Planning for Innovation:
An Analysis of Bus Rapid Transit and Institutional Approaches to Transportation Innovation

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Abstract

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This study explores the institutional implications of Bus Rapid Transit (BRT) as a technological innovation. As an alternative to rail-based mass transit systems, bus rapid transit has emerged as an adaptable and cost-effective means of providing high quality urban mobility. Since its development in Curitiba, Brazil in 1974, over 140 cities have since gone on to implement BRT. While the technological features of BRT are well understood, the role of various stakeholders, institutions, and planning processes is often underemphasized, despite holding the key to successful implementation. By focusing on the experience of Bogota, Colombia and Johannesburg, South Africa in incorporating existing transportation service providers into new BRT systems, this study explores the institutional implications of innovation and the embedding of new planning practices into local contexts. By addressing these questions, I hope to shed light on the processes of innovation and diffusion, so that planners, policy makers, and other stakeholders can be better informed when implementing new technologies such as bus rapid transit.

KEYWORDS

Bus Rapid Transit; Technological Innovation; Policy Diffusion

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Introduction

Cities strive to innovate. As population centers and economic hubs, cities constantly evolve, and are in a perpetual state of development and adaptation. Whether to stimulate economic growth, overcome limited public resources, or address new and emerging policy challenges, planners and policy makers increasingly seek new and innovative ways to address urban planning needs. The transportation sector – constantly in motion by definition – is a fertile proving ground for innovative technologies, policies, and planning techniques. Given growing populations, congestion, air pollution, limited public finances, and inequitable access to mobility, amongst other planning problems, cities around the world face critical transportation investment needs. In many North America cities, transportation infrastructure is often in a state of disrepair, while local, regional and state governments are financially constrained and limited in their ability to invest in new services. Throughout much of Asia, Africa, and Latin America, urban population growth is staggering, and governments struggle to provide sufficient infrastructure and services for their burgeoning populations. Sustained economic development requires an effective urban transportation system to maintain growth, without which cities face exacerbated congestion, pollution, and other negative externalities from increased motorization and automobile ownership rates.

As an alternative to rail-based mass transit systems (MRT), bus rapid transit (BRT) has emerged as an adaptable and cost-effective means of providing high quality urban mobility. BRT has been a particularly popular transportation innovation in developing cities, where the technology's relatively low cost and simplified infrastructure requirements enable a quick and flexible implementation schedule. Yet while BRT technology is well understood, the role of actors, institutions, and planning processes is often underemphasized, despite holding the key to successful implementation. Using the emergence and diffusion of bus rapid transit technology as a research context, this study explores the institutional implications of innovation and the embedding of new planning practices into local contexts, focusing on the specific experiences of Bogota, Colombia and Johannesburg, South Africa in incorporating existing transportation service providers into new BRT system management. Understanding this process is of critical importance to urban planners and policy makers facing the complex planning and decision-making processes of the 21st century, and can also aid the growing number of non-governmental, multilateral, and private-sector stakeholders in improving the services they offer to cities. Thus, by addressing these questions, I hope to shed light on the processes of innovation and diffusion, so that planners, policy makers, and other stakeholders can be better informed when implementing new technologies such as bus rapid transit.

Background

Defining BRT

Bus rapid transit refers to "a flexible, rubber-tired rapid transit mode that combines stations, vehicles, services, running ways, and Intelligent Transportation System (ITS) elements into an integrated system with a strong positive identity that evokes a unique message" (Levinson et al, 2003, p. 12). By combining these elements, BRT provides a cost-effective means of providing fast, efficient, convenient, and comfortable urban mobility. The most successful BRT systems achieve travel speeds, service capacity, and passenger throughput levels comparable to rail-based mass transit services at a fraction of the cost, using roadway infrastructure and bus-based vehicle platforms.

While specific BRT characteristics vary from one city to another, BRT systems generally include the following elements, which when combined provide a level of service comparable to rail-based systems:

1. **Physical infrastructure** including exclusive bus lanes or bus-only roadways, an extensive network of routes and corridors, enclosed stations with prepaid boarding areas, a level station-platform-to-vehicle-floor design, and multi-door buses for rapid boarding and disembarkation;
2. **Operational features** including frequent bus headways (e.g. waiting time between buses) and rapid operating speeds, limited stop services, ample passenger capacity, fare integration between routes, modes, and feeder services, and coordinated land use planning;
3. **Technological features** such as automated fare collection and verification, signal prioritization and/or grade separation at intersections to minimize bus stoppage at intersections, centralized tracking and system management using GPS and Intelligent Transportation System applications, and efficient, low-emission vehicles;
4. **Business and regulatory features** such as roadway access restrictions to authorized bus operators (e.g. enforced exclusivity of bus lanes) and independent quality control oversight; and
5. **Marketing features** such as unique and distinctive branding for BRT stations and service vehicles, excellence in customer service and operational performance, and ease of transfer between the BRT system and other transportation options (Wright & Hook, 2007, pp. 11-12).

Though such features are neither exhaustive nor absolute requirements, they represent "best practices" in system design, which urban transportation experts generally agree provide the ideal combination for effective bus rapid transit service.

Development of BRT

Bus rapid transit was first implemented in Curitiba, Brazil in 1974. During the 1970s, Curitiba experienced tremendous population growth – faster than any other Brazilian city – at 4 percent annual growth, placing a strain on the city's transportation infrastructure (Cervero, 1998, p. 266). Earlier planning efforts, most notably the 1943 Agache Plan, called for the creation of imposing boulevards, with major thoroughfares widened to 60 meters, and a hub-and-spoke roadway system premised on near universal automobile ownership (Cervero, 1998, p. 268). Due to financial constraints, the city was never able to implement the Agache Plan, and replaced the concept of a hub-and-spoke roadway network with a corridor-based development scheme under the 1965 Curitiba Master Plan.

The 1965 Master Plan incorporated several elements that laid the foundation for the development of bus rapid transit. In particular, the 1965 Plan was premised on the "notion that Curitiba would meet the mobility needs of people rather than automobiles" (Cervero, 1998, p. 269). To do this, the plan called for the concentration of growth along five radial corridors, with a 'trinary' axis road system on the rights-of-way set aside in the 1943 Agache Plan (Demery, 2004, p. 7). As Cervero explains, the trinary road concept (*sistema trinario)* was built around two central restricted lanes dedicated to buses, and supported by a series of auxiliary roads:

> The central busway is flanked by two one-way roads that function as auxiliary lanes, providing direct access to buildings fronting the busway. Running parallel to the central axis, a block away, are high-capacity one-way streets heading in opposite directions: one for traffic flowing to, the other for traffic flowing from, the central city (1996, p. 272).

In addition, the 1965 Plan closed Curitiba's downtown and historic core to traffic, creating a pedestrianized hub in the center of the city. Furthermore, land-use objectives such as preservation of the historic downtown and the development of mixed-use districts along designated linear axes drove transportation policy decisions (Cervero, 1998, p. 270). As Cervero notes, "the goal of creating a linear city spawned the guiding principal that urban development, mass transit services, and hierarchical road networks must be closely integrated and harmoniously planned. The primary tool for creating structural axes would be exclusive busways" (1998, p. 269). Linking land use to transportation, the plan encouraged density along the trinary network by limited high-rise buildings to a four-block strip on either side of the busway arterials (Demery, 2004, p. 7). The results have been noticeable, and certainly contributed to the success of Curitiba's bus-based transit system: "between 1970 and 1978, Curitiba's overall population increased by 73 percent but along the five axes, it increased by 120 percent. By 1992, almost 40 percent of Curitiba's population resided within 3 blocks of the major transit arteries" (Demery, 2004, p. 8).

Thus, the trinary system became the centerpiece of Curitiba's bus rapid transit system. The city's highly integrated bus network includes "high-speed buses operating on dedicated busways, limited-stop high-speed buses paralleling busways along one-way couplets, orbital routes that interconnect the busways, and more than 100 feeder lines that run between the low-density neighborhoods and trunkline services" (Cervero, 1998, p. 267). System implementation began in 1971 with the election of Jaime Lerner as mayor. Lerner was committed to implementing the 1964 Master Plan, and exercised bold leadership in urban planning. As Cervero notes, "to gain credibility and establish momentum, Lerner's philosophy was to do things simply and quickly, which meant at low cost" (1996, p. 271). As mentioned above, Lerner began by pedestrianizing the historic city center and developing the trinary road system. Within three years of Lerner's election, Curitiba opened 20 kilometers of exclusive bus lanes (Cervero, 1996, p. 276). Initially, several private bus operators served Curitiba, in a loose yet competitive confederation, which eventually led to congestion along the trinary system and a "confluence of buses in the city center choking downtown streets" (Cervero, 1996, p. 276).

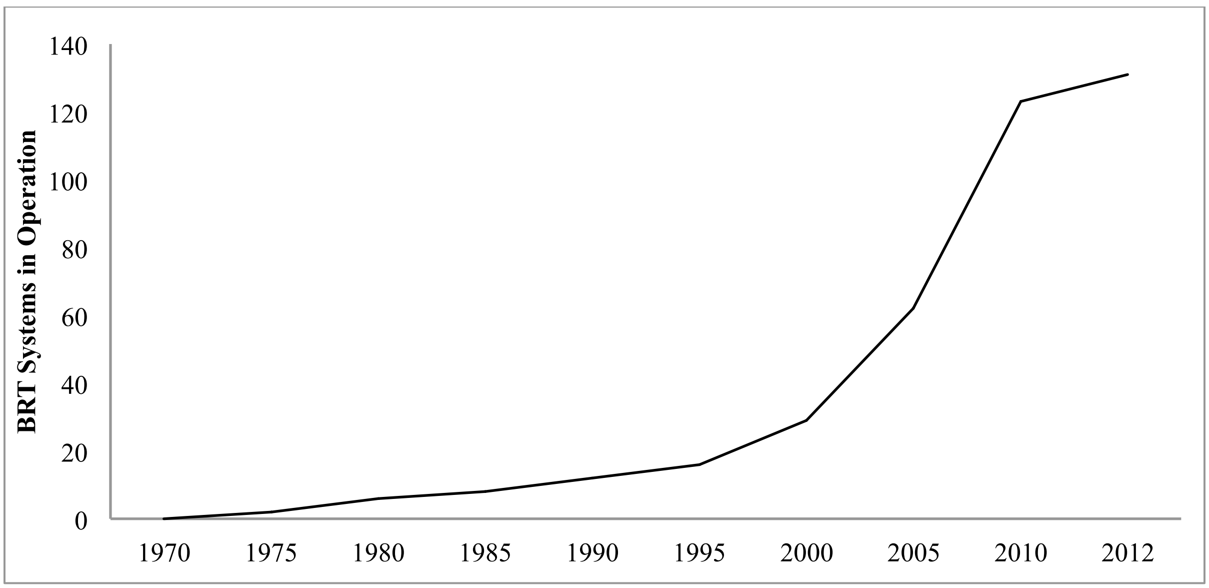
This congestion prompted the establishment of an Integrated Transit Network (ITN) in 1979, combining feeder, express, and inter-district routes. ITN was modeled on a trunk and branch system, whereby "buses operating along exclusive lanes in the center of the trinary system formed the system's backbone. Concentric bus loops connected lower-density sections of the city to the trunk lines at transfer points (Cervero, 1996, p. 278). While the ITN system proved popular, ridership growth through the late 1970s and early 19890s eventually led to capacity constraints and delays, jeopardizing the operational efficiency of the system, and leading to subsequent innovations in what are now considered design standards of bus rapid transit. To ease crowding, Curitiba deployed articulated buses in the mid-1980s; in addition, transportation planners modified the trinary bus system with raised bus stations, allowing rapid boarding and disembarkation, and launched express bus service connecting transfer stations and running along the one way couplets paralleling exclusive bus way trunk lines (Cervero, 1996, p. 279). Express service combined with raised station platforms allowed these buses to carry 3.2 times the passengers per hour as standard bus service (Cervero, 1996, p. 279). Overall, the system carried nearly 10,000 passengers per lane per hour, approaching the efficiency of many rail-based metro systems that Curitiba could otherwise not afford to implement (Cervero, 1996, p. 279).

Curitiba's Integrated Transit Network is operated by ten private companies, though buses are uniformly branded, and a single fare and payment system provides seamless integration and nearly system-wide access. Two municipal agencies share responsibility for ITN: the IPPUC is responsible for long-range planning, while URBS manages day-to-day operations, and is responsible for "setting timetables and performance standards; negotiating contracts with private bus companies; monitoring private operations for compliance with service standards; planning new routes and services; collecting and distributing revenues; and maintaining transfer stations" (Cervero, 1996, pp. 289-290). Contracts are structured such that bus operators are paid by the kilometer travelled rather than the number of passengers carried, ensuring that routes and services are fully deployed, and limiting direct competition over passengers between bus operators. Operators also receive payment for 1 percent of capital expenditures on buses, providing "a financial incentive to renovate their rolling stock" (Cervero, 1996, p. 290). Combined, these innovative components and institutional arrangements have yielded a high quality bus-based transportation system, which has since formed the basis of bus rapid transit as an integrated approach to urban mass transit service delivery. In Curitiba, the results were striking: during ITN's first twenty years of service, "system-wide ridership grew by an average annual rate of 15 percent, three to four times faster than population growth [while] transit's share of commute trips rose from 8 percent to more than 70 percent" (Cervero, 1996, p. 291).

Through an incremental process, responding over time to the city's evolving transportation priorities and constraints, Curitiba developed its bus-based transportation system into what is now understood as bus rapid transit. Since then, planners and policy makers looking to implement BRT have sought lessons from Curitiba and other cities that have adopted BRT, while a supporting industry of transportation consultants, equipment manufacturers, activists, researchers, international organizations and NGOs – such as the Institute for Transportation and Development Policy and the World Resources Institute's EMBARQ Center for Sustainable

Transport – has entered the fray of BRT development, advocacy, and implementation. Thus, following Curitiba's experience with ITN, dozens of cities have developed BRT systems – initially in Brazil and elsewhere in Latin America, though now BRT can be found in cities around the world. According to EMBARQ and ALC-BRT's *Global BRT Database* (2012), 143 cities currently operate bus rapid transit systems, totaling 3,748 kilometers, and carrying over 21 million passengers per day (see Appendix 1 for a list of BRT cities). While BRT grew gradually in during the 1970s, 1980s, and 1990s, it has proliferated in the 21st century (see Figure 1).

Figure 1: BRT Systems in Operation



Source: EMBARQ & Across Latitudes and Cultures – Bus Rapid Transit (ALC-BRT). (2012). *Global BRT Data*. Retrieved from http://brtdata.org

Benefits of BRT

Cities around the world have realized significant benefits from implementing bus rapid transit. By utilizing existing roadway infrastructure and avoiding the need to lay track or construct elevated or underground rights-of-way, BRT systems typically cost 4-to-20 times less than a tram or light rail system and 10-to-100 times less than a metro system (Wright, L. & Hook,

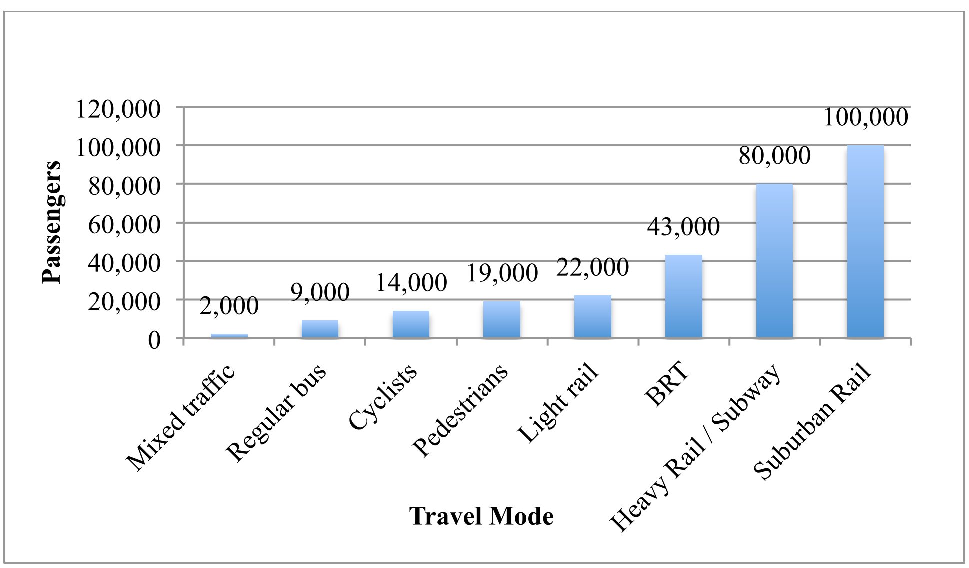
W. eds., 2007, p. 11). The Victoria Transport Policy Institute estimates that per-kilometer construction costs for BRT range from $1-20 million, compared to $15-25 million for light rail systems and $50-200 million for subway systems (Victoria Transport Policy Institute, 2011).

Due to its relatively low infrastructure costs and simplified design and construction requirements, BRT systems can be implemented more rapidly than rail-based alternatives, within 1-3 years of conceptualization (Wright, L. & Hook, W. eds., 2007, p. 2). Similarly, because BRT systems utilize existing road-based infrastructure, they are more flexible and adaptable than rail systems, allowing for more cost-effective adaptation to changing city conditions (Wright, L. & Hook, W. eds., 2007, p. 2).

To be most effective, a transit system such as BRT must be well integrated into the urban environment. A public transit system's effectiveness is "a function of many factors, including overall travel speed, frequency of service, directness and ease of transfers, fare policy, access and egress conditions to and from stations or stops, and passenger security and comfort" (Asian Development Bank, 2010, p. 31). While rail-based mass rapid transit systems often provide high speed, high capacity, and direct service by operating on underground or elevated track, building such systems can entail significant capital cost, and a timely construction process. Conversely, "well-designed BRT systems often provide more direct one-seat rides and can match MRT systems for other elements at a far lower cost if given priority access to surface street space" (Asian Development Bank, 2010, p. 31).

Amongst travel modes, BRT also offers some of the greatest passenger throughput potential on a person-per-hour comparison over a 3.5-meter lane equivalent of urban roadway. As Figure 2 indicates, a single 3.5-meter BRT corridor can move 43,000 people per hour. While lower than suburban and subway rail equivalents, this provides far greater capacity then mixed traffic, or non-BRT bus and light rail alternatives (Hickman, R. et al., 2011, p. 55). From a capital expenditure perspective, bus rapid transit systems are a very favorable public transportation investment option, offering some of the greatest hourly passenger throughput per dollar of capital expense. For example, every $1 million investment in high capacity BRT has the potential to move 5,000 people per hour. While walking and footpaths have far greater capital cost efficiency, with the potential to accommodate 20,000 to 24,000 people per hour per $1 million in capital expenditures, comparable public transit investments to BRT offer far less bang for the buck. Underground metros provide an hourly capacity of 1,000 people per $1 million invested, while elevated rail lines provide an hourly capacity of 625 people per $1 million invested. For developing cities in particular, where public expenditures and construction management expertise may be limited, and where effective urban transport solutions are needed as quickly as possible, bus rapid transit represents a very favorable investment option.

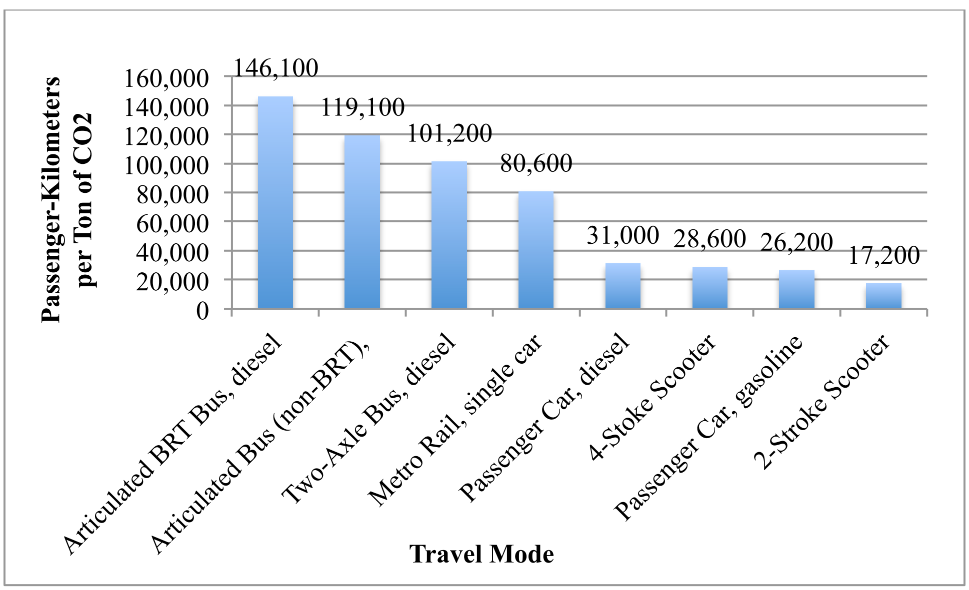
Figure 2: Corridor Capacity, by Mode (people per hour on 3.5m lane)



Source: Hickman, R. et al (2011)

Environmentally, BRT also offers tremendous potential benefit over alternative travel modes and public transport investment options. On a CO2 emissions basis, a diesel-powered articulated BRT bus offers the best passenger-kilometer performance per ton of CO2 emitted compared to other motorized urban travel modes, with an efficiency of 146,000 passenger-kilometers per ton of CO2 emitted (see Figure 3; Hickman, R. et al., 2011, p. 55). Of course, these efficiency comparisons are approximate, and are based on 100% vehicle occupancy. Actual performance will vary by load factor, road conditions, traffic flow, travel speed, and vehicle technology. If powered with alternative fuels, such as compressed natural gas, bio-diesel, or hybrid-electric engine technologies, BRT systems can obtain potentially higher passenger mobility efficiency. From a capacity standpoint, performance comparisons between a full BRT bus and a single- or double-occupancy passenger vehicle (as opposed to full-occupancy passenger vehicle) are even less favorable.

Figure 3: Transport CO2 Emissions – Passenger-Kilometers per Ton of CO2, by Mode



Source: Hickman, R. et al (2011)

Including construction-related emissions, BRT once again represents one of the most energy efficient and carbon saving investment options for improving urban transportation. When life-cycle greenhouse gas emissions from building and operating BRT systems are factored in, the Asian Development Bank's BRT investments typically reduce CO_2 emissions by 2,500 tons per kilometer per lane per year when replacing dirtier modes of transport. By contrast, only commuter rail projects generate greater CO_2 savings, at over 3,000 tons per kilometer per lane per year, while expressway projects add nearly 500 tons of CO_2 per kilometer per lane per year (Asian Development Bank, 2010, p. 14). In part, this is because BRT systems are less carbon intensive to build than rail-based mass rapid transit systems, which require greater quantities of steel and concrete and greater use of heavy-duty construction equipment to excavate underground tunnels or build elevated rights of way (Asian Development Bank, 2010, p. 19). Regardless, CO_2 emissions reductions are entirely a function of the extent of modal shifting and system ridership, and the efficiency of new system design and operations. Achieving these savings requires effective planning and integration with the broader transportation network and urban context. Poorly designed or underutilized systems may actually contribute to a city's emissions profile. According to a 2010 Asian Development Bank report, BRT systems have a high potential to induce modal shift, improve traffic management, and reduce transportation-related CO_2 emissions, but "need good walking and bicycling access if they are to succeed in supporting transit-oriented development" (Asian Development Bank, 2010, p. 33).

These benefits help to explain the widespread adaptation of bus rapid transit systems, and have helped to establish BRT as a significant transportation innovation. Yet, while the technology to achieve these benefits is well understood, successful implementation often hinges on the actors, institutions, and policies related to BRT planning. The following section will address technological innovation, and the political and institutional forces that influence it.

Understanding Technological Innovation

The emergence and spread of bus rapid transit must be framed within the context of technological innovation. As an integrated system incorporating the infrastructural qualities, technological features, and operational practices discussed above, BRT represents a form of technology itself, combining Srinivas & Sutz's definition of technologies as "artifacts, machines, organization, skills and techniques" (2008, p. 130) with Dosi's definition of technology as a set of practical and theoretical pieces of "knowledge, know-how, methods, procedures, experience of successes and failures and also, of course, physical devices and equipment" (1982, p. 152). Following this definition, BRT emerged as a technological innovation through the consolidation of various new and existing technical features, and the dissemination of knowledge relating to physical and operational design by engineers, planners, and policy makers in cities around the world.

Several frameworks help to explain BRT-related technological innovation. Srinivas & Sutz (2008) provide a particularly useful starting point in their discussion of innovation in developing countries. Though they focus on economic development through industrialization, a comparison can be drawn to the developmental contributions of urban transportation innovations. An efficient transportation system is an important component of a productive urban economy, serving as a factor input of production in both the circulation of goods and in the mobility of labor (Harvey, 1985). Thus, Srinivas and Sutz's definition of development through industrialization as the "engagement of people with technologies and embedded in larger production systems" (2008, p. 130) can be extended to bus rapid transit. Within the broader urban context, BRT can support development by improving the overall efficiency of urban mobility, and the productive processes that rely on the transportation system, from consumers travelling to markets, workers travelling to factories and offices, or manufacturers shipping goods.

Continuing with Srinivas and Sutz, BRT adaptation closely matches their theory of scarcity-induced innovation, stemming from developmental processes embedded in scarcities that are uncommon in industrialized countries, leading to the incorporation and production of different technologies. These scarcities include

> Problems at the level of infrastructure that is missing or is not up to date, of access to materials and equipment of the required quality or accuracy, of institutional support for the building of endogenous capacities, of enough people with appropriate skills to run projects or discuss ideas, and of money to rely on well-known solutions (1998, p. 130).

“Idiosyncratic solutions” are a potential outcome from this form of scarcity, addressing problems for which solutions have been found in advanced industrial countries, but for which solutions applicable to developing counties either do not exist, or are not suitable to be transferred. This context provides “a potential opportunity to build technological capabilities and innovate in truly substantive ways” (p. 137), which can certainly be said for bus rapid transit. This is not to suggest that BRT is a transportation solution restricted to developing country contexts, as indeed, many cities in developed countries have implemented and continue to implement BRT. The key point, however, is that BRT as a technological innovation first emerged and subsequently spread as a response to scarcity in a developing country context of insufficient financial capital to implement rail-based metro systems and institutional and organizational struggles to manage congestion. The fact that cities in advanced industrial countries have adopted the technology simply reinforces the assertion that BRT represents a “substantive innovation.”

Building on this discussion, Dosi (1989) provides a number of important insights into the institutional implications of bus rapid transit as a technological innovation. In his discussion of technology, Dosi cites two contrasting theories of innovation: “demand-pull”, where market signals are the main driver of technological change; and “technology-push”, where technology is understood as an autonomous or semi-autonomous factor, at least in the short run (1989, p. 148). Though actual innovation is usually a mix of both, the distinction highlights the role of “market signals in directing innovative activity and technological change” (Dosi, 1989, p. 148). Arguably, market failures – such as externalities and imperfect competition – could also fall under the “demand-pull” paradigm, serving as a market signal that prompts innovation. For example, firms might innovate to develop a new product or process and break the hold of another firm with monopoly power in a given market. Similarly, firms might innovate to reduce pollution in the most cost effective way as a response to environmental regulation. Understood this way, BRT innovations are better explained by the “demand-pull” theory, at least to the extent that growing urban populations, increasing congestion and air pollution, and rising consumer demand for improved mobility signal the need for innovative transportation solutions.

According to Dosi, technological innovation supports economic development by expanding the production possibilities function outward for a given set of factors, improving factor productivity either quantitatively or qualitatively, and increasing the number of producible goods (1989, p. 151). Following this logic, a region’s transportation technology can be seen as the set of modes, systems, and options available to residents at various budget constraints to fulfill their mobility needs and support the broader economic activity of residents, firms, workers, and so on. The goal of a technological innovation in the transportation sector would then be to expand the number of choices and/or reduce costs in a way that shifts the production possibility function, or perhaps “mobility possibility function”, outwards. Given congestion, safety concerns, and the environmental impacts of transportation, innovative transportation technologies should also seek to improve efficiency, reduce environmental externalities, and enhance safety.

Finally, Dosi describes technological innovations as “incremental” versus “radical”, depending on the connection they have to an existing technological paradigm (1989, p. 158). Similar to David’s notion of path dependence (2001), a technological paradigm is defined as a specific set of technologies that present solutions to problems to the exclusion of other notionally possible technologies. Within a technological paradigm, the technological trajectory represents the pattern and sequence of problem solving using the same base technology (Dosi, 1989, pp. 152-153). Incremental innovations continue the technological trajectory within a technological paradigm, while radical innovations introduce new technological paradigms. BRT represents a slightly more complicated case. While it is primarily an “incremental” innovation in improving upon existing vehicle and roadway technologies, it is a radical innovation in that it has set a new paradigm for urban transportation through the bundling of vehicle technology, road infrastructure, urban design, and operating procedures.

Institutional Challenges Related to Innovation

While technological innovations often provide important economic development benefits, they can also face significant institutional challenges. Most notably, this is through the Schumpeterian “creative destruction” process, whereby new technologies and the firms that harness them replace less innovative firms that rely on outdated technology. According to Dosi, the degree of creative destruction is mediated by the market mechanism:

> Markets perform as a system of rewards and penalizations, thus checking and selecting amongst different alternatives… The […] multiplicity of risk-taking actors […] is crucial

> to the trial-and-error procedures associated with the search for new technological paths (1989, p. 156).

Commercially viable innovations emerge by successfully responding to “demand pull” signals and gaining market share. In opening up new markets and potentially obtaining monopoly rents, innovative, risk-taking firms may secure high rewards, though failure is also a distinct possibility. Indeed, this uncertainty is a central function of the market mechanism, and part of the logic by which the market supports a dynamic, productive economy.

Based on market forces alone, the creative destruction process is not explicitly problematic. The risk of firm failure, or of being overtaken by a more technologically advanced competitor, is an institutionalized norm within market economies; these are the rules of the game. This is where bus rapid transit, as a technological innovation, diverges from orthodox economic theory. Public transportation systems are often run as monopolies to provide a comprehensive service network for customers, maximize the efficiency of operations, and achieve economies of scale. When in control of a natural monopoly, the state may find itself in a position to dictate the nature and process of technological innovation. Because innovation in this context is state-led, rather than market-led, it is less subject to market risk, and the “trial and error” procedures that apply to firms in a market system and that regulate the creative destruction process. In part, this can lead to poor technology choices. But more importantly for the discussion of institutions, state-led innovation can essentially eliminate pre-existing markets and the profitability of pre-existing firms. In opting to implement BRT, planners and policy makers are choosing a specific technology over both potential and pre-existing alternatives. By disrupting and potentially eliminating pre-existing markets, governments can introduce significant conflict and generate substantial backlash, despite the potential benefits and improvements provided by bus rapid transit.

More specifically, BRT implementation can adversely impact a number of stakeholders, including private transit operators, taxi drivers and owners, truck drivers and delivery companies, private automobile owners and users, pedestrians and cyclists, businesses and property owners along BRT corridors, environmental and civic organizations, and traffic police (Wright & Hook, 2007, p. 3). By dedicating travel lanes for the exclusive use of buses and converting lanes, medians, or sidewalk space for stations, BRT systems can reduce available parking, decrease available street space for other transportation modes, eliminate open space, and disrupt delivery access to businesses. While bus rapid transit systems generally increase the overall efficiency of urban transportation, implementation can nonetheless provoke resistance and backlash from these groups who see BRT as taking away a service or land use that they previously benefitted from.

Policy Transfer & Diffusion

Building on the discussion of technological innovation, a discussion of policy transfer is also important in addressing the widespread adaptation of bus rapid transit systems in cities around the world. Borrowing from Dolowitz and Marsh, policy transfer refers to the process in which "knowledge about policies, administrative arrangements, institutions, etc. in one time and/or place is used in the development of policies, administrative arrangements, and institutions in another time and/or place" (Marsden, G. & Stead, D., 2011, p. 493). Policy transfer can also be characterized as a form of learning between individuals and/or organizations, involving the "voluntary flow of ideas" and the "acquisition and utilization of knowledge about policies elsewhere" (Hoyt, L., 2006, p. 223). Several distinct terms fall under the umbrella concept of policy transfer. As Evans & Davies note, “policy transfer is used as a generic concept which encompasses quite different claims about the nature of policy development” (1999, pp. 363-364). For example, sub-processes of policy transfer can include lesson drawing, policy diffusion, and policy convergence. Lesson drawing tends to be a “volantaristic” exercise, while policy diffusion and convergence depend on structural and institutional dynamics as well as technocratic determinism (Evans & Davies, 1999).

Thus, policy transfer processes are influenced and determined by both the stakeholders involved and the underlying structure of the policy or problem in question. In reference to local environmental policy responses to ground water pollution, urban air pollution, and waste management, Tews et al note that “the global convergence of [local] environmental policies [can] be explained as a result of the international diffusion of ideas, approaches, institutions, and instruments in the field of environmental protection” (2003, p. 571). Three factors primarily influence the ‘diffusability’ or applicability of policy innovations:

1. The underlying problem structure – e.g. how visible, and therefore politically salient, the problem in question may be;
2. Compatibility – e.g. the extent to which innovations are compatible with existing technologies and institutions; and
3. Political feasibility – e.g. the extent to which an innovation will generate conflict (Tews et al, 2003, pp. 577-578).

Coordinated actors and social networks play an increasing role in this process as well. According to Hoyt, “policy transfer entrepreneurs”, including planners, policy makers, academics, and activists – representing both public and private organizations – create transnational information networks through which ideas and policies spread. Within the urban planning field, entrepreneurs have historically formed networks by visiting other cities, hosting tours and site visits, attending lectures, and/or participating in studios (Hoyt, L. 2006, p. 223). Increasingly, these networks are supported through the globalization of communications and advances in information and communications technology (Tews et al. 2003, p. 572).

Referring specifically to transportation policy transfer, Marsden et al identify a number of actors that influence policy and technology transfer: elected officials, private suppliers and vendors, consultants, interest groups, and the general public (2011, pp. 506-507). Despite the diversity of actors, the transfer of innovative transportation policies is frequently a social process, "built around curiosity, exchange and trust" between city officials and transportation stakeholders, in which "informal networks and information sharing through professional networks [are] the predominant methods of initial knowledge transfer" (Marsden et al., 2011, p. 511). In large part, this is due to an overabundance of publically available information, and questions over quality and bias with 'best practice' guides and other online resources, and the subsequent importance of utilizing trusted peer networks for applicable lessons and transferable policy innovations (Marsden et al, 2011, p. 511). Further highlighting the networked and multi-perspective aspect of policy transfer, the majority of transport policy innovations reflect hybrid solutions that incorporate lessons and practices from multiple cities (Marsden et al, 2011, p. 510).

Research Design

Based on the discussion of technological innovation and policy transfer thus far, this study seeks to explore the institutional implications of bus rapid transit innovations and the processes through which new transportation technologies embed within local contexts. Given its growing popularity, I am interested in understanding the institutional implications of implementing BRT, including the role of various actors and stakeholders, the process of adapting infrastructure, and the applicability of enabling policies and planning approaches. Furthermore, in light of the widespread adaptation of BRT, I am interested in understanding how different cities have addressed these institutional questions, and the lessons that planners, policy makers, and other stakeholders have drawn from cities that have implemented BRT.

Of course, these are very big questions, many of which cannot be fully or even partially addressed within the scope of this Masters thesis. As such, I have opted to focus on two cities – Bogota, Colombia and Johannesburg, South Africa – and the experiences of those cities in adapting BRT to the existing transportation system, particularly with respect to loosely organized, semi-formal taxi and bus operators. While implementing bus rapid transit for different reasons, Bogota and Johannesburg encountered similar challenges in implementing BRT, thus providing a basis for comparison in understanding the role of institutional adaptation and development, and the process by which planners and policy makers engaged the various actors involved in BRT implementation.

In addressing these questions, I have developed two frameworks to help explore the institutional implications of BRT implementation. The first is a comparative taxonomy of institutions and actors engaged in BRT, including system metrics, system management, key motivations for implementation, and the various actors responsible for BRT development, operations, and management. Table 1 provides a full list of these variables.

Table 1: Taxonomy of Institutions and Actors

Case Study City:	**Bogota, Colombia**	**Johannesburg, South Africa**
System Overview	TransMilenio	ReaVaya
Year Implemented	2000	2009
System Size	9 corridors; 65 routes; 150 km	1 corridor; 1 route; 25 km
Ridership	1.8 million	38,000

Previous Transportation System	Low Transit share and growing private automobile use; fragmented network of informal bus operators	Fragmented and chaotic network of mini-bus / taxi operators organized into loose confederations; lack of established route networks, schedules, or fare systems
Government Role		
Local / City	Mayor Enrique Penalosa prioritized public transportation improvements; City Council authorized establishment of TransMilenio S.A. public-private partnership structure	City Government established public-private partnership structure responsible for planning, developing, operating and managing ReaVaya; controls 33% stake in ReaVaya parent company, PioTrans
National	Funds 40% of transportation projects	Prioritized transportation improvement
Key Motivations for Implementing	Rapid growth in population, private automobile use, and associated congestion; need for enhanced, low-cost public transportation system as rail-based metro system was cost prohibitive	Highly fragmented and informal transportation services; need for enhanced public transportation service in preparation for 2010 FIFA World Cup
Key Actors Responsible for Implementation	Mayor, City Council	City Government, City Taxi Unions
System Management	TransMilenio S.A., a public authority, oversees overall planning, management, and operations. Individual routes operated by private contractors under a public-private partnership scheme	PioTrans, a public-private partnership between the City of Johannesburg and Taxi Owners & Taxi Association members; Taxi union members control 66.7% of PioTrans, while the City of Johannesburg controls the rest

Source: EMBARQ & ALC-BRT, 2012

The second framework, represented by Table 2, builds off of the taxonomy of institutions and actors to express BRT implementation (the dependent variable) as a function of institutional planning (the independent variable). Analyzing and expressing BRT implementation in this way helps to frame the success or failure of technological innovation in terms of the adaptation of underlying institutions, and when extended across cities can provide a basis of comparison in studying institutional approaches to BRT implementation.

Table 2: Implementation Analysis

City:	Bogota	Johannesburg
Dependent Variable: BRT Implementation – e.g. degree of success	Highly Successful; considered model BRT system	Ongoing implementation; encountered initial problems that required modified management arrangement
Independent Variables: Institutional Planning – e.g. how was BRT plan developed, negotiated; how did actors coordinate?	• Strong leadership from Mayor Enrique Penalosa • TransMilenio developed as part of a bundle of transportation investments, including pedestrian and bicycle infrastructure improvements, roadway and automobile use restrictions • Existing taxi and bus operators were engaged from the start and incorporated into TransMilenio operating and management structure	• Developed as part of overall transportation improvements in preparation for the 2010 FIFA World Cup • ITDP consulted on various aspects of BRT system design, including incorporation of informal bus operators • Expedited implementation schedule required by World Cup prevented full integration of informal operators until after system launch

Analysis of City Experiences

Bogota

TransMilenio - Bogota, Colombia's bus rapid transit system – was initiated in 2000 utilizing "exclusive bus lanes, high capacity articulated buses, efficient private operation, advanced fare collection, and a new public authority for planning, developing, and controlling the system (Sandoval & Hidalgo, 2002, p. 37). Service was initiated with a capital investment of $2.3 billion to cover infrastructure construction costs, and funded through a 50% earmark on local gas tax revenues (Sandoval & Hidalgo, 2002, p. 44). In addition, the development of TransMilenio was part of a bundle of transportation reforms: in addition to BRT, the city implemented an extended network of pedestrian and bicycle ways; peak hour automobile limitations using license plate restrictions, increased parking prices, and increased day-long automobile prohibitions (2002, p. 38). Together, these features achieved quick success and led the Institute for Transportation and Development Policy (ITDP), a BRT advocacy and advisory NGO, to designate TransMilenio a "gold standard" of BRT (ITDP, 2011a). After less than two years of service, TransMilenio was transporting 650,000 passengers per day through 38 kilometers of exclusive busways and 62 stations, with a route network totaling 125 kilometers (Sandoval & Hidalgo, 2002, p. 37). Today, the system carries 1.8 million passengers per day, representing 73.5% of regional commuters, over an exclusive bus corridor network spanning 87 kilometers (Embarq & ALC-BRT, 2012).

In response to Bogota's rapid population growth and increasing reliance on private automobile usage, and in response to the city's low quality and disorganized public transportation services, Mayor Enrique Penalosa made transportation planning and investment a political priority, and initiated planning for a bus-based transit system in 1998. Prior to TransMilenio, Bogota's transportation system was comprised of numerous private operators, utilizing old and inefficient vehicles. Bus operators often did not utilize designated bus stops, and would pick up and drop off riders anywhere along their routes. This, of course, contributed to slow speeds and congestion, and made for a low-quality public transportation system. Fragmented ownership and lack of route regulation also led to aggressive competition between bus drivers to pick up passengers, and contributed to unsafe traffic conditions. Lack of regulation also meant an overcapacity of buses relative to passenger demand, which also contributed to road congestion and aggressive competition for passengers. Thus in 1998, over 52,000 accidents and 1,000 fatalities were recorded in Bogota.

In February 1999, Bogota's City Council authorized the creation of a new transit authority to develop a BRT system. Eight months later, in October 1999, the city government and local agencies developed a charter establishing TransMilenio S.A. as the transit authority responsible for BRT planning, development, operations, and management. TransMilenio S.A. then initiated the bidding process for trunk line concessions in November 1999, and by April 2000, four separate companies, operating as a consortium of existing local transportation providers and national and international investors, were awarded contracts to initiate service (Sandoval & Hidalgo, 2002, pp. 42-44).

One of Bogota's key innovations was in the management of TransMilenio and the integration of existing transit providers. Comparable to Curitiba's ITN, TransMilenio's operations are contracted out to private companies based on conditions stipulated in concession agreements. According to Sandoval & Hidalgo, bus operators are selected through a competitive bidding process, and are responsible for staffing, bus fleet procurement, and operations and maintenance. As in the Curitiba model, TransMilenio operators are paid based on the number of kilometers they serve (2002, p. 41). The bid evaluation for bus operations considered "local experience in transit operations, environmental performance of buses, and cost per kilometer" of service, thus rewarding efficiency of operations (Sandoval & Hidalgo, 2002, p. 43). In addition to bus operators, fare collection is also contracted out, and daily fare collections are deposited into a trust fund used to pay various system contractors (Sandoval & Hidalgo, 2002, p. 41).

Importantly, Bogota's planners recognized the role of pre-existing bus operators, and the resistance that operators might mount to their potential replacement and/or loss of livelihood through the implementation of TransMilenio. Thus, from early planning stages, existing bus service operators were incorporated into TransMilenio's operations and service delivery structure. As discussed above, the concession process factored in local transportation service experience, thus granting these operators a competitive advantage in bidding on TransMilenio bus routes. According to Sandoval & Hidalgo, this process was effective in securing the support of local transportation firms and smoothing the transition to TransMilenio: as a result of the concession process, 96% of the local transport companies (62 out of 66 transit companies) acquired stock in the four companies that were awarded with the trunk line concession contracts" (2002, p. 43). By structuring concession awards in this way, TransMilenio planners thus not only enabled the successful deployment of new technology for enhanced transportation service delivery, but also initiated an institutional framework that mitigated against the economically disruptive, and hence politically challenging aspects of technological innovation. This success has provided a valuable lesson for bus rapid transit planners in Johannesburg, South Africa, which the following section will discuss.

Johannesburg

In conjunction with its winning bid for the 2010 FIFA World Cup, the South African national government made a commitment to improve the country's public transportation services. In Johannesburg, the city government initiated planning for BRT in 2006 with the design of the 78-station, 120 km Rea Vaya ("We Are Moving") system. Service began in August 2009, with 40 buses operating along the 25.5 km route between Soweto and Johannesburg Inner City, and is projected to be fully operational by 2013 (GTZ, 2010).

Prior to Rea Vaya, Johannesburg's transportation system was dominated by informally operated taxis and minibuses, which were often operated by unlicensed drivers with irregular schedules and unpublished fares. According to Weinstock (2009), informal mini-bus taxis were the primary transportation mode for the 63% of city residents who do not own a car. This system relied on a complex and informal institutional framework. As Weinstock describes,

> The 15-seat minibuses operate without schedules waiting at taxi ranks until they are full to depart, so passengers never know how long a trip will take. Hailing the right minibus taxi requires knowledge of a complex array of hand signals. Most minibus taxis terminate in Johannesburg's central business district (CBD), so passengers who need to travel beyond the CBD must transfer and pay a second fare. The taxis also travel at breakneck speeds, trying to capture passengers as quickly as possible (2009, p. 17).

Because mini-buses are largely unregulated and are operated by overlapping and competing taxi owner associations, routes and fare systems are not integrated, requiring multiple transfers and payments for trips that do not begin or end in the central business district.

Johannesburg's informal mini-bus industry first emerged in the 1970s, when the City reduced public service and opened the public transport market to private operators. At the time, under apartheid rule, the mini-bus industry represented one of the few sectors that allowed black entrepreneurship, attracting numerous entrants and eventually ruthless competition. According to Weinstock, "shortly after the taxi industry's emergence, driver associations were formed to protect individual routes. Violence, and a mafia mentality, took hold. Taxi organizations declared war on one another, resulting in driver and passenger deaths" (2009, p. 17).

With the development of Rea Vaya, the mini-bus industry expressed strong resistance due to the inability of mini-bus operators to compete with BRT on speed, price, convenience, or security, risking lost revenue and potential unemployment (GTZ, 2010). When the City of Johannesburg first proposed Rea Vaya, the taxi industry protested, went on strike, and formed the United Taxi Association Forum as an anti-BRT association (Weinstock, 2010, 18). To address this conflict, the City sought to incorporate displaced taxi drivers directly into the planning and management for Rea Vaya. To plan, manage, and operate the system, the City of

Johannesburg implemented a public private partnership governance structure split between City Government and Taxi Owners and Taxi Association members. PioTrans, the company responsible for running Rea Vaya, has a long-term contract with the city to implement bus rapid transit; former taxi owners and taxi union members control 66.7% of the company, while the remaining shares are held by the City of Johannesburg. PioTrans' board includes 13 former taxi operators, and the Director of Corporate Affairs previously served as chair of the Greater Johannesburg Regional Taxi Council (Jennings, 2011; Environmental News Services, 2011).

As part of the concession and ownership agreement, the City of Johannesburg financed taxi driver ownership through a taxi recapitalization scheme in which taxi owners surrendered operating licenses and allowed their vehicles to be scrapped in exchange for shares of PioTrans. So far, over 500 taxi owners and drivers from over nine taxi associations have bought into Rea Vaya (Jennings, 2011). Generally, former taxi owners are employed as bus drivers, station attendants, or as community ambassadors for Rea Vaya.

Johannesburg's transition to BRT has not been seamless, despite proactive efforts to incorporate the minibus taxi industry. According to Weinstock, the taxi industry was not able to form an operating company in time for the system launch, and the City handed initial operations over to Metrobus, a public non-BRT bus company. In addition, non-incorporated minibus taxi owners continue to oppose and protest Rea Vaya, and have targeted taxi association members that have joined Rea Vaya with violence, in a few cases killing prominent pro-BRT association members (Weinstock, 2010, p. 18). However, by February 2011, the taxi association formally assumed control for ReaVaya (ITDP, 2011b). Moving forward, PioTrans and the City of Johannesburg can seek to further incorporate minibus taxi owners by developing integrated fare and feeder services, whereby customers can transfer seamlessly between mini-bus routes and Rea Vaya.

Implications

Institutions

Bogota and Johannesburg's experiences implementing bus rapid transit highlight the importance of understanding actors and institutions when planning for technological innovation. In this context institutions include norms, rules, and contractual mechanisms, as discussed by North, as well as organizational forms, as advanced by Hodgson. Following North, property rights play a critical role in the proper functioning of a commercial transportation system, whether publicly or privately owned and operated. Under Johannesburg's earlier informal mini-bus taxi system, taxi owners lacked property rights such as set routes, service networks, queuing systems, or formal fare collection mechanisms providing greater access to fare-paying customers. As a result, to use North's language, drivers were compelled to "cheat and shirk", sometimes resorting to violence, and frequently leading to unsafe, inefficient, and costly service for taxi riders. By establishing "well-specified and well-enforced property rights", whether through taxi licenses, route concessions, or a monopoly service in the case of TransMilenio or Rea Vaya, state-backed public transportation institutions serve to enhance service reliability, productivity, and efficiency, both for the service user and the service provider (North, 1987, pp. 420-421). Likewise, as Hodgson (2006) notes, institutions are "systems of established and embedded social rules that structure social interaction", and include organizations to the extent that organizations dictate structure, control, and responsibility (Hodgson, 2006, p. 18).

In both Bogota and Johannesburg, TransMilenio S.A. and PioTrans, the respective BRT parent companies, serve an important institutional role in providing a public-private governance structure that facilitates cooperation between city government and transit operators in planning and managing bus rapid transit services. In Bogota, TransMilenio achieves this through a targeted concession process designed to encourage local transit providers to operate the system. PioTrans takes this arrangement a step further by enabling taxi owners to take an ownership stake in the system. Were it not for these institutional and organizational arrangements, both cities' innovative urban transportation planning efforts would have met far more political resistance, and might have failed to get off the ground.

While Rea Vaya is still in a development phase, early signs are promising, as the system attracted 17,000 riders per day in its first week of limited service alone (Weinstock, 2010, p. 18). By launching Rea Vaya on the right institutional footing, the City of Johannesburg has primed itself for future success, despite ongoing conflicts with anti-BRT taxi owners. As Stiglitz (1989) notes, institutions and social organization play an important role in growth potential. Differences in growth and performance "can be attributed to differences in organization, to how individuals interact, and to the institutions which mediate those interactions" (Stiglitz, 1989, p. 197). Thus, for urban transportation planning in cities such as Johannesburg or elsewhere in the developing world, the issue is as much institutional as it is physical or technological. While technologies exist to improve the performance of urban transportation systems, the key to successful planning and policy ultimately lays in institutional development. In the case of both TransMilenio and Rea Vaya, this entailed an institutional framework for property rights allocation and conflict resolution. For urban transportation innovations more generically, this could also include the development of traffic and safety regulations, general acceptance and adherence to these regulations as social norms, and the organizational capacity to plan, finance, and implement transportation services.

Policy Diffusion

Returning to the earlier discussion of policy diffusion, social learning and networks of information exchange have also played an important role in the diffusion and adaptation of bus rapid transit. Throughout TransMilenio's planning stages, obtaining information about BRT systems in other cities was "a very important factor of the process" (Sandoval & Hidalgo, 2002, p. 42). During this period, TransMilenio planners visited Quito, Ecuador; Curitiba, Sao Paulo, and Goiania, Brazil; Santiago, Chile; and Mexico City and Puebla, Mexico to "identify key elements for system design" (Sandoval & Hidalgo, 2002, p. 42). Likewise, officials from Bogota have since gone on to share their experiences and expertise with other cities seeking to implement bus rapid transit. According to Matsumoto (2007), planners and policy makers from Jakarta, Indonesia; Seoul, South Korea; and Beijing, China drew lessons from Bogota's "best practice" examples and organized official exchanges to experience and learn from TransMilenio firsthand. Highlighting the importance of informal networks and personal connections in the policy learning process, Sutiyoso, the Governor of Jakarta who led BRT implementation, was heavily influenced by Enrique Penalosa, the former Mayor of Bogota responsible for implementing TransMilenio. In particular, Sutiyoso made BRT implementation a key component of his winning 2001 re-election campaign, and drew lessons from Bogota on the specification of bus lanes, stations, vehicles, and fare collection systems (Matsumoto, 2007).

Technological Innovation

The discussion of bus rapid transit thus far highlights several important implications for technological innovation more broadly. To be successful, BRT innovations have needed to be flexible and adaptable, combining infrastructure enhancements with operational and managerial improvements. According to Kost & Nohn

> Treating BRT only as a road infrastructure improvement leads to low capacity and poor system quality. Besides good physical design, successful implementation of BRT requires system management, operations planning, a dedicated BRT bus fleet with easy boarding and alighting, and sound placement of stations (2011, p. 14).

As demonstrated by Curitiba, Bogota, and Johannesburg, this is a comprehensive effort, often requiring staged implementation, changes in institutional structure, and coordinated transportation policies. Though a potentially monumental task, this process should not be pre-determined, but rather pursued incrementally. As Cervero points out, Curitiba's city leaders did not start out with a preconceived idea of a transportation solution when developing ITN, but instead "asked what would be the most cost-effective transport investments consistent with building a linear city as well as the goals of preserving the inner core, improving environmental quality, and keeping costs reasonable" (1996, p. 292). As the former Mayor of Curitiba, Cassio Taniguchi points out, "we are constantly innovating, with creativity. The system [ITN] is not exhausted. We have developed new projects incrementally, new changes to make it better. This has occurred in the past and occurs through the present" (Demery, 2004, p. 35-36).

While bi-lateral exchanges and informal learning networks have played an important role in the diffusion of BRT systems, this process has not always led to success. According to Weinstock et al, the "lack of a common understanding of what constitutes a BRT system has led to branding problems. The lack of any sort of quality control on bus-based mass transit interventions has made it possible for marginal bus system improvements to be branded as BRT, leading to some community backlash against the concept of BRT" (2011, p. 6). For example, several cities in Brazil, Indonesia, China, and India have incorporated "sub-optimal bus system improvements [that] were branded as BRT" after gaining some familiarity with well-known BRT systems, such as Bogota's TransMilenio or Jakarta's TransJakarta (Weinstock et al., 2011, p. 6). To address this issue, ITDP is developing a BRT Standard metrics system to uphold the design and quality standards of bus rapid transit and assist planners and policy makers in implementing BRT. This standard will rate BRT systems through a weighted scoring of several indicators across 5 categories: service planning; infrastructure; station design and station-bus interference; quality of service and passenger information systems; integration and access (Weinstock et al., 2011, p. 17). In so doing, ITDP will help to bridge the gap between formal and informal learning processes, and will supplement valuable social learning exchanges with high quality best practice resources that are readily at the disposal of planners and policy makers interested in implementing bus rapid transit.

The Role of Planners

Finally, Bogota and Johannesburg's experiences with BRT offer several lessons for planning theory and discussions on the role of planners in supporting technological innovation. Though not exactly "insurgent", planning for Bogota and Rea Vaya reflects Miraftab's notion of critical and contextualized planning. Specifically, planners in both cities recognized "the power struggle within which [transportation planning] is practiced" by actively and deliberately engaging mini-bus taxi owners in both the planning process and the organizational structure (2009, p. 43). For the PioTrans case in particular, radical planning's emphasis on inclusion and participation is important given the legacy of apartheid in South Africa, and the role of the mini-bus taxi industry in supporting middle-class black entrepreneurs under apartheid. In the post-apartheid era, the political, economic, and symbolic importance of supporting and maintaining this group was surely apparent to planners and policy makers, even if the explicit goals of Rea Vaya were to fundamentally reformulate the transportation sector and its relationship to both society and the state.

Likewise, the TransMilenio and Rea Vaya cases validate Sanyal's emphasis on "anticipatory" public sector planning, which entails "an awareness of institutional constraints" and the anticipation of "institutional resistance to reform efforts" (2005, pp. 227-228). As Sanyal notes, "a key objective of innovative planning is to create new and 'alternative' institutional mechanisms in contradistinction with mainstream bureaucratic institutions" (2005, p. 237). TransMilenio and PioTrans' innovative governance structures, utilizing public private partnerships between city government and local transit companies are surely cases in point.

Finally, this analysis of BRT implementation, and of technological innovation more generally, underscores the importance of smart planning, political savvy, and a strong institutional basis within the state. The introduction of new technology and management systems, such as BRT, risks the type of international knowledge transfer failures identified by Banerjee in the post-colonial Indian context, in which innovations failed to diffuse because they did not correspond to local capabilities and institutional structures. As Banerjee notes, the inability of planners to "anticipate and negotiate local institutional traditions and to build broader support among the public and local civil society" undermines the implementation of plans and the diffusion of innovations" (2009, p. 206). Negotiating these questions is a critical component of technological innovation, and is thus a fundamental responsibility of planners in pursuing BRT or any other technological innovation.

Limitations & Areas of Future Research

This study has sought to clarify the role of institutions and the relationships between actors in implementing bus rapid transit, but in doing so has prompted as many questions as it answers. Likewise, several questions simply fall outside the scope of this project, despite having incredible importance to the discussion of BRT implementation and the diffusion of technological innovations. For example, I have focused on the relationships between city planners and policy makers and existing transit providers, and the institutional arrangements deployed to mitigate conflict between these two groups. Thus far unaddressed, and therefore in need of future clarification, are the roles of the many additional stakeholders engaged in BRT implementation. These include international donors, such as the World Bank, advocacy and capacity building NGOs, such as EMBARQ and ITDP, and private-sector actors, such as bus manufactures and transportation consulting firms that may have an interest in and/or influence over the spread of Bus Rapid Transit. Understanding the role of these actors, in addition to the experience of cities not discussed in this study, is an important area for future research. Likewise, the sheer number of cities that have implemented bus rapid transit provides a wealth of additional data and potential lessons relating to questions of technological innovation. While Bogota has experienced tremendous success with TransMilenio, and Johannesburg shows early signs of promise with ReaVaya, other cities have had vastly difference experiences, both successful and unsuccessful. A full understanding of the institutional implications of BRT implementation cannot be understood using such a small sample of cities; moving forward, the experience of additional cities should be addressed.

Conclusion

As an alternative to rail-based mass transit systems, bus rapid transit represents an important technological innovation that has quickly gained popularity as an adaptable and cost-effective means of providing high quality urban mobility. While the technological aspects of BRT implementation are well understood, the role of actors, institutions, and planning processes has garnered less attention. Focusing on the experiences of Bogota, Colombia and Johannesburg, South Africa, this study has sought to explore the institutional implications of BRT implementation by examining the role of different actors and enabling policies in facilitating technological innovation. Specifically, I have focused attention on the processes by which existing transit service providers are incorporated into new BRT systems, and the lessons that planners and policy makers have drawn from other cities while embarking on this process. Like other technological innovations, BRT offers many potential benefits. Nonetheless, several challenges and potential conflicts can threaten the success of BRT, including political backlash to the "creative destruction" wrought by innovation, and failures on behalf of planners and policy makers to consider pre-existing transportation services and institutional arrangements.

Against this backdrop, Bogota and Johannesburg's experiences implementing Bus Rapid Transit offer a number of valuable lessons in planning for technological innovation in urban transportation. These include the development of appropriate institutional mechanisms for defining transportation-related property rights, facilitating the inclusion of existing transit providers, and managing conflict resolution. Of course, as part of the broader effort to support a sustainable and equitable urban transportation paradigm, planners must consider many additional factors beyond service integration. These include the adaptation of physical infrastructure and urban design, identification of equitable pricing and fare levels, coordinated land use planning and transportation demand management, amongst other considerations. With respect to actors and institutions, this also includes the role of actors outside the scope of this study, including consultants, vendors and equipment manufacturers, NGOs, advocacy groups, and policy networks. Nonetheless, by beginning to explore these dynamics, and developing a basis of institutional comparison between cities implementing BRT, I have sought to shed light on the processes of innovation and diffusion, so that planners, policy makers, and other stakeholders can be better informed when implementing new technologies such as bus rapid transit.

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Appendix 1: List of BRT Cities

City	Country	Year
Curitiba	Brazil	1974
Belo Horizonte	Brazil	1975
Goiania	Brazil	1976
Porto Alegre	Brazil	1977
Pittsburgh	United States	1977
São Paulo	Brazil	1980
Recife	Brazil	1982
Ottawa	Canada	1983
Campinas	Brazil	1986
Adelaide	Australia	1986
Campo Grande	Brazil	1987
Mauá - Diadema	Brazil	1988
Paris	France	1993
Ipswich	United Kingdom	1994
Leeds	United Kingdom	1995
Quito	Ecuador	1995
Oberhausen	Germany	1996
Jonkoping	Sweden	1996
Criciúma	Brazil	1996
Vancouver	Canada	1996
Dublin	Ireland	1997
Miami	United States	1997
Orlando	United States	1997
Taipei	Taiwan	1998
Juiz de Fora	Brazil	1998
Kunming	China	1999
Joinville	Brazil	1999
Twente	Netherlands	2000
Bogotá	Colombia	2000
Nagoya	Japan	2001
Nancy	France	2001
Rouen	France	2001
Utrecht	Netherlands	2001
Brisbane	Australia	2001
Caen	France	2002
Amsterdam	Netherlands	2002
Bradford	United Kingdom	2002

Boston	United States	2002
Prato	Italy	2003
Eindhoven	Netherlands	2003
Gothenburg	Sweden	2003
Crawley	United Kingdom	2003
León de los Aldama	Mexico	2003
Oakland	United States	2003
Melbourne	Australia	2003
Sydney Parramatta/Rouse Hill	Australia	2003
Sydney, Blacktown /Rouse Hill	Australia	2003
Sydney, Liverpool /Parramatta	Australia	2003
Beijing	China	2004
Jakarta	Indonesia	2004
Seoul	Republic of Korea	2004
Edinburgh	United Kingdom	2004
Las Vegas	United States	2004
Hamburg	Germany	2005
Olinda	Brazil	2005
Mexico City	Mexico	2005
Monterrey	Mexico	2005
Halifax	Canada	2005
York Regional Municipality	Canada	2005
Kansas City	United States	2005
Los Angeles	United States	2005
Auckland	New Zealand	2005
Hangzhou	China	2006
Pune	India	2006
Douai	France	2006
Lyon	France	2006
Nantes	France	2006
Brescia	Italy	2006
Kent	United Kingdom	2006
Luton	United Kingdom	2006
York	United Kingdom	2006
Uberlândia	Brazil	2006
Santiago	Chile	2006
Pereira	Colombia	2006
Guayaquil	Ecuador	2006
Tehran	Iran	2007
Istanbul	Turkey	2007
City	**Country**	**Year**

Lorient	France	2007
Guatemala	Guatemala	2007
Merida	Venezuela	2007
Eugene	United States	2007
Lagos	Nigeria	2008
Changzhou	China	2008
Chongqing	China	2008
Dalian	China	2008
Jinan	China	2008
Xiamen	China	2008
New Delhi	India	2008
Lille	France	2008
Maubeuge	France	2008
Toulouse	France	2008
Natal	Brazil	2008
Cali	Colombia	2008
New York	United States	2008
Phoenix	United States	2008
Johannesburg	South Africa	2009
Zhengzhou	China	2009
Ahmedabad	India	2009
La Rochelle	France	2009
Cambridge	United Kingdom	2009
Swansea	United Kingdom	2009
Santos	Brazil	2009
Guadalajara	Mexico	2009
Cleveland	United States	2009
Snohomish County	United States	2009
Guangzhou	China	2010
Hefei	China	2010
Yancheng	China	2010
Zaozhuang	China	2010
Jaipur	India	2010
Bangkok	Thailand	2010
London	United Kingdom	2010
Diadema - São Paulo	Brazil	2010
João Pessoa	Brazil	2010
Londrina	Brazil	2010
Maceió	Brazil	2010
Niteroi	Brazil	2010
Sumaré	Brazil	2010

Barranquilla	Colombia	2010
Bucaramanga	Colombia	2010
Ecatepec	Mexico	2010
Lima	Peru	2010
Brampton	Canada	2010
Cape Town	South Africa	2011
Buenos Aires	Argentina	2011
Blumenau	Brazil	2011
Brasília	Brazil	2011
Rio de Janeiro	Brazil	2011
Medellín	Colombia	2011
Panama	Panama	2011
Winnipeg	Canada	2012

Source: EMBARQ & Across Latitudes and Cultures – Bus Rapid Transit (ALC-BRT). (2012). *Global BRT Data*. Retrieved from http://brtdata.org