off. That is the goal of all the recent transportation policies: making all transportation projects or programs more efficient.

In addition, three key conclusive elements emerged from the analysis of this dissertation research. First, the collaboration of transit services of different transit providers within a travel region makes a difference in their productive efficiency levels. Secondly, the impact of public transit collaborativeness becomes even more pronounced when there is a transit mode operating in an exclusive right-of-way (ROW) that eliminates the effect of congestion. Finally, the effect of collaborativeness on public transit productive efficiency is not mainly a result of the increased service area size. There is evidence that urban sprawl has impact on the productive public transit efficiency services meaning that the more an area is sprawled, the higher the propensity for traffic congestions. Thus, increases the need for alternative means of transportation especially for modes with exclusive ROW. This research effort does not find reasonable evidence that increasing the service area of operations of public transit providers outside those resulting from collaborations make them any better off in terms of their productive efficiencies. It might increase their productivity inefficiently.

The inquisition of this dissertation is to investigate whether public transit collaborative arrangements are like the “game theory” postulation of collaboration planning approach, where there is no dichotomy of winners vs. losers; rather, all participating players are considered winners (Innes, J. E. et al, 1999). All things considered, this study has validated the theory, which states that there are no losers in a collaborative planning approach. All participating players come out winners (Innes, J. E. et al, 1999). That is true in the sense that all participants in public transit collaborativeness saw improvements in their public transit productive efficiency, regardless of their participation levels. There is no better validation of a positive correlation between collaborative public transit service arrangements (*Rail Fare-Transit Mode*) and improved transit productive efficiency (*Passenger Trips Per Revenue Hour*) than the one shown on Table 5-9 of this report.

Appendix A

Productivity Measures of Public Transit Providers

Table A: Transit Productivity Factors

PTPRH *	RFTM *	TM *	RF *	PD *	TOF *	RR *	RO **	SI **	MR **	MI **	ZCH **	ED **
5.0	0	0	1	2292	3.90	0.003	0	124.4	0.302	62.171	0.06	993
5.0	0	0	1	1693	0.67	0.818	0	73.55	0.325	47.046	0.01	167
5.2	0	1	0	758	6.52	0.116	0	76.74	0.330	60.072	0.02	545
5.3	0	0	0	3843	7.20	0.035	0	78.32	0.175	53.365	0.03	229
5.4	1	1	1	732	17.27	0.727	0	105.18	0.254	66.192	0.02	600
6.1	0	0	1	2641	0.69	1.032	0	93	0.197	56.371	0.02	310
6.5	0	0	1	755	3.86	1.190	0	116.29	0.293	60.015	0.03	322
6.5	0	0	0	479	1.24	0.630	0	82.92	0.171	50.932	0.03	2121
7.0	0	0	0	162	4.77	0.109	1	95.97	0.096	58.093	0.03	61
7.4	0	0	1	497	25.27	0.332	0	194.28	0.430	83.222	0.07	1430
7.5	0	1	0	386	17.90	0.482	0	107.72	0.040	59.573	0.03	254
7.7	0	1	0	2753	9.03	0.187	0	77.6	0.185	56.994	0.02	212
7.8	1	1	1	6279	5.07	0.095	0	80.75	0.156	55.729	0.03	389
8.0	0	0	1	1648	70.55	0.145	0	117.04	0.389	67.066	0.23	1818
8.3	0	0	0	2737	26.59	0.184	1	100.9	0.184	45.603	0.03	343
8.3	0	1	0	419	18.25	0.437	1	105.12	0.092	58.587	0.02	39
8.3	0	0	0	1669	3.60	0.081	1	115.19	0.365	71.501	0.05	798
8.5	0	0	0	1697	16.35	0.165	0	112.64	0.066	45.257	0.03	329
8.9	0	0	1	330	7.16	0.135	0	79.51	0.389	67.066	0.23	256
8.9	0	0	0	3114	34.42	0.086	1	123.35	0.139	49.508	0.02	152
9.2	0	0	0	1912	10.66	0.096	1	97.48	0.388	43.642	0.01	315
9.3	1	1	1	790	17.75	0.275	0	56.25	0.330	54.586	0.02	120
9.5	0	0	1	2244	11.77	0.113	0	115.84	0.066	45.257	0.03	329
9.7	0	0	1	3616	11.52	0.112	0	109.62	0.066	45.257	0.03	329
9.9	0	1	0	1727	23.84	0.099	0	105.49	0.107	52.077	0.02	1818
9.9	0	0	0	638	6.84	0.164	0	99.22	0.185	46.876	0.03	884
10.0	0	0	0	1135	10.66	0.097	0	114.66	0.365	71.501	0.05	798
10.5	0	0	1	1938	1.93	0.695	0	95.45	0.108	52.293	0.04	359
10.7	0	0	0	160	9.65	0.148	1	75.23	0.117	58.026	0.08	106
10.9	0	0	0	1524	7.31	0.135	0	91.2	0.469	47.159	0.02	258
11.0	0	0	0	2431	28.26	0.099	0	73.55	0.325	47.046	0.01	167
11.0	1	1	1	759	8.86	0.134	0	99.27	0.293	60.015	0.03	322
11.3	0	0	1	1271	13.73	0.158	0	113.87	0.179	67.771	0.02	249
11.3	0	0	0	3670	34.22	0.158	1	124.4	0.130	60.32	0.03	443
11.4	0	0	0	2780	31.98	0.132	0	105.03	0.216	58.02	0.02	212
11.5	0	0	0	1229	21.81	0.131	0	125.9	0.218	55.535	0.03	273
11.6	0	0	0	130	4.49	0.115	1	88.7	0.172	43.993	0.02	258
11.7	0	0	1	475	124.34	0.085	0	112.94	0.294	55.227	0.03	216
11.7	0	0	0	1467	10.74	0.184	1	76.84	0.215	50.003	0.02	220
11.7	0	0	1	3608	32.83	0.156	0	127.24	0.430	83.222	0.07	1430
11.8	0	0	0	1559	6.56	0.132	1	118.43	0.032	40.83	0.03	545
11.8	0	0	0	1847	8.68	0.192	1	132.69	0.066	60.106	0.02	164
12.0	0	0	0	1199	10.63	0.125	0	104.34	0.195	75.667	0.07	1009

12.3	0	0	0	3476	82.57	0.180	0	98.18	0.270	48.458	0.04	888
12.3	0	0	1	3157	27.06	0.171	0	108.42	0.131	57.527	0.02	180
12.7	0	0	1	589	7.27	0.214	0	63.5	0.330	42.565	0.02	289
12.8	1	1	1	1290	40.95	0.122	0	103.15	0.151	50.538	0.03	604
12.9	0	0	0	410	20.08	0.178	0	89.68	0.161	42.468	0.02	285
12.9	0	0	0	2041	17.74	0.176	1	86.65	0.212	50.74	0.02	114
13.1	0	0	0	1915	15.61	0.098	0	114.98	0.168	48.385	0.03	328
13.2	0	0	0	2052	18.03	0.193	0	106.33	0.141	59.411	0.02	191
13.2	0	0	0	3477	107.25	0.139	0	137.17	0.282	52.462	0.03	825
13.3	0	0	0	924	20.35	0.136	0	73.84	0.364	51.988	0.03	233
13.5	0	0	0	1969	11.24	0.162	1	67.45	0.379	50.091	0.03	163
13.5	1	1	1	1362	14.34	0.117	0	104.34	0.195	75.667	0.07	1009
13.6	0	0	1	2357	65.89	0.113	0	78.56	0.285	59.53	0.02	527
13.7	0	0	1	1360	20.44	0.164	0	194.28	0.430	83.222	0.07	1430
13.7	1	1	1	624	55.11	0.199	0	56.25	0.330	54.586	0.02	120
13.8	0	0	0	646	19.37	0.112	1	106.99	0.079	47.729	0.03	326
13.8	0	0	1	1044	21.10	0.207	0	80.75	0.156	55.729	0.03	389
14.0	0	0	0	3675	19.64	0.179	1	111.4	0.156	57.742	0.04	265
14.3	0	0	1	6292	61.44	0.080	0	130.33	0.421	60.514	0.04	2121
14.3	0	0	1	3078	20.26	0.079	0	116.11	0.231	71.273	0.04	447
14.5	1	1	1	1258	34.73	0.440	0	107.21	0.419	91.193	0.06	718
14.5	0	0	1	8022	4.04	0.195	0	59.18	0.427	56.166	0.03	475
14.6	0	0	0	1423	22.60	0.086	0	55.6	0.390	52.091	0.02	151
14.6	0	1	0	2665	24.74	0.108	1	82.07	0.209	52.416	0.02	454
14.6	0	0	0	654	28.37	0.200	0	106.48	0.230	41.682	0.03	492
14.7	0	0	0	1106	9.66	0.108	0	78.08	0.124	42.228	0.04	256
14.8	1	1	1	2294	14.77	0.279	0	40.99	0.427	56.166	0.03	475
14.9	0	0	1	4852	11.10	0.238	0	99.27	0.293	60.015	0.03	322
14.9	0	1	0	1231	86.53	0.139	1	80.85	0.272	51.117	0.03	339
15.0	1	1	1	1016	33.19	0.248	0	98.07	0.254	47.581	0.02	76
15.1	0	0	1	434	10.73	0.109	0	105.49	0.107	52.077	0.02	1818
15.1	0	0	0	2116	11.95	0.172	1	77.91	0.145	47.907	0.03	351
15.3	0	0	0	2300	24.97	0.292	1	104.9	0.103	62.446	0.02	153
15.4	0	0	0	4485	7.78	0.030	0	80.85	0.270	48.458	0.04	888
15.6	0	0	0	1772	30.70	0.068	0	107.21	0.419	91.193	0.06	718
15.7	1	1	1	958	70.44	0.176	0	88.69	0.163	69.111	0.03	798
15.9	0	0	1	2782	29.77	0.130	0	84.25	0.207	52.64	0.02	135
15.9	0	0	1	2344	85.29	0.180	0	83.89	0.203	52.268	0.02	114
16.0	0	0	0	3620	20.70	0.163	0	99.22	0.144	49.055	0.03	646
16.1	0	0	0	476	17.00	0.208	1	137.9	0.131	56.059	0.03	50
16.1	1	1	1	2715	102.10	0.339	0	116.11	0.231	71.273	0.04	447
16.1	0	0	1	1600	209.95	0.186	0	125.9	0.319	61.598	0.06	999
16.1	0	0	0	1295	66.82	0.186	0	41.49	0.207	52.64	0.02	161
16.2	0	0	0	2419	12.74	0.140	0	86.67	0.156	49.405	0.03	232
16.4	0	0	0	4585	13.96	0.246	0	119.74	0.285	59.53	0.02	527
16.6	0	0	1	1908	112.59	0.162	0	107.48	0.254	66.192	0.02	600
16.6	0	0	1	2648	76.31	0.164	0	119.08	0.419	91.193	0.06	718
16.7	0	0	1	4372	19.10	0.173	0	113.87	0.190	75.449	0.02	441

16.8	1	1	1	2721	25.22	0.365	0	40.99	0.427	56.166	0.03	475
16.9	1	1	1	2694	93.79	0.187	0	104.45	0.376	58.871	0.03	474
16.9	0	0	0	3039	13.84	0.216	1	70.32	0.138	45.721	0.03	320
17.2	1	1	1	2111	9.22	0.317	0	51.74	0.207	52.64	0.02	212
17.2	0	0	1	709	6.17	0.205	0	93.5	0.141	66.148	0.02	454
17.4	0	1	0	772	119.18	0.246	1	83.97	0.259	48.27	0.03	151
17.5	0	0	0	4957	137.66	0.152	0	137.17	0.282	52.462	0.03	825
17.5	0	0	0	2260	73.19	0.169	0	82.92	0.171	50.932	0.03	2121
17.6	0	0	0	3200	60.61	0.171	0	105.64	0.165	40.133	0.02	110
17.6	0	0	1	553	21.99	0.164	0	104.34	0.114	64.556	0.03	345
17.7	0	0	0	2123	23.60	0.153	0	63.5	0.330	42.565	0.02	289
17.7	0	0	1	4958	121.20	0.179	0	78.32	0.175	53.365	0.03	229
17.8	0	0	1	378	25.62	0.130	0	56.25	0.330	54.586	0.02	120
17.9	0	0	1	2961	14.57	0.262	0	104.34	0.195	75.667	0.07	1009
17.9	0	0	0	4512	14.27	0.178	1	72.63	0.423	42.157	0.03	105
17.9	0	0	0	415	28.73	0.065	1	117.29	0.110	52.05	0.03	181
18.0	0	0	0	2940	11.38	0.190	1	131.95	0.093	52.046	0.02	258
18.1	1	1	1	2650	44.91	0.182	0	109.94	0.231	71.273	0.04	447
18.3	0	0	0	3577	14.22	0.238	1	131.25	0.056	38.312	0.03	215
18.4	0	0	1	3209	107.34	0.197	0	93	0.197	56.371	0.02	310
18.4	0	1	0	605	20.04	0.147	0	115.81	0.383	51.809	0.04	201
18.5	1	1	1	3277	20.34	0.276	0	40.99	0.427	56.166	0.03	475
18.6	0	0	0	4961	24.69	0.191	0	81.78	0.236	47.644	0.02	77
18.6	1	1	1	1494	25.20	0.201	0	78.56	0.285	59.53	0.02	527
18.6	0	0	0	1042	23.35	0.118	1	116.76	0.165	50.27	0.03	194
18.7	0	0	1	1840	20.60	0.192	0	203.36	0.389	67.066	0.23	1818
18.9	0	0	0	1093	5.94	0.168	0	58.98	0.200	44.783	0.03	240
19.0	0	1	0	1482	44.22	0.747	0	111.4	0.156	57.742	0.04	265
19.0	0	0	0	635	15.97	0.627	0	115.19	0.419	91.193	0.06	718
19.0	0	1	0	3965	19.53	0.165	1	98.53	0.311	53.572	0.02	197
19.5	0	1	0	2445	63.91	0.237	0	98.49	0.185	46.876	0.03	884
19.6	0	0	1	7599	125.21	0.185	0	194.28	0.430	83.222	0.07	1430
19.7	0	0	0	2040	61.69	0.162	1	101.48	0.190	46.697	0.03	490
19.7	0	0	1	3205	70.02	0.224	0	56.25	0.330	54.586	0.02	120
19.9	0	0	1	8077	12.48	0.261	0	107.21	0.419	91.193	0.06	718
20.0	0	1	0	3128	454.40	0.174	1	76.74	0.330	60.072	0.02	175
20.1	0	0	0	2234	52.63	0.177	1	70.77	0.512	45.844	0.03	87
20.2	0	0	0	3226	93.10	0.333	0	80.75	0.156	55.729	0.03	389
20.3	0	0	1	2513	3.13	0.194	0	116.29	0.205	68.532	0.03	620
20.3	0	0	0	1999	25.38	0.087	0	110.49	0.125	56.186	0.03	117
20.4	0	1	0	1650	59.41	0.167	1	129.4	0.072	49.32	0.02	69
20.5	1	1	1	6541	272.17	0.232	0	105.18	0.421	60.514	0.04	2121
20.6	0	0	1	4636	65.86	0.286	0	130.33	0.421	60.514	0.04	2121
20.6	0	0	0	2254	81.63	0.148	0	77.6	0.185	56.994	0.02	213
20.7	1	1	1	291	20.70	0.237	0	105.18	0.421	60.514	0.04	2121
20.8	1	1	1	2530	33.65	0.181	0	122.76	0.225	62.845	0.05	390
20.9	0	1	0	2609	48.94	0.231	0	79.18	0.119	54.372	0.02	276
20.9	0	0	0	1472	187.52	0.147	0	77.37	0.185	52.689	0.03	232

21.0	0	**0**	**0**	**3434**	**68.51**	**0.240**	**1**	**98.49**	**0.185**	**46.876**	0.03	884
21.0	1	**1**	**1**	2193	34.14	**0.097**	**0**	**116.29**	0.205	68.532	0.03	620
21.3	0	**0**	**1**	4298	16.26	**0.170**	**0**	**113.28**	0.206	51.084	0.03	315
21.4	1	**1**	**1**	**2108**	**83.49**	**0.236**	**0**	**105.18**	**0.254**	**66.192**	0.02	600
21.5	**0**	**0**	**0**	**2365**	**74.11**	**0.171**	**0**	**78.92**	**0.184**	**45.856**	0.04	87
21.9	**0**	**0**	**1**	17226	11.92	**0.134**	**0**	**130.33**	0.421	60.514	0.04	2121
22.0	0	**0**	**0**	730	110.53	**0.222**	**1**	**104.34**	0.141	55.836	0.03	374
22.3	0	**0**	**0**	3165	10.91	**0.411**	**1**	**113.41**	0.182	45.825	0.02	270
22.3	1	**1**	**1**	382	70.70	**0.237**	**0**	**95.12**	0.131	62.265	0.04	241
22.4	**0**	**0**	**1**	1826	39.95	**0.190**	**0**	**104.34**	0.195	75.667	0.07	1009
22.6	1	**1**	**1**	3592	674.83	**0.157**	**0**	**86.15**	0.285	59.53	0.02	527
22.8	0	**1**	**0**	2019	202.39	**0.125**	**1**	**102.44**	0.194	63.603	0.02	333
22.9	0	**1**	**0**	488	30.05	**0.158**	**0**	**120.28**	0.375	51.659	0.02	365
23.5	**1**	**1**	**1**	2410	31.43	**0.237**	**0**	**120.85**	0.152	52.728	0.03	210
23.9	**1**	**1**	**1**	**2556**	**326.36**	**0.219**	**0**	**109.96**	**0.138**	**62.642**	0.02	101
24.0	**0**	**0**	**1**	**2581**	**22.29**	**0.138**	**0**	**73.84**	**0.364**	**51.988**	0.03	233
24.8	**0**	**1**	**0**	**2760**	**270.29**	**0.215**	**0**	**82.06**	**0.218**	**55.535**	0.03	273
25.2	0	**0**	**0**	3215	182.69	**0.216**	**0**	**78.32**	0.175	53.365	0.03	229
25.2	**1**	**1**	**1**	5436	377.91	**0.124**	**0**	**128.76**	0.473	96.481	0.02	553
25.9	0	**0**	**0**	**2815**	**48.09**	**0.090**	**0**	**98.07**	**0.254**	**47.581**	0.02	76
25.9	0	**1**	**0**	1229	529.94	**0.253**	**0**	**107.1**	0.156	66.87	0.03	244
26.2	0	**0**	**1**	11599	18.96	**0.156**	**0**	**105.18**	0.421	60.514	0.04	2121
26.2	**0**	**0**	**1**	2115	16.23	**0.265**	**0**	**93.5**	0.205	68.532	0.03	620
26.3	**1**	**1**	**1**	5431	110.54	**0.334**	**0**	**194.28**	0.430	83.222	0.07	1430
26.6	0	**0**	**0**	1962	110.33	**0.199**	**0**	**114.66**	0.419	91.193	0.06	718
26.7	0	**1**	**0**	617	47.17	**0.162**	**1**	**125.63**	0.073	44.877	0.04	61
26.8	0	**0**	**0**	1883	44.41	**0.297**	**1**	**96.65**	0.128	51.915	0.05	208
27.2	0	**0**	**0**	2115	43.07	**0.209**	**1**	**111.61**	0.148	49.697	0.03	243
27.2	0	**0**	**0**	4485	125.87	**0.287**	**0**	**75.23**	0.270	48.458	0.04	143
27.6	1	**1**	**1**	**2720**	**342.57**	**0.199**	**0**	**127.24**	**0.430**	**83.222**	0.07	1430
27.6	0	**1**	**0**	**1826**	**368.76**	**0.273**	**0**	**95.45**	**0.108**	**52.293**	0.04	359
27.7	0	**1**	**0**	**751**	**127.50**	**0.107**	**1**	**106.36**	**0.173**	**50.074**	0.05	567
27.8	0	**0**	**1**	**3083**	**256.63**	**0.202**	**0**	**85.62**	**0.238**	**49.889**	0.04	806
28.2	**0**	**0**	**1**	4700	120.71	**0.379**	**0**	**203.36**	0.389	67.066	0.23	1818
28.3	**0**	**0**	**1**	3999	151.63	**0.282**	**0**	**134.18**	0.235	53.164	0.04	888
28.3	**0**	**0**	**1**	5892	23.48	**0.138**	**0**	**130.33**	0.421	60.514	0.04	2121
28.6	0	**0**	**1**	1165	41.18	**0.207**	**0**	**93.5**	0.205	68.532	0.03	620
28.6	1	**1**	**1**	8158	523.36	**0.248**	**0**	**144.12**	0.270	48.458	0.04	202
28.8	0	**0**	**1**	**1282**	**68.66**	**0.200**	**0**	**93.5**	**0.205**	**68.532**	0.03	620
28.8	**0**	**1**	**0**	**1597**	**126.65**	**0.256**	**1**	**70.45**	**0.292**	**53.549**	0.03	344
28.9	**0**	**0**	**1**	945	662.76	**0.208**	**0**	**116.11**	0.231	71.273	0.04	447
29.5	0	**0**	**1**	3234	21.79	**0.319**	**0**	**93.5**	0.239	85.925	0.04	1115
30.1	0	**0**	**0**	**3515**	**54.09**	**0.258**	**0**	**136.69**	**0.107**	**60.903**	0.04	270
30.4	0	**0**	**1**	5949	6.42	**0.418**	**0**	**105.18**	0.254	66.192	0.02	600
30.7	**0**	**1**	**0**	4923	105.04	**0.192**	**1**	**119.74**	0.406	46.784	0.04	212
30.9	1	**1**	**1**	4445	68.94	**0.187**	**0**	**121.41**	0.270	48.458	0.04	888
30.9	0	**1**	**0**	1228	676.78	**0.204**	**0**	**115.19**	0.365	71.501	0.05	798
30.9	**1**	**1**	**1**	5319	2199.35	**0.443**	**0**	**109.62**	0.389	67.066	0.23	1818

31.3	1	1	1	7174	182.65	0.393	0	121.2	0.320	51.214	0.05	53
31.9	0	0	1	2370	71.14	0.346	0	106.36	0.167	51.086	0.01	253
32.4	1	1	1	26131	76.53	0.164	0	130.33	0.421	60.514	0.04	2121
32.7	1	1	1	3433	4.09	0.527	0	116.11	0.231	71.273	0.04	447
33.3	1	1	1	2087	26.83	0.217	0	105.18	0.421	60.514	0.04	2121
34.2	1	1	1	4484	151.61	0.218	0	99.27	0.293	60.015	0.03	322
34.9	0	1	0	487	45.73	0.437	0	91.67	0.319	61.598	0.06	999
35.3	0	1	0	2805	358.51	0.271	0	88.69	0.163	69.111	0.03	798
36.0	0	0	1	2109	139.52	0.355	0	203.36	0.389	67.066	0.23	1818
36.6	1	1	1	2893	435.05	0.301	0	109.85	0.145	60.248	0.03	759
37.8	0	0	1	8990	66.02	0.207	0	130.33	0.421	60.514	0.04	170
39.2	1	1	1	3641	199.09	0.434	0	130.33	0.421	60.514	0.04	2121
39.9	0	0	1	10355	19.16	0.199	0	99.27	0.421	60.514	0.04	2121
40.0	1	1	1	3099	221.38	0.412	0	105.18	0.254	66.192	0.02	600
40.6	0	0	0	31584	702.08	0.317	0	203.36	0.389	67.066	0.23	1818
41.3	0	0	1	8163	79.77	0.223	0	130.33	0.421	60.514	0.04	2121
42.1	0	0	1	12341	1220.72	0.560	0	203.36	0.389	67.066	0.23	1818
42.3	1	1	1	2644	239.14	0.277	0	116.11	0.231	71.273	0.04	447
44.3	1	1	1	146239	17.49	0.444	0	120.28	0.375	51.659	0.02	365
45.0	1	1	1	3500	562.65	0.294	0	40.99	0.427	56.166	0.03	475
46.6	1	1	1	3915	1682.08	0.455	0	107.21	0.419	91.193	0.06	718
47.1	0	0	0	3826	1452.49	0.507	0	203.36	0.389	67.066	0.23	1818
47.8	1	1	1	4020	1252.16	0.397	0	122.42	0.302	62.171	0.06	993
52.2	1	1	1	3743	698.83	0.460	0	125.9	0.319	61.598	0.06	999
53.4	0	0	1	8022	52.24	0.157	0	203.36	0.389	67.066	0.23	1818
54.0	0	1	0	10911	1394.88	0.442	0	125.9	0.319	61.598	0.06	999
54.7	0	1	0	2323	25.13	0.015	0	83.97	0.259	48.27	0.03	441
55.5	1	1	1	5702	1560.44	0.261	0	130.33	0.421	60.514	0.04	2121
61.1	1	1	1	1289	1708.48	0.403	0	113.6	0.195	75.667	0.07	1009
66.4	1	1	1	3066	69.79	0.564	0	107.21	0.419	91.193	0.06	718
67.6	1	1	1	17074	750.75	0.298	0	194.28	0.430	83.222	0.07	1430
69.8	1	1	1	8965	676.39	0.779	0	127.24	0.430	83.222	0.07	1430
75.8	1	1	1	8683	114.89	0.595	0	105.18	0.430	83.222	0.07	1430
93.6	1	1	1	913	6.25	0.346	0	116.11	0.231	71.273	0.04	447

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