Spatial Infrastructure in the Modern Economy

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Abstract

This chapter introduces the concept of spatial infrastructure and distinguishes it from locational infrastructure, which is tied to a specific location. Spatial infrastructure facilitates the movement of people, goods, capital, and information between locations. Spatial infrastructure is characterised by an internal space governed by specifically designed rules for the movement of matter. The integrity of this internal space is maintained by controlling entry and exit through selective access points. The chapter argues that equitable access to these selective access points is essential to overcome the spatial unevenness of economic opportunities and activities in a country. Further, the chapter explores the role of the banking network as spatial infrastructure and uses a successful policy experiment in India to show how spatial infrastructure could engender inclusive development in the modern economy.

Introduction

> "Stay local, go far." This was the rallying cry on a recent poster in Teesside. – Government of the United Kingdom (2022, p. x)

Modernity is synonymous with movement. It entails the movement of people from one place to another for work and pleasure, the flow of information from one place to another and the flow of goods and resources so that people can buy from and sell to faraway places. The potential movement of people, information, goods and resources creates opportunities and prosperity locally. This aspiration to stay local but still benefit from the movement is aptly captured in the aforementioned poster in Teesside and is a stated objective of the UK Government's levelling up strategy (Government of the United Kingdom, 2022). The aim of the levelling up strategy to equalise opportunities to prosper at all locations across the country.

We follow Larkin (2013) in calling any objects that moves from one location to another *matter*. Movement of matter is key to equalising opportunities across locations for people. Movement though requires transforming the pre-existing geographical space to facilitate the movement of matter, i.e., people, goods, resources and information, from one location to another. This transformation requires the creation of *spatial infrastructure* which would facilitate the movement of matter from one location to another through the intervening space. While much of the literature on economic development, such as works by Graff (2024), Redding (2022), Trew (2020), Burgess et al. (2015), and Donaldson (2018), has focused specifically on transport infrastructure, this chapter argues that the prosperity of a modern economy critically depends on its ability to create a broad range of spatial infrastructure, which, in turn, would equalise opportunities across locations by facilitating the movement of matter.

The role of the state in a modern economy is to transform the pre-existing geographical space with the objective of making it conducive for economic and social activity in the country. The chapter distinguishes between infrastructure that is tied to a location and infrastructure that spans across space. We call the former *locational infrastructure* and the latter *spatial infrastructure*. It is the spatial infrastructure that has the potential to transform the pre-existing geographical space by allowing factors of production to flow seamlessly across space, providing

equal opportunity across all locations within the country.

The chapter defines and describes the characteristics of locational and spatial infrastructure. Spatial infrastructure is characterised by the following three defining properties. First, while locational infrastructure is tied to a specific location, spatial infrastructure creates an *internal space* through which matter can move seamlessly from one location to another. Second, creating a conducive internal space through which matter can move requires *designing specific rules* that govern the movement of matter within it. Third, the internal integrity of the spatial infrastructure's inner space can only be maintained if the entry and exits to the internal space are controlled through *selective access points*. The selective access points facilitate the functioning of the internal space by ensuring that the rules that govern the internal space are complied with in its confines. These three specific features characterise spatial infrastructure like electricity grids, gas supply networks, water and sewage infrastructure, railway networks, road networks, broadband networks and banking networks.

By developing these ideas, the chapter presents a framework for understanding infrastructure not only as physical systems, but as institutional and spatial constructs that shape economic life. It explores why spatial infrastructure tends to be unevenly distributed due to historical path dependency, how this reinforces unevenness of economic opportunity across space, and what policy strategies can help redress these imbalances. The chapter reviews a wide range of empirical literature, showing that newly constructed spatial infrastructure can have a positive or uneven effect on an area that is persistent depending on the context. The final section explores the resource constraint governments face in building expansive spatial infrastructure and proposes policy principles that can ensure more equitable and future-oriented infrastructure projects.

A key contribution of the chapter is to reframe the financial networks, especially the banking systems of a country, as a spatial infrastructure. Using India's rural bank expansion programme as a case study, it shows how a regulatory framework that pushes the banking system to create new access points, i.e., bank branches, can potentially reduce poverty and increase national savings. This potentially alleviates the resource constraints that limit a country's investment in

large infrastructure projects. This insight broadens the scope of spatial infrastructure policy and highlights how non-transport systems also facilitate trade and development by moving other critical factor inputs across space.

Conceptual Framework

Location and Spatial Infrastructure

> Infrastructures are matter that enable the movement of other matter. – Larkin (2013, p. 329)

We distinguish between the infrastructure that is rooted in a particular location and the infrastructure that spans across space and allows either people or resources to move from one location to another. We define *locational infrastructure* as infrastructure that provides its service from a specific location. Examples of locational infrastructure include universities, schools, hospitals, social housing, prisons, public buildings, monuments, parks, and other leisure facilities. These are infrastructure facilities that are tied to a specific location, and the services they provide can only be accessed from that specific location. It follows that people need to make their way to these specific locations to avail themselves of its service.

Conversely, we define *spatial infrastructure* as infrastructure that creates an *internal space* that facilitates the movement of people and resources between different locations. The notion of the internal space here is best examined through Henri Lefebvre's conceptualisation of space, as described by Lefebvre (1974). Lefebvre (1974) argues that space is synonymous with the rules that govern movement within that space. The idea of rules being synonymous with space may seem counterintuitive. This may be because as humans, we internalise the rules of the space and use it instinctively to navigate that space. Yet, all spaces that humans engender and produce have rules associated with them. For instance, it is not just the asphalt that constitutes a road. The rules that govern the movement of vehicles and pedestrians on the road encoded in white and yellow paint are an integral part of what constitutes a functional road.

The first key characteristic of spatial infrastructure is that it creates its own *internal space*

within which movement takes place. The spatial infrastructure's internal space has its own *rules* that govern the movement of matter within its internal space. This internal space is best understood as a Lefebvreian space, that is, a space embodied with its own set of rules. When a new spatial infrastructure is built over a pre-existing space, the spatial rules of the new infrastructure replace the rules that govern movement in the pre-existing space. The set of rules that govern movement within its internal space is the second key characteristic of the spatial infrastructure.

To illustrate this, let's take the example of a new motorway that is built on a piece of land. If the land on which the motorway was built was publicly owned land, it would have allowed people and animals to move freely across it. If the land was owned privately, the usage and the rules that governed the space would have been largely determined by the owners of the land. In the case of private ownership, the owners have to ensure that the rules that govern the space comply with the laws of the country. Once the motorway is built and starts operating, the rules that previously governed the movement across the land get replaced by the traffic rules that govern the movement along the motorway. These rules are specifically designed to facilitate the movement of traffic along the motorway. While people and animals may have freely crossed the land before the motorway was built, the motorway restricts their movement to facilitate the movement within the internal space of the motorway. The internal space of the motorway can only be accessed by vehicles at specific locations, that is, the motorway exits. The internal space of the motorway is thus de-linked from the space around it. The rules of the previous space are replaced by the rules that govern the movement along the motorway.

Just like roads, railways create an internal space that is governed by specific rules which govern the movement from one location to another. While vehicles on roads have more latitude for lateral movement, such as changing lanes, trains can move faster than road vehicles because their lateral movements are restricted. Trains are effectively limited to movement in one dimension along the railway track. Moreover, railways employ a comprehensive set of signalling rules that permit only one train to operate on a specific section of the track at any given point in time. This precautionary rule helps prevent collisions between trains.

The spatial infrastructure is not limited to transport infrastructure. Energy infrastructure moves fuel, gas, and electricity from one location to another. For instance, the electricity transmission infrastructure allows electricity to move from the point of generation to the point where it is actually consumed. Similarly, the internet and communication technology infrastructure moves information and voice across space. Irrigation canals move water to areas where they provide surface irrigation that can be utilised for growing crops. While the water infrastructure delivers water to people's homes, the sewage system safely disposes of waste produced by humans.

Anand (2017) studies the water infrastructure of Mumbai, a city where the water supply is far from adequate. Anand (2017) investigates the system of rules governing the water supply infrastructure, which is responsible for distributing 3.4 billion litres of water through 3,000 miles of pipes across Mumbai. There are 800 valves located across Mumbai which control the water supply of the city. Functionaries of Mumbai's municipal corporation constantly travel from one location to another in the city to operate these valves and allocate water to Mumbai's citizens. Just as a city prone to congestion requires a responsive system of traffic lights to manage traffic, the scarcity of water in Mumbai necessitates the presence of these functionaries to respond to the changing needs of its citizens and distribute water equitably across the city. Just like the example of the motorway, the water has very specific entry and exit points from the internal space of the water supply infrastructure, which are actively controlled by the functionaries of Mumbai's municipal corporation. Anand (2017) illustrates the complex set of rules that govern the flow of water through Mumbai's pipes and ensure its equitable distribution to the city's inhabitants.

Carlsson et al. (2013) presents a useful taxonomy of infrastructure which classifies it into five broad categories. The five broad categories are energy, water, transport, internet and communication technology and waste. All five infrastructure categories move people, resources and ideas across space. The infrastructure in each case creates a conducive internal space that facilitates movement. The rules that govern this internal space are designed to facilitate the movement of goods, people, and information from one location to another.

Internal Space and Selective Access Points

It is important to note that the internal space for movement, created by spatial infrastructure, goes beyond the technology and tangible physical representation. While the rules that govern the movement within a spatial infrastructure's internal space may seem intangible, they are integral to its functioning. These rules ensure smooth movement within its internal space.

The internal spaces are delinked from the space around it and require specific points of entry and exit. These *selective access points* maintain the integrity of the internal space within the spatial infrastructure. The selective access points are tied to a location and act as the interface between the internal space of the infrastructure and the space external to the spatial infrastructure. Examples of the selective access points of spatial infrastructure include water taps, electricity plugs, motorway exits, mobile phones, metro stations, and railway stations, to name a few.

The selective access points, which maintain the integrity of the internal space, are the third key characteristic of the spatial infrastructure. For instance, the water infrastructure consists of a network of pipes that create the inner space for water to flow from one location to another. It enters and leaves this inner space through selective access points, i.e., taps, faucets, etc. A network of spigots controls the inner space through which the water flows. A leak in the pipe compromises the integrity of the water supply network's inner space. To maintain the integrity of the inner space, it is absolutely critical that the inner space interfaces with the space outside only at the selective access points.

We can summarise the three key characteristics of spatial infrastructure that we have set out in the discussion above as follows.

1. Each spatial infrastructure constructs an *internal space* that facilitates the movement of matter from one location to another. The matter that moves in the internal space could be people, resources or information.
2. Constructing the spatial infrastructure entails *designing specific rules* that govern the movement of matter in the internal space. These rules are designed to ensure that matter moves smoothly within the internal space of the spatial infrastructure.

3. The integrity of the internal space is maintained by ensuring that the access to the internal space is only through *selective access points*. That is, that matter can enter and exit the internal space of the spatial infrastructure only through these access points.

While banks, post offices, railway stations, and airports may seem like locational infrastructures at first glance, they are actually just selective access points. These selective access points enable people to access the internal space of the respective spatial infrastructure. For instance, a post office allows people to access the postal network, which subsequently moves the post from one location to another. There are specific rules put in place by the postal network to ensure that the post moves smoothly in thorough the inner space of the postal network. Railway stations and airports facilitate the movement of people and freight from one location to another. Similarly, a well-functioning banking system collects savings from various locations and moves it across space to redeploy it as loans at locations where the projects yield the highest marginal return to capital. Local bank branches are the selective access points that give people access to the internal space of the country's banking system which moves funds across space.

There may be more than one entity accessing the inner space of the spatial infrastructure. For the inner space to function as it is intended, it is critical that all entities accessing the inner space adhere to the rules that govern the movement of matter through the inner space. Adherence to these rules could either be through formal legislation of or through rules voluntarily agreed by all entities involved. For instance, the rules that govern the flow of information through the telephone lines and fibre broadband are rules that are voluntarily agreed by all the broadband companies without the need for any formal legislation. Conversely, the de facto rules that govern the flow of pedestrians on the road may deviate from the de jure rules of the road. The de facto rules are agreed upon unwittingly by the various users of the road.

Banking System as Spatial Infrastructure

Thinking of a country's banking system as a spatial infrastructure may seem counter-intuitive. At first glance, individual banks may appear to be locational infrastructures, but this is simply because a bank branch is tangible and we can experience it. The individual banks though are

simply the selective access points for the banking system's internal space. A country's banking system possesses all the characteristics of a spatial infrastructure. It plays a critical role in redeploying resources from one location to another. It accomplishes this by collecting savings from locations across the country and lending them to firms and individuals that are located elsewhere. The internal space of the banking system is carefully constructed by the rules that are put in place by the Central Bank of the country. The banking network facilitates the smooth flow of funds through its internal space from one location to another. The range of financial institutions licensed by the country's Central Bank serves as the selective access points for the banking system.

Both saving and borrowing are acts of concomitantly moving funds across time and across space. Saving for an agent is the act of transferring funds from the present to the future. Conversely, borrowing for an agent is the act of transferring the funds expected in the future to the present. The banking system reallocates the funds that agents choose not to consume today to agents and firms that choose to borrow against future income. The potential savers and borrowers are also spatially separated from each other and unlikely to find each other on their own. A well-functioning financial system effectively moves savings from one location to another, ensuring that all resources not consumed in the country during the current period are redeployed in projects that yield the highest marginal return on capital. Essentially, a well-functioning banking system facilitates mutually beneficial transactions between borrowers and lenders who are spatially separated. It is the spatial matching that allows borrowers and savers to move funds across time.

The way bank branches are located across the country determines the access to the banking system.[1] Beck et al. (2007) studies the access to the banking system and finds that there is significant variation in access to the banking system across countries. It finds that Spain exhibits a remarkably *high demographic penetration* (95.87 branches per 100,000 people), nearly twice the rates observed in Austria (53.87), Belgium (53.15), and Italy (52.07). Japan (9.98) and the United Kingdom (18.35) record significantly lower demographic penetration, which is

[1]Before the advent of ICT and mobile banking, the easiest way to access the banking system was through a local bank branch. Just like ATMs in the 1980s, mobile banking now complements the role of bank branches. Yet, the bank branches still retain numerous specialised functions.

somewhat surprising given their high levels of economic development and urbanisation. In terms of *geographic branch penetration*, Belgium stands out with an exceptionally high density (181.65 branches per 1,000 square kilometres), considerably surpassing Germany (116.90), Italy (102.05), and Spain (78.90). The United States shows a notably low geographic branch density (9.81 branches per 1,000 square kilometres). Spain, despite having the highest demographic branch penetration, does not have a correspondingly high geographic branch penetration, suggesting a concentrated branch network relative to population distribution rather than spatial distribution.

The disparities highlighted by Beck et al. (2007) suggest significant differences in access to banking infrastructure across the developed world and present a striking example of how even access to a critical spatial infrastructure like banking is far from universal even in developed countries. Similarly, Combes et al. (2011) analyse the distribution of manufacturing and services across France and find that the spatial concentration declined from 1930 to 2000 due to an expansion of the road and rail network which led to to a decline in cost of transporting goods to the market. This underscores the point that access to spatial infrastructure continues to evolve and expand even after a country has become developed.

Bank Branch Penetration in India

Until the 1960s, the saving rate in India was extremely low, hovering around the 15 per cent mark. There was a significant increase in the saving rate in India in the 1970s. According to Basu & Maertens (2007), there is a policy puzzle as to why the savings rate started increasing suddenly in the 1970s. This rise is significant because it was followed by an increase in the growth rate of India's GDP.[2] Basu & Maertens (2007) argue that the nationalisation of banks in 1969 and the subsequent increase in bank branch penetration led to an increase in India's saving rate. Figure 1 shows the increase in savings and credit as a share of India's GDP in the 1970s. Burgess & Pande (2005) examines the impact of a large-scale, state-led bank branch expansion programme on savings mobilisation and credit expansion across India. Burgess & Pande (2005) demonstrates that in areas where new branches were opened, there was a decline in the rural poverty rate across India. Conversely, the urban poverty rates were not impacted by

[2]Virmani (1997), DeLong (2003), Wallack (2003), Panagariya (2004) and Rodrik & Subramanian (2005)

the state-led bank branch expansion programme.

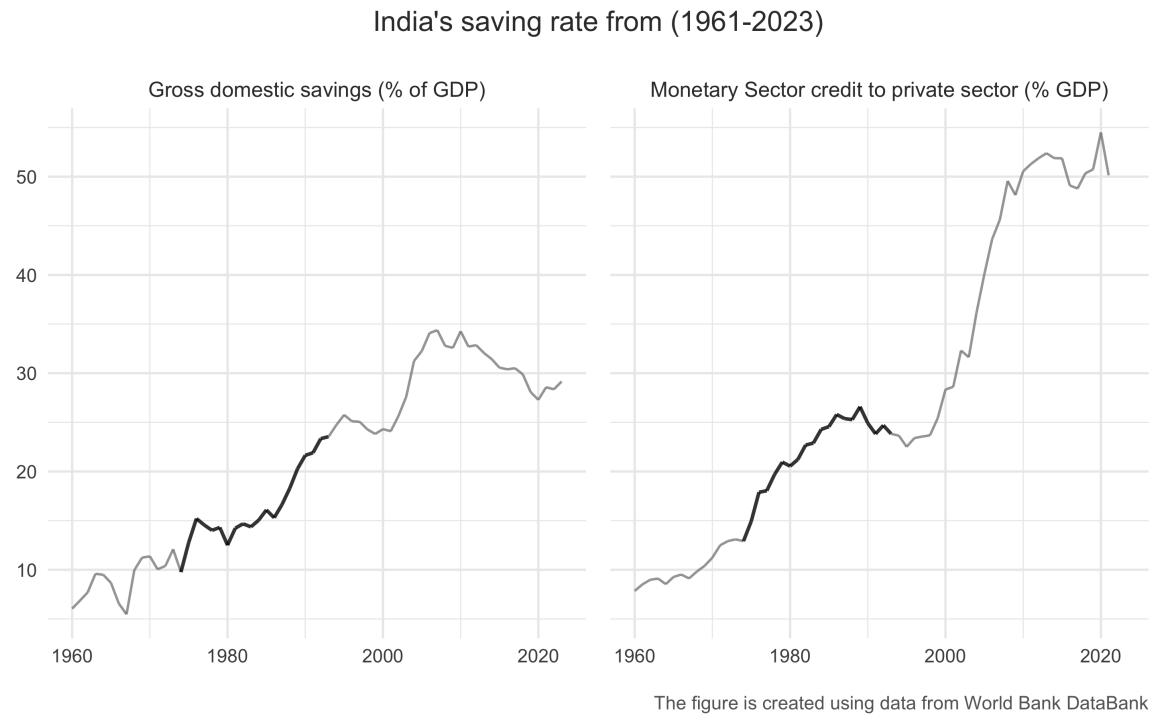

Figure 1: Figure 1: India savings and credit as a share of GDP.[3]

Left to their own devices, banks prefer to establish branches in wealthier urban areas. After the banks were nationalised in India in 1969, the government initiated a programme that aimed to increase the rural poor's access to formal credit and savings. The primary objective of the programme was to expand branches into the most populous rural locations that were unbanked. An area was defined as unbanked if it did not previously have any formal financial institutions. This led to approximately 30,000 new bank branches being opened between 1969 and 1990 in rural areas that lacked formal credit and savings institutions.

To further incentivise rural branch expansion, the Indian Central Bank introduced a new branch licensing policy in 1977. This licensing policy, in effect until 1990, required banks to open branches in four eligible unbanked locations to obtain a license for a branch opening in a location with one or more branches. The one-to-four licensing policy resulted in an increase in bank branches in less financially developed states and districts between 1977 and 1990, thereby moving

[3]The figure is created using data from the World Bank DataBank at https://databank.worldbank.org.

towards equalising the presence of bank branches across Indian states. Figure 2 illustrates the increase in the demographic bank branch penetration rate in India from 1961 to 2000.

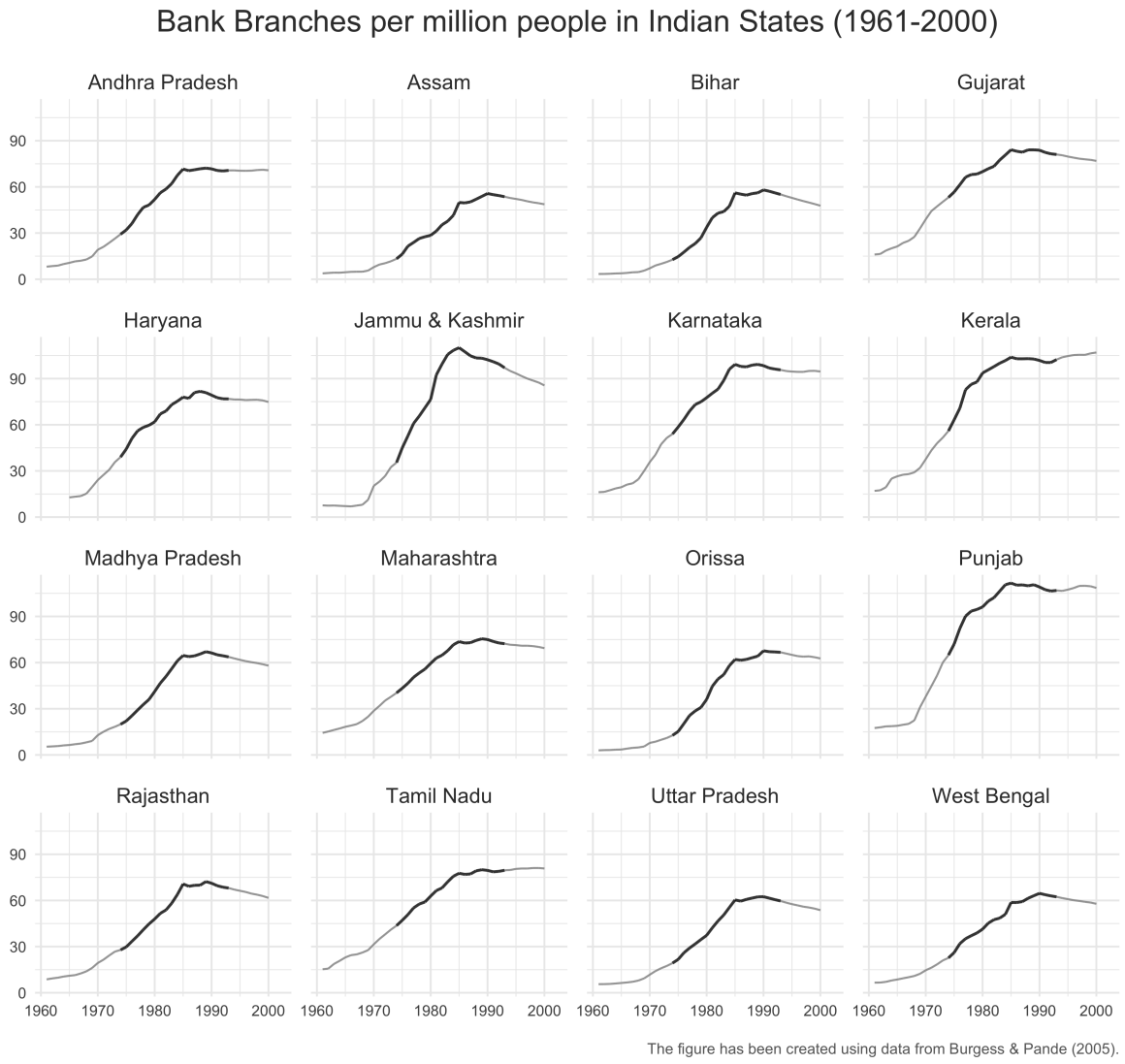

Figure 2: Figure 2: Demographic Bank Branch Penetration in Indian States from 1961 to 2000.[5]

Burgess & Pande (2005) finds that the rural branch expansion can account for a decline in rural headcount by 14 to 17 percentage points. This accounts for approximately half of the total poverty reduction during that period. What is significant is that while the expansion of branches into rural unbanked locations significantly reduced rural poverty through financial intermediation, the programme did not affect urban poverty outcomes. This is because the

[5]Figure 2 is created using data from Burgess & Pande (2005) which is publicly available at https://www.openicpsr.org/openicpsr/project/112313.

branch expansion programme was increasing access to spatial infrastructure in rural areas of India where the saving and borrowing opportunities were previously local. These areas previously did not have a mechanism to escape the constraint of the location and access the opportunities to save and borrow from other locations.

While there is usually emphasis on the fact that saving and borrowing are intertemporal trades,[6] there is less emphasis on the fact that saving and borrowing are also concomitantly spatial trades. The scope for spatial trades is due to the fact that income shocks are often spatially covariate (Dercon, 2005). This implies that income shocks at two locations are less likely to be correlated as the geographic distance between the two locations increases. This gives households who live further apart a much greater opportunity to lend and borrow to mutually insure each other in times of crisis by being part of a risk-sharing agreement. While it may be easier to have informal risk-sharing arrangements locally, enforcing the risk-sharing arrangements becomes more difficult over long distances. Hence, the informal financial networks are sub-optimal because they spatially constrain the risk-sharing arrangement. A functional risk-sharing arrangement thus usually remains local.[7]

Bank branches are critical in allowing households to mitigate risk by accessing the country-wide formal financial network. Faced with an unpredictable income stream, households can borrow and save to smooth their consumption. In the absence of access to formal financial institutions, households often rely on local moneylenders or informal networks to borrow funds when faced with an income shock.

Access to the formal financial system allows households to potentially borrow and save across the country. This access to the formal financial network's internal space requires having access to a selective access point, i.e., a branch of a formal financial institution.[8] This is the reason why the state-led bank expansion programme in India led to an increase in the saving rate in rural areas (Burgess & Pande, 2005). The bank expansion programme provided the rural areas

[6] See Besley (1995).

[7] Banerjee & Duflo (2005) presents empirical evidence that shows that there is huge variation in the cost of borrowing within developing countries. Conversely, the opportunities to save in developing countries are very limited and savings offer either zero or negative rates of return (Besley, 1995).

[8] For instance, bank branches still play an important role in the subjective evaluation of loans for local entrepreneurial projects.

access to the banking system's internal space that allowed them to access saving and borrowing opportunities from locations across the country. The bank branch licensing policy of the Indian Central Bank, which resulted in increased bank branch penetration in Indian states, starkly sets out the policy challenge of investing in spatial infrastructure to provide equitable opportunities to participate in the modern economy.

Incomplete Financial Network

A complete financial network would offer opportunities for all savers and borrowers to save and borrow from the network. It should ideally link all potential borrowers and savers in the country either directly or indirectly through financial intermediaries so that they can save and borrow at the prevalent interest rate. The financial intermediaries are the banks and other formal and informal financial institutions that offer agents opportunities to borrow and save.

Incomplete and fragmented financial networks emerge when some potential borrowers and savers cannot join the financial network. Gale & Kariv (2007) characterises an incomplete financial network as one where some pairs of traders cannot trade directly with each other. This creates a role for financial intermediaries who facilitate transactions between a pair that cannot trade directly. The more incomplete the network, the greater the need for financial intermediaries to facilitate transactions and the higher the transaction costs associated with intermediation.

Financial institutions are often concentrated in large metropolitan areas and urban agglomerations where there is economic activity. The high population density lowers the cost of financial intermediation. The centrality of these locations ensures that there is more economic activity in these areas, which, in turn, skews the architecture of the financial network towards these large metropolitan areas and urban agglomerations. It also means that people living in these areas have easier access to the financial network of the country. This feedback loop between the location of financial institutions and economic activity creates a closed financial network that disadvantages the locations and places where there are no branches of financial institutions. This potentially leads to a core-periphery architecture of a financial network that is extremely densely connected in metropolitan areas and urban agglomerations and very sparsely connected

in rural areas.

Having a financial institution like a bank at a reasonable distance is key for individuals in a locality to be connected to the financial network of the country. It follows that creating a complete formal financial network requires a high degree of demographic and geographic bank branch penetration in the country.[9] In the absence of a complete formal financial network, fragmented financial networks emerge locally that are delinked from the country's formal financial network.

Investment in Spatial Infrastructure

Spatial infrastructure has an extraordinarily long life. Its life is measured in decades and centuries. For instance, the railway networks and the sewage system set up during the 19th century still persist in large parts of the world (Donaldson, 2018). The problem is that setting up the spatial infrastructure requires a considerable upfront fixed cost investment. This spatial infrastructure also exhibits increasing returns to scale. The scale of spatial infrastructure is determined by the resources available for infrastructure investment. Aniket (2018) presents a model that delineates the resource constraints encountered by a country in the process of financing new infrastructure. A country's economic output in any given period of time can be directed towards three usage categories.

The first category is private consumption. This is simply the consumption expenditure incurred by households within the country. The second category is tax. This is the portion of the current output that the government collects as revenue by taxing the economic activities in the country. This tax revenue can be further subdivided into three subcategories: the amount expended by the government on its own consumption, the amount allocated for the creation of new public capital and the amount allocated to the maintenance of existing public infrastructure i.e., accounting for depreciation of the public infrastructure. The third category is private savings. The banking sector plays a pivotal role in collecting savings from private households and loaning them to entrepreneurs across the country. In doing so, the banking sector channels

[9] Using data from 99 countries, Beck et al. (2007) provides an excellent discussion of financial sector outreach in a country and its relationship with financial sector depth.

savings towards gross investment. In aggregate terms, the savings in the economy are ultimately utilised for the formation of new private capital and the maintenance of existing private capital (factoring in depreciation).

The new capital stock in the economy, whether it is publicly or privately funded, is simply the residual portion of the country's output that is not consumed in the current period and is used to maintain the pre-existing capital stock. This implies that resource constraints limit the amount of privately or publicly funded infrastructure that a country can establish in a period.

Empirical Evidence

There is an emerging body of empirical research that quantifies the impact of new transportation and communication infrastructure that connects previously isolated or under-connected rural communities to urban markets and the broader economic system of a nation. There are basically three distinct strands in the empirical literature.

Positive Impact of Investment in Spatial Infrastructure

The first strand of the empirical literature finds spatial infrastructure has a positive impact on its economic activity in the area. The seminal paper in this strand in this strand of the literature is Donaldson (2018). It examines the impact of colonial investment in Indian railways during the period of British Raj. The newly constructed railway network connected the previously isolated rural areas and gave these areas access to the country-wide markets. Donaldson (2018) finds that reduction in trade cost led to reduced price dispersion in agricultural markets and increased real agricultural incomes.

In a similar vein, Jensen (2007) finds the introduction of mobile phones in the 1997-2001 period reduced the price dispersion of fresh fish in the 15 coastal fish markets it studied along the northern cost of Kerala in India. The mobile phones gave the fishermen access to contemporary market information while they still at sea. This information enabled them to strategically land their catch at markets where the demand was high and avoid markets where there was oversupply of fresh fish. The reduced price dispersion that follow the introduction of mobile phones in the

area benefited both the consumers and the fisherfolk.

Donaldson & Hornbeck (2016) find that the newly constructed railway network in the US increased the market value of agricultural land by giving market access to the previously isolated rural areas. Jedwab & Moradi (2016) studies the impact of the construction of two railway lines during the colonial era that connected the interior regions of Ghana to the port cities of Sekondi and Accra. These railways lines significantly increased production and export of cocoa. The increased cocoa production directly led to a substantial increase in the population of urban areas within a 10km radius and rural areas within a 30km radius of the railway station.

Asturias et al. (2019) examine the construction of the Golden Quadrilateral in India, a network of highways that connected the four major metropolitan areas across the country. It finds that states that were closest to the Golden Quadrilateral experienced an increase in economic activity while the states that were the furthest away were either unaffected or negatively affected by it. Similarly, Ghani et al. (2016) finds that the construction of the Golden Quadrilateral led to substantial increase in economic activity in the narrow corridor of districts that were 0-10 kilometres away from the Golden Quadrilateral. Conversely, there was no growth in economic activity beyond this narrow corridor in districts that were 10-50 kilometres away from the Golden Quadrilateral.

While most study the impact of construction of a new infrastructure, Storeygard (2016) takes a different approach. Storeygard (2016) examines the variation in transport cost on economic activity in a more natural context, i.e., the variation in global oil price shocks during the 2002-2008 period. The study uses this to examine the impact of transport cost on economic activity in 289 countries across 15 countries in Sub-Saharan Africa. The study finds that in the cities connected to the port cities via paved roads, the elasticity of economic activity with respect to the transport costs is quite high. Conversely, the economic activity in the cities connected to the port city by unpaved road depends on the transport cost to its nearest city. This reflects that fact that the former are integrated into the global markets as compared to the latter.

Nuanced Impact of Investment in Spatial Infrastructure

The second strand of empirical literature consists of studies that find a nuanced impact on the economic activity of the area once it has access to spatial infrastructure. In this literature, the impact of spatial infrastructure is uneven with some regions benefitting at the expense of other areas. Asher & Novosad (2020) study the impact of an ambitious 40 billion dollar rural road construction building project in India. It aimed to build a paved road connection to remote villages that were more than 2 kilometres away from a paved road. The study finds that while the road building programme led to a significant increase in availability of transportation services, it did not lead to any changes in the nature of the economic activity in these villages. Agricultural production remained stagnant, and farmers engaged in subsistence agriculture continued to do so. There was also no increase in either assets or incomes for the people living in these newly connected villages.

Asher et al. (2022) study the long-run impacts of India's century old irrigation canals network which span over 300,000 km across India and deliver water to over 100,000 villages. There was neither a structural transformation in the villages that got access to the surface irrigation nor was there a spillover effect in adjacent villages. The consumption of 60% of households who own little to no land remained stagnant. While access to surface irrigation from the canals raised the agricultural productivity and economic returns to land in the area, it actually led to labour migrating away from the villages to regional urban areas.

Faber (2014) finds that counties that were inadvertently connected to China's National Trunk Highway System, simply because they were located along the route connecting two major metropolitan areas, experienced a decline in economic activity largely due to a decrease in industrial output. Baum-Snow et al. (2020) studies the impact of the Chinese highway system on local economic outcomes and finds that the expansion of the high system led to primary metropolitan areas specialised in manufacturing and services leaving the rest of the areas in the region to specialise in agriculture. As a result, the metropolitan areas grew faster and experienced faster private sector wage growth than the rest of the areas in the region.

Long-lasting Impact of Investment in Spatial Infrastructure

The third strand of the empirical literature finds that initial investment in spatial infrastructure has persistent effects that last on a long time on the spatial pattern of population settlements and economic activity.

Jedwab & Moradi (2016) document a compelling example of this historical dependence in Ghana. It examines the impact of the railroad construction during the colonial period in Ghana on the present-day road network. Despite the eventual collapse of the railway network established during the colonial era, its influence persists in the present-day road network of the country. The current infrastructure continues to adhere to the patterns initially established by the railway network, thus underscoring the enduring impact of early infrastructure investments in equalising opportunities across space within a country. Similarly, Burgess et al. (2015) finds that the historical imbalance in the road network persists in Kenya and the new roads that have been built in Kenya in the post-colonial period have failed to correct this imbalance. Graff (2024) examines the transport network in every country in Africa and finds that these transport network still follows the patterns established during the colonial period.

Production can only occur at a specific location if the firm has access to all the necessary factor inputs at that location. Therefore, production at a location necessitates the existence of the spatial infrastructure that could facilitate the movement of the required factor inputs to the specific location. This is especially true if the factor inputs are complements in the production process and the spatial infrastructure makes some complementary factors more mobile than others. The newly constructed spatial infrastructure in this case would simply displace the economic activity to a location where all the complementary factor inputs are available. Mobility of factor inputs critical for the production process is the key difference between the first and second strands of empirical literature.

Without access to spatial infrastructure, the production would remain localised and the size of the market would be limited to local consumers. The product would not reach all its potential consumers in the wider economy. It is evident that increased market access that spatial infrastructure brings with it will increase the economic activity in the wider region.

Though, exactly where that economic activity is located within the wider region depends on the differential mobility of the factors across locations.

While mobility of some factors, such as electricity and capital through bank loans, is more dependent on the available selective access point, there is one factor input that stands out as being more mobile than others. That factor is labour. Given human agency, labour is always mobile and responds to economic opportunity. Consequently, we frequently observe the outward migration of labour from rural areas in response to the construction of new spatial infrastructure in the second strand of the empirical literature producing nuanced analyses of the communities they leave behind. While productivity gains are realised through spatial relocation of labour, this migratory pattern leaves behind communities where the benefits from the investment in the spatial infrastructure are limited. The third strand of the empirical literature is a useful reminder that population settlement patterns are in the first place a result of either natural spatial infrastructure, such as rivers and oceans, or human-made spatial infrastructure of the past like railways, roads and ports.

Discussion and Recommendations

The Resource Constraint

Building spatial infrastructure requires a large investment up front. The resource constraint limits the scale of the spatial infrastructure. This results in the spatial infrastructure being confined to certain parts of the country leaving behind swathes of rural areas that are not covered by the spatial infrastructure.[10] Resource constraints may limit the spatial infrastructure to certain parts of the country leaving behind swathes of rural areas. It could also be the case that the selective access points are not equitably distributed across the country due to resource constraints. The internal space of the spatial infrastructure can only be accessed from certain selective access points, which are tied to locations. The internal space is accessible for individuals and firms if they have a selective access points nearby.

[10] Aghion (1999) and Mazzucato & Penna (2016) stress the role development banks can play in adding the much needed infrastructure in the country.

Access to spatial infrastructure can significantly boost the economic activity in a location. Spatial infrastructure moves critical factor inputs like electricity, gas, water and capital financed by banks loans across space. Access to these critical factor inputs increases the productivity of local firms. Spatial infrastructure allows labour to be efficiently allocated across space. The movement of matter is key for markets to function. Spatial infrastructure creates the space over which the matter moves and allows the markets to work (Aniket, 2023). Access to spatial infrastructure allows the firms to buy inputs from all the locations that are connected to the spatial infrastructure. It also allows local firms to sell their products to all the locations that are connected to the spatial infrastructure.

As discussed in the section above, building new infrastructure requires channelling output that is not consumed in the current period towards new infrastructure projects. The financial network plays a crucial role in gathering savings from agents in the economy who want to save and directing it towards private and public investment. Low demographic and geographic penetration of the financial sector can severely limit the ability of the country to build spatial infrastructure. The lack of spatial infrastructure in turn inhibits the functioning of the market and leaves economic opportunities unexploited. The Indian bank nationalisation and subsequent branch expansion programme is a really interesting experiment in this regard. It is striking that incentivising bank branch access led to an increase in India's national saving rate (See Figures 1 and 2). This allowed the Indian banking network to channel savings to private and public infrastructure projects across the country.

The uneven distribution of spatial infrastructure is the root cause of uneven economic activity across space. The uneven distribution of spatial infrastructure is further exacerbated as future investments in spatial infrastructure tend to follow the trajectory of previous investment patterns. This phenomenon is particularly pronounced in developing countries, where the effects of early infrastructure investments persist for long periods. The longevity of these effects can be attributed to the resource constraints, which limit the ability to diversify and expand the spatial infrastructure.

The historical dependence of spatial infrastructure investment patterns poses significant

challenges, particularly in developing countries. It underscores the need for strategic planning and diversified investment approaches to break away from historical patterns and achieve a more equitable distribution of spatial infrastructure. The policy challenge for a country is to construct a spatial infrastructure that is evenly distributed throughout the country. This can be achieved either directly by the government building publicly funded spatial infrastructure or by creating a policy environment that incentivises the private sector to create spatial infrastructure that is accessible and affordable for all. Fabre & Straub (2023) surveys the infrastructure investment patterns and finds that private participation in infrastructure projects still remains very low across the world. The responsibility for providing adequate infrastructure still remains with the government.

Investing in key spatial infrastructure projects has the potential to create equal opportunities for economic prosperity and development nationwide. Although the social returns from such investments are substantial and can radically transform a country, they are highly resource-intensive and require significant up-front investment. At each stage of development, a country is constrained by the resources it can allocate to spatial infrastructure. This challenge lies at the core of the low and middle-income traps that many countries face. Progressing from one stage of development to another necessitates securing the resources needed to invest in spatial infrastructure, which facilitates the movement of goods and services and fosters economic prosperity.

Policy Recommendations

Investing in spatial infrastructure goes beyond merely constructing the physical aspects of the infrastructure. It is a strategic decision that shapes the underlying geography of economic opportunities. The main argument of the chapter is that spatial infrastructure determines who can access markets, services, and factor inputs across space. It is the unequal distribution of spatial infrastructure that underpins spatial disparities in development. There are numerous policy implications that follow from this.

1. The investment in infrastructure should not be measured by its volume. It should be

measured through the access it provides and the movement it facilitates. This means not just measuring the length of railway network but quantifying its demographic and geographic penetration. This would naturally lead to targeting interventions in underserved regions, particularly those that have been historically excluded from financial, transport, or digital networks. As we know from the New Economic Geography literature, not being connected to the wider economic system can give an area trade protection where people buy local. While this may be suboptimal, any investment in spatial infrastructure that drains the human capital away from the area could potentially leave the area worse.

2. It follows that when investment in spatial infrastructure targets under-connected areas, it should ensure that the spatial infrastructure facilitates the movement of a full range of complementary factor inputs. If this does not happen, the economic activity from the area will simply be displaced to previously better-served areas, such as port cities and the largest metropolitan areas in the region. For example, simply building roads without improving access to electricity, gas, the financial system, and other support institutional infrastructure will lead to out-migration of human capital from the area, leaving behind empty communities that may potentially be worse off.

3. It is important that spatial infrastructure is designed with equity as an objective in mind so that it ensures fair and equal access to selective entry points like bank branches, railway stations, mobile towers, etc. Equity is an important objective in the design of spatial infrastructure that often gets overlooked. This is especially true given that often spatial infrastructure is designed by metropolitan elites in a self-serving way.[11] Selective access points, while giving access to the underserved, are also naturally costly to put in place. Equitable access requires deliberate placement of access nodes to ensure all members of the communities can access the internal space of the spatial infrastructure with ease. The chapter has set out why rules governing the internal space of the spatial infrastructure are as important as its physical components. The governments thus must ensure that regulatory frameworks, interconnection standards, and governance arrangements enable smooth and

[11] Flyvbjerg (2014) describes the process through which mega-projects are often badly designed because they are designed to serve the people who design it rather than its end users.

inclusive access, especially in systems involving multiple actors like in broadband and banking.

4. The case of Indian banking nationalisation illustrates how a push by the regulator can expand access to financial networks across the country, which in turn reduces poverty and increases the available national savings for further private and infrastructure investment. Given that income shocks are often locally spatially covariate, high demographic and geographic penetration of the banking network can facilitate risk-sharing across different parts of the country. The banking network can not only enable trade and productivity by providing saving and borrowing opportunities to local communities, they can also enhance their resilience by allowing people living in these communities to borrow when there is an unanticipated income shock due to unanticipated events like floods or droughts. Expanding the demographic and geographic penetration of the banking network in underserved areas should be viewed as both a development and financing policy which can potentially break the resource constraint and engender further spatial infrastructure investment.

5. Investment in spatial infrastructure could potentially increase agglomeration in areas where economic activity is flourishing while causing outmigration or stagnation from the under-connected areas initially targeted by the spatial infrastructure. It is important that policymakers anticipate these distributional effects and spatial trade-offs in the design of the infrastructure. The chapter makes the case for the broad big push spatial infrastructure project where investment in a broad range of spatial infrastructure is made concomitantly. These types of projects that concomitantly target a broad range of factor inputs may have better returns to the investment as compared to narrow spatial infrastructure projects. It is very difficult to break the historical path dependence given that spatial infrastructure persists for an inordinately long time and creates path dependence in the economy. New investments in spatial infrastructure often follow the contours of past infrastructure investment, thus reinforcing spatial inequality. Overcoming the historical imbalances requires broad big push spatial infrastructure projects as described above.

Conclusion

Modern economies are characterised by the movement of matter, i.e., people, goods, capital, and information. This chapter contends that spatial infrastructure serves as the foundation of a modern economic system by facilitating the movement of matter across locations. Access to spatial infrastructure creates economic opportunity, fosters market integration, and enables development that is inclusive in nature. Without it, communities remain disconnected from the national and global economic system, and their geographical location becomes their destiny.

A central contribution of the chapter is to distinguish spatial infrastructure and locational infrastructure. While locational infrastructure delivers services from fixed sites (e.g., schools, hospitals), spatial infrastructure facilitates the movement of matter across locations. Further, spatial infrastructure consists of an internal space, governed by rules and accessed through selective points, which allows it to facilitate the movement of matter from one location to another. For instance, roads, railways, electricity grids, water systems, financial networks, and digital platforms all have the three characteristics that define spatial infrastructure.

The chapter also aims to reframe the understanding of financial systems, in particular the banking network, as a type of spatial infrastructure that facilitates the movement of a critical factor input for firms across locations, i.e., capital investment that is financed through bank loans. The banking system transforms savings gathered at the saver's location into bank loans that are then delivered to a borrower at its location. In transforming savings into bank loans, the banking system facilitates the flow of funds from the saver's location to the borrower's location. When loans are repaid, the banking system transforms the borrower's repayment into returns for savers. It does so by facilitating the flow of funds from the borrower's location to the saver's location. The Indian Bank nationalisation experiment documented by Burgess & Pande (2005) shows how deliberate state intervention in expanding selective access points through regulatory means can potentially increase national savings and alleviate poverty.

The empirical literature shows that investment in new spatial infrastructure could in some contexts increase the economic activity and incomes of previously under-connected communities. Conversely, it could also displace the economic activity to large metropolitan areas and trigger

an outward migration from these very communities.

The empirical literature also documents how the effects of the spatial infrastructure persist for a long time. The patterns of spatial infrastructure are shaped by past investments and shape the future development trajectories of the area over a very long horizon. This long-horizon persistence highlights a core policy challenge. Spatial infrastructure requires large upfront investment. The returns from these investments occur through long-horizon path-dependent outcomes. Resource constraints and historical imbalances limit who gets access to these spatial infrastructure. Thus, left to its own accord, future spatial infrastructure investment would continue to reinforce or exacerbate the existing spatial divides.

The chapter contends that overcoming the historical path dependency of the under-connected and underserved areas through a broad, big push spatial infrastructure is resource-intensive. The broad, big push should concomitantly facilitate the flow of a range of complementary factor inputs. Naturally, broad, big-push spatial infrastructure mega-projects are resource-intensive.[12] The resources constraint that governments of developing countries face limits what they can invest in. They turn away from resource-intensive broad spatial infrastructure mega projects that could connect remote localities and focus instead on narrow infrastructure projects like a road construction programme. An extensive banking network can be a powerful tool in alleviating this resource constraint for a country and allow it to finance ambitious infrastructure projects that overcome the historical path dependency of the under-connected and underserved areas.

Policymakers must approach spatial infrastructure not only as a technical or financial endeavour, but also as a strategic tool for promoting equity. This involves ensuring the equitable distribution of access points, ensuring that regulatory frameworks and institutional rules governing internal spaces are put in place, and implementing mechanisms that allow all communities, not just metropolitan centres, to participate fully in modern economic life.

The promise of a truly modern economy lies in its ability to enable people to prosper where they are, i.e., to "stay local, go far." It suggests that people do not have to move to partake of

[12] Using France and Mexico as examples, Aghion (1999) makes a case in favour of establishing a government-backed "development bank" that can finance long-term projects that a decentralised banking system would not be able to finance.

the opportunities for prosperity that the modern economy offers. It suggests that it is possible for economic opportunities to gravitate towards communities, allowing communities to remain intact. Achieving that vision requires more than laying pipes or paving roads. It requires rethinking infrastructure as a spatially expansive system and placing it at the centre of inclusive, future-oriented public policy.

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