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On the Impact of Infrastructure Improvement on Real Estate Property Values: Evidence from a Quasi-natural Experiment in an Emerging Market

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Abstract

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Keywords: Infrastructural development, inner-city rejuvenation, real estate pricing, hedonic modeling, value capture.

J.E.L. Classification Codes: C22 R21 R42

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Abstract

Prior studies show infrastructural improvements impact property values positively. The effect is often reflected soon after the announcement and continues until the project is complete. These studies, however, are primarily set in developed countries. Emerging markets pose unique risks where uncertainty around implementation and funding could dampen these positive effects significantly. We utilize a quasi-natural experiment around an inner-city road redesign and improvement project in Bangalore, the fastest growing city in India. We exploit the difference-in-difference regression approach to examine the project's impact on residential and commercial property values around two sets of geographically proximate roads, one of which was chosen for the redesign. Unlike in developed countries, we find that property values are unaffected by the announcement when uncertainty is the highest but start reflecting the positive value of the infrastructure once construction starts and show significant gains upon completion. Our findings carry important policy implications for structuring value capture strategies in emerging markets.

Introduction

The impact of infrastructure development and improvements on property values has been studied extensively in the literature (e.g., Ahlfeldt & Wendland, 2011; Bowes & Ihlanfeldt, 2001; Voith, 1993). The economic impact of infrastructure improvements derives from the bid-rent theory of urban economics which posits that an improvement in accessibility or local amenities *increases* land and property values due to higher productivity, superior quality of life and lower transportation costs (e.g., Vadali, 2014; Mulley et al., 2016). Extant empirical evidence is generally consistent with this notion. However, the context for most of these studies are set in developed markets. To our knowledge, the evidence on the impact of infrastructure development in emerging markets, where infrastructure projects face unique challenges in planning and execution, is scarce. For example, Mohammad et al. (2013) cite only three studies on Asian countries (South Korea, Turkey, and China) in a meta-analysis of 23 studies that examine the impact of railway projects on property values. In a similar meta-analysis of 23 studies on bus rapid transit systems globally, Zhang and Yen (2020) find empirical research in only three emerging markets – Colombia, China, and South Korea.

Moreover, the timing of increases in property values due to infrastructure development and improvements is likely to differ between emerging and developed markets. Earlier work by McDonald and Osuji (1995), and more recent work by Yen et al. (2018) find that much of the increase in property values related to infrastructure projects such as new metro rail lines in developed markets happens between the announcement and start of construction of the project. In emerging markets, however, price adjustment at announcement may be minimal because of budget and execution uncertainty, which may persist beyond construction, causing a delay in the full capitalization of the benefit of the infrastructure. It is, therefore, an open question as to the extent to which the findings from developed economies apply to the emerging countries.

This study aims to shed light on this issue by conducting a quasi-natural experiment in a major metropolis in India, a large and fast-growing emerging market. We study the changes in values of commercial and residential real estate properties, both sales and rentals, associated with a road improvement project in the city of Bangalore, the fifth largest city in India. The project - called Tender S.U.R.E. - was aimed at redesigning short stretches (typically less than 2 km) of inner-city roads with improved road design.[1] Tender S.U.R.E. roads combined the benefits of walkability, bike-ability, organized parking spaces and precise lane discipline, and most importantly, underground management of utility ducts. The project's design was such that some roads in the city's Central Business District (CBD) were chosen for improvement, but adjacent roads were not. This setting provides us with a unique opportunity to examine the marginal impact of the road improvement project on property values using the adjacent roads as a control group. The second and the more substantive issue we focus on is determining when the value from improved infrastructure occurs. As in Dubé et al. (2018), we examine property value changes around three distinct phases of the project - announcement, commencement, and

[1] S.U.R.E. is the acronym for "Specifications for Urban Roads Execution."

completion. This setting allows examining how the resolution of uncertainty about execution and completion of the project plays out in the property markets of emerging economies.

Until recently, the non-availability of reliable data on real estate transactions has been a deterrent to serious inquiry on the impact of infrastructure development in India. A notable exception is a study by Deng et al. (2019), who present evidence that infrastructure improvements in India lead to higher capitalization in property prices in the long run. Their study examines rental values and capitalization rates around infrastructure investments based on yearly reporting by the Indian government. The longer time interval makes it difficult to determine whether the increase in property values happened at the announcement or the project's completion. In contrast, our granular data allows us to evaluate the timing of the value capture more clearly. We use sale and rental values reported by owners, prospective buyers, and real estate brokers in two of India's largest property listing portals. This listing data include various attributes of the property in terms of size, amenities, and location. We use a difference-in-difference (DID) regression approach to examine price effects before and after the announcement, commencement, and completion dates for roads impacted by the Tender S.U.R.E. project, as well as for adjacent streets not covered by the project. Multiple studies have used the DID approach (Melser, 2020; Yen et al., 2018) to enumerate land value changes surrounding infrastructure improvement projects.

Our main findings are as follows. Overall, we find a significant increase in real estate property values attributable to the improvements brought in by the Tender S.U.R.E. project. However, this increase is observable mainly at the commencement and completion of the project but not at the time of its announcement. This is contrary to the received evidence in developed markets where property values generally increase around the announcement of infrastructure improvements (e.g., Golub et al., 2012; Dubé et al., 2018; Yen et al., 2018). We contend that our evidence of absence of announcement effect reflects the uncertainty surrounding the Tender S.U.R.E. project at its inception and the offsetting effects of the anticipated inconvenience and disruption during the construction of the project and the potential benefits at completion. The positive impact on property values after commencement of the Tender S.U.R.E. roads suggests that market participants recognize the resolution of initial uncertainty. The increase in property values continues until the project is finally completed, which implies that the uncertainty does not get fully resolved until that time. The relationship between property values and uncertainty resolution during infrastructural development is also captured in Yen et al. (2018). They show a gradual increase in property values during the construction and continuing until the start of operation of the Light Rail System in Australia's Gold Coast.

Contrary to Billings (2011), but more in line with Melser (2020), we find no significant difference in the response of commercial and residential property values to the road improvement project. Both types of properties post gains in value at the time of commencement and completion of the project. Only residential rental values exhibit an increase upon announcement. Given the limited supply of residential housing in business-heavy CBD in Bangalore, landlords may be in a position to increase rents despite the congestion and nuisance brought on by impending infrastructure improvement.

We make several contributions to the literature. First, a series of extant studies have documented increases in land and property values due to better transportation provision (see Mohammad et al., 2013, for a list of studies on rail projects, and Zhang and Yen, 2020, for a list of studies on bus rapid transit projects). However, the evidence on the impact of road maintenance and up-gradation on property values is scarce, particularly in emerging economies.[2] Our study fills this critical gap. Second, unlike in developed countries, infrastructure projects in emerging nations like India are plagued by governmental and institutional inefficiencies, weak regulatory structure, bureaucratic barriers, and budget constraints which result in uncertainty and delay. In this environment, the value uplift from an infrastructure improvement project may not

[2] Kemp and Mollard (2011) examine similar issues for a more developed market like Australia.

happen at the same rate as in developed economies. Our study is one of a select few that examine the timing of the value uplift in an emerging market context. Third, our findings have important policy implications. As Yen et al. (2018) note, the value capture of infrastructure improvements cannot be rolled out without a reliable estimate of the immediate and long-term effects of local amenity provisions on land and property values. Identifying the timing of value capture is important to garner higher revenues and maximize public acceptance. Our study lends important insight into that process.

Finally, our findings help support the economic rationale of retrofitted infrastructure improvements. In India, the discourse on urbanization has increasingly centered on the creation of 'smart cities.' Greenfield smart cities, however, are rare. As such, building smart city competencies largely entails retrofitting newer technologies incrementally into existing infrastructure in impoverished, high-density cities. If the market does not fairly value such infrastructure improvements, the initiative to retrofit cities may face public resistance.

The remainder of the paper is organized as follows. Next, we provide a literature review and develop our key hypotheses. We then describe the project under study, followed by a discussion of our data and methodology. We present our empirical findings next and discuss some limitations before providing a conclusion.

Literature Review and Hypothesis Development

Our study is at the confluence of *three* related streams of literature - the impact of infrastructure improvements on property values, the timing of the value uplift over the life of an infrastructure project, and the differential response of residential and commercial property values (sale and rentals) to infrastructure changes. In this section, we review the extant literature on each of these areas.

The bid-rent theory of urban economics has generated extensive literature on the impact of infrastructure such as highways, metro stations, telecommunication lines, light rail, etc. on land and property values (light rail – Hess and Almeida (2007), Damm et al. (1980); bus rapid transit – Cervero and Kang (2011); Mulley (2014); and transit-oriented development – Duncan (2011)). Most of these studies are set in developed markets where data are readily available. Exceptions include Targa (2003), who examines rental prices around busway stations in the city of Bogota (Colombia), and Deng and Nelson (2010). They study apartment prices near a bus rapid transit station in Beijing (China). Knaap et al. (2001) find that due to anticipated accessibility, a proposed light rail system in Washington County, Oregon, led to positive land value changes at the time of announcement. Tsai et al. (2017) explore property values along the Brisbane ferry and find that locations where more ferry-oriented development opportunities have been undertaken in recent decades are the sites with the most significant positive changes in property values. Yen et al. (2018) find that property prices in the catchment areas start to increase after the announcement of the LRT system along the Gold coast of Australia. Corroborating this evidence in the case of India, Deng et al. (2019) confirm that investment in infrastructures such as highways and bridges leads to property price increases.

Our focus is the improvement in property values induced by road maintenance and redesign, for which there is scant literature, especially in the context of an emerging market. However, a handful of studies that explore the impact of integrated pedestrian-friendly roads (Litman, 2003) have a bearing on our research. Rauterkus and Miller (2011) study the effect of walkable localities on neighborhood prices and find those walkable communities (based on a Walk Score methodology) command a premium land value. Pivo and Fisher (2011) find that all else being equal, greater walkability, which they consider a proxy for access to amenities, induces higher values for office, residential and retail properties. However, traffic congestion from improved roads can lead to a fall in housing values. For example, Li and Brown (1980) suggest that housing prices rose due to accessibility but fell due to congestion, pollution, or unsightliness. They note that in addition to the longer time to commute and consequent loss of productivity during construction, traffic congestion also poses immediate health hazards that precipitate a fall in property values. Our study is the first to examine the impact of a road improvement project in an emerging market to the best of our knowledge.

In addition to the magnitude and direction of price changes around road improvements, a related issue that has received attention in the recent literature is the timing of the value uplift. Since infrastructure interventions usually take time to complete, the impact of an ongoing project may evolve over the time of its development and completion, mainly because, unlike other asset classes such as stocks and bonds, real estate markets tend to adjust gradually to new information. The timing of price change transmissions can be separated into an announcement effect and a completion effect. One of the early studies to examine the timing impact is McMillen and McDonald (2004), who relate changes in property prices to the announcement, construction, and operation of transportation investment. They argue that property prices begin to rise when an improvement project is announced and continues to increase at a constant rate up to its completion. McIntosh et al. (2014) posit that the rate of capitalization of the impact of a new infrastructure project would be low in the beginning but will accelerate as the project nears completion. Similarly, Golub et al. (2012) show that positive value effects of a new light rail transit system in a major US city accrue steadily throughout the planning and construction process. Yen et al. (2018) use the difference-in-difference approach to show that residential property prices increased at the announcement of the construction of the LRT system in Gold Coast, Australia, with the highest increment happening only after the government made the financial commitment.

Though the value impact on the announcement is mostly positive, some studies find negative or zero announcement effects because of a lack of pent-up demand for transit solutions or inconveniences during construction overshadowing the potential benefits. For example, Henneberry (1998) documents adverse price effects in anticipation of disruption caused by the construction of the Supertram light rail project in South Yorkshire, U.K. Jud and Winkler (2006) show that proposed airport expansion plans precipitated a fall in prices at the time of announcement due to the anticipated noise effect. Several other studies suggest that properties that are near the intervention may suffer a decline in value due to disruption and congestion, while other properties that are further away may experience a positive impact (Damm, 1980; Fershau, 2003; Kim et al., 2014; Mohammad et al., 2017).[3]

Most of these studies, however, do show a positive impact upon completion of the project. Using data from France, Dubé et al. (2018) show a negative effect at the announcement but a significant positive impact on the completion of a new tramway. Boucq and Papon (2008) document a negligible anticipation impact for most of the years leading up to the opening of a tramway line but a positive impact after the opening.

Finally, our data allow the analyses of sales and rental values on both residential and commercial properties. There has been limited research on the value uplift from infrastructure development on commercial properties. Billings (2011) finds differential price reactions in residential and commercial properties, while Cohen and Brown (2017) find variations in value changes among different categories of commercial properties following the announcement of a new light rail system. Besides, most studies focus on sale values, not on the rental values of properties when examining the impact of infrastructure. Efthymiou and Antoniou (2013) consider both prices and rents when examining the impact of a new train line in Athens. More recently, Melser (2020) suggests that rental rates could be impacted differently from sale transactions given that tenants care about the value provided by enhanced infrastructure only during their short tenure and may not be willing to pay for its long-term benefits. Consistent with this view, Deng et al. (2019) find that infrastructure investments impact rental rates negatively while they have a positive impact on sale values in India.

In this study, we test whether the road improvement project in the city of Bangalore enhances property values. Our focus is on the timing of this potential value uplift based on

[3] Hack (2002) suggested that the association between public transport investment and land value should be evaluated at multiple points in the project management phase.

different phases of the project. We discuss three separate phenomena that have potentially different effects on the valuation impact of the project. Based on the bid-rent literature, the first phenomenon is the "*Value*" effect which induces an increase in property values, both commercial and residential, in response to the improvement of the infrastructure. Most developed market studies present evidence consistent with this notion. However, we posit that bureaucratic inefficiencies and the greater uncertainty prevalent in emerging economies could depress the magnitude of the positive valuation impact at the announcement. Announced infrastructure projects may be frequently delayed, scaled down, or canceled due to budgetary constraints and political changes. McDonald and Osuji (1995) and Agostini and Palmucci (2008) discuss the impact of uncertainty surrounding the infrastructure project on anticipated property value changes. Similarly, Yen et al. (2018) report that the maximum uplift for a rail transit project even in a developed market like Australia happens only after the uncertainty regarding funding for the project is resolved by the government. Moreover, in emerging economies, ineffective governance, including favoritism, and corruption, could hinder the efficiency and speed of execution and impose high costs of disruption during the implementation of the project. Studies such as Boucq and Papon (2008), Golub et al. (2012) and Dubé et al. (2018) highlight how disruption during project execution could negatively impact property values.

These unique challenges in developing countries lead us to the two other phenomena. The second phenomenon is the "*Uncertainty*" effect which implies that the project would have no impact on property values since the market does not expect it to be initiated or completed. The third phenomenon is the "*Disruption*" effect which causes a decline in property values owing to poor execution and the ensuing negative impact on the neighborhood. We sum up the three phenomena as follows:

- *Value:* The infrastructure improvement project will positively impact property values because the anticipated benefits outweigh its costs.
- *Uncertainty:* Property values will be *unimpacted* by the infrastructure improvement project because of the high degree of uncertainty in its start and completion.

- *Disruption:* The infrastructure improvement project will *negatively* impact property values because its costs outweigh its benefits.

While the above effects are all plausible, some are likely to be more relevant at different project stages, especially in emerging markets. Specifically, in India, due to the uncertainty and lack of political commitment and funding to undertake a disruptive project, property values may not show any potential gains from infrastructure improvement at the time of announcement of the project. While a significant part of the uncertainty gets resolved when construction starts, lingering doubts about its completion and expected delays and inconveniences due to poor implementation practices prevalent in developing economies could trigger negative changes in property values at the commencement of the project. Indeed, as noted by McIntosh et al. (2014), property values may not start reflecting the potential infrastructural benefits until the construction is nearly completed. This argument suggests that the value uplift in emerging markets could happen only late in a project's development lifecycle, unlike the received evidence in the developed economies. Based on the above discussion, we present the hypotheses for the different phases of the project in our study:

- *Hypothesis 1 (Uncertainty effect):* Property values will not vary between roads chosen for improvement (treatment group) and roads not chosen for improvement (control group) at the time of *project announcement*.

- *Hypothesis 2 (Disruption effect):* Property values will be lower in roads chosen for improvement (treatment group) than inroads not chosen for improvement (control group) at the time of *project commencement*.

- *Hypothesis 3 (Value effect):* Property values will be higher in roads chosen for improvement (treatment group) than inroads not chosen for improvement (control group) at the time of *project completion*.

We expect the above hypotheses to hold for both residential and commercial property values. Similarly, we do not expect differential changes in the value of sale and rental properties at the time of announcement and completion. However, we do expect some differences during construction. Since renters care only about the quality of infrastructure during their stay, they would be willing to pay higher rents only if the infrastructure improvement is completed before their lease expires. Given the short duration of rental leases in India (usually 11 months) and the expectation that construction work would impede their day-to-day operations, we expect rental values to fall more than sale values during construction. This notion leads us to our final hypothesis.

- *Hypothesis 4:* The drop in rental values will be more significant than in sale values for commercial and residential properties in roads chosen for improvement (treatment group) at the time of *project commencement*.

Need for Tender S.U.R.E.

India is at the cusp of large-scale urbanization triggered by a rising population and a fast-growing economy. It is the world's second-most populous country with 1.25 billion people that are spread across 53 urban agglomerations, each with a population of one million or more as per the Census of India, 2011. The Government of India has been focussing on an incremental development model, focusing on a few areas (such as infrastructure corridors and retrofitting neighborhoods) against the "big bang" reforms of other Southeast Asian mega-cities.

The Tender S.U.R.E. project was launched in the southern city of Bangalore as a road redesign project in the first quarter of 2013. Bangalore is the fifth largest and fastest-growing urban agglomeration in India, with a population close to 9 million within 900 square kilometers of area (Census of India, 2011). As the country's information technology hub, Bangalore is also the third-largest city in terms of real estate investment and infrastructure improvement.[4] The absorption of real estate in Bangalore is about 10 million square feet of commercial space (on a stock of 100 million square feet) and 319 million square feet in the residential market, making it the third most dynamic real estate market in the country.[5]

[4] Cushman and Wakefield (2014, 2015, and 2016)

[5] See Hans (2013) and L J Hooker (2013).

With the increasing demand for real estate from global firms, infrastructure, especially around transportation, is a key bottleneck that various state governments have tried to address.[6] The road redesign model was initially mooted by a Bangalore-based civic body ("Janaagraha") to upgrade a few selected roads in Bangalore to international standards. The project guidelines include details on design, specifications, and procurement contract for urban road execution, with integrated networked services combining the principles of underground management for water, sewage, power, OFC, gas, and stormwater drains. The design of Tender S.U.R.E. roads recognizes the needs of pedestrians, residents, and commercial entities, including street vendors and other users of the road, focusing on walkability and non-vehicular traffic movements.

The costs of laying roads traditionally (siloed approach where different government departments handle utilities and road maintenance) were around $350,000 (Indian Rupees (INR) 21.3M) per kilometer, with an additional $60,000 (INR 3.6M) per kilometer of road for repairs once every few years.[7] In contrast, Tender S.U.R.E. roads cost more initially - $1,500,000 (INR 91M) a kilometer – since it requires a significant upgrade of the underground infrastructure. More than 60 percent of the project cost is related to this upgradation alone. However, it is expected that future maintenance costs will be significantly lower (by as much as 75 percent) and would pose minimal traffic disruptions compared to the traditional method.

The project, however, attracted adverse scrutiny when it was initially rolled out. First, Tender S.U.R.E. was considered an insignificant change due to its scale. Less than 100 kilometers of roadways, or 0.33% of the total 30,000 kilometers within Bangalore, was expected to be redesigned, with most of the improvements being limited to high-street, inner-city roadways. Second, the management of the project was poor. To elaborate, though a non-government organization initiated the project, the execution was retained by the local

[6] See Pandey (2016)
[7] 1 USD =60.936 INR as per average rates in 2013, when Tender S.U.R.E. was announced (https://www.taxesforexpats.com/expat-tax-advice/historical-fx-rates.html).

government known for its rampant delays and budget over-runs. Moreover, the government failed to set aside adequate funds for the project from other priorities.[8] Third, critics argued that the project was doomed as it challenged prevalent behavioral norms of motorists and street vendors that were hard to change. Further, they felt that its design in increasing footpath size without increasing the motorable space failed to address the real needs of the growing metropolis.

Notwithstanding these reservations, Tender S.U.R.E. continues to be recognized as a best practice in incremental road improvement in India by the Government of India's Smart City Mission. According to the Global Designing Cities Initiative of the National Association of City Transportation Officials (NACTO), a New York-based advocacy group on urban mobility, Tender S.U.R.E. led to a 250 percent increase in the volume of pedestrians and a decrease of 3 minutes in average travel time along the roads. However, there has been no rigorous study on the project's impact on the change in walkability or bikeability or the short or long-term implications on critical metrics such as traffic, vehicle congestion, and pollution.

Data and Methods

Research Design

Unlike other infrastructure impact studies, which focus on either residential or commercial properties, we examine the impact of the road redesign project on the value of both property types. Cohen and Brown (2017) highlight the dearth of studies on commercial property values, especially regarding the impact of infrastructure improvements like rail rapid transit lines. Melser (2020) argues that rental contracts are more likely to capture the effects of infrastructure improvements cleanly and quickly than home prices which tend to internalize benefits over a long horizon. Given that commercial property rentals are more ubiquitous than

[8] Sea Ray (2017) and DHNS (2017) outlining Tender S.U.R.E. project delays.

home rentals in India, including them provides us an opportunity to contrast the impact of the road redesign on shorter-term stakeholders through rentals and longer-term stakeholders through sale values.

Following extant literature, we use a hedonic model approach to tease out the marginal impact of various known factors from the road redesign project on property values. We include several property attributes, including distance to key transport hubs like the metro rail, property form and function, size, and other value-added features of the property.[9] Office, Shop, Showroom, and Hotel categorical variables are used only in the estimation of commercial property values, while attributes such as the number of bedrooms are used only in residential property value estimations.

Most of the prior studies on rail or bus infrastructure improvements examine their impact using the proximity of the properties to the infrastructure as a key variable. For example, Yen et al. (2018) use a distance grid of 100 meters, 101-400 meters, and 401-800 meters from the light railway system to measure the impact on property values. Levkovich et al. (2016) use distance cut-offs of 300 meters, 1 kilometer, and 10 kilometers to assess the impact of a highway on property prices. Mesler (2020) uses five different distance thresholds for determining treatment and control groups for determining the effect of a new train line. Likewise, Dubé et al. (2018) use six different thresholds ranging from 100m to 600m of walking distance to estimate the impact of a new tramway line on residential property values. Given that many of these studies are based on the introduction of a public transit system, such a distance-based approach captures the positive and negative externalities arising from the infrastructure.

Our study, in contrast, focuses on a road redesign project that was introduced only on selected roads. Web content that the project's impact is more likely to be on the properties that are located on those roads. To address the endogeneity concern arising from the selection of

[9] See Zabel, J. E., & Kiel, K. A. (2000) for an exhaustive overview of variables that may be used for hedonic housing price models.

roads for the project, we examine changes in property values on adjacent roads with comparable built-up area and property price levels prior to the project's announcement. While the benefits from the project are likely to accrue directly to properties on project roads, the costs related to heavier traffic and congestion during construction are likely to be imposed on even adjacent streets as they are part of the same traffic stream. This “quasi-natural experiment” approach allows us to tease out the specific impact of Tender S.U.R.E. interventions on the roads under development.

Table 1 presents the seven roads that were initially chosen for redesign under Tender S.U.R.E. Of these, four roads were longer and had adjacent roads of similar length and property composition. We use these roads as our treatment group. We use five adjacent roads as our control group. Figure 1 provides a map of the treatment and control groups of roads for our analyses in the context of the Greater Bangalore metropolitan area. The area of intervention of Tender S.U.R.E. roads is within 3 kilometers from the Central Business District (CBD) of Bangalore. As shown in the figure, both treatment and control groups of roads form part of the same CBD traffic stream and hence would be impacted by negative externalities that arise from the project.

We use the difference-in-difference (DID) specification to investigate whether there are significant differences between values of properties in the treatment group and the control group of roads following the introduction of the Tender S.U.R.E. project. The DID estimation method is recognized as one of the efficient tools to estimate the effects of policy implementation in applied economics (Yen et al., 2018; Mohammad et al. 2017). As noted by Mohammad et al. (2017) and Yen et al. (2018), the DID design overcomes the potential problem of endogeneity in experimental design where omitted variable bias could be high due to self-selection of property types on the project roads. To capture the timing of the value uplift due to road redesign, we examine differences in property values around the announcement, commencement, and completion of the project. The dates of each of these phases are provided in Table 1.

Construction began a year from the announcement for all treatment roads, while the actual completion of all construction activity happened a little more than two years later, except for one road (St. Marks Road), where the project was completed a year earlier. We use both sale and rental property values and examine residential and commercial property listings separately.

Data

Our data is drawn from publicly available real estate listings from India's two largest real estate listing sites by page view and traffic rank as per Alexa.com.[10] While developed market studies mostly use property transactions data to study the infrastructure impact, such data are either unavailable in digital form or inaccurate given the rampant under-reporting of prices (to avoid taxes) in emerging markets. Zhang and Yen (2020) list several studies on the impact of bus rapid transit lines on property prices in South American and Asian countries that use listing price data for lack of transactional data. Even in a western European market like Greece, Efthymiou and Antoniou (2013) lean on listings data to examine the impact of transport infrastructure on property values. We follow these studies in using listings data to overcome the lack of reliable property-level transactional data in India.

For most of our analyses, we use data from July 1, 2011 (almost 20 months before the Tender S.U.R.E. project was announced) until December 31, 2016 (7 months after the project was completed). We include data from July 2011 to ensure that the common trends assumption (similarity in property values between treatment and control group roads *before* announcement of project) can be established. We end in December 2016 to mitigate the effect of a significant economy-wide shock that was imposed in November. On November 8, 2016, the government of India, in a surprise move, recalled more than 90 percent of its currency in circulation to replace it with a new currency at midnight. The move was to demonetize the holdings of citizens

[10] Alexa is a web traffic analysis company that ranks websites based on popularity and traffic for each sector/keyword. Alexa ranks sites based primarily on tracking a sample set of Internet traffic—users of its toolbar for popular web browsers.

operating in the shadow economy. There were some active transactions in the real estate market soon after the announcement in a rush to convert old currencies into real assets. The government allowed the conversion of currencies through the banking system until the end of December 2016. Moreover, there was also a rush to register property sale transactions at or close to market values rather than substantially lower values to avoid transaction taxes (stamp duties and registration charges are levied on every real estate transaction at a fixed rate). This temporary but unexpected increase in demand helped support real estate prices at least for a short period despite the overall economic slump (Sharma (2021)). We test the robustness of all our results to the short-term impact of demonetization as well.

We collected a total of 25,696 residential and commercial property sale and rental values from the websites over a six-year period between July 2011 and December 2016. We classify properties as residential if they are labeled as one of the following: studio apartment, multi-story apartment, service apartment, builder floor apartment, residential house, penthouse, or a villa. Similarly, we classify properties as commercial if they are categorized as one of the following: commercial office space, commercial showroom, commercial shop, space in the shopping mall, office in IT park or an SEZ (special economic zones), warehouse, godown, hotel or a business center in the listings data.

From this master sample, we removed properties with multiple listings (2,274 properties), properties that were not triangulated to the specific roads under consideration (3,762 properties), properties that had been listed under the relevant roads but later had been reclassified (151 properties), properties without information on amenities (2,047 properties), and properties that had listing in both rental and sale (661 properties). Of the remaining observations, a further 319 properties were excluded due to conflicting property information. The final sample contained 16,482 property listings with comprehensive information on a wide variety of amenities, of which 2,084 were residential properties (906 for sale and 1,178 for rentals) and 14,398 were commercial properties (1,059 for sale and 13,339 for rentals).

Table 2 presents the summary statistics for residential (Panel A) and commercial (Panel B) sale and rental values in our full sample.[11] Though the treatment group has fewer roads than the control group (4 compared to 5 roads), the number of properties available for sale or rental was slightly higher in our sample. We attribute this to the larger length of treatment group roads in general, as seen in Figure 1. The average property value (price per square feet) is higher in control group roads irrespective of whether the property is listed for sale or for rental. Except for commercial sales, the difference is statistically significant using a simple t-test for difference in means. Interestingly, when we limit the data only to the period between July 2011 and Mar 2013 (period prior to the announcement of Tender S.U.R.E. project), we do not see any statistical significance in the difference in average property values between treatment and control group roads, suggesting that they were priced similar prior to the project.[12] In the subsequent section, we present a more rigorous parallel trends analysis test using a simple hedonic model to demonstrate the similarities of the two groups before the start of the project.

Since there were more than 25 different amenities included in the dataset, we grouped them into three major categories. Amenities such as elevator, apartment maintenance, green areas, and security features were grouped as '*Basic Amenities*.' Amenities that reflect resource constraints or lacunae in governance or mandatory provisions by law such as water storage, rainwater harvesting, sewerage treatment plants, power backup were grouped as '*Resource Amenities*,' and amenities that are lifestyle enhancing such as clubhouses, sports facilities such as swimming pools, tennis courts and indoor gaming areas, are grouped as '*Lifestyle Amenities*.'

Difference-in-Differences (DID) Model

To analyze the impact of Tender S.U.R.E. project on property values, we apply the difference-in-differences approach to the traditional hedonic pricing model that is well-

[11] 1 USD averaged around INR 55.911 in 2012, 60.936 in 2013, 63.469 in 2014, 66.768 in 2015 and 69.956 in 2016 (https://www.irs.gov/individuals/international-taxpayers/yearly-average-currency-exchange-rates and https://www.taxesforexpats.com/expat-tax-advice/historical-fx-rates.html).

[12] For brevity, we do not present the summary statistics only for the pre-project time period.

established in the literature.[13] Each real estate property is considered a bundle of individual attributes, the consumption and enjoyment of each of which is additive and contributes to the total utility derived from an accommodation. The price of the property is, therefore, the sum of the implicit prices that can be ascribed to each of the attributes in the bundle. The standard hedonic value of a property *j* can be written as:

$$Log\ Price_j = \beta_0 + \sum_{i=1}^{i=n} \beta_i X_{i,j} \quad \text{.........} (1)$$

Given that we are looking to compare changes in property values between treatment and control group roads before and after the project, the DID variation of the standard hedonic model shown in (1) is written as:

$$Log\ Price_j = \beta_0 + \sum_{i=1}^{i=n} \beta_i X_{i,j} + \gamma TS_j + \sum_{t=1}^{t=k} \varphi_t H_{t,j} + \sum_{t=1}^{t=k} \left(\eta_t H_{t,j} * TS_j \right) \quad \text{.....} (2)$$

The purpose of the DID model specification is to determine whether property values in treatment and control group roads were similar before but different after the start of the project. The dependent variable, *Log Price,* is the natural logarithmic transformation of the property value (sale/rental) per square foot of the unit. We use a Tender S.U.R.E. indicator variable (*T*S), which takes the value of 1 for properties located on project roads (treatment group) and 0 for properties located on adjoining roads that did not have the infrastructure improvement (control group). While the bid-rent theory predicts a positive value for γ, the coefficient for TS variable, the values for interaction coefficients, η, will depend on the trade-off between the value provided by the infrastructure and the cost of disruption during its construction.

Unlike other studies that use distance grids (for example, Yen et al. (2018) use 0-100m, 101-400m, and 401-800m from the Light Rail Station) to measure the potential impact of infrastructure, we use the location of properties based on roads since the improvement is on selected roads only. To ensure proper comparison, we choose roads that are part of the same

[13] For a brief review of the hedonic pricing model and the related literature, see Yen et al., (2018)

traffic pattern with similar property density as our control group roads. The hedonic variables (X_i) include property-specific attributes like size and the three groups of amenities described earlier and location-specific characteristics like distance to the nearest metro rail station. To denote size, we take the logarithmic transformation of the super built-up area, which includes the area specific to the unit and its share of the common area.[14] Table 3 contains the complete list of the hedonic model variables used in residential and commercial property model estimations.

To capture the temporal trend in property values and the timing of value uplift during different stages of the project, we categorize time in two ways – in calendar time and in project time. Following previous work such as McMillen and McDonald (2004), McIntosh et al (2014) and Melser (2020), we break up our sample period into calendar time intervals which may not correspond directly with the project phases. This approach assumes that value uplift happens gradually over time, especially when the project takes a long time to complete. Accordingly, we include ten explicit half-yearly intervals, H_t, starting from January to June 2012 and ending with July to December 2016, in our model.

Alternatively, studies such as Agostini and Palmucci (2008), Golub et al. (2012), and Dubé et al. (2018) use the project timeline where time is categorized based on the various phases of the project. For example, Dubé et al. (2018) use three time periods to denote essential phases of the project – announcement, construction, and the opening of service. Yen et al. (2018) break up time into five phases but use yearly calendar time intervals to roughly correspond with these phases. We use four time periods – the period immediately preceding the announcement, period from announcement till the start of construction, period from start to end of construction, and period post-completion for an alternative measure of time in our model. We interact our time

[14] We use area and the squared value of the area to account for potential non-linearity in the relationship between size and property values, but our results are qualitatively similar.

variables with the *T*S variable to identify the timing of value uplift correctly. The model is estimated for sale as well as rental values for residential and commercial properties separately.

Alternative DID Model

Melser (2020) argues that the DID specification may not be appropriate if the estimation is done over a long period. This is because the common trends assumption that is critical to the model's validity may be violated. Property values in control and treatment group roads could drift apart, making them no longer comparable as the project progresses. To mitigate this effect, we use an alternative DID specification of (2) that uses data from six months before to six months after around the start of each of the phases of the project (announcement, commencement of construction, and completion), as defined in Table 1.[15] We use a post-phase dummy (*P*P) variable to capture the effect of the specific project phase on property values in lieu of H_t. Our alternative model is specified as follows:

$$Log\ Price_j = \beta_0 + \sum_{i=1}^{i=n} \beta_i X_{i,j} + \gamma TS_j + \varphi PP_{t,j} + \eta\left(PP_{t,j} * TS_j\right) \ \ldots\ldots (3)$$

where *P*P equals 1 if the property was valued after the phase and 0 otherwise. While the anchor dates for the announcement and commencement of the project are the same for all treatment group roads, the completion date is different for one road. The project was completed on June 20, 2015, for St. Marks Road as against June 4, 2016, for the other three treatment group roads. We use the actual completion date rather than the announced completion date based on news reports on when the roads were opened for traffic. Like before, we estimate (3) for sale and rental values of residential and commercial properties separately. Since the estimation involves data only over a six-month before and after, we believe the DID model specification will appropriately capture the impact of this project on property values.

[15] We try alternative time windows instead of six months, but our results remain similar.

Empirical Findings

We estimate the DID model described in Equation 2 on data starting from July 2011, which is almost a year and a half before the announcement of the Tender S.U.R.E. project. We use ten half-yearly time intervals starting from the period between January to June 2012, leaving the period between July 2011 and December 2011 as our baseline period (represented by the intercept in our results). Each of these time intervals was interacted with the treatment indicator (*T*S) to capture the differences between the treatment and control group roads.

Testing the Common Trends Assumption

We start by testing for the common (parallel) trends between treatment and control groups which is a critical assumption underlying the DID estimation. This assumption requires that property values on the control group roads be similar to those on the treatment group roads *prior* to the administration of the treatment (start of the project). For this test, we focus on the interaction between *T*S and the first two half-yearly time intervals, *HY1* and *HY2,* representing the periods prior to the project's announcement. Tables 4 and 5 report the results of the DID model with calendar times indicators for residential and commercial properties, respectively. We winsorize all variables at 99 percent. Results for sale and rental values are reported separately within each table. We find that the TS variable is not significant in any of the four models (residential sale, residential rental, commercial sale, and commercial rental). Further, the coefficients of the interaction variables between TS and *HY1* and *HY2* are statistically insignificant and cannot be distinguished from zero. These results indicate that property values – both sale and rental values – on control and treatment group roads are statistically similar *prior* to the project.

Next, following Melser (2020), we plot the predicted values of this model for the median residential (multi-story apartment) and commercial (office) property types to capture the common trends in Figure 2 visually. We use the median values of all other continuous hedonic variables from the data to arrive at a composite value for each of these property types. Panels A and B of the figure show these trends for apartments and office properties, respectively. Each of the three phases of the project is marked by vertical lines in the figures. The trendlines for Tender S.U.R.E. and non-Tender S.U.R.E. properties are sufficiently close *prior* to the administration of the treatment (start of the project); much of the variability between property values on treatment and control group roads occurs only after the announcement of the project. The analyses suggest that our common trends assumption before the project is indeed valid.

Analyses of Results from D.I.D. Model Using Calendar Time

Analyzing the results from the full model in Tables 4 and 5, we find, consistent with extant literature, that properties farther away from the rail metro line are valued lower irrespective of whether they are residential or commercial. A property that is 1km away from the metro rail line is valued at a 10-15 percent discount, with the residential rentals having the least discount and the commercial rentals the largest discount.[16] Similarly, larger residential and commercial properties command larger premiums in price per square feet in both sale and rental markets. The number of bedrooms is also positively related to residential property values, with each additional bedroom increasing sale values by 26 percent and rental values by 60 percent.[17] Among amenities, Basic features seem to be valued in commercial but not in residential properties. This result may be driven by many older commercial buildings in this area that may find it exorbitantly costly to retrofit basic features such as elevators. Resource and Lifestyle amenities are valued in residential and rental properties, but they do not seem to matter as much in commercial property valuations. Only in commercial sales do we see a premium for Lifestyle amenities such as a sports facility. Multi-storey apartments seem to be valued at a significant discount suggesting that high-rise residential units are not attractive as individual houses in the Central Business District (CBD). Not surprisingly, Offices command a high premium among

[16] Exp (coefficient of Log Distance to Metro * 1km) from Tables 4 and 5 represents the factor by which the value of properties situated away by 1km deviates from the value of properties closest to the rail metro. For residential rentals, the discount is exp (-0.096*1) = 0.90, or 10% lesser than properties closest to the rail metro.
[17] Using exp (coefficient of Bedrooms * 1 room) from Table 4 minus 1.

tenants while Shops extract the highest premium among buyers of commercial properties. Hotels are valued at a significant premium, which possibly reflects the high business traffic in this area of Bangalore.

The large number of statistically significant positive coefficients among the half-yearly time intervals (HY1 – HY10) is consistent with the general upward time trend of real estate values. Of the 22 significant coefficients seen among HY time variables in Tables 4 and 5, 16 are positive. Though the TS variable remains insignificant in both tables, we focus on the interactions between TS and the various time intervals to determine the timing of the value uplift.

As previously noted, we find no significant impact on property values when the project was announced. The interaction variable between TS and HY3 (Jan – Jun 2013, which straddles the announcement date) is insignificant in 3 out of the 4 models estimated in Tables 4 and 5. It remains weakly negatively significant for commercial rentals suggesting possible effects of disruption. These results are broadly in line with Hypothesis 1. However, they are in contrast with reported evidence in studies in developed markets. For example, Yen et al. (2018) document a significant 11.94 percent increase in residential sale values upon the announcement of a light railway transit project in Australia. Debrezion et al. (2007) and Cohen and Brown (2017) show increases in commercial property values at the time of the announcement of a new transport infrastructure. In contrast, Dubé et al. (2018) report a 7 percent drop in residential sale values around the announcement of a new tramway in France. The absence of any impact of the road design project on property values in an emerging market like India is consistent with the high level of uncertainty and scepticism that these projects face, both in funding and execution.

For testing the impact of the start of construction of the project, we look at the interaction between TS and HY5 (Jan – Jun 2014, that straddles the commencement date). While residential property values remain unaffected by the project's commencement, the commercial property values seem to have declined more on treatment roads than on control roads at the start of construction, validating Hypothesis 2. The coefficient for the interaction between TS and HY5 was -0.17 in commercial rental regression, suggesting that the drop in commercial rentals was 16 percent more for properties on treatment roads than on control roads.[18] The equivalent incremental decline for commercial sale values was 11 percent for treatment road properties. These results confirm our Hypothesis 4 as project-related disruption seems to impact rental values more than sale values.

Of the 19 interaction coefficients that are significantly positive (in Tables 4 and 5), 14 are after July 2014, and 10 are after July 2015. This result is consistent with the value effect that is captured in Hypothesis 3. Properties on treatment roads reflect higher values as the project nears completion. Figure 2 visually captures this divergence in property values between treatment and control group roads over time. Interestingly, the coefficients for interaction between TS and HY10 (Jul – Dec 2016) are positive and significant in all four individual regressions, suggesting that value uplift happens even after completion, a result consistent with developed market studies such as Dubé et al (2018).

Analyses of Results from DID Model Using Project Phases

The timing of the value changes in properties is more easily discernible when we define the timeline based on the project phases rather than on calendar time. We use four time periods – immediately before the announcement (*Prior_to_Announce*), from announcement to start of construction (*Announce_to_Commence*), from construction till completion (*Commence_to_Complete*), and after completion (*Post_Complete*). Unlike in the previous section that focused only on the half-year pertaining to the phase, these periods span a longer calendar time interval (as shown in Table 3) to reflect the project's different stages. Like before, we focus on the interaction between these time variables and the treatment indicator (*T*S) to determine the project's impact on property values.

[18] Exp (-0.17) = 0.84 (or 16% lower on TS roads than on non-TS roads).

Tables 6 and 7 present the DID results using this approach. Like before, we find that the coefficients of TS*Prior_to_Announce remain insignificant in all the regressions validating our assumption of common trends prior to the announcement of the project. We find both residential and commercial property values to be lower for treatment roads in the period between announcement and start of construction, with significantly negative effects in residential sale values (coefficient = -0.053 or 5% lower) and commercial rental values (coefficient = -0.10 or 10% lower). This result is consistent more with the disruption effect than with the uncertainty effect laid out in Hypothesis 1. As indicated by the significantly positive coefficient of the interaction between TS and the indicator for the commence-to-complete period, the resolution of uncertainty following the start of construction increases property values for 3 out of 4 categories, suggesting that the inconveniences of disruption are overweighed by the expected benefits from the infrastructure improvement. Since the post-construction period spans more than two years for 3 out of the 4 treatment roads, we also add a robustness test that separates this period into early construction and late construction by splitting the total post-construction period into two equal periods. We find the results to be broadly consistent with the value effect rather than the disruption effect following the commencement of the project, as postulated in Hypothesis 2.

In line with Hypothesis 3, the significantly positive coefficients of the interaction between TS and the indicator for the post-complete period indicates that property values are higher on treatment roads than on control roads after the project is completed. The greatest impact is seen in commercial rentals, which suggests that much of the benefit from the infrastructure is monetized by landlords through higher rents.

With respect to control variables, the results in these tables are generally consistent with our previous findings and the extant evidence. Specifically, for residential properties, size, number of bedrooms, various amenities, and a separate house carry a significant premium, while the distance from metro and multi-story detract from value. While amenities carry a premium for commercial properties, larger properties and the ones distant from the metro are significantly less attractive.

Overall, our results in Tables 4 to 7 suggest that property values, while not reacting immediately to the announcement of the infrastructure improvement project, become depressed soon after, reflecting the costs of uncertainty and potential disruption. This negative trend reverses once construction starts, with the most significant value increase happening closer to completion. Properties on roads improved by the project continue to increase in value even after completion, suggesting that the full benefit of the infrastructure continues beyond the project. We account for the fact that one of the roads in our treatment group (St. Marks Road) is completed early by defining the completion period appropriately in all our analyses.[19] Our results do not qualitatively change if we drop this road altogether as well.

To test the robustness of our results to the demonetization shock, we refine our data in two ways. First, we truncate data till October 2016 and ignore the months of November and December 2016 in our post-completion period. Second, we add data until June 2017 and include a demonetization indicator variable for property values recorded after November 8, 2016. We do not report these results for brevity but find them to be consistent with our overall results.

Alternative DID Model Results – Controlling for Time Span

The longer span of time used in the previous analysis to represent the different phases of the project may limit the appropriateness and validity of the DID model, as argued by Melser (2020). Accordingly, we restrict our estimation to a 12-month period anchored around the beginning of each phase of the project. For example, to examine the impact of the project's announcement, we estimate the DID Model shown in Equation 2 using 6-months of data before and after the announcement date. We replace all-time variables with one post-phase indicator variable, as shown in Equation 3. In Table 8, we report the number of listings in pre-and post-

[19] See Table 3 for more details.

phases for both residential and commercial properties; the data show that the listings are evenly distributed across the various samples, except for commercial rental listings which outnumber other types by a significant margin reflecting the predominantly commercial nature of the project's location.

Tables 9 and 10 report results for the alternative DID model estimation for each of the project's three phases. For brevity, we show the results report the coefficients only for the key independent variables – *TS*, *Post-phase dummy*, and the interaction between the two. As before, our focus remains on the interaction variables that capture the incremental impact of the project on property values in treatment roads over control roads. We find clear evidence that the project's announcement did not impact property values, presumably because of the uncertainty about its inception and implementation. This result is in sharp contrast to the experience in developed economies where the announcement of infrastructure projects is usually accompanied by an increase in land and property values.[20] The only exception to this trend was in the case of residential rental values, which increase significantly, suggesting that residential landlords may have been able to monetize the positive impact of road improvement early on. We offer two potential explanations for this effect – one, the area under TS development is a prime location in Bangalore where residential housing is in short supply. Two, our data included new construction, which usually attracts higher rentals.[21]

Our analyses reveal no evidence to support the disruption hypothesis at the start of construction in the project. We find significant increases at the commencement of the project in residential and commercial property values (sale and rentals) on Tender S.U.R.E. roads. The highest increase is seen in residential rentals, where the coefficient for the TS*post-phase dummy

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[20] Most of these studies (for example, Agostini and Palmucci, 2008; Golub et al., 2012) and Yen et al. (2018) document partial adjustment of property values on announcement due to uncertainty.
[21] RBI's (Reserve Bank of India, India's Central Bank) price Index for Bangalore City shows increasing real estate prices, which indicates that landlords may have the bargaining power (short supply, rising prices etc.), and may exploit the intervention through higher rents even at the early stages of the construction. However, we cannot verify this conjecture because of insufficient data. Future research may explore this in more detail.

is 0.457, or 58 percent more for properties on treatment roads than on control roads.[22] Analogous to the experience in Australia as reported by Yen et al. (2018), resolution of uncertainty around infrastructure projects positively impacts property values, offsetting the potential costs of disruption during construction. Finally, as expected, the completion of construction results in significant increases in property values, both residential and commercial sales and rentals reflecting the opportunity to monetize the infrastructure improvement without any uncertainty fully. Commercial rentals see the highest increase in value, while commercial sales have the smallest growth in value in the six months following the completion of the project.

Conclusion and Limitations

Using a quasi-natural experiment in Bangalore, the fifth largest city in India, we provide evidence on the impact of the road improvement project on real estate prices in a fast-growing emerging market. We use a difference-in-difference econometric approach on a sample of roads directly impacted by the project and a matched sample of adjacent roads but not covered by the project. Unlike in developed markets, we do not find evidence that the announcement of such projects results in an immediate increase in either residential or commercial property values. We attribute this to the uncertainty overhang in these projects early on as governments struggle to commit funding and manage the political fallout of disruption that may arise.

However, we find evidence of the positive impact of the project on property values once construction starts. Commencement of the project provides a strong indication of the intent and commitment of the government to go ahead with the project. Such signaling may not be required in developed markets where property values increase soon after the announcement. Interestingly, the value increases are visible even at the early stage of construction, indicating that the costs of disruption are outweighed by the benefits of the infrastructure improvements in emerging economies. Like in developed markets, we find value increases on completion when

[22] Exp (Coefficient of TS*Post-phase dummy) from Residential Rent regression in Table 9.

the project is entirely certain, suggesting a positive relationship between value changes and the degree of resolution of uncertainty. Overall, our results indicate that such retrofitted infrastructure improvements in developing economies are value-enhancing, and much of the value increase can be captured by governments if they can credibly reduce the uncertainty surrounding them. The surest way to mitigate the uncertainty seems to be to initiate work on the project.

Our results are subject to standard limitations and caveats stemming from selecting the sample period and the nature of the underlying data. For example, we use pricing information for property listings that are not the same as transactions. Transactions in India are notorious for under-reporting actual values, and hence listing provides the best estimate of the market bid and offers prices for such properties. Researchers have adopted this approach in other developing countries, such as in Latin America (e.g., Zhang and Yen, 2020). Our sample for sale transactions is limited and fewer than our rental sample reflecting the challenging market for sales during our sample period. Also, our results may be sensitive to the event interval window.[23] We use different interval windows for commercial rentals where availability of data was not an issue and found similar results.

[23] We thank Special issue editor Gangzhi Fan for this suggestion.

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Table 1

Roads under Phase 1 of Tender S.U.R.E Considered for Analysis

The table presents basic statistics for the seven roads earmarked for improvement under the Tender S.U.R.E project.

Name of the Road	Approx. Length (in kms)	Date of Announcement	Date of Commencement	Date of Completion
Considered in the study				
Residency Road	2.00	March 5, 2013	March 4, 2014	June 4, 2016*
Richmond Road	2.70	March 5, 2013	March 4, 2014	June 4, 2016*
Cunningham Road	1.47	March 5, 2013	March 4, 2014	June 4, 2016*
St. Marks Road	0.90	March 5, 2013	March 4, 2014	June 20, 2015
Not considered in the study				
Vittal Mallya Hospital Road	0.60	March 5, 2013	March 4, 2014	June 20, 2015
Museum Road	1.20 (revised to 0.50 km)	March 5, 2013	March 4, 2014	June 4, 2016
Commissariat Road	0.60	March 5, 2013	March 4, 2014	June 4, 2016

* The roads were opened for traffic on June 4, 2016 though the announced completion date was November 30, 2016.

Table 2

Summary Statistics

This table provides summary statistics for residential and commercial property listings in both treatment and control group roads between July 1, 2011 and December 31, 2016. Panel A shows statistics for outright sales while Panel B presents statistics for rentals. Treatment group consists of roads covered by Tender S.U.R.E project while the control group includes roads that are close by but were not earmarked for improvement under the Tender S.U.R.E project. Both average and standard deviation are in INR/sft. INR represents the Indian Rupee. 1 USD was equivalent to INR 62.934 on average (ranged from INR 55.911 in 2012 to INR 69.956 in 2016).

Panel A: For Residential Properties

Group	Road	Residential Sale			Residential Rental		
		N	Average	Standard Deviation	N	Average	Standard Deviation
Treatment	Cunningham Road	119	12,591	1,537	311	34.33	4.78
	Residency Road	107	16,531	2,305	90	22.96	4.30
	Richmond Road	213	10,185	1,297	300	26.97	5.84
	St. Marks Road	93	13,187	2,031	26	36.60	5.87
Treatment Group Summary		528	12,653	1,878	727	29.86	6.47
Control	Brigade Road	56	18,262	2,795	43	31.86	5.27
	Commercial Street	66	15,174	1,667	76	22.95	5.87
	Langford Road	84	8,826	1,105	131	26.89	7.43
	Lavelle Road	135	16,261	1,868	126	41.55	6.32
	Rest House Road	37	13429	1,749	75	38.16	5.28
Control Group Summary		378	14,352	2,039	451	32.47	4.53
Full Sample Summary		906	13,673	2,002	1,178	31.61	6.21

Panel B: For Commercial Properties

Group	Road	Commercial Sale			Commercial Rental		
		N	Average (INR/sft)	Standard Deviation	N	Average (INR/sft)	Standard Deviation
Treatment	Cunningham Road	257	16,091	6,618	3,570	64.72	6.14
	Residency Road	82	17,409	4,725	237	73.06	6.09
	Richmond Road	225	12,491	5,555	3,752	63.58	6.75
	St. Marks Road	49	12,051	8,768	124	59.58	7.27
Treatment Group Summary		613	14,643	8,689	7,677	64.36	6.78
Control	Brigade Road	131	17,398	8,881	1,219	75.16	7.14
	Commercial Street	88	16,599	9,780	270	44.61	4.87
	Langford Road	58	8,604	5,004	761	54.51	5.24
	Lavelle Road	89	16,618	9,974	2,680	68.90	5.94
	Rest House Road	80	14,666	9,202	695	63.39	5.87
Control Group Summary		446	15,464	7,989	5,662	66.14	8.20
Full Sample Summary		1,059	15,102	8,863	13,339	65.37	7.65

Source: Authors' Compilation from magicbricks.com, 99acres.com

Table 3

Variable Definitions

This table provides descriptions for the variables used in all subsequent analyses. Some property related variables are relevant only for residential price analysis while some others are relevant for commercial price analysis only. The two variables at the end are used only for robustness tests that are described later in the paper.

Variable Name	Description
Log Price per sft	Natural logarithm of sale price or rental per square feet
TS	Defined as 1 if the property is listed on a Treatment road (under TenderSURE project) and 0 otherwise.
Log Area	Natural logarithm of the super built up area (built-up area plus the common area in square feet) of the property
Log Distance to Metro	Natural logarithm of distance (in kms) of the property from the nearest rail metro station by road
Basic Amenities	Defined as 1 if the property has basic amenities like elevator, green areas, 24/7 security with managed third-party maintenance etc.
Resource Amenities	Defined as 1 if the property has amenities that solve resource bottlenecks like power backup, 24/7 water availability including rainwater harvesting and storage, sewerage treatment etc.
Lifestyle Amenities	Defined as 1 if the property has lifestyle amenities like clubhouse, sports facilities such as swimming pool and gymnasium etc.
Commercial Property related variables	
Office	Defined as 1 if it is a multi-office property and 0 otherwise
Shop	Defined as 1 if it is an individual or small group of shops and 0 otherwise
Showroom	Defined as 1 if it is a dealer or retail showroom and 0 otherwise
Hotel	Defined as 1 if it is a hotel property and 0 otherwise
Residential Property related variables	
Bedrooms	Number of bedrooms in the property
Multi-storey apartment	Defined as 1 if it is a conventional apartment within a larger multi-storey apartment complex and 0 otherwise

House	Defined as 1 if it is an individual house, and 0 otherwise
Time related variables	
HY1 – HY10	Defined as 1 if listing is during successive half-year periods starting January 1, 2012 to June 30, 2012, July 1, 2012 to December 31, 2012 and so on. The last variable, HY10, corresponds to July 1, 2016 to December 31, 2016, and 0 otherwise
Prior_to_Announce	Defined as 1 if listing is during the period September 5, 2012 to March 4, 2013, and 0 otherwise
Announce_to_Commence	Defined as 1 if listing is during the period March 5, 2013 to March 3, 2014, and 0 otherwise
Commence_to_Complete	Defined as 1 if listing is during the period March 4, 2014 to June 3, 2016 (June 19, 2015 for St. Marks Road only), and 0 otherwise
Post-Complete	Defined as 1 if listing is during the period June 4, 2016 (June 20, 2015 for St. Marks Road only) to December 31, 2016, and 0 otherwise
Robustness test variables	
Commence_to_Post-Commence	Defined as 1 if listing is during the period March 4, 2014 to April 19, 2015 (October 26, 2014 for St. Marks Road only), and 0 otherwise
Post-Commence_to_Complete	Defined as 1 if listing is during the period April 20, 2015 (October 27, 2014 for St. Marks Road only) to June 3, 2016, and 0 otherwise

Table 4

Difference-in-Differences Model Results for Residential Properties

This table provides the DID regression results of residential real estate sale and rental prices per square feet (expressed in natural logarithms) as seen in two of the largest online property portals for Bangalore between July 2011 and December 2016. The key independent variable of interest is the TS dummy variable and its interaction with various time dummies. Time dummies are represented by calendar half-yearly intervals while all other variable definitions are as given in Table 3. Constant captures builder-floor apartments (small-sized apartment complexes with limited number of open apartments) listed during the period July 1 to December 31, 2011. All data are winsorized at 99 percent. T-statistics use robust standard errors and *, ** and *** represent statistical significance at 90, 95 and 99 percent confidence levels respectively.

Log Price per sft (Dependent variable)	Residential Sale				Residential Rental			
	Coeff	Std Err	T-stat		Coeff	Std Err	T-stat	
TS	0.095	0.719	0.132		0.056	0.038	1.473	
Hedonic variables								
Log Distance to Metro	-0.128	0.076	-1.687	*	-0.096	0.041	-2.366	**
Log Area	0.185	0.092	2.014	**	0.127	0.043	2.944	***
Basic Amenities	-0.042	0.072	-0.585		0.093	0.056	1.659	*
Resource Amenities	0.141	0.072	1.967	**	0.191	0.066	2.874	***
Lifestyle Amenities	0.462	0.152	3.047	***	0.231	0.122	1.882	*
Multi-storey Apartment	-0.331	0.109	-3.027	***	-0.312	0.026	-12.088	***
House	0.109	0.135	0.812		0.462	0.059	7.769	***
Bedrooms	0.231	0.090	2.570	**	0.473	0.079	6.024	***
Time fixed effects								
HY1 (Jan-Jun 2012)	0.057	0.069	0.825		-0.214	0.278	-0.770	
HY2 (Jul-Dec 2012)	0.155	0.076	2.027	**	0.005	0.149	0.036	
HY3 (Jan-Jun 2013)	0.004	0.067	0.065		-0.091	0.216	-0.422	
HY4 (Jul-Dec 2013)	-0.037	0.016	-2.309	**	-0.023	0.010	-2.357	**
HY5 (Jan-Jun 2014)	0.108	0.064	1.705	*	-0.039	0.178	-0.217	
HY6 (Jul-Dec 2014)	0.093	0.046	2.035	**	0.043	0.020	2.083	**
HY7 (Jan-Jun 2015)	0.083	0.022	3.719	***	-0.059	0.088	-0.671	
HY8 (Jul-Dec 2015)	0.094	0.015	6.362	***	0.352	0.022	15.714	***
HY9 (Jan-Jun 2016)	-0.006	0.164	-0.034		0.022	0.032	0.699	
HY10 (Jul-Dec 2016)	-0.170	0.094	-1.813	*	-0.033	0.030	-1.071	
Interaction effects								
TS*HY1 (Jan-Jun 2012)	0.024	0.030	0.811		0.005	0.378	0.013	
TS*HY2 (Jul-Dec 2012)	0.040	0.094	0.430		0.073	0.045	1.622	
TS*HY3 (Jan-Jun 2013)	-0.139	0.086	-1.619		-0.083	0.176	-0.471	
TS*HY4 (Jul-Dec 2013)	-0.140	0.085	-1.642		-0.163	0.097	-1.683	*
TS*HY5 (Jan-Jun 2014)	0.094	0.082	1.140		0.104	0.173	0.601	
TS*HY6 (Jul-Dec 2014)	0.095	0.048	1.966	**	0.474	0.164	2.884	***
TS*HY7 (Jan-Jun 2015)	0.053	0.020	2.664	***	0.079	0.050	1.573	
TS*HY8 (Jul-Dec 2015)	0.254	0.274	0.925		0.156	0.085	1.835	*
TS*HY9 (Jan-Jun 2016)	0.075	0.042	1.800	*	0.098	0.041	2.366	**
TS*HY10 (Jul-Dec ‘16)	0.071	0.020	3.518	***	0.089	0.052	1.704	*
Constant	10.141	1.437	7.057	***	3.121	1.112	2.807	***

Table 5

Difference-in-Differences Model Results for Commercial Properties

This table provides the DID regression results of commercial real estate sale and rental prices per square feet (expressed in natural logarithms) as seen in two of the largest online property portals for Bangalore between July 2011 and December 2016. The key independent variable of interest is the TS dummy variable and its interaction with various time dummies. All variable definitions are provided in Table 3. Constant captures warehouses listed during the period July 1 to December 31, 2011. All data are winsorized at 99 percent. T-statistics use robust standard errors and *, ** and *** represent statistical significance at 90, 95 and 99 percent confidence levels respectively.

Log Price per sft (Dependent variable)	Commercial Sale				Commercial Rental			
	Coeff	Std Err	T-stat		Coeff	Std Err	T-stat	
TS	0.385	0.312	1.236		-0.197	0.337	-0.584	
Hedonic variables								
Log Distance to Metro	-0.126	0.045	-2.800	***	-0.142	0.074	-1.924	*
Log Area	0.181	0.072	2.514	**	0.139	0.051	2.725	***
Basic Amenities	0.090	0.027	3.333	***	0.123	0.030	4.070	***
Resource Amenities	0.091	0.099	0.924		0.217	0.127	1.709	*
Lifestyle Amenities	0.761	0.321	2.371	**	-0.109	0.122	-0.893	
Office	0.109	0.056	1.930	*	0.391	0.130	2.997	***
Shop	0.219	0.026	8.488	***	0.219	0.127	1.724	*
Showroom	-0.845	2.044	-0.413		-0.071	0.127	-0.558	
Hotel	0.399	0.173	2.308	**	0.412	0.223	1.848	*
Time fixed effects								
HY1 (Jan-Jun 2012)	0.302	0.102	2.963	***	0.035	0.033	1.051	
HY2 (Jul-Dec 2012)	0.102	0.016	6.375	***	0.109	0.040	2.730	***
HY3 (Jan-Jun 2013)	0.023	0.103	0.223		-0.070	0.096	-0.736	
HY4 (Jul-Dec 2013)	0.237	0.098	2.418	**	-0.026	0.013	-2.044	**
HY5 (Jan-Jun 2014)	0.406	0.216	1.884	*	0.041	0.116	0.351	
HY6 (Jul-Dec 2014)	-0.490	0.099	-4.949	***	0.202	0.109	1.844	*
HY7 (Jan-Jun 2015)	0.121	0.145	0.835		-0.160	0.212	-0.751	
HY8 (Jul-Dec 2015)	0.043	0.020	2.145	**	0.261	0.099	2.627	***
HY9 (Jan-Jun 2016)	-0.070	0.041	-1.729	*	0.062	0.130	0.478	
HY10 (Jul-Dec 2016)	0.344	0.261	1.319		0.371	0.079	4.722	***
Interaction effects								
TS*HY1 (Jan-Jun 2012)	0.099	0.123	0.806		0.130	0.098	1.326	
TS*HY2 (Jul-Dec 2012)	-0.038	0.169	-0.223		-0.222	0.187	-1.186	
TS*HY3 (Jan-Jun 2013)	-0.052	0.220	-0.235		-0.093	0.052	-1.787	*
TS*HY4 (Jul-Dec 2013)	0.124	0.086	1.442		-0.280	0.092	-3.051	***
TS*HY5 (Jan-Jun 2014)	-0.114	0.064	-1.770	*	-0.17	0.091	-1.870	*
TS*HY6 (Jul-Dec 2014)	0.038	0.164	0.230		0.445	0.481	0.926	
TS*HY7 (Jan-Jun 2015)	0.043	0.020	2.145	**	-0.100	0.094	-1.066	
TS*HY8 (Jul-Dec 2015)	0.276	0.141	1.954	*	0.084	0.024	3.510	***
TS*HY9 (Jan-Jun 2016)	0.156	0.148	1.049		0.195	0.028	7.030	***
TS*HY10 (Jul-Dec '16)	0.176	0.084	2.092	**	0.224	0.086	2.605	***
Constant	13.421	2.312	5.805	***	3.623	1.119	3.236	***

Table 6

Estimation of Impact of Different Phases of the Project on Residential Property Values

This table presents results from DID regressions of residential property sale and rental prices (expressed in natural logarithms) around key phases of the Tender S.U.R.E project using property portal data between July 2011 and December 2016. Dates for these phases – announcement, commencement, and completion - are shown in Table 1. The key independent variable of interest is the TS dummy variable and its interaction with various event (phase) time dummies. All variable definitions are provided in Table 3. Constant captures builder-floor apartments (small-sized apartment complexes with limited number of open apartments but has an option to expand) listed during the period July 1, 2011 to September 4, 2012. All data are winsorized at 99 percent. T-statistics use robust standard errors and *, ** and *** represent statistical significance at 90, 95 and 99 percent confidence levels respectively.

Log Price per sft (Dependent variable)	Residential Sale				Residential Rental			
	Coeff	Std Err	T-stat		Coeff	Std Err	T-stat	
TS	0.045	0.619	0.073		0.066	0.074	0.888	
Hedonic variables								
Log Distance to Metro	-0.148	0.088	-1.677	*	-0.061	0.011	-5.780	***
Log Area	0.152	0.049	3.131	***	0.272	0.043	6.294	***
Basic Amenities	-0.033	0.023	-1.419		-0.023	0.056	-0.416	
Resource Amenities	0.194	0.057	3.395	***	0.091	0.066	1.369	
Lifestyle Amenities	0.562	0.152	3.707	***	0.231	0.052	4.394	***
Multi-storey Apartment	-0.531	0.192	-2.764	***	-0.321	0.059	-5.457	***
House	0.494	0.290	1.701	*	0.562	0.156	3.591	***
Bedrooms	0.223	0.088	2.541	**	0.523	0.179	2.930	***
Phase effects								
Prior_to_Announce	0.024	0.030	0.811		-0.005	0.778	-0.006	
Announce_to_Commence	-0.091	0.039	-2.320	**	0.297	0.147	2.020	**
Commence_to_Complete	0.214	0.116	1.841	*	0.183	0.086	2.132	**
Post-Complete	0.210	0.109	1.925	*	0.463	0.330	1.404	
Interaction effects								
TS*Prior_to_Announce	0.045	0.048	0.926		0.047	0.036	1.301	
TS*Announce_to_Commence	-0.053	0.020	-2.664	***	-0.077	0.049	-1.570	
TS* Commence_to_Complete	0.454	0.274	1.654	*	0.096	0.045	2.131	**
TS* Post-Complete	0.075	0.042	1.800	*	0.098	0.041	2.366	**
Constant	10.351	1.317	7.859	***	3.071	1.342	2.289	**

Table 7

Estimation of Impact of Different Phases of the Project on Commercial Property Values

This table presents results from DID regressions of commercial property sale and rental prices (expressed in natural logarithms) around key phases of the Tender S.U.R.E project using property portal data between July 2011 and December 2016. Dates for these phases – announcement, commencement, and completion - are shown in Table 1. The key independent variable of interest is the TS dummy variable and its interaction with various event (phase) time dummies. All variable definitions are provided in Table 3. Constant captures warehouses listed during the period July 1, 2011 to September 4, 2012. All data are winsorized at 99 percent. T-statistics use robust standard errors and *, ** and *** represent statistical significance at 90, 95 and 99 percent confidence levels respectively.

Log Price per sft (Dependent variable)	Commercial Sale				Commercial Rental			
	Coeff	Std Err	T-stat		Coeff	Std Err	T-stat	
TS	0.359	0.322	1.115		0.010	0.273	0.035	
Hedonic variables								
Log Distance to Metro	-0.134	0.028	-4.735	***	-0.184	0.082	-2.236	**
Log Area	0.155	0.069	2.251	**	-0.135	0.062	-2.192	**
Basic Amenities	0.070	0.026	2.643	***	0.102	0.209	0.485	
Resource Amenities	0.087	0.089	0.988		0.261	0.099	2.627	***
Lifestyle Amenities	0.571	0.102	5.606	***	-0.160	0.212	-0.751	
Office	0.151	0.096	1.576		0.624	0.130	4.781	***
Shop	0.312	0.072	4.364	***	0.468	0.224	2.087	**
Showroom	-1.956	1.344	1.455		-0.067	0.267	-0.251	
Hotel	0.290	0.173	1.677	*	0.371	0.271	1.369	
Phase effects								
Prior_to_Announce	0.499	0.223	2.238	**	0.199	0.098	2.032	**
Announce_to_Commence	0.604	0.319	1.892	*	-0.175	0.069	-2.533	**
Commence_to_Complete	-0.035	0.220	-0.160		0.255	0.197	1.296	
Post-Complete	0.402	0.192	2.096	**	0.210	0.191	1.096	
Interaction effects								
TS*Prior_to_Announce	0.174	0.264	0.658		0.245	0.281	0.874	
TS*Announce_to_Commence	-0.374	0.231	-1.618		-0.100	0.034	-2.950	***
TS* Commence_to_Complete	0.557	0.148	3.749	***	0.423	0.260	1.629	
TS* Post-Complete	0.176	0.091	1.928	*	0.878	0.277	3.169	***
Constant	13.334	2.894	4.607	***	3.654	0.815	4.484	***

Table 8

Distribution of Property Listings by Different Phases of the Tender S.U.R.E Project

This table presents the distribution of number of residential and commercial sale and rental listings from two of the largest property portals for Bangalore around different phases of the Tender S.U.R.E project. The data are presented for a 12-month period anchored around 3 key event dates – announcement date, commencement, and completion dates – related to the Tender S.U.R.E project as given in Table 1. Treatment group refers to properties on roads impacted by the project and Control group refers to properties on adjacent roads not impacted by the project.

Event	Period	Residential Properties				Commercial Properties			
		Sale		Rent		Sale		Rent	
		Treatment	Control	Treatment	Control	Treatment	Control	Treatment	Control
Announcement (Mar 4, 2013)	Pre-period Sep 4, 2012 – Mar 4, 2013	37	43	72	28	42	32	430	334
	Post-period Mar 5, 2013 – Sep 4, 2013	23	13	49	26	16	18	231	198
Total		*60*	*56*	*121*	*54*	*58*	*50*	*661*	*532*
Commencement (Mar 4, 2014)	Pre-period Sep 5, 2013 – Mar 3, 2014	48	39	98	67	40	34	772	593
	Post-period Mar 4, 2014 – Sep 4, 2014	37	56	147	91	89	66	1,248	898
Total		*85*	*95*	*245*	*158*	*129*	*100*	*2,020*	*1,491*
Completion (Nov 30. 2016)	Pre-period Jan 5, 2016 – Jun 4, 2016	88	42	67	38	75	59	1,032	712
	Post-period Jun 5, 2016 – Dec 4, 2016	97	18	37	18	35	17	1,334	971
Total		*185*	*60*	*104*	*56*	*110*	*76*	*2,366*	*1,683*
Grand Total		*330*	*211*	*470*	*268*	*297*	*226*	*5,047*	*3,706*

Table 9

Estimation of Short-term Impact of Different Phases of the Project on Residential Property Values

This table presents coefficient estimates from phase-wise DID regressions of residential property values using 12-month data anchored around the phase date. Results for sale and rental values are presented separately. The dependent variable remains the (natural logarithm of) market price while all hedonic control variables remain the same as reported in Table 6. Three phases of the project are examined – announcement, commencement, and completion – and the dates for these phases are provided in Table 1. TS is 1 for properties listed on roads directly impacted by the Tender S.U.R.E project, and 0 otherwise. Post-phase dummy equals 1 for properties listed in the 6 months *immediately following* the phase start date, and 0 for properties listed in the 6 months *immediately before* the phase start date. Data used in each of the phase-based regression have been winsorized at 99 percent. For brevity, estimates for other control variables are not reported. T-statistics use robust standard errors and *, ** and *** represent statistical significance at 90, 95 and 99 percent confidence levels respectively.

Log Price per sft (Dependent variable)	Residential Sale						Residential Rent					
	Announcement		Commencement		Completion		Announcement		Commencement		Completion	
	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat
TS	0.211	1.298	0.233	1.435	0.088	0.918	0.072	0.64	0.017	0.338	0.003	0.096
Post-phase Dummy	0.002	-0.023	0.371***	3.889	0.319	0.889	-0.079	-0.655	5.767***	3.712	0.432***	2.812
TS*Post-phase Dummy	-0.149	-0.674	0.278***	2.940	0.129**	2.450	1.242***	3.495	0.457**	2.516	0.071***	2.896
Adjusted R-Sq	0.349		0.298		0.361		0.33		0.091		0.149	
F-statistic	6.013		2.128		5.023		5.28		9.26		12.26	
Sample size	116		180		245		175		403		160	

Table 10

Estimation of Short-term Impact of Different Phases of the Project on Commercial Property Values

This table presents coefficient estimates from phase-wise DID regressions of residential property values using 12-month data anchored around the phase date. Results for sale and rental values are presented separately. The dependent variable remains the (natural logarithm of) market price while all hedonic control variables remain the same as reported in Table 7. Three phases of the project are examined – announcement, commencement, and completion – and the dates for these phases are provided in Table 1. TS is 1 for properties listed on roads directly impacted by the Tender S.U.R.E project, and 0 otherwise. Post-phase dummy equals 1 for properties listed in the 6 months *immediately following* the phase start date, and 0 for properties listed in the 6 months *immediately before* the phase start date. Data used in each of the phase-based regression have been winsorized at 99 percent. For brevity, estimates for other control variables are not reported. For brevity, estimates for other control variables are not reported. T-statistics use robust standard errors and *, ** and *** represent statistical significance at 90, 95 and 99 percent confidence levels respectively.

Log Price per sft (Dependent variable)	Commercial Sale						Commercial Rent					
	Announcement		Commencement		Completion		Announcement		Commencement		Completion	
	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat
TS	0.249	0.379	0.178	0.269	0.002	0.003	0.013	0.109	-0.002	-0.013	0.016	0.134
Post-phase Dummy	-0.128	-1.264	0.165*	1.769	0.268	1.031	-0.010	-0.589	0.067***	4.265	0.033	0.930
TS*Post-phase Dummy	0.037	0.298	0.324**	2.492	0.253	1.622	-0.014	-0.595	0.060***	2.906	1.597**	2.564
Adjusted R-Sq	0.422		0.339		0.219		0.188		0.146		0.271	
F-statistic	2.401		2.361		2.617		130.100		130.100		91.200	
Sample size	108		229		186		1,193		3,511		4,049	

Figure 1

Location Map of the Treatment and Control Group Roads

The figure shows the geographical map of the area in Bangalore (India) that contains the treatment group roads (those selected under the Tender S.U.R.E project) and control group roads (adjacent roads not selected for improvement project). Many of the roads selected for improvements under the first phase of the Tender S.U.R.E project connect key intersections and the control group roads have been identified as feeder roads to the same key intersections.

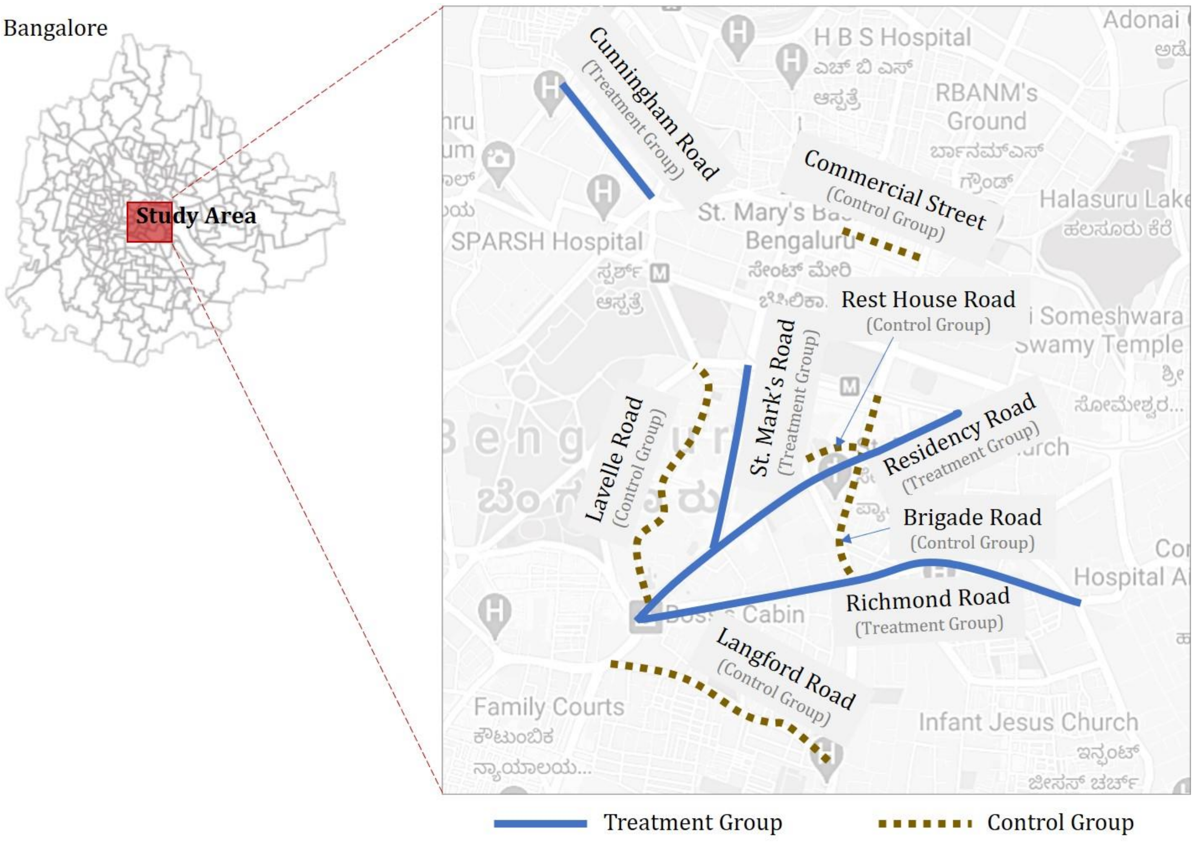
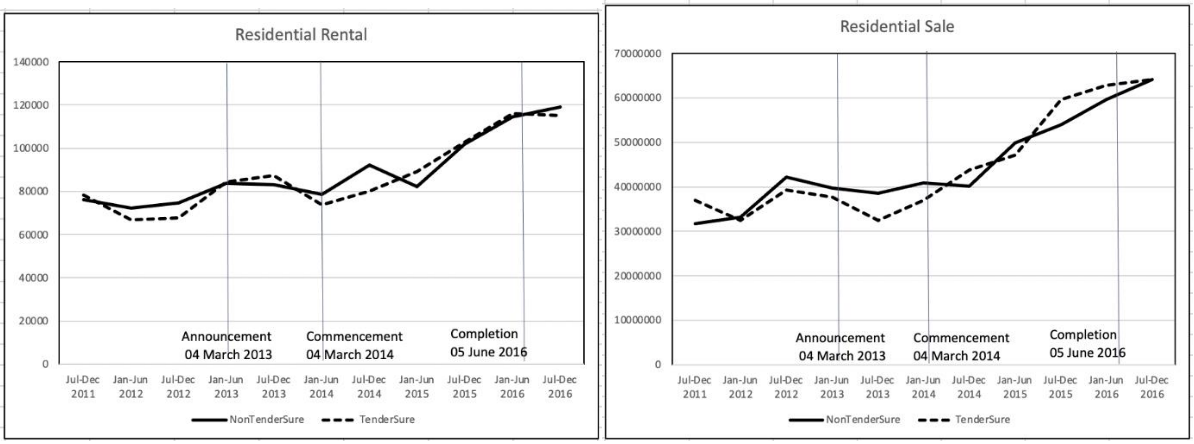


Figure 2

Common Trends in Property Values on Treatment and Control Group Roads

This figure depicts common trends in property values on Treatment group roads (those impacted by the Tender S.U.R.E project) and on control group roads (those that were not impacted by the project but are adjacent to treatment group roads) during the period July 1, 2011 to December 31, 2016. Trends represent predicted values drawn from the hedonic models described in Tables 4 and 5 for a representative multi-storey apartment and an office property respectively. Median values in the data are used for all other continuous hedonic variables. Vertical lines represent the start of the different phases of the project.

Panel A: Trends in Sale and Rental Value for a Representative Multi-storey Apartment



Panel B: Trends in Sale and Rental Value for a Representative Office Property