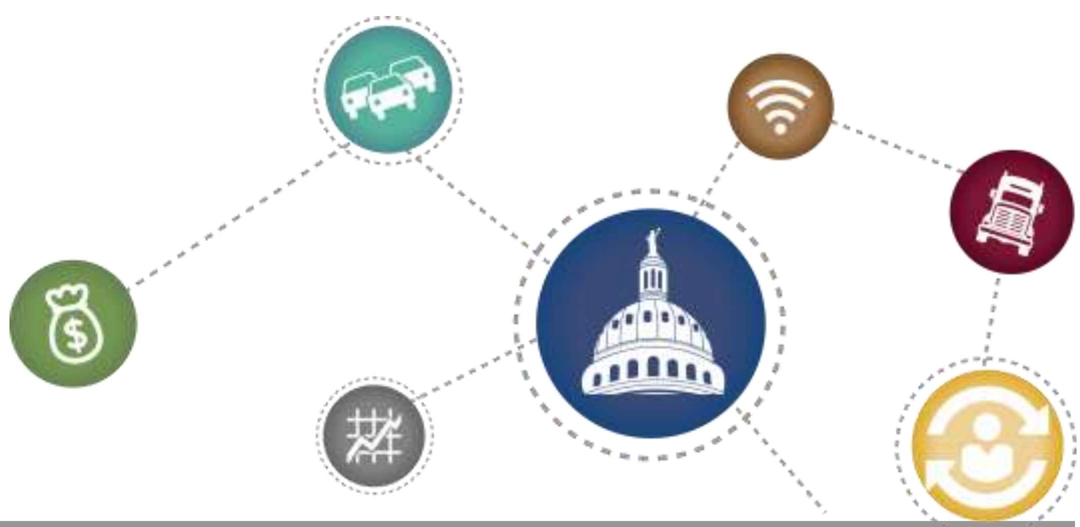
Texas A&M Transportation Institute

Finding the Value of Urban Parking: An Analysis of the Impacts of Smart Parking Systems on Congestion and Land Values in Downtown Houston

Final Report

PRC 17-88 F



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Finding the Value of Urban Parking: An Analysis of the Impacts of Smart Parking Systems on Congestion and Land Values in Downtown Houston

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Authors

Brett Huntsman

Phil Lasley

Madison Metsker-Galarza

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Finding the Value of Urban Parking

In this report, researchers examined smart parking, a parking management tool that helps drivers efficiently find and pay for available parking by knowing where they will park before reaching their destination. This can prompt more traffic to have a definitive destination when exiting from major roadways near dense urban areas, potentially leading to increased efficiencies of existing parking structures and land use. Smart parking can also reduce congestion, 30 percent of which in urban cores is attributable to drivers searching for parking spaces. Researchers anticipate that smart parking systems will spark property redevelopment as land values increase and parking demand patterns change. A number of observations emerged from the study, which used downtown Houston as a case study.

- Using value capture mechanisms to collect revenues from smart parking improvements, an urban core and existing roadway networks would, if marginal property tax revenues exceed the cost of implementing and maintaining the system, receive congestion benefits and property value increases for no additional taxes or fees to the property owners. The revenues would come solely from the taxes levied on increased property values instead of diverting funds or raising taxes.
- Study results estimate about $4.4 million per year in congestion savings for the City of Houston if a smart parking system were to be implemented (though implementation and maintenance costs are not estimated).
- The potential value of redevelopment of surface parking in the analysis area ranges from $82 million to $722 million, based on a variety of different land uses. Using tax increment financing, the estimated additional annual tax revenue from increased property values is estimated between $575,000 and $4.7 million, depending on the new land use.
- Estimates are subject to current landowners' willingness to sell or redevelop property. As such, these results are hypothetical and are intended to determine whether there is unleveraged value in the redevelopment of parking.
- There are approximately 10 acres of government owned, tax-exempt surface parking within the central business district (CBD). While data on the value of this land is not available, these parcels offer ideal opportunities for public-private partnerships to occur.
- Improvements to transportation infrastructure at the local level will also benefit the state system; therefore, encouraging local transportation initiatives, in many cases, may increase efficiency of the state system, delaying or eliminating the need for the state to fund other, costlier transportation improvements.
- While this report is narrow in scope, researchers believe that the findings are applicable to not only other CBDs within Texas, but also to surrounding urban areas.

Table of Contents

List of Figures

List of Tables

Executive Summary

As of 2010, nearly 85 percent of the Texas population lived in an urban area.[1] According to Texas demographers, the state population is expected to more than double by 2050,[2] most of which will occur in urban areas. As the largest metropolitan areas within the state grow at an exponential rate, the ability for local governments to address the challenges of congestion and safety become increasingly important. While many of the efforts to address congestion and safety and their financing are being made at the local level, they can directly impact some of the most congested roadways on the state system. Therefore, research is needed to examine ways in which the adoption of innovative technologies at the local level might impact the efficiency of state infrastructure, while identifying opportunities to leverage funding for such programs.

Approach

For this report, researchers have examined smart parking, which is a parking management tool that uses various technologies to aid drivers in efficiently locating and paying for available parking. Smart parking systems allow drivers to know where they will park before reaching their destination, in turn prompting more traffic to have a definitive destination when exiting from major roadways near dense urban areas. This leads to increased efficiencies of existing parking structures and land use, while also reducing congestion on both local and state roads. These systems work by allowing drivers to know where they will park before reaching their destination. Transportation investments such as these have the potential to increase overall accessibility, increasing land values in turn. Non-exempt properties with higher land values will pay a larger amount in ad valorem taxes to the different entities that have jurisdiction of the property. To provide funding for this system, researchers began identifying innovative strategies to capture this incremental property value change.

Researchers anticipate that the implementation of smart parking systems will spark property redevelopment within an urban core, as land values increase and parking demand patterns change. Any parcel can be redeveloped to a certain extent, however, parcels with high land value and lower improvement values would be more likely to redevelop first. Surface parking lots, in this case, would be prime sites for redevelopment as the existing improvement value is typically low, and changes in parking patterns are expected to affect these lots the most. This report focuses on land use changes of these types of properties.

Using value capture mechanisms to collect revenues from smart parking improvements, an urban core and existing roadway networks would, if marginal property tax revenues exceed the cost of implementing and maintaining the system, receive congestion benefits and property value increases for no additional taxes or fees to the property owners. The revenues would come solely from the taxes levied on increased property values instead of diverting funds or raising taxes.

[1] U.S. Census Bureau 2010 Decennial Census estimates of population in designated urban areas.
[2] Based on 2010–2050, Texas State Data Center population projections.

Analysis

For this report, researchers chose downtown Houston as a case study to identify whether these benefits exist, and if there are opportunities available to leverage funding. An investigation into available data for the Houston central business district (CBD) shows that parcels being used entirely for public surface parking encompass approximately 16 percent of all developed acreage in downtown Houston, yet account for less than 3 percent of the total assessed value.[3] There are also approximately 10 acres of government owned, tax-exempt surface parking within the CBD. While data on the value of this land is not available, these parcels offer ideal opportunities for public-private partnerships to generate additional parking and tax revenues.

This reports follows the following structure to conduct the analysis:

- Literature review of parking management systems and value capture mechanisms.
- Case study review of existing smart parking deployments and value capture usage for transportation investments.
- Data collection of existing roadway congestion levels within the Houston CBD.
- Data collection of current Houston parking inventory and respective land values.
- Analysis of smart parking benefits, including congestion reduction and existing parking efficiencies.
- Estimation of value added through the redevelopment of existing surface parking lots, and potential revenue through value capture mechanisms.

Literature Review Summary

The literature and case study reviews of smart parking show that while there are many forms of parking management available, there have been limited instances of large scale smart parking deployments in the United States. The smart parking systems deployed in San Francisco, CA, (SFpark) and Columbus, OH, serve as examples for domestic deployments. Smart parking systems (SPS) in Istanbul, Turkey, represents an international case study.

There are numerous case studies for using value capture mechanisms to fund transportation improvements, but only one report attempted to identify parking redevelopment as a source of new tax income. To supplement this report, researchers examined case studies of actual revenues that have been acquired through value capture, and how those have covered project costs.

[3] Calculations using Harris County Appraisal District (HCAD) data along with the reported 2017 parking inventory collected by the Houston Downtown District and TTI. Includes tax-exempt properties.

Results

Congestion Saving and Occupancy

The analysis revealed that the introduction of a SFpark-style smart parking system in downtown Houston would provide close to 200,000 hours per year of congestion delay reduction with the city experiencing a $4.4 million savings per year in congestion costs. Furthermore, an analysis on the existing parking inventory revealed a significant oversupply and inefficient spatial distribution and use of parking. The analysis suggests that public parking garages are used most efficiently with daily occupancy between 53 and 80 percent (with a mean occupancy of 66 percent). Public and private surface lots are used much less efficiently, ranging between 27 and 68 percent occupancy (with means of 54 and 46 percent, respectively). Researchers noted that there is also a significant spatial imbalance of supplied parking compared to demand. This oversupply of parking may grow further if a smart parking system is introduced that focuses on efficiency and spatial distribution using dynamic pricing. Greater efficiency would leave some lots empty, which would in turn motivate some lots to redevelop into higher uses.

Added Value and Revenue

To estimate potential added value and increment tax revenue, researchers identified assessed values per land use type currently in downtown Houston. These values allowed for the calculation of potential redevelopment value of surface parking lots analyzed as part of this report. Potential redevelopment includes converting surface parking into a land use already present in downtown Houston, such as mid- or high-rise apartments or offices. The results of the analysis suggested a potential added taxable value through redevelopment of all surface parking outside of existing TIRZs between approximately $82 million and $722 million. Redevelopment within existing TIRZs could produce between $562 million and $6 billion of added taxable value in a given year (using 2020 for an analysis year). This represents a range of possible land uses and their calculated value in this project.

Once a potential incremental taxable value was calculated, researchers determined whether there were opportunities to capture that value and convert it into revenue. Tax increment financing provides the most suitable approach. As there are two existing TIRZs in downtown Houston, researchers identified the surface parking outside of these zones, indicating parcels that had no tax increments obligated to an established authority.

Researchers developed a hypothetical tax increment financing model to calculate revenues over a 20-year period. Using set parameters and 2017 tax rates, surface parking lot redevelopment is estimated to generate between $575,000 and $4.7 million average incremental annual revenue. These figures would vary based on tax entity participation rates, growth rates, added value to existing developments, and the amount of surface parking redeveloped.

Considerations

While many elements of this analysis are built on hypothetical scenarios, due to non-zoning laws in Texas, land owners have the right to develop property as they see fit, given that they meet any state, county, and local development regulations. For this research, we assume that some land owners would choose to redevelop based on market pressures due to income reduction from the introduction of smart parking systems and increasing opportunity costs. However, there are a multitude of variables affecting property owners' decisions to buy, sell, or redevelop property. As such, these results are hypothetical and are intended to determine whether there is unleveraged value in the redevelopment of parking.

Another aspect of redevelopment worthy of consideration is the role of public agencies engaging in public-private partnerships to invest in overhauling surface parking. The research conducted in this report strongly suggests that there are millions of dollars of potential redevelopment of surface lots in the Houston CBD. However, there are also approximately 10 acres of government owned, tax-exempt surface parking within the Houston CBD. While data on the value of this land are not available, these parcels offer ideal opportunities for public-private partnerships to occur.

Introduction

As of 2010, nearly 85 percent of the Texas population lived in an urban area.[4] According to Texas demographers, the state population is expected to more than double by 2050,[5] most of which will occur in urban areas. This level of growth raises concerns of not only the efficiency of existing transportation infrastructure, but also the ability of future infrastructure funding to meet the needs of the population. Traditional funding mechanisms are becoming less effective, and the need for innovative funding and financing programs is increasing. New revenue sources, such as Proposition 1 (83(3)) regarding oil and gas tax revenues and certain sales tax revenues dedicated through Proposition 7 (84R) provide relief, but gaps between revenue and needs remain (*1*, *2*, *3*). These funding challenges are then shared with local governments, all of which have unique challenges in funding transportation. As such, innovative strategies to supplement infrastructure investments within urban areas are needed.

Increasing the efficiency of new and existing infrastructure, expanding multi-modal options, and encouraging employment changes such as flexible work hours, telecommuting, and employment locations are all strategies for local governments to consider. As technological innovations are being introduced, new congestion reduction and mobility strategies are becoming available. Research is needed to examine ways urban areas can utilize these new strategies to improve accessibility and reduce congestion in their area. As gaps in funding introduce additional barriers to implementation for state and local governments, innovative financing solutions should also be examined. Decisions made at the local level can result in a direct impact on some of the most congested roadways in the state system.

[4] U.S. Census Bureau 2010 Decennial Census estimates of population in designated urban areas.
[5] Based on 2010–2050, Texas State Data Center population projections.

Project Purpose

The purpose of this report is to investigate smart parking, a strategy that has developed from recent technological advances, and its effects on congestion in urban areas. Smart parking, a form of parking management, is a system which uses various technologies to aid drivers in efficiently locating and paying for available parking. This report examines how investments into these systems by local governments could reduce congestion and increase accessibility within urban centers. Smart parking systems allow drivers to know where they will park before reaching their destination, in turn prompting more traffic to have a definitive destination when exiting from major roadways near dense urban areas. Dynamically priced street spaces based on current demand can ensure that parking is used efficiently and available when and where needed. This serves to lessen congestion within downtowns as drivers could spend less time searching for parking; it is estimated that approximately 30 percent of traffic congestion in these areas is attributable to drivers searching for parking (*19*). These improved efficiencies could lead to downtowns becoming more accessible and thus, more attractive to businesses and customers.

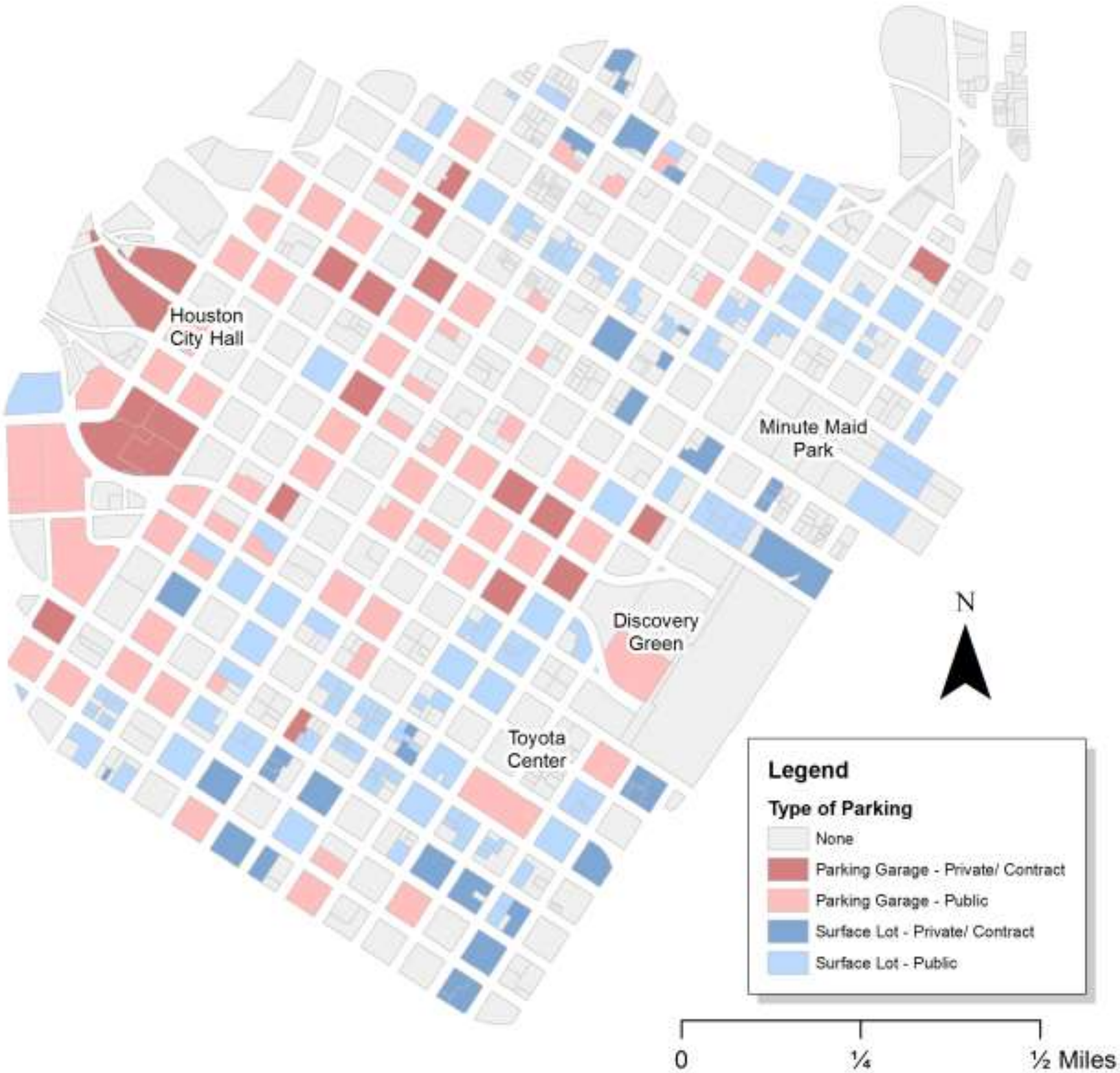
Researchers considered the opportunity to generate funding for these technologies by capitalizing on the resulting efficiencies through the redevelopment of existing excess and underutilized surface parking. Researchers analyzed the effectiveness of selected value-capture methods set in place by local governments to capture incremental differences in assessed values as redevelopment occurs. While it is possible that any parcel can be redeveloped to a certain extent, parcels which have high land value and lower improvement values would be more likely to be redeveloped first. Surface parking lots, in this case, would be the most reasonable sites for redevelopment as the existing improvement value is typically low.

Redevelopment of these sites could offer the same level of service while generating additional ad valorem tax revenues for local governments and sales tax revenue for the state (the latter not discussed in this report). There is also potential economic gain for the state as additional parking may stimulate economic growth arising from the increase in accessibility generated by smart parking management. An investigation into available data shows that parcels being used entirely for public surface parking encompass approximately 16 percent of all developed acreage in downtown Houston, yet account for less than 3 percent of the total assessed value.[6] Figure 1 illustrates the amount of land used for parking in downtown Houston per available data and onsite observations.

While these surface lots may provide valuable services to nearby facilities, they are underdeveloped in terms of assessed value when compared to structured parking and other land uses. Reports of underdeveloped parking from other downtowns in Texas and other states show that these opportunities are not unique to Houston. While this report focused on the Houston

[6] Calculations using Harris County Appraisal District (HCAD) data along with the reported 2017 parking inventory collected by the Houston Downtown District and TTI. Includes tax-exempt properties.

central business district (CBD) as a case study, it is likely that similar conditions exist in many other urban cores across the state.



Source: Harris County Appraisal District (CAD), Houston Downtown District, Texas A&M Transportation Institute (TTI)

Figure 1. Parking Inventory – Downtown Houston (2017).

Researchers gathered assessed value, lot size, construction costs (where applicable), the parking inventory of individual parcels, and occupancy rates for parking on each selected block. This information was obtained from available sources on downtown Houston, as well as on-site analysis where researchers confirmed and updated the nature of the parking. The data were used to estimate average potential annual revenues and the change in assessed value for all parcels, whether in an existing TIF (tax increment financing) district or not.

The results of this part of the analysis should not be used to inform detailed development plans, since they do not account for all potential costs or barriers unique to each municipality. The results of the analysis are to present an estimation of possible value capture through redevelopment.

To conduct the analysis, researchers collected key information through several steps:

- Literature review of the following:
    - Definition and types of smart parking systems available.
    - The effects of smart parking systems on land value and land usage.
    - Brief overview of the most common value capture strategies for funding transportation.
    - Use of value capture to leverage funding from site redevelopment.
- Case study review of the following:
    - Existing smart parking programs and their effects on accessibility, congestion, land value, and usage.
    - Value methods capture being used in conjunction with site redevelopment to generate funding or financing for transportation projects.

Researchers used the collected information to estimate potential benefits in terms of congestion reduction, funding, land values, and accessibility that can be leveraged through the implementation of such mechanisms and to describe associated costs. Furthermore, researchers created a model framework that municipalities or the State can use to realize the potential congestion and economic benefits in urban areas throughout the state.

What Is Parking Management?

Parking management is the use of various techniques and strategies to administer the availability and price of parking in crowded, high-activity areas, such as downtowns. When optimally enacted, these strategies work to reduce congestion on the surrounding roadways and spur economic development in an area. Urban areas could often make better use of scarce and expensive parking resources through the conversion of parking lots into buildings, as unmanaged parking restricts infill development and redevelopment ([7]). Effective parking management can spur the development of underutilized parking lots, yielding increases in tax revenues to cities, which may also increase revenues for the state. To illustrate costs, the following provides an order of magnitude of capital costs and operational and maintenance (O&M) costs for subsurface parking in suburban, urban, and central business districts (CBDs) (*4*):

- Suburban surface parking: $2.42 per space per day ($200,000 per acre land, $5,000 per space capital cost, $200 per space per year O&M).
- Urban three-story parking structure: $7.44 per space per day ($500,000 per acre land, $23,800 per stall capital cost, $300 per space per year O&M).
- CBD underground structure: $11.16 per day ($0 land cost, $40,000 per space capital cost, $500 per space per year O&M).

Through deploying effective parking management strategies, cities and states will increase the efficiency of space devoted to parking and reduce underutilized parking for (*5*):

- A given population.
- A specific level of economic activity.
- Or a building area.

The Institute of Transportation Engineers (ITE) Parking Generation Handbook seeks to illustrate different approaches cities can take to reduce the amount of parking and maximize efficiency. Note the data used for this paper does not endorse the ITE standards, but rather is used as an example to illustrate an approach. The average level in the ITE Parking Generation Handbook for office building parking is 2.84 spaces per 1,000 square feet compared to the conventional approach of 4 spaces per 1,000 square feet (*4*). Thus, in an office building of 100,000 square feet, the typical building requirement would contribute to the overbuilding of 116 spaces, with many of the buildings built to this standard contributing to unused parking spaces (*4*).

The highest building rate (highest rate of required parking for new construction) and highest parking utilization of these spaces is 5.58 spaces per 1,000 square feet providing sufficient parking for an office building (*4*).

[7] The development of buildings in vacant areas usually in urban areas that are already largely developed.

With this type of approach, cities can adopt parking management strategies that aim to maximize the efficiency of space use. Parking management strategies for this purpose include:

- Space designations.
- Shared parking.
- Space search (driver looking for a parking space).
- Space turnover.
- Parking density.
- Off-site parking.
- Smart parking.

This report will focus on the smart parking strategy. Note that there are now many other resources for parking management techniques other than the ITE Handbook.

What Is Smart Parking?

Smart parking is a form of parking management that consists of a variety of systems to help reduce traffic congestion, space search time, travel time, and vehicle miles traveled (VMT) while maximizing the utilization efficiency of developed land. Smart parking uses equipment and technologies such as cameras, wireless communications, data analytics, induction loops, smart parking meters, and advanced algorithms to gather information, predict future parking patterns, and manipulate parking strategies to create a more dynamic and efficient parking system. No single technology is proven to be the most effective in creating a dynamic parking system for cities; this report posits that the integration of a combination of the available technologies along with effective parking practices and concepts can be used to create the system most appropriate for a specific city.

Smart Parking Systems

Smart parking systems can be subdivided into five categories: parking guidance and information systems (PGIS), transit based information systems, smart payment systems, E-parking, and automated parking (*6*).

- *Parking Guidance and Information Systems (PGIS):* Provide information for drivers to aid in the decision-making process involved in reaching their destination and locating vacant parking spaces within the parking facility. PGIS consists of smart systems such as static/dynamic variable message signs (VMS); global positioning systems (GPS) within mobile phones; and vehicle detection sensors. VMS can help direct drivers to open lots as they near their desired destination. The GPS within the vehicle can interface with a parking guidance system to help direct drivers to parking lots using their current location, and vehicle detection sensors installed at parking lot entrances/exits/or individual spaces can detect vehicle occupancy.

- *Transit Based Information Systems:* Uses the same technology as PGIS except that its goal is to guide users to park-and-ride facilities. Real-time information includes public transit schedules and traffic conditions, which provide users with the ability to make the best decision to meet their needs. This type of parking system aids in parking management while promoting the use of public transportation, thus increasing transit revenue (*6*).
- *Smart Payment Systems:* Include the use of smart phones, smart cards, debit cards, and credit cards to efficiently pay for parking, including directly paying a meter. These systems allow drivers to adjust their time as needed, without the added stress of trying to make it back to their car before their time expires and has the potential to provide refunds or credits to users who pay for more time than needed.
- *E-parking*: Uses text messages or the internet to allow drivers to reserve or check the availability of vacant parking spaces before arriving at a parking facility. Improving the information used in the planning process allows users to make better-informed decisions as they can choose a parking location based on both supply and proximity to their destination. Users do not have to include an end time and can park indefinitely, eliminating the worry of expired times.
- *Automated Parking*: Consists of users getting to their parking lot, locking their car, and allowing automatic machines to place the vehicle in an allocated space. This ensures maximum efficiency of parking spaces and increases safety as drivers will no longer cruise the parking lot to find a vacant space.

Smart Parking Concepts

Smart parking concepts are another way cities are implementing new technology to increase customer satisfaction and revenue from parking.

- *Parking reservation*: allows drivers to reserve and pay for their parking in advance, eliminating the stress and uncertainty of finding parking once they have arrived at their destination.
- *Dynamic pricing (variable parking):* varies the cost of parking based on factors including time, location, and consumer need, and serves to maximize efficiency during peak periods of demand. This provides drivers with an economic impetus to make better decisions when choosing to drive their personal vehicle or opt for a different mode. Fees are set to ensure that a couple of vacant spaces always exist for those willing to pay for it.

- *Smart parking deployment:* integrates various smart parking concepts to develop an optimal smart parking system based on the needs of an area. These systems may include the use of real-time parking availability, parking reservations, transit-based information systems, and dynamic pricing (*7*).

Project Financing through Value Capture

The parking management strategies mentioned in this report thus far aim to increase accessibility within urban centers. Accessibility measures the ability of individuals to reach locations such as work, school, shopping, etc. The increased ease of movement between destinations that such transportation infrastructure provides creates value for the project. Transportation improvements also create economic value. This economic value arises from the increased accessibility (i.e., time and fuel savings from relieved congestion) and from the resultant appreciation of land values. As accessibility increases around an area, either through such investments as highway expansion or improved transit service, the land itself becomes more desirable (*8*).

This section explains information on strategies designed to capture the incremental value. An introduction into what these strategies aim to achieve, as well as an examination of the most common forms of value-capture, are provided. As part of the analysis of these projects, identified strategies will be examined based on their effectiveness and suitability for implementation in a given area.

What Is Value Capture?

Value capture is a financing mechanism that captures the increased value of a parcel of land as a result of public infrastructure investment. These funds are then available either to reimburse local agencies for the original public investment, or to fund new projects. This type of project financing is not a new tool for local agencies. Value capture has been in use since the 18th century and has been adopted by at least 30 countries around the world (*9*).

For this project, researchers examined literature thought to be the most directly related to the purpose of this report. This is not an exhaustive listing of value capture literature in this field, nor does it explore the nuances within each method. Instead, the literature examined for this report provided researchers with a general understanding of the value capture process and the most common mechanisms used for transportation related purposes. The next sections give an overview of value capture legislation in Texas, the function of the most common value capture strategies, and a brief overview of how these tools could be used by local governments to better leverage the value of infrastructure improvements associated with more efficient parking systems.

Value Capture Methods

These mechanisms have a wide range of purposes from encouraging increased mass transit utilization (Transit Based Information [TBI] smart parking systems), to mechanisms that favor transportation investments. The following provides a brief overview of several value-capture methods, their usage, and major considerations regarding implementation. Table 1 summarizes common value capture options along with corresponding enabling state legislation. Value capture methods without direct state legislation are mentioned in the following section.

Table 1. Texas Value Capture Funding and Financing Options Authorized by Law.

Option	Statute Enabling Code	Key Provisions
Tax Increment Financing	Texas Tax Code Ch. 311	• Tax increment financing (TIF) districts are created by counties and municipalities. • A municipality or county can create a Tax Increment Reinvestment Zone (TIRZ) pursuant to this chapter; however, only a city may issue bonds pursuant to the Texas Constitution. • Cost of improvements within the districts is repaid through the future taxes levied against property owners.
Transportation Reinvestment Zones (TRZ)	Texas Transportation Code Ch. 222	• A form of tax increment financing designed to address added value from transportation projects. • Under current law, cities, counties, and port authorities have the authority to establish a TRZ. • Many local governments have used tax increment reinvestment zones and tax increment financing, but a TRZ allows for a broader range of transportation projects and does not require a local entity to create a board.
Special Assessment Districts	Texas Local Government Code Chapter 372	• Provide infrastructure and services in a designated area. • May serve as tools to help raise revenue. • Typically can come in two forms: a municipal management district and public improvement district. • These districts can provide a source of revenue of funding for capital improvements and, if authorized, used to fund operations and maintenance activities. • These districts are common: Nearly every major Texas city has at least one special assessment district.
Development Impact Fees	Local government Code Ch. 395	• Charge or assessment by political subdivision to generate revenue for funding or to recoup loss from expansion of existing systems for new development.
Local Government Corporation	Texas Transportation Code 431	• Enacted to help “encourage donations of right of way for state highways, and donations of funds for preliminary planning and design for those highways.” • Helps provide cities and counties with an additional vehicle to conduct public-private partnerships for transportation projects.
Chapter 380 Economic Development Programs	Local Government Code Ch. 380	• Authorizes municipalities to offer a range of incentives to promote state or local economic development. • Authorizes grants and loans to city funds for economic development purposes; does not specifically provide for a specific tax or fee to fund these grants and loans. • A home-rule municipality may issue bonds to fund an economic development program, per certain conditions.

Source: TTI

The subsections below provide further information on each option presented in Table 1 above.

Tax Increment Financing

Tax increment financing (TIF) is a widely-used tool for capturing the value of infrastructure improvements. This value-capture mechanism is structured in the form of districts that manage collection and distribution of funds. The common responsibilities of a TIF board can be found in Table 2.

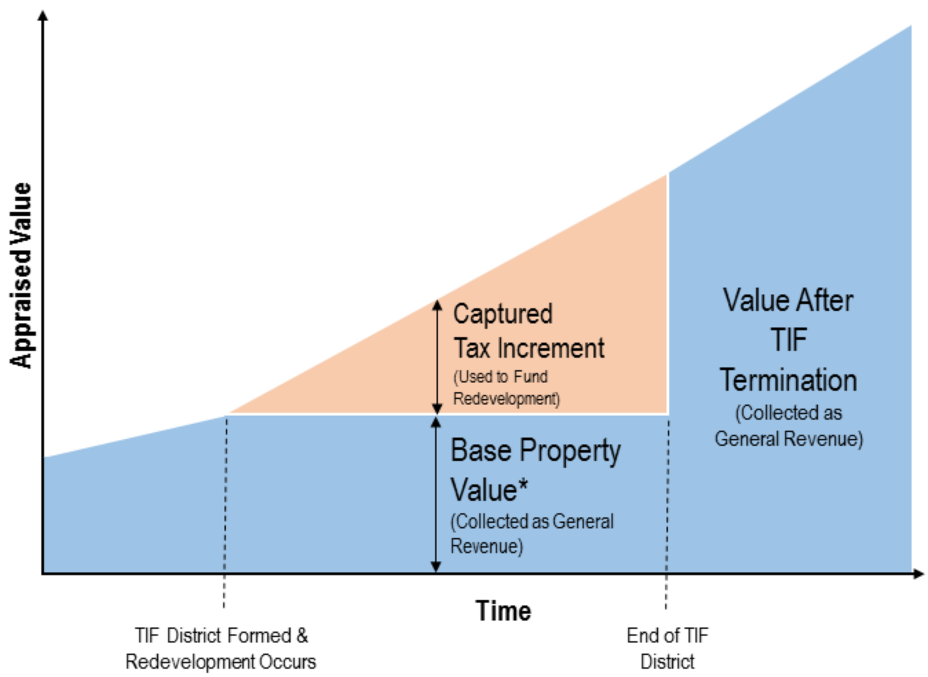
Table 2. Common Responsibilities of a TIF Board.

Element	Description
Establish Authority	Authority to manage the TIF District that is normally delegated to a municipality or county can be further delegated to a commission or an authority.
Assess Needs	Most states require a "qualitative" or "quantitative" blight finding. Additionally, states often require that applicants show the redevelopment would not occur without a TIF in place. Some even require a cost-benefit analysis to justify their existence.
Draft a Plan	Most statutes require a formal development plan that tells the home-rule municipality the purposes for which a TIF may be used. These can include costs of land assembly and building demolition, rehabilitation and repair of buildings, costs of relocation of persons and businesses, and the costs of infrastructure.
Adopt a Redevelopment Plan	Provide a public hearing and notice, and develop a strategic plan for the redevelopment of the respective area.
Draft a Finance Plan	Develop a plan that details exactly what form the financing will take. Traditionally, TIFs rely on bonds or developer up-front funding repaid with the incremental revenues as they accrue.
Set Monitoring Function	Many states require some form of accountability, such as an annual report to the state.
Plan for Termination	Many states allow TIFs to exist as long as necessary to accomplish their purpose. For this reason, many states require TIF boards to establish a termination date. In Texas, many TIFs are only authorized to exist for a period of around 40 years.

Source: (10)

Some common variations of TIF are Tax Increment Reinvestment Zones (TIRZ), Transportation Infrastructure Zones (TIZ), and Transportation Reinvestment Zones (TRZ or TRIZ). These types of zones function similarly to each other, but vary in size, scope, and purpose as defined by the Texas Tax Code.

What a TIF district is designed to do is set aside the incremental value increase resulting from infrastructure investment. These fund set-asides are usually only captured for the life of the district (*8*, *11*, *12*). Figure 2 shows how a TIF functions. Prior to TIF creation, property values fluctuate slightly. Once a TIF district is formed, the property value that will be levied for general revenue will be frozen. Any additional value created will be levied for the district to repay redevelopment/investment costs. After the capture period concludes, the full value of the property will be collected as general tax revenue for the local taxing agency (*12*). As such, this type of value-capture mechanism would be better suited for single investments over a large area, such as a new highway facility, transit line, or transit facility (*8*, *11*). A challenge to applying this type of program is that the economic impact of transportation improvements is not always clear. As such, there is risk involved with relying on increases in land value to fund a project.



**General revenue from property values frozen at value prior to TIF creation*

Figure 2. Tax Increment Financing.

To establish a TIF district within Texas, the TIF's location must meet certain criteria. The criteria generally involve geographies that are blighted, underdeveloped, or would otherwise not experience growth unless investment is made. A full list of criteria can be found in Chapter 311.005 of the Texas Tax Code.

The exposure faced by TIF districts arises when assessed values within the district fall because of an external influence, such as an economic downturn. If projects are being funded or repaid exclusively through increment revenue, there is a high risk to the governing authority of the TIF.

Transportation Reinvestment Zones

In 2007, the Texas Legislature created transportation reinvestment zones (TRZs). A TRZ is similar to a TIF in the way it leverages economic value growth: it allows local governments, such as counties or municipalities, to establish a jurisdiction and raise funds using part of the incremental growth in property and sales taxes as a result of transportation improvements/ investments. This incremental tax revenue can be used to support funding and financing from the growth in the tax base. Funds from this increment gain can also be combined with traditional and non-traditional transportation funding sources (i.e., state gas tax funds, vehicle registration fees, Mobility Fund bond funds).

First authorized by SB 1266 in 2007, the Texas Legislature has made several mostly incremental changes to TRZ legislation. Since 2007, lawmakers have changed TRZ enabling legislation to allow for increased flexibility in their adoption and implementation (HB 563 in 2011), changing which types of projects could be funded through a TRZ (SB 1110 in 2013), and expanding their authority to include port and navigation projects (SB 971 in 2013).

While TRZ legislation has not been used specifically for parking improvements, the broad authority does allow a municipality to establish a TRZ and use those funds for transportation infrastructure that could increase the value of an urban area. This is dependent on the type of project funding, such as a state infrastructure bank (SIB) loan or general obligation bonds. Using a SIB loan would require the money to be spent on a state highway project. However, a TRZ could be set up to help fund roadway improvements while other revenue sources that would have normally been directed to fund those improvements could be used instead to implement smart parking and other parking enhancements.

Special Assessment District

Special assessment districts are a type of tax that is placed on a designated area in order to fund a transportation improvement. The basis of this imposed tax is that those being taxed will receive a marginal benefit from the transportation improvement (*11*, *13*). This method has been used widely to fund minor improvements such as streetlights, transit stops, and sidewalks (*8*). A challenge associated with these districts is that the imposed fee is highly visible. This can create political concerns as it is, on the surface, a new tax.

Other Value Capture Options

Transportation Utility Districts

Similar to special assessment districts, transportation utility districts are an imposed tax specific to the addition of a new facility. Much like water and sewer lines, transportation facilities can be seen as a utility that should be financed through user chargers (*11*), where the funding is proportional to expected use of the facility (*8*). Similar to special assessment districts, this tax is visible and can be difficult to implement due to political concerns.

Development Impact Fees

Development impact fees are another form of usage fee that can be imposed by a city to provide more proportional funding for transportation facilities. Instead of a recurring tax, developer impact fees are one-time fees on new development used to offset the cost of adding a transportation facility. These additional costs typically come from the need to install new infrastructure, such as water and sewage lines, and the increased demand on existing infrastructure. These fees can be calculated either through a demand-driven or improvement-based systems (*11*). These fees are used in more than half of the states (*8*) in the country. These fees are not highly visible, but must be calculated appropriately to retain demand for new development (*11*). These additional costs to developers are typically passed on to the consumer in the final cost of the development.

Negotiated Exactions

Negotiated exactions are similar to development impact fees in almost every way. The difference between these mechanisms lies in the means of determining the fee. This process involves less formal negotiations between developers and local jurisdictions (*11*).

Joint Development

Joint development is a value-capture method in which a private developer will either implement or provide funding or financing assistance for new transportation projects. In many cases, these joint developments merely reflect concurrent interests between local jurisdictions and developers (*11*). In addition to these developments, exactions or impact fees are often present as well. Joint developments reflect cooperation between parties, changing the dynamic from the jurisdiction providing infrastructure and the land developer consuming it (*8*). This can be a valuable tool when developers are producing transit-oriented developments (TODs) (*13*).

Air Rights

Air rights are a form of value-capture that establishes developer rights above or below a transportation facility, such as a depressed highway or subway/metro system (*11*). These transportation facilities improve accessibility, thus increasing land value. In turn, the value of the land above the transportation facility can be marketed and leased to developers (*8, 11*). Often, this source of revenue will follow the initial investment in the infrastructure, posing risk to the local jurisdiction. However, the feasibility of this financing mechanism increases if used in conjunction with a joint development (*13*).

Local Government Corporation

Enacted into law in 1984, a local government corporation (LGC) is a corporate entity that is formed by a municipal or county government to act on behalf of that city or county. By establishing a separate corporation, a city or county can be protected from lawsuits. In addition, an LGC limits the risk incurred by the local government.

Chapter 431 of the Texas Transportation Code established specific guidelines for the creation and operation of LGCs in the state. In Texas, transportation projects developed by an LGC must be part of the state highway system; projects on the local transportation system are not permitted. For this reason, LGCs may not be a suitable tool for funding parking programs. However, future legislative changes to LGCs could broaden their purview so that they could finance local infrastructure improvements both on and off the state transportation network.

Chapter 380 Agreements

Chapter 380 agreements refer to Chapter 380 of the Texas Local Government Code. This legislation authorizes Texas cities to provide assistance for economic development. Texas cities may provide several resources, including monies, loans, city personnel, and city services for the promotion and encouragement of economic development.

Before 1987, Texas cities were unable to provide economic assistance to businesses for the promotion of economic development. In 1987, Texas voters approved a constitutional amendment authorizing "the making of loans and grants of public money…for the public purposes of development and diversification of the economy of the state, the elimination of the unemployment or underemployment of the state…or the development or expansion of transportation or commerce in the state."[8]

The relative flexibility of this tool means that it has the potential to serve as one of the best tools available for the application of smart parking management technology. Because many parking lots are owned and managed by private corporations, a tax abatement or other form of assistance could be granted to a private company, as long as there is demonstrated proof that the improved parking system provides a tangible public benefit.

Value Capture as Opportunity for Local Governments

The strategies mentioned above could be potential options available for regional and local policymakers to better leverage value created from land use changes from underutilized surface parking lots. Experience in other states suggests the efficacy of employing opportunities to utilize land value taxes as a mechanism to incentivize productive uses of property and to disincentivize maintaining unproductive properties in high-value locations.

Land-value taxes (LVTs) are a type of value-capture method that assess a tax on the value of the land rather than the improvement on a piece of property. After the development of a transportation facility, this tax captures the value of the added benefit of the public good, most notably through the increase in accessibility (*11*). As a result, this split tax rate could be beneficial to the redevelopment of a property, such as underdeveloped lots in downtowns where demand is high and supply is low, as it incentivizes improving parcels quickly to have the largest return on investment (*8*, *14*, *15*).

Taxation changes can be hindered by political and public opposition. As such, LVTs have not been widely used in the United States. However, there are a few cases studies of this type of tax policy being successful. During the 1970s, the city of Pittsburgh implemented a LVT on its property that taxed land at six times the rate of buildings. As a result, Pittsburgh saw a much larger growth in commercial development relative to comparable cities (*16*, *17*). There may be limitations to this type of taxation policy. It is difficult to properly assess land value, and even more so to assess the increase in the value of land as a direct result of a transportation improvement. As such, it would be more useful in a large area of a city (*14*).

Ultimately, the funding options above could be used to better leverage the value in changes in land use to help fund and finance improvements to surface parking lots and vacant land. In addition to changes in land use for underutilized land, other technologies could better maximize the potential benefits from existing parking facilities in urban areas. One set of technologies,

[8] Texas Constitution art. III, § 52-a.

known collectively as “smart parking,” could also be considered. The sections that follow will feature case studies of urban areas around the U.S. and present potential ways these lessons learned could be applied to Texas.

Smart Parking Case Studies

SFpark, San Francisco, California

Curb space is being reconsidered as a valuable commodity rather than a free good, forming a conceptual basis for the adoption of a pricing model that ensures at least one parking space is available on each block in urban areas each day. The goal is to eliminate underpriced parking and reduce the number of drivers cruising[9] streets to find an open space. Cruising to find a parking spot leads to wasted fuel, additional air pollution, increased carbon emissions, and worsening traffic congestion (*7*). Cruising greatly impacts traffic congestion with an average of 34 percent of cars in congested downtown traffic looking for parking (*18*). A study conducted in a 15-block Los Angeles commercial district estimated cruising caused an excess of nearly 1.5 million vehicle kilometers (approximately 932,000 miles) of travel per year (*19*).

SFpark is a parking management program the city of San Francisco developed with the help of a grant from the U.S. Department of Transportation. The program used variable pricing techniques to set the prices of curb parking by installing meters that charge variable prices and sensors to report the occupancy of each space in real time (*18*). With this technology, the city adjusted curb parking prices in response to the observed occupancy rates, and sought a pricing structure that varied by time and location throughout the city (*18*).

The intention was to maintain two or more open spots on every block by setting the optimal price to achieve this goal for each specific block. Underpriced parking can have a large social cost, but overpriced parking can cause spaces to remain empty contributing to the loss of customers for nearby stores, loss of jobs to employees, and loss in tax revenues to governments (*19*).

SFpark had a positive impact on traffic congestion and traffic volumes. The key findings from the SFpark pilot program are:

- 43 percent reduction in the time it took for drivers to find a parking spot, resulting to drivers finding parking within 6.5 minutes.
- 30 percent reduction in vehicle miles traveled and greenhouse gases from vehicles searching for parking.
- 8 percent decrease in traffic volumes in areas with improved parking availability.
- 22 percent reduction in double parking in pilot areas (*20*).

Opposition to the SFpark program included the group, ANSWER (Act Now to Stop War and End Racism Coalition), as they believed the program was an attempt to defeat workers and small business. Another major source of opposition was from the business community who feared that metered parking would affect customer satisfaction. In practice the city used the additional

[9] Driving around surrounding streets and parking lots to find a parking spot.

revenue generated through metered parking for the funding of public services. San Francisco uses all parking meter revenue to subsidize public transit. As SFpark revenues increase, more low-income families relying on public transit can be served (*19*).

The overall goal of the program was to optimize efficiency, not to maximize revenue (*20*). The program was relatively well-received as it was fairly transparent to the public.

Results

With two groups of customers: short-term (hourly parkers, visit to shop or eat at nearby businesses) and commuters (park all day via early bird or monthly parking passes and storing their vehicles for nine or more hours per day), SFpark maximized the efficiency of the garages (*20*). Benefits provided to businesses because of SFpark include:

- The amount of time needed to find a parking space decreased by 41 percent from a search time of 9.2 minutes to 6.5 minutes.
- The number of short-term parkers in garages increased by 11 percent or about 130,000 short-term parkers per year.
- Of respondents surveyed in the pilot areas before and after the implementation of SFpark, 74 percent stated that it was "somewhat or very easy to pay for parking" (*20*).

Downtown Columbus, Ohio

The Capital Crossroads Special Improvement District formed in 2001 with the goal of creating a downtown that is the cleanest, safest, and best place to live, work, and play in Central Ohio. The special improvement districts (SID) composed of property owners, with property taxing authority, agreed to pay for the services necessary to pursue this goal. The group hires safety ambassadors, special-duty police officers, a homeless outreach specialist, and a safety coordinator. It also maintains a public-private partnership with the city and business owners in the area.

A group of property owners realized one of the biggest problems facing them was the lack of parking to accommodate the more than 40,000 downtown workers. Instead of spending millions of dollars on the four parking garages it would take to accommodate this number of workers, business owners opted to make transit more appealing by offering free transit passes for employees. Free transit passes were offered to district workers, allowing them to ride the bus for free instead of driving to work.

The program would cost $5 million, half of which would be paid for by the 550 property owners in the Capital Crossroads Special Improvement District. The business owners would be taxed three cents per square foot of space per year, and the other half would come from grants funded by foundations.

Results

An $80,000 pilot program was conducted from June 2015 through January 2017 and involved 844 employees from companies in the district (*21*). Throughout the pilot program, the proportion of those commuting by bus almost doubled, from 6.4 percent to 12.2 percent (*21*). One commuter estimated savings of at least $150 per month in parking costs. The District estimates that if the program continues and expands to all 40,000 plus employees:

- 2,400 parking spaces would free up.
- 4,000 to 5,000 people would trade their current mode of transportation for transit.
- An additional 2,900 employees could work in the District (*21*).

The program would especially benefit the District's low-wage employees in the service industry, who usually cannot afford to drive to work and park. Low-wage employees who make less than $25,000 comprise 19 percent of the employees working in the District, among these, eight percent are paid less than 150 percent of the poverty level (*21*). The program provides employees with options reducing high worker turnover attributable to the un-affordability of transportation, saving businesses money.

Smart Parking Systems, Istanbul, Turkey

Turkey's largest city, Istanbul, is also the country's largest industrial hub, generating 55 percent of Turkey's trade, 22 percent of Turkey's gross national product, and containing 33 percent of Turkey's commercial enterprises (*22*). With Istanbul's large economic role in the country, the city's population has doubled to over 13 million people since 1986. During this same period, the number of registered automobiles in the city has increased by six fold, reaching 1.7 million vehicles (*22*). Negative consequences, including traffic congestion, accidents, and exhaust emissions, have caused the city to rethink their transportation system.

Many of the everyday trips generated consist of private vehicles using the highway; the existing rail-based public transport was unable to accommodate the needs of traffic demand (*22*). Transportation demand management strategies were evaluated, and a smart parking guiding system was determined to be the best method to reduce congestion and preserve the historical and cultural heritage of the city.

Fatih Municipality, a metropolitan municipality within the City of Istanbul, is a high-density historical area with many tourism-related facilities such as hotels, restaurants, and souvenir shops. Some of the roads in this area were closed to vehicle traffic to protect pedestrians and the historical architecture of the area, which in turn has improved traffic.

Smart Parking System (SPS) was the system adopted by the Fatih Municipality to help reduce traffic congestion for drivers trying to find parking that fit their needs. As a kickoff to the project, a social survey was distributed to assess the current traffic and transportation problems and gauge the perception from stakeholders in the historical area. Feedback from the survey showed traffic as the major issue, indicating a parking system that maximized the efficiency of existing parking facilities and limited cruising by vehicles would be the most beneficial. The goals of the program are as follows:

- Reduce the number of vehicles looking for available parking lots.
- Motivate drivers to use car parks outside the most congested area by utilizing the shuttle bus service.
- Alleviate traffic congestion in the central area.

The program used internet and smart phone applications to provide drivers with updated information on parking locations, parking fees, capacity, occupancy rates, and access to car parks. Information boards were installed at access points providing drivers with real-time free space information every 5 minutes.

A shuttle bus service that operated every 15–20 minutes during off and on-peak hours was available only to program participants. The goal of the shuttle bus was to encourage users to park further from their destination, knowing a ride would take them to their destination (*22*).

Results

The SPS Pilot Project results showed:

- Shorter travel times for users by 20 to 30 minutes.
- Shorter travel time for around 90 percent of parking users, with trip times from car parks to destinations of no more than 10 minutes.
- Several users of the program switched from a private vehicle and taxi to walking (*22*).

The users of SPS expressed high anticipation for expanding the program to other parts of Fatih/Istanbul, and even illegal parkers showed positive interest in the SPS, although the program did not lead to their utilization of legal parking lots.

Future Expansion of the Smart Parking System

The city of Istanbul is part of the CitySDK (Smart City Service Development Kit and its application pilots) project, which partners with other cities to create smart mobility, tourism, and active participation. The city of Istanbul plans to improve the project management structure of the SPS program. Transportation planners believe that the program could be strengthened through the following:

- Additional campaigns and public relations activities to promote the utilization of legal parking areas.
- Enforcing existing parking regulation to incentivize compliance among illegal parkers.

Value Capture Redevelopment Case Studies

For this step in the process, researchers sought case studies of value capture being used in the redevelopment process. Researchers focused on studies that examined redevelopment of underutilized parcels within urban cores to leverage revenue for transportation infrastructure. Because of the uniqueness of this scope, a limited number of examples were found. Two major studies were identified, which will serve as the basis for estimating potential revenue.

Center for Neighborhood Technology

The first report examined was a study conducted in 2006 by the Center for Neighborhood Technology (CNT) in Chicago, IL. The study examined the development potential of surface parking lots in the Chicago area (*23*). While they focused on transit-oriented development, the same general principles could be applied to the development of smart parking systems.

The study examined 84 transit station areas and selected nine surface parking lots in these areas to act as case studies. After selecting the case studies, CNT created potential development scenarios that were realistic for each area, allowing them to estimate potential revenues from development of the surface parking lots. The results of these case studies are shown in Table 3.

Table 3. Estimated Captured Revenues from Parking Lot Redevelopment.

Station	Surface Parking Spaces	Parking Lot Net Annual Revenue	Potential Annual Property Tax	Potential Net Annual Public Revenues
Arlington Heights	180	-$33,120	$606,981	$640,101
Palatine	235	$39,574	$287,673	$248,099
Hanover Park	1,302	-$75,256	$569,987	$645,243
Oak Park	88	$19,501	$178,560	$159,059
LaGrange Road	230	$24,380	$363,217	$338,837
Franklin Park	190	-$11,476	$479,293	$490,769
Homewood	215	$50,740	$375,851	$325,111
Blue Island	795	-$52,669	$533,652	$586,321
Tinley Park	1,733	-$95,662	$528,425	$624,087

Source: (23)

During their research, the CNT also developed a set of recommendations for organizations undertaking transit-oriented development. The relevant recommendations are as follows:

- Establish a joint development authority to oversee development.
- Incorporate transit oriented development principles into planning and policy.
- Place more emphasis on land value taxation over improvement based taxation system.

While the parking lots provided in this case study do not fall within the urban core, the methodology provided in this report will help researchers develop a unique methodology for estimating potential revenues. As land values vary greatly by city, it will be necessary to formulate a methodology that considers variables that can be estimated for each city.

U.S. Government Accountability Office

The second report came from the U.S. Government Accountability Office (GAO) and focuses on past redevelopment that incorporated value capture methods (*24*). The 2010 study collected data from 55 transit agencies to determine what value capture methods had been used to fund the development of transit facilities. Of the 55 agencies studied, 32 reported that they had previously used joint development, and 19 had used tax increment financing, special assessment districts, and/or development impact fees to leverage transit funding from redevelopment. These developments varied greatly in size, though many were a single parcel near a transit station. Others were much larger, such as Atlanta’s Lindbergh City Center, which covered 47 acres of mixed-use development. The GAO found that revenues generated from value capture methods were typically small relative to operating expenses.

Per the GAO, agencies using joint development typically shared these four characteristics:

- Operate older, larger fixed-guideway systems.
- Have formal joint development or transit oriented development policies.
- Have in-house real estate expertise.
- Have developable land holdings on which to build joint developments.

The report found that the permanent nature of fixed-guideway systems made development more attractive than on non-fixed-guideway systems, although there were some exceptions, including King County Metro in Seattle, which implemented several joint developments at permanent intermodal transit centers. Finally, these agencies reported that having developable land was important for joint development. Many of these agencies converted existing surface park-and-ride lots into transit-oriented developments with parking structures.

The GAO report focuses on the development of capital improvement projects for the transit agencies. Most of the projects listed in the report look at transit infrastructure, such as new fixed-guideway systems, transit centers, and streetcars. However, the report also examined some transit-oriented developments that did not rely on joint development and instead focused on other value capture strategies. These case studies would be applicable to the redevelopment of underutilized parking lots. These can be seen in Table 4.

Table 4. Major Transit Infrastructure Projects Funded by Value Capture.

Transit-oriented development (status)	Location	Value capture strategy(ies)	Amount of revenue generated through the use of value capture strategy(ies) ($ in millions)	Onsite infrastructure improvements funded through the use of value capture strategy(ies)
BART Pleasant Hill transit-oriented development (in progress)	Contra Costa County, CA	Tax increment financing and special assessment district	$750	Backbone infrastructure, such as roads and drainage systems; place-making infrastructure, such as parks and plazas; and a new structured parking garage to replace the station's existing surface parking lot.
Dallas Area Rapid Transit transit-oriented development tax increment financing district (established)	Dallas, TX	Tax increment financing	$182	Basic infrastructure improvements, including parking garages and water and sewer systems.
MDOT State Center transit-oriented development (in progress)	Baltimore County, MD	Tax increment financing (backed by a special assessment district)	$100	Structured parking, station amenities, affordable housing, and other infrastructure improvements, in combination with other local bonds.
MDOT Owings Mills transit-oriented development (in progress)	Baltimore County, MD	Tax increment financing and special assessment district	$60	Tax increment funds to pay for the construction of two state-owned parking garages and special assessment funds to pay for the operation of state-owned garages, roads, and other improvements.
MDOT Savage transit-oriented development (in progress)	Howard County, MD	Tax increment financing (backed by a special assessment district)	$14	Structured parking garage to replace the commuter rail station's surface parking lot.

Source: (24)

A key case study included in this report is the development by Dallas Area Rapid Transit (DART). DART established tax increment financing districts along the light rail lines to pay for infrastructure such as streets, water and sewer systems, and portions of parking garages. The revenue collected from this district, as reported by the GAO, is $100 million. This will aid in estimating revenues of value-capture for these types of projects specifically within Texas.

From the findings, it is noted that revenue from value capture strategies vary by project. In none of these cases were value capture mechanisms able to fund the entirety of the project. However, the funds generated were critical to a project's success (*24*). Officials from Washington Metro, the Seattle Department of Transportation, Portland Transit, and the Maryland Department of Transportation all noted in the report that value capture revenues were necessary in the development of the project.

The findings from these case study reports provide researchers with information to inform their determination of the potential values of underutilized parking lots in Texas urban cores. Actual redevelopment values and tax increment revenues from these case studies are compared to the findings in this report.

Analysis

The analysis conducted in this report is divided into two sections: congestion mitigation from smart parking systems and value added and revenue estimation. Due to the nature of the project, the research team needed to conduct two different analyses to help determine the overall value of urban parking spaces in downtown Houston. The smart parking systems and congestion mitigation portion of the analysis examines the current parking situation in downtown Houston and calculates the congestion and dollar value of benefits if a smart parking system were to be implemented in downtown Houston. The value added and revenue estimation portion of the analysis assesses the value of redevelopment of the existing surface parking within downtown Houston.

Data Collection and Parking Inventory Development Database

Data for the analysis of this report came primarily from the Harris County Appraisal District (HCAD) public data (*25*). The downloaded data included 2017 parcel spatial and account data, existing TIF district shapefiles,[10] existing management districts, and tax entity boundaries.

Additional parking inventory data came from the Houston Downtown Management District. This group provided public and private garage/surface parking locations that were matched against HCAD parcel data. An on-site evaluation of the parking in downtown Houston was warranted due to the quickly changing nature of the land use in downtown Houston. Researchers spent a full day matching the on-site data with the recorded data and addressed any changes needed. The research team used this confirmed on-site data to conduct the analysis.

Parcel data provided 2017 assessed values for land, improvement, extra features, and total assessment. Additional data on commercial and residential parcels provided land and improvement (building sq. ft.) areas for each parcel. Parcel data in combination with the on-site inventory analysis was used to classify the current parking facility types in downtown Houston and create the parking inventory database to be used throughout the methodology.

Methodology: Smart Parking Systems and the Congestion Benefit

Estimating the True Mean Percent Occupancies of Parking Facilities

To gain a better understanding of the current parking situation downtown Houston faces, the research team needed to estimate the true mean percent occupancy of each parking facility type: public surface lots, private surface lots, public parking garages, and private parking garages. Researchers ran a statistical analysis to determine the sampling size for each group of parking facilities, based on the total number of parking facilities. Table 5 displays the total number of

[10] TIF districts in Harris County are established as tax increment reinvestment zones (TIRZs). As such, this is the nomenclature that will be used to refer to these districts for the rest of the report.

parking facilities in each group and the sample size needed to estimate a statistically significant occupancy for each group.

Table 5. Total and Sampling Size of Each Parking Facility.

Type of Parking Facility	Total Parking Facilities	Sampling Size of each Parking Facility (n)
Public Surface Lot	79	20
Private Surface Lot	18	8
Public Parking Garage	58	12
*Private Parking Garage	15	5

**Denotes limited accessibility of garage access*

After the sample size for each group was determined, on-site data collection was conducted during two peak workdays to determine the occupancy of each parking facility. Occupancy was observed during two periods: 9:30 a.m. to 12:00 p.m., and 1:30 p.m. to 3:30 p.m. These times were chosen because most parking facilities will experience their highest occupancy during these time spans, as most travelers have reached their work destinations during these times. Researchers conducted a trial run on a Friday (an off-peak day) to determine the length of time it would take to sample the total number of parking facilities during the selected periods. Researchers collected the occupancy data for the surface lots and garages by counting the number of vehicles on each floor (for garages) and in the parking lot (for surface lots). Many private garages restricted access that limited or eliminated the ability to perform an accurate count.

To determine the occupancy for each parking facility, researchers ran a statistical analysis to estimate the true mean percent occupancies. Two confidence intervals were identified as possibilities to use for the statistical analysis, based on a 95 percent confidence interval: z-confidence and t-confidence. The formulas for each of these confidence tests for the mean occupancies are given by:

- ***Z-Confidence*** – to be used if the sample size is large:

$$\bar{X} \pm (z\ critical\ value)\frac{\sigma}{\sqrt{n}}$$

- ***T-Confidence*** – to be used if we can assume the percent occupancies are normally distributed:

$$\bar{X} \pm (t\ critical\ value)\frac{s}{\sqrt{n}}$$

Results

Since the sample size is small, less than 30, t-confidence interval tests were selected for this project. A normality assumption is needed for the percent occupancies to use the t-confidence interval test. Table 6 shows the results of the t-confidence interval test for the estimation of the true mean percent occupancy.

Table 6. Summary Statistics and Confidence Intervals for the True Mean Percent Occupancy by Parking Facility.

Parking Lot Type	*N**	$\bar{X}$ (%)	*S* (%)	Lower Limit for 95% CI**	Upper Limit for 95% CI
Public Surface Lot	20	54.1	33.1	37.4	67.6
Private Surface Lot	8	45.8	22.3	27.1	64.5
Public Parking Garage	12	66.4	21.2	52.9	79.9
Private Parking Garage	5	37.4	21.4	10.8	63.9

**n represents the sample size.* ***CI denotes a t-confidence interval*

Based on the occupancy ranges listed above, public parking garages are used most efficiently with a conservative mean occupancy throughout Houston of 66.4 percent (upper limit occupancy of 79.9 percent). Public and private surface lots have a much lower occupancies and are used less efficiently with respective mean occupancies of 54.1 percent and 45.8 percent, both with upper limit occupancy of only about 65 percent.

The results of this preliminary analysis suggest that the existing parking supply within downtown Houston is highly underutilized, with slightly less than half being used throughout the day. For the purposes of this report, this analysis simply suggests that parking facilities could be removed through redevelopment, especially if a smart parking system increased how efficiently the parking supply is used. While additional parking would likely be desired for any new development, opportunities exist for a reduced supply in the new development, shared parking with other surrounding uses, and other parking policy strategies.

Estimated Congestion Benefits of a Smart Parking System

Researchers used the results of SFpark and other similar systems integrated into TTI's sketch planning tool for congestion benefit estimation, the Future Improvement Examination Technique (FIXiT), to help estimate the benefits a smart parking system would provide to downtown Houston. FIXiT uses a variety of data sources, which provide speed values and average daily traffic, to estimate a magnitude value of reduction benefits from the implementation of a congestion mitigation strategy. Congestion mitigation strategies are strategies which can be implemented by cities and state departments of transportation including traffic operations, travel options, system capacity techniques and alternative modes of transportation. These strategies will serve a certain role in the road network system, such as improving efficiency by clearing collisions or improving signal coordination; reducing demand on the system by offering alternatives to driving; or modifying the road network system to use existing road space more efficiently. Parking management is a congestion mitigation strategy that encompasses a smart parking system.

FIXiT uses delay reduction assumptions to estimate the magnitude values of reduction benefits. In the smart parking system case, FIXiT based some of its assumptions on the 30 percent reduction in vehicle miles of travel the SFpark system found through a follow up study. FIXiT translates this and other benefits information into a conservative 4 percent delay reduction benefit for recurring local congestion that is then applied to the local road network.

To determine the benefit a smart parking system would have for the entire road network system around downtown Houston, researchers used the most current speed, volume, and delay information from the Texas 100 Most Congested Roadways database. The Texas 100 Most Congested Roadways list is published annually by the Texas Department of Transportation and ranks the most congested corridors in Texas from over 1,800 roadway segments. Researchers used the downtown freeway dispersal loop as the boundary for this analysis, including all available data inside the loop in addition to the loop itself. This accounts for efficiencies in parking that directly impact collector streets downtown and also have a minor impact on the surrounding state freeway system as vehicles are better able to exit and enter the freeways closer to their final parking destination. Note that this is a conservative network to use as not all of the collector roads are represented (due to lack of data), and some benefits may impact segments directly outside of the downtown freeway dispersal loop. Figure 3 displays the network used for this analysis.

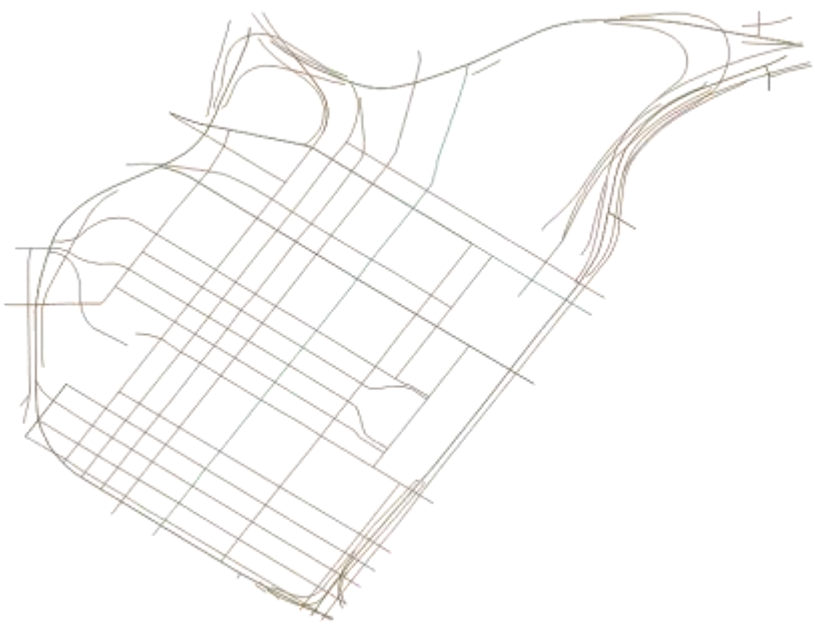


Figure 3. Congestion Analysis Road Network.

Using the roadway network, researchers calculated person hours of delay for both the freeway and non-freeway segments. The FIXiT tool then uses the following equations to calculate congestion benefits in terms of overall delay reduction and congestion cost savings in dollars. Houston consistently ranks near the top for the most congested roads in Texas, costing the city and commuters $22.50 per person hour of delay. Researchers calculated the delay reduction and delay savings using the formulas below:

- ***Delay Reduction*** = Delay Benefit (4%) * Person Hour Delay (by road system type)
- ***Delay Savings*** = Delay Reduction * Houston Cost of Congestion ($22.50)

These numbers were calculated for the freeway, arterial roads, and a combined total of the two roadway types. Table 7 provides a detailed look at the estimated congestion benefits of implementing a smart parking system and the potential congestion savings for the system.

Table 7. Estimated Congestion Benefit for Downtown Houston.

Roadway Type	Person Hour Delay	Delay Reduction (hours)	Delay Savings ($ dollars)
Freeway	3,653,689.00	146,147.56	$3,288,320.10
Arterial	1,296,023.00	51,840.92	$1,166,420.70
Total	4,949,712.00	197,988.48	$4,454,740.80

Methodology: Value Added and Revenue Estimation

Through the literature search and case study review conducted as a part of this report, researchers determined that a form of tax increment financing (TIF) would be best suited for capturing the value of the redevelopment of large surface parking lots.

As shown by occupancy rates of existing parking facilities and estimations of smart parking effectiveness in downtown Houston, the introduction of a smart parking system may cause a shift in land use for large surface parking lots. As such, these parcels are likely to redevelop to a higher value use, and the establishment of a TIF district would be the most suitable form of value capture to use.

Other examined value capture methods would be less effective than a TIF due to how the revenue is obtained. For example, through special assessment districts, the city or management district would be required to tax existing property owners at a higher rate to pay for benefits, which would be a smart parking system in this case. With a TIF, property owners would see no change in the amount they are paying until after the improvement is implemented. This would then raise property taxes according to the new value of the property.

Using a TIF district to collect revenues from smart parking improvements, downtown Houston and existing roadway networks would receive congestion benefits and property value increases for no additional taxes or fees to the property owners if marginal property tax revenues exceed the cost of implementing and maintaining the system. The revenues would come solely from the taxes levied on increased property values.

The first step in this analysis was to determine where within the Houston CBD a TIF would be feasible. This required identifying existing TIF districts, or equivalent, within the study area.

Existing Tax Increment Financing Districts

There are currently two existing tax increment reinvestment zones (TIRZs) within the Houston CBD. As discussed earlier in this report, a TIRZ is a form of TIF, which focuses on the redevelopment of blighted or underdeveloped properties. Both existing TIRZ districts originated in the Houston CBD, but have since expanded. As such, the tax base and area of influence for each TIRZ has expanded past the scope of this project. Per the examination of parking inventory within downtown Houston, the majority of surface parking resides within one of these existing TIRZs. Therefore, any investments using increment tax dollars in these districts must align with the previously established goals.

The following identifies existing TIRZs within downtown Houston and their characteristics. Moreover, any goals related to the construction of transportation infrastructure improvements and other accessibility improvements within those districts have also been identified.

Tax Increment Reinvestment Zone 3: Main Square/ Market Square

The Downtown Redevelopment Authority (the "Authority") established this TIRZ in 1999. The Authority is a public, non-profit agency, which operates under Texas law, Chapter 431 of the Texas Transportation Code, and Chapter 394 of the Texas Local Government Code. The Authority was created through the Tax Increment Financing Act, Chapter 311, Texas Tax Code (*26*).

The purpose of TIRZ 3 in downtown Houston is to facilitate growth of new housing in the CBD. The TIRZ was established for a 30-year period and requires the expenditure of $34 million for public improvements and services to be repaid through tax increment funds generated within the district. Per the creation ordinance, the following improvements are authorized in the TIRZ (*27*):

- Streetscape enhancements (lighting, walks, landscaping, etc.).
- Buffalo Bayou greenbelt improvements (walkways, landscaping, etc.).
- Improvement of sites for residential redevelopment and the provision of housing.
- Utility improvements and security enhancements.
- Pedestrian and parking facilities (above and below ground).
- The acquisition and rehabilitation of historic buildings.

The state of the original area when the TIRZ was established in northwest downtown Houston is noted as having vacant and deteriorating building stock. There was also surface parking in the area.

Since the establishment of the district, there have been eight additions to the original boundary to create the current TIRZ boundary. The current boundaries, within the project area (downtown Houston), can be seen in Figure 4.

Tax Increment Reinvestment Zone 24: Greater Houston

The Greater Houston TIRZ was established in 2012 to facilitate the development of 7,548 acres within the Houston CBD. The TIRZ was established for a period of 30 years, and will expire on December 31, 2042. The area in which the TIRZ was created met the criteria listed in Section 311.005 of the Texas Tax Code as an area that impairs sound growth of the City of Houston due to deteriorating structures, inadequate or defective sidewalk and street layouts, unsanitary or unsafe conditions, and conditions that endanger life or property by fire or other cause.

In addition to the stated reasons listed above, the Houston City Council also deemed the area to meet designation criteria because the land is involved in a connection between a regional commuter or mass transit system, or for a structure or facility that is beneficial to a regional rail system.

The purpose of the zone, per the Greater Houston TIRZ financing plan is to develop public works within the area (*28*). Improvements can include utilities, streets, streetlights, water and sewer facilities, pedestrian malls and walkways, parks, flood and drainage facilities, or parking facilities.

The project cost for the TIRZ is estimated at over $265 million. The TIRZ will spend this amount, and it will be financed by the incremental tax growth from the base period within the area.

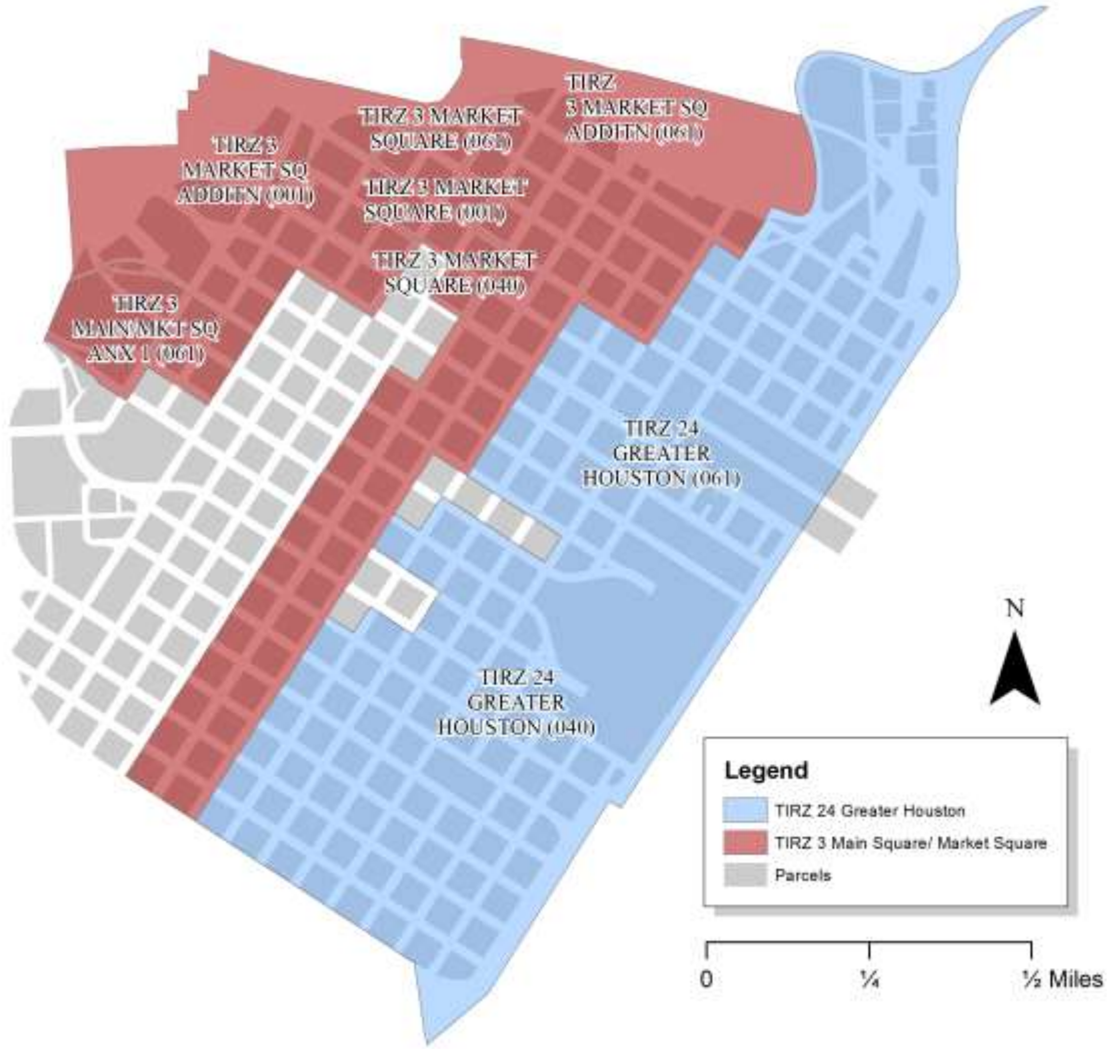


Figure 4. Tax Increment Reinvestment Zones in Downtown Houston.

Source: Harris County Appraisal District (HCAD) Public Data

Redevelopment Identification

Using the parking inventory database, parcels that would be most likely redeveloped due to market changes were identified. For this, only parcels used exclusively for parking were included in the analysis. In the case of private surface lots, it was common to find the improvement (building) included in the same account with surface parking. The combination of parking and improvement made differentiating the value of the building and surface parking impossible. As a result, many private surface lots were eliminated from the analysis.

After lots were identified, researchers sought to identify which of the surface parking parcels fell within existing TIRZs in the CBD. This was done using GIS with the shape file data available through the HCAD database. This resulted in the number of parcels and their total land area.

Estimated Redevelopment Value

The next step in the process was to determine an estimated redevelopment value. Assessed values (2017) of the various land uses within the CBD were used to create an estimated assessed value per improved square foot.

In addition to assessed value per improved square foot, it was also necessary to determine the number of floors for each land use. As the data for the surface parking only provides a land area, it was necessary to multiply the land value by a multiplier to determine estimated improved square foot for each land use.

The calculated values and floor multiplier with the corresponding land uses are shown in Table 8.

Table 8. Land Use Estimated Assessed Value per Improved Square Foot and Floor Multiplier.

Land Use	Assessed Value Per Sq. Ft.	Floor Multiplier
Misc. Commercial	$119.23	1.6
Office	$216.36	11.6
Apartments - Garden Style	$117.98	0.9
Apartments - Mid Rise to High Rise	$208.75	3.0
Real, Residential, Multi-Family	$146.38	3.4
Extended Stay Hotel-Motel	$105.32	1.9
Hotels, Full Service	$162.82	7.8
Motels\Limited Service Hotels	$173.92	7.0
Medical	$122.80	6.6

This analysis excluded exempt properties such as government and religious buildings. The analysis also excluded condominium units. These units are recorded in the HCAD database individually. These units, however, did not include a clear distinction on which building each unit resides within. This resulted in an inaccurate representation of the total square footage of this land use.

After establishing a price per square foot for each land use, total land area of each surface parking lot meeting the criteria for analysis was calculated and multiplied by the values in Table 8. An important distinction was to differentiate between the total square footage and calculated acreage inside existing TIRZs and that found outside of existing TIRZs, shown in Table 9.

Table 9. Total Surface Parking Area for Analysis.

	Square Feet	Acreage
Outside of Existing TIRZ	250,424	5.75
Inside of Existing TIRZ	2,107,733	48.39

Tax Increment Financing

With the total area of surface parking meeting the analysis criteria in the Houston CBD collected, and estimated assessed value per improved square foot for each land use, the next task in the analysis involved building a TIF model to show potential revenues. Inventory was separated by TIRZ and those surface lots not currently in a TIRZ.

A hypothetical TIF scenario was created to determine the potential incremental tax revenues from surface parking outside of existing TIRZ districts. The results from this hypothetical TIF scenario are not intended to be taken as the result of a detailed market analysis of the area, but rather to determine potential untapped revenue that can be generated from these parcels. The parameters for this TIF are as follows:

- TIF establishment: 2018.
- Duration: 20 years.
- Construction start/completion: 2020.
- City of Houston as participating tax entity (0.586420 tax rate).
- Annual growth rate: 2 percent.[11]
- No additional obligations (i.e., affordable housing, flood control).

Projected revenues from each existing TIRZ are not included in this report. Each TIRZ has varying degrees of participation from each tax entity. Moreover, there are existing financial obligations for each TIRZ authority. Therefore, any potential incremental tax revenues generated by the redevelopment of surface parking in these districts are already accounted for.

To determine how the governing board of each TIRZ would choose to allocate additional incremental tax revenues is outside of the scope of this project. Results will show potential assessed value growth from redevelopment of existing surface parking only.

Results

For the purposes of this project, tax revenues are shown for only surface parking lots in the CBD. Typically, when developing a TIF financing plan, the estimated revenue will encompass all properties within the designated boundary.

Analysis of potential added taxable value through the redevelopment of surface parking outside of existing TIRZs, given the parameters set in the previous section, has an approximate range of $82 million to $722 million for 2020. This represents the incremental gains over existing assessed values through redevelopment of all surface parking acreage in the analysis area. Refer to Table 10 for a detailed look at the estimated potential redevelopment for each land use. These

[11] The TIRZ 24 and TIRZ 3 project financing plans were used as reference for growth rates. A 2 percent growth rate was used for conservative estimates. Higher growth rates were used after detailed area analysis was conducted. For purposes of this project, a conservative approach was most appropriate.

values are intended to be independent of the others (i.e., if all acreage used as surface parking in the analysis area were to redevelop as the selected land use). Redevelopment values were calculated based on available land and the values noted in Table 8.

Table 10. Potential Incremental Assessed Value, Outside of Existing TIRZ.

Land Use	Base (2018) ($)	Potential Post-Development Value (2020) ($)	Increment ($)
Misc. Commercial	50,480,163	313,276,936	262,796,773
Office	50,480,163	772,098,079	721,617,916
Apartments - Garden Style	50,480,163	132,066,551	81,586,388
Apartments - Mid Rise to High Rise	50,480,163	271,192,616	220,712,453
Real, Residential, Multi-Family	50,480,163	555,667,809	505,187,646
Extended Stay Hotel-Motel	50,480,163	156,116,040	105,635,877
Hotels, Full Service	50,480,163	442,247,020	391,766,857
Motels\Limited Service Hotels	50,480,163	426,106,433	375,626,270
Medical	50,480,163	319,577,659	269,097,496

**Base year frozen at 2018 values. These values remain frozen for the duration of the TIF.*

The values in Table 10 represent a one-year change in assessed value from the base year (2018) to the set construction year (2020). Using these values, one can calculate incremental tax revenue projected over the course of the 20-year TIF.

If a TIF is set up to capture the tax revenue increment resulting from the increased property values shown in Table 10, using the parameters set in the methodology section of this report, there is an estimated average annual revenue of between $575,000 and $4.7 million, depending on the land use of the redevelopment. A detailed look at estimated revenue per land use is shown in Table 11.

Table 11. Estimated Average Annual Tax Increment Revenue, Outside of Existing TIRZ

Land Use	Revenue ($)	Revenue Per Acre ($)
Misc. Commercial	722,480	125,673
Office	4,657,593	810,171
Apartments - Garden Style	575,362	100,082
Apartments - Mid Rise to High Rise	1,462,732	254,437
Real, Residential, Multi-Family	1,242,108	216,060
Extended Stay Hotel-Motel	728,753	126,764
Hotels, Full Service	2,553,746	444,215
Motels\Limited Service Hotels	2,450,799	426,307
Medical	1,771,340	308,118

The estimated tax increment revenue results do not account for tax delinquency, a lag in tax collections, or any tax exemptions/abatements on new development. The results also do not account for any changes in assessed value to existing development in the area or any administrative costs to establish and maintain the TIF.

The upper boundary of the results is the most unlikely outcome of development. This amount would indicate that all existing surface parking would redevelop as the highest valued land use in the same year. Without a detailed development plan for the entire area, these results are hypothetical. It would be more likely that the surface parking would redevelop as a mix of these land uses.

The results for this part of the analysis show the potential redevelopment value of all surface parking within the existing TIRZs. As stated previously in this report, it is unlikely that every parcel used for surface parking would redevelop simultaneously. This is especially true of the nearly 50 acres of existing surface parking within the existing TIRZ districts.

Examining surface parking within existing TIRZs, the potential changes in taxable values, and resulting revenues collected, is more challenging than lots outside of an increment-financing district. As stated in the Methodology section of this report, each existing TIRZ has unique participation rates by taxing entity, scheduled and completed projects, and various administrative and external costs. As such, it would be outside of the scope of this project to determine how much of the incremental value would be captured as revenue, and how each TIRZ authority would use those revenues.

For this report, researchers estimated the change in value in the year 2020. The year 2020 was chosen to be consistent with the hypothetical TIF scenario developed for properties outside of an existing TIRZ. In addition, this analysis assumed that the value of both existing parcels and redevelopment would grow at 2 percent annually. Each TIRZ was established at different times. TIRZ 3 and TIRZ 24 were established in 1999 and 2012 respectively, which means that their base tax values were frozen in these years. Any added value, such as appreciation of the property, is counted as the incremental value. To simplify the results, the analysis estimated values if redevelopment of all parcels was to occur in 2020.

Table 12 suggests that through redevelopment of surface parking lots currently in TIRZs, there is between $562 million and $6 billion of unleveraged increment tax revenue. These figures assume that all 48.39 acres were to redevelop as a single land use type.

Table 12. Potential Incremental Assessed Value, Inside of Existing TIRZ.

Land Use	No Land Use Change Value (2020) ($)	Potential Post-Development Value (2020) ($)	Increment ($)
Misc. Commercial	336,382,518	1,092,146,816	755,764,297
Office	336,382,518	6,284,934,858	5,948,552,340
Apartments - Garden Style	336,382,518	898,008,796	561,626,277
Apartments - Mid Rise to High Rise	336,382,518	2,068,985,214	1,732,602,696
Real, Residential, Multi-Family	336,382,518	1,777,849,370	1,441,466,851
Extended Stay Hotel-Motel	336,382,518	1,100,425,102	764,042,584
Hotels, Full Service	336,382,518	3,508,691,522	3,172,309,004
Motels\Limited Service Hotels	336,382,518	3,372,841,728	3,036,459,209
Medical	336,382,518	2,476,225,537	2,139,843,018

**Base year represents 2020 values. These values remain frozen for the duration of the TIF.*

Considerations of Findings

Many elements of this analysis are built upon hypothetical scenarios. In reality, land owners in Texas have the right to develop property as they see fit, given that they meet any state, county, and local regulations for development. For purposes of this research, we assume that the real estate markets and auto industries (with the introduction of autonomous vehicles and their ability to self-park) will change due to the introduction of new technologies. This assumption, however, should be accepted with reservations as a multitude of variables affect property owners' decisions to buy, sell, and/or redevelop property. As such, these results are hypothetical in nature and are intended solely to determine whether there is unleveraged value in redevelopment of surface parking.

Another consideration for redevelopment relates to the role of public agencies engaging in public-private partnerships to invest in surface parking. The research conducted in this report suggests that there are millions of dollars in the potential redevelopment of surface lots in the Houston CBD. However, there are also approximately 10 acres of government owned, tax-exempt surface parking within the CBD. While data on the value of this land is not available, these parcels offer ideal opportunities for public-private partnerships to occur.

Summary

The purpose of this report is to identify the potential effects that smart parking systems could have on congestion and land uses within a CBD in Texas, and how value capture methods could provide a source of revenue to partially pay for these and other types of transportation improvements. This report used the Houston CBD as a case study for analysis.

While the analysis approach was limited to the local level, the probable benefits of a smart parking system to the state's roadway network and how these benefits could be garnered at no cost to the state was the focus of the analysis. This report aided in the development of a parking inventory to identify disparities in the assessed values between land use types in the Houston CBD. While this report is narrow in scope, researchers believe that the findings in this report are applicable to not only other CBDs within Texas, but also to the surrounding urban areas where the majority of the population lives, in addition to other similar congestion mitigation strategies.

The analysis conducted in this report suggests that opportunities exist to capture the increased value of redeveloped surface parking lots outside of existing TIRZs in downtown Houston. The results estimate approximately $4.4 million per year in congestion savings for the City of Houston if a smart parking system were to be implemented. Additionally, there are millions of dollars in feasible assessed value not currently being leveraged in existing TIRZs. These existing TIRZs are tasked with improving infrastructure, including transportation enhancements. Improvements to transportation infrastructure at the local level will also benefit the state system; therefore, encouraging local transportation initiatives, in many cases, may increase efficiency of the state system, delaying or eliminating the need for the state to fund other, costlier transportation improvements.

Although an estimated dollar per year in congestion savings was reported, the report does not include an estimated cost value of implementation of a smart parking system in Houston. The case study of SFpark found implementation of their smart parking system was approximately $38.5 million over a seven-year period. SFpark's approximate cost can only be used as a point of reference and not as an estimate for a similar parking system in Houston due to various factors. Additional research will need to be conducted to provide an estimated cost value of a smart parking system in Houston.

It is important to reiterate that although these findings suggest the potential for multi-million dollar values in redevelopment, they rely on hypothetical market changes. The analysis conducted in this report shows disparities between the assessed values of land uses within downtown Houston that may encourage inefficient land uses. Regardless of market changes by private developers, this disparity may offer opportunities for state, county, or local governments to engage in public-private partnerships to leverage additional funds for transportation infrastructure improvements.

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