Curtin University Sustainability Policy Institute

Financing Urban Rail Projects through Land Value Capture – The Indian Case

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Author’s declaration

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgment has been made.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

Rohit Sharma

Date: July, 2018

Statement of contributors

All of the written materials submitted as part of this PhD by Hybrid Publication were conceived and coordinated by Rohit Sharma. I also undertook the majority of the writing and case study analysis for each publication.

Signed detailed statements from each co-author relating to each publication are provided as appendices at the back of this thesis (Appendix A).

Signed:

Rohit Sharma, PhD Candidate

Professor Peter Newman, Principal Supervisor

Date: July, 2018

Abstract

This PhD thesis consists of five publications supported by an exegesis. The thesis is focussed on the potential of urban rail projects to create land value that can be used to finance urban rail. This was achieved by the two empirical case studies: the publicly funded Bangalore Metro project and the privately funded Mumbai Metro project. The basis for the selection of these two case studies was that neither sought to use land value capture financing and thus the opportunity was provided to see how important this could have been.

The thesis begins by examining economic theories that led to an enquiry on city-level assessment of urban rail's impact on land markets to assess if urban rail results in agglomeration benefits at the city level in addition to the generally accepted impacts on catchment areas. The thesis applies this enquiry to analyse the extent of the impact of urban rail on land value due to commencement of the Bangalore Metro.

The panel data hedonic price model for Bangalore Metro showed a 23 per cent increase in land value in the 1 km catchment and of great significance showed increased land values over the whole city by an average of 4.5 per cent due to commencement of the urban rail system. This indicates a major agglomeration economic event resulting in substantial willingness to pay of USD 306 million from the urban rail accessibility. The Bangalore case is significant as it is based on the largest compiled data set, of around 160,000 apartments over the period 2012-16, for an emerging city and one of the first for an Indian city.

A panel data hedonic price model showed a significant uplift of 14 per cent in property prices in the Mumbai Metro catchment area resulting in USD 179 million value capture opportunity under Mumbai's existing legislative framework. The Mumbai case showed that land value capture for a private

led urban rail project can be used to avoid high dependence on fare box revenue with the consequent public policy struggles over fare fixation.

The thesis shows that both publicly and privately funded urban rail projects require land value capture-based financing with integrated transit and urban land development to create the best economic value. The thesis calls this integration as TFUL - transit, finance and urban land development. The thesis suggests that with private sector involvement from the concept stage, TFUL projects could increase economic gains and lead the public sector to focus on their core role of governance including community engagement and partnership development. This will increase economic value significantly.

The thesis ends by examining whether Indian cities can help achieve IPCC 1.5°C agenda of renewable based electric urban mobility through urban rail and land development financed through land value capture. The urban transport emissions analysis showed that if Bangalore and Delhi achieve similar mode share to Mumbai, which is dominated by rail, Delhi can cut urban transport emissions by 40% and Bangalore by 34%. This can create land value capture finance as an integral part of climate change policy as it can finance electric urban rail and enable density and land development.

The thesis shows that India has started relative decoupling of income and fossil fuel in the past decade which may change to an absolute decline in fossil fuels in coming years. Indian cities are thus likely to contribute to the 1.5°C agenda based on their established urban fabric, electric rail growth and the commitment to solar/battery-based mass transit and electric vehicles.

Further work is needed to examine other cities as they create new opportunities for innovative approaches to alternative funding and financing. The application of the TFUL approach should now be applied to a range of cities in the developed and emerging world to see how best to engage private sector investment. The need for more work on delivery mechanisms and partnership development is particularly highlighted.

Acknowledgements

तद्विद्धि प्रणिपातेन परिप्रश्नेन सेवया |
उपदेक्ष्यन्ति ते ज्ञानं ज्ञानिनस्तत्त्वदर्शिनः || 34||

Learn the Truth by approaching a spiritual master. Inquire from him with reverence and render service unto him. Such an enlightened Saint can impart knowledge unto you because he has seen the Truth.

Bhagavad Gita: Chapter 4, Verse 34

I would like to thank many people for their support and encouragement during my PhD studies.

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Finally, I am very thankful for my friends and colleagues, all of them have helped me in many different ways.

Dedication

I would like to dedicate this thesis to my late Father, my Mother, my Sister and my wife.

Publications submitted as part of this thesis

Below is a bibliographic list of the publications representing the body of research for this PhD thesis.

Publication 1:

Sharma R. & Newman P. (2017). Urban Rail and Sustainable Development: Key Lessons from Hong Kong, New York, London and India for Emerging Cities. *Transportation Research Procedia*, 26, 92-105. https://doi.org/10.1016/j.trpro.2017.07.011

Publication 2:

Sharma, R., & Newman, P. (2018). Does rail increase land value in emerging Cities? Value uplift from Bangalore metro. *Transport Research A: Policy and Practice* (Submitted, two positive reviews).

Publication 3:

Sharma, R., & Newman, P. (2018). Can land value capture make PPP's competitive in fares? A Mumbai case study. *Transport Policy*, 64, 132-140. 10.1016/j.tranpol.2018.02.002

Publication 4:

Sharma, R., & Newman, P. (2018). Land Value Capture Tools: Integrating Transit and Land Use through Finance to Enable Economic Value Creation. *Journal of Planning Literature.* (Submitted).

Publication 5:

Sharma, R. (2018). Financing Indian Urban Rail through Land Development: Case Studies and Implications for the Accelerated Reduction in Oil

Associated with 1.5° C. *Urban Planning, 3*(2), 21. DOI: 10.17645/up.v3i2.1158.

Other relevant publications (not submitted as part of this thesis)

Publication 1:

Sharma, R., Newman, P., & Matan, A. (2015). Urban Rail - India's Great Opportunity for Sustainable Urban Development. *In European Transport Conference 2015.*

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Chapter 1 Introduction

With the adoption of the Paris Agreement in 2016 and the New Urban Agenda in 2017 governments around the world are focusing on cities to achieve their new climate change and sustainable development targets as cities have been the cradle of innovation and change (UN Habitat, 2017). Urbanization is predicted to be one of the most transformative trends of the 21st century and is associated with economic growth and sustainable development (Glaeser, 2011; Ahluwalia, 2011; UN Habitat, 2017). The scene is therefore set for all cities, including Indian cities, to demonstrate a sustainable future.

The Intergovernmental Panel on Climate Change (IPCC) chapter on Transportation (Sims et al., 2014) notes that reduction in urban transport sector emissions is critical to achieve future climate change goals as urban travel is oil based and automobile dependent (Rode et al., 2017; Van Audenhove et al., 2014). Newman, Kosonen & Kenworthy (2016) show that the most significant factor to counter automobile dependence is rail based transit which leads to density enabling walking and transit urban fabric to replace oil based automobile fabric; these factors are also associated with creating agglomeration benefits and innovation (Carlino & Kerr, 2014; Matan & Newman, 2016). Such rail projects can help reduce the use of oil, create economic development and help in climate policy.

Thus, many cities of the 21st century, especially fast growing emerging cities like in India, are now required to support their rapid urbanization with urban rail. This requirement is not politically difficult as many cities and communities are wanting urban rail to solve their many problems from traffic (Newman & Kenworthy, 2015).

The growth of rail lines in the 21st century has been dramatic in all parts of the globe, especially in China and India but also in most developed cities (Newman, Kenworthy & Glazebrook, 2013). The patronage of existing urban rail systems has seen a significant rise in this period suggesting there is now a major market for urban rail. Whilst traditionally these projects have been predominantly government-funded across the globe, they are now struggling to meet the required finances to cater for transit demand. Urban rail agencies have significantly struggled to recover operating cost through fare box revenue as it is inherently limited due to equity demands (Flyvberg, 2007; Jillella et al., 2016; Newman & Kenworthy, 2015; Sharma, Newman & Matan, 2015).

This traditional way of urban rail financing will lead to a growing debt-subsidy cycle which would undermine economic development and minimize the possibility of countries actually phasing out oil based urban travel the way that the world needs for the global sustainability agenda of 1.5°C.

At the time when urban rail investment appears to be a priority for cities, governments face budgetary pressure leading to challenges in the financing of urban rail. The fiscal challenge for urban rail has prompted cities to find alternative funding and seek different governance frameworks to implement rail projects. Cities are recognizing the potential of urban rail in creating economic value through its multiple non-transport benefits specially its impact on land values and thus its potential for influencing more intensive land development and hence urban regeneration with its associated agglomeration benefits (Banister & Thurstain-Goodwin, 2011; Capello, 2011; Newman, Davies-Slate & Jones, 2017; Newman & Kenworthy, 2015; Glaeser, 2011).

Researchers have widely documented that gains in land value due to urban rail can be managed through land value capture tools to help finance urban rail, in many developed and some developing cities (see Anantsuksomsri & Tontisirin, 2015; Armstrong & Rodriguez, 2006; Cervero, 2003; Du & Mulley, 2007; Garrett, 2004; Laakso, 1992; McIntosh, Trubka & Newman, 2014; Medda & Modelewska, 2009; Mulley, 2014; Newman, Davies-Slate & Jones, 2017; Suzuki, Cervero & Iuchi, 2013; Yankaya, 2004). However, there is a significant research gap in such studies on emerging cities which are very important in the current scenario of urbanization and also on how land value capture finance can enable wider economic value creation (see Publication 2; Publication 4).

India is set to witness peak urbanization in the next four decades with accompanying rapid economic growth. India's urban population would almost double from 2011 to 2031. This would mean India will have 87 cities with million plus population by 2031 from 50 in 2011. The predicted urbanization growth and economic growth in India would possibly be the largest national urban transformation of the 21st century. In this scenario, urban rail has emerged as an efficient and reliable solution to cater to urban travel demand in many cities. The need for urban rail in India comes from a primarily economic perspective rather than seeing it as a welfare or sustainability perspective which includes critical externalities of traffic congestion, critical air pollution levels and energy security (Ahluwalia & Mohanty, 2014; Heilig, 2012; Ahluwalia, 2011; WBG, 2017).

The growth of India's modern urban rail system has happened in the last decade after the transit-success of Delhi Metro (started in 2002). Urban rail is now (September 2017) operational in 11 cities and under-construction in another 9 Indian cities. Indian cities have added 370 km operational urban rail and another 556 km is under-construction in the period of 2002 – 2017. This growth is driven by demand for urban rail travel and supported through political leadership. However, this is far behind China's over 3,000 km of urban rail most of which was built in the past decade but Indian cities have extensive future plans for urban rail in over 30 cities. The Indian government has been financially supporting urban rail since 2011 in cities with population over two million but this norm has been reduced to one million to extend this benefit to medium size cities (Government of India 2017a; Government of India 2017b; Kai et al., 2016; Sharma, Newman & Matan, 2015).

India's ambitious plan for a large urban rail network would require substantial investment and would need to be financially viable due to India's significant socio-economic budget deficit (Government of India 2017a; 2017b; Ministry of Finance, 2017). Existing Indian urban rail systems are facing a financial deficit as they are highly dependent on fare box revenue and conventional budgetary support from the government, as has been the case globally (Flyvberg, 2007; Jillella et al., 2016; Sharma, Newman & Matan, 2015). It is essential for Indian cities to explore alternative financing sources by recognising urban rail's non-transport benefits specifically its impact on land value and land development potential for economic value creation. If Indian cities cannot generate investment for these necessary changes then it will undermine the 1.5°C agenda which India takes very seriously as a part of their global recognition and acceptance as a nation of innovation for the future.

This thesis seeks to address these issues by estimating the potential impact of urban rail on land value; the focus of this is not just to finance urban rail but to provide for the demand in associated transit-oriented development. A public funded urban rail – Bangalore Metro - and a private funded urban rail project – Mumbai Metro - were selected for this enquiry to estimate the spatial extent of the impact of urban rail on land values and willingness to pay for such capital intensive urban rail projects (Publication 2; Publication 3). This analysis was based on a panel data hedonic price model (HPM) to estimate 'before' and 'after' commencement of urban rail impacts on land value in the catchment area and at city level. The reasoning for city level impact analyses was established through linking economic theories.

The reasoning for the selection of the two cases for this thesis was to understand and categorise the governance, financing, project structuring and public policy issues for publicly funded and privately funded urban rail projects (see Publication 1; Publication 2; Publication 3). This understanding then led to the enquiry of how value creation and economic benefit can be increased through integration of transit and urban land development based on land value capture finance. The thesis calls this integration as TFUL. The thesis further explores how private finance and expertise can be both the source of capital and the integrative governance force required for TFUL projects for larger value creation and economic value (see Publication 4). These processes would require a paradigm shift from the existing urban planning processes in Indian cities and also globally but are essential for achieving wider economic goals. The thesis discusses these urban planning implications (see Publication 5).

This thesis examines the fossil fuel based urban travel in Indian cities to show that Indian cities may not succumb to oil based automobile dependence based on their established urban fabric, automobile saturation and new electric urban rail growth through land development and public private participation. The Indian government policies about electric mobility and rail as well as solar energy-related to these systems, may surprise the world with a dramatic shift from fossil fuel dependence to widespread usage of renewables that are likely to contribute to the 1.5°C agenda.

The bulk of this thesis comprises the five publications; the full publications are included at the end of this thesis. Each publication responds to a different aspect or scale of urban rail impact on land value and how that can provide opportunities for public private participation to create larger economic value to help decouple wealth and fossil fuel use.

The thesis thus sets out to create awareness among policy makers, urban economists, city managers and urban professionals. The thesis has both applied and academic policy implications that aim to make an original contribution to existing knowledge on cities, especially on emerging cities.

1.1 Research Aims

The overarching research question this study seeks to answer is:

What is the potential of urban rail in creating land value that can be used to finance urban rail and create economic value?

Answering this overarching question involves a multi-disciplinary approach by integrating the research fields of: transportation, land economics, transport economics, econometrics, public policy, project financing, sustainable cities and urban planning.

Thus, the overarching research question required investigation into several subquestions with its objective as discussed below:

Subquestion 1:

How are urban rail projects structured and financed for their role in urban development, especially emerging cities?

The objective of this subquestion was to investigate the project structuring and financing of urban rail projects through historic and recent case studies in several large iconic cities. This included analysing if public and private owned urban rail projects can sustain and expand based on the conventional revenue source of fare box revenue. The research further explores the link between urban rail's land based financing and its potential for shaping urban development, especially in Indian cities and other emerging cities.

This subquestion is addressed in Publication 1: "Urban Rail and Sustainable Development – Key Lessons from Hong Kong, New York, London and India for Emerging Cities".

Subquestion 2:

Can emerging cities estimate the potential of a government led urban rail project in creating land value at catchment area and at the city level?

The objective of this subquestion was to analyse the extent of the impact of urban rail on land value on an emerging city (Bangalore). This included the enquiry on economic theories of urban land to assess if urban rail results in agglomeration benefits at city level in addition to the generally accepted impacts on catchment areas. The research included econometric analyses to quantify the willingness to pay for land value uplift due to commencement of urban rail.

This subquestion is addressed in Publication 2: “Does Urban Rail Increase Land Value in Emerging Cities? Value Uplift from Bangalore Metro”.

Subquestion 3:

Can land value capture enable a private led urban rail project to achieve financial and social viability?

The objective of this subquestion was to understand if a private urban rail project can create land value to avoid fare-related equity issues in one of the most densely populated cities (Mumbai) in the world. This included econometric analysis to estimate the impact of urban rail on land value and project-associated public policy issues on fare affordability. The willingness to pay was calculated based on the impact of urban rail on land values and how this can be captured in order to create a more financially and socially viable solution.

This subquestion is addressed in Publication 3: “Can Land Value Capture make PPP’s Competitive in Fares? A Mumbai Case Study”.

Subquestion 4:

Can urban rail financing through land value capture tools be used to enable land development and wider economic value creation?

This subquestion focuses on understanding the potential of various land value tools in integrating urban rail and land development through finance. This included investigation of whether private finance and expertise can be both the source of rail capital and the integrative driver for urban rail and associated land development. The TFUL concept is expanded in this paper along with an understanding of how private investment at early stages in an urban rail project, in partnership with all levels of government and the impacted local community, can be the source of economic value creation.

This subquestion is addressed in Publication 4: "Land Value Capture Tools: Integrating Transit and Land Use through Finance to Enable Economic Value Creation".

Subquestion 5:

Will India's growth in urban rail continue due to global agendas such as the 1.5°C IPCC scenario and will India contribute positively to this agenda?

The objective of this subquestion is to investigate whether urban rail growth in India is likely to continue past the present spurt and help in achieving the IPCC 1.5°C agenda which requires the rapid phasing out of coal and oil and renewable based electric urban mobility. The research examines the transition of 'oil-based automobile dependence' to 'urban rail plus renewable energy' to cater for transport demand in Indian cities. This includes analysis on urban transport emissions and if India has started relative decoupling of wealth and fossil fuel use and if land value capture finance is likely to assist this.

This subquestion is addressed in Publication 5: “Financing Indian Urban Rail through Land Development: Case Studies and Implications for the Accelerated Reduction in Oil Associated with 1.5°C”.

1.2 Structure of thesis

The exegesis provides an explanatory overview to this thesis. It includes a brief introduction (Chapter 1), summary of literature review (Chapter 2), brief description of research methods adopted (Chapter 3), overview of the five publications (Chapter 4), results and discussion (Chapter 5) and conclusions with recommendations for future work (Chapter 6). The full publications are annexed with this exegesis.

Publication 1 shows that both private and public funded urban rail globally require innovative financing mechanisms (specifically land based) to sustain or revive themselves financially in both developed and emerging cities. It suggests urban rail lends itself in shaping urban development with multiple other co-benefits.

In Publication 2, the econometric analyses showed that there is a significant willingness to pay for urban rail in Bangalore and hence is likely to be the case in other emerging cities. Urban rail projects have potential for a major agglomeration economic event in emerging cities as they are in a rapid growth phase where economic change is very sensitive to the provision of quality rail and associated urban developments. Land value increases are found well beyond the traditional 500m catchment area as the development has such a powerful impact on the whole ethos of the city. The analysis showed that although government funded this urban rail project it could have been financially viable through land value capture mechanisms.

Publication 3 examined Mumbai as a case study of a fully private rail project that did not use any land value capture mechanism but is now failing. The research showed that the application of land value capture is possibly necessary to enhance fare affordability and mitigate the financial strain imposed by public transport on the community in Mumbai and probably in any city. The econometric analysis showed that there is a significant uplift in land value due to commencement of the private urban rail project. The analysis showed that land value capture for a private urban rail project can be used to avoid a high dependence on fare box revenue thus avoiding the consequent public policy struggles over fare fixation.

Publication 4 researched the various land value capture tools and how they can create economic value. The investigation on conventional funding of urban rail reveals that there is a vicious and regressive cycle of conventional funding – loans, fare box, subsidies. The research addresses this issue with integrated transit, finance (land value capture) and urban land development – the TFUL model. A major conclusion is that partnerships create economic value and hence working with communities and the private sector from the concept stage for TFUL projects can enable wider economic value creation opportunities.

In Publication 5, the analysis shows how India is participating in a global agenda that is likely to continue to drive the growth in electric urban rail systems. It shows how urban travel and fossil fuel use in India has started relative decoupling from growth in wealth in the past decade and that this may change to an absolute decline in fossil fuels in coming years. The thesis shows that Indian cities may contribute to the global need for addressing the 1.5°C agenda based on their urban fabric, travel characteristics, electric urban rail growth through land development, growth of EV’s and local shared transport systems. It shows land value capture finance can help in finance this development and help achieve climate change goals.

1.3 Background and Significance

I would like to give a personal narrative before I discuss the significance of this thesis. I have worked in the urban transport sector for about 4 years with government agencies in India. I was involved in a study on Land Value

Capture – Revenue Estimation for urban rail project in India (Nagpur Improvement Trust, 2013). During this study, I noticed a significant research gap on estimating the impact of urban rail on land values in Indian cities and even on other similar emerging cities. Therefore, in lieu of complementing the time-bound study we assumed a 2% annual increase in land prices due to the planned urban rail based on stakeholder discussions. Although the study did not represent the actual potential of value capture in an Indian city the outcomes of the study increased the urban rail project financial internal rate of return from 0.47% to about 10% which determined the viability and approval of the project. However, this research gap still exists for Indian cities. Perhaps Indian cities would not grow by so much or maybe they would grow even higher?

Many Indian cities have existing provisions for land value capture such as Nagpur Improvement Trust Act, 1936 (Nagpur Improvement Trust, 2013); they have a regulation enabling 'Betterment Charging' which provides a legislative framework to implement value capture mechanisms. However, the Nagpur local agencies have not been able to implement this regulation due to the inability to estimate the impact of infrastructure on land values. Similar cases exist in Mumbai and other cities (Government of India, 2017b).

The Indian government has recently approved three highly significant policies that make land value capture, private participation and land development provisions mandatory for Indian cities for urban rail projects: National Transit Oriented Development Policy (Government of India, 2017a); Value Capture Finance policy framework (Government of India, 2017b); and Metro (Urban Rail) Policy (Government of India, 2017d). These are highly relevant to this thesis and they show the Indian government is ready for a rapid expansion of urban rail and are looking for alternative financing mechanisms; they therefore need such research. The need was also highlighted during my interaction with Indian government officials, professionals and urban rail agency officials.

The local significance of this research is therefore quite clear but more importantly it is of considerable global significance for similar reasons as to that being found in India: most cities need more urban rail and they don't know how to finance it.

The global focus of governments is to provide competitive, productive and sustainable cities (Newman, Beatley & Boyer, 2016). The global focus of researchers, especially in the urban policy space, is therefore how to understand the rationale for this, how to assess whether different cities are doing it, and how to facilitate their needs. As outlined in the literature review and Publication 1 this reduces quite quickly to the need to show how land value capture can be used to finance urban rail and economic growth (Commonwealth of Australia, 2017; Government of India, 2017a; Government of India 2017b; Government of India 2017d; Newman & Kenworthy, 2015; Newman, Davies-Slate & Jones, 2017; Sun et al., 2017; Transport for London, 2017).

This thesis may fill the research gap by empirically estimated willingness to pay studies that show how urban rail-based windfall gains in land values in the catchment area and at city-level can then be captured to help provide the finance for building the rail projects. The suggested transit finance and urban land use (TFUL) framework in this thesis is not just aimed at addressing the land value capture but to enable projects that produce value creation, urbanization, private participation, land development and economic benefits. This thesis should therefore be highly relevant for global cities, especially emerging cities with high growth potential, and will have high relevance to Indian cities that are planning for urban transit systems aimed at economic growth.

Chapter 2 Literature Review

A detailed literature review was conducted for this thesis to describe characteristics of urban rail and land value capture. Secondary sources were drawn from academic literature, for example journal articles, academic books, research papers and conference papers as well as relevant industry and government literature, for example, international, national and local government reports, industry reports, press releases, statistical yearbooks and websites. The latter material is essential for a thesis where so little has yet been published on emerging cities and value capture financing of urban rail.

This Chapter summarises the literature review conducted as a part of this thesis. The detailed literature reviews—on each subtopic in this section—are included in the annexed publications.

2.1 Urban rail and economic benefits

Glaeser & Gottlieb (2008) suggests that transportation infrastructure is a nontraded productive capital which relates to its potential in creation of value. Transport infrastructure is also a fundamental part of the urban economic value partnership as it creates the urban fabric around which the economy is created (Glaeser & Kahn, 2004; Newman, Kosonen & Kenworthy, 2016). Urban rail is a significant fixed transport infrastructure that has substantial potential for value creation as historically rail growth has been associated with local economic development and urbanization (Glaeser & Gottlieb, 2008; Hanies & Margo, 2006).

The literature on agglomeration value focusses on how clustering of different economic activity and skills creates extra value through synergies and partnerships (Glaeser & Gottlieb, 2008; Melo et al., 2017). One example from Glaeser and Xiong (2017) is of the Chicago stockyard where people and businesses have clustered around the associated rail stations. Initial formation of such urban clusters is due to the new rail infrastructure that reduces the cost of moving people which is an agglomeration benefit. Agglomeration theorists suggest that such clusters attract additional business and lead to innovation due to the proximity to people and access to a large labour resource (Glaeser & Xiong, 2017). Knowledge economy jobs are particularly attracted to such transit oriented centres of activity (Kane, 2010; Malecki, 2007; Yigitcanlar, 2010).

Nathaniel Baum-Snow (2007) showed that historically cities with rail networks had lesser suburbanization which is another substantial economic benefit for cities due to large savings in infrastructure and other associated costs (see Trubka, Newman & Bilsborough, 2010). Cities with rail networks have lesser automobile dependence resulting in significant saving from automobile externalities (Newman & Kenworthy, 2015). These benefits associated with density lead to further density and economic value. Chauvin et al. (2017) shows that agglomeration, urbanization and density led to large growth outcomes and human capital. Banister & Berechman (2011) suggests that to realize these economic gains it is necessary that the investment conditions and the political and institutional conditions are operating at the same time.

These are significant direct economic impacts associated with urban rail networks however there are also large indirect economic impacts from dense land developments in cities that also make them candles of innovation (Glaeser, 2011; Florida, 2010). These economic benefits of urban rail provide windfall gains to the urban land market that represent willingness to pay for these economic gains (McIntosh, Trubka & Newman, 2014). Such willingness to pay is also reflected in location theories, urban rent and urban land demand studies.

Von Thunen’s (1826) classic location theory concepts that were applied to urban activities by Hurd (1903), Haig (1926) and Ratcliff (1949), suggest that urban activities reflect rent competition for locations that minimize movement.

Robert Park (1929) theorized that improvement in transportation and population growth augments benefits of the city center. Alonso (1964) and Muth (1969) showed the positive relationship of land value with its proximity to a city center due to minimization of transportation cost (spatial friction) that also represents the willingness to pay for access to transit. In cities, the economic rationale of choosing to situate a firm or household at a specific location in an urban space is to minimize transportation costs in the context of agglomeration economies (Capello, 2011)[1].

Camagni (2016) suggested that urban land rent emerges from two preconditions, first being a limited supply that leads to a 'scarcity absolute rent' (Scott, 1976; Sraffa, 1960) and the second, a 'demand for city' i.e. a household's willingness to pay more than the supply cost for a desirable good or production factor such as access to transit. He notes that the demand is generated by the need to benefit from an urban environment which is a product of agglomeration economies (Camagni, 1992, as cited in Camagni, 2016). Demand may increase due to time/ space specificities when a city becomes crucial for economic activities, for instance, the knowledge economy emerges or a city provides an innovative environment (Camagni, 1992, as cited in Camagni, 2016). This demand may arise due to introduction of an urban rail line (which I aim to examine in this thesis).

These economic theories indicate the significance of density, mixed land use and the notion of travel time saving in an urban area. Travel time saving is economically significant as it contributes to decreases in transportation and opportunity cost. In the last decade, the travel time by car has become significantly higher as compared to urban rail in cities across the globe (Newman & Kenworthy, 2015). The average urban rail speed to average

[1] The variable 'Distance from the city center' was included in the econometric analysis for both Mumbai and Bangalore to show the impact of city-center as distinct from city-fringe.

urban traffic speed is now over 1 with significantly higher values in Europe and Asia. The importance of travel time saving is driving the demand for urban rail that is further catering to the urban knowledge economy and the culture of people-centred urban form to support this process (Glaeser, 2011; Matan and Newman, 2016). The relevance of these theories was ignored by cities and some urban planners (Gordon & Richardson, 1989) even slammed these concepts which were advocated and analyzed by Newman and Kenworthy (since the 1980's) (1989).

2.2 Limitations of conventional funding of urban rail

Urban rail systems have historically faced financial deficits when they are highly dependent on fare box revenue and conventional/ traditional financial support from government who saw the rail services as essentially an equity issue (Sharma, Newman & Matan, 2015; Ubbels et al., 2001). The conventional financial support for urban rail includes subsidies and loans and both are becoming increasingly limited (Graham & Van Dender, 2009; Ingram & Hong, 2012; Medda & Modelewska, 2009; Salon & Shewmake, 2011; Zhao et al., 2012). Proost et al. (1999, as cited in Ubbels et al., 2001) argue that subsidies work against economic efficiency, impose higher taxes and may reduce spending on other public services (Smith & Gihring, 2006).

Subsidies for transit systems has resulted in urban sprawl in a number of cities (see Brueckner, 2005; Buehler & Pucher, 2011; Parry & Small, 2009; Tscharaktschiew & Hirte 2012). Transit subsidies have also been widely criticized on the issues of equity and been blamed for worsening the productivity and efficiency of transit agencies (Cropper & Bhattacharya, 2012; Pucher & Lefèvre, 1996; Pucher, Markstedt & Hirschman, 1983). Loans, in current economic scenarios are significantly restricted for governments and yet all major global economies require significant infrastructure funding (Medda, 2012; American Society of Civil Engineers, 2013; Planning Commission of India, 2011; KPMG, 2016; Schulz & Smith, 2015). Therefore, the vicious cycle of conventional revenue and costs –

loans, fare box, subsidies – seems to be economically regressive for urban rail. An alternative is the need to realize the economic benefits of urban rail and use it for its financing.

2.3 Land value uplift due to urban rail

The uplift in land value due to urban rail is widely documented (see Anantsuksomsri & Tontisirin, 2015; Armstrong & Rodriguez, 2006; Cervero, 2003; Du & Mulley, 2007; Garrett, 2004; Laakso, 1992; McIntosh, Trubka & Newman, 2014; Medda & Modelewska, 2009; Mulley, 2014; Newman, Davies-Slate & Jones, 2017; Yankaya, 2004). The uplift of land value is a result of investments that accrue to the landowners (both government institutions and private) without the owners making any direct investment (Chapman, 2017; Mathur & Smith, 2013; Medda, 2012; Pagliara & Papa, 2011; Smolka, 2013). Murakami & Cervero (2010) notes that this uplift can be spatially redistributive within a city-region and largely localized around the stations. Though the increased desirability of that land stimulates changes in land use, zoning and development intensification resulting in economic improvement (Cervero & Murakami, 2009; Salon, Wu, & Shewmake, 2014).

The co-development can enable density, place-making opportunities, activity centers and active transport enabling knowledge economy. This unlocking of land value leads to a greater value creation by significant economic returns and productivity (Glaeser, 2011; Matan & Newman, 2016; Newman, Davies-Slate & Jones, 2017). This makes urban land development an important parameter in operational efficiencies for urban rail systems, specifically for the kind of focused land development – Transit Oriented Development. This process can enable a major economic benefit both in the agglomeration economies and the savings in alternative more scattered urban forms that it replaces (Cervero, Ferrell & Murphy, 2002; Noland et al., 2014; Trubka, Newman & Bilsborough, 2010).

Simple comparison methods and HPM methods have been used to estimate the uplift of land value due to urban rail (Du & Mulley, 2012; Du & Mulley, 2007; Cervero & Landis, 1993). Simple comparison methods segregate transport accessibility impact from various factors influencing land value through simple comparison between different land values. On the other hand, the HPM method is a regression model that estimates the relationship between land value price, accessibility and other variables influencing land value. HPM is considered as the most suitable method available to estimate the impact of urban rail on land value, the subject of this thesis (Cervero & Duncan, 2001; Freeman, 1979; McIntosh, Turbka & Newman, 2014; Rosen, 1974) (discussed further in Chapter 3).

The HPM is multi-disciplinary and specifically used to estimate the value or demand (willingness to pay) for a commodity. It has been used globally to analyse issues of political significance (Sopranzetti, 2015). HPM was used to analyse value of open spaces in America (Brander & Koeste, 2011; Hoshino & Kuriyama, 2010; Nordman & Wagner, 2012; Poudyal, Hodges, & Merrett, 2009; Sander & Polasky, 2009) and China (Jiao & Liu, 2010), valuation of cars (Cowling & Cubbin, 1972), value of trees along a street (Donovan & Butry, 2010), air quality (Bayer, Keohane, & Timmins, 2006; Kim et al., 2010), prices of cattle (Abdulai, Kassie & Wollny, 2011), tax assessment (Berry & Bednarz, 1975), and other, in addition to the analysis of land value, the theme addressed in this thesis.

Hedonic price models have revealed the land value increase with respect to distance from stations at about 16% of the land value up to 1 km from the urban rail station in Izmir, Turkey (Yankaya, 2004); 11% increase in land values from 500 m to 750 m in Helsinki, Finland (Laakso, 1992); 17% increase in land values within 800 m in San Diego, USA (Cervero, 2003); 10% increase in land values within 800 m in Massachusetts, USA (Armstrong & Rodriguez, 2006); 7% increase in land values within 1 km in Warsaw, Poland (Medda & Modelewska, 2009).

However, uplift from urban rail projects can exhibit mixed results in different local settings. For instance, mass transit in Atlanta, USA has led to property value uplift in economically weaker areas but has decreased value of properties in economically affluent areas; Miami, USA presents a reverse case (Bowes & Ihlanfeldt, 2001; Diaz, 1999). Whilst in Perth different urban rail lines had significant variation on the impact of land value (McIntosh, Turbka & Newman, 2014). There is also significant difference in various scholarly research studies between developing and developed countries in term of availability of data, scale of impact of urban rail on land value and willingness to pay (see Publication 2).

2.4 Land value capture tools

Land value capture (LVC) tools have long been applied to recover the land value uplift to fund public infrastructure such as urban rail (Chapman, 2017; Gihring, 2009; Ingram & Hong, 2012; Smith & Gihring, 2006; Zhao et al., 2012). The earliest implementation dates back to the days of the Roman Empire when the citizens to be benefited by the infrastructure where charged for the construction and maintenance of public roads and aqueducts, this practice was also followed by other civilizations the world over (Smolka, 2013). The literature on land value capture tools is large, some of the recent contributions on LVC tools includes Chapman, 2017; Connolly & Wall, 2016; Iacono et al., 2009; Levinson & Istrate 2011, Mathur & Smith 2012; Mathur, 2014, Medda, 2012; Medda & Modelewska, 2009; McIntosh et al.,2015; Newman, Davies-Slate & Jones, 2017; Roukouni & Medda, 2012; Smolka, 2013; Sun et al., 2017; Zhang & Wang, 2013; Zhao, Das & Larson, 2012; Zhao & Larson, 2011; Zhao et al., 2012.

Development of LVC tools is an evolving process and various tools have been classified based on their different timing, payment schedule, incidence (Chapman, 2017), scale and actors involved (Connolly & Wall, 2016; Medda, 2012; Peterson, 2009; Smolka, 2013; Walters, 2012; Zhao et al., 2012). LVC tools can be seen as an economically progressive for cities with the potential to drive urban land development for economic gains (Newman, Davies-Slate & Jones, 2017). However, there is a gap in literature on the delivery of integrating transit, land development, land value capture and land use through private finance for creating value and economic gains. Publication 3 and Publication 4 categorizes LVC tools and provide detailed discussion.

A transparent and equity based delivery strategy is critical for enabling benefits of LVC (Zegras, Jiang & Grillo, 2013). In the analysis of implementing value capture in Latin America Smolka (2013) noted that effective delivery of an integrated railway and station complex demands partnership between community, government, planning and private sector for effective application of LVC tools. Public participatory approaches during the planning and execution stages of urban rail can enable the government to gauge community requirements and concerns in order to increase the success of LVC mechanisms (Giering, 2011). Such community engagement can be enabled to ensure value and fiscal decentralization to enhance public sector efficiency, accountability, transparency in service delivery and policy-making. This can further help in strategizing future assessment and planning assessment and enable local entrepreneurialism (Environment Protection Agency, 2017; Jillella & Newman, 2015; Mello, 2000).

2.5 Implementation issues of land value capture in emerging cities

The level of uncertainty in implementation of LVC is higher in emerging cities as compared to developed cities. Bahl and Linn (2014) concluded from a study of 50 emerging cities that in all cities experience of LVC implementation has been poor. Medda (2012) notes that in Columbia betterment tax is preferred in areas where landowner's ability to pay is higher than the low-income group neighbourhoods. This results in socio-spatial segregation over time as only well-off neighbourhoods receive public interventions.

Emerging cities reflect a complex setting, marked by disparity and inequitable resource distribution. It is challenging to identify the users of transport infrastructure and the contributors of LVC policy. In fact the absence of holistic framework and adequate knowledge has kept some cities from implementing a policy already in place.

When there is initiation to formulate and implement a LVC policy, to policymaker's further dismay, data banks are either not available or not maintained well. Demography changes rapidly, land registries are not updated, property valuation methods are not sophisticated, property tax collection is compromised and transactions are not transparent, resulting in a speculative real estate market. A McKinsey study (2001) notes that 90% land titles in India are unclear which account for 1.3 per cent of lost growth annually.

Indian cities have several value capture tools in their respective development control regulations ranging from betterment levy, development charges and incentive zoning. But very few Indian cities are able to implement the methods which are mainly land assembly and tax-based models (Ahluwalia & Mohanty, 2014; Government of India, 2017b). Perhaps this will change after the findings in this thesis.

Chapter 3 Research design and methods

The chapter provides study area, data sets, empirical analysis and modelling techniques adopted in the research.

3.1 Real Estate Data Collection Issues

Land/ property valuation and registry is essential to efficiently manage land which is an important economic factor of production. India is among the worst ranked countries in land/ property registry (The World Bank, 2016). Municipal bodies maintain records of properties for collection of property tax but do not update them annually. If cities like Bangalore and Mumbai are growing rapidly then much of the properties may not be assessed annually for property tax. Economic Survey of India 2016-17 (Ministry of Finance, 2017) notes that Bangalore has over 80% of built-up area not assessed.

For this thesis, I started the land value data collection through government authorities by using the Right of Information Act of the Indian government. The received data from different Indian cities was for neighbourhood level as the government agencies do not value land at plot level. However, plot level chronological data was essential for evaluating the urban rail commencement impact through the hedonic price model. Thus, government authority real estate prices were not used in this thesis for the following reasons:

- Government rates are not updated regularly
- No scientific valuation method used for government rates
- Government rates do not incorporate spatial characteristic of property
- Government rates are not based on individual property level valuation
- Government rates are significantly lower than the market rate (Ministry of Finance, 2012)

On the other hand, it was possible to use private real estate data as real estate companies record the sale price of properties and the fluctuation in prices on a real time basis. Financial institutions often use private real estate data for decision making on housing loans which signifies the authenticity and quality of data. Therefore, real estate company data was used in this study rather than government rates for both Bangalore and Mumbai cases. However, only residential apartment data were made available for these cities. To analyse the impact of urban rail on land value in Publication 2 (Bangalore) and Publication 3 (Mumbai) the data set is for the residential apartment only. However, these are the main housing typologies in most new housing developments in India.

A significant advantage of using the residential apartment sample for this thesis is that an apartment transaction is largely transparent in India unlike a land/ house transaction. This is because apartment transactions involve a property developer/ builder and an individual as opposed to two individuals in the case of land/ house transactions.

3.2 Data Size of Real Estate

Intrinsic issues related to real estate data availability in India limited the amount of data used in this thesis as compared to developed countries cases (see Publication 2). For example, in Perth, McIntosh, Trubka & Newman (2014) used over 400,000 plots of land value data.

Among developing countries cases (see Publication 2), the Bangalore study employs one of the most comprehensive data sets because the real estate company data was based on about 160,000 apartments in 458 condominiums (apartment/ flat projects)[2] over the period of 2012-16 (on a half yearly basis) and about 314,000 apartments in 898 condominiums in

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[2] Each condominium (sample) consists of about 350 apartments of varying size and type, which suggests that individual samples hold a substantial quantum for analysis.

2016. Mumbai data set comprised of 333 condominiums (about 66,000 apartments)[3] for 2014 and 2015.

The data sizes used for both cities were significant based on the recommended sample size for a regression model, suggested by prominent studies such as Green (1991) and Harris (1985):

3.3 Hedonic price model

The hedonic price model (HPM) is a regression model with its basis in economic thinking of the early 20th century. Agricultural economists around the 1920s explained unit prices of a commodity by regressing them on land variables (Colwell & Dilmore, 1999). A case in point is Frederick Waugh (1928) regressing the price of different asparagus types, to guide farmers in producing the quality demanded by the market. Another significant reference is of a study on monopolistic prices by Andrew Court (1939 as cited in Goodman, 1998) whom General Motors appointed to defend them against the Congress' allegations of anticompetitive price raising, following the substantial increase (45%) in the price index for cars between 1925 and 1935.

Lancaster (1966) was the first to attempt a theoretical foundation for hedonic modelling, through consumer behaviour with respect to a commodity. He opined that a commodity (e.g. land) does not signify utility to a consumer but possesses characteristics (e.g. locational attributes of a land entity) that contribute to a rise in its utility. These characteristics can be categorised based on their contextual likeness (e.g. neighbourhood characteristics of a land entity). Lancaster did not comment on pricing or pricing models.

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[3] A property sample used in the study consists of around 200 apartments of varying size and type, which suggests that individual samples hold a substantial quantum for analysis.

Rosen (1974) was the first to show a model of the HPM for a commodity based on its characteristics. He argued that a commodity can be valued (priced) as the sum of its individual characteristics’ prices based on their utility. Suggesting that commodity price can be regressed into individual characteristics’ prices as uniquely contributing to the total price (Sopranzetti, 2015).

The HPM consists of the application of ordinary least squares (OLS) regression which requires a linear relationship between the dependent variable (e.g. land value) and independent (explanatory) variables. The explanatory variables include factors influencing land value like distance to work centres, transit, neighbourhood characteristics and others (see Publication 2). Zhao & Larson (2011) highlight the limitation of econometric models such as HPM as it is difficult to separate the value uplift due to improved transport accessibility from the uplift due to general increase. However, size and nature of data can ensure efficiency in assessments through availability of updated registries and detailed data sets.

This thesis uses cross-sectional data for cross sectional HPM and panel data HPM for Bangalore Metro and Mumbai Metro to estimate their impact on residential land market.

Cross-section data are on one or more variables data collected at the same point in time. For this thesis cross-section data refers to the data of number of independent variables (impacting land values) and the dependent variable of land value, both collected at the same year. Panel data are pooled data containing time series observations of a number of variables. For this thesis panel data refers to the pooled data of number of independent variables (impacting land values) and the dependent variable of land value, both collected at the same periods (temporal). Panel data HPM is needed to estimate the variations in land prices before and after commencement of operations of new urban rail (Gujarati & Porter, 2004)

3.4 Structural Equation Modelling

Structural equation modelling is a collection of statistical methods used by researchers across disciplines that enables the examination of complex relationships by combining econometric analysis with qualitative assumptions of causality. (see Cervero & Murakami, 2010; Hopper, Coughlan & Mullen, 2008; McIntosh, Trubka & Newman, 2014).

3.5 Hedonic price model for Bangalore

Cross sectional data HPM and panel data HPM were evaluated to estimate the impact of commencement of Bangalore Metro Phase 1. The cross sectional HPM shows the impact of explanatory (independent) variables on condominiums prices for a single period (June, 2016). The panel data HPM shows the impact of explanatory (independent) variables on condominiums prices over time (December, 2012 to June, 2016). The two different HPM's were included in the study to see if cross-sectional data are adequate for achieving LVC results. This is because many emerging cities do not have panel data. Data used for the panel data HPM and cross sectional data HPM were at the city-level. The city-level data provided the opportunity to estimate the impact of an urban rail project at both city level and the urban rail catchment area.

The average sale price of residential condominium (apartment projects) in Bangalore was used (as a dependent variable for HPM). Explanatory variables found through the literature review were expanded based on the availability of data and due to the absence of existing empirical studies on factors influencing real estate price in Indian cities to check their impact. A total of 22 independent variables were considered in this study based on key attributable categories such as 'Property variables; Neighbourhood/ socio-economic variables; Accessibility variables; Metro rail specific variables' but only statistically significant variables were included in the HPM (see Publication 2).

For the panel data HPM, additional property price and urban rail specific time dummy variables were included along with the 22 explanatory variables (see Publication 2). The quantitative input data were sourced from various secondary data sources, including Census of India, local planning agencies and M/s LJ Hookers.

A spatial analysis software was used to map the properties and analyse their characteristics is relation to other land value influencing variables (urban infrastructure and amenity) and to prepare the database that was used for HPM (Figure 1). Four functional forms (linear, log-linear, linear-log and log-log) were tested for both the HPM's. The variance inflation factor (VIF) test was also conducted, to avoid estimation errors caused by a multicollinearity issue[4]. The test showed that all explanatory variables' VIF values were lower than 3.

[4] Multicollinearity occurs when an explanatory variable is highly correlated with one or more of the other explanatory variables in a OLS regression. This can undermine the statistical significance of an explanatory variable.

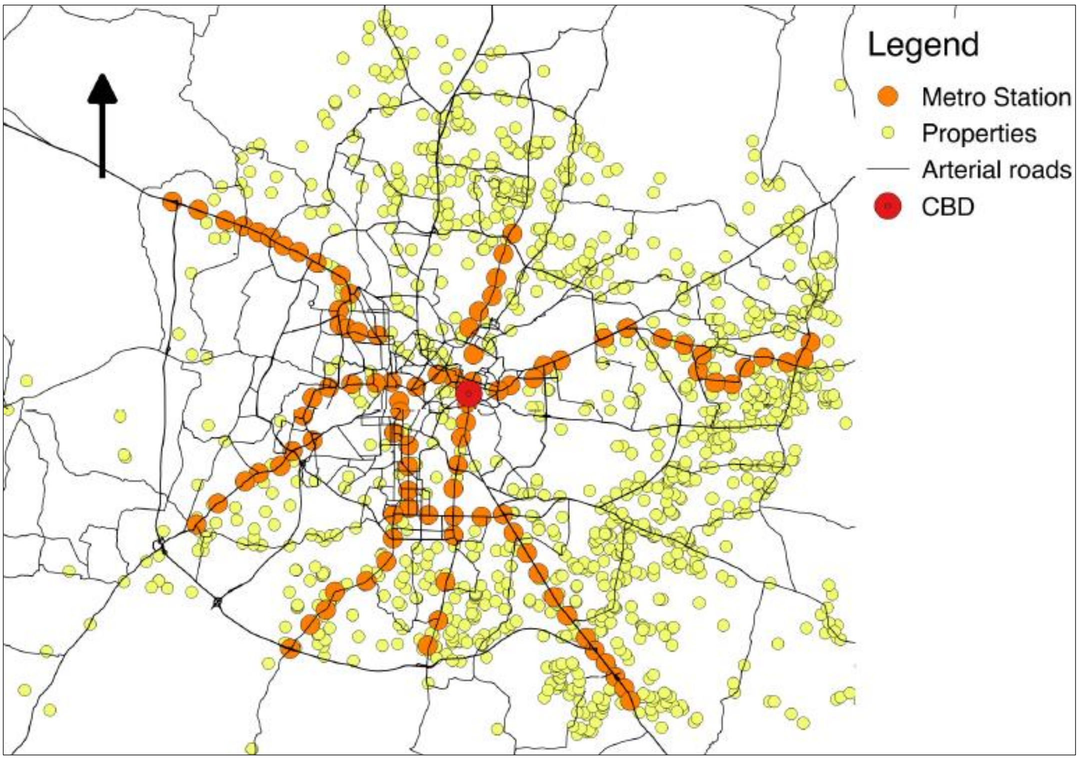

Figure 1: Bangalore Metro

3.6 Hedonic Price Model for Mumbai Metro

Panel data HPM was evaluated to estimate the impact of commencement of Mumbai Metro's Line 1. This thesis uses the average sale price of residential apartment projects in Mumbai as a dependent variable for the panel data HPM.

Explanatory variables influencing property price were considered based on neighbourhood variables, accessibility variables and city-specific variables. Additionally, property price and urban rail specific time dummy variables were included (see Publication 3). The quantitative input data were sourced from various secondary data sources, including Census of India, local planning documents and maps and M/s Liases Foras.

A spatial analysis software was used to map the properties and analyses their characteristics is relation to other land value influencing variables (urban infrastructure and amenity) and to prepare the database that was used for HPM (Figure 2). Four functional forms (linear, log-linear, linear-log and log-log) were tested for both the HPM's. The VIF test was also conducted, to avoid estimation errors caused by a multicollinearity issue. The test showed that all explanatory variables' VIF values were lower than 3.

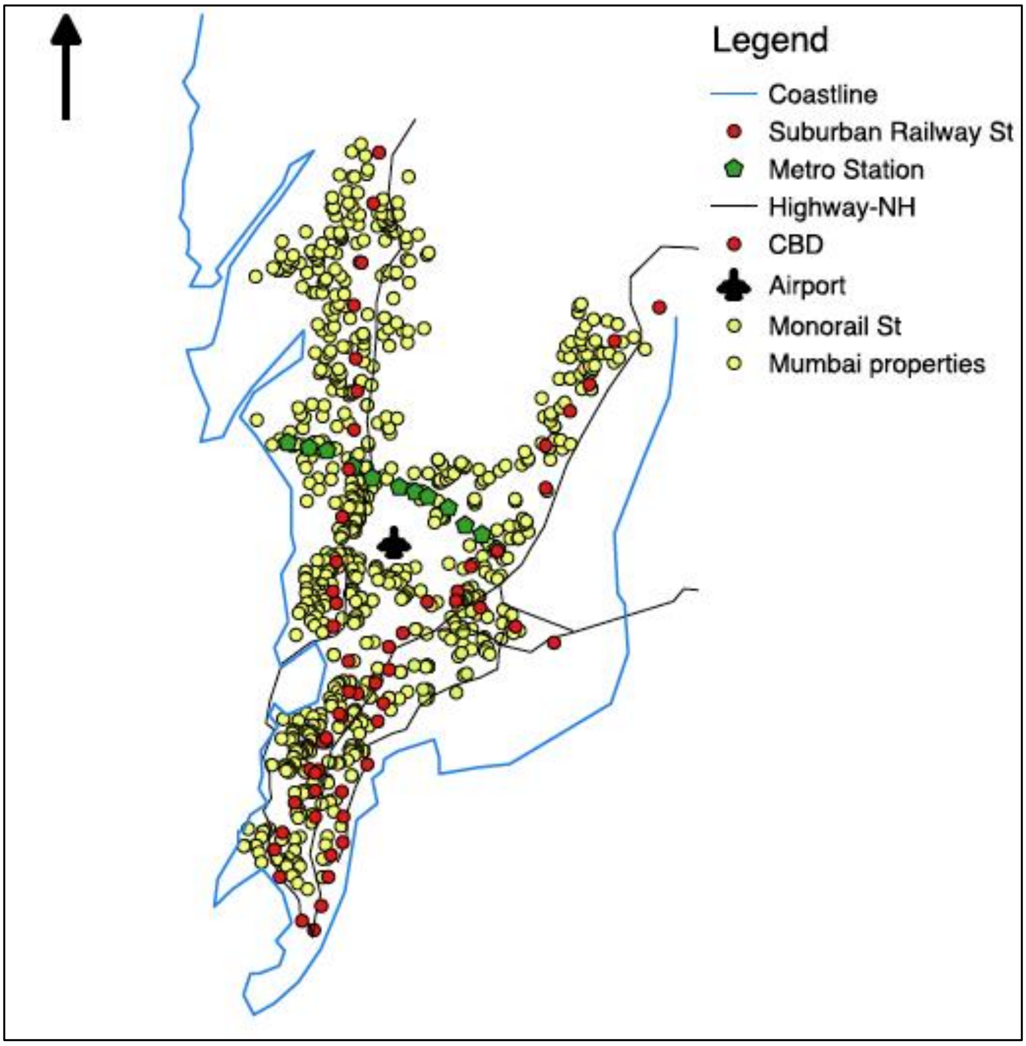

Figure 2: Mumbai Metro

Chapter 4 Overview of Publications

This chapter provides a summary of each publication submitted, the full publications are provided later. Each publication answers a subquestion of this thesis as outlined in Table 1.

Table 1**:** Publication titles and status

Paper title	Publication and status	Subquestions
Publication 1: “Urban Rail and Sustainable Development Key Lessons from Hong Kong, New York, London and India for Emerging Cities”	Journal: *Transportation Research Procedia*, 26, 92-105. DOI: 10.1016/j.trpro.2017.07.011 Published.	*How are urban rail projects structured and financed for their role in urban development, especially emerging cities?*
Publication 2: “Does Urban Rail Increase Land Value in Emerging Cities? Value Uplift from Bangalore Metro”	Journal: Transport Research A: Policy and Practice Submitted (two positive reviews).	Can emerging cities estimate the potential of a government led urban rail project in creating land value at catchment area and at the city level?
Publication 3: “Can Land Value Capture make PPP’s Competitive in Fares?	Journal: *Transport Policy*, 64, 132-140. 10.1016/j.tranpol.2018.02.002. Published	Can land value capture enable a private led urban rail project to achieve financial

Paper title	Publication and status	Subquestions
A Mumbai Case Study".		and social viability?
Publication 4: "Land Value Capture Tools: Integrating Transit and Land Use through Finance to Enable Economic Value Creation"	*Journal:* Journal of Planning Literature. Submitted.	Can urban rail financing through land value capture tools be assisted to enable land development and wider economic value creation?
Publication 5: "Financing Indian Urban Rail through Land Development: Case Studies and Implications for the Accelerated Reduction in Oil Associated with 1.5°C"	Journal: *Urban Planning, 3*(2), 21. DOI: 10.17645/up.v3i2.1158. Published.	Will India's growth in urban rail continue due to global agendas such as the 1.5°C IPCC scenario and will India contribute positively to this agenda?

4.1 Publication 1

Sharma R. & Newman P. (2017). Urban Rail and Sustainable Development Key Lessons from Hong Kong, New York, London and India for Emerging Cities. *Transportation Research Procedia*, 26, 92-105. https://doi.org/10.1016/j.trpro.2017.07.011

Paper abstract:

This paper discusses the significance of urban rail in sustainable development in the developing and developed world by examining the cases of Hong Kong, New York, London and Indian cities. The paper analyses the project structuring and financing of the urban rail system in these cities and its contribution to shaping sustainable urban growth and sustainable urban development in general. Observations from the case studies underscore the paper's main emphasis which is that both private and public funded urban rail require innovative financing mechanisms (specifically land based) to sustain or revive themselves financially and that urban rail lends itself to such innovation more than urban road projects as well as multiple other co-benefits. The paper reviews metro projects in several Indian cities and explores the applicability of innovative financing mechanisms and the challenges in adopting them in the Indian context to enable a sustainable urban development model for emerging cities.

4.2 Publication 2

Sharma, R., & Newman, P. (2018). Does rail increase land value in emerging Cities? Value uplift from Bangalore metro. *Transport Research A: Policy and Practice* (Submitted).

Paper abstract:

This paper seeks to understand how urban rail can influence land value uplift, especially in emerging cities which are largely unstudied. It examines

the Bangalore Metro and shows that the uplift from the metro rail was substantial in the ‘catchment area’ and ‘across the city’. The analysis was based on the panel data hedonic price model for around 160,000 apartments over the period 2012-16 and a cross-sectional data hedonic price model for 314,000 apartments in 2016. The panel data resulted in a stronger model and show significant land value increases, even beyond the traditional 500m catchment. A ‘before’ and ‘after’ from the commencement of the metro rail operations shows a price uplift of 4.5% across the whole city and indicates a major agglomeration economic event resulting in substantial willingness to pay of USD 306 million from the metro rail accessibility. Emerging cities can expect metro rail to substantially improve their economies and other co-benefits as long as finance can be obtained by capturing this value.

4.3 Publication 3

Sharma, R., & Newman, P. (2018). Can land value capture make PPP's competitive in fares? A Mumbai case study? A Mumbai Case Study. *Transport Policy* , 64, 132-140. 10.1016/j.tranpol.2018.02.002

Paper abstract:

Mumbai Metro is planning to build 152 km of high-speed urban rail lines. The first line of Mumbai Metro was built through a Public-Private Partnership (PPP) and opened in 2014. Financial issues since its opening necessitated a fare increase—among one of the highest in India to maintain the line's commercial viability for the private operator. This paper examines how high dependence on farebox revenue could have been avoided by using Land Value Capture (LVC) to finance Mumbai Metro. A panel data hedonic price model was used to assess the impact of Mumbai Metro's commencement on approximately 66,000 apartments. The model shows a significant uplift of 14% in property prices in the Mumbai Metro catchment area resulting in USD 179 million value capture opportunity under Mumbai’s existing legislative framework. This paper suggests that LVC could enable a PPP urban rail

projects to achieve financial and social viability if governance systems can enable appropriate mechanisms.

4.4 Publication 4

Sharma, R., & Newman, P. (2018). Land Value Capture Tools: Integrating Transit and Land Use through Finance to Enable Economic Value Creation. *Journal of Planning Literature.* (Submitted).

Paper abstract:

This paper shows how private finance and expertise can be both the source of urban rail capital and the integrative governance force required for co-operative partnership-based TOD's. We call this TFUL - transit, finance and urban land development. A range of land value capture (LVC) tools from developed and emerging cities are outlined that are used to provide TFUL outcomes for creating economic value in TOD's. The analysis shows the significance of integrating political capital, financial capital and social capital, and how private sector involvement from the concept stage can enable much greater economic value creation and hence LVC opportunities.

4.5 Publication 5

Sharma, R. (2018). Financing Indian Urban Rail through Land Development: Case Studies and Implications for the Accelerated Reduction in Oil Associated with 1.5°C. *Urban Planning*. 3(2), 21. 10.17645/up.v3i2.1158

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Paper abstract:

Urban travel demand and oil dependence need dramatic change to achieve the 1.5°C degree target especially with the electrification of all land-based passenger transport and the decarbonizing of electric power. In this paper we investigate the transition of 'oil based automobile dependence' to 'urban rail plus renewable energy' to cater for transport demand in Indian cities. India is perceived to be a key driver of global oil demand in coming decades due to

the potential increase in car use driven by a fast growing national average income. However, it is possible that India could surprise the world by aggressively pursuing an electrified transit agenda within and between cities and associated supporting local transport with electric vehicles, together with renewable power to fuel this transport. The changes will require two innovations that this paper focuses on. First, innovative financing of urban and intercity rail through land based finances as funding and financing of such projects has been a global challenge. Second, enabling Indian cities to rapidly adopt solar energy for all its electrified transport systems over oil plus car dependence. We suggest that Indian cities may contribute substantially to the 1.5°C agenda as both policies appear to be working.

Chapter 5 Results and Discussion

The results and discussion is split into three sections:

Section 5.1 *Urban rail – Land value creation:* this section discusses the urban rail significance and its impact on land value in the cases of Bangalore Metro and Mumbai Metro. It discusses the policy, academic and practical implication of these results.

Section 5.2 *Land value capture – Economic value creation:* describes a framework to implement transit, finance and land development for economic value and value creation in cities based on the TFUL model.

Section 5.3 *Policy analysis – Future of Urban Rail:* describes the use of decoupling economic growth and fossil fuel consumption and how the 1.5°C agenda from the IPCC has created a range of policy developments that all involve expansion of urban rail along with renewables.

5.1 Urban rail – Land value creation

The Journal paper 1 showed that cities have revived and innovated urban rail projects due to the local demand and for broader economic objectives. Urban rail significance in economic growth and shaping urbanization has been established around the globe for more than a century now. This has never been more needed globally than now, particularly in the emerging world as they are proposed to have 95% of global urbanization in coming decades. But financing urban rail remains a key challenge to set the pace of these capital intensive projects (UN Habitat, 2016).

Emerging cities may not be able to afford a financial failure in their budgets through funding urban rail projects with conventional sources leading to economically vicious cycle of – loans, fare box, subsidies. Such governance would also avoid the emerging cities to exploit the land development benefits for larger agglomeration benefits, urbanization, value creation and economic growth (see Publication 1; Publication 4).

This thesis analyses on emerging cities of Bangalore urban rail and Mumbai urban rail showed significant uplift of residential land value due to urban rail commencement (see Publication 2 and Publication 3).

Bangalore case showed that urban rail specific variables are statistically significant and generally reflected similar trends in both the cross sectional data and the panel data hedonic price models suggesting that cross sectional data may well be good enough for a city to assess impact of urban rail on land value. However, the panel data HPM resulted to be a stronger model and has been used to assess the significance of WTP and draw results.

A key result of Bangalore study was a price uplift of 4.5% across the whole city due to the commencement of the urban rail operations (Figure 3). This indicates a major agglomeration economic event resulting in substantial willingness to pay of USD 306 million from the metro rail accessibility. It is perhaps easy to understand why there would be such an economic impact in an emerging city, such as Bangalore for the reasons of: urban rail projects bring substantial capital investment in the city that may help to accelerate economic activity; travel speed of urban rail during peak hour is about 3 times higher than of road network; it increases the attractiveness of the city (see Publication 2).

Bangalore's panel data HPM for urban rail impact on its catchment area redefines the generally acceptable theory of increasing of land value with the proximity to urban rail (Figure 3). The price uplift (25%) in properties located within the 500 m to 1 km catchment was found higher than the uplift (11%) in properties located within 500 m from an urban rail station. The generic reasons of higher noise levels, vibrations due to high-speed rail, prolonged construction and intense traffic flow as most of the rail stations are located on the arterial roads can be applicable to most of the cities. Specific reasons for the case of Bangalore seems to be the construction prolonged for over 2 years than planned, unplanned commercialization and hawking activities triggered in the vicinity of rail stations after the commencement urban rail. Also, the 500 m to 1,000 m station catchment is served by paratransit modes like auto rickshaw/ taxi/ cycle rickshaw though these modes creates highly crowded conditions in the immediate surrounding of the stations. These reasons may impact the residential property buyer willingness to reside in 500 m to 1,000 m catchment area over residing within 500 m catchment. These also help explain the 8% increase out to the 1 km to 2 km catchment (see Publication 2).

This decreasing land valuation in the catchment area of Bangalore urban rail also extend Luca Bertolini (affiliated to Universiteit van Amsterdam) work on ‘node’ and ‘place’ by finding a decreasing land valuation without proper planning within the urban rail catchment. He suggested that real estate value is likely to be generated more from the place than the node, although both are important but people choose to live in places, not nodes. Luca Bertolini has been writing on this for nearly last 20 years. This finding was actually highlighted by John Renne (affiliated to Florida Atlantic University and Oxford University) during his review of Publication 2.

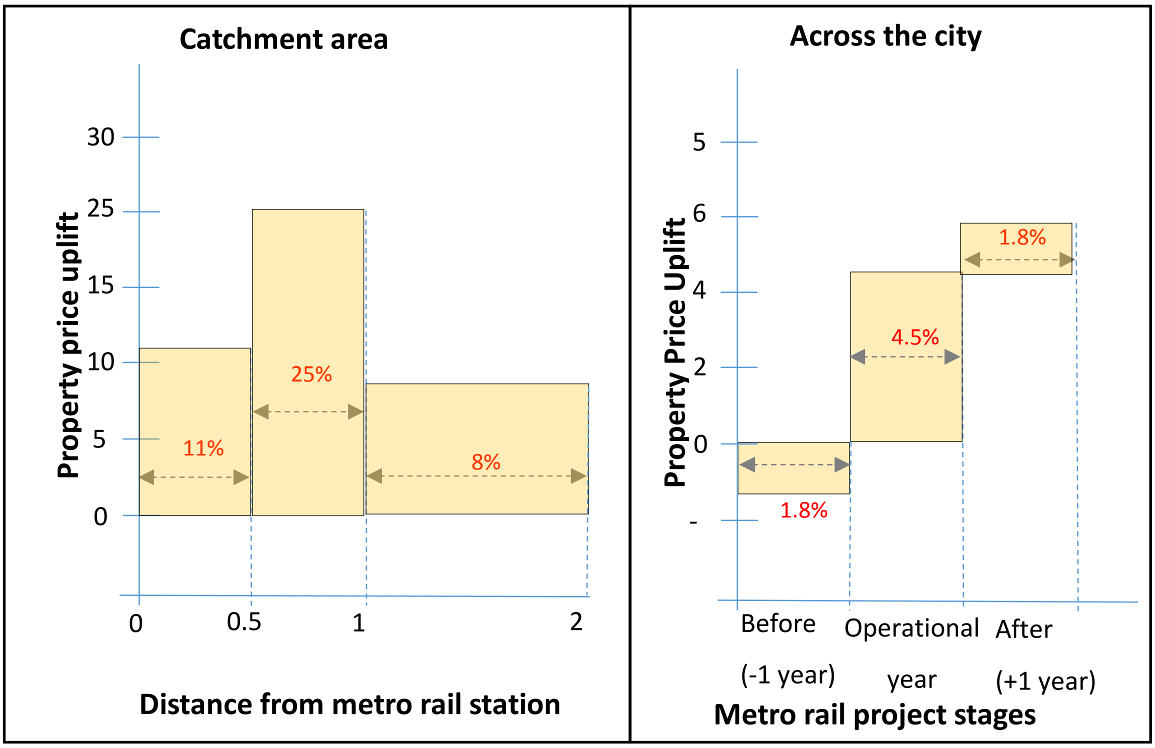

Figure 3: Impact of urban rail (metro) on property price in Bangalore

Mumbai panel data hedonic price model illustrated that the impact of urban rail is beyond the traditional 500 m which is similar to Bangalore results discussed above. However, only 1 km to 2 km were statistically significant in the calibrated model which may be due to the lower sample size at 0 km to 0.5 km and 0.5 km to 1 km and due to the slums and industrial area around the stations. The model showed significant uplift of 14% in property prices in the Mumbai urban rail catchment area resulting in USD 179 million value capture opportunity under Mumbai's existing legislative framework. Mumbai cases demonstrated that LVC can enable a public private partnership urban rail project to achieve financial and social viability (see Publication 3).

Both Mumbai and Bangalore cases showed that high dependence on fare box revenue and associated struggle over fare fixation can be avoided by realizing the benefits of urban rail on land values. My meetings with officials working on urban rail projects in Mumbai, Delhi and Bangalore highlighted that the key issue of not able to implement land value capture tools is that they have not been able to scientifically quantify the windfall gains in land value due to commencing of urban rail. This thesis has demonstrated this.

The thesis has significant implications for Indian policies on the demarcation of influence zones for urban rail. The Indian government transit-orient development policy and various Indian cities policies on LVC (Bangalore, Nagpur, Delhi and other cities) considers the influence zone up to 500 m - 800 m which would need to be reviewed based on the results from Bangalore and Mumbai. The influence zone should not be fixed in such a policy and should to assessed on case-by-case basis.

The reduced uplift values next to stations suggests more attention should be given to a Local Area Station Management Plan policy and Walkable Urban Design Plan policy to create more walkable urban fabric (Matan & Newman, 2016). As investment and upgradation of local amenities can increase land value.

In order to fund metro rail systems, cities can venture into value capture tools as there is clearly value uplift happening. The extent of value uplift can be used to determine value capture tools such as Beneficiary Zoning Levy in the catchment areas (0 to 2 km), and Public Transport Levy on all new developments across the whole city.

5.2 Integrating Transit and Land Use through Finance to Enable Economic Value Creation

Publication 4 showed that the political, social and economic driver in creating new urban rail is not just dealing with transport problems but in providing for the demand in the associated transit-oriented urban fabric: Transit Oriented Developments (TOD's). Government limitations to assess capital and lack of integrative governance can be addressed through private finance and expertise which can be both the source of rail capital and the integrative driving force required for co-operative partnership-based TOD's. This thesis calls the process TFUL - transit, finance and urban land development.

There are two key components of the TFUL approach which determine the associated project scope and risk assessment, the first is land development and the second is urban rail development, both use finance based on land value capture tools. This was the basis for the review of land value capture tools that were then categorized in four groups of: Fully Public: Land-Based Levies; Partially Private: Tax Increment Financing; Partially Public: Special Improvement Districts; and Fully Private: Entrepreneur Rail Development. These tools can be context sensitive and path dependent (to assessed on case-by-case basis). Analyses showed that private participation from the concept stage of the TFUL project under the Entrepreneur Rail Development is essential creating economic value (integrated financial capital, political capital and social capital in Figure 4) and for wider value creation in cities (Figure 5).

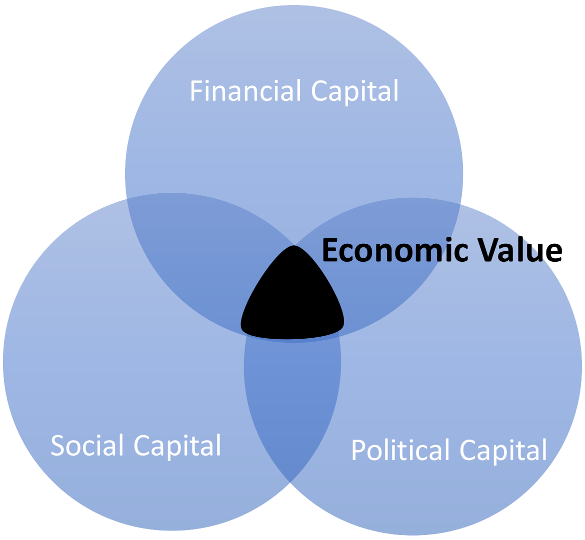

Figure 4: Economic value creation through integration of financial, social and political capital

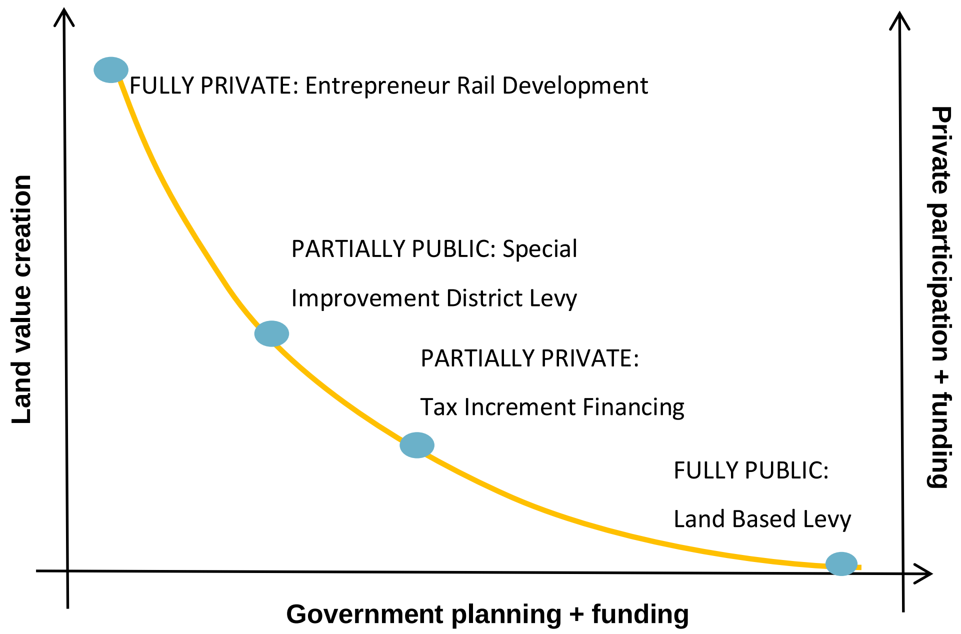

Figure 5: How land value creation varies with the extent of private involvement in TFUL partnerships.

There are several ways of understanding how private sector investment creates economic value in cities. Wealth creation is essentially a process that is based on a combination of the hard infrastructure that services buildings and their needs as well as the soft infrastructure that enables opportunities for innovation and job creation (Newman, Davies-Slate & Jones, 2017; Glaeser, 2011; Porter, 1998).

The economic value creation approach is detailed in Paper 4 in terms of the theory of value creation and the tools to enable it. But it does not go further into delivery processes, so in this final section I have set out some possible mechanisms though this will require a lot of further research based on real projects.

To implement and deliver TFUL development the public sector can initially make a call for private sector interests for a joint development, the interested private sector companies or consortia can then be shortlisted and invited for discussion on the TFUL concept approach in line with the local context. The private sector can provide suggestions on project packaging and structuring of land development and rail development components. Private sector suggestions will be essential at this stage in checking the private sector risk appetite for investment in TFUL development projects in the local context. Negotiations then begin between the public and private partners in an attempt to reach a preferred land use and zoning mix that will prove to be acceptable and beneficial to both parties and provide the rail and the land development outcomes desired.

For the land development process, the first requirement is land identification along the proposed urban rail corridor. The private party involved can identify properties along the corridor to realize the land value gains and the public sector can provide public land for leasing or through land assembly/ adjustment and rezoning. This process provides private sector insights on local land market values that help optimize the risks involved in the project structuring of the TFUL development project. This process helps cater to the urban growth demand issues faced by the public sector and the private sector benefits by being involved from the concept stage of a long life-cycle project.

After the winning consortium is chosen to build the project the PPP contract would specify mutual responsibilities.

For urban rail development projects, private sector participants could design, finance, own and operate the urban rail systems which enable project efficiency through better integration with land development. The phasing of land development integration with urban rail development maximizes land value capture opportunities as the impact of urban rail is highly dependent on local land market and urban elements. Public sector participants should determine integration with the rest of the system, key performance indicators, safety and operational standards and other legal factors for the urban rail option. Crucially government departments should provide right of way, access to stations and integration of fares and local networks within the existing transport network.

The project structuring of the two components will determine the level of risk allocation and contribution of the private sector, whilst the level of private contribution will determine the additional value creation and innovative revenue sources as noted in the joint development cases (see Publication 4). This can be done through greater private participation in the TFUL development with a longer concession period to ensure larger risk allocation to the private sectors which in turn can drive additional value creation. Governments can provide concessional loans or equity in order to stimulate private investment. The government can reserve land based levies as a revenue risk mitigation option.

5.3 Policy analysis – Future of Urban Rail

The question of whether urban rail is likely to continue expanding is answered by examining the global pressures to respond to climate change through the 1.5°C agenda set by the IPCC. This requires electrification of all land-based mobility and hence significant increase in urban rail. It also requires expansion of renewable energy into the electricity supply. The thesis analysed whether India has begun this journey away from fossil fuels and how new policies from India are likely to enable this to accelerate.

Publication 5 showed that India has started relative decoupling of income and fossil fuel in the past decade (Figure 6). The thesis shows that the ‘soft power’ characteristics of Indian cities – travel pattern, road length growth, and dense, mixed use urban fabric, seem to be the factors that could have ensured the start of decoupling wealth and car use (Figure 7). Even with a small per capita car ownership the urban fabric of Indian cities has resulted in high traffic congestion and low travel speed thus minimizing growth in the use of cars. It also suggests that without a massive road building program that completely alters the urban fabric (as happened in US cities) there is unlikely to be much more ability of Indian cities to cope with high traffic growth.

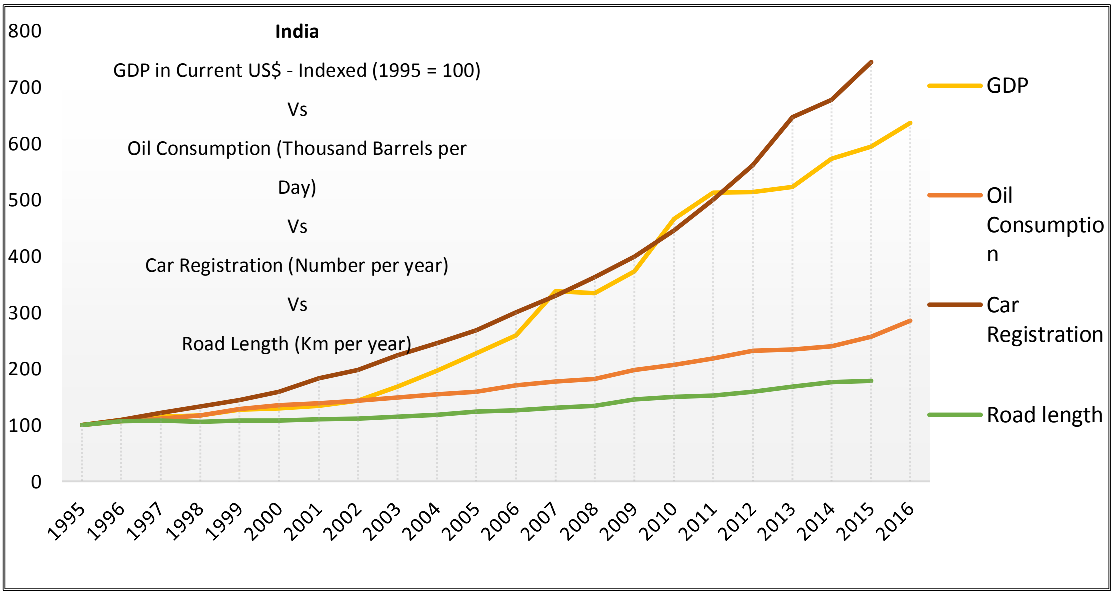

Figure 6: Historic growth rates of GDP, oil consumption, car registration and road length in India.

Source: Complied by author based on data sourced from CEIC, 2017; EIA, 2016; Government of India, 2017c; Ministry of Petroleum & Natural Gas, 2017; OPEC, 2016; WBG, 2016.

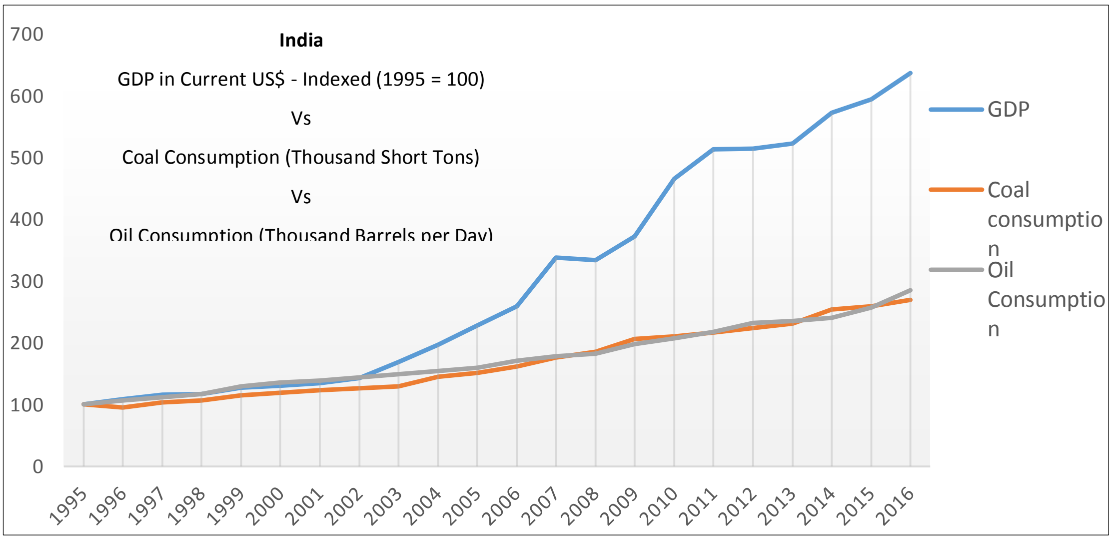

Figure 7: Decoupling wealth from coal and oil in India.

Source: Complied by author based on data sourced from CEIC, 2017; EIA, 2016; Ministry of Petroleum & Natural Gas, 2017; OPEC, 2016; WBG, 2016.

The transitions that are underway in Indian cities towards urban rail expansion, the involvement of private investment based on land value capture through TODs, the rapid growth of solar and battery storage in new urban developments, the growth of EV's and shared mobility, are all subjects that need urban planning to facilitate. A series of structural reforms and policy interventions would need to follow from Indian cities to support this transition, all with a strong partnership between citizens, government and industry.

The Indian government recently approved three highly significant policies of relevance to the topic of this thesis: National Transit Oriented Development Policy (Government of India, 2017a); Value Capture Finance policy framework (Government of India, 2017b); and Metro (urban rail) Policy (Government of India, 2017d). Together these policies show the intent of the policy makers to enable density, transit, accessibility, urban agglomeration and land based financing. However, there are significant challenges for such processes to be implemented in Indian cities such as digitizing urban infrastructure maps, institutional integration in cities, land use and transit integration, land valuation (at plot level), digitization of land use maps and others (discussed in Publication 1 and Publication 5).

Urban planning schemes would play a key role in also enabling integrated financing and infrastructure schemes in a build environment at neighbourhood level. Such as the substantial land values increase due to urban rail in Indian cities may be used to help finance the solar plus battery infrastructure and walking fabric that will be beneficial for Indian energy security and environmental concerns.

The electric urban rail growth through TFUL developments together with Indian government policies on electric vehicles (all vehicles by 2030), collaborative consumption, urban fabric and rail growth may surprise the world with a dramatic shift from fossil fuel dependence to widespread usage of renewables that is likely to contribute to the IPCC 1.5°C agenda.

6 Conclusions & recommendations for future research

Classical economist David Ricardo (1821, p. 63) claimed: "..corn is not high because a rent is paid, but a rent is paid because corn is high". The study aligns with the idea, "higher rent is paid in the city because of the benefits of urban rail".

This thesis shows that there is significant uplift in residential property value due to the opening of new urban rail lines in emerging cities through the cases of Bangalore and Mumbai. Willingness to pay for urban rail goes beyond the traditional 500m as it appears to have reached right across the city. This indicates substantial willingness to pay and therefore opportunities for value creation. These finding disrupts the traditional theory of increasing of land value with the proximity to urban rail station.

This thesis has explained these findings based on economic theories and the recent Asian Development Bank article on "Financing urban planning in Asia: From land value "capture" to "creation" (and more)" (Farrin, 2018) shows that such discourses are becoming popular and being recognized by international agencies. This PhD will add to that discourse.

Once cities begin to see how significant is this value creation they are likely to demand their city competes in this innovation. This will require changes in transport and planning policy such as density zoning which will benefit land markets by pushing them to their highest value and best use. Although it is too late for the Bangalore Metro Phase 1 and Mumbai Metro Line 1 other phases and lines could tap the LVC tools for funding. Other emerging cities can be given some confidence about using the LVC tools as well to build or expand urban rail.

The Bangalore and Mumbai studies showed that urban sustainability-related variables like accessibility to bus, metro, CBD and park have positive impacts on urban land value. This was not further analysed (apart from the metro) but it is clear that the data strengthens the argument for investing in sustainable urban infrastructure that supports the amenity of the metro system. Policy makers can consider such analysis to quantify benefits and judiciously determine sustainable urban infrastructure initiatives as part of any metro-scale planning.

The thesis has shown that the application of LVC is possibly necessary to enhance fare affordability and mitigate the financial strain imposed by public transport on the community in any city. The more the private sector is involved in the investment and the process of developing a project, the more value creation and LVC is likely.

Private sector involvement for joint PPP development of a TFUL project from the concept stage could increase the redevelopment potential commitment from the private sector and lead the public sector to focus on their core role of governance including community engagement and partnership development. This will lead to wider agglomeration benefits and economic gains as well as many local amenity gains. Delivery mechanisms and procurement processes for TFUL will need detailed consideration as the structures of most town planning and transport planning do not easily lend themselves to such outcomes.

This thesis shows that India has started relative decoupling of income and fossil fuel use in the past decade. The Indian cities can contribute in achieving IPCC 1.5°C agenda of renewable based electric urban mobility through urban rail and associated development financed through land value capture. The Indian policy initiatives in this area suggest the political and public support for such development. However, it will not happen unless partnerships to create private investment opportunities in urban rail are initiated.

6.1 Further research

Six areas of further research are highlighted:

Other Indian cities. Further work is needed to examine other Indian cities as they create new opportunities for innovative approaches to alternative funding and financing. This should involve in addition to apartments, the land value increases associated with houses and commercial properties. At the same time studies should be done on how the application of LVC tools is carried out in Indian cities as the government follows through on their new policies.

TFUL. The application of the TFUL approach should now be applied to a range of cities in the developed and emerging world to see how best to engage private sector investment as well as other partnerships between different levels of government and the community. The need for more work on delivery mechanisms and partnership development is particularly necessary.

PPP economic benefit evaluation. Further research on public private partnerships for a major project like urban rail and TODs can show the efficiencies and challenges in the life cycle of the project in order to assess the true economic value of these partnerships.

Planning implications. The need for integration of planning and transport based on achieving partnerships between government, private investment and community, undermines most of the processes, modelling and manuals of traditional planning for transport (Newman, 2016). These need research to enable 21st century approaches to be available.

Impacts. The scale of the impacts of new urban rail systems, in India and other emerging cities, on the geographies and local neighborhoods is happening (eg. Chava, Newman & Tiwari, 2016) but will need to ensure that the economic decoupling impacts are observable as well as potential gentrification impacts are being managed.

National carbon accounts. The 1.5°C agenda discussed here provides an opportunity for nations like India to assess the national impact on global responsibilities and how urban policies such as those outlined in this thesis are helping or not.

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Appendix A: Publications

Publication 1:

Sharma & Newman (2017). Urban Rail and Sustainable Development Key Lessons from Hong Kong, New York, London and India for Emerging Cities. *Transportation Research Procedia*, 26, 92-105. https://doi.org/10.1016/j.trpro.2017.07.011

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Urban Rail and Sustainable Development Key Lessons from Hong Kong, New York, London and India for Emerging Cities

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Abstract

This paper discusses the significance of urban rail in sustainable development in the developing and developed world by examining the cases of Hong Kong, New York, London and Indian cities. The paper analyses the project structuring and financing of the urban rail system in these cities and its contribution to shaping sustainable urban growth and sustainable urban development in general. Observations from the case studies underscore the paper's main emphasis which is that both private and public funded urban rail require innovative financing mechanisms (specifically land based) to sustain or revive themselves financially and that urban rail lends itself to such innovation more than urban road projects as well as multiple other co-benefits. The paper reviews metro projects in several Indian cities and explores the applicability of innovative financing mechanisms and the challenges in adopting them in the Indian context to enable a sustainable urban development model for emerging cities.

Peer-review under responsibility of the Association for European Transport

Keywords: urban rail; cities; sustainable development; innovative financing; project structuring.

1. Introduction

The 21st century is characterised by extensive and rapid urbanisation in developing countries. UN Habitat (2008, p. xi) suggests that over the next four decades the urban population in developing countries would grow by five million per month on average, comprising 95% of the global urban growth. According to Glaeser (2011), urban development is essential for driving economic growth and that it can also contribute to broader sustainable

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development. The new sustainable development goals (SDG's) include a city goal as it is recognized that urbanization can play a critical role in addressing all the SDG's (Daniel, 2015).

India is set to witness peak urbanization in the next four decades (Heilig, 2012, p. 1). India's urban population is projected to increase from 377 million in 2011 to 600 million by 2031 (Ahluwalia, Kanbur, & Mohanty, 2014, p. 2). This frames a challenging scenario for Indian policy makers, but also provides opportunities to improve existing and furnish new sustainable urban development policies that could provide a model for emerging cities globally.

Newman & Kenworthy (2015) draw attention to decreased automobile dependence and increased economic growth across cities globally being synchronous with thriving urban rail and consequent revitalization of the urban fabric. This paper shows how such development that simultaneously reduces car dependence and increases economic growth can be a key tool for achieving sustainable development. Indian cities are in a position to leapfrog automobile dependence by packaging urban rail and land revitalization based on global best practice. Urban rail displayed its potential as an axis for sustainable urban development and economic growth in the early 20th century in New York and London. Hong Kong followed the same path in the latter half of the 20th century. These case studies will be examined before applying them to Indian cities.

Most sustainable development, specifically in cities, requires new infrastructure and this require investment. This paper will show that governments increasingly cannot provide such investment at the levels required and thus private investment through partnership projects are required. The case studies are on to show that urban rail is more likely to provide such investment opportunities than urban roads and achieve more sustainable outcomes.

The Government of India (GoI) has been financially supporting urban rail since 2011 in cities with population over two million (Ministry of Urban Development, 2012). Public acceptance of urban rail has enabled a cut-back of this population norm to one million to extend this benefit to medium size cities (Ministry of Urban Development, 2014a). Urban rail (metro) is currently being planned for over 50 Indian cities (Modi, 2015).

India, like all emerging nations, faces a critical investment gap in infrastructure so investing public funds in over 50 capital-intensive metro projects is impossible without new sources of investment. The situation demands that metro financing be looked at from a new perspective. This includes analysing the existing framework of governance, community participation, project structuring and implementation, learning from evolved urban rail systems and looking for improvised financing solutions.

Cervero and Duncan (2002), Cervero (2004) and McIntosh et al. (2017) demonstrate that increased transit accessibility uplifts the value of the accessible land market. This transit-linked shift in value can be captured through land value capture (LVC) mechanisms. According to Vadali, Aldrete and Kuhn (2013), LVC mechanisms provide a significant untapped resource for developing nations where the real-estate market is less rigid, more profitable and can sustain healthy population density and transit ridership. The National Urban Transport Policy (2014) and the 12th Five Year Plan (2012-2017) of India acknowledged the impact of urban rail on land and LVC as a possible financing mechanism to be used in Indian cities (Ministry of Urban Development, 2014b; Planning Commission, 2013).

This paper provides an overview of the development of urban rail systems using three global case studies, their evolving project structure and potential for innovative financing, especially LVC. It examines these three global urban rail systems first, and draws comparisons with them further to develop a way forward for Indian urban rail systems and hence any emerging urban area seeking greater sustainable urban development.

2. Global Case Studies

London, New York and Hong Kong have for long integrated land use with transit. This enabled distinctive and innovative methods of financing where LVC emerged as a source of finance to defray the urban rail project cost. Within these methods, private developers played a significant role in the financing and development of the New York and London rail systems in late 19th and early 20th centuries. In case of Hong Kong, the government only integrated transit and land use plans to finance their rail system. These cities provide lessons for the rapidly evolving urban rail sector in India and for other emerging systems around the globe.

2.1. The Hong Kong Metro

The Hong Kong Mass Transit Railway Corporation (MTRC) was set up by the government to implement and operate the metro system in Hong Kong under prudent commercial principles. The first line of around 8 km became operation in 1979 (Victor & Ponnuswamy, 2012, p. 113)

The Hong Kong government has enjoyed significant financial returns without subsidising their urban rail network. Their net financial returns in the period from 1980 to 2005 amounted to nearly USD 2.33 billion (Cervero & Murakami, 2008, p. 14). The Hong Kong government sold 23% of its capital share in MTRC to private investors in 2011 to increase private investment and capital flow (Suzuki, Murakami, Hong, & Tamayose, 2015, p. 77). According to Wong (2015), this restructuring improved the corporation's efficiency, competitiveness and profit. MTRC's market value rose significantly with its stock price doubling (in 2014) since restructuring (Verougstraete & Zeng, 2014, p. 3). It is one of the rare profit-making transit organizations in the world and recorded a net profit of about USD 2 billion in 2015 (Mass Transit Railway [MTR], 2016, p. 33). These facts render the case of Hong Kong a competent reference for innovative financing.

MTRC carries about 4.7 million passengers daily and its fare-box revenue covers 175% of its operating expenses despite having an economical fare structure (USD 0.50 to USD 7.50) and relatively shorter network (218 km) as opposed to London Underground (402 km) and New York Subway (373 km) (Transport Department, 2016). From 2000 to 2012, 38% of MTRC's revenue came from property development, 28% from commercial and property leases and 34% from transit operations (Suzuki, Murakami, Hong, & Tamayose, 2015, p. 83).

MTRC used the Rail plus Property development (R+P) program to integrate transit with land use. Under the R+P program, the government granted MTRC the exclusive air (development) rights of the land above transit stations and depots and that around stations, at the 'before-rail' market price (market value of the property before the construction of the metro) (Verougstraete & Zeng, 2014, p. 2). Development rights and land were the only form of subsidy provided by the local government (Tiry, 2003). Using these development rights MTRC partnered with private developers to jointly develop the land and to rent/sell the completed units under a revenue sharing model. This allowed it to capture the windfall gain of the 'after-rail' property value by sharing the profit with private developers rather than leasing the property for one-time lease money (Suzuki, Murakami, Hong, & Tamayose, 2015; Verougstraete & Zeng, 2014). Thus, MTRC could integrate and plan different phases of its rail and property development projects, ensuring smooth project implementation and reducing delays and transaction costs.

Apart from tangible financial benefits, MTRC's initiatives have also created intangible benefits to the city, such as Hong Kong's compact urban form, high population density and efficient transportation. The R+P program effectively guided the city's urban fabric through high-density development along metro corridors, promoting sustainable urban development. Land market's accessibility attracted people closer to the metro with 41% (in 2002) of Hong Kong's population residing within the catchment area (500m) of a metro station (Tang, Chiang, Baldwin, & Yeung, 2004, 8). Together these benefits led MTRC away from net loss in 1980s towards profit worth USD 2 billion in 2015 (Cervero & Murakami, 2008, p. 13; MTR, 2016, p. 33).

2.2. New York Subway

The New York state government approved the Rapid Transit Commission (RTC) in 1904 to administer urban rail for New York City (Hood, 1995). The construction and operation of the first corridor of this system (christened New York Subway) was leased to the Interborough Rapid Transit Company and the line opened in 1904, with investment from public and private partners (Cheape, 1980). Three separate companies—two owned privately and third by the City—expanded the subway throughout four of New York's five boroughs. These lines were planned and developed in densely populated areas (King, 2011) which ensured that towards the end of the decade public transit usage and automobiles for personal travel were competing at par (Schrag, 2000). Rising demand for transit was supplied through private investment allowing for ridership to boom for four decades and peak in 1947 (King, 2011; Metropolitan Transport Authority [MTA], 2016).

The two private operators were solely dependent on fare box revenues and were not allowed to increase the fixed nickel fare (USD 0.05) (King, 2011). The project lost its financial viability and the operators went bankrupt when the system peaked (1947). The City acquired their corridors and consolidated them with theirs. The City doubled the fare in 1948 and imposed a tax for transit improvement to induce financial viability (Benjamin & Nathan, 2001, p. 140). In 1953 a separate body, the New York City Transit Authority (NYCTA)—a state authority headed by New York City—was created to operate the urban rail and cover operating costs from fare-box revenues, while the City continued to provide capital investment (King, 2013). In 1968 NYCTA was positioned under control of a state level Metropolitan Transportation Authority (MTA) (Sparberg, 2014).

Restructuring could not improve the financial condition as public ownership of the system adversely impacted its efficiency. In 1956, a policy of 'deferred maintenance' was adopted which entailed that brakes and signals be inspected less frequently, supplies of replacement assets such as signal bulbs be allowed to run down to zero, and electrical relays last 30 years whereas they require replacement every 5 years (Caro, 1975). Following these changes, annual ridership that had surpassed 2 billion in 1930's dipped below 1 billion by the end of 1970's (MTA, 2015).

The New York Subway was trapped in a vicious cycle of deteriorating system, lack of investment, falling ridership and continuous neglect by the authorities. Road based car-focused planning policies furthered drew attention away from the subway (Brown, 2003; Caro, 1974). Minimum parking requirements, parkways, investment in multiple lane highways, freeways and low-density suburbs were among the policies to accommodate cars (Altshuler, Womack, & Pucher, 1979; Ferguson, 2003; Shoup, 2011).

The subway's revival began in 1982 with a public referendum on a 'Capital Program' for investment in the subway. The Capital Program referred to an investment pool legislated by the Transportation System Assistance and Financing Act of 1981 addressing the alarming situation of public transit in New York (Permanent Citizens Advisory Committee, 2012, p. i). It allowed MTA to issue bonds towards raising capital that is tied to the delivery of new assets and achievement of particular objectives related to upgradation of the subway (Allport, Brown, Glaister, & Travers, 2008, p. 104).

Under the Capital Program of 1982-1991, replacement and refurbishment of system components accounted for 70% of the expenditure on the subway (MTA, 2004, p. 73). This cut down the future (Capital Program of 2005-09) investment in maintenance to 27% (MTA, 2004, p. 13). The revival of the subway was rewarded with public acceptance for the system, which now reflects in an increased ridership level. The New York Subway recorded its highest annual ridership in 2016 since it peaked in 1948 (MTA, 2016). It is worth noting that the above-mentioned bonds and the system's continuing rehabilitation reflect a USD 32 billion long-term debt with MTA (PCAC, 2012, p. ii).

New York has been exploring and attempting ways to augment funds through financing mechanisms like the payroll mobility tax (PMT) and tax incremental financing (TIF). PMT refers to a tax on employees of all firms (above a certain size) within the public transport service area. TIF allows a local government to generate 'incremental' tax revenue from windfall increase in property values (within a prescribed development area or 'TIF District') and use it to fund infrastructure—like the subway—that led to the said increase in property values (Krogulecki, 2016). Generating additional tax revenue by TIF does not involve higher or additional taxes but expanding the base of taxpayers (International Council of Shopping Centers, 2012). Part of this additional revenue is directed from state's treasury to TIF authority (PricewaterhouseCoopers, 2008). A USD 2 billion subway extension project (to Hudson Yards) in New York City is being financed by raising funds through municipal TIF bond sales (Demause, 2015).

MTA receives a share of two state-wide non-fare box revenue namely 'long lines tax' (48%) and 'petroleum business tax' (55%) (UN Habitat 2013, p. 171). The former is a transportation-oriented tax levied on trucking, telegraph and telecommunications companies, and the latter is levied on refining or selling petroleum (Transportation Research Board, 2009). These regional level sources of finance provide assured funds to MTA and create agencies appetite for regular investment in the rail system.

MTA has planned station area development projects explicitly to integrate land use and transit. Residential and commercial towers are proposed over Hudson Yards (railyard). Another proposed project is the Penn station redevelopment (USD 14 billion) aimed at redeveloping the existing station and its surrounding area (Bagli, 2007). Plans include relocating the Madison Square Garden, demolishing Hotel Pennsylvania to accommodate two new towers one of which will be taller than the Empire State Building (Bagli & Fitzsimmons, 2016). These development projects and LVC mechanisms are proposed to repay the capital costs of the proposed subway extension-lines.

Over the years, the New York Subway has achieved one of the highest fare-box recovery ratios while maintaining low fares in comparison with other urban rail systems in America, like San Francisco's Bay Area Rapid Transit (Johnson, 2013). The comparative analysis of fare-box revenue and expenditure (operating and maintenance cost) of buses and the subway shows better financial performance of subway over the road-based bus service in New York, a significant consideration in determining the economically preferred public transport system.

The subway’s cost per passenger is lower than that of bus (3:4 ratio) whereas revenue per passenger is higher (9:7 ratio), as shown in Table 1. This analysis displays the success of the subway’s revival and justifies investment in rail based mass transit system.

Table 1: Cost and Revenue Comparison of Subway and Bus Service in New York

	Financial Characteristics						
Mode	Ridership (R1) (Million)	Revenue (R2) (fare-box)	Operation Cost (O)	Maintenance Cost (M)	O&M (O+M)	Cost per Passenger (O+M/R1)	Revenue per Passenger (R2/R1)
Train	1,735.6	$3,111.9	$10,367	$16,186	$26,553	$15.3	$1.8
Bus	688.9	$964.0	$10,475	$3,735	$14,210	$20.6	$1.4

Source: Data compiled from MTA Annual Report, 2014

Note: Financial figures in USD Million

The New York Subway has illustrated how alternative financing works effectively with referendum-backed (public participation) bond issues, TIF, air rights and developer contributions. These factors have been crucial for revival of the subway service and sustained financing for required upgradation. The New York Subway provides a noteworthy case of deliberative democracy and collaborative efforts at the city scale in favour of public transport. The tact to finance and upgrade subway infrastructure has enabled the city to integrate land use and transit to meet present day needs.

2.3. London Underground

London’s population grew rapidly since the beginning of the 19th century. Around 200,000 people daily used the suburban railway system to visit London to pursue economic opportunities (Wolmar, 2004). The system was comprised of seven railway terminals with different private railway companies operating trains to the suburbs. In 1846, construction of new lines or stations in the central city was banned by a Royal Commission following issues of congestion (Simpson, 2003). Around the same time, Charles Pearson, Solicitor to the city introduced the idea of a central railway station to be used by all railway companies. After multiple rejections the scheme took shape partially in 1852 when the City Terminus Company was established to build the first line of the London Underground (Day & Reed, 2008). The company was restructured and renamed to Metropolitan Railway (the Met).

Lack of funds necessitated an agreement (1858) between the Met and City of London where the Met bought the required land from the City for USD 274,872 and the latter purchased USD 307,120 worth of the railway shares (Wolmar, 2004). With this public-private partnership, a 6 km long underground railway was opened (1863) to serve the city centre (Green, 1987; Day & Reed, 2008).

Ridership of 9.5 million in the first year and 12 million the following year marked the underground project a success (Simpson, 2003). The Met utilised the land stock in possession and promoted housing estates along the rail corridor in London anticipating additional income (Jackson, 1986). It then merged many private and public railway companies and expanded the network. These actions made private operators anxious and instilled fierce competition, which reflected through several marketing activities and ticket pricing (Horne, 2003). Most of the private companies started joint marketing which included maps, publicity and signs outside stations (Horne, 2003). Adoption of common ticketing system—and common logo—helped passengers embrace the system as one rather than separable lines and benefit from easy transfers across lines (Armstrong & Gourvish, 2000). By the time World War I broke, London had built an underground urban rail system (Armstrong & Gourvish, 2000).

Early 20th century marked the commencement of the electrification of the railway with the American financier Charles Yerkes investing in the system (Green, 1987). He later founded the Underground Electric Railways Company of London (UERL), a precursor to present day London Underground. UERL followed a policy of expansion by acquisition and took control over majority of the underground railway lines in and around London (Green, 1987). London's profitable bus and tram companies were also acquired. The UERL established virtual monopoly as a bus operator and eventually integrated its bus and rail services creating a new lifestyle for a large part of the London population (Green, 1987).

UERL faced fierce competition from private motorbus operators as the latter served on unregulated routes as large-scale people movers with unsafe, profit-seeking, unorganised and anti-social practices. The ensuing chaos on London streets called for a single body to coordinate the city's 5 railways, 14 tramways and 60 bus undertakings. Thus a 1933 Act of Parliament set up the London Passenger Transport Board which was one of the first quasi non-governmental and non-profit organisations in the world and remarkably successful (Armstrong & Gourvish, 2000). It was a move that integrated multi-modal mobility and removed any horizontal institutional conflicts.

The expansion of the Underground lines helped build the suburbs. Most of the railway companies had no authority to develop land but coordinated with developers in mutually beneficial deals. This allowed for the railway's expansion to become integrated with London's development. This co-development of land and rail continued through first half of the 20th century (Levinson, 2007).

In 1947, Britain nationalised all modes of mass transport (Mulley, 2009) and a separate executive institution called the London Transport. The 1950's through 1980's saw limited augmentation of the rail network in London owing to complete public ownership.

The Victoria line opened in 1971 was the first new line in over half a century. It was unprecedented on the service front for a line to be designed for riding comfort rather than purely financial considerations (Armstrong & Gourvish, 2000).

London Transport managed transport issues until 1969 when many of its policy-making roles were transferred to the Greater London Council (Armstrong & Gourvish, 2000), a move that helped better integrate transport and land use.

London's integrated transit agency called Transport for London (TfL) was established in 2000. TfL has under its jurisdiction the region's rail-based public transport infrastructure, bus service, streets infrastructure, bicycle routes and pathways. This institutional integration was followed by adoption of the London Plan (Greater London Authority, 2004) which provides a framework for integrated development of brownfield areas and accessibility of the public transport system.

TfL has undertaken various transit financing initiatives including value capture strategies, notable among them the Business Rates Supplement (BRS). An addition to a current property levy on commercial buildings, BRS is the largest locational value capture mechanism currently implemented in London (Greater London Authority, 2010). Revenue raised through BRS will partially fund the construction of the 21 km Crossrail line. Funds will also be raised through a spatially graduated tax—based on the property's proximity to the line—on new developments (Barone, Hsu, & Emily Roach, 2015). Crossrail line is currently under construction phase and has already uplifted house prices (Denham, 2017)

With a growing interest in sustainability, London became involved in brownfield redevelopment. The Kings Cross revitalization project spreads about 67 acres of brownfield land and redevelopment of three stations, the adjoining site are proposed to be developed as a mixed land use space with homes, serviced apartments, retail space, office space, a new university and a school (Tourism & Transport Forum, 2010). The project is focused to provide a walkable and open space environment to promote knowledge economy with engagement between residents, students and employees while being connected to key transit transport hubs in London.

David Levinson (2007) in his empirical study on co-development of land use and rail in London portrays that rail was a precursor to population growth which in turn was a precursor to rail deployment. The study concludes that the two systems, land development and rail networks, have co-developed gradually, circumstantially but in a noteworthy manner and contained the economic course of London for more than a century. The institutional framework for transit has alternated earlier between public and private control, rearranged later multiple times and upgraded itself with change in the scale of services. The transit has evolved institutionally without halting and so have the services.

3. Inferences from International Case Studies

The cases of New York and London urban rail systems suggest that urban rail can address the unsustainable characteristic of urban development trajectories caused by rapid motorization and automobile dependency. This requires public participation, political leadership and innovative financing. The city's indigenous leadership and innovation together can unlock unexplored funding sources (especially from land) to finance transit projects. Both cases provide a noteworthy example of evolution in urban rail system. New York case shows that the shift from road based policies to urban rail provides significant opportunity for sustainable growth and redevelopment.

Hong Kong Metro stands firm as the most efficient urban rail system in terms of revenue while maintaining a high ridership level. It follows a comprehensive approach to exploit the potential of integration of land and rail through innovative financing. Hong Kong presents a multi-directional solution to the issues much closer to the developing countries' context. China has chosen to follow this model for their new metro systems and is now building metros in 86 cities (Newman & Kenworthy, 2015).

4. Urban Rail Systems in India

The first urban rail (metro) project of independent India was implemented in Kolkata in 1984 (Metro Railway Kolkata, 2015). It is a public-owned indigenous system constructed by trial and error method with uncertain funds, court injunctions and an irregular supply of construction material. Kolkata Metro's first section (3 km) was completed in about 12 years. Currently the network stretches over 27 km. It has been incurring huge losses since the operations commenced. Recent years' increase in ridership has reduced the operating ratio from 311 in 2011-12 to 254 in 2014-15 (Metro Railway Kolkata, 2015).

India's second metro system the Delhi Metro became operational in 2002 setting into motion the development of metro in Indian cities (Delhi Metro Rail Corporation [DMRC], 2017). Eleven of these cities now boast of operational metro systems and another six are under construction. The following section discusses a government-funded Delhi Metro and a privately-funded Gurgaon Metro that together provide an appropriate reference to compare public and private urban rail systems.

4.1. Delhi Metro

Delhi Metro is a government-owned rail transit system with an assured revenue stream from government. It is equipped with modern technology, safety and security systems all of which the Kolkata Metro lacked. The first line (4 km) was completed in three and a half years and the system is now ranked second-best globally (DMRC, 2017; Times of India, 2014a). Delhi Metro Rail Corporation (DMRC) constructed Phase I and II without delay and cost overrun (Agarwal & Gomez-Ibanez, 2012; DMRC, 2017). The quality delivery of the project is credited to the ex-Managing Director, Sreedharan (1997-2011) (India Today, 2011), who gained the title of 'Metro Man' for his exemplary leadership, an inspiration for the sector. His background as a technocrat inspired a debate on the efficacy of the traditional choice of appointing a bureaucrat to manage public organizations mandated for infrastructure projects.

Delhi Metro as a transit system, has provided and will provide significant economic and environmental benefits to the city. It is estimated to save 16 million tonnes of emissions annually (Business as usual scenario) due to modal shift of 0.4 million private vehicles users by 2025 (RITES Ltd., 2011, p. 5.5). It targets cumulative CO2 emission reduction by 4.808 million tonnes in the lifetime (70 years) (RITES Ltd., 2011, p. 5.5).

With a focus on using renewable energy, DMRC plans to achieve carbon neutrality by purchasing power from solar energy providers. It has already commissioned implementation of solar power plants summing to a capacity of 3160 kW and plans capacity of 50 MW by 2021 (DMRC, 2016, as cited in Goswami, 2016). The primary reason for opting for solar over thermal power is the latter's higher tariff i.e. USD 0.11 per kilowatt-hour (Malik, 2015) while solar power's rate in India is down to USD 0.08 per kilowatt-hour (Times of India, 2014b).

Delhi Metro's existing network stretches over 213 km with a daily ridership of about 2.6 million (DMRC, 2016, p. 9). The network length is comparable to that of Hong Kong (another developing world city) but Delhi is way behind in ridership and revenue. The fact reflects the system's failure to utilize innovative financing through land-use and transit integration.

Delhi Metro incurred net loss of USD 70 million in 2015-16 and has been operating in net loss since commencement (DMRC, 2016, p. 79). Revenue from fare-box contributed 79% and 3% was earned through leasing of real estate and 18% from rental income (advertisement and station space rental) in financial years 2015-16. The share of fare-box revenue was significantly lower in 2006-07 (41%) and 2007-08 (63%) due to higher share of revenue generated from one-time leasing of DMRC land to a private developer in order to reduce capital debt during the initial years' operations. This land was given by the GoI to DMRC at a nominal intergovernmental transfer rate. This was an opportunity lost for on-going LVC and capitalising on the metro-induced windfall gains in land values, as had happened in Hong Kong. In recent years, DMRC opted for aggressive advertisement strategy (sold naming right of stations) and extensively rented spaces in stations (space for kiosks, parking, shops, restaurants and malls) which has significantly improved their rental income.

JLL India speculates that more than 50% escalation in real estate can be expected following the launch of metro rail (Shankar, 2015). An empirical study by Singh and Sharma (2012, p. 7) based on simple comparison method (using 50 property samples) placed the windfall increase in property values at about 14.7% in a suburban area (Rohini) of Delhi following the opening of a metro line.

Delhi Metro's efforts to integrate land use with transit have been stifled by the multi-layered and overlapping nature of control in Delhi authorities. The Master Plan of Delhi 2021, notified in 2007, recommended demarcation of influence zones along metro corridors to be planned as intensive development zones, in other words transit-oriented development (ToD), but without any specific statutory guidelines for ToD (Sabikhi, 2016). Local government bodies (who are prepared Master Plan) responsible for land management have delayed DMRC's applications for modification in land use and floor area ratio (FAR) for property development which is a result of lack of institutional integration (Suzuki, Murakami, Hong, & Tamayose, 2015). After 12 years of metro operation, in 2015, the Master Plan was amended and a ToD policy was introduced (Delhi Development Authority [DDA], 2015). This integrates the land use and metro plan after the implementation of metro but without institutional integration which restricts DMRC for implementing LVC at a comprehensive scale.

An act that should have been anticipated before implementation of Delhi Metro comes as substantially less rewarding being made after operationalization of system. Post-operation application of TOD brings scope for spatial rearrangement but does not necessarily ease out the way for DMRC. The policy only states to benefit it with increased ridership and value capture in the longer term and does not outlay any action plan for the latter (DDA, 2015). Though this is an initiation of urban policies towards sustainable urban growth and recognizing metro as significant element for it by local development authorities. However the delay has put DMRC under heavy debt and is responsible for the financial burden the institution has been holding for years. The situation certainly holds lesson for the 50 Indian cities in-process and ready to implement metro.

4.2. Rapid Metro

Rapid Metro Gurgaon, operational since 2013, is a mass rail transit system (elevated) developed to provide transit facility in and around the commercial center of Gurgaon . The network (6 km) is integrated with the Delhi Metro by a pedestrian bridge (90m-long) (IL&FS, 2012). In contrast to the Delhi Metro, the Rapid Metro Gurgaon is a privately financed system on a Build Operate Transfer (BOT) basis, with a 99-year concession period. The private developer recovers fare box revenue, while advertisement revenue is shared with the State Government for the first five years (Seth, 2012).

Rapid Metro has adopted for aggressive advertisement strategy to augment revenue. Advertisement revenue amounted to 61% of the total revenue in 2014-16 through auctioning of naming rights of the stations (even before the stations were opened) and advertisement space inside and on the exterior of the train coaches (Deloitte Haskins & Sells, 2015, p. 20).

Ridership has significantly improved from 18,614 (March 2014) to 42,000 (Aug. 2015) and contributed 39% (fare-box revenue) to the total revenue in 2014-16 (Deloitte Haskins & Sells, 2015, p. 20; Rapid Metro Gurgaon Limited, 2014, as cited in Kumar, 2014). However, the existing ridership of the system remained at about 40% of the projected ridership. The less ridership is attributable to the delay in anticipated commercial land development projects (private) along the corridor and intense competition with cheaper (by 50%) and highly available informal transport modes. The same situation occurred in London, where informal buses tapped on the ridership of formal sector. Based on the learning from case of London, Gurgaon being a new city with weak public transport, should explore modal and institutional integration.

4.3. Remarks for Delhi and Gurgaon cases

The difference in nature of ownerships of the two cases reflects significantly from the first stage of urban rail implementation i.e. land acquisition. Delhi Metro being a government agency faced little difficulties, referring to issues like legal and environmental clearances, in comparison with Rapid Metro Gurgaon. Moreover, Delhi Metro received land at a nominal inter-governmental transfer rate from the local government bodies, but Rapid Metro had to pay market value (sometimes even more). In this sense, Rapid Metro has a more sophisticated finance and project structure.

Although LVC approach is absent from the frameworks of both metro systems, Rapid Metro has effectively garnered considerable revenue through advertisements from its construction phase. Both the systems form lifeline of transportation in and around the National Capital of India and are significant for economic growth. DMRC and Rapid Metro have not been able to comprehensively tap on land-based finance initiatives. The government authorities should enable metro agencies to provide a distant vision and shift from piecemeal to strategic approach to financially sustain the metro systems using LVC mechanisms.

4.4. Evolving Project Structuring of Indian Metro

The Mumbai Metro started in 2014 is a notable public private partnership (PPP) project. A special purpose vehicle (SPV) was constituted to design, finance, build, operate, maintain and transfer the system at the end of a 35-year concession period to the state government. The selected concessionaire and local government agency hold 74% and 26% equity share in capital respectively (Reliance Mumbai Metro, 2013).

Mumbai Metro is hugely dependent on fare-box revenue and require government approval for fare revision. This condition has become ground for power struggle between the concessionaire and government. The Mumbai Metro concessionaire has filed a legal case for fare hike and threatened to exit the project. Over-reliance on fare-box revenue for sustaining the project in privately-funded metro is a critical issue, as was reflected in the case New York Subway.

An intrinsic challenge been faced in metro projects is that of project delays due to the lengthy and multi-layered bureaucratic process for obtaining approvals from different agencies for the project's implementation. This can significantly hinder private investment in urban rail projects. A case in point is of the Mumbai Metro where the 83% escalation in project costs is believed to have been caused by delays (Kulkarni & Shaikh, 2014) .

Apart from Mumbai Metro and Rapid Metro, all operational Indian metro systems are funded by the public sector. The fiasco of delays and blowing out of project cost has occurred in public-financed metro systems too. Bangalore Metro project's costs escalated by 19.3% and with the existing project delays this number could rise to 60% (Ray, 2015). These delays and cost escalations are restraining economic benefits and value.

In case of the Delhi Airport Express Line, the PPP structure failed and the government had to take over operations. The public sector (DMRC) built and financed all civil works including viaduct, tunnels and stations. The private concessionaire's responsibilities included operation, and financing of the operating system (primarily the track, signals, power distribution system and rolling stock) in return for the operational revenue, both fare-box and non-fare box. The selected concessionaire began operations in 2011 with a 30-year concession period but in 2013 exited the project and terminated the Concession Agreement citing defects in the civil structure (Reliance Infrastructure Limited, 2013). It is believed that the concessionaire had been incurring huge losses and according to Pratap (2013, of the Planning Commission, GoI) the following reasons made it financially unviable to operate the system:

- Low ridership – While the projected daily ridership was 42,500, only 17,000 passengers used the system per day. This gap in ridership is attributable to inaccurate transportation modelling.

- Aggressive bidding – The concessionaire's bid was on the higher side i.e. USD 7.7 million annual concession fee and a progressively increasing revenue share. The losing bidder on the other hand had asked for an annual subsidy of USD 5.2 million or a long-term interest-free loan of USD 217.4 million. Kumar Pratap of the Planning Commission of India speculated that the concessionaire followed India's 'jugaad' (translating to makeshift) principle to bag the project through aggressive bidding and renegotiate the terms later.

Alternative project structuring models for metro projects are now being conceived in Indian cities, Noida city being the pioneer. Noida is a satellite city of Delhi, governed by another state government with different legislative and political framework. The first (2009) phase of metro in Noida was established as an extension of the Delhi Metro network by DMRC. The Noida Development Authority financed the civil works, construction and land (depot, office and station) while DMRC bears rolling stock and operating expenses and collects revenue. For the proposed second (2017) phase of the metro in Noida, the city will bear all civil works, construction and land (depot, office and station) expenses and will provide additional land to DMRC to develop towards generating revenue for the system. Additionally, DMRC would be reimbursed for operational losses and not be expected to furnish any operational revenue.

For the proposed third phase in Noida, the city has taken the lead to own and operate the system and has set up a separate company for planning, implementing and exploring various PPP options for the project. Noida Development Authority has raised the permissible FAR along the metro corridor (for a 500m radius) and estimates that it will generate a revenue of about USD 603.9 million by selling additional land and exploring other non-fare box revenue options (Keelor, 2015). This is of one the first line of metro in India to is integrating land use and transit to implement innovative financing mechanisms at the planning of metro.

4.5. Issues

Indian metro projects are not planned in integration with land use and lack institutional integration at city level, which has deterred them to strategize innovating financing mechanism and reduce dependence on conventional sources of finance.

A significant legal factor preventing the integration is that urban transport plans are not statutory in nature and are not prepared in concurrence with land use plans. Also, urban transport plans and land use plans are drafted by separate urban local bodies (ULB's), and different agency implement and operate the metro system.

Local community has generally no role in the planning process of mobility plans and metro projects. The detailed project report (DPR) prepared for a metro project requires no mandatory local community inputs. The DPR (a traffic study) decides the metro alignment, and land use and community component is largely absent. This leads to the issues faced by implementing agencies, like land acquisition, which leads to project delays resulting in significant financial cost.

Lack of property mapping, updated land use maps and flawed property valuation procedures hinders to quantify the impact of metro, and strategize and implement LVC mechanisms. For example, Bangalore has 80% untapped built-up area (Ministry of Finance, 2017). These issues are reflected in the revenue estimation sections of DPR's, which include simple calculations for fare-box and non-fare-box revenue.

These intrinsic issues have led to high dependence of both private and public metro projects on fare-box revenue. As the existing systems expand network and new ones are being planned it is essential to address these issues and explore alternative financing methods to keep pace with the rapidly growing demand.

5. Recommendation

Indian cities and other emerging cities can learn from these case studies and create a new historical process of sustainable urban development based on innovative funding. Key steps forward include:

- Urban rail needs to be prioritized over urban road.
- Community and local planning processes to be involved at very early stage and community participation to occur at every stage of the project.

- Structuring finance for project life cycle is needed to allow regular land based contribution to feed into infrastructure financing model.
- Finance needs to be sought from private investment at very early stage of project planning/ conceptualizing and given more significance than simply looking at transport objectives.
- Capacity building and urban governance reforms to enable local level planning to bring desired outcomes.
- Cities to invest in digitising land use maps and real estate valuation, and regularly update this data base to plan for LVC initiatives and other planning process. It is required for economically and financially establishing the notion that metro uplifts cities land market and these benefits can be quantified and captured judiciously.
- Integration between land use and transport policy with institutional integration between local governments and transit authorities would allow opportunities for sustainable urban development.

6. Conclusion

The significance of urban rail in economic growth has been established around the globe for more than a century now. Cities have revived and innovated urban rail projects due to the local demand and for broader economic objectives. This has never been more needed globally than now as cities in the emerging world face terrible congestion and yet have clear objectives to achieve the SDG's.

Indian cities and other emerging cities struggle with issues of pollution, congestion, increasing travel time and parking can be contained through integrated policies that are strategically planned around and executed in close link with urban rail systems, like development of active activity centres to promote knowledge economy (as done in the case of London), urban design and value capture to finance development. To implement this, community participation should be the center of urban policies in order to create sense of ownership of urban space and smooth implementation of projects.

The Indian urban rail sector is at nascent stage. The current plan to build metro systems in 50 cities, inspired by the political leadership, provides India the opportunity to shape its urban areas banking on the significance of urban rail. The sustainable urban development goals in Indian cities demand policymakers to be astute to facilitate innovative LVC financing. Collaborative effort by local governments, transit agencies, developers, landowners and communities can generate progressive investment for transit systems and steer for sustainable urban growth. These can realise economic agglomeration benefits.

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Does Urban Rail Increase Land Value in Emerging Cities? Value Uplift from Bangalore Metro

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Highlights

1. There is a significant willingness to pay for urban rail in the emerging city of Bangalore.
2. Land value increases beyond the traditional 500m catchment area of 25%.
3. Panel data hedonic price modeling shows over 4% increase in the whole city's land value.
4. Urban rail projects have potential for a major agglomeration economic event in emerging cities.

Abstract

This paper seeks to understand how urban rail can influence land value uplift, especially in emerging cities which are largely unstudied. It examines the Bangalore Metro and shows that the uplift from the metro rail was substantial in the 'catchment area' and 'across the city'. The analysis was based on the panel data hedonic price model for around 160,000 apartments over the period 2012-16 and a cross-sectional data hedonic price model for 314,000 apartments in 2016. The panel data resulted in a stronger model and show significant land value increases, even beyond the traditional 500m catchment (Figure 1). A 'before' and 'after' from the commencement of the metro rail operations shows a price uplift of 4.5% across the whole city and indicates a major agglomeration economic event resulting in substantial willingness to pay of USD 306 million from the metro rail accessibility. Emerging cities can expect metro rail to substantially improve their economies and other co-benefits as long as finance can be obtained by capturing this value.

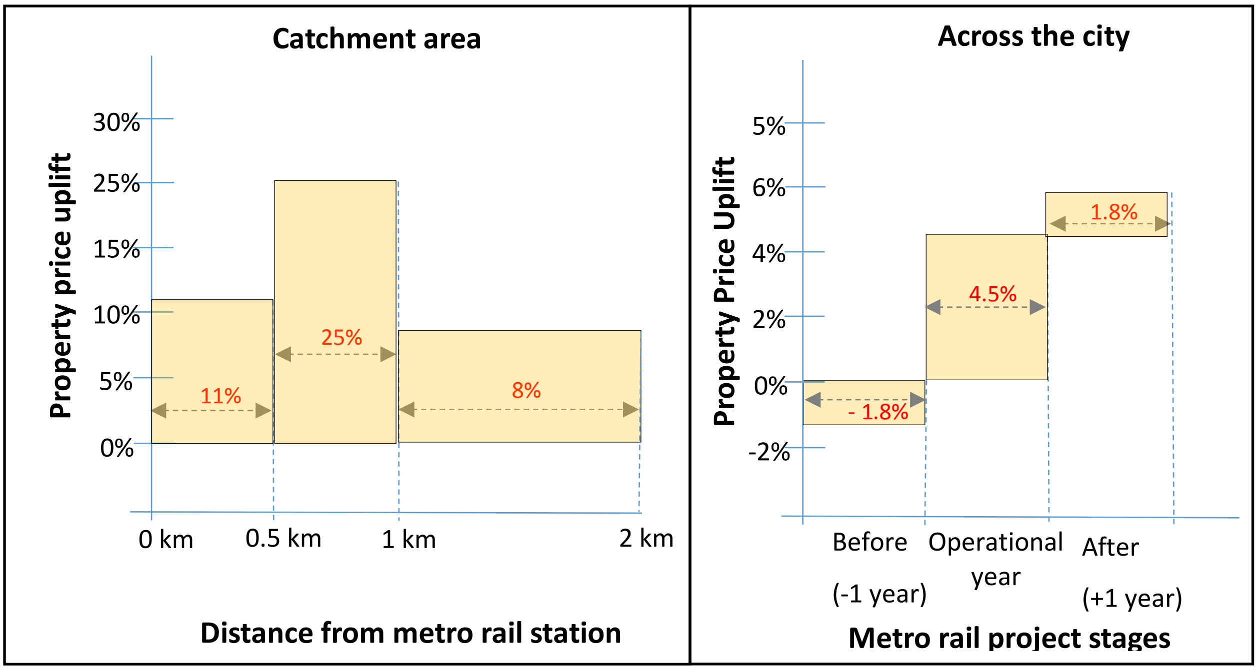

Figure 1: Impact of metro rail on property price

Keywords: Urban rail; land value capture; emerging cities; hedonic price model; agglomeration economics.

1. Introduction

In the latter half of the 20th century, governments favoured urban road systems and failed to allocate substantial public funds for urban rail projects. This approach contributed to removal of urban rail across most of the cities around the globe in the 1950's and 1960's. Those that remained like London and New York's subway were significantly underfunded (Black 2007; Green, 2016; Sharma & Newman, 2017).

Urban rail is back on the urban development agenda. It is thriving in densely populated cities of Asia, Europe and the Middle East and in the American and Australian cities which are heavily reliant on cars. Over the last two decades, China and India introduced over 25 high capacity urban rail systems (metro rail) with another 25 currently under construction[1]. This surge is driven largely by rapidly growing demand for rail in cities due to increasing travel time differentials between urban rail and urban traffic as well as a growing need for dense urban centers that are facilitated by urban rail. However, financing remains a constant struggle with the conventional model of government grants and fare-box revenue proving to be inadequate to meet the increasing rail demand. An alternative is the need to realize the economic benefits of urban rail and use it for its financing (Debrezion, Pels &

[1] In addition to urban rail, China has constructed over 20,000 km of high-speed rail to support its growing economy (Chen, 2012; Gao & Newman, 2018).

Rietveld, 2007; Newman, Kenworthy & Glazebrook, 2013; Newman & Kenworthy, 2015; Sharma, 2018).

Land value capture (LVC) mechanisms have shown significant potential as a sustainable source of finance for urban rail projects. This financing alternative emerges from the potential of urban rail to increase the land value in transit catchments. Most of the LVC studies have been done on cities in developed nations. This paper seeks to enable a better understanding of LVC in emerging cities as the need for alternative funding is even more significant in emerging cities where there is a high deficit in social infrastructure as well as lean budgets.

It is speculated that urban rail (metro rail) has increased real estate value in Indian cities (Jillella & Newman, 2016; Ministry of Urban Development [MoUD], 2012; Shankar, 2015) but there are unanswered questions on how to quantify the value uplift and willingness to pay (WTP) for accessibility. This paper attempts to answer these questions in stages. It begins by examining the relevance of location theory, land rent and demand, and WTP for transit infrastructure in any city including emerging cities to see how metro rail influences land value. The subsequent section discusses prominent studies on residential land value uplift due to metro rail in developing and developed countries based on the hedonic price model (HPM) method. Following this, a methodology is proposed to evaluate the impact of metro rail (as a property attribute) on the residential property market using HPM to estimate user's WTP. The methodology is applied to the Indian case of Bangalore[2]. The case study uses cross sectional and panel data to prepare HPM's for calculating WTP for different property attributes, particularly metro rail accessibility. The estimated HPM's are used to capture the increase along the metro rail catchment land market and at city-level. The latter is rarely done in LVC studies.

In the next sections, theory is used to show a) why particular HPM variables were chosen to evaluate land value in Bangalore and b) how the land value uplift can be explained.

2. Literature Review

2.1 Urban Rail and Real Estate

Table 1 shows that urban rail uplifts residential real estate (land and property) value in cities around the globe. This value appreciation could be captured to finance urban rail (see Anantsuksomsri & Tontisirin, 2015; Armstrong & Rodriguez, 2006; Cervero, 2003; Du & Mulley, 2007; Garrett, 2004; Iacono et al., 2009 McIntosh, Trubka & Newman, 2014; Medda & Modelewska, 2009; Sharma & Newman, 2018; Yankaya, 2004).

[2] The name of the city is officially Bengaluru since 2014, but the old name is used for convenience with references.

Value capture requires that the extent of impact in a city be quantified, followed by analyzing if urban rail generates sufficient value (demand – WTP) to be captured. Econometric models have been extensively used to assess the impact of urban rail on real estate. The most popular among these models is the hedonic price model (HPM).

2.2 Hedonic Price Model (HPM)

The HPM is a regression model with its basis in economic thinking of the early 20th century. It involves the application of least squares regression analysis which requires a linear relationship between the dependent variable (eg. property value) and independent (explanatory) variables (eg. characteristics of property). It estimates separately the contribution of each independent variable price to the total estimated (hedonic) price. The HPM functional forms include linear, linear-log, log-linear and log-log. Equation 1 represents the equation for the observed dependent variable (D) (McIntosh, Trubka & Newman, 2014; Rosen, 1974; Sopranzetti, 2015).

Equation 1 Parametric Land Price Equation

$$D_i = f(X_j; \beta_j) + \varepsilon_i$$

Where

D_i is the estimated land price of the ith observation,

X_j is a vector of quantitative and qualitative property attributes,

β_j is the unknown hedonic price of the property for attribute j, and

ε_i is the stochastic error term.

2.3 Location Theory

Von Thunen's (1826) classic location theory analyzed the spatial division of different production activities to minimize transportation expenses between production area and marketplace (Fischer & Nijkamp, 2014). His concepts were applied to urban activities by Hurd (1903), Haig (1926) and Ratcliff (1949) to suggest that urban activities reflect rent competition for locations that minimize movement. On the other hand, Robert Park (1929) theorized that improvement in transportation and population growth augments benefits of the city center. Alonso (1964) built his location theory based on earlier pioneering studies (Isard, 1956 and Wingo, 1961) to suggest that minimization of transportation cost (spatial friction) between residence and work increases land rent in urban settings, as high accessibility to central areas activates competition for locations closer to the central business district (CBD) (Capello, 2011).

The above location theories when applied to an urban context, essentially explain the economic rationale of choosing to situate a firm or household at a specific location in an urban space to minimize transportation costs in the context of agglomeration economies (Capello, 2011). The primary consideration in selecting the location for an urban household is to ensure efficient access to the benefits of agglomeration viz. urban resources, services and workplaces. Thus, location theories highlight the significance of activity centers and travel time in a city.

Saving on travel time is economically significant in a city as it contributes to decreases in transportation and opportunity cost. Over the last decade travel time by car has exceeded that by urban rail in cities across the globe (Newman & Kenworthy, 2015). The importance of saving on travel time is driving the demand for urban rail that is further catering to the urban knowledge economy and the culture of people-centered urban form to support this process (Matan & Newman, 2016; Glaeser, 2011; Glazebrook & Newman, 2018).

Based on the above discussion, this study examined HPM variables on activity centers, urban infrastructure, locational attributes, density and mixed land use as factors affecting the residential land market in Bangalore.

2.4 Urban Land Rent

An important feature common to urban location choice theories is the cost of land, or land rent (Capello, 2011). Urban land rent represents the manifestation—in price terms—of the economic value of a scarce resource, e.g. urbanized land endowed with general accessibility characteristics (to the center and to specific facilities like railway stations, airports, parks and green areas) or agglomeration benefits discussed above.

Camagni (2016) suggests that rent emerges from two preconditions, first being a limited supply that leads to a ‘scarcity absolute rent’ (Scott, 1976; Sraffa, 1960) and the second, a ‘demand for city’ i.e. a household’s willingness to pay more than the supply cost for a desirable good or production factor such as access to transit. This demand is generated by the need to benefit from an urban environment which is a product of agglomeration economies. Demand may increase due to time/space specificities when a city becomes crucial for economic activities, for instance the knowledge economy emerges or a city provides an innovative environment or introduction of a public urban infrastructure like metro rail (Camagni, 1992, as cited in Camagni, 2016).

2.5 Urban Land Demand

As a scarce resource, urban land displays certain peculiar characteristics to qualify as a marketable commodity (Johnston, 1977, as citied in Kivell & Shaw, 1988). It plays a role in optimization processes in the locational choice of actors, in allocation decisions of land-owners, and in minimizing of mobility and interaction costs. These processes and characteristics contribute to the demand of urban land.

Alonso (1964) suggested that the demand of urban land is a utility function of the characteristics of land, geographical location and income constraint. He suggested that an individual household buyer trades off between accessibility, land characteristics and money to reach a decision. The trade-off forms a three-dimensional relationship to represent householder's equilibrium demand. He expressed this in the form of bid-rent curves to describe the relationships between land value, commercial location and transportation cost. Muth (1969) accorded Alonso (1964) on the positive relationship of land value with its proximity to a CBD. Muth (1969) expanded Alonso's model and showed that population density and proximity to CBD are relative to household income and age of dwellings. Alonso (1964) added that the only way to channel high income demand for land back to central areas[3] is by up-zoning it (as cited in Kirwan, 1966).

Based on these urban rent and demand theories, a city-level assessment of urban rail impact on residential land markets was conducted on Bangalore in order to assess if urban rail results in agglomeration benefits at city level in addition to the generally accepted impacts on catchment areas.

2.6 HPM Case Studies – Influence of urban rail on residential real estate

Table 1 presents a compilation of case studies on the impact of urban rail on residential value using HPM. The compilation includes eleven cases from developed countries and six from developing countries along with their findings, methodology, functional form, and dependent (land/ property price) and differing independent variables. The selected case studies (1992 to 2015) provide a temporal outlook on the subject over the past two decades. There are many more studies on developed cities but these six seem to cover those on emerging cities.

The difference in availability of property records in the various case studies reflects a contrasting situation between developing and developed countries. While the cities of developed countries have organized database and property transaction records, the same appears to be lacking in the studies from developing countries. For instance, the cases of Seoul, Izmir, Beijing and Taipei reply on a small sample size of about 350 observations each. The study from Bangkok manages 622 observations being the most recent. In all the cases the value of R^2 appeared to be independent of the number of observations used in each study, the nature of the city, the model used or the resultant impact[4].

In the studies from developing countries, the database has been expanded by using a wide range of structural, neighborhood, accessibility and time based variables to compensate for the lesser number

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[3] Park (1952) noted that in 1960's the low-dense American suburban land value was increasing and the city centre value was decreasing.
[4] Nagelkerke (1991, p. 161) defined R^2 as "the proportion of variance 'explained' by the regression model useful as a measure of success of predicting the dependent variable from the independent variables". As per Gujarati & Porter (2004), R^2 in cross sectional data is generally low due to the inherent diversity of cross sectional data. An HPM is considered acceptable or satisfactory if the independent variables and the model are statistically significant (Gujarati & Porter, 2004). Achen (1982) and Granger & Newbold (1976) share the same view.

of observations. The studies from developed countries analyzed datasets ranging from 1,000 to 124,000 observations and a fair range of variables. Cases from the United States of America (USA) include details on building utility and structural variables. All other cases, especially from developing countries, collect a substantial number of neighborhood variables like presence of parks, schools, health centers, convenience shops, sports facilities and water bodies.

The cases from the United States of America suggest a substantial proximity premium, ranging from 10% to 34% for the proximity variable from 60 m to 800 m around a railway station. The Tyne & Wear, Helsinki and Warsaw studies show 17%, 11% and 7% proximity premium at 200 m, 500 m and 1 km proximity variable respectively. The Lisbon Metro rail case registers a 9% impact on average from the accessibility attribute. Contrary to expectations, the cases from developing countries suggest low impact on accessibility, except in the case of Izmir Subway and Bangkok Mass Transit System. The Izmir case study places a proximity premium at up to 16% for properties within 1 km of the transit station and the Bangkok study places it at USD 9,210 per 1 km closer to the transit station. Factors such as typology and quality of housing registered considerable impact in the Asian cases of Beijing and Seoul.

These case studies indicate that LVC has significant potential but it needs further development in emerging cities through better data and more parameters to explore the impact of urban rail accessibility on WTP and hence LVC. The paper thus moves to a more advanced study of Bangalore using better data and more parameters than have been used in other emerging cities.

Table 1: Authors' compilation of HPM studies on impact of urban rail in real estate value

Sl. No.	Author	Location - Transit System	HPM Form: Model R^2	Dependent Variable	Independent Variables				Data & Methodology	Finding(s) from HPM
					Land/Structural	Neighbourhood	Accessibility (Distance to)	Time Based		
1	Bae, Jun & Park (2003)	Seoul, South Korea - Line 5, Heavy Rail KoRail	Log-Linear: 0.95	Sale price	• Apart. Size • Age of structure • Residential blocks • Parking • Heating type	• School district • Pop. density • Job density	• Subway • CBD • Sub centre • River • Park	Time dummies: • Price in 1995 • Price in 1997 • Price in 2000	Panel data of 241 condominiums. Data pooled for 4 years, of which only 3 years (before metro rail) data was significant in HPM.	Insignificant impact of rail on real estate.
2	Lin & Hwang (2004)	Taipei, Taiwan – Taipei Metro	Linear: 0.766	Property price	• Floor space • Building age	-	• CBD • Public facility • Transit station	• Economic growth rate • Consumer price index • Time of the year	Panel data of 317 residential property located within 400 m from metro rail line, from 1993 to 1995. Time dummy variable for before and after operation of metro rail.	Floor space price increased at about USD 480 per sq.m., after subway opening along the corridor.

Sl. No.	Author	Location - Transit System	HPM Form: Model R^2	Dependent Variable	Independent Variables				Data & Methodology	Finding(s) from HPM
					Land/Structural	Neighbourhood	Accessibility (Distance to)	Time Based		
3	Yankaya (2004)	Izmir, Turkey - Izmir Metro	• Linear: 0.73 • Log-Linear: 0.71 • Linear-Log: 0.74 • Log-Log: 0.73	Sale price	• House size • Apts. in bldg. • Apts. on floor • Age of structure • Bed • Storeys in bldg. • Corner location • Parking • Heating	• Location • Type of ground	• Subway • Bus • Shop	-	Cross-sectional data of 360 multi-family residential units, was used for two impact zones, 500 m and 1 km around the stations.	Property value uplift was mixed between stations. About 16% premium at some locations for properties within 1km from subway station. For whole system, a percent increase in distance from metro rail reduces property value by 0.07%. Relationship weakens with distance.
4	Gu (2006)	Beijing, China - Batong	Log-Log: 0.89	Property price	• FAR • Decoration • Typology • Land use • Property service fee	-	• Convenience shops • Hospital • High school • Park • Stations • Water body • Trunk road • CBD • Tiananmen square • Railway station	Month of sale of property (continuous variable)	Cross-sectional data of 141 residential property located within 4 km from rail line, from June 2002 to April 2006	Insignificant impact of metro rail on real estate in the whole study area. The impact on housing prices in suburbs was 1.8% premium per 1km proximity to railway stations, whilst impact on property near CBD was insignificant.
5	Zhang & Wang (2013)	Beijing, China - City Rail; Batong	• City rail – Linear: 0.773	Property price	• Housing type • Home finishing • Availability (readily or post down	• FAR of the project • Green area ratio	• Transit station • CBD • Expressway • Health centre	Time dummies for property in year 1999, 2000, 2001, 2002, 2003,	Panel data of 217 residential property located within 6 km from rail line, from 1999 to 2005 for City	Property premium of 0.35% for every 100 m closer to the City Rail station. Property premium of 0.02% for every 100 m closer to

Sl. No.	Author	Location - Transit System	HPM Form: Model R^2	Dependent Variable	Independent Variables				Data & Methodology	Finding(s) from HPM
					Land/Structural	Neighbourhood	Accessibility (Distance to)	Time Based		
			• Batong – Linear: 0.687		payment)		• Public park • Sports facilities	2004 and 2005.	Rail. Panel data of 275 residential property located within 6km from rail line, from 1999 to 2005 for Batong.	the Batong line station. Distance to city centre and quality of housing have more impact in the three cases than proximity to transit.
6	Anantsuksomsri & Tontisirin (2015)	Bangkok, Thailand – Mass Transit System	Linear: 0.56	Land price	-	• Population density	• Metro station • Arterial road • CBD • Airport • Hospital • Park • School • University	-	Cross-sectional data of 622 residential property located within Bangkok Metropolitan Region for year 2010.	USD 9210 premium on land value per 1 km proximity to transit station.
7	Laakso (1992)	Helsinki, Finland - Helsinki Metro	Log-Linear: 0.94	Sale price	• Ln (Age) • Ln (Area) • Terrace House • Pool • Indoor sports • Health centre • Library • Daycare	• Ln %Park • Ln Income quartile	• Metro station dummies • Feeder bus dummies • Commuter rail dummy • Shopping centre dummy • Coast • Ln CBD	• Transaction time dummies	Cross-sectional data of 6,700 residential properties located within Helsinki city for years 1980, 1985 and 1989 - The first year represents pre-metro rail times, and the last two years post-metro rail times.	11% property price increase due to metro rail on the most desirable locations, and price decrease by 8% in the most remote feeder transport areas. Positive impact is highest at the distance of 500 m – 750 m from the metro station, lower at 250 m – 500m and lowest at less than 250m.

Sl. No.	Author	Location - Transit System	HPM Form: Model R^2	Dependent Variable	Independent Variables				Data & Methodology	Finding(s) from HPM
					Land/Structural	Neighbourhood	Accessibility (Distance to)	Time Based		
8	Gatzlaff & Smith (1993)	Miami, USA - Heavy Rail/Metro	• Linear: 0.71 • Log-linear: 0.67 • Linear-log: 0.78 • Log-Log: 0.77	Sale Price	• House area • Lot size • Age of structure	• Est. House price index	• Metro rail	• Construction announcement dummy	Panel data of 912 residential property located within 1 square mile of train stations, from 1971 to 1990.	Insignificant increase in values of homes nearby to station.
9	Benjamin & Sirmans (1994)	Washington D.C., USA - Metrorail	Log-Linear: 0.744	Observed monthly rent of the apartment unit	• Bathrooms • Bedrooms • Utilities • Parking available • If the building is high rise • Fireplace • Washer/dryer • Occupancy rate of the complex	• Zip code	Distance to metro stations in tenth of miles	-	Cross-sectional data of 250 apartment rents for year 1992, from 81 condominiums.	When distance increases to 800 m from the stations, rent declines by more than 10%.
10	Cervero (2003)	San Diego, USA - LRT	• Multi-family housing – Linear: 0.695 • Condominiums –	Sale Price	• Size • Units • Bath • Bed • Age	• Housing density • Income • Racial profile • % Senior citizens • % Vacant land	• Half mile LRT • Highway/ freeway • Freeway ramp	Time dummies: • Monthly, to reflect different sale times	Cross-sectional residential data for year 2000 on: • Multi-family housing: 1,495 parcel records • Condominiums: 9,672 parcel	Multi-family: 17.6% increase in prices of properties located within 800 m of an East Line Trolley stop. Condominiums: 6.4% increase in prices of properties located near

Sl. No.	Author	Location - Transit System	HPM Form: Model R^2	Dependent Variable	Independent Variables				Data & Methodology	Finding(s) from HPM
					Land/Structural	Neighbourhood	Accessibility (Distance to)	Time Based		
			Linear: 0.735 • Single-family housing – Linear: 0.605						records • Single-family housing: 14,756 parcel records	East Line Trolley stations and 46% for those near Coaster stations. Single-family: 17% increase in prices of properties located within a 800 m of a non-downtown Coaster station.
11	Garrett (2004)	Missouri, USA - St. Louis Metrolink LRT	Log/ Linear	House Price	• Bed • Bath • Storeys • Garage • Pool • Age of structure • Lot size • House size	• %Residents with college education • Income • Property tax rate • School district test scores • Does nearest LRT have PAR?	• LRT station • Noise impact from LRT by dist. to LRT • Highway interchange	-	Cross-sectional data records of 1,516 single-family homes that were sold from 1998 to 2001 and are located within 1.6 km of a MetroLink station. Analysis and comparison between sets of homes located up to 2,300 ft. from a station/track and those located 2,300 ft. to 5,280 ft. (1 mile) from a station/track.	Home located at 100 ft. from station will hold 32% higher value than home located at 1,460 ft. For homes located beyond 1,480 ft., home values increase by USD 69.50 every 10 ft. farther they are from the station. From 2,300 ft. to 2,800 ft. from station, USD 12.14 price increase in property price for every 10 ft. farther from the track amounting to 0.7% increase.
12	Armstrong & Rodrigu	Massachusetts, USA –	• Log-Linear: 0.582		• Lot size • Usable living area	• Pop. density • Quality of	Median household income for	-	Cross-sectional data of 1,860 single-family residential property	Properties within 800 m of a commuter rail station sell at 10.1% premium; additional

Sl. No.	Author	Location - Transit System	HPM Form: Model R^2	Dependent Variable	Independent Variables				Data & Methodology	Finding(s) from HPM
					Land/Structural	Neighbourhood	Accessibility (Distance to)	Time Based		
	ez (2006)	Commuter rail	• Log-Log: 0.951		• Bedrooms • Bathrooms • Age of structure • Architectural style	education system • Municipal property tax rates • Quality of local police service	property's block group, as value of accessibility rail.		records were collected for the year 1992 and first quarter of 1993. Hedonic price function comparison between 4 local municipalities with commuter rail service and 3 without rail service.	minute of drive time from station results in 1.6% decrease in price; additional 1,000 ft. from rail results in price increase of between USD 732 to USD 2,897.
13	Du & Mulley (2007)	England, UK -Tyne & Wear light rail	Log-Linear: 0.38	House Price	• House type • Bedroom	• Local school indicator • % long-term unemployed • % Higher managerial and professional occupation	• Public Transport access (school, college) • Car access (school, college) • LRT	-	Cross-sectional data with 2,855 real estate transactions for Tyne and Wear Region was recorded in 2004.	A minute faster travel (car or public transport) to large employers increase house price by 29.81%.
14	Martinez & Viegas (2009)	Lisbon, Portugal - Lisbon metro	Linear: 0.76		• Bedrooms • Typology • Floors • Area • Age of property • Garage	• Educational index • Entropy index	• Metro rail • Road • Rail	-	Cross sectional data for residential properties on sale during February, 2007 with a total of 8,742 complete records, 70% within	The metro rail accessibility attributes coefficients in the two all-or-nothing models vary between 3.49% and 5.18% for accessibility to two metro rail lines and between 4.62% and 6.17%

Sl. No.	Author	Location - Transit System	HPM Form: Model R^2	Dependent Variable	Independent Variables				Data & Methodology	Finding(s) from HPM
					Land/Structural	Neighbourhood	Accessibility (Distance to)	Time Based		
					space				Lisbon's municipality and remaining in Amadora and Odivelas.	for accessibility to a single metro rail line, reflecting a significant impact of metro rail proximity over property values.
15	Atkinson - Palombo (2010)	Phoenix, USA - Rezoning around the Phoenix LRT	Log-Linear: 0.76	Sale Price	• Lot size • House size • Swimming Pool • Age of structure	• Socio-economic data • TOD overlay zoning	• LRT Pedestrian catchment • Freeway • CBD	• Pre-and Post-dates from the introduction of the TOD overlay	Cross-sectional data of 4,048 single-family houses that were sold in either 1995–99 ('before') and 2001–07 ('after') and second dataset of 2,467 condominiums with transactions in 1995–99 ('before') and 2001–07 ('after'). Separate hedonic analyses for two neighbourhood - residentially dominated neighbourhood (type 5) and mixed use neighbourhoods dominated by amenities (type 4).	Land use or locality setting defines if an LRT station is a walk-and-ride or a park-and-ride, and whether land parcels are subject to overlay zoning. Overlay zoning—and the potential of TOD beneficial land uses in the future—increases price of condominiums by 37% in type 4 set, while single-family houses prices increases by 6% 'before' overlay zoning is announced and 6% 'after'. Single-family houses in type 5 set prices deceases by 12% if they are subject to overlay zoning and condominiums of 13%.

Sl. No.	Author	Location - Transit System	HPM Form: Model R^2	Dependent Variable	Independent Variables				Data & Methodology	Finding(s) from HPM
					Land/Structural	Neighbourhood	Accessibility (Distance to)	Time Based		
16	Medda & Modelewska (2009)	Warsaw, Poland - Warsaw Metro	Log-Linear: 0.69	Sale Price	• Area • Rooms • Floors in bldg. • Age of structure • Parking	• School district	• Hospital • Green area • Metro rail catchment dummy	• Transaction time dummies	Panel data of 1,130 residential properties, from 2006-2010. The samples are located within two similar districts of Warsaw, Bielany district (with existing metro rail line) and Targówek (where a line is planned). Two districts were chosen to estimate the impact of planned metro rail.	In Bielany, properties located within 1 km of a metro station show 6.7% higher selling price than those located beyond 1 km. In Targówek, properties located within 1 km from a planned stations show 7.13% increase in price. The estimation of the increase in price due to the extension of metro rail was obtained by subtracting the actual price from the estimated price.
17	Golub, Guhathakurta & Sollapuram (2012)	Phoenix, USA - Phoenix Light Rail Transit	Log-Log: 0.533	Adjusted Sale Price	• Living size • Lot size • Age of structure • Patios • Bath • Floors • Pool • TOD zoning	-	• LRT Stn. • LRT alignment • CBD • Airport	• Time dummies • Prior National Environment Policy Act (NEPA) • During NEPA review • Planning & design • Construction • Operations	Panel data of 122,222 residential properties within 3.2 km from LRT network, from year 2006-2010. HPM for was carried out separately for the four real estate markets.	Single-family homes: Negative impact on prices of properties located within 200 ft. of the rail line. Multi-family homes: Positive impact on prices of properties located within 200 ft. of the rail line. Vacant properties: Statistically insignificant.

3. Bangalore Metro Context

The Bangalore Metro project is being executed by the Bangalore Metro Rail Corporation Limited (BMRCL). BMRCL is a special purpose vehicle – a joint venture of the Government of India (GoI) and the Government of Karnataka (state government). Bangalore Metro is being developed in two phases, 42 km in Phase 1 and 72 km in Phase 2 (BMRCL, 2016).

Construction of Phase 1 commenced in 2007 and the stations opened in 2011, 2014, 2015 and 2016 (BMRCL, 2016). The last set of stations of Phase 1 opened in June 2017. As of March 2016, Bangalore Metro was operational along 30.28 km out of the total 42.30 km of the Phase 1 network (BMRCL, 2016) with average daily ridership of 0.17 million (Indian Express, 2016). Phase 1 has suffered delays throughout its timeline, resulting in over USD 1267 million cost overrun (BMRCL, 2016; Madhavan & Satyanarayan, 2016). Phase 2 is proposed to start operations by 2020 though construction is yet to commence. Considering the delays in Phase 1, Phase 2 was excluded from this study. Only Phase 1 of Bangalore Metro was considered.

The GoI and the state government together contributed 59% of Bangalore Metro's project cost while the balance 41% has been raised as debt from financial institutions including Japan International Corporation Agency, Agence Française Development and Housing and Urban Development Corporation Limited. BMRCL has also raised USD 44 million by issuing bonds (10 year secured), which is significant and representative of the overall financial attractiveness of the project (BMRCL, 2016).

BMRCL incurred a loss of USD 9 million during operations in financial year 2015-16, marginally higher than in 2014-15 (BMRCL, 2016, p. 17). Non-fare box revenue in 2015-16—mainly from property development—amounted to about USD 2.5 million, marginally lower than in 2014-15 (BMRCL, 2016, p. 17). BMRCL argues in the annual report that the financial loss is mainly on account of expansion of the network for commercial operations (BMRCL, 2016, p. 18). They anticipate that revenue will improve substantially as ridership will augment once the entire Phase 1 network is in operation (by April 2017). This approach reflects significant fiscal reliance on fare box revenue.

BMRCL currently owns 35 acres of land and claimed plans to develop it through public private participation and setting up commercial spaces above metro stations. They plan to earn revenue by expanding the norm of 4-FAR (floor area ratio) from 150 m to 500 m from operational (not applicable for under-construction or planned) stations (Bangalore Development Authority, 2015). These plans are yet to be executed. BMRCL has missed the opportunity to financially gain from positive impact on real estate value due to metro rail operations till now. On the other hand, private developers are cashing in on this impact of metro rail and planned increase in FAR on land market by buying land parcels for development and redeployment (Satyanarayana, 2016). This signifies that the market is responding to a location-based speculative demand of real estate due to the Bangalore Metro project.

BMRCL could well be in a position to package a rail network with land development to finance the metro rail project in Phase 2. For this, their financial model must include the land value appreciation at different stages of the project. This paper provides the basis for such analysis.

Subsequent sections discuss the methodology and analysis of the impact of Bangalore Metro (Phase 1) on Bangalore real estate.

4. Bangalore Case Study Methodology

4.1 Real Estate Data Collection

Land/property valuation and registry is essential to efficiently manage this important economic factor of production. India is among the worst ranked countries in terms of land/property registry (The World Bank, 2016). Indian cities lack a comprehensive system to maintain and update urban land records and construction profile (Bheenaveni, 2011). Municipal bodies maintain records of properties for collection of property tax but do not update them annually. If a city like Bangalore is growing rapidly then much of the properties will not be assessed for property tax. Economic Survey of India 2016-17 (Ministry of Finance, 2017) notes that Bangalore has over 80% of its built-up area not assessed.

Government authority real estate prices were not used in this study for the following reasons:

- Government rates are not updated regularly,
- No scientific valuation method is used for government rates,
- Government rates do not incorporate spatial characteristics of property,
- Government rates are not based on individual property level valuations, and
- Government rates are significantly lower than the market rate (Ministry of Finance, 2012).

On the other hand, it is possible to use private real estate data as real estate companies record the sale price of properties and the fluctuation in prices on a real time basis. Financial institutions often use real estate company data for decision making on housing loans which signifies the authenticity and quality of such data. Therefore, data from a real estate company (M/s LJ Hookers) was used in this study which comprised of residential apartment projects (hereafter referred to as property) in Bangalore.

Intrinsic issues related to real estate data availability in India have limited the amount of data used in this study as compared to developed countries cases. For example, McIntosh, Trubka & Newman (2014) used over 400,000 land value parcels of data for a similar study on Perth. Among developing countries' cases, this study employs one of the most comprehensive data samples, comprising 898 property samples (314,000 apartments) for year 2016; and 458 property samples (160,000 apartments) from 2012 to 2016 on a half yearly basis.

4.2 Hedonic Price Model's for Bangalore

This study considered cross sectional data HPM and panel data HPM to evaluate the impact of Bangalore Metro Phase 1. The two different HPM's were included in the study to see if cross-sectional data are adequate for achieving LVC results. This is because many emerging cities do not have panel data. Data used for the panel and cross sectional HPM's are at the city-level to estimate the impact of a metro rail project at both city level and the metro rail catchment area. Independent variables and the dependent variable used for HPM's are discussed in the next two sections.

4.2.1 Dependent Variable

This study uses average sale price of property in Bangalore as a dependent variable for both the cross sectional data HPM and panel data HPM. Cross sectional data comprised 898 property samples for a single period (June, 2016 in this case). Panel data comprised 458 property samples for eight time periods between December, 2012 to June, 2016, thus total observations for panel data were 3,664 (458x8); this is important for understanding the impact of metro on property prices over the years as it is a large sample size of data when multiplied by the number of apartments.

4.2.2 Independent Variables

Independent variables mentioned in the literature review were expanded based on the availability of data and due to the absence of existing empirical studies on factors that influence real estate prices in Indian cities.

The literature review (Table 1) suggested that independent variables should include city specific, structural, neighborhood and locational variables. Independent variables influencing property price (dependent variable) were considered based on property variables, neighborhood/ socio-economic variables, accessibility variables and metro rail specific variables, as listed in

Table 2. City specific independent variables like lake and airport were also included. A total of 22 independent variables were considered in this study but only statistically significant variables were included in both the cross-sectional data HPM and panel data HPM.

Additional dummy variables for panel data HPM were included along with the 22 independent variables – eight dummy variables for property prices were provided in December 2012; July 2013; January 2014; July 2014; January 2015; July 2015; January 2016; and July 2016.

Table 2: Independent Variables

Property variables	Neighborhood/ socio-economic variables	Accessibility variables	Metro rail specific variables
1. Developer grade 2. Project possession/ completion date	1. Literacy rate 2. Rented properties 3. Mix of residential and commercial properties (mixed land use) 4. Car ownership	Distance from: 1. Metro station 2. CBD 3. Bus stop 4. Park 5. Inter-city railway station 6. Activity centre 7. Educational centre 8. Arterial road 9. Hospital 10. Lake 11. Airport	1. Nearest metro station operational year 2. Nearest metro station operational status (dummy variable) 3. Properties within 0.5 km distance from metro station (dummy variable) 4. Properties within 0.5 km to 1 km distance from metro station (dummy variable) 5. Properties within 1 km to 1.5 km distance from metro station (dummy variable)

Independent variables like 'distance from airport' are self-explanatory, however some of them are not and are explained below:

- **Neighborhood/ socio-economic variables** are at ward level as that is how the data we obtained from Census of India, 2011.
- **Developer grade** is a qualitative value-related estimate of housing and neighborhood quality. Developer grade data was collected from real estate companies. Grading is performed as good, average and bad, and was based on the following parameters:
  - Social and physical infrastructure in the neighbourhood
  - Amenities provided by developers within the property
  - Income level of neighbourhood
  - Construction quality of building
  - Absorption rate of the developers' previous projects
  - Project completion record history
  - Delay/expected delay
- **Nearest metro station operational year**: This variable was included to estimate the impact of metro rail over the years. Input data for this variable is the 'number of years' from the year the metro rail operations started or are expected to be started at the nearest metro station from the property. The maximum value of this variable is '4.7 years' and minimum is '4 years'.
- **Nearest metro station operational status (operational/ under-construction) (dummy variable):** This dummy variable was included to estimate the change in metro rail status from

‘under-construction’ to ‘operational’ at the nearest metro station from the property. As the stations of Bangalore Metro were opened in 2011, 2014, 2015 and 2016, this variable captures the impact of metro rail’s pivotal stage of becoming operational on land market.

Four functional forms (linear, log-linear, linear-log and log-log) were tested for both the HPM’s. This investigation into the different functional forms of the HPM was necessary as the studies presented in Table 1 used differing functional forms of HPM each and a guidance for best suited form could not be established.

5. Bangalore Case Study Results

5.1 Comparing Panel and Cross Sectional HPM’s

Statistical software (SPSS 22) was used for estimating both HPM’s. ‘Enter OLS’ method was used in SPPS to delineate statistically significant independent variables by multiple iterations and estimate the best fitted model with up to 95% confidence level. The analysis results in Table **3** shows that both cross sectional data HPM and panel data HPM are statistically significant. As other emerging cities rarely have property price panel data, Bangalore results suggest that cross sectional data may well be good enough for the city to assess its value capture potential.

Table 3: Model summary and ANOVA[5] for statistically significant variables

Model	**Model Summary**			**ANOVA**	
	Function	**Adjusted R^2**	**Std. Error of the Estimate**	**F**	**Significance**
Cross Sectional HPM	Linear	0.45	2230.77	67.19	0.000
	Linear-Log	0.49	2147.62	86.63	0.000
	Log-Linear	0.5	0.28	65.83	0.000
	Log-Log	**0.54**	**0.27**	**105.13**	**0.000**
Panel Data HPM	**Log-Linear**	**0.64**	**0.239**	**325.997**	**0.000**

Table 3 shows that the Ordinary Least Squares (OLS) for cross sectional HPM for the linear, log-linear, linear-log and log-log functional forms displayed varying levels of success in modelling property price and all four functions are not random up to 99.99%. For panel data HPM, only the log-linear functional form was statistically significant for the desired independent variables and not random up to 99.99%.

The log-log functional form of the cross sectional HPM explains the highest variation (54%) in the dependent variable and the log-linear functional form of the panel data HPM explains 64% of the variation in the dependent variable, thus these were selected for further analysis[6].

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[5] Analysis of variance

5.2 Results from Cross Sectional HPM

Table 4 shows the cross sectional HPM results for the impact of statistically significant independent variables on Bangalore's property price with descriptive statistics. All metro rail related variables were statistically significant in the model and suggest an upward trend of property prices due to metro rail accessibility. It shows 35.8% value uplift in properties located within 500 m catchment of a metro station and 19.3% value uplift in properties located within 500 m to 1 km catchment of a metro station. Value uplift in properties located within 1 km to 2 km catchment of a metro station is 13.9%. These value uplift trends in properties based on proximity to metro station are similar to that of global cities cases represented in Table 1.

Table 4: OLS Log-Log HPM of Property in Bangalore (2016)

Independent Variables	Mean	Std. Deviation	% of total no. of parcels in catchment	Coefficients	Significance	% increase in mean property price with a unit in independent variables
(Constant)				9.91	0.000	
Nearest metro station operational year	2.4	2.4		-0.02	0.029	
Nearest metro station operational status *	0.7	0.5		0.11	0.008	10.90%
Properties between 0.5 km to 1 km from metro station *	0	0.1	2.10%	0.19	0.012	19.30%
Properties within 0.5 km from metro station *	0	0.2	3.30%	0.36	0.000	35.80%
Properties between 1 km to 2 km from metro station *	0.1	0.2	5.50%	0.14	0.005	13.90%
LN Distance from metro station (km)	1.8	0.9		0.08	0.004	
LN Distance from CBD (km)	2.4	0.5		-0.55	0.000	
LN Distance from	-0.9	1		-0.03	0.006	

[6] R-square comparison is meaningful as the dependent variable is same for the functional forms.

Independent Variables	Mean	Std. Deviation	% of total no. of parcels in catchment	Coefficients	Significance	% increase in mean property price with a unit in independent variables
bus stop (km)						
LN Distance from park (km)	-0.3	1.3		-0.03	0.000	
LN Distance from airport (km)	3.2	0.4		-0.12	0.000	

Notes:

1. LN - Log
2. * - Dummy variable

The results of cross sectional HPM suggests that change in metro rail's operational status from under-construction to operational raises the property price by 10.9% across the city. This increase reflects a significant citywide land market response to the availability of new rail transit and the substantial capital investment it brings in the city. Also, the policy to increase FAR along the catchment area after the operation of metro rail could be playing a major role in this increase. This signifies that the operation of metro rail is an agglomeration (urban) event that can increase economic productivity of the whole city. The Panel data model (see below) also shows a similar impact for 'across the city'.

Other metro specific studies suggest property values decrease by 1.7% across the city with each passing year after the commencement of the metro rail. However, in this study no such decline is yet apparent; this variable has a positive impact in the panel data HPM and is a stronger model than the cross sectional one.

5.3 Results from Panel Data HPM

Table 5 shows the panel data HPM results for the impact of statistically significant independent variables on Bangalore's property price with descriptive statistics. The statistical significance of property values from 2013 to 2016 shows that the model was strong. Metro rail-related time-variant variables, 'operational year of metro rail' and 'metro rail operational status', were statistically significant and capture the impact of metro rail over the years.

Table 5: OLS Log-Linear HPM of Property Price in Bangalore (2012 to 2016)

Independent Variables	Mean	Std. Deviation	% of total no. of parcels in catchment	Coefficients	Significance	% increase in mean property price with a unit in independent variables
(Constant)				10.293	0.045	
Developer's grade	2.93	0.33		-0.53	0.014	-53.00%
Possession (in years)	0	2.01		-0.016	0.003	-1.60%
Nearest metro station operational year	0.6	2.58		0.018	0.004	1.80%
Metro rail operational status *	0.57	0.5		0.045	0.019	4.50%
Properties between 0.5 km to 1 km from metro station *	0.02	0.15	2.60%	0.253	0.027	25.30%
Properties within 0.5 km from metro station *	0.03	0.16	2.40%	0. 107	0.027	10.70%
Properties between 1 km to 2 km from metro station *	0.03	0.17	3.10%	0.081	0.025	8.10%
July 2013 *	0.13	0.33		0.055	0.016	5.50%
January 2014 *	0.13	0.33		0.134	0.017	13.40%
July 2014 *	0.13	0.33		0.148	0.017	14.80%
January 2015 *	0.13	0.33		0.184	0.018	18.40%
July 2015 *	0.13	0.33		0.186	0.019	18.60%
January 2016 *	0.13	0.33		0.219	0.021	21.90%
June 2016 *	0.13	0.33		0.212	0.022	21.20%
Distance from CBD	11.76	4.64		-0.051	0.002	-5.10%
Distance from bus stop	0.72	0.88		-0.048	0.006	-4.80%
Distance from park	1.29	1.52		-0.024	0.004	-2.40%
Distance	9.32	5.06		0.022	0.002	2.20%

Independent Variables	Mean	Std. Deviation	% of total no. of parcels in catchment	Coefficients	Significance	% increase in mean property price with a unit in independent variables
from inter-city railway station						
Distance from airport	25.58	8.43		-0.005	0.001	-0.50%
Distance from education	1.04	1.43		0.051	0.005	5.10%

Note:

1. *Dummy variable

The Panel Data Model shows an upward trend of property prices due to metro rail related variables. It suggests 10.7% value uplift in properties located within 500 m catchment of a metro station and 8.1% value uplift in properties located within 1 km to 2 km. The value uplift in properties located within 500 m to 1 km catchment of a metro station is 25.3% value uplift – higher than the properties with greater accessibility to metro stations. The difference is attributable to noise levels, vibrations due to high speed rail and prolonged construction-related inconvenience due to delays in construction and other reasons discussed in the next section related to the intense activity in this area.

At city level, the change in metro rail's operational status from under-construction to operational raised the property price by 4.5% across the whole city. This is a very significant outcome and suggests a significant citywide land market response to the availability of new rail transit and the substantial capital investment it brings in the city. Also, the policy to increase FAR along the catchment area after the operation of metro rail could be playing a major role in this increase. This signifies that the operation of metro rail is an agglomeration (urban) event that can increase economic productivity of the whole city. Other metro specific variable suggests an 1.8% value uplift in properties with each passing year after the metro rail became operational.

The analysis shows that developer grade is a significant variable as it yields 53% appreciation in property prices with improvement in grade. This underscores the importance of quality of development, facilities in the property, neighbourhood and other property specific parameters. Whilst a year's delay in possession of a property reduces its price by 1.6% -- in practical terms, the property owner loses rental value with delay in possession.

6. Discussion

Although the cross sectional data and the panel data HPM's cannot be directly compared due to different independent variables used in the models, both models displayed metro rail specific variables as statistically significant and generally reflected similar trends. As the panel data HPM is a stronger model and shows the impact of metro on property prices over the years, it has been used to assess the significance of WTP and draw conclusions in the study. In the next two sub-sections, we attempt to explain the panel data HPM results that are summarized in Figure 2 for the rail catchment area and across the whole city.

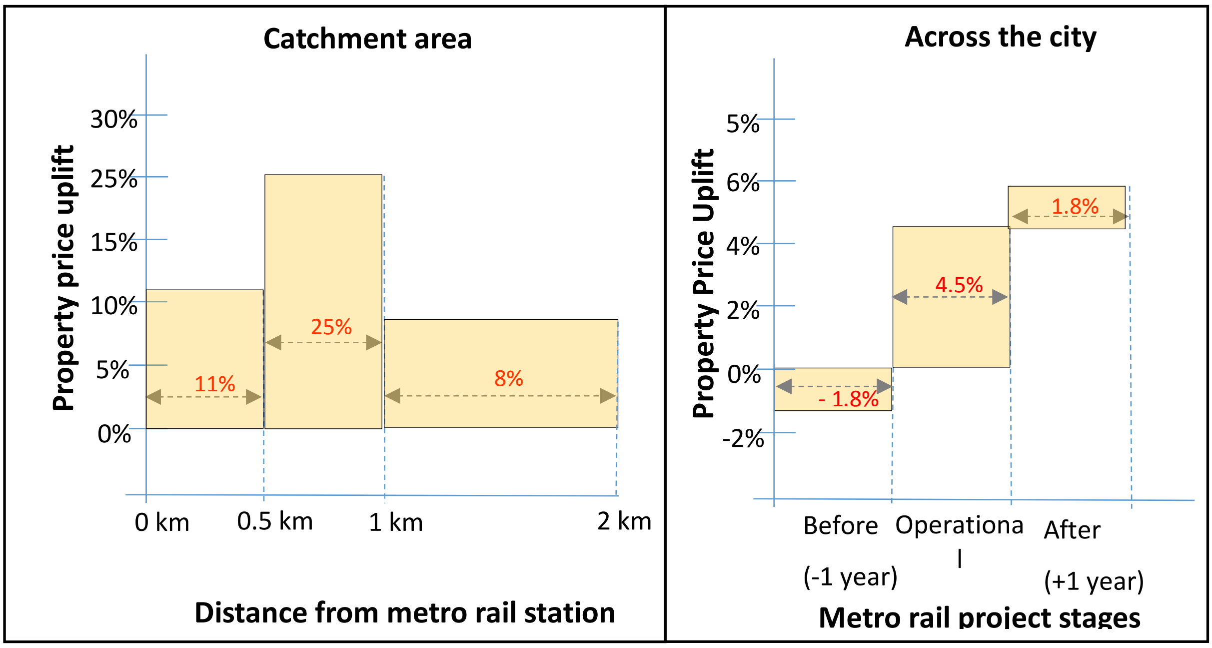

Figure 2: Impact of metro rail on property price

6.1 Property Price Impact – Metro Rail Catchment Area

Bangalore's panel data HPM shows that the impact of metro rail in the catchment areas goes beyond the traditional influence zone of 500 m. The property value increase (25%) in properties located within the 500 m to 1 km catchment is higher than the value (11%) in properties located within 500 m from a metro station. This redefines the generally acceptable theory of increasing of land value with the proximity to urban rail which was also shown in the studies on Perth, Australia (McIntosh, Trubka & Newman, 2014) and Helsinki, Finland (Laakso, 1992).

The generic reasons for the decreasing land value in the catchment area can be due to the negative externalities for residential land market immediately adjacent to the high intensity stations – higher noise levels, vibrations due to high-speed rail, prolonged construction and intense traffic flow as most of the rail stations are located on arterial roads. These negative externalities can be applicable to most of the cities. Specific reasons for the case of Bangalore seem to be: the construction was prolonged for over 2 years longer than planned; the absence of policies to guide any land use change before or during implementation of metro rail; and the metro rail only triggered gradual commercialization because there had not been experience in the city with modern electric rail before this so the attraction of stations for developers had not been fully realised (Singh & Sharma, 2012). The land use change is mostly unplanned and piecemeal, while it further attracts informal and hawking activity in the vicinity of metro stations, a phenomenon peculiar to emerging cities. Also, the 500 m to 1,000 m station catchment is well served by paratransit modes like auto rickshaw/ taxi/ cycle rickshaw which enables easy access beyond walking and cycling, though these modes create highly crowded conditions in the immediate surrounding of the stations. Thus, the land value increases in the immediate surroundings of the metro rail but the higher values are found just beyond these very crowded areas. These reasons may impact the residential property buyer willingness to reside in 500 m to 1,000 m catchment area over residing within the 500 m catchment. This also helps explain the 8% increase out to the 1-2 km catchment.

This decreasing land value in the catchment area of Bangalore Metro also extends Luca Bertolini's model of 'node' and 'place' by finding a decreasing land valuation without proper planning within the urban rail catchment (Bertolini & Spit, 2005). He suggested that real estate value is likely to be generated more from the place than the node, although both are important, but people choose to live in places, not nodes.

6.2 Property Price Impact – City Level

The metro rail specific variables 'operational year of metro rail' and 'metro rail operational status' in the city level HPM have revealed substantial agglomeration benefits of the metro rail even out to 29 km radius from metro stations[7]. The 4.5% increase in property price across the whole city[8] due to the opening of the metro is a very strong economic impact for an infrastructure – this city level increase was suggested in the urban rent and demand theories discussed in this paper. This is rarely measured in any HPM study on urban rail impacts and has significant policy implications.

The extent of the impact, across the whole city, is not generally understood by some economists and agencies who do not see property uplift from rail as a general economic benefit but only as a local catchment area benefit shifting economic value from one area to another. This research shows that urban rail value uplift covers the whole city. It may suggest that other value uplift studies could examine the extent to which the whole city benefits however it may be that it is too small to measure in a developed city.

It is perhaps easy to understand why there would be such an economic impact in an emerging city, such as Bangalore for the following reasons:

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[7] The mean distance from metro to properties was 7.8 km and 75% were located within 10 km
[8] Uplift in the capital value of Bangalore's property market is 2.5% (Compounded Annual Growth Rate) from 2012 to 2016 (LJ Hookers, 2017).

a) **Investment:** The substantial capital investment metro rail projects bring to the city helps to accelerate economic activity of a city and such investment is highly significant in Bangalore.

The cost of Phase 1 of Bangalore Metro is USD 2,068 million (BMRCL, 2016), about two times (USD 1,005 million) the size of the municipal budget of Bangalore (Nag, 2015). Such investment can be hypothesized to have a larger economic impact than has been seen in developed cities due to its proportional investment impact. Transportation being the engine of the urban economy tends to have much more accumulated impact as a sector since it has relevance to all the existing industries and inhabitants of the city. Recalling the location theories, metro rail projects (transportation) can be seen to be playing an elemental role in shaping a city's demand.

b) **Travel Time:** Significant economic growth potential is being blocked by large scale traffic congestion in most dense, emerging cities like Bangalore; hence a metro rail can unlock significantly greater economic opportunity through this improvement in accessibility. The difference in accessibility between emerging cities and developed cities means that far greater agglomeration benefits can be obtained due to the proportionally bigger accessibility gains. Newman & Kenworthy (2015) show that the ratio of transit speeds to traffic speeds of global cities are highest in Asian cities (0.86) as compared to developed cities (0.69) due to very low traffic speeds. The developed cities still have higher traffic speed and lower infrastructure deficits as compared to emerging cities so as new urban rail projects are built in emerging cities there are dramatic accessibility benefits.

In Bangalore the dramatic population growth in recent times (42% over the last decade of 2001-2011) resulting in 9 million trips every day (2015) has reduced travel speeds from 18 kph in 2008 to 11 kph in 2015 (survey of 375 km of major road network by the Bangalore Development Authority, 2017). In the city center it was lower than 10 kph in 2011 (Karnataka Urban Infrastructure Development & Finance Corporation, 2011). The Bangalore Metro's average speed is 34 kph (BMRCL, 2017) and its existing network is connecting the CBD (with south-north and north-south rail corridor) and its planned extension will connect all major economic centers of Bangalore. The travel speed is important for a growing city like Bangalore which has an average trip length of about 10 km (in 2015) that has increased from 9 km (in 2011) (Bangalore Development Authority, 2017; Karnataka Urban Infrastructure Development & Finance Corporation, 2011).

The combined effect of low traffic speed and increasing trip length affects travel time reliability (Taylor, 2013). A significant factor metro rail adds over other modes is the reliability to reach a destination on time – a major factor in workforce travel behaviour (Carrion & Levinson, 2012) and hence in generating accessibility benefits.

A study done by a cab aggregator, OLA (2015, as cited in Rao, 2015), showed that average traffic speed in all major Indian cities is about 19 kph and the average travel time is 34.8 minutes to reach the workplace. This would explain why Indian cities are demanding and implementing metro rail projects that have a reliable average speed of 35 kph. Delhi, where transport has the largest share of road land use among all major Indian cities, witnessed traffic speeds of 20 kph in 2013 and is constructing the biggest metro rail system in India (MoUD, 2013). A study on mode choice modelling of private and public modes in Delhi showed that travel time is more significant than travel cost and other factors according to both modes users (Sharma, 2011).

6.3 Willingness to Pay (WTP)

WTP for metro rail transit is calculated by multiplying the catchment hedonic price and the average property value. WTP with respect to proximity to metro stations in Bangalore is shown in Table 6.

Table 6: Willingness to Pay for Bangalore Metro

Proximity to Metro Station	Property Value Uplift (Panel Data HPM)	WTP per sq. m.
At 0 – 0.5 km	11%	INR 5,016 (USD 75)
At 0.5 – 1 km	25%	INR 11,862 (USD 172)
At 1 – 2 km	8%	INR 3,800 (USD 54)
At whole city	4.5%	INR 1,033 (USD 32)

The WTP for change in metro rail's operational status across the whole city in the panel data HPM sample of 458 property results in an aggregate WTP of USD 360 million[9], whilst the total cost of Phase 1 of the Bangalore Metro is about USD 2,068 million (BMRCL, 2016). This is substantial value creation.

6.4 Policy Implications

Based on this study the following policy implications are suggested:

1. Bangalore shows that metro rail can not only uplift value around stations but across the whole city. This would suggest metro rail has a major strategic role in any emerging city's economy.
2. In order to fund metro rail systems, cities like Bangalore can venture into alternative financing via value capture mechanisms. There is clearly value uplift happening. The extent of value uplift can be used to determine value capture mechanisms:

    a. The 11%, 25% and 8% value capture in the catchment areas (0 to 2 km) could have a Beneficiary Zoning Levy, and

[9] Each apartment was about 70 sq.m. and each apartment project has about 350 apartments.

b. The 4.5% value uplift across the whole city could be a Public Transport Levy on all new developments.

3. The reduced uplift values next to stations suggests more attention should be given to a Local Area Station Management Plan and Walkable Urban Design Plan to create more walkable spaces (Matan & Newman, 2016).
4. This study has shown that Bangalore's existing policy to sell density zoning after the metro rail is operational proves to be financially correct as the uplift peaks (4.5%) during the opening of metro rail. Nevertheless, the policy to allow density zoning to properties within only 150 m (and proposed 500m) from operational metro station needs to be amended as the impact of metro rail is citywide.

7. Conclusion

This study shows that urban rail has substantially increased property value in Bangalore. The impact of metro rail is beyond the traditional 500m as it appears to have reached right across the city. The increase in the whole city indicates a major agglomeration economic event resulting in substantial willingness to pay of USD 306 million. This increased willingness to pay in Bangalore now will demand changes in the policy and density zoning that will benefit land markets by pushing them to their highest value and best use. These benefits qualify to be recognized by the policy makers and be used to build urban rail as a maximizer for economic development. Although it is too late for this phase of the Bangalore Metro, other phases could plan to tap such an increase for funding. Other emerging cities can be given some confidence about using the value capture mechanisms to build or expand urban rail.

The findings of this study disrupt the traditional theory of increasing of land value with the proximity to urban rail. We have explained these findings based on theories and peculiar factors in Bangalore, and implications of these findings on urban policy have been discussed. The analysis of this study can help other emerging cities to quantify the impact of urban rail and help explain its findings as there are limited academic studies on emerging cities. Thus the analyses and the detailed literature review of this paper can benefit policymakers to make informed decisions on urban rail projects.

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Can land value capture make PPP's competitive in fares? A Mumbai case study

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ABSTRACT

Mumbai Metro is planning to build 152 km of high-speed urban rail lines. The first line of Mumbai Metro was built through a Public-Private Partnership (PPP) and opened in 2014. Financial issues since its opening necessitated a fare increase—among one of the highest in India to maintain the line's commercial viability for the private operator. This paper examines how high dependence on farebox revenue could have been avoided by using Land Value Capture (LVC) to finance Mumbai Metro. A panel data hedonic price model was used to assess the impact of Mumbai Metro's commencement on approximately 66,000 apartments. The model shows a significant uplift of 14% in property prices in the Mumbai Metro catchment area resulting in USD 179 million value capture opportunity under Mumbai's existing legislative framework. This paper suggests that LVC could enable a PPP urban rail projects to achieve financial and social viability if governance systems can enable appropriate mechanisms.

1. Introduction

21st century India has opened over new 10 urban rail systems and is planning another 40. Mumbai[1] is the first Indian city to conceptualise a Public-Private Partnership (PPP) model for urban rail. The concept hinged on projected ridership resulting from a traffic demand model. The planning process did not factor the impact of urban rail on land value and prospective Land Value Capture (LVC). The traffic demand model has failed and the existing ridership amounts to only half the anticipated number. This has led the private operator to request an increase of the fare through a Fare Fixation Committee (FFC) (2015) of the Government of India. The FFC noted that non-fare box revenue options are limited therefore an increase in fares creates the only way to make Mumbai Metro commercially operational. The FFC however did not explore the option of land-based financing. The fare hike has not been implemented yet as Mumbai Metro's government partner has taken legal recourse rebuking the hike and arguing that higher fares would render the system unaffordable for members of society's low-income sections. Such issues of finding how to balance commercially and equity in transit are common around the world (King and Streeting, 2016; Suzuki et al., 2015; Ubbels et al., 2001).

In this paper, we examine whether the proposal for the Mumbai Metro could have incorporated LVC as a source of finance, and thus the proposed fare hike could have been avoided. The role of LVC in achieving a balance between affordable fares and business viability in PPP's has been an issue in other cities (Sharma et al., 2015; Smith and Gihring, 2006; Suzuki et al., 2015). To investigate this in Mumbai, a Hedonic Price Model (HPM) was estimated to assess the impact of Mumbai Metro's 11 km Line 1 commencement on the value of land in its catchment area. This research is essential in highlighting this impact, as Mumbai is planning to expand Mumbai Metro to 190 km in the next 6 years (Bloomberg, 2017). This paper further discusses which LVC mechanisms can be applied in Mumbai based on a literature review and existing applicable LVC mechanisms in Mumbai.

2. Conventional funding sources

Public transport systems have historically faced financial deficit when highly dependent on farebox revenue and government funds (Sharma et al., 2015; Ubbels et al., 2001). The cost-revenue gap is considered widest in urban rail as this is one of the most capital-intensive forms of city public transport (Knight & Trygg, 1977; Viton, 1980). Urban rail is supported primarily by public funds as its cost-revenue structure (business model) is burdened by labour-intensive construction, increasing

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[1] The Municipal Corporation of Greater Mumbai area (generally referred to as Greater Mumbai) was considered as the study area for this research. It is referred to as 'Mumbai' in the paper.

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maintenance needs of older systems and increasing travel demand due to urbanisation (Transportation Research Board TRB, 1998). Public funds are generally in the form of capital loans and operational subsidies.

Subsidy can be defined as a payment not requiring direct exchange of goods or services of equal market value in return. It is aimed at accomplishing a specific objective or effect (Black, 1995, as cited in Ubbels et al., 2001). Subsidy for public transport is justifiable for it being a 'service'. However, subsidies impose one or both of higher taxes and reduced spending on other public services (Smith and Gihring, 2006). Proost et al. (1999, as cited in Ubbels et al., 2001) argue that subsidies work against economic efficiency when they become excessive.

Another form of public funds i.e. loans involve significant risk for the borrower. Flyvberg (2007) provides empirical evidence for this from a study on 44 urban rail projects (including extension projects) completed between 1966 and 1997 in North America (18), Europe (13) and developing nations (13) worth approximately USD 37 billion (2005 prices). The study revealed (Flyvberg, 2007):

1. Average cost escalation for urban rail is 45% in constant prices.
2. For 25% of urban rail projects, cost escalation is at least 60%.
3. Actual ridership is on average 51% lower than forecast.
4. For 25% of urban rail projects, actual ridership is at least 68% lower than forecast (Flyvberg, 2007).

Flyvberg (2007) concluded that urban rail reflects a risk profile when cost and revenue risk are combined. Borrowings on projects with high economic risk are most likely to push the nation into a series of debt and significant fiscal deficit. These studies were mostly from 20th century projects and since then significantly better patronage has happened in urban rail (Newman et al., 2013). However, the stark problem of urban rail requiring capital loans and operational subsidies continues.

In emerging Indian cities, the loan borrowing scenario discussed above impacts public and private players differently. The cities have raised soft loans from international donors at about 1%–2% interest rate against a sovereign guarantee to develop urban rail. The funds have been used to construct publicly-owned urban rail systems. The sovereign guarantee option was not available to privately built and operated projects (such as Mumbai Metro) leading them to borrow at a high interest rate (market rate of over 11%) (FFC, 2015).

Urban rail projects in India both public and private are running into losses. The privately-operated systems i.e. Mumbai Metro and Gurgaon Metro have raised fares to compensate for losses but the public systems rely on government subsidies. Neither of these financing models is economically progressive as fare hikes can exclude sections of society from urban rail.

The universal issue of finding a more viable and progressive way of financing the building and operations of urban rail is pushed in this paper by examining how governments can tap the quantitative value created by public investments in urban rail through land value increase. This will be done by examining the case study of Mumbai and how the potential of Indian metro projects can be improved in general through land value capture (Banister and Thurstain-Goodwin, 2011; Lohia, as recorded in Blagg, 2015).

3. Literature review

3.1. Impact of urban rail on land value

Urban rail impact on land value is well established. There is a wealth of empirical studies demonstrating increase in land value due to urban rail in both developed and emerging cities (see Anantsuksomsri and Tontisirin, 2015; Armstrong and Rodriguez, 2006; Cervero, 2003; Du and Mulley, 2007; Garrett, 2004; Laakso, 1992; Medda and Modelewska, 2010; McIntosh et al., 2014; Mulley, 2014; Sharma and Newman, 2017; Sun et al., 2017; Yankaya, 2004; Zhong and Li, 2016). Governments are recognizing this can be used as a significant source of public finance, for example in India and Australia they have instructed their state and city authorities to act on LVC implementation (Commonwealth of Australia, 2016; Ministry of Urban Development, 2017). City deals in Australia now require partnership with all levels of government and the private sector in order to create LVC mechanisms to pay back infrastructure (Smart Cities Plan, 2017).

3.1.1. Impact assessment using hedonic price model

In theory, urban rail transit systems catalyse development opportunities and enhance accessibility of adjacent properties, increasing their desirability, locational value and land value (McIntosh et al., 2014; Newman and Kenworthy, 2015). This increase can be calculated using econometric price models specifically hedonic price models which have been used extensively to calculate this increase.

HPM is based on the notion that land/property value is a sum of different attributes affecting land value. Thus, the land price can be divided into the component (or 'hedonic') prices of each attribute. The HPM involves the application of ordinary least squares (OLS) regression analysis which requires a linear relationship between the dependent variable (e.g. property value) and independent (explanatory) variables (e.g. characteristics of property). The HPM functional forms include linear, linear-log, log-linear and log-log. It is one of the most applied methods to identify the effects on house prices associated with factors such as proximity to transportation facilities, the subject for this study. Over 30 studies have used HPM to calculate the impact of transit on land values (McIntosh et al., 2014; Sharma and Newman, 2017).

A basic meta-analysis equation can be:

$$Y = f\,(P,X,R,T,L) + \epsilon$$

Where,

Y = Independent variable under examination
P = Set of causes of the outcome Y
X = Characteristics of the set of objects under examination affected by P, to determine outcome Y
R = Characteristics of the research method
T = Time period covered by the study
L = Location of each study conducted
ϵ = Error term.

Estimation of the windfall gains using HPM depends to a large extent on the nature of data and attributes selected for the model. The attributes include factors influencing land value like distance accessibility to work centres, transit, neighbourhood characteristics and others. Zhao and Larson (2011) highlight the limitation of econometric models as it is difficult to separate the value uplift due to improved transport accessibility from the uplift due to general increase. However, size and nature of data can ensure efficiency in assessments through availability of updated registries and detailed data sets.

An examination of several HPM case studies on impact of urban rail on land value shows that there is a contrasting situation between developing and developed countries for the availability of property records. The cities of developed countries have organized databases and their datasets range from 1000 to 400,000 with a large number of independent variables. The studies from developing cities show a small number of independent variables and dataset of about 350 observations (McIntosh et al., 2014; Sharma and Newman, 2017).

HPM cases from developed and emerging cities show significant increase in land values due to urban rail, few cases are marked below:

In developed cities:

1. An HPM study on Perth by McIntosh et al. (2014) showed 40% increase due to commencement of an urban rail line.
2. In Lisbon, this value was found to be 6%, calculated by Martinez and Viegas (2009) through HPM.

3. A study on the San Francisco Bay Area revealed that for every metre a single-family home was closer to an urban rail station in 1990, its sales price increased by USD 2.29 per meter (Landis et al., 1994).
4. An HPM study in 1993 on residential properties adjacent to the 14.5-mile urban rail in Philadelphia concluded that access to rail created an average housing value premium of 6.4% (Voith, 1993).

In emerging cities:

1. Sharma & Newman's (2017) HPM study on Bengaluru showed a 23% increase in land value in the 1 km catchment area of urban rail and of great significance it appears to have increased land values over the whole city (up to 29 km out) by an average of 4.5%.
2. An HPM study for Izmir reveals a proximity premium of up to 16% for properties within 1 km of the transit station (Yankaya, 2004).
3. Anantsuksomsri & Tontisirin's (2015) HPM study on Bangkok shows windfall gain at USD 9210 per km proximity to transit station.
4. Beijing's HPM study showed property premiums of 0.35% per 100 m proximity to urban rail station (Zhang and Wang, 2013).

These examples support the case for assessment of the land value impact using HPM in emerging cities. If the assessment is positive, cities can potentially utilise LVC as a public finance instrument.

3.2. Land value capture

LVC focuses on realizing a portion of the increase in land value originating from urban rail as public revenue through taxes and fees (Medda and Modelewska, 2010). LVC mechanisms can be structured to support cost recovery in the case of urban rail transit projects (Bahl and Linn, 2014). The structuring involves factors such as timing of application (before or after transit development), payment schedule, scale and actors involved (Connolly and Wall, 2016; Medda, 2012; Peterson, 2009; Smolka, 2013; Walters, 2012; Zhao et al., 2012), and incidence (Chapman, 2017). Various LVC structures can be designed to optimise returns from the potential of land either in sum or on-site land improvements that benefit the community and foster urban development. The following subsections discuss the four broad classifications of LVC that have been used for urban infrastructure and specifically transportation, and which can be applied in urban rail.

3.2.1. Betterment contributions

These are taxes or fees levied on properties to fund capital or operation and maintenance cost for the infrastructure. Landowners pay specific taxes for payment schedules of varied duration. The payment may commence before, during or after the infrastructure is developed and can be charged from local to city scale. Examples of betterment contributions include land value tax, transport utility fee and betterment levy.

Latin American cities have been levying betterment tax to fund infrastructure since the 17th century (Reyes, 1980, as cited in Smolka, 2013). Latin American countries have national legislation that allow the local government to capture the unearned income (*Plusvalias* in Spanish) resulting from a public investment in order to be shared with the public. In Bogotá, the betterment fees (*contribución de valorización*) contributed USD 1.0 billion from 1997 to 2007, and USD 1.1 billion was planned to be collected for 2008–2015 (Smolka, 2013).

France has established a public transport funding system known as "Versement Transport". It is a specific tax paid by public or private companies when there are more than nine workers located within a 10,000 habitants urban transport limit (Pascal, 2003, as cited in Milan, 2015). The idea is to tax property owners that benefit from the transport infrastructure. The funds collected are used to cross-finance operational costs and/or new transport infrastructure.

Betterment contribution is considered easy to understand and economically efficient as it is aligned with the benefits of public investment. It is favourable, in terms of benefit distribution equity, as it generates public funds. However, it has some equity considerations as some of the population may not be able to pay but it can be means tested. The levy is viable long-term as a low tax rate remains adequate with its extensive target base even if the economic growth potential is uncertain (Connolly and Wall, 2016). It is easy to implement, however accurate property valuations can be challenging. Overall, it is a progressive tax and is consistent with efficient urban growth.

3.2.2. Regulatory charges & negotiated development

This LVC mechanism imposes a levy on private developers for any development or spatial transformation triggered by the transport project. The rationale is that the private development benefits from the accessibility provided by the infrastructure set-up using public funds. The levy could be in the form of monetary payment (e.g. change in land use and development impact fee), special building permissions (transfer of development rights, air rights and purchasable zoning) and negotiated provisions (execution of public works and forfeiture of a portion of development area). The levy is in addition to the existing charges proportional to the windfall gains by developers due to infrastructure. The revenue from the levy is used to fund public infrastructure. They may be exacted either upfront or ongoing.

Hass-Klau (2006) explains how this mechanism works in Germany. For a license to build in Munich, a land developer must obtain the current land value from a real estate experts' panel, as the land value is bound to increase once construction commences. This increase in value may be claimed (up to as high as 2/3) by government to finance the construction of public infrastructure. The rest of the value accrues to the land developer.

The objective of regulatory charges and negotiated development levies is to realize the opportunity created by the transport infrastructure and boost urban development in its catchment area. The proportional nature of such taxation promotes stability and efficiency in land markets. However, these LVC tools may intrude on the developer's share of the benefit equity and developer's may compensate by choosing to build high-income residences in a desirable market. Thus it may not be a progressive LVC mechanisms.

3.2.3. Taxed local development

This category of LVC mechanisms involves payment of taxes at an elevated rate to fund projects identified for local development. The rate is fixed by earmarking future revenue to finance current expenditures aimed at accessibility improvement. The payers include residents and business-owners from an identified catchment area. A few examples include tax increment financing, business improvement district, benefit assessment district (BAD) and business rate supplement (BRS).

The development of Crossrail in the Greater London Area is financed partially by BRS. The BRS is expects to fund GBP 4.1 billion of the GBP 14.8 billion project by 2038. It requires non-domestic properties with rateable values above GBP 55,000 to pay higher tax (2 pence for a pound). The tax will to be increased by 15% in revaluations to take place every five years. In the first financial year 2010-11, collection surpassed the projected amount (Roukouni and Medda, 2012). Considering the project is on a regional scale, the LVC mechanism does not include specific local development projects and focuses entirely on financing the Crossrail.

The BADs in San Francisco are highly successful. The process begins with constitution of a local committee by the district's residents, business owners, tenants, schools and developers. The committee prepares a local development proposal including financial plan and seeks approval from the local government. The proposal is aimed at uplifting services and infrastructure level in the district to boost business and accelerate local economic growth. The local government scrutinises the proposal and grants BAD eligibility to the district. The district residents are charged with elevated property taxes to fund the development. Involvement of developers in the committee from early stages catalyses investment. Funds from the BADs have been used for various infrastructure projects including the urban rail system. The Los Angeles Red Line sourced 9% of the construction cost (USD 1.4 billion) from BADs (Clark and Mountford, 2007).

The LVC tools of this category encourage deliberation as the local development projects are either initiated by or drafted in consultation with residents. The projects range from developing transit hub, bicycle lanes, social housing, and public amenities, to redeveloping brownfields. The tool enables financing of various improvements in districts with low accessibility levels or low quality services, to induce economic growth. This encourages private investors to further invest in the district as the development is certain and so is their financial gain. However, there may be a few unintended effects like an inflated market and displacement of low-income residents (Medda, 2012).

3.2.4. Joint development on public-private partnership

This tool involves the private sector from the beginning. The public sector enables private sector bids for a joint development of a transport project and the adjacent land. The private sector is involved either directly in the development or through financial support for the same. The development can proceed by privatisation of public land or public acquisition of private land for private leasing. Joint development involves mutual benefit for the public and private partner while the finance and risks are externalised to the private partner (Mathur and Smith, 2013). The most suitable examples of joint development are in Hong Kong and Japan.

Hong Kong Mass Transit Railway (MTR) Corporation co-develop land around stations with private developers in order to cover its capital and operational costs. This approach guides the city's urban fabric through high-density development along metro corridors as land market's accessibility attracts people closer to the transit with 41% (in 2002) of Hong Kong's population residing within the catchment area (500 m) of a metro station (Tang et al., 2004, 8). MTR turned a net loss in 1980s into profit worth USD 2 billion in 2015 (Cervero and Murakami, 2008, p. 13; Mass Transit Railway, 2016, p. 33; Sharma and Newman, 2017a) using joint development.

Japan has historically used joint development in order to amalgamate irregularly formed properties that result in smaller but fully serviced urban neighbourhoods and sale of 'extra' land to fund railways. The government, as in-kind support, enables land consolidation and acquisition. This approach is popularly known as land adjustment. Land readjustment helps in efficiently assembling the right of way for a new rail line and land parcels for development. The approach is different to Hong Kong as they go beyond individual buildings. Economic downturn in the last few decades in Japan resulted in additional strategies for value capture such as strategic infill urban development around train stations (Metrolinx, 2013).

Cape Town offers a case to illustrate joint development using a PPP. A sum of USD 1.0 billion was raised through the sale of Victoria and Albert Waterfront property by Transnet (the parastatal transportation agency) in 2006 were used to recapitalize Transnet and support its investment in core transportation infrastructure (Peterson and Kaganova, 2010).

The Entrepreneur Rail Model (Newman et al., 2017a, b) emphasizes utilizing private sector resources and skills to co-develop urban rail and adjacent land. This model's concept begins by assessing the amount of land that can be developed and used as the primary fund source, followed by planning the development and finally estimating a transit patronage to suit the development. The government asks for bids to build, own and operate new transit lines based on fare box and land development opportunities created by the consortia. This ensures that the urban rail is constructed along the right-of-way that promises high ridership and more importantly an on-going way of paying for their infrastructure through land development. This model is happening in Florida (Newman et al., 2017a, b).

3.3. Land value capture and economic equality

Tax on land value is a progressive tax for several reasons. George (1879) argued that the economic rental generated when the location value of land is improved (non-produced inputs) through public works is the most rational source of public revenue (Ingram and Hong, 2011). It helps counter economic inequality (Plummer, 2010) as it charges the beneficiaries of the project and is applied in proportion to land values and land ownership (which is unequally distributed). It also addresses public concern surrounding imbalanced windfalls—factual or perceived—for owners of specific land units whose values increase following public investment in infrastructure. This tax can not only help the existing urban rail systems become financially viable and expand their network more rapidly but can also enable other cities' self-reliance to implement urban rail.

The financial viability of urban rail allows planners and project managers to implement and package urban rail projects in a manner that promotes amenity and affordable housing by providing incentives to developers to consider elements that address social equity concerns (some percentage of housing reserved for every income class), local community spaces, work centres, shopping areas and community services, where all these would ideally be at walking distance from the mass transit (Chava and Newman, 2016; Matan and Newman, 2016; Pendall et al., 2012).[2]

4. Case study - Mumbai Metro

Mumbai is a mega city and the financial capital of India. It is the centre of commercial, cultural and trade activities. Mumbai developed as a monocentric city initially (19th and early 20th century) with port, industry, government, banking and insurance, stock exchange and wholesale trade being concentrated in its southern neighbourhoods. In the latter half of the 20th century Mumbai grew linearly as a polycentric city with a more diverse economy, attracting a sizeable immigrant population, effecting a four-fold population increase i.e. around 3 million in 1951 to around 12 million in 2011 (BMC, 2015). The linear development occurred due to the geographic boundaries of Mumbai and was enabled by the north-south connectivity provided by the suburban rail network. These factors enabled Mumbai to develop as a dense city with high demand for its urban rail system.

The number of public transport users in Mumbai amounts to over 11 million accounting for 75% of total daily trips (BMC, 2016). This high percentage is attributable mostly to the suburban railway (43)% as it is the fastest and most reliable mode to travel in the highly congested corridor than bus or car. This mode-share of public transport remained constant through two decades before shifting slightly in recent years with public transport declining nominally and private modes rising (BMC, 2016). Both private vehicle ownership and road capacity have increased in the last decade but further growth is impossible due to spatial constraints. Expansion of the rail system has been demanded due to heavy overloading, lack of east-west rail connectivity and delay in implementing further rail options (BMC, 2015, 2016). Thus Mumbai is planning to implement a Mumbai Metro (Mumbai Metropolitan Region Development Authority, 2013). The government has estimated that 43% (USD 11 billion) of the total investment in Mumbai's transport sector should be allocated towards investment in Mumbai Metro (BMC, 2016).

[2] In India, government housing authorities are legislatively bound to include housing for every income group in housing schemes. In some states, like Madhya Pradesh, private developments must also include a percentage of housing for economically weaker sections.

4.1. Mumbai Metro

Mumbai Metro was conceptualized on the Build, Own, Operate and Transfer model (a PPP model) with a 35-year concession period (5 years' construction, 30 years' operation). Commercial operations of Line 1 of the Mumbai Metro (about 11 km) were successfully commenced on June 8, 2014. A special purpose vehicle (SPV) was constituted to implement the Mumbai Metro Line 1 with the selected concessionaire and government agency entitled to 74% and 26% equity share capital respectively (Mumbai Metro, 2013). The SPV serves to design, finance, build, operate, maintain and transfer the system to the state government at the end of the concession period.

A key impact of Mumbai Metro is that the reduction in travel time for its 11-km corridor is from 71 min to 21 min. It provides an essential link between the suburban eastern rail line and the suburban western rail line and areas unserved by the suburban rail system. It is integrated to the suburban rail system through a foot-bridge thus making it an integrated system. Additionally, the rail line's adjacent area has emerged as a business district over the past two decades and the high population density of Mumbai can result in high ridership (Rangwala et al., 2014). These factors were all considered to provide the Mumbai Metro with a significant advantage that should provide sufficient patronage to pay for the system. However, although the daily ridership of 0.3 million on 11 km (11 stations) is high on any global comparison, it is not reaching the anticipated levels of over 0.5 million in 2016 (Mumbai Metropolitan Region Development Authority, 2013; Sharma, 2017).

The ridership shortfall of 60% significantly impact the revenue of Mumbai Metro as the project is depends predominantly on farebox and partially on non-farebox (rent from shops at stations and advertisement). Mumbai Metro has consistently run into substantial financial loss since operations commenced. The 2015-16 losses amounted to USD 44 million (Deloitte Haskins & Sells, 2016). Being a private system on at limited 35-year lease period it is essential for it to overcome the financial loss.

There seem to be three main causes for Mumbai Metro's financial loss. Firstly, construction costs blew out by around 83% following construction delay, which heavily impacted on the repayment of capital loans.[3] Secondly, the private operator raised capital at standard market interest rates (over 11%) rather than acquiring soft loans like other Indian government metro systems (e.g. Delhi Metro) which raised capital from international donors at a minimal (about 1%) interest rate under the sovereign guarantee of India (FFC, 2015). This rate of interest creates repayment of raised capital substantial and pushes an operator to optimize its revenue. The last factor is the dependence on farebox revenue which we discuss in the next section and is the more fundamental factor.

4.2. Mumbai Metro's financial challenge

A detailed discussion on Mumbai Metro's fare structure merits an introduction to the legislative framework governing fare fixation of urban rail projects in India: Railways being a subject of federal jurisdiction in India, Indian urban rail projects are implemented under the federal legislation Metro Railway Act of 2002. The Act allows the operator to fix the initial fare independently, while fare revision is decided upon by a Fare Fixation Committee (FFC) constituted by the federal government.

The financial health of operational Mumbai Metro Line 1 did not reflect the vision of the project's conception, that of high ridership resulting in high farebox revenue enabling a commercially viable PPP project. In order to overcome financial losses the operator demanded to increase the fare and a FFC was set-up to fix the fare in 2015. The FFC report highlights that the Mumbai Metro project had raised capital at market interest rates and relied on farebox revenue to sustain the system commercially.[4]

The FFC recommended a higher fare for Mumbai Metro which could render it one of the most expensive commuter urban rail systems in India. The proposed fare stands at INR 110 (USD 1.7) for 11 km at INR 10 per station, while the existing fare is (sold as discounted fare) INR 40 (USD 0.6). While Mumbai Metro's revised fare is comparable to that of urban rail systems in developed world cities including Milan, Tokyo and Sydney, it significantly exceeds that of other Indian metro systems - Jaipur Metro (INR 20 for comparable distance), Delhi Metro (INR 18 for comparable distance), entirely privately owned Rapid Metro Gurgaon (INR 20 for 5 km). The FFC notes that the steep fare hike may not even suffice for the operator to recover their cost for the next few years. This reflects the substantial lacunae in the project's planning and risk analysis. A section of the FFC report notes that the private operator is not sharing risks on delay in the project which may contradict the fundamental principle of PPP projects. Rather, the private operator seemingly seeks to pass such costs (risk) on to the people of Mumbai.

The significant fare hike can have social and political impacts for Mumbai as it is an emerging city with the majority of population residing in slums at significantly low income levels. It is apparent that for many Mumbai Metro users cost is not an overriding factor compared to comfort, travel time saving, safety and convenience. However, cost overrides all factors for members of economically weaker sections of society whose transport costs command a significant share of living expenses. Cropper and Bhattacharya (2012) note that Mumbai's economically weaker section spend the highest percent of their income on public transport (16%) among all economic classes. This was noted when the public transport was highly subsidized (in year 2012) by the government.

Despite the burdensome cost (higher fare than Milan's subway), Mumbai commuters might resort to using Mumbai Metro to save 50 min on a one-way trip as no other travel option exists.

The concerns discussed in this section can significantly hinder private investment in future PPP urban rail projects in India and emerging cities. Over-reliance on farebox revenue towards sustaining a privately-funded metro project poses a critical issue for emerging countries seeking substantial private investment in the urban rail sector.

The Mumbai Metro case demonstrates how governments may fail to balance urban rail fare affordability, travel time and private investment in emerging cities. Such a scenario demands that the government explore non-farebox revenue sources, specifically LVC that—as discussed in the literature review—are generally economically progressive.

The subsequent sections investigate the application of LVC to Mumbai Metro. The study involved using HPM to calculate the impact of Mumbai Metro's commencement on property values, followed by exploring the LVC options suitable to Mumbai.

5. Hedonic price model for Mumbai Metro

The study considered panel data HPM to evaluate the impact of commencement of Mumbai Metro's Line 1 (11 km line operation since June 2014). Thus, panel data HPM consisting of the years 2014 (before rail) and 2015 (after rail) were investigated. The dependent and independent variables used for panel data HPM are discussed in the two succeeding sections.

5.1. Dependent variable

This study uses the average sale price of residential apartment projects (hereafter referred to as property) in Mumbai as a dependent variable for the panel data HPM. Property data were collected from a real

[3] The private operator blames the government approval and the private operator has been criticized by a few civil society organizations for artificial escalation of project costs (Kulkarni and Shaikh, 2014).

[4] The FFC notes that Mumbai Metro should explore options to increase non-fare revenue but are limited with no mention to land value capture, this may be due to their scope of work.

Table 1
Descriptive statistics.

Sl. No.	Variables	Mean	Std. Deviation
1.	Property price	22,016.2	13,401.7
2.	Property price 2015 (dummy variable)	0.5	0.5
3.	Distance from local activity centre	0.5	0.30
4.	Distance from airport	9.3	4.6
5.	Distance from central business district	11.1	7.3
6.	Distance from suburban railway station	1.4	1.0
7.	Distance from park	0.5	0.3
8.	Distance from inter-city railway station	4.3	3.1
9.	Distance from coast line	2.7	1.6
10.	Distance from industrial area	2.1	1.3

estate company for March 2014 and March 2015. The data set comprised 333 property samples (about 66,000 apartments)[5] for each year.

5.2. Independent variables

Explanatory variables influencing property price were considered based on neighbourhood variables, accessibility variables and city-specific variables. Additionally, property price and metro rail specific time dummy variables were included. A property price dummy variable was included for 2015 prices to estimate the conventional annual increase in property prices. The following Mumbai Metro rail corridor specific dummy variables were included for year 2014 and 2015 for the panel data HPM. These dummy variables are in addition to the variables listed in Table 1 to investigate the impact of the commencement of Mumbai Metro in its catchment:

1. Properties located within 0 km–0.5 km from metro station: includes 4% samples of total sample
2. Properties located within 0.5 km–1 km from metro station: includes 5% samples of total sample
3. Properties located within 1 km–2 km from metro station: includes 7% samples of total sample

QGIS was used to map the properties (dependent variable) and analyze their characteristics in relation to other land value influencing variables (independent variables) and to prepare the database that was used for HPM (Fig. 1). Table 1 lists the variables used for the panel data HPM with their descriptive statistics.[6]

5.3. Results from panel data HPM

Four functional forms (linear, log-linear, linear-log and log-log) were tested for the panel data HPM. Investigating the different functional forms of HPM was necessary for identifying the form best suited for the study. Statistical software (SPSS 22) was used for estimating the HPM.

Out of the four functional forms, only the log-linear functional form was statistically significant for the desired explanatory variables and not random up to 99.99%. According to the analysis presented in Table 2, the log-linear functional form of the panel data HPM explains 58.4% of the variation in the dependent variable, demonstrating that the model is statistically significant. The variance inflation factor (VIF) test was also conducted, to avoid estimation errors caused by a multicollinearity issue. The test showed that all explanatory variables' VIF values were lower than 3, ruling out serious collinearity concerns in the model.

Table 3 displays the panel data HPM results for the impact of statistically significant explanatory variables on Mumbai's property price. The

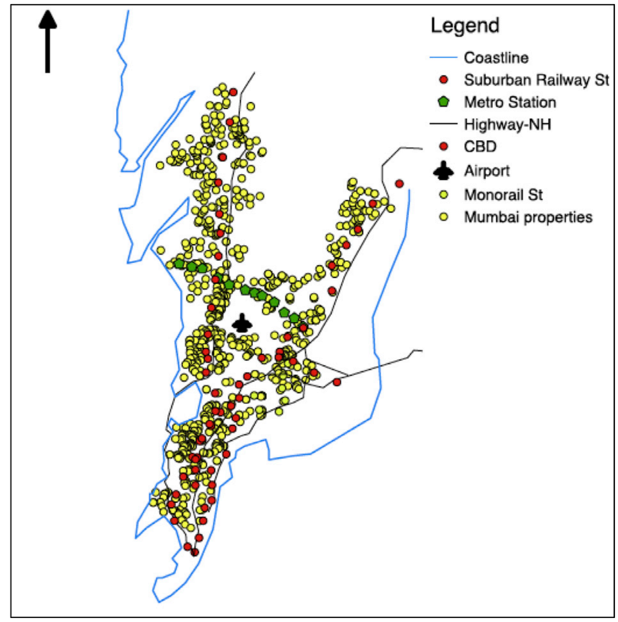

Fig. 1. Mumbai Metro.

Table 2
Model summary and ANOVA[7] for statistically significant variables.

Model	Model summary			ANOVA	
	Function	Adjusted R^2	Std. error of the estimate	F	Significance
Panel Data HPM	Log-Linear	0.584	0.315	94.499	0.000

statistical significance of the property price dummy variable for 2015 shows that the model recognizes the panel data for both 2014 and 2015, which is essential for panel data HPM. In the Mumbai Metro catchment specific time dummy variables only '1 km–2 km dummy variable' was statistically significant in the calibrated model.[8]

The calibrated panel data HPM shows that the commencement of Mumbai Metro resulted in a windfall gain of 14% in the properties located within 1 km–2 km from metro stations. This property value uplift seems to align with the Knight Frank (2015) report which notes the highest value uplift happened in the micro-markets adjacent to the Mumbai Metro as compared to all real estate micro-markets in Mumbai. This significant increase can be attributed to the travel time saving and new network linkages as discussed in detail in the 'Mumbai Metro' section of this paper. Commuters can get easy access to reach the 1–2 km catchment area through walking[9] and paratransit modes like auto rickshaw/taxi/cycle rickshaw which help explain the 14% increase out to the 1–2 km catchment.

The calibrated panel data HPM results also shows a conventional annual increase of about 5% in the studied properties from 2014 to 2015. This is a direct reflection from the real estate data. The model shows that with each km decrease in distance from the activity centre increases property prices by 32%. This is attributable to the diversified economy of Mumbai, emergence of activity centres and their local economic benefits.

The HPM model shows that a km decrease in distance from suburban railway stations decreases property prices by 3.9%. There are two possible reasons for this, firstly, residents of an emerging city are

[5] A property sample used in the study consists of around 200 apartments of varying size and type, which suggests that individual samples hold a substantial quantum for analysis.

[6] The *ceteris paribus* (all else being equal) assumption is not being violated as all distance based independent variables values are the same for both year 2014 and 2015.

[7] Analysis of variance.

[8] This may be due to the lower sample size at 0 km - 0.5 km and 0.5 km - 1 km and due to the slums and industrial area around the stations.

[9] Average walking trip distance of Mumbai commuters is about 1 km (Rastogi and Krishna, 2003).

Table 3
OLS log-linear HPM of property price in Mumbai (2014–2015).

Sl. no.	Explanatory variables	Coefficients	Std. error	Significance	% increase in mean property price with a unit increase in explanatory variables
1	(Constant)	10.859	0.06	0	–
2	Property price 2015 (dummy variable)	0.049	0.025	0.05	4.9%
3	Price change in properties at 1 km–2 km from metro stations (dummy variable)	0.142	0.072	0.04	14.2%
4	Distance from activity centre	−0.318	0.041	0.00	−31.8%
5	Distance from airport	−0.029	0.003	0.00	−2.9%
6	Distance from central business district	−0.028	0.003	0.00	−2.8%
7	Distance from suburban railway station	0.039	0.014	0.00	3.9%
8	Distance from park	−0.09	0.04	0.02	−9.0%
9	Distance from inter-city railway station	−0.027	0.005	0.00	−2.7%
10	Distance from coast line	−0.11	0.01	0.00	−11.0%
11	Distance from industrial area	0.059	0.012	0.00	5.9%

deterred from residing adjacent to the rail station as it attracts informal commercial setups, hawking activities, traffic congestion, pollution and presence of access/egress modes or paratransit modes like auto rickshaw creating highly crowded conditions in the immediate surroundings of the stations. Secondly, the value of properties located equidistant from station on the west side and the east side vary significantly due to the local planning factors[10].

The HPM model predicts that a km decrease in distance from the coast increases property prices by 11%. This was predictable on the global phenomenon of residents willing to pay higher for residing closer to the coast. Whilst, a km decrease in distance from industrial areas decreases property prices by 6%. This was expected due to the polluting characteristics of industrial areas.

5.4. Willingness to pay for Mumbai Metro

Willingness to Pay (WTP) in monetary terms for the Mumbai Metro is calculated by multiplying the windfall gain from HPM with the average property price.

The WTP for properties located within 1 km–2 km from metro stations is INR 33,651 (USD 524) per square meter due to the impact of the commencement of the Mumbai Metro Line 1. This windfall gain is substantial and results in an aggregate WTP of USD 161 million[11] when applied to the number of properties (22 studied samples) falling in the catchment area of 1 km–2 km results. The total cost of Line 1 of the Mumbai Metro was about USD 670 million. Thus the value creation is highly significant in relation to the cost of building the metro and warrants an evaluation as to how LVC could have been applied.

6. Discussion on land value capture for Mumbai

Mumbai is one of the few Indian cities with existing legislative provisions for LVC. Maharashtra Regional and Town Planning Act, 1966 entitles Brihanmumbai (Mumbai) Municipal Corporation (BMC) to levy development charges to sell additional floor area/space and on the change of land use. Mumbai Municipal Corporation Act, 1888 entitles BMC to collect property tax upon all land and buildings within the city and levy a betterment charge on the windfall gain due to any public investment (improvement project).

The Mumbai Metropolitan Region Development Authority (MMRDA) is the government authority involved in implementing the Mumbai Metro and is its part owner. MMRDA has approached the court on the fare hike issue. Therefore, we discuss MMRDA's options to generate revenue through the LVC under their existing statutory powers.

The MMRDA Act 1974, entitles them to levy ‘betterment charges’ on the windfall gains to private land owners due to MMRDA's development project. This levy can't be more than 50% of the windfall gain. The MMRDA is required to notify every land owner about the levy and allow three months to raise any concerns. In case an issue prevails, the individual can approach the court or arbitration panel. As per the MMRDA Act, the betterment charges apply only to land value for properties, not to the value of apartments or buildings. Based on our discussions with the MMRDA, they have considered implementing betterment charges for Mumbai Metro but have not been able to implement it. This is due to the lack of empirical analysis available on the windfall increase in land values and its catchment area due to Mumbai Metro commencement. This study fills this knowledge gap to show the impact of Mumbai Metro Line 1 on residential values.[12]

The estimated 14% windfall gain applied on land value within the 1 km–2 km residential catchment area[13] from Mumbai Metro results in an estimated revenue of USD 179 million,[14] based on the government land rate of about INR 60,000 (USD 934) square meter (at a very conservative rate) .[15] This substantial revenue can sustain Mumbai Metro losses for the next four years (based on their existing USD 44 million loss in 2016) without any substantial hike fares. This study could help government committee's and policy makers in emerging cities to show how LVC can to implemented to finance urban rail.

7. Conclusion

This study has shown significant land value uplift potential due to the commencement of urban rail in Mumbai. The study illustrates that the impact of metro rail is beyond the traditional 500 m. The analysis has shown that Mumbai could have used existing legislation to capture this uplift to make the PPP metro project financially viable along with keeping fares competitive. Although it is too late for the Line 1 phase of the Mumbai Metro, other phases could tap the LVC mechanism for funding.

This paper illustrates how LVC for urban rail can be used to avoid a high dependence on farebox revenue with the consequent struggles over fare fixation. Mumbai is one city where the fare box may have been

[10] The suburban railway divides Mumbai longitudinally and western part of the city has significantly higher land price as compared to the eastern part.

[11] Each apartment measured 70 sq m and each apartment project included 200 apartments.

[12] The MMRDA and the state government of Maharashtra had set up a committee to propose non-fare revenue, specifically LVC, options for financing urban rail projects. The committee discussed on key two points, first on how to evaluate the impact of urban rail and second how to implement land value tools.

[13] 25% of the total area is under residential land use as per Draft Development Plan – 2034, Greater Mumbai, 2016.

[14] This calculation is based on the multiplication of residential area (25% of 22 million sq m), per sq m price (USD 934) and 25% betterment charge levy on windfall gain worth 14%.

[15] Mumbai has the highest real estate capital values as compared to any other Indian city (Knight Frank, 2015). Thus application of land value capture tool can return substantial funds for urban rail.

possible to cover all costs but even here it does not. Application of LVC is possibly necessary to enhance fare affordability and mitigate the financial strain imposed by public transport on the community in any city. This analysis and the detailed literature review of this paper should benefit policymakers to make informed decisions on urban rail projects.

The use of LVC will require governance to include financial mechanisms in future PPP arrangements that can enable the value increases around stations to be captured in a reasonable and transparent way. Detailed studies of land use along new lines can provide the basis of projected financial uptake based on the data from this first line.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.tranpol.2018.02.002.

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Land Value Capture Tools: Integrating Transit and Land Use through Finance to Enable Economic Value Creation

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Abstract

This paper shows how private finance and expertise can be both the source of urban rail capital and the integrative governance force required for co-operative partnership-based TOD's. We call this TFUL - transit, finance and urban land development. A range of land value capture (LVC) tools from developed and emerging cities are outlined that are used to provide TFUL outcomes for creating economic value in TOD's. The analysis shows the significance of integrating political capital, financial capital and social capital, and how private sector involvement from the concept stage can enable much greater economic value creation and hence LVC opportunities.

Key words: Urban rail; project finance; land value capture; public private partnership.

1. Introduction

The growth in demand for new urban rail lines in the 21st century has been dramatic in all parts of the globe, especially in China and India but also in most developed cities. The patronage of existing urban rail systems has seen a significant rise in this period suggesting there is now a major market for urban rail. Whilst traditionally these projects have been predominantly government-funded across the globe they are now struggling to meet the required finances to cater for transit demand. The conventional loan and subsidy based public investment has been unable to meet the demand. Urban rail agencies have attempted to recover operational and capital costs through fare box revenue whilst at the same time undertaking network expansion, operation and maintenance. But agencies have significantly struggled to even recover operating cost as fare box revenue is inherently limited due to equity demands (Jillella et al., 2016; Newman & Kenworthy, 2015; Newman, Kenworthy & Glazebrook, 2013; Sharma & Newman, 2017).

The fiscal challenge for urban rail has prompted cities to find alternative funding and seek different governance frameworks to implement rail projects. The political and economic driver in creating new urban rail is not just dealing with transport problems but in providing for the demand in the associated transit-oriented urban fabric: Transit Oriented Developments (TOD's). Cities are recognizing the potential of urban rail in creating economic value through its multiple non-transport benefits that form the basis for the creation of TOD's: its impact on land values and thus its potential for influencing more intensive land development and hence urban regeneration with its associated agglomeration benefits (Banister & Thurstain-Goodwin, 2011; Glaeser, 2011; Capello, 2011; Newman, Davies-Slate & Jones, 2017; Newman & Kenworthy, 2015; Sharma & Newman, 2018a; Sharma, 2018).

The gains in land value due to urban rail are widely documented and can be managed through land value capture tools to help finance urban rail (see Anantsuksomsri & Tontisirin, 2015; Armstrong & Rodriguez, 2006; Cervero, 2003; Du & Mulley, 2007; Garrett, 2004; Laakso, 1992; McIntosh, Trubka & Newman, 2014; Medda & Modelewska, 2009; Mulley, 2014; Newman, Davies-Slate & Jones, 2017; Sharma & Newman, 2018a; Sharma & Newman, 2018b; Yankaya, 2004). The kind of focused land development, Transit Oriented Development, which is fostered by this process is a major economic benefit both in the agglomeration economies and the savings in alternative more scattered urban forms that it replaces (Cervero, Ferrell & Murphy, 2002; Noland et al., 2014; Trubka, Newman & Bilsborough, 2010). The land development is also an important parameter in operational efficiencies for urban rail systems as TOD's have significantly lower car dependence and enable two-ways flows of people along corridors minimizing peak loading issues (Noland et al., 2014; Cervero, 2004).

The project life cycle of urban rail systems with their associated land uses, are generally longer than any road based system and hence can attract private investment as there are long-term financial and economic benefits when the transit, land use and finance are integrated (Giuliano, 2004; Bowman & Ambrosini, 2000; Medda, 2012; Pojani & Stead, 2015; Sharma, Newman & Matan, 2015).

This three dimensional integrated development approach we have called TFUL - transit, finance, and urban land development. We suggest it can simultaneously meet the demand for urban rail and for focused, well-located urban redevelopments. The TFUL approach can trigger a space for various levels of private sector investment and involvement in urban rail projects, from entrepreneur models that are predominantly private investment through to traditional land value capture that is predominantly government-based (Newman, Davies-Slate & Jones, 2017; Mathur, 2014; Zhao, Das & Larson, 2012). This paper will expand on these tools to show how they can be tailored to meet the needs of different combinations of public and private investment.

This TFUL approach of integrated development is not new and was used in 19th and early 20th century rail development in Japan, Australia, Canada and America, mostly to develop green fields. As the 21st century cities are now redeveloping more than spreading out into greenfields, the TFUL approach can now be reinvented to achieve urban redevelopment and regeneration goals. As cities are a mix of urban fabrics–walking, transit, automobile–the TFUL can be used in each kind of fabric area: rejuvenating central city walking fabric, rebuilding old station hubs along transit fabric and most importantly enabling automobile fabric with its car dependent, single use housing estates and shopping centers to create new multiple use TOD's in the suburbs (see The Theory of Urban Fabrics Chapter in Newman & Kenworthy, 2015; Newman, Kosonen & Kenworthy, 2016; Newman, Davies-Slate & Jones, 2017).

Land value capture (LVC) tools enable the TFUL approach to be implemented. Other than being a public financing option for urban rail where public funding is limited, LVC is being used by these governments to help create greater urban economic value by channeling private funds directly into the dense urban centers that are desired in their urban plans. Thus LVC Tools can be seen as an economically progressive revenue for cities with the potential to drive urban land development into economic gains. This ensures it is an essential tool to be applied to cities. Cities around the world are using this TFUL approach; for example in India and Australia over the last year, the federal governments have actively advised cities to implement LVC to finance urban rail projects (Commonwealth of Australia, 2016; Ministry of Urban Development, 2017; Newman, Davies-Slate & Jones, 2017).

Development of LVC tools is an evolving process and various tools have been classified based on their different timing, payment schedule, incidence (Chapman, 2017), scale and actors involved (Connolly & Wall, 2016; Medda, 2012; Peterson, 2009; Smolka, 2013; Walters, 2012; Zhao et al., 2012).

In this paper we divide all major land value tools into four broad categories to emphasize their different character and different functions depending on the extent to which private participation and options are possible to involve in the planning process. We investigate the dynamics of land value capture tools by analyzing cases from both developed and emerging cities to investigate the most suitable tools for TFUL development for wider value creation and economic gains. We further discuss the importance of involving the private sector at various stages of the project in creating value and wider economic gains.

In the next section we discuss why there is a need for private investment in urban rail after decades of managing without it.

2. Limitations of conventional funding of urban rail

Urban rail systems have historically faced financial deficits when they are highly dependent on fare box revenue and conventional financial support from government (Sharma & Newman, 2017; Ubbels et al., 2001). The conventional financial support for urban rail is based mostly on subsidies and loans; both of these are becoming increasingly limited (Graham & Van Dender, 2011; Ingram & Hong, 2012; Medda & Modelewska, 2009; Salon & Shewmake, 2011; Zhao et al., 2012).

2.1. Subsidies

Proost et al. (1999, as cited in Ubbels et al., 2001) argue that subsidies work against economic efficiency and have been excessive. Subsidies impose either higher taxes, reduced spending on other public services, or both (Smith & Gihring, 2006). Transit subsidies have also been widely criticized for worsening the productivity and efficiency of transit agencies (Cropper & Bhattacharya, 2012; Pucher & Lefèvre, 1996; Pucher, Markstedt & Hirschman, 1983).

Subsidies for transit systems are based on the notion of transit being a ‘service’ and fare revenues cant financially sustain the system anywhere in the world as equity considerations prevent fares being large enough for a completely user pays system. Thus, transit systems have not been extended as they cost too much for governments and hence minimal bus services have been the standard in many cities. But this has not prevented highly subsidized road systems from being built into urban areas that have resulted in car-based urban sprawl as no alternative urban fabric is possible without its base in alternative transport systems (see Brueckner, 2005; Buehler & Pucher, 2011; Parry & Small, 2009; Newman, Kosonen &

Kenworthy, 2016; Tscharaktschiew & Hirte 2012). Therefore, cities are facing hard choices: first, increase subsidies by building more rail transit into their cities and hence creating the urban forms that are in demand, or second, save operating subsidies by building more urban road systems with their poorly performing urban fabric. This paper points to a better way where subsidies are reduced and urban rail is built by integrating it with urban land development that can pay for capital and on-going operational expenses.

2.2. Loans

Governments have to borrow money for their spending needs and their financial accreditation determines their ability to raise funds. The global economic recession of 2008, significantly restricted governments, urban enterprises and financial institutions in their lending activities (Medda, 2012). The need for investment in infrastructure however has not diminished, for instance: the USA faces an infrastructure deficit worth USD 3.6 trillion (American Society of Civil Engineers, 2013); India needs about USD 20 billion for urban rail (Planning Commission of India, 2011); China requires about USD 44 billion for constructing new urban rail lines (KPMG, 2016; Schulz & Smith, 2015); and, Australia is planning to expand urban rail in all their major cities.

The current market interest rate for loans in countries against a capital-intensive urban rail project with a high-risk profile (a project based on proposed high ridership) can push the private urban rail developers into a series of debt and fiscal deficit problems (Flyvberg, 2007). Most countries are therefore seeking significant private investments for implementing such urban rail projects as the political pressures to solve transport problems continue to grow as does the awareness that urban road capacity increases are never going to solve traffic congestion (Newman & Kenworthy, 2015).

Governments are now exploring the option of concessional loans of 1% or below 1% interest rates that may incentivize urban rail development and private participation. But in both these loan scenarios, if the project is highly dependent on fare box revenue the risk of servicing their capital debt will still exist which will result in growing subsidies. There is evidence to show that the application of land value capture tools can be used to service the debt for both scenarios (McIntosh, Trubka & Newman, 2014; Sharma & Newman, 2018a; Sharma & Newman, 2018b).

Thus, the vicious cycle of conventional revenue and costs – loans, fare box-subsidies – seems to be economically regressive for urban rail. This may be avoided through application of LVC tools for TFUL development to unlock wider urban economic gains – as TFUL development can cover various essential urban components such as transit provision and catering to urban growth demand in an integrated and sustainable way (see McIntosh, Trubka & Newman, 2014; Newman & Kenworthy, 2015; Suzuki, Cervero & Iuchi, 2013; Wang & Lo, 2016).

3. Why private investment in TFUL creates economic value.

Transport infrastructure is a fundamental part of the urban economic value partnership as it creates the urban fabric around which the economy is created (Glaeser & Kahn, 2004; Newman, Kosonen & Kenworthy, 2016). The three urban fabrics each have their roles in urban economic value creation:

1. Walking city urban fabric where major government and financial services are provided as well as many tourist and recreational services;
2. Transit city urban fabric (TOD's) around which increasingly the knowledge economy services of education and health and many business services are created; and
3. Automobile city urban fabric around which manufacturing and consumer services and space-hungry freight services are created and where increasing need is now seen for transit fabric.

The overlap of these city fabrics and the trend towards knowledge economy jobs in cities means that there is an increasing demand to create TOD's and this means TFUL projects, where car use is minimized allowing space efficient dense urbanism to be created (Newman, Matan & Mcintosh, 2015). However, each of these urban fabrics require significant private investment.

There are several ways of understanding how private sector investment creates economic value in cities. Wealth creation is essentially a process that is based on a combination of the hard infrastructure that services buildings and their needs as well as the soft infrastructure that enables opportunities for innovation and job creation (Newman, Davies-Slate & Jones, 2017; Glaeser, 2011; Porter, 1998). The private sector do the vast majority of this city building within a framework of governance providing equity and sustainability, and a wider framework of community values. The three sectors of private, government and community, need to work in partnership to enable urban economic value creation (Newman & Kenworthy, 1999, 2015). Such economic value in cities is the major element of economic growth around the world. See Figure 1.

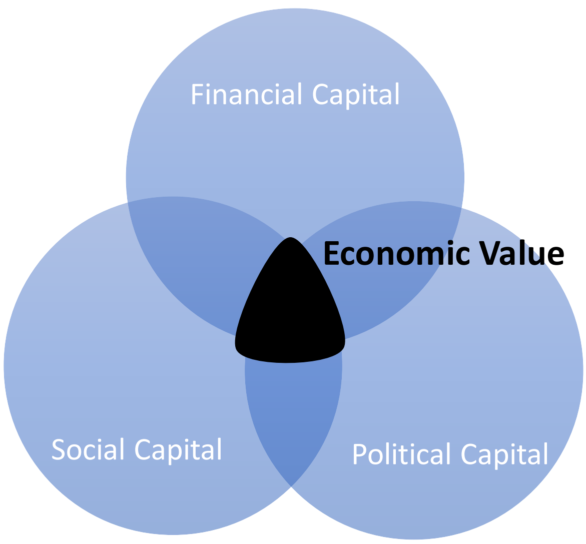

Figure 1: Economic value creation through integration of financial, social and political capital

Economic value is created in a city through integrating different forms of capital that are all involved in city building. There is financial capital that is necessary to build anything in a city; this depends on a range of technical assessments of how well the infrastructure will be used and what kind of demand there is for the urban development. This financial capital depends on risk assessment and demand evaluation which are also associated with social capital.

Social capital comes from communities that develop trust in an urban development because they see the demand and they recognize the risk if they don't have the new infrastructure and urban development. Social capital provides the ethical value and third party political validation necessary for the difficult process of urban regeneration.

The third kind of capital is about the system of government which provides the settings and processes that either encourage or discourage the infrastructure and urban development; it could be called political capital. The political capital is a combination of the transport and town planning regulations and the way it enables the links to the other kinds of capital.

When the three kinds of capital – financial, social and political – are integrated into a partnership then the best and highest value is created. This is what we are calling economic value and can be measured in terms of flows of activity and agglomeration benefits but it depends on the three other kinds of value being integrated.

Underlying the need for investment in TFUL is the need for risk management that can enable both rail investment and urban development investment. In both investment situations there is a need for the three sectors of private, government and community to be in partnership if the full value of a TFUL project is to be enabled.

Governments need to encourage an optimal land use mix through zoning, planning and operation of transit that integrates with the rest of the system and with local interchanges, planning for long-term project life cycle risks, and all the land assembly and statutory planning requirements of local amenity. Community is needed to ensure the TFUL provides the extra services and opportunities as well as the specific demands of local amenity as part of the bigger goals for access and new services in the TOD. Private sector involvement can address these elements by bringing innovation, technology, design stage efficiency, market driven land development skills, improved operational efficiency and long-term value for money through risk sharing. These latter skills are not readily available within government.

Figure 2 is a qualitative explanation of sharing risk for private participation in an urban rail project life cycle. The risk appetite of the private sector is higher when it is involved from the concept/ development (design) stage of the project and it decreases when the participation happens during the following stages of the life cycle. This is due to the fact that the private sector would be able to decide on technology, infrastructure, cost optimization, revenue streams and others for the project life cycle during the concept and planning stage. Private participation in urban rail projects has shown efficient exploitation of non-transport revenues such as advertisement, station area development and kiosks/ shops at stations along with bringing efficiency in construction and operations when involved from the design stage. Bigger projects which depend on even more land development for private investment opportunities, require even more obvious ways of incorporating private bids on how best to do it.

Involvement of the private sector at design stages can also enhance budget predictability for government. Private sector taking the life cycle risk can secure economies of scale (GIZ, 2013; Sakamoto, Belka & Metschies, 2010; Sharma, Newman & Matan, 2015; The World Bank, 2016). After the design stage, optimization of cost and revenue streams becomes limited in the construction stage and even further limits opportunies in the operational stage of urban rail if private sector involvement is delayed.

In sectors like mining and energy private participation has been engaged from the concept stage which has proven to show positive results (Cheah & Garvin, 2009). Transport has been mixed in its involvement with the private sector. Airports and seaports have become primarily private investment-based incorporating much closer integration with land development as a result. In the Modernist period of planning after the 1940's both road and rail have been primarily public within a strongly silo'ed regime of governance. Urban road provision remains heavily government based with some toll roads but few links to urban land development. Urban rail has been seen as a completely public responsibility in most developed and emerging cities with a few exceptions in Asia. However as shown below a range of mechanism are now developing to enable the same partnership approach to be applied for a TFUL development.

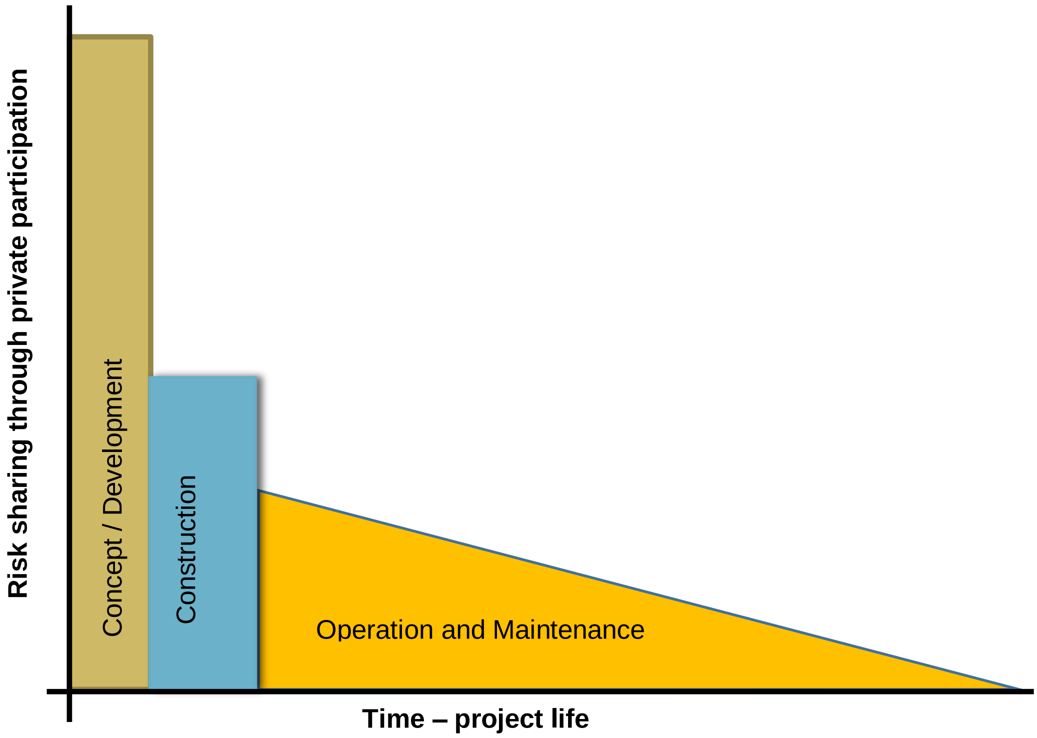

Figure 2: Urban rail project risks – sharing through private participation

Source: Authors

In order to optimize private participation LVC tools need to be aligned with two core needs:

1. How much cities are looking for help with financing TFUL development to avoid conventional sources of finance, and
2. The extent to which cities are looking for economic outcomes in the associated TODs.

In the next section we discuss land value capture tools' potential for TFUL development with private participation by discussing how land value increases happen.

4. How land value increases due to urban rail

The impact of urban rail on land value is well documented (see Anantsuksomsri & Tontisirin, 2015; Armstrong & Rodriguez, 2006; Cervero, 2003; Du & Mulley, 2007; Garrett, 2004; Laakso, 1992; Medda & Modelewska, 2009; Mulley, 2014; Sharma & Newman, 2018a; Sharma & Newman, 2018b; Yankaya, 2004). There is a large variation in how much land value increases; this is expected as the factors that cause land value to increase include: the extent to which a station precinct is now connected to an improved transport system that can save time; how much local amenity is improved around the station; and probably most of all whether other economic opportunities are created through the TOD with its access to the train line.

Land value gain is generally estimated through quantitative price modelling (Freeman, 1979; Rosen, 1974). Hedonic price models have revealed the land value increase with respect to distance from stations at about 16% of the land value up to 1 km from the urban rail station in Izmir, Turkey (Yankaya, 2004); 11% increase in land values from 500 m to 750 m in Helsinki, Finland (Laakso, 1992); 17% increase in land values within 800 m in San Diego, USA (Cervero, 2003); 10% increase in land values within 800 m in Massachusetts, USA

(Armstrong & Rodriguez, 2006); 7% increase in land values within 1 km in Warsaw, Poland (Medda & Modelewska, 2009).

In the case of Perth, the Southern Railway increased land values in the 500m around stations by 42% over 5 years after the announcement of the rail service (McIntosh, Trubka & Newman (2014). In Bangalore the value around Metro stations increased by 25% in the area going out between 500m and 1km and more significantly a 'before' and 'after' from the commencement of the metro rail operations shows a price uplift of 4.5% across the whole city; this indicates a major agglomeration economic event resulting in substantial economic value increase of USD 306 million from the metro rail's accessibility (Sharma & Newman, 2018a).

The traditional approach to building urban rail based on top down supply of funding without much orientation to land development options will provide an increase in land value due to urban rail that benefits the landowners (both government institutions and private) without the owners making any direct investment in the rail. The increased desirability of that urban rail-accessible land, stimulates changes in land use, zoning and development intensification resulting in economic improvement which can be of significance across the city (Bowes & Ihlanfeldt, 2001; Cervero & Murakami, 2009; Chapman, 2017; Mathur & Smith, 2013; Medda, 2012; Pagliara & Papa, 2011; Salon, Wu & Shewmake, 2014; Smolka, 2013). However, the full value creation is mostly lost to the land owners who did very little to deserve such a windfall gain but happen to be in the right place to receive the gain. It is not hard to see why attempts are therefore made to try and capture some of that value to help pay for the rail infrastructure.

5. Land value capture tools

LVC tools have long been applied to recover the windfall of land value uplift to fund public infrastructure (Chapman, 2017; Gihring, 2009; Ingram & Hong, 2012; Smith & Gihring, 2006;

Zhao et al., 2012). The earliest implementation dates back to the days of the Roman Empire when the citizens to be benefited by the infrastructure where charged with the construction and maintenance of public roads and aqueducts, this practice was also followed by other civilizations the world over (Smolka, 2013). The literature on land value capture tools is large, some of the recent contributions on LVC tools includes Chapman, 2017; Connolly & Wall, 2016; Iacono et al., 2009; Levinson & Istrate 2011; Mathur & Smith 2012; Mathur, 2014; McIntosh et al., 2015; Suzuki et al., 2015; Vadali, 2014; Zhao, Das & Larson, 2012; Zhao et al., 2012.

As discussed in the sections above there is an important role for the private sector in enabling the best partnerships that create the most value in TFUL. If projects are fully planned and delivered by governments without involving private land development in investment partnerships then they will leak value and the opportunity to capture it will be minimal. It is not enough just to see value capture simply as a way of taxing windfall gain after it has happened. The full financial, social and political capital is not achieved in such projects.

The LVC tools are therefore set out under four groups that move from Fully Public through to Fully Private with two groups in between that are Partially Private or Partially Public. The four groups are shown in Figure 3 to illustrate the extent to which they create economic value.

5.1. Fully Public: Land Based Levies

Governments set up land based levies to immediately begin recouping value increases due to infrastructure construction. The tools include Business Levy, Developer Levy, Special Area Levy and Parking Levy.

a) Business Levy is used in various countries such as France (‘Le Versement Transport tax), Austria (Dienstgeberabgabe tax), the USA (employer/ employment tax) and the UK (Business Rate Supplement tax) to fund transit.

The Le Versement Transport tax is paid by public or private companies in France when the company has nine or more workers located within a 10,000 inhabitant urban transport zone to fund public transport services (Pascal, 2003, as cited in Milan, 2015).

In the United Kingdom the Business Rate Supplement (BRS) tax is used by local authorities to impose a levy on business taxpayers to help finance local projects that can promote economic development like urban rail. BRS is a temporary tax imposed for a period to cover full cost of the infrastructure. The development of Crossrail in the Greater London Area is financed partially by business rate supplement (BRS). The BRS is expected to fund GBP 4.1 billion of the GBP 14.8 billion project by 2038. The tax is proposed to be increased by 15% in revaluations to take place every five years. In the first financial year 2010-11, collection surpassed the projected amount (Roukouni & Medda, 2012; Medda & Cocconcelli, 2013).

b) Developer Levy is charged from land developers to fund public infrastructure gap created due to the new development.

In the US, the Impact Fee is charged from the land developer as a form of developer levy. The Impact Fee is a one-time charge levied on development projects during the issue of building permits to fund new public infrastructure and services associated with new development (Vadali, 2014).

In Latin American countries developers are either asked to mitigate any shortage in supply of public services caused by their private project (Colombia, Guatemala and

Argentina), referred to as an ‘in kind payment’, or are simply offered additional development rights against a ‘cash payment’ (in Colombia and Brazil) (Smolka, 2013).

c) The Special Area Levy is used by governments to charge all land owners in a specific area to fund local transport services. These are imposed by governments rather than being partnerships as explained in the Partially Public: Special Investment Districts LVC tools section below.

Two examples of Special Area Levies and rail projects are in Milan and the Gold Coast in Australia. In Milan, such a levy was imposed on properties located up to 500 meters from local transit stations. The levy was proportional to the windfall gains on the land value to help fund the construction of the subway system (Ridley & Fawkner, 1987). In Australia, a Transport Improvement Levy of AUD 111 per year for every rateable property (245,687) in the Gold Coast City was introduced to fund the Gold Coast Light Rail (SGS Economics and Planning, 2015). In both cases most of the funding was coming from other government sources and in the case of the Gold Coast with its very wide area the imposed levy did not help with TOD’s.

Betterment Contribution charges are a form of special area levy that has been widely documented in statutory documents in the UK, Latin America, India and Australia. The overall application of Betterment Contribution has however been poor except in a few Latin American countries. The Indian city, Nagpur, has not been able to implement Betterment Contribution charge since 1936 due to lack of an implementation strategy and framework (Nagpur Improvement Trust, 2013). Smolka (2013) notes that most successful cases of Betterment Contribution seem to rely on rather arbitrary technical shortcuts to keep it manageable.

d) The use of Parking Levies as a government charge on parking spaces in a designated area have been used to fund transit. The levy is based on the notion of discouraging the use of cars as well as providing an alternative transit mode. These parking levies can be just imposed but if done with the involvement of community and businesses then they enable more effective economic value to be created. The City of Perth, Australia uses the Perth Parking Levy to fund the local transit, pedestrian and cycling infrastructure system and has significant community and business support as it minimises car dependence. Perth is funding 'free' local transit through this levy (Parliament of Western Australia, 2014).

Land based levies are completely governmental tools through which specific public infrastructure services are funded without private participation. If the levies are imposed they will obviously have some effect on development being driven away; at the same time the infrastructure to be built through the levy makes the site more attractive for developers to invest in an area close to the infrastructure. The result will be less economic value in the TOD but it is still better than doing nothing and continuing with car dependence. This first set of LVC tools is thus seen by us as having the lowest economic value creation potential as it does not create the kind of partnerships needed for optimal value creation.

However, such levies are also probably the simplest set of tools to implement as it does not mean much change to transport and town planning agencies; the levy generates the funds for the rail and the governance remains un-integrated and does not need partnership development. For the TOD to be more integrated in planning and delivery the governance systems require another kind of process that can include private finance and expertise from the beginning rather than just putting a levy on them and it requires community and business partnerships. Fully public LVC tools that impose an LBL are not therefore really TFUL as described in this paper as the F is not providing the integration and need for partnerships.

5.2. Partially Private: Tax Increment Financing:

Tax increment financing (TIF) is a tool used to fund redevelopment projects (infrastructure and community projects) based on forward hypothecation of property tax due to prospective land value increase. It simply requires governments to set up a Treasury Fund that hypothecates funding from a specific area where government rail investment is improving the area resulting in land-based rates and taxes going up (McIntosh, Trubka & Newman, 2015).

US cities use TIF extensively for redevelopment and infrastructure provision in urban 'blight' areas. Blighted areas are usually characterized by dilapidated infrastructure, low income, unsanitary conditions, and a high rate of tax delinquency (Mathur & Smith, 2012). TIF has also been used to fund rail extensions and station area projects in several American cities such as Chicago and Portland. TIF is considered a 'self-financing' tool as local governments do not need to put up additional fees or increase existing tax rates. In terms of private sector involvement, TIF is less likely to drive away private investment as the normal taxes are used to collect the increased value and they are simply hypothecated in later years. The Land Based Levies begin immediately in order to pay back government loans but TIF waits until the developments are completed and value has seeped through the land-based taxes into Treasury. It is therefore likely to create more economic value as market forces are not impeded but are tapped in the same way they are in any other part of the city.

TIF has enabled cities to issue project-specific TIF bonds to raise capital costs of the project. A USD 2 billion subway extension project (to Hudson Yards) in New York City is being financed by raising funds through municipal TIF bond sales (Demause, 2015). The city of San Francisco uses a tax increment financing approach to fund transit and local development (Clark & Mountford, 2007; Schlickman et al., 2015).

TIF is a fully government-controlled LVC tool where no extra private investment is required directly into the infrastructure. It also does not need to involve partnerships with community and businesses to enable it to happen. However, TIF does eventually flow into the infrastructure pool controlled by Treasury and can be re-used for other projects. Because the infrastructure is targeted to enable urban regeneration it is better at value creation as it is attempting to invite more private investment into the precinct being targeted and thus there is an integrative force linking transit building to urban regeneration. TIF tools thus are targeting broader economic gains from specific areas though they are somewhat remote from the process of TOD building and could indeed be marginalized in the focus on building the rail system as has happened in many cities.

One other flaw in TIF is that revenue streams are not always stable and predictable due to fluctuations in real estate values. It is possible for governments to suspend or cancel TIF districts due to budget deficits or according to local and political circumstances like in the case of California and Chicago. TIF also requires significant institutional capacity to implement due to assessment, planning and compliance processes at local levels however this is a necessary part of any attempt to create urban economic value through TFUL.

5.3. Partially Public: Special Improvement District Levies:

Special Improvement District (SID) levies come historically from a local amenity based levy set up where an area needs improving and private interests initiate or are willing to contribute a levy to improve the amenity of an area. Businesses are encouraged to tax themselves for the good of the infrastructure or amenity that they create together. Local governments simply collect the funds and manage the procurement of the disbursement to enable the improvements. This can be for security, for heritage conservation or simply providing better spaces that attract people to stay and hence create value in the area (Matan & Newman, 2016). SID levies are now being extended into whole corridors to create urban rail and urban regeneration in TOD's.

SID levies are called various things in various parts of the world. In America, Special Assessment District (SAD) fees have begun to be used in Los Angeles and Seattle to fund new rail lines. The SAD is also known as BAD or Benefit Assessment Districts in Los Angeles and LID or Local Improvement District in Washington DC and even a BID or Business Improvement District as they have become known in Australia. To implement a SID, SAD, BAD, LID or BID fee, governments identify specific special districts which can benefit from the planned public infrastructure in terms of land value uplift. The identified area usually comes out of a partnership from the bottom up where businesses, local governments and communities recognize the need for a new urban rail line and a new set of TOD's that could be unlocked by this. Through negotiations a partnership is established where a SID levy is agreed that can enable the whole process of urban rail and urban regeneration to proceed (Mathur & Smith, 2012). This is different to the Land-Based Levies as they are worked out in partnership based on the redevelopment potential that is assessed to be unlocked by the private investment enabling the infrastructure. They are not imposed from a remote agency and hence they create good will about urban development among the private and community partners which can contribute significantly to value creation. SID can also include special area levies and parking levies as set out in the Fully Government LVC tool but only if they worked out in partnership with business and community to enable more significant economic value possibilities.

In the case of the South Lake Union Streetcar project in Seattle, a SID fee from 760 land parcels was estimated to provide 52 percent of the total project cost. The City of Seattle issued government bonds to raise capital and linked them with a SID fund. The city assessed a SID fee in 2004 and land owners of the SID area approved it in 2005, the street car project became operational in 2007. The assessed SID fee was based on estimated land value uplift for various land uses. The land owners were provided an option to pay a SID fee up front or in 18 years at a 4.4% interest rate. In this case the use of SID was considered as low-risk as it was applied in an established urban area with a strong real estate market (Mathur & Smith, 2012).

In San Francisco the process their SID began with the establishment of a local committee by the district's residents, business owners, tenants, schools and developers. The committee prepared a local development proposal including financial plan and sought approval from local government authorities. The district residents were charged with elevated property taxes to fund the infrastructure. The involvement of developers in the committee from early stages was notable as they were perceived as a catalyst for the investment (Clark & Mountford, 2007).

Business Improvement Districts (BID) are common in the US and Australian cities for small area improvements. A BID is a non-profit organization for a designated commercial area involving the local land owners and is used to enhance infrastructure and services of the commercial area to help improve local business. BID services are funded through an additional charge on land owners. There are about 72 BID's in New York City serving 84,000 business (City of New York, 2016). The potential to turn a BID into a larger SID with urban rail and TOD outcomes remains as a real option in many cities as the BID processes are well understood and trusted.

Most of the SID based tools are structured as public private partnerships involving community participation, sometimes called PPPC's. In this partnership property owners and businesses self-impose a fee, in partnership with the government and community, for perceived land value gains due to the improved benefits in access or multiple non-transport services in TOD's. Thus the financial risk is primarily borne by the beneficiaries of the project.

No BID or SID tool has ever been used to create an urban rail project in Australia but could be used in the new City Deal process outlined below.

5.4. Fully Private: Entrepreneur Rail Development

The Entrepreneur Rail model developed by us (Newman, Evans, Davies-Slate, 2017) was created out of the need to truly integrate transit and land use through finance to create the highest value outcomes. However, it is not as though it is entirely new as historically this is how tram and train lines were developed; also ‘joint development’ has been used for building urban rail since the 1980’s wherever a major TOD was considered as a joint outcome (Newman & Kenworthy, 1999). These joint developments were set up to supplement government money through land development but they can also be used to go further and create a fully private approach.

The Entrepreneur Rail model emphasizes the important role of involving private sector expertise and approaches to redevelopment in the early stages of any new urban rail project otherwise it is not going to be possible to generate private investment or to create the economic value that is sought from developing urban regeneration-based TOD’s.

Thus the tools in this section are based on formal public-private partnership arrangements designed to implement infrastructure projects through risk-sharing but all the finance is coming from private investment. These PPP arrangements where the private sector pay for the infrastructure and make money out of the value created, are common in mining, energy, ports and airports but are not yet very common in many parts of the world like Europe, America and Australia for transit projects. They are however common in Japan and Hong Kong. In our view, this LVC tool is likely to create the most economic value.

Historically private entrepreneurs have initiated public transport in cities. The US’s first omnibus started in New York City in the 1820s by private operators who then laid down rails (in 1860’s) to replace horse drawn carriages (Glaeser, 2012). The first private rail projects began in the 1840’s in the UK and the earliest in the US dates back to the Pacific Railroad Act of 1862, under which government provided land grants, 400-foot rights of way plus ten square miles for every mile of track built, for the construction of the transcontinental railroad. Other private projects in history, especially in Perth, are outlined in Newman, Davies-Slate & Jones (2017). These projects are similar to what is now known as ‘unsolicited bids’ from the private sector. The Entrepreneur Rail Model enables partnership proposals that involve fully private investment but are still best developed with community and government involved as well.

Fully private capital and operational funding with minimal government in-kind support can be illustrated from case studies where this approach has been used including the Brightline project in Florida, Rapid Rail in Gurgaon and Tokyu Den-en-toshi Line in Tokyo.

Brightline is a privately owned inter-city rail service and TOD project linking Miami to Fort Lauderdale and West Palm Beach using a relatively fast train (160 kph). The phase 1 of the Brightline project will be opened in late 2017. The project utilizes an existing freight rail line of 312 kms and plans to add 64 kms to Orlando after the first stage has been established. Project finance was raised through a mixture of debt, bonds and equity. Private developers have not had to seek public subsidies or grants other than federal low-interest private activity bonds which provide a risk guarantee. Such private sector financing structure has been made feasible through the establishment of TOD’s at each of the four rail stations (Renne, 2017). Brightline’s economic study (The Washington Economics Group, 2014) notes that in the timeframe from 2014 to 2021 the project will result in an economic impact of approximately $6.4 billion comprised of $3.4 billion from Rail-Line Construction, $887 million from Rail-Line Operations, $1.8 billion from TOD Construction, and $284 million from TOD Operations, in the same timeframe the project will add USD 653 million to Federal, State and Local Tax revenue, $945 million from rail and $235 million from TODs. Therefore, Brightline is showing significant value creation through private investment and expertise in land development.

In the case of Gurgaon, the urban rail project is fully privatised under a Design Build Finance Operate Transfer (DBFOT) agreement with a 99-year concession period. The private developer financed the project through private loans and equity raising. The government provided an existing right of way for the rail line, however access to the station and transport interchange facilities as well as land acquisition for stations was undertaken by the private developer. Project revenue sources include fare box collection, advertisement and leasing of shops within the station area, however no land development was involved. The private developer conducted an aggressive advertising campaign which resulted in 61% of the total revenue in 2014-16 through the auctioning of the naming rights for the stations (even before the stations were opened) and advertisement space on the inside and exterior of the train coaches (Deloitte Haskins and Sells, 2015). The private developer operates 'free' feeder bus service to adjacent industrial hubs from stations in order to increase fare box revenue. The feeder service benefits the commuters by providing comfortable last mile connectivity. This case shows that full private participation results in innovative revenue strategies and greater public benefit however it is very unusual not to have used land development opportunities and it remains to be seen whether the project can survive without this.

Hyderabad Metro is another Indian case but involves significant land development. It is built on a DBFOT agreement wherein a private developer was provided about 10% of the capital cost as grant (equity) from the federal government of India and the state/ provisional government granted air-rights for commercial development of about 12.5 million sq. ft. over the three depots and 6 million sq. ft. at the 25 select stations. The private developer has raised capital through loans and equity. The private developer's concession period is for 35 years. The project is planned to be operational in mid-2017. The private developer has started renting the spaces before the rail is operational. This case shows the private sector's active approach towards enhancing revenue streams.

The government owned Hong Kong Mass Transit Railway (MTR) Corporation has to run as a private corporation undertaking significant land development with private sector partnership to turn a net loss in the 1980s into profit worth USD 2 billion in 2015. The key to MTR financial success is starting the land development based finances before the actual rail line operation (Cervero & Murakami, 2009; Mass Transit Railway, 2016; Zhao, Das & Larson, 2012). Such an entrepreneur approach is required in urban rail projects which necessitates private involvement.

Japan has historically used Entrepreneur Rail Model development in order to fund and build urban railways. They amalgamate irregularly formed properties that result in smaller but fully serviced urban neighbourhoods and involves sale of 'extra' land to fund the associated railways. The government, as in-kind support, enables land consolidation and acquisition. This approach is known as land assembly or land adjustment. In case of Tokyu Den-en-toshi Line in Tokyo, in addition to land adjustment, the private company purchased land before announcing their plan to build the rail line and on some land parcels they co-developed the land with landowners. A private developer promoted the area development by selling land, constructing housing, and attracting shopping centres and schools. This project was mainly implemented on a greenfield area (Bernick & Cervero, 1997; Sanders, 2015). The economic downturn in Japan in the last few decades has resulted in additional strategies for value capture such as strategic infill urban development around train stations. Private companies have been able to raise equity from the stock market for rail projects in Japan to avoid interest on loans (Metrolinx, 2013).

The Entrepreneur Rail development cases show a larger value creation potential through such extensive private participation enabling comprehensive and integrated development of TODs. The cases show that urban rail projects require private involvement to enable any active and entrepreneurial approaches for creating innovative ways for higher value and revenue.

5.5. LVC Tools and Value Creation

Considering different value capture tools the joint PPP development is the best one to create new economic value through bringing innovations in the planning and administration of public infrastructure, new technology, and most of all in creating the best market-oriented development potential in the land areas around stations. In other words, the Fully Private model enables a high value creation TFUL.

The fully government land value capture tools are rigid in terms of their application to fund a specific infrastructure element and will make some development around stations less attractive for investment. Value capture occurs in land based levy, tax increment financing, and special investment district levy tools to help government fund urban rail. But this capture may not lead to enough further private investment and wider value creation to enable the full economic potential of the infrastructure and its agglomeration opportunities.

As shown in Figure 3 if government agencies continue to plan and fund urban rail they will have fewer and fewer opportunities to create sustainable transport and high value TODs. If governments seek greater involvement of the private sector from the start of projects, then by competitive transparent bidding it is possible to achieve greater and wider public and private economic goals through economic value creation.

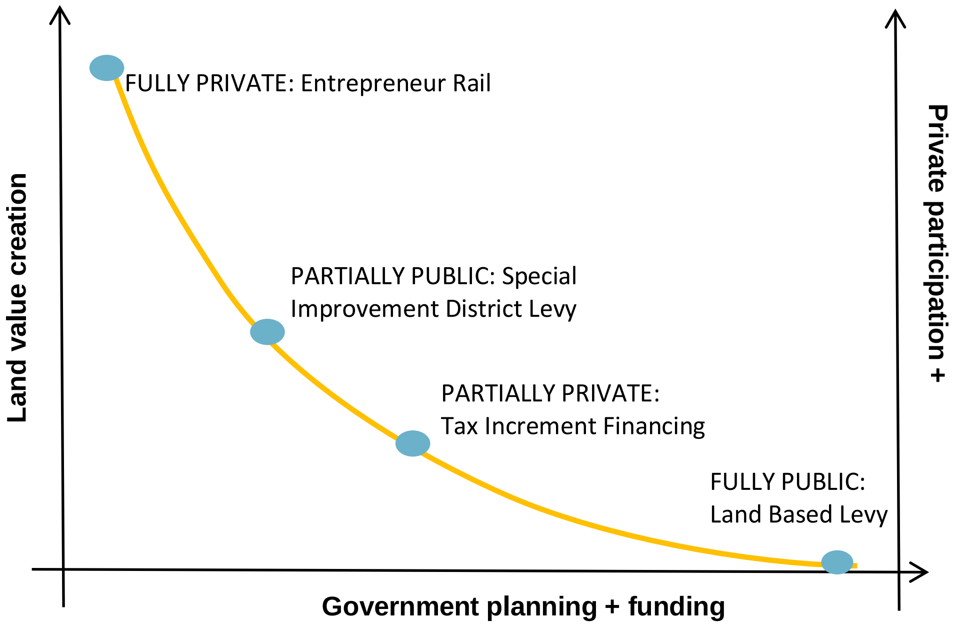

Figure 3: How land value creation varies with the extent of private involvement in TFUL partnerships.

Source: Authors

In the case of Entrepreneur Rail development, the full private participation can create additional value and capture opportunities as entrepreneurial opportunities are created, such as in the case of Brightline and Japan. Therefore, for the TFUL development approach the optimal tool seems to be the Entrepreneur Rail Development model due to the private sector participation and comprehensive development for wider economic gains.

However the next best is the Special Improvement District Levy model where private and community partnerships that help drive the rail and TOD planning and delivery, are developed in specified corridors. The other tools are able to deliver urban rail but may not achieve much in the way of value creation in the associated TOD's.

The Australian Federal Government have begun a new approach to funding urban rail – they only provide financial risk guarantees. Many governments reacted by saying they would prefer the traditional approach of being given cash for projects. However, this misses the point that with financial risk guarantees significant numbers of new projects can be built but they require a new approach with various levels of LVC tools and partnerships with community and private expertise and investment. City Deals mean that cities must create partnerships between the three levels of government and be based around partnerships with private investors who provide the capital that they can return through TOD and urban rail activity. City Deals also require multiple urban outcomes for inclusive, smart and sustainable cities, as well as being clear about community goals (https://cities.dpmc.gov.au/city-deals). The LVC tools can all provide some help but the Fully Private and the Partially Public tools are likely to be the only ones that can create a City Deal. Such approaches are increasingly occurring around the world (Clark & Clark, 2014).

6. Conclusion

The LVC tools vary from traditional wholly government controlled processes that enable value to be captured but sacrifice value creation, through to entrepreneurial development where greater value creation happens with lower levels of government control but extensive partnerships. We have discussed these through various global examples in this paper. Obviously each city and each project will have different needs and requirements that will determine the appropriate mix of public and private investment in a PPP for integrated land use and transit. The main conclusion from this paper is that the more the private sector is involved in the investment and the process of developing a project, the more value creation is likely.

Private sector involvement for joint PPP development of a TFUL project from the concept stage could increase the redevelopment potential commitment from the private sector and lead the public sector to focus on their core role of governance including community engagement and partnership development. This will lead to wider agglomeration benefits and economic gains as well as many local amenity gains.

The implementation process for TFUL is not straightforward; it will require significant dialogue between community, private and public sectors. The public sector will have to create regulations to enable such processes and frame contracting documents for TFUL that will address equity, sustainability and livability concerns of the community. Community engagement should be seen as an essential component not an optional extra as this can enable political validation as well as improving local amenity through their detailed knowledge of needs and options and hence provide the basis for partnerships with government and business.

Further research on such partnerships for a major project like urban rail and TODs can show the efficiencies and challenges in the life cycle of the project. The Australian City Deals for urban rail projects could show such partnerships required for infrastructure provision and sustainable urban growth in a city. Delivery mechanisms and procurement processes for TFUL will need detailed consideration as the structures of most town planning and transport planning do not easily lend themselves to such outcomes.

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Article

Financing Indian Urban Rail through Land Development: Case Studies and Implications for the Accelerated Reduction in Oil Associated with 1.5 °C

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Abstract
Urban travel demand and oil dependence need dramatic change to achieve the 1.5 °C degree target especially with the electrification of all land-based passenger transport and the decarbonizing of electric power. In this article we investigate the transition of 'oil-based automobile dependence' to 'urban rail plus renewable energy' to cater for transport demand in Indian cities. India is perceived to be a key driver of global oil demand in coming decades due to the potential increase in car use driven by a fast growing national average income. However, it is possible that India could surprise the world by aggressively pursuing an electrified transit agenda within and between cities and associated supporting local transport with electric vehicles, together with renewable power to fuel this transport. The changes will require two innovations that this article focuses on. First, innovative financing of urban and intercity rail through land-based finances as funding and financing of such projects has been a global challenge. Second, enabling Indian cities to rapidly adopt solar energy for all its electrified transport systems over oil plus car dependence. The article suggests that Indian cities may contribute substantially to the 1.5 °C agenda as both policies appear to be working.

Keywords
Keywords: 1.5 °C agenda; cities; climate change; India; renewables; substantially; urban rail; urban travel

Issue
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1. Introduction

Urban travel is the largest source of global transport related greenhouse emissions as well as associated issues such as air pollution. This is due to the urban travel being oil based and automobile dependent (Rode et al., 2014; Van Audenhove, Korniichuk, Dauby, & Pourbaix, 2014). The Intergovernmental Panel on Climate Change, chapter on Transportation (Sims et al., 2014), notes that reduction in transport sector emissions is critical to achieve the future climate change goal such as the 1.5 °C target suggested as the preferable limit to be addressed under the Paris Agreement. Electrification of all land-based passenger transport and the decarbonizing of electric power will be required to help achieve the 1.5 °C target; this has been clearly stated as the necessary and fundamental change needed in all urban systems and has been agreed to by the nations of the world in the Paris Agreement. This article will try to show urban rail can play a significant part in this transition due to its ability to replace car use and its ability to create new funding opportunities through rail-oriented land development due to land value uplift.

Urban rail has shown its potential to simultaneously electrify transport and help reduce the occurrence of automobile dependence. Urban rail can also help increase economic development in cities as urban rail facilitates the creation of dense urban centres with walking and transit urban fabric that are known to help with new economy jobs and other social, economic and environmental outcomes (Matan & Newman, 2016; Newman, Kosonen, & Kenworthy, 2016). One example from Glaeser and Xiong (2017) is of the Chicago stockyard where people and businesses have clustered around the associated rail stations. Such clusters attract additional business and lead to innovation due to the proximity of people and access to a large labour resource (Glaeser & Xiong, 2017). Knowledge economy jobs are particularly attracted to such transit-oriented centres of activity (Newman & Kenworthy, 2015; Yigitcanlar, 2010). Also, the energy intensity of rail transport is only about 15% of that of traditional cars, 50% of electric vehicles and 50% of buses (Lu, 2015). The major difference in the climate change debate is that urban rail is already mostly electric and therefore can be based quickly on renewable power. Thus, infrastructure investments that encourage rail may therefore lead to significant emission reductions in cities (Hoen et al., 2017).

If urban planning is to help with the 1.5 °C agenda it would need to facilitate the transition from oil-based automobile dependence to renewable electrified rail transit though this may not be a simple or linear process, especially in emerging cities like in India. This article will look at whether the process is underway in Indian cities where considerable momentum to remain in an oil-based transport system has been the agenda for many decades. The article begins by looking at the overall picture in India with respect to fossil fuels and economic growth in comparison to other nations before examining the first Indian cities that have attempted to begin to build electric rail mass transit systems and use more solar in their systems.

The process of decoupling economic growth from use of fossil fuels is at the heart of the 1.5 °C agenda. This process is already underway and the data on decoupling growth in wealth from growth in fossil fuels is now clearly showing not just a relative decoupling but an absolute decoupling globally and in most developed nations and cities (Newman, 2017a, 2017b; Newman, Beatley, & Boyer, 2017). See Figure 1a on Denmark, which is perhaps a leader in the developed world though most European nations are similar and even America and Australia are now moving down this path.

However, the decoupling in China (Figure 1b) and India (Figure 1c) now becomes the key focus for global policy as their coupled growth can easily make the 1.5 °C target impossible for the world due to their size and their leadership in the emerging world. The decoupling in China is led by strong top down policies and bottom-up demand in their major cities which has led to rapid declines in coal and oil growth (Gao & Newman, 2017). But India is less obviously decoupling and seems more poised to go either way; it is relatively decoupling and thus is demonstrating potential to go into absolute decoupling of wealth from coal and oil but could just continue growing also. Which outcome is likely is the underlying motivation behind this article.

This article will look at India and its growing cities to see whether a similar rapid decoupling trajectory can happen and whether the seeds for this transition are already present. The article will discuss the case of how Indian cities can contribute to the 1.5 °C target through its rapid growth in electric urban rail and its commitment to solar. The transition is being formally expressed as: from 'oil-based automobile dependence' to 'urban rail plus renewable energy' whilst continuing to cater for transport demand in Indian cities. The changes will require two innovations that the article focuses on. First innovative financing of urban and intercity rail through land based private investment as funding of such projects has been a global challenge and is one India is now taking on. Second, enabling Indian cities to rapidly adopt solar energy for all its electrified transport systems rather than fossil fuel based. The article further briefly discusses electric vehicles (EV), collaborative consumption and urban planning implications that would contribute to the future ability of Indian cities to contribute to the 1.5 °C agenda.

2. India's Urban Transport Demand and Oil

Urbanization is essential for driving economic growth (Glaeser, 2011). India is set to witness rapid urbanization in the next four decades with accompanying economic growth. India's urban population is projected to increase from 377 million in 2011 to 600 million by 2031. This would mean India will have 87 cities over a million population by 2031 from the 50 in 2011. The predicted urbanization and economic growth in India would possibly be the largest national urban transformation of the 21st century (Ahluwalia, 2011; Ahluwalia, Kanbur, & Mohanty, 2014; Heilig, 2012; WBG, 2017).

India is predicted to play a key role in future oil demand growth due to increased car ownership driven by high income growth. While the proposed oil consumption has been anticipated by the Organization of the Petroleum Exporting Countries it would however result in financial and environmental adversity for India and would be a significant setback in assisting achieve the Paris Agreement. Financially it will be a problem as India imports over 75% of its total crude oil resulting in energy security, trade deficit and foreign exchange issues. Environmentally it is an issue due to air pollution that has been a significant public health issue in all major Indian cities. Traffic congestion, noise and associated externalities are attached to the predicted automobile increase as well. It is also essential for Indian cities to avoid oil-based automobile dependence in order to fulfil their Paris Agreement and make progressive steps towards the 1.5 °C target (International Energy Agency, 2015; Van Moerkerk & Crijns-Graus, 2016).

Private vehicles in Indian cities are dominated by two-wheelers and cars. Two-wheelers are the dominant private mode with over five times the number of two-wheelers than cars in 2015.[1] High dependence on private

[1] The mode shift from two-wheelers to transit has higher probabilities than car that help in the growth of transit, especially rail based.

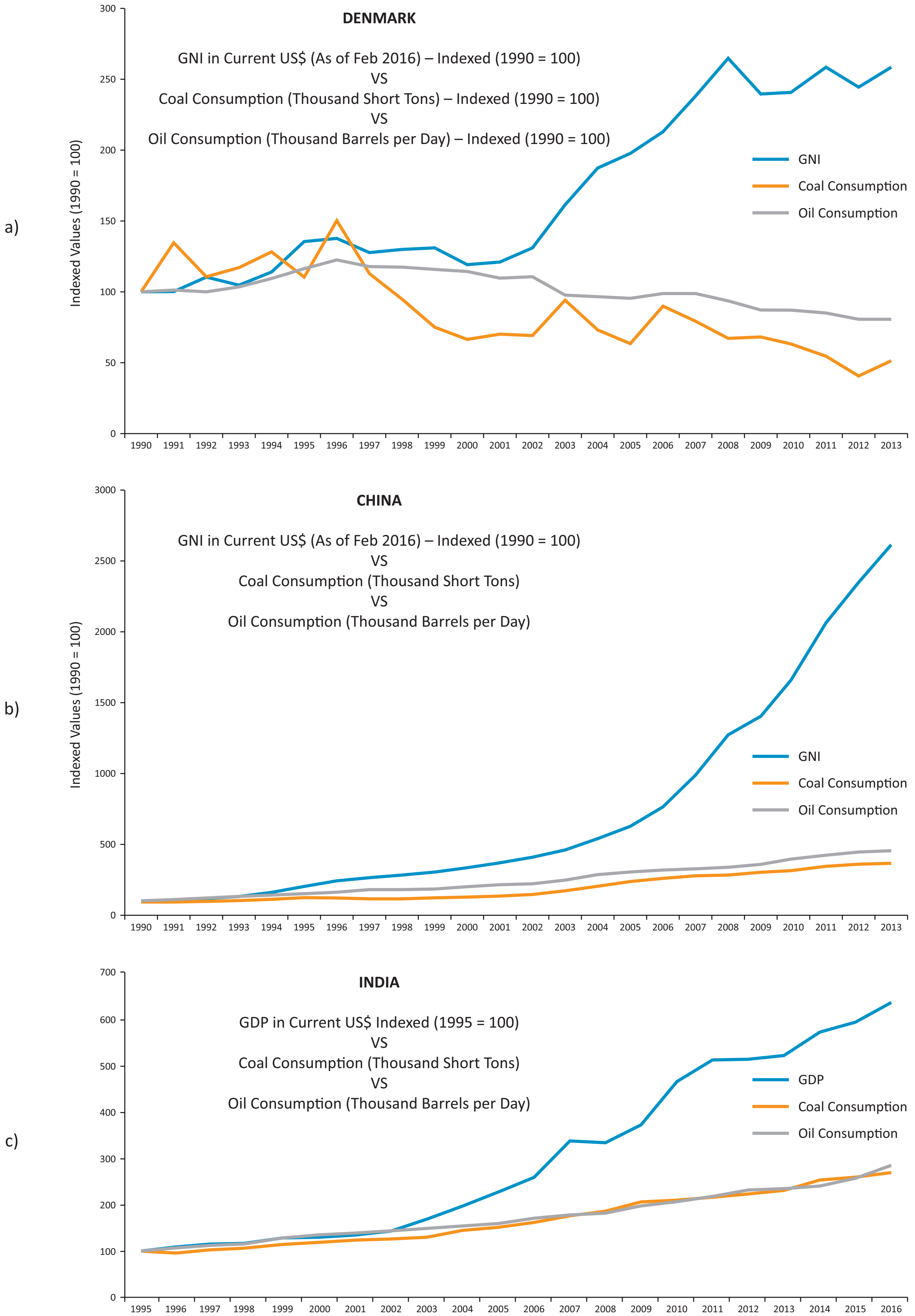

Figure 1. Decoupling wealth from coal and oil in Demark (a), China (b) and India (c). Note: GNI stands for Gross national income, which is almost equivalent to GDP but is more available in terms of data. Source: Compiled by author based on data sourced from CEID (2017), United States of America Energy Information Administration (EIA, 2016), Ministry of Petroleum & Natural Gas (2017), Newman (2017b), OPEC (2016) and The Worldbank Group (WBG, 2016).

vehicles has happened in the last two decades with a subsequent decline in public transport share but not totals as every available mode has been crowded with people during the rapid growth of Indian cities. 85% of the total private vehicles registered in India has happened between the years 1991 to 2011. The private vehicle growth rate has been over 10% annually which is one of the highest globally; however, India is still low in-terms of per capita vehicle ownership on a global scale.[2] The growth rate has been largest associated with high increases in income (Ahluwalia, 2017; Dhar & Shukla, 2015; Goel, Mohan, Guttikunda, & Tiwari, 2016).

Goel et al. (2016) show that registered vehicles in India are highly overestimated; they suggest that the actual number of in-use vehicles compared to officially registered is out by over 120%. The findings of Goel et al. (2016) indicates that the wealth increase leading to vehicle ownership may not essentially mean the increase of private vehicle km in Indian cities. To understand this further I have plotted historic growth rates in Figure 2 of the gross domestic product, oil consumption, car registration and road length in India.

Figure 2 indicates that there has been exponential growth of car registration even more than the GDP growth. But this has not resulted in road length increase or increased oil consumption levels. This is consistent with the earlier Figure 1c which shows wealth is being relatively decoupled from oil. The big question is whether this can be turned into an absolute decline in oil.

2.1. Automobile Saturation in Indian Cities?

At a macro level (from Figure 2) it seems that Indian cities have intrinsic features that could be acting as a 'soft power'[3] to hinder the growth of vehicle kilometre travelled as compared to car registration. One possible factor is limited road space in Indian cities as like many emerging cities they are historically walking cities with all that associated fabric in density and mixed use (Newman et al., 2016).

As per the Census of India (2011) about 24% of the population work from home,[4] 23% walk to work, 13% bike to work, 19% use public transport, 4% use a car and 17% use two-wheelers to go to work in Indian cities. A quarter of commuters travel less than 1 km and another third travel between two and five km. This travel pattern shows that the majority of workers do not use any motorized mode to travel to work and travel short distances—reflecting the dense walking fabric and mixed land use in Indian cities (Rode et al., 2014; Tiwari, Jain, & Rao, 2016). Thus, Indian cities need to invest significantly to improve and build their walking and cycling infrastructure which is in poor condition and do not even cover major transit/road corridors in order to improve walking fabric (Ministry of Urban Development, 2013). An increase in walking and cycling mode share is critical for achieving climate changes goals in cities and as mentioned before in this article urban rail can facilitate this increase due to its ability to replace car use and its ability to

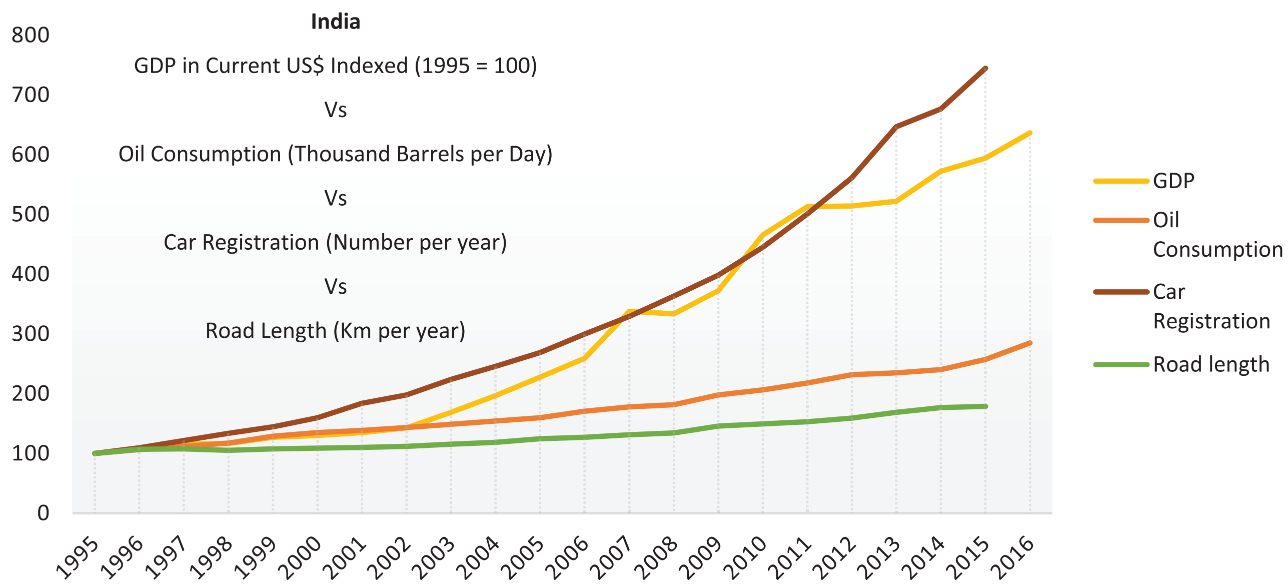

Figure 2. Historic growth rates of GDP, oil consumption, car registration and road length in India. Source: Compiled by author based on data sourced from CEID (2017), EIA (2016), Government of India (2017a), Ministry of Petroleum & Natural Gas (2017), OPEC (2016) and WBG (2016).

[2] India's car ownership is about less than four times of China and less than twenty-five times of OECD countries.
[3] For this article we used the term 'soft power' (inspired from Joseph Nye's work) of cities: characteristics of a city to influence the travel behavior without push or coercion (Nye, 2004).
[4] This could be possibly due to the traditional houses having shop and house on the same land, small business like tailors, tradesman and others are located within the residence.

be funded from the facilitation of transit oriented developments due to the increased value in land around rail stations (Newman & Kenworthy, 2015; Sharma & Newman, 2018).

The 'soft power' characteristics of Indian cities—travel pattern, road length growth, and dense, mixed use urban fabric, seem to be the factors that could have ensured the start of decoupling wealth and car use. Even with a small per capita car ownership the urban fabric of Indian cities has resulted in high traffic congestion and low travel speed thus minimizing growth in the use of cars. It also suggests that without a massive road building program that completely alters the urban fabric (as happened in US cities) there is unlikely to be much more ability of Indian cities to cope with high traffic growth.

The travel speeds of private vehicles in various large Indian cities during peak hour is less than 15 km/hr in most major corridors. This means that even the most basic of urban rail expansions and building would enable Indian residents to travel faster than in the road traffic.[5] Urban rail in Indian cities has an average speed of over 35 km/hr. This would suggest that the big problem is automobile-saturation in Indian cities rather than automobile dependence as is the case in some Chinese cities (Gao & Newman, 2017; Sharma & Newman, 2017a). This is an easier problem to solve as the attraction of urban rail when it is built will be immediate and long lasting.

If the trend to decouple oil from wealth is to continue and accelerate into an absolute decoupling, then Indian cities will need to focus on building a lot more urban rail. As suggested here large Indian cities are looking for fast urban rail solutions to help overcome traffic problems which will increase the urban rejuvenation potential in their dense areas and land development opportunities. The question is whether the political will is there and whether financial mechanisms are available to make it happen.

2.2. Public Transport and Economic Growth in Indian Cities

The strong link between public transport and economic growth has become a major part of national and urban policy in recent decades (Glaeser, 2011; Glaeser, Kahn, & Rappaport, 2008). This is now being widely recognized by Indian cities. Public transport service levels are currently low in Indian cities with a significant public transport supply gap of 240%. This has contributed to the 21% mode share of private transport and 19% mode share of public transport. However, Mumbai's suburban rail is an example of how private vehicle use is restricted without it restricting economic growth (Government of India, 2014; Newman & Kenworthy, 2015; NITI Aayog & Rock Mountain Institute, 2017).

Mumbai's suburban rail-dominated public transport has restricted private vehicle use to 12% as compared to the 40% mode share for private vehicles in Delhi and Bangalore which had no significant urban rail presence in 2011 (Census of India, 2011). A brief analysis of CO_2 emissions in Mumbai, Bangalore and Delhi show that if Bangalore and Delhi achieve similar mode share to Mumbai, which is dominated by rail, Delhi can cut urban transport emissions by 40% and Bangalore by 34%. This analysis is based on Census of India, 2011 data for passenger km and CO_2 intensity has been referred from Dhar, Pathak and Shukla (2018) as presented in Table 1.

Mumbai's low road density, high density of cars per km and high population density among all major Indian cities seems to have resulted in automobile-saturation and hence the dominance of transit mode share at about 79% (Rode et al., 2008; Census of India, 2011). Mumbai has the highest per capita income, quality of life and productivity among all major Indian cities (UN-HABITAT, 2012) coinciding with the analysis of global cities on wealth increase and vehicle km growth by Newman and Kenworthy (2015). Mumbai shows how a rail based urban transport can cut emissions and increase wealth. The Indian government recognizes that densification linked with public transport is essential to sustain urbanization and economic growth (Ministry of Urban Development, 2014). This recognition has resulted in effective policy formulation at the federal government level paving way for over 50 Indian cities to plan for urban rail.

Chauvin, Glaeser, Ma and Tobio (2017) shows that there is a high correlation between density and earnings across Indian cities, that is stronger than in the U.S. cities.

Table 1. Passenger km and CO_2 intensity in Mumbai, Bangalore and Delhi.

	Mumbai & Suburban	Bangalore	NCT of Delhi	
All Modes	Passenger km (million)			CO_2 Intensity (tCO_2/M pkm)
Moped/Scooter/Motor Cycle	1.9	6.9	7.8	31.9
Car	2.9	4.5	8.5	99.1
Bus	7.4	9.9	14.2	14.6
Train	21.5	0.5	3.0	14

[5] The travel speed and passenger carrying capacity per lane of urban rail is much higher than rubber-based transit. For this article rubber-based transit is not discussed as an option; this is seen as the mode which can help as a feeder to urban rail where the last mile distances are above 1–2km. The potential of urban rail to create high density transit orient development centres would mean walking as a main access mode to rail also and this is better for the 1.5 °C agenda. Cities will always need to invest significantly to improve walking and cycling infrastructure around mass transit.

Cities with higher density also tend to be more productive and have higher quality of life parameters. This density and income would be further facilitated with India's plan to implement urban rail in over 50 cities with aligned policies of land value capture (LVC) and density.

3. India's Plans for Growth in Urban Rail

In rapidly growing Indian cities urban rail has emerged as an efficient and reliable solution to cater to urban travel demand. The growth of India's modern urban rail system has happened in the last decade after the transit-success of Delhi Metro (started in 2002). Urban rail, in August 2017, is operational in 11 cities and under construction in another nine cities. Indian cities have added 370 km operational urban rail and another 556 km is under-construction in the period of 2002–2017. This is far behind China's over 3,000 km of urban rail most of which was built in the past decade.

Indian cities have extensive plans (712 km) for urban rail as shown in Table 2. Delhi's 467 km urban rail network is planned to be constructed by 2021 and around 60% of the city would be within 15-minute walking distance from the network. Mumbai Metropolitan Region plans to add over 192 km of urban rail network in addition to the existing 465 km of suburban rail by 2021 (Delhi Development Authority, 2007; Government of India, 2017b; Kai, Baoming, Fang, & Zijia, 2016; MMRDA, 2017).

This growth is driven by demand for urban rail travel and supported through political leadership. The Indian government has been financially supporting urban rail since 2011 in cities with a population over two million but this norm has been reduced to one million to extend this benefit to medium size cities (Sharma & Newman, 2017b). This is a good outcome for the 1.5 °C agenda though it may not have been a part of the rationale for this decision.

Globally UIC, the International Railway Association

Table 2. Urban rail network in Indian cities.

				Urban Rail Network in km		
Sl No.	**City**	**Population (in million)**	**Urban Rail Project Name**	**Operational**	**Under Construction**	**Planned**
1	Delhi	16.3	Delhi Metro	218	179*	148*
2	Noida	0.6				
3	Ghaziabad	1.1				
4	Faridabad	1.4				
5	Gurgaon	8.7				
			Rapid Metro	12	0	0
6	Mumbai	12	Mumbai Metro	11	124	57
			Mumbai Monorail	8	0	0
7	Kolkata	4.4	Kolkata Metro	28	113	
8	Chennai	4.6	Chennai Metro	28	19	104
9	Bangalore	8.4	Namma Metro	42	34	57
10	Kochi	0.6	Kochi Metro	13	26	37
11	Jaipur	3	Jaipur Metro	10	2	23
12	Lucknow	2.8	Lucknow Metro	0	33	140
14	Hyderabad	6.8	Hyderabad Metro	0	72	168
15	Nagpur	2.4	Nagpur Metro	0	19	38
16	Gandhinagar	0.2	Metro-Link Express for Gandhinagar and Ahmedabad	0	19	38
17	Ahmedabad	5.5				
18	Kanpur	2.7	Kanpur Metro	0	24	38
19	Navi Mumbai	1.1	Navi Mumbai Metro	0	11	12
20	Pune	3.1	Pune Metro	0	60	0
Total		**84.6**		**370**	**556**	**712**

Note: * includes Noida Metro and Ghaziabad Metro projects. Source: Compiled by author based on data from Census of India (2011) and Ministry of Urban Development (2013, 2014).

(with 240 members worldwide), has proposed to improve the energy efficiency of the rail sector by a 50% reduction of final energy consumption from train operations by 2030 through technical measures, improved management, decarbonization of energy consumption and better use of existing rail assets. There are further energy savings to be achieved by using lighter weight/composite materials (30% potential energy savings), and by optimizing energy recovery devices (up to 45% potential energy savings) and train operation management (Hoen et al., 2017). All these will contribute to the 1.5 °C agenda and will reduce the life cycle emissions of urban rail.

4. The Problem of Urban Rail Funding

At the time when urban rail investment appears to be a priority for cities, governments across the world face budgetary pressure leading to challenges in the funding and financing of urban rail. Funding of urban rail through traditional gross budgetary support from the government seems increasingly difficult in the existing global economic scenario. This traditional way of urban rail investment will lead to a growing debt-subsidy cycle which would undermine economic development and minimize the possibility of India actually phasing out oil the way that the world needs in the 1.5 °C agenda.

Existing Indian urban rail systems are facing a financial deficit as they are highly dependent on fare box revenue and conventional budgetary support from the government, as has been the case globally. Urban rail agencies have significantly struggled to recover even operating costs through fare box revenue as it is inherently limited due to equity demands (Flyvberg, 2007; Jillella, Matan, Sitharam, & Newman, 2016; Sharma, Newman, & Matan, 2015). This has resulted in fare increases in Delhi Metro and proposed fare increases in Mumbai Metro which have created community and political dissension. Mumbai is one city where the fare box may have been possible to cover all costs but even here it does not. It is thus essential for Indian cities to explore alternative funding sources. However, the role of urban rail in facilitating the 1.5 °C agenda and creating better cities in general, is likely to be far more transformative than using other sustainable transport modes as it has an inherent ability to attract private funding through land development opportunities associated with rail systems. Urban rail's impact on land values and the potential of land development, rejuvenation and agglomeration benefits, suggest economic value can be captured by a range of LVC mechanisms (Banister & Thurstain-Goodwin, 2011; Capello, 2011; Newman, Davies-Slate, & Jones, 2017; Newman & Kenworthy, 2015; Sharma & Newman, 2017b).

LVC studies on urban rail projects provide evidence that both government and public private partnership (PPP) urban rail projects are financially viable and can maintain affordable fares through LVC-based funding mechanisms. Indian urban rail systems have shown significant uplift in land value at both a city and corridor level. Sharma and Newman's (2017a) hedonic price model on Bangalore Metro showed a 23% increase in land value in the 1 km catchment area of urban rail and of great significance it appears to have increased land values over the whole city by an average of 4.5%. A study on Mumbai Metro showed a 14% increase in land value for properties between 1 km and 2 km from stations (Sharma & Newman, 2018). Similar results were found on Chinese cities. Zhang, Liu, Hang, Yao and Shi (2016) panel data hedonic price model on housing prices of 35 Chinese cities from 2002 to 2013 showed that a 1% increase in rail transit mileage improves housing prices by 0.023% at the city level. This shows urban rail's crucial role on land values and hence how various 'beneficiary pays' mechanisms could be tapped to rapidly increase urban rail investment.

Not only is there a clear case that urban rail increases land value around stations but the project life cycle of urban rail systems with their associated land uses, are generally longer than any road-based system and hence can attract private investment as there are long-term financial and economic benefits when the transit, land use and finance are integrated. Private sector involvement can address this multidisciplinary integration by bringing innovation, technology, design stage efficiency, market driven land development skills, improved operational efficiency and long-term value for money through risk sharing. These latter skills are not readily available within government. Private participation in urban rail projects has shown efficient exploitation of non-transport revenues such as advertisement, station area development and kiosks/shops at stations along with bringing efficiency in construction and operations when involved from the design stage. Bigger projects which depend on even more land development for private investment opportunities, require even more obvious ways of incorporating private bids on how best to do it. Involvement of the private sector at design stages can also enhance budget predictability for government (Bowman & Ambrosini, 2000; Giuliano, 2004; Medda, 2012; Pojani & Stead, 2015; Sharma et al., 2015).

Governments are therefore seeking private investments and partnerships to implement urban rail projects. This is based on rail's impact on urban land values providing value creation potential thus enabling land development to provide the returns needed by the private sector. Privately financed urban rail is being proposed and debated globally including Australia, India, Canada and the US.

Hyderabad Metro is one such urban rail being built on a Design Build Finance Operate Transfer agreement wherein a private developer was provided about 10% of the capital cost as grant (equity) from the federal government of India and the state/provisional government granted air-rights for commercial development of about 12.5 million sq. ft. over the three depots and 6 million sq. ft. at the 25 selected stations. The private developer has raised capital through loans and equity. The private developer's concession period is for 35 years and the private developer was able to start renting the spaces before the rail was operational. This case shows the private sector's active approach towards enhancing revenue streams. This increase in non-fare box revenue may help maintain low transit fares in the long term based on a similar outcome that has been found in all of Japan's rail system and Hong Kong's Metro where private land development is used to keep fares low and fund the whole system (Newman, Davies-Slate, & Jones, 2017; Sharma & Newman, 2017b).

The Indian government recently approved three highly significant policies of relevance to the topic of this article: the National Transit Oriented Development Policy (Government of India, 2017c); the Value Capture Finance policy framework (Government of India, 2017d); and the Metro (urban rail) Policy (Government of India, 2017b). These policies were also necessary to realize the potential of significant investment in urban rail for future urbanization. Together these policies show the intent of the policy makers to enable density, urban rail, accessibility, urban agglomeration and land-based financing. These will assist in framing a supportive mobility oriented urban planning framework that can increase India's GDP by 1–6% (NITI Aayog & Rock Mountain Institute, 2017) whilst decoupling from automobile dependence and fossil fuels.

The Metro Policy of August 2017 (Government of India, 2017b) mandates Indian cities to involve 'private sector participation' and 'land value capture' in urban rail to access 10% equity funding from the federal government. Such approaches of mandatory private sector involvement will increase the private sector risk appetite. Private sector involvement from the concept stage for urban rail and land development can increase the redevelopment potential commitment from the private sector and lead the public sector to focus on their core role of governance including community engagement and partnership development. Community engagement should be seen as an essential component not an optional extra as this can enable political validation as well as improving local amenity through their detailed knowledge of needs and options and hence provide the basis for partnerships with government and business.

These are a significant set of policy decisions by the Indian government to maximize value creation from urban rail. This may also allow implementation of innovative contracting mechanisms such as the Entrepreneur Rail Model of Newman, Davies-Slate and Jones (2017). There are significant challenges for such processes to be implemented in Indian cities such as digitizing urban infrastructure maps, institutional integration in cities, land use and transit integration, land valuation (at plot level), digitization of land use maps and strategic planning frameworks. However, these are possible to add as the system grows and the key factor in tapping private funds to transform the urban rail market is to have the ability to create integrated partnerships between government at all levels and the private entrepreneurs in urban redevelopment as well as private rail operators. India has begun to do this.

The land development based financing and private sector participation outlined above is likely to help facilitate the expansion of urban rail in Indian cities, as long as urban planning tools are used to help and not hinder this process. This rail growth would enable economic growth while decoupling car use. Indian cities have the advantage that their walking and transit urban fabric are already ideal to be served by urban rail. Thus, these policies are likely to lead to a decline in oil consumption whilst enabling economic growth to accelerate. Urban fabric benefits should mean that the extra wealth will go into using easier ways to enable urban rail as happened in China, and wealth will come to be associated with 'rail not car'. These rail systems would need to be renewable based along with other modes of urban transport to contribute to the 1.5 °C target, we discuss these in the next sections.

5. Solar in Indian Rail

To contribute to the 1.5 °C target urban rail systems should operate on renewable energy, specifically solar in the Indian case. Electric urban rail systems are nonsite emitters. Their emissions depend upon the type of fuel used for the generation of electricity which is currently coal dominated in the case of India. However solar is rapidly competing with coal for Indian urban rail operations.

India plans to generate 175 gigawatts (GW) of renewable energy by 2022—100GW to come from solar. According to Morgan Stanley (2017) solar power is becoming more affordable than electricity generated from coal power generators. This is significant as India is the third-largest source of carbon emissions. The key argument for using coal was that it is affordable and accessible in India but now with solar being 18% cheaper than coal the Indian energy sector is on the edge of a major transformation (Farand, 2017). The Indian government has shown it intends to reduce coal consumption by doubling the 'Clean Environment Cess' on coal in year 2017 budget, and by initiating the International Solar Alliance which is envisaged as an inter-government treaty between solar resource-rich countries aimed at efficient exploitation of solar energy to reduce dependence on fossil fuels and to mobilize USD 1 trillion for it (Ministry of Finance, 2017; UNFCCC, 2017).

India has started relative decoupling in the past decade of Coal and GDP as shown in Figure 1c. The growth of coal has slowed and may change to an absolute decline as India invests strongly in renewables and urban electric rail. Ben Caldecott (2017) from Oxford University suggests that Indian power company's investments in coal are financially unviable whilst solar would be a future investment with many economic benefits. This suggests that Indian economic growth has clear potential to be based around renewable sources rather than fossil fuels leading into the future.

The most recent urban rail system of India—the Kochi Metro—has rooftop solar on all of its rail stations to meet 25% of its electricity requirement. Delhi Metro (urban rail) started in 2002 and thus had negligible solar panels then but now meets 80% of its daytime energy from solar (Energy World, 2017; Sood & Bhaskar, 2017). The recent decline of the cost of energy storage systems may assist the further use of solar energy for urban rail systems. New TODs being built around stations need to be covered in solar with battery storage in the area as is happening in various demonstration sites such as Bordeaux and Boulder, Colorado. The next generation urban rail systems are predicted to be powered by solar and batteries with electric power through high-powered contactless charging at stations (Newman & Kenworthy, 2015).

Indian Railways has also started the process to modernize their existing inter-city railway stations through PPPs. The modernization process will include mixed land use development, maximized solar energy utilization and a focus on non-fare box revenue. The proposed fast-rail along urban growth corridors in India, such as the Rapid Rail Corridor around Delhi, are incorporating solar energy and LVC within the planning and design stage of the project.

The Indian government in their 2017 budget has committed to install rooftop solar in 7,000 inter-city rail stations. This is a significant commitment. The first 300 stations have had solar panels installed (Ministry of New and Renewable Energy, 2017). A recent trial of solar panels on the roof of Indian trains has been made to reduce the energy requirement for wagon's lighting and fans but not for locomotives.

Electric trains with batteries are likely to be another trial especially in smaller trains. Newman (2017a) suggests that this transformation may happen much quicker as the demand for renewables is high and cost of solar and batteries are on a rapid decline curve. Economic growth appears to be substantially changing to being based around renewable energy rather than the fossil fuel-based economic growth of the past 15 years.

6. Electric Mobility

The EV market is growing globally at over 40% per year. In India there is currently a negligible presence of EV at 0.0004% of its total vehicles as compared to Norway's 23%, the Netherland's 6% and China's 1.4% share of EV (International Energy Agency, 2017).

India's National Electric Mobility Mission Plan recognizes that the growth of EV's is critical for the energy transition in India as this will reduce oil imports and help with the air quality problem. As part of the mission the Indian government is providing financial incentives, subsidies and tax rebates to EV users and manufacturers to increase EV presence in India. The Indian government has provided over 30 million USD subsidy for 154,557 EV as of August 2017. India's domestic manufacturing capacity of EV is growing with two-wheelers and cars. However, there is no manufacturing unit for electric buses despite some cities having introduced electric buses on a pilot basis (Dhar, Pathak, & Shukla, 2017; National Automobile Board, 2017).

India has set a goal of 6–7 million EV by 2020 which is higher than China's goal of 5 million. The recent target of India is for all-electric mobility by 2030. This ambitious goal is aimed to provide large economic benefits. NITI Aayog and Rock Mountain Institute (2017) notes that with electric and shared vehicles India can save 100 USD billion annually in fossil fuel foreign exchange and cut 1 GT carbon emission by 2030 (PIB India, 2017; Sharma, Kulkarni, Veerendra, & Karthik, 2016).

Unlike developed countries, EV in India are dominated by two-wheelers and recently by E-Rickshaws that act as an intermediate public transport for short distances (~2km). Delhi's subsidy of 470 USD for each E-Rickshaw is significant for shared-electric public transport in that it also acts as a feeder system to urban rail such as Delhi Metro (Rokadiya & Bandivadekar, 2016). Such EV vehicles can be efficiently used in smaller Indian cities where travel distances are shorter.

The critical challenge for Indian cities in enabaling EV growth would be providing EV infrastructure in urban planning schemes. In 2016, India only has 328 publicly accessible charging stations which hasn't increased since 2014. Cities would need to play an active role in regard to EV infratructure and can start with pilot city projects as in the case of other countries. India's abundance of solar enegy potential is an opportunity as with only 1% land area of Rajasthan (Indian State) could power the entire EV fleet traffic by 2030 on solar power (International Energy Agency, 2017; PIB India, 2017).

7. Collaborative Consumption

Collaborative consumption is a growing world phenomenon.[6] It is likely to take over much of the growth in the private urban transport sector and create instead shared transportation options. Its most important function is likely to be the 'first mile last mile' service that links people to fast urban rail services. The shared systems can use smart cards to enable a combination of modes that can provide good mobility options including the urban rail services themselves. Thus the future is likely to see city rail and multi-modal local systems integrated around stations and centres. EV shared systems are already operating in many global cities and are on the rise with many cities planning for them. Cities with bike sharing schemes have increased from 4 in 2001 to over 1,000 in 2016 globaly (Tiwari, 2017).

[6] Collaborative consumption is phenomena born of the Internet age driven by information and communication technologies: the peer-to-peer-based activity of obtaining, giving, or sharing the access to goods and services, coordinated through community-based online services.

Technological advancements in recent years have resulted in several cycling start-up companies in India such as Zoom-Pedl, Mobike, Ola-Pedal, Mobycy and Yulu. Mobycy is a recent mobile-app based bicycle sharing platform which allows commuters to unlock a bicycle parked in a dockless way at public places through a mobile-app generated QR code. It has started operations in Gurgaon with a fleet of 5,000 cycles and plans to spread in other major Indian cities. This can contribute to reducing oil based transport along with the other innovations mentioned above.

8. Discussion: Urban Planning Implications

The transitions that are underway in Indian cities towards urban rail expansion, the involvement of private investment based on LVC through TODs, the rapid growth of solar and battery storage in new urban developments, the growth of EVs and shared mobility, are all subjects that need urban planning to facilitate. A series of structural reforms and policy interventions would need to follow from Indian cities to support this transition, all with a strong partnership between citizens, government and industry.

All the major tools of urban planning will be needed to help make Indian cities contribute to the 1.5 °C agenda as well as to develop economically and sustainably. Tools needed include:

1. Tools that ensure equity in housing policies and planning regulations to ensure that not only the wealthy benefit from transit systems and transit-oriented development;
2. Tools to ensure that pedestrian qualities and good building design are features of all the new development around stations;
3. Tools to ensure that transport, land use and finance can be integrated at all stages of the planning process.

A committee (Ahluwalia, 2011) of the Indian government notes that transport, land use and other urban infrastructure are not planned in an integrated way which makes the integration of EV, TODs and urban rail challenging. Shared EV would require parking spaces and integration with transit and publicly accessible charging stations that would need to be addressed in an integrated manner at the city level in urban plans. More importantly, as outlined above, urban planning needs to facilitate partnerships as much of the planning needs to begin with private sector involvement in highlighting the best redevelopment options that urban rail can unlock in a funding partnership.

Recent research on integration between information and communications technology and spatial planning technology is showing the potential to integrate energy, transport and urban planning. Such technologies may help cities create more integrated planning of urban infrastructure. This is on the government agenda in countries such as Australia (Commonwealth of Australia, 2017; Mosannenzadeh et al., 2017; Plume, Simpson, Owen, & Hobson, 2015; Yamamura, Fan, & Suzuki, 2017).

9. Conclusion

India has made a strong start on the transition from ‘oil-based automobile dependence’ to ‘urban rail plus renewable energy’. The Indian government policy to make mandatory private participation and LVC may result in transformative higher density urban redevelopment projects that can fund many of these urban rail and solar projects. This would lead to greater economic gains and agglomeration benefits. Such processes may deepen the correlation of wealth, density and urban rail with reduced oil-based automobile dependency. The key issue will remain in the implementation of such policies and the financial viability of such projects, however Sharma and Newman (2017b, 2018) and the existing Hyderabad case suggest that with existing LVC legislation private-led urban rail can be financially viable.

The critical level of air pollution in Indian cities coupled with energy security issues can lead to rapid adoption of electric based transport modes in automobile saturated Indian cities. Considering the travel patterns in Indian cities the shared-EV, bike sharing and E-Rickshaws could potentially act as a feeder into any expanded urban rail system. This can cater for the majority of motorized travel in major Indian cities in coming decades. Innovative models of shared and connected urban transport systems with a high level of access to smart technology to end-users may enhance seamless integration of multiple modes within each city.

The continuation of these trends will require a combination of different forms of solar-based power and cities would need to integrate and organize such processes into urban planning schemes and different forms of urban fabric (Newman, 2017a, 2017b). As outlined, there are many signs of this beginning in India.

India has started relative decoupling of income and fossil fuel in the past decade which may change to an absolute decline in fossil fuels in coming years. Indian cities are thus likely to contribute to the 1.5 °C agenda based on their urban fabric (inherently low in automobile dependence), electric urban rail growth through financing from land development and public private participation, increased walking and cycling, and the commitment to solar/battery-based mass transit and EV.

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Conflict of Interests

The author declares no conflict of interests.

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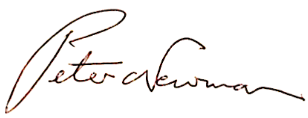

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