Markets, Space and Infrastructure

Kumar Aniket*

Faculty of Built Environment

UCL

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Abstract

The paper explores the relationship between markets, space and infrastructure through an interdisciplinary lens. There are two competing conceptualisations of space, i.e., the Cartesian space and the social space as conceived by Lefebvre (1974). Economics assumes that markets operate over Cartesian space. To explore the relationship between market and space, we break down market transactions into its four spatial flows, i.e., the flow of information about the price and quality of the goods and the actual flow of goods and money between buyers and sellers. We define market-space as a contiguous social space between all potential buyers and sellers through which these four spatial flows occur. Our main argument is that the pre-requisite for a well-functioning market is a market-space that has public good characteristics. Further, we use the notion of Lefebvrian social space to understand the key role transport and telecommunication infrastructure play in creating a conducive market-space that can support the markets and explore why some remote areas are not able to access certain markets.

Keywords: Economic Development, Philosophy, Markets, Spatial inequality, Infrastructure

*Address: Faculty of Built Environment, UCL, 1-19 Torrington Place London WC1E 7HB, UK.

1 Introduction

> One of the most striking empirical regularities is the huge divergence in economic activity both within and across countries. – (Redding & Venables, 2004, p. 1766)
>
> Economic activity is highly unevenly distributed across space, as reflected by the existence of cities and the concentration of economic functions in specific locations within cities. – (Redding & Rossi-Hansberg, 2017, p. 22)

Does location still matter in the age of the Internet? With the advent of new Information and Communications Technology (ICT), people can increasingly do things in the virtual world that they used to do in the real world. This includes buying and selling things over the Internet. At the start of the telecommunication revolutions, the promise of ICT lay in the idea that productive firms, freed from the constraints of their location, could outcompete their less productive competitors and capture their respective market segments in the globalised virtual market. Yet, this dream of being freed from the constraint of location is far from being realised. Location matters as much now as before the ICT revolution. From urban agglomerations to rural hinterlands, there still remains an extraordinary amount of variation in the intensity of economic activity across geographical space.

The "uneven distribution of economic activity across space", as Redding & Rossi-Hansberg (2017) characterise it means that agglomerations lie side by side with economic deserts, i.e., areas where there is very little economic activity. The Ricardian principle of comparative advantage should lead to mutually beneficial trade flows between the agglomerations and economic deserts, thus reducing the spatial variation in economic activity. This means if all locations have identical access to markets, it would even out the spatial distribution of economic activity by dispersing economic activity away from urban agglomeration to rural hinterlands.

The puzzle is why, in the age of the internet and instant communication, does the distribution of economic activity across space remain unevenly distributed across space. According to influential New Economic Geography literature, access to markets and transport costs are some of the key factors that explain the spatial variation in economic activity (Davis & Weinstein, 2002; Donaldson, 2018; Donaldson & Hornbeck, 2016; Hanson, 1996, 1997; See Krugman, 1991). The pertinent question is whether the advances in the ICT revolution has freed the consumers and producers from the constraints of their location and given them access to the opportunities that

global markets offer and consequentially reduced the spatial variation in economic activity.

It is a question that cannot be answered without deconstructing the market and examining its relationship with location and space. The reality is most markets work across real and virtual space.[1] Answering the question of how access to market varies across locations requires a conceptualisation of space that allows us to analyse how markets operate in both virtual and real-world space concomitantly. To do this, we have to unlearn the Cartesian conceptualisation of space that remains prevalent in discussions across academe and policymakers.[2]

There is a vibrant contrary tradition in Cultural Theory, largely amongst French philosophers, that challenge the Cartesian conceptualisation of space.[3] While Cartesian space only captures the tangible aspect of space, the intangible aspect of space that human beings experience is captured in Henri Lefebvre's conceptualisation of the idea of *social space* (Lefebvre, 1974). The advantage of using social space to examine the relationship between market and space is that while real and virtual spaces are different from the Cartesian perspective, they are similar in the way they function as social space from a Lefebvrian perspective. Deconstructing the market and examining it from first principles using Lefebvre's conceptualisation of space allows us to make five contributions to the literature on markets. It also allows to examine the relationship between market and infrastructure.

1. Our first contribution is to deconstruct the market and examine its relationship with space from first principles. We posit that a successful market transaction requires *four spatial flows* between potential buyers and sellers. To be precise, the term *spatial flow* is used to describe the flow between the initial location of the buyer and sellers. The aforementioned four spatial flows are the *flow of information about the price and the quality* between the potential sellers and the potential buyers in anticipation of a transaction and if the buyer and seller agree to a mutually beneficial trade, the *flow of actual goods and services* from the seller to the buyer and *flow of money* from the buyer to the seller. The relationship between these four distinct spatial flows is one of *complementarity*. Complementarity

[1] Papers like Duch-Brown et al. (2017), Brynjolfsson et al. (2009), Loginova (2009) and Goolsbee (2001) analyse the offline-online competition and find that the presence of real world offline shops nearby decreases people's propensity to buy online.

[2] The Cartesian conceptualisation of space is so prevalent that it has acquired what Aldrich & Fiol (1994) called *cognitive* and *socio-political legitimacy*.

[3] For instance, see Marc Augé *non-place*, Paul Virilio's *high-speed society* and its impact on space humans experience, Jean Baudrillard's *media spaces*, Bruno Latour's *common space* and Étienne Balibar's *fictional spaces* within which human society functions.

means that an obstacle in even one spatial flow could fatally disrupt the market transaction. Conversely, if the relationship between the spatial flows was one of *substitutability*, obstacles in one of the spatial flows could be compensated by other flows. With complementarity, obstruction in one flow disrupts the market fatally. For instance, we can infer from the literature on asymmetric information in economics that a disruption in the flow of information about the quality of goods from sellers to the buyers could fatally disrupt the market (Akerlof, 1970; Michael, 1973).[4] Jensen (2007) documents how the fisherfolk had to often jettison their catch of the day because the coastal fish markets in Kerala did not clear essentially due to lack of flow of prices from the marketplaces to the fisherfolk at sea.

2. A market for any good requires space over which it operates. The question is what specific spatial characteristics allow the market to operate efficiently over it.[5] The second contribution that paper makes is in defining the notion of *market-space*. Just the way the spaces over which a game of cricket or football can be played or spaces over which cars and trains can operate have specific characteristics, there are specific characteristics that allow markets to operate efficiently.

   We define *market-space* as a contiguous social space between all potential buyers and sellers through which the aforementioned four spatial flows could occur. Contiguity is an important characteristic of the market-space. It follows that given contiguity, the market-space for a particular good naturally has boundaries. It means not all goods are available everywhere. The areas that lie beyond the boundaries of the market-space of a particular good are *remote*. There is a cohort of recent studies that document the spatial aspects of the market and show that rural areas don't have access to the same variety of goods as urban areas in developing countries (Krishnan & Zhang, 2020; Li, 2021). Mengistu et al. (2022) show that the variety of goods available in the local market decreases with fewer varieties available in villages that are remote, relative to their closest market. Similarly, Prabhu et al. (2017) document the difficulties in supplying products to the rural markets. We also posit that the market-space has to have *public good characteristics*, i.e., it is *non-rival* and *non-excludable*, for a market to operate efficiently over it. This implies

[4] See Goldfarb & Tucker (2019) for an overview of flow of information in the digital markets.
[5] Efficiency here refers to the Pareto efficiency criteria.

that markets cannot provide market-space for themselves. That is, market-space requires non-market provision.

3. The third contribution the paper makes is in examining the critical role infrastructure plays in supporting the market-space. Each of these four spatial flows occur in a particular space. Space can be either in the real world or in the virtual world. The real world includes challenging terrain, which can prove to be an obstacle. With any flow, there is also a possibility of congestion. The role of transport and telecommunication infrastructure is to shape spaces in such a way that they both support spatial flows and prevent any congestion in it.

   Understanding how infrastructure can facilitate the four spatial flows by preventing congestion and removing obstacles requires looking at space as social space as conceptualised by Lefebvre (1974). Lefebvre (1974) argues that space is shaped by the *de jure* rules and the *de facto* social rules that are embedded in the space. These are social rules that distinguish the empty physical or Cartesian space from the social space which is shaped by social rules. These social rules, amongst other things, facilitate the flow of objects through space. For instance, the railway network is useless without a well-designed signalling system that ensures safe passage of trains on it. Similarly, roads across the world may look similar in their physical characteristics, but differ in the way they operate. Roads are social spaces that are shaped by the *de jure* rules and the *de facto* social rules that prevail within them.

4. Besley & Ghatak (2006) distinguish *market-supporting* and *market-augmenting* public goods. Market-supporting public goods facilitate the participation of people in markets and allow people to benefit from the gains that accrue from the ensuing market exchange. Conversely, market-augmenting public goods are goods that are under-provided by the markets and require the intervention of the government to ensure its adequate provision. The fourth contribution the paper makes is setting out the reasons why transport and telecommunication infrastructure should be classified as market-supporting public goods. From a policy perspective, transport and telecommunication infrastructure are a prerequisite for creating a conducive market-space that can then support markets.

5. Target 9.1 in Sustainable Development Goals addresses the lost opportunities that result

from the lack of access to market. It lays the responsibility of "equitable access for all" on "sustainable and resilient infrastructure". The advent of new telecommunication technologies has created a degree of complacency amongst policymakers about market access. This paper sets out why the relationship of complementarity between the four spatial flows implies that the transport and telecommunication infrastructure has to be developed concomitantly in order to extend market-space to all denizens of an area. Remoteness is intimately linked to the lack of appropriate transport and telecommunication infrastructure and the critical role it plays in extending the market-space. Our fifth contribution is developing a notion of *remoteness* which occurs when an area lies outside the boundaries of a contiguous market-space.

From a policy perspective, understanding the relationship between markets, space and infrastructure is of critical importance. To do this, we have to examine the role transport and telecommunication infrastructure play in facilitating the four spatial flows within the market-space and extending the boundaries of the market-space. The relationship of complementarity between the four flows means that a market for a particular good can be disrupted if there is an obstacle in even one of the flows. Transportation and telecommunication infrastructure has to facilitate all four spatial flows concomitantly if the boundaries of the market-space are to be extended.

In the section below, we discuss an empirical study of Kerala's coastal fish markets by Jensen (2007). It allows us to frame our discussion about the relationship between markets, space and infrastructure.

1.1 Fish market-space along the Kerala coastline

Jensen (2007) studies 15 coastal fish marketplaces along the 225 km Northern coast of Kerala before and after the rollout of mobile phones along the coastline in 1997. The fisherfolk fishing in the adjoining seas had a choice to make once they had caught their quota for the day. They had to choose which of the 15 coastal fish marketplaces to land their catch of the day. If too many fisherfolk landed their fish near a particular marketplace, there would be an excess supply of fish in the marketplace driving down the price of fish. It often resulted in some fisherfolk jettisoning their catch of the day. Conversely, if very few fisherfolk landed their fish near a

particular marketplace, there would be excess demand, which then would drive up the price of the fish.

Jensen (2007) documents the volatility of the price of fish in these marketplaces before and after the mobile phone service was rolled out along Kerala's coastline in 1997. It finds that the price volatility dropped significantly in the 15 fish marketplaces and the markets for fish cleared more often in these marketplaces. While Jensen (2007) focuses on the data collected from the 15 marketplaces, our interest lies in examining the characteristics of market-space, as we have defined above, in the Jensen (2007) study.

The market-space is the contiguous space that exists between the fisherfolk once they have caught their quota for the day and the buyers at their home who would like to buy fish. Before the rollout of mobile phones, the fisherfolk had to physically visit the marketplace to get information about the prevalent price in the market. This led to excess demand in certain markets and excess supply in others. Once the mobile phones were rolled out, it created a new social space through which price information could flow from the market to the fisherfolk at sea and it led to a significant reduction of price volatility in the market.

In Lefebvre's conceptualisation of space, telephone qualifies as social space through which information about the price could flow across space. When it comes to the market, the social space that the mobile phone creates competes directly with geographical space. The fisherfolk could either traverse the geographic space to get the information in person from the market or the information could flow through mobile phones. These are just alternative spaces through which price information flows from the market to the fisherfolk at sea and informs their decision about where to land their catch of the day. It is useful to note that the mobile phone rollout did not obviate the need for buyers and sellers to physically exchange the fish and the money in person at the marketplace.

The example of the Kerala fish market is an atypical one. The sea provides the fisherfolk with a contiguous space that allows them to travel in any direction they want. The 15 markets along the Kerala coastline are equally accessible in terms of time and money for the fisherfolk at sea. Once they obtain the price information through their mobile phones, the fisherfolk can simply choose which markets to land their fish.

Water bodies offer unusual flexibility in terms of the direction of travel. The cost of moving

goods on water is lower than the traditional ways of moving goods across land. The advent of modern transportation networks, i.e., roads and railways, changed the calculus of transportation in the 19th century. This is the reason why before the advent of modern transport infrastructure, trading cities like Venice, Rome, Banaras, Alexandria and Zanzibar amongst numerous others were often located at the edge of a waterbody. Travelling across land is far more restrictive and people have to rely on the existing transport network like roads and railways. A dense transport network can give people a huge amount of flexibility, just like being at sea. Conversely, the transport network is sparse in rural inland areas leaving the denizens of the area very few options. This is the reason why road building is such a contentious issue in developing countries. Burgess et al. (2015) explore how the roads have been seen as the harbinger of prosperity in the landlocked areas of Kenya and how the various Presidents in Kenya have preferentially directed road-building programmes to their own political base at the expense of the rest of the country.

Market-space may not be as constrained in urban areas as much as it is in the inland rural areas. This is because urban areas across the world are often served by a dense transport network. Collier & Venables (2016) argue that it is cost-effective to provide urban areas with dense transport network because of their high population density. A dense transport network in urban areas allows flexibility in terms of direction of travel akin to what one would experience on water. It may be counter-intuitive but the key lessons about the impact of telecommunication infrastructure on functioning of the market from Jensen (2007) apply more to urban areas and coastal areas than it does to inland rural areas.

The benefits of mobile phones on their own are limited in terms of the functioning of the market in inland rural areas. While mobile phones allow price information to flow freely, it does nothing to alleviate the challenges facing other spatial flow, especially moving goods across the geographical space. This problem is particularly acute in inland areas, away from the waterbodies and dense urban transport networks.

Engendering market-led development in rural inland areas is resource intensive. This is because while a dense transport network may lead to a more even spatial distribution of economic activity by creating a contiguous market-space, they are extremely resource intensive to build. Combes et al. (2011) show that building dense transport networks led to an even spatial dispersion of economic activity in France during the 1930–2000 period. Donaldson (2018)

documents how the expansion of railway network across India from 1853 to 1930 dramatically changed the market-access for remote areas in the country. Prior to railroads, bullocks carted the commodities across India at the speed of 30km per day. Railroads in contrast could transport commodities 600 km in a day at much lower cost. Similarly, Fogel (1979) and Donaldson & Hornbeck (2016) document how the railway and canal network changed market access within the United States of America in the 19th Century.

Donaldson (2018) and Fogel (1979) throw light on the role transport infrastructure plays in shaping inland space and giving remote areas access to markets. The length of railways in India was 67,247 km in 1930 (Donaldson, 2018) and stood at 68,103 kms in 2021 (Government of India, 2022). As we discuss below in the section on remoteness, in spite of a high population density, the transport network density in India is relatively low compared to France and Germany. Hence, there has been limited progress in terms of market-access for the remote rural inland areas in India in the last 91 years.

The key insight from a policy perspective is that the relationship between internet and telecommunication technology and transport infrastructure is one of *complementarity*. When it comes to market-access, internet and telecommunication technology is not a substitute for transport infrastructure. The complementarity with transport infrastructure severely constrains the efficacy of telecommunication infrastructure in facilitating markets in terms of market-access. This is why location within the transport network still matters almost as much today as it did before the advent of the new internet and telecommunication technology.

2 Literature on Markets and Space

2.1 Economics and Markets

There are varied interpretations of what exactly constitutes a market across academic sub-disciplines. Similarly, the colloquial usage of the term market differs from its usage within academe. While to some it conjures up images of a bustling bazaar, for others it may be a supermarket aisle or an auctioneer's gavel.

Within economics, there are various distinct traditions that conceptualise the idea of the market in different ways. The First welfare theorem states that a competitive market leads to an

efficient allocation of resources if there are no externalities associated with the goods and there is no asymmetric information between the buyers and the sellers (Arrow, 1951; Debreu, 1951). Basu (2010) calls it the invisible hand theorem and restates it in the following way.

> If we have a competitive economy, where all individuals choose freely according to the respective rational self interest, then (given a few technical conditions) the equilibrium that will arise will be Pareto optimal. – (Basu, 2010, p. 25).

Pareto optimality is usually taken as the benchmark for a well-functioning market in Economics. By its very definition, a Pareto optimal market equilibrium is one where no one can be made better off without making someone worse off. Markets require space over which they can operate. A conducive space is thus a pre-requisite for a market to function. To our knowledge, the question that has not been raised within economics is what are the characteristics of the space that support a Pareto-efficient market equilibrium?

Friedrich Hayek characterises market equilibrium as one where individuals with local knowledge could have plans that do not interfere with each others' plans (Bowles et al., 2017; Hayek, 1937). It allows for individuals to experiment and allows local knowledge to flourish. Decentralised competition in the market then works as a mechanism for disbursing knowledge across space that local experimentation generates. Friedrich Hayek's emphasis is on the process of social interaction between market participants and the social learning process that the market engenders. Friedrich Hayek thus emphasises the social interaction and social learning process that occurs at a location where all buyers and sellers convene, i.e., the marketplace.

Adam Smith argued in *The Wealth of Nations* that the lower the cost of exchange in the market, the more it would allow workers to specialise in a task. This specialisation would lead to the production process in the society becoming more productive. Coase succinctly captures Adam Smith's intuition in the quote below.

> The welfare of a human society depends on the flow of goods and services, and this in turn depends on the productivity of the economic system — (R. Coase, 1998, p. 73).

While Friedrich Hayek visualised social learning and its impact on productivity through social interaction at the marketplace, which is then dispersed across space through decentralised competition, Adam Smith's intuition was that productivity would increase due to specialisation that occurs because of opportunities to exchange. Friedrich Hayek and Adam Smith's insight

about the functioning of the market complement each other. While Friedrich Hayek emphasises social learning and knowledge accumulation through social interaction at a particular location, i.e., the marketplace, Adam Smith emphasises the flow of goods across space, which leads to specialisation and productivity gains across the economy. Implicit within these views are also different conceptualisation of space over which markets work.

Walrasian General equilibrium assumes that the market transactions take place over a homogeneous and abstract Cartesian space. In Cartesian space, each point is described by a set of coordinates that correspond to its position along the orthogonal axes. Cartesian space is an empty container that animate and inanimate objects could occupy. Its characteristics are not influenced by who or what occupies the space and the social processes that operate within it.

The focus of the New Institutional Economics literature is on the internal organisational structure of these entities and they largely side-step the issue of space. Market is represented simply in terms of transaction cost, i.e., the cost of making an exchange. R. H. Coase (1937) argued that transaction costs play a crucial role in determining the boundary of the firm, i.e., what it produces in-house and what it buys from the market. Williamson (1985) argued transaction costs determine the choice of governance structures within firms and North Douglas (1990) argued that transaction costs are shaped by institutions.

> In transaction cost economics, the functioning market is as much a black box as is the firm in neo-classical microeconomic theory. — (Holmström & Roberts, 1998, p. 77)

Transaction cost theory has very little to say about the functioning of the market, especially the space within which it operates. Transaction cost approach effectively collapses the multi-dimensional space into a unidimensional measure of transaction cost.

While the Spatial General Equilibrium models take into account the transportation costs, location-specific factors and the distribution of economic activity across geographical space (Duranton & Puga, 2004; Fujita & Thisse, 1996; Krugman, 1991), and analyse how economic process like agglomeration and regional development occur, the analysis is almost exclusively done in Cartesian space.

2.2 The Lefebvrian Social Space

> Place is simply there, while space is produced or invented. — (Conley, 2012, p. 2)

The conceptualisation of space in Economics varies with the tradition in philosophy and sociology that follow Henri Lefebvre's conceptualisation of space in his seminal contribution *The production of space* (Lefebvre, 1974). The central proposition in Lefebvre (1974) is that *humans produce social space and are in turn produced by it.* Lefebvre argues that the verb *produce* is key to understanding the nature of space. That is, societies take the empty Cartesian space as an input and *produce* the social space in which they live collectively.

For instance, humans *produce* space through transport and telecommunication infrastructure projects that shape the social space in which they live. The production of space involves not just altering the physical aspects of the space but also shaping the intangible aspects that allow human minds to navigate the space. Henri Lefebvre argues that humans learn to assign meaning to signs, codes, and symbols embedded in space. For instance, a place of worship, a railway station or a marketplace may have their own codes that humans learn through their social learning process. Similarly, people assign meaning to symbols on the roads and walkways. The produced space has both tangible and intangible aspects. The intangible aspects could either be the *de jure rules* designed by someone in power or *de facto rules* that the users of the space agree upon. The social process that operates in the space creates new codes, signs, and symbols as people choose whether to adhere to the codes or deviate from them. Henri Lefebvre's key insight was that the production of space is a continuous ongoing learning process influenced by social processes that play out in the social space. Traffic norms are a good example of how the *de facto* and *de jure rules* emerge as people use constructed roads. We explore this further when we discuss the radical experiment a traffic engineer called Hans Monderman conducted in the Dutch city of Drachten (Vanderbilt, 2008) in the section on infrastructure and market-space.

3 The Conceptual Framework

3.1 Marketplace

It is important to draw a distinction between a market and a marketplace. For instance, in Jensen (2007) the market for fish in coastal Kerala was operating across 15 marketplaces. For a mutually beneficial exchange to occur, the buyer and a seller need to find each other, appraise

the goods, enquire about the goods and if a trade is agreed, exchange the good for money. A marketplace simply facilitates this process by being a *focal point* where a sufficiently large number of potential buyers and sellers convene and search for a mutually beneficial exchange. The key characteristic of the physical marketplace is that it requires a coincidence of geographic location at a point in time between potential buyers and sellers.

The actual space over which the market for a particular good operates goes far beyond the physical marketplace. For a successful market transaction to occur at a physical marketplace, the market participants, i.e., sellers and buyers, travel from their initial positions to the marketplace. The market participants facilitate the *flow of goods and money* by travelling to the marketplace from their initial positions. In doing so, they carry goods and money with them to exchange it at the marketplace. While the transactions may take place at the marketplace, their impact goes much beyond the marketplace. It leads to efficient allocation of goods across a wider geographical space that naturally includes the initial position of all the market participants. Adam Smith's insight was that by engendering these flows across space, a well-functioning market ensures a Pareto-efficient allocation of goods across a wider geographical space.

Market-space is the entire space over which the market operates through spatial flows. It includes the contiguous space between all potential market participants' initial positions. *Marketplace*, on the other hand, serves simply as a focal point where they can meet, interact, exchange and transact. The social interaction that Friedrich Hayek emphasises and the externalities that result from the interaction is complementary to the role the marketplace plays in engendering flows across a wider geographical space.

While the coincidence of geographic location at a point in time is a key feature of a physical marketplace, it is not necessary for a market to function. Markets can operate over a market-space even if there is no discernible location that can be called a marketplace if the spatial flows required for market transactions is feasible, as is the case in virtual marketplaces.

3.2 The four spatial flows

A successful market transaction requires four distinct spatial flows between the buyer and the seller. These flows are initiated from the buyer and seller's initial position. For instance, the

buyer could either traverse the space to get to the physical marketplace or in the case of the virtual marketplace, the good could flow to the buyer, i.e., be delivered at home. In either case, the good has to flow from the seller's initial position to the buyer's initial position using the transport infrastructure. The four spatial flows are as follows.

1. The flow of information from the sellers to the buyers about the quality of goods available in the market.
2. The flow of information about the market price of the goods.
3. The flow of the actual good from the seller to the buyer.
4. The flow of money from the buyer to the seller.

It should be self-evident that each flow requires a space through which the flow could occur. The space through which each flow takes place is not unique and the buyers and sellers may choose the space through which they prefer their flow depending on convenience and its cost. In the past, these flows required people to travel across geographical space which was expensive in terms of time and resources. In human history, new technology has constantly created new spaces which allow flows to occur at a lower cost. For instance, Fogel (1979) documents how the transportation revolution of the 19th century in the United States of America created new spaces like canals and railroads that facilitated the flow of goods. As a result of the transportation revolution, transporting grain and flour by constructed canals and railroads became extremely inexpensive as compared to what it was when it was transported by horse and wagon.

The advent of new technology has led to a new wave of telecommunication infrastructure for mobile telephony, the internet and mobile banking. As Jensen (2007) documents, this new technology has created new spaces through which the spatial flows could occur at a fraction of the cost. This new telecommunication infrastructure has created virtual spaces for the three flows, namely flow of information about quality and price of good and flow of money at a fraction of the cost. Yet, the actual good still has to traverse the physical space from the seller's initial position to the buyer's initial position. The way in which the goods are transported depends on the transport infrastructure.

It is important to note that the relationship between these four spatial flows is one of *complementarity*. Complementarity between the different flows means that the obstacles or bottlenecks in any one space can have disproportionate effect in disrupting the functioning

of the market. It also implies that when it comes to the functioning of the market, there is a relationship of complementarity between transport infrastructure and telecommunications infrastructure that facilitate these flows.

3.3 Market-space

We define *market-space* as the contiguous space between the initial position of buyers and sellers of a particular good through which all four aforementioned spatial flows occur. Market-space is the space through which flow of information about price and quality, the flow of goods and the flow of money occurs. The market-space includes roads, railways, shipping lanes, telephones and the internet, etc. Existence of a market-space is a prerequisite for a successful market transaction. While information, goods and money may flow through different spaces, buyers and sellers have to be linked through all the spaces that facilitate these flows for a successful market transaction to occur.

A conducive market-space that facilitates the four spatial flows is critical for the existence of markets. These four spatial flows also delineate the endogenous boundary of the market-space. The complementarity that exists between the four spatial flows implies that obstacles that prevent even one of the spatial flows can restrict the market-space and restrict its boundaries.

3.4 Characteristics of Market-space

Contiguity is an important characteristic of market-space. Without contiguity, it would be impossible for the spatial flows associated with market to occur. For instance, if the terrain is such that it is very difficult for someone to travel to the marketplace, they would not be able to participate in it. Only people who can reach the marketplace can transact in it. It is the role of the infrastructure to create a contiguous market-space and extend it as far as possible. Contiguity is related to the notion of *remoteness* that we develop below.

For a well-functioning competitive market, the contiguous market-space also needs to be *non-rival* and *non-excludable*. If there is rivalry in market-space, then a transaction by one pair of agents would preclude a transaction by another pair of agents. Further, a well-functioning market must allow everyone to enter the market freely and explore and exploit the opportunities of mutually beneficial trade with other market participants.

The fact that a market requires the existence of non-rival and non-excludable space within which the market transactions take place undercuts the First welfare theorem or the Invisible hand theorem discussed above. The first welfare theorem argues that exchanges between self-interested parties in a well-functioning competitive market can attain efficiency. The First Welfare Theorem is silent on the characteristics of market-space and the nature of its provision. The Transaction cost theory takes the functioning of the market as a black box (Holmström & Roberts, 1998). Given that an efficiently working market requires a market-space that has public goods characteristics, there is no incentive for the self-interested market participants to provide such a space. There needs to be non-market provision of the market-space. Ensuring the provision of market-space is a prerequisite for efficient functioning of markets.

4 Infrastructure

4.1 Types of public goods

> Effective provision of public goods is a key determinant of quality of life. – (Besley & Ghatak, 2006, p. 285)

The key question for a market-based economy is the role policy can play in creating conditions that facilitate the functioning of the market so that it can attain Pareto efficiency. Markets are unable to provide public goods because they are non-rival and non-excludable in nature. In the section above we set out the reasons why for a market to function properly, the market-space has to be non-rival and non-excludable in nature. That is, a market can function properly only if the market-space is a public good. The provision of the market-space thus is the key policy question for any market-based economy.

Besley & Ghatak (2006) provide a classification that is useful in disentangling the relationship between public goods and markets. Besley & Ghatak (2006) distinguish between the two kind of public goods that the government needs to provide. *Market-supporting public goods* are those that facilitate the participation of people in markets and allow them to benefit from gains from trade. This is especially true for the poor and marginalised communities. *Market-augmenting public goods* are the type of goods that a well-functioning market under-provides. It is up to the government to ensure its adequate provision. Besley & Ghatak (2006) cite law

and order as an example of the former and health and education as examples of the latter.

Transport and telecommunication infrastructure in the economic development literature has traditionally been seen as market-augmenting public goods, i.e., it is under-provided and government intervention is required to provide adequate amounts. It literature often argues that the role of the state is simply to fill in the gaps in the infrastructure provision. This paper makes the case that telecommunication and transport infrastructure are also market-supporting public goods. As such, they are critical for extending the market-space and need to be prioritised.

If transport and telecommunication infrastructure are perceived as a market-augmenting public good, then the policymaker's focus is on adequate provision for its end users. Conversely, if transport and telecommunication infrastructure are perceived as market-supporting public goods, then it is the role of the state to extend the market-space and ensure that all denizens of the area have access to markets. As we set out below, this entails creating rules and norms that govern the usage of infrastructure so that the four spatial flows associated with the market transaction can occur without any hindrance or congestion.

4.2 Infrastructure and market-space

> Infrastructures are built networks that facilitate the flow of goods, people, or ideas and allow for their exchange over space. – (Larkin, 2013, p. 328.)

A successful market transaction requires congestion-free spaces for the four spatial flows to occur concomitantly. Larkin (2013) states that it is the role of infrastructure to create conducive space for flows in the society. Hence, it is infrastructure that supports the spatial flow that allows the markets to function properly and attain Pareto efficiency.

Lefebvre (1974) argues social space is produced by humans. While pre-existing Cartesian space is empty, social space incorporates the rules that are used to navigate it. Social space is distinct from Cartesian space. That is, the rules that are used by users to navigate the space are an integral part of the social space. These rules can either be *de jure* rules or *de facto* rules. If *de jure* rules create chaos, then there is scope for *de facto* rules to evolve through collective social endeavour. That is, *de facto* rules can potentially compensate for inappropriate *de jure* rules.

The process through which the collective rules used to navigate space evolve is best il-

lustrated by a radical experiment a traffic engineer called Hans Monderman conducted in the Dutch city of Drachten (Vanderbilt, 2008). Monderman removed all the traffic lights and signs on a crowded four-way intersection called the Laweiplein. After a year, the congestion went down, there were half as many accidents and the use of electronic or hand signals by drivers and cyclists went up. The traffic lights and traffic signs are the *de jure* rules in this example that are part and parcel of the road infrastructure. Monderman removed all the *de jure* rules and left the road users to fend for themselves. The road users over time developed their own *de facto* rules in response to the lack of *de jure* rules on the Laweiplein intersection.

Infrastructure is often perceived as something tangible like a road, a bridge or a mobile phone network. While these tangible aspects of the infrastructure get more attention, the intangible aspects are the rules and norms that govern its use and are as such an integral part of infrastructure. Vanderbilt (2009) contains a detailed discussion on how the prevalent behaviour of the road users is determined by the way the roads, intersection and traffic signs are designed. There is a substantial body of work in Cultural Anthropology and Science and Technology Studies that have explored intangible aspects of infrastructure like the rules and norms that govern its use (Anand, 2017; Anand et al., 2018; Hofmann, 2015; Von Schnitzler, 2008; Winther, 2008).

The Lefebvrian notion of social space and Larkin's notion of infrastructure, especially transport and telecommunication infrastructure, are intimately related to each other. They both involve the process of creating and reshaping physical space and influencing the rules that facilitate flows across space without congestion or hindrance. The key aspect of any infrastructure project is to design a space that facilitates the flows that occur within that space. This requires designing the rules that allow objects within it to navigate the space. Badly designed space lead to congestion and bottlenecks in space.

As we saw in the section above, the four spatial flows associated with a market transaction have a complementary relationship amongst themselves. This means government interventions have to be designed to concomitantly provide spaces that facilitate all four flows that a market transaction requires. If there are obstacles in any of the spatial flows, then improving the other three flows does not yield any significant benefits.

The advantage of Lefebvre's conceptualisation of social space is that it is conceived as the space that is *produced* through human agency. This allows us to examine the virtual and real-

world physical space in one unified framework. It also allows us to examine the role *produced* space plays in the functioning of the market. For instance, the fisherfolk on the high seas along the coast of Kerala could either travel to the marketplaces to acquire information about the prevalent price or after the roll out of the mobile phone network long the coast, they could call to obtain the price information through the telephone. From the perspective of the market, both the mobile telephony space and physical space are part of the market-space and the market participants are free to choose which space they would like to use to pursue a market transaction.

5 Remoteness from Markets

> Develop quality, reliable, sustainable and resilient infrastructure, including regional and trans-border infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all. – Sustainable Development Goals, Target 9.1.
>
> Nearly a third of the world's rural population does not live near a paved road, and it is widely believed that this limits their access to economic opportunities. (Aggarwal, 2018, p. 375)

Both the developed and developing world are dotted with prosperous urban agglomerations. The urban agglomerations are marked by congested high streets and marketplaces with a high volume of market transactions. The leading contender that explains the uneven distribution of economic opportunities across geographical space in new economic geography literature is access to markets (Davis & Weinstein, 2002; Hanson, 1996, 1997; Krugman, 1991). There is overwhelming evidence that in developing countries proximity to urban centres and market access raises income and well-being (Dercon et al., 2009; Dihel, 2011; Fafchamps & Shilpi, 2008; Jacoby, 2000; Jacoby & Minten, 2009; Stifel et al., 2012; Stifel & Minten, 2008, 2017). This leaves behind remote hinterlands of underdeveloped rural areas where there is either limited or no market access for buyers and sellers. *Remoteness* occurs when an area lies beyond the boundaries of market-space for range of goods and services.[6]

[6]Ver Ploeg (2010) examines the link between modes of transport and market access. Ver Ploeg (2010) finds that 8.4% lived in deprived neighbourhoods that are further than a mile from any supermarkets. Further, 2.2% of people don't have access to a car on top of living further than a mile from a supermarket.

5.1 Europe and India

The 1949 division of Germany abruptly cleaved the market-space for the cities in West Germany that bordered East Germany. Redding & Sturm (2008) examine the dramatic transformation in the economic landscape of West Germany that followed the division of Germany.

In the wake of the 1949 division, the market-based economy of West Germany experienced a robust period of economic growth and prosperity. However, this economic prosperity was unevenly distributed across its cities. The cities that were closer to the newly established border with East Germany witnessed a relative decline. Through their analysis, Redding & Sturm (2008) show that their decline is primarily attributable to the disruption of their spatial trading due to the division of Germany. Essentially, they suffered because their market-space was effectively cleaved by the division. Conversely, cities further removed from the border remained relatively unscathed, as their trading links in proximate regions remained within the confines of West German borders.

The empirical analysis of Redding & Sturm (2008) throws light on the intricate interplay between market access and economic development. The division of Germany, by abruptly severing the spatial contiguity of the market-space, engendered a pronounced disparity in the distribution of economic activity within post-War West Germany. It underscores the pivotal role proximity to markets plays in shaping economic activity within a region.

Similarly, Combes et al. (2011) conduct a comprehensive analysis of the spatial distribution of manufacturing and services in France. Their investigation reveals that while there was an initial phase of spatial concentration of economic activity from 1860 to 1930 in France, it was succeeded by increasing dispersion of economic activity from 1930 to 2000. Combes et al. (2011) provide evidence that establishes the link between the dispersion of economic activity across geographical space and enhanced market access for various departments across France. This transformation, they argue is attributable to the persistent decline in transport costs, driven by the comprehensive expansion of a dense rail and road network.

Redding & Sturm (2008) and Combes et al. (2011) through their respective analyses provide compelling insights into the intricate relationship between market access, the spatial distribution of economic activity, and the profound implication it has for economic development. The case of divided Germany and the evolution of economic spatial patterns in France serve as

illustrative examples of how changes in market access can shape the economic destiny of regions and nations.

5.2 Transport and Telecommunication Networks

Table 1 below compares India's rail network with France and Germany. India's rail density at 8.29 km/km^2 is considerably lower than France and Germany's rail density. To reach the current rail density of France and Germany, India would have to add 97,826.44 km and 239,333.2 km respectively to its existing rail length. This translates to increasing its rail length by 143.648% and 351.43% respectively. Rail stations are crucial for giving people access to the network. India's railway station density at 8.29 km/km^2 is significantly lower than France and Germany's rail density. A low stations density implies low accessibility to the rail network.

Table 1: Table 1: Railway Network[7]

Country	Surface area (km^2)	Rail length (km)	Rail density (km/400km^2)	Stations	Station density (per 400 km^2)
India	3,287,260	68,103	8.29	7,337	0.89
France	549,087	27,716	20.19	3,000	2.19
Germany	357,140	33,401	37.41	5,681	6.36

Muralidharan & Prakash (2017) report that the cycle programme for school girls launched by the Bihar government in 2006 led to an increase in enrolment up to 20 km away from the homes of the girls. Taking 20 km as the reasonable measure of accessibility in rural India, we have chosen to report the rail density in Table 1 for an area of size 400 km^2 whose sides measure 20 km. To get an intuitive sense how often on average the railway lines criss-cross an area the size of 400 km^2 we calculate the criss-cross ratio. The *rail criss-cross ratio* in Table 1 is calculated by dividing the rail density per 400 km^2 by the length of two diagonals criss-crossing a flat square area of 400 km^2. The rail criss-cross ratio for an area of 400 km^2 for India, France

[7]The surface area and rail network length data is from https://data.worldbank.org. The rail length data is for the year 2021. Station data for France and Germany is from the SNCF and Deutsche Bahn websites accessed on 12 September 2023. The data for India is from Indian Railways Year Book for the year 2021-22.

and Germany is 0.29, 0.71 and 1.32 respectively. The rail criss-cross ratio of Germany is greater than 1 implying that on average each 400 km^2 area in Germany is criss-crossed by the rail lines more than once. In contrast, France is approximately half and India is one-fifth of the rail criss-cross ratio of Germany.

Table 2 below shows us that India's road network density is very similar to France and Germany. There is an important caveat though. Only 64.69% of the roads in India are surfaced. This means India's surfaced road density is much lower than France and Germany. This indicates that there is still a significant proportion of the population that does not have access to surfaced roads. The lack of surfaced roads remains an obstacle to extending the market-space across India.

Table 2: Table 2: Road Network[8]

Country	Population Density (people/4km^2)	Road length (km)	Road density (km/4km^2)	Surfaced (%)	Surfaced road density (km/4km^2)
India	1,878.64	6,331,757	7.70	64.69	4.98
France	493.60	1,053,215	7.67	100.00	7.67
Germany	952.08	830,000	9.30	100.00	9.30

The empirical evidence suggests that when it comes to trading within the country, geographic distance matters more in developing countries than in developed countries. This leaves the remote hinterlands at a distinct disadvantage as compared to the urban agglomerations in developing countries. Atkin & Donaldson (2015) examine the rate at which cost of trading increases with distance for within-country trade in Ethiopia, Nigeria and the United States. They find the rate at which trading cost increases with distance within Nigeria and Ethiopia is four to five times higher as compared to the United States.

Aggarwal (2018) assesses a road-building program in India[9] that aimed to connect sparsely

[8]The population density data is from year 2020 from https://data.worldbank.org. The road network data is from Government of India (2022). The road network data for France and Germany is from year 2011 from 2022 respectively, obtained from the CIA World Factbook.

[9]*Pradhan Mantri Gram Sadak Yojana.*

populated remote villages to their nearest markets. This initiative provided access to markets for over 110 million individuals between 2001 and 2010, resulting in lower prices and a broader range of goods becoming available to people residing in these remote areas. Similarly, Krishnan & Zhang (2020) study the variety of goods being sold in rural markets in Ethiopia. They find that the variety of goods decline with distance to urban markets.

The figure below shows that in mobile voice subscriptions, India has closed the gap with France and Germany. Conversely, India still lags significantly behind in percentage of people accessing the internet through any device. The fact that more than half the country does not have access to the internet implies that the internet has played a limited role in extending the market-space and eradicating remoteness in India.

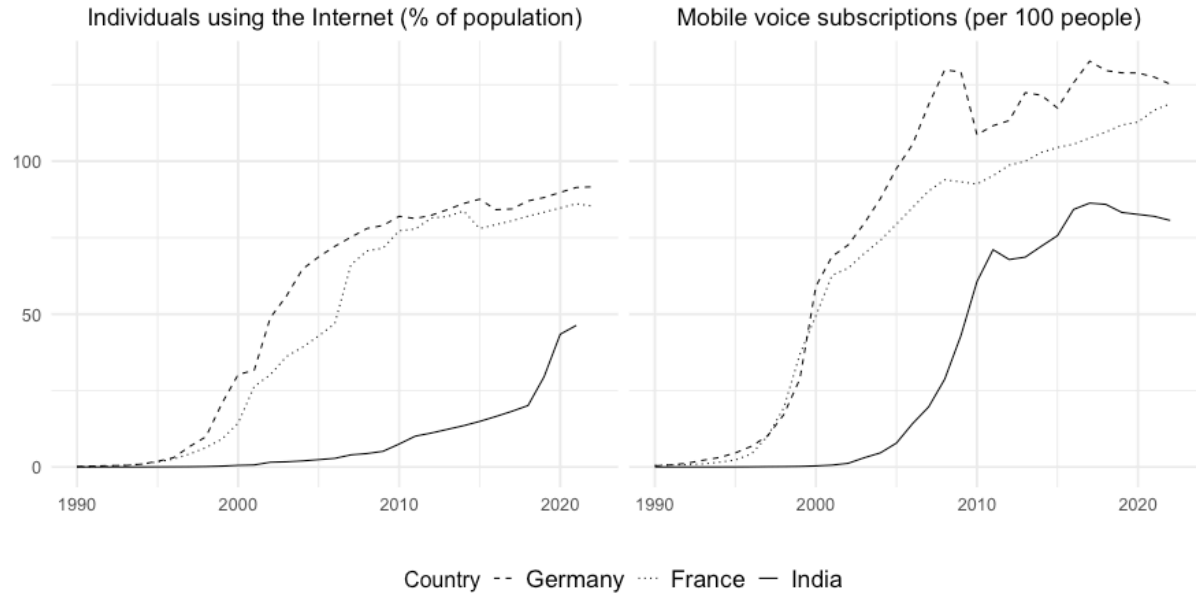

Figure 1: Figure 1: Internet and mobile phone usage in Germany, France and India[10]

As we set out above, a sufficiently dense transport and telecommunication network is a prerequisite for markets to distribute economic activity evenly across geographic space. Remote areas are the ones that lie beyond the market-space and don't have access to the markets. Combes et al. (2011) reports how building a dense transport network extended market space across France and led to the dispersion of economic activity across space during the period 1930–2000. The lack of access to the rail network and the fact that 35.51% of roads are unsurfaced

[10]Individuals using the internet are individuals who have accessed the internet from any type of device from any location in the country in last 3 months. Mobile voice subscriptions are voice subscribers to a mobile phone service. Data for the figure was obtained from the World Bank database.

roads means that a significant part of India is remote and not part of the market-space for a large number of goods. Further, a significant portion of people in India does not have access to internet.

Increasing the proportion of people who can access the internet remains a significant challenge for Indian policymakers dealing with telecommunications. In transport, surfacing roads and extending the rail network across India to give remote areas access to markets and ensuring an even distribution of economic activity remains a significant challenge for Indian policymakers dealing with transport.

6 Conclusion

The spatial variation in the intensity of economic activity where urban agglomeration exists side by side with rural hinterlands is extensively documented in the New economic geography literature. The leading explanation in the literature for the spatial variation in economic activity is access to market and transport costs. By deconstructing a market transaction into four complementary spatial flows, the analysis above sets out the reasons why transport and telecommunication infrastructure play complementary roles in extending market access. The complementarity between the transport and telecommunication infrastructure means that extending market access to remote areas requires investing in both concomitantly. While transport and telecommunication networks have been perceived as market-augmenting public goods, the paper argues that they are in fact market-supporting public goods and their provision is critical in facilitating access to markets.[11]

The efficacy of telecommunication infrastructure in engendering market-led development across geographical space is constrained by the density of transport infrastructure. New technologies have dramatically reduced the cost of creating a dense telecommunication network.[12] Yet, the cost of creating a dense transport network remains high, especially when it comes to inland rural hinterlands. Building a dense transport network may lead to economic development in the long run, but the problem is that building dense transport networks requires a huge

[11] Besley & Ghatak (2006) were the first to draw a distinction between market-augmenting and market-supporting public goods.

[12] Nordhaus (2007) analyses the increase in computer power over the twentieth century and finds that computer performance has improved anywhere between 1.7 and 7.6 trillion times.

up-front investment.

While building a dense transport network has led to the dispersion of economic activity across space in France and Germany, the Indian transport network still remains sparse. Using statistics for transport network density, the paper shows that India lags significantly behind France and Germany in being able to extend market-space across the country. The paper also shows that while India has closed the gap with France and Germany in mobile voice subscriptions, there still remains a significant gap in internet usage.

Extending market access and achieving the *Sustainable Development Goal 9* requires India to invest in transport and telecommunication infrastructure concomitantly. In pursuit of this goal, increasing the proportion of surfaced roads, extending the rail network across India and increasing internet usage remains a significant challenge for Indian policymakers.

For any country, the promise of freeing people from the constraint of their location in accessing the opportunities the global markets offer cannot be realised without creating a dense transport that complements the telecommunication network.

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