Infrastructure and Local Economic Development

PETER HALLER & JOACHIM MÖLLER

Abstract Investments in infrastructure have always been an issue in political discussions about future (local) economic development. Besides the overall effects of infrastructure on a country's GDP, the regional and local consequences of the latter are of special interest to policymakers. Infrastructure is generally defined by its different constituents – for example, the water and power supply, communication network, or transport infrastructure (such as road or rail) – of a region. Questions about the role of infrastructure mainly concern spatial aspects: for instance, the importance of proximity to main transport axes, or how information and communication networks can reduce physical distance are issues often addressed. In developed countries, infrastructure mainly drives the spatial economic interaction between cities, suburbs and peripheral regions. In contrast, a lack of infrastructure is one reason for the rapid urbanization of developing countries. This chapter reviews the current findings in this field. To put the literature into perspective, we utilize the case of transport infrastructure on the regional labor market development. For this, we examine the long-term effects of the German Autobahn network on regional wages and local employment structure, and look at current road investment in Germany.

Keywords: • investment in infrastructure • German Autobahn • urbanization • wages • employment structure • Germany

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1 Introduction

A nationwide, robust and reliable infrastructure constitutes the base for sustainable economic development or the transition from a locally fragmented agricultural economy to an integrated nation dominated by a tertiary sector. Around 40% of investment goes on assets such as buildings and public structures (e.g., roads, bridges, dams, excluding dwellings) (OECD 2019). In Europe, investments into roads have accounted for the dominant part of expenditure on transport infrastructure since 1995 (European Environment Agency 2017).

However, basic infrastructure such as roads, rail, communication technologies and electrical power, as well as water and sanitation, remains scarce or defective in many developing countries. The OECD stresses the importance of transport infrastructure which provides "economic and social benefits to both advanced and emerging economies by: improving market accessibility and productivity, ensuring balanced regional economic development, creating employment, promoting labour mobility and connecting communities" (OECD 2019). In other words, inadequate infrastructure leads to a lack of access to national or international good markets and employment opportunities, and hinders information transfer and education – which all hamper economic development. For this reason, the United Nations defines investing into infrastructure as one the 17 sustainable developments goals for transforming developing countries. By 2030, the aspiration is to "build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation" (OECD 2019). Admittedly, these are ideal goals whose realization is very complex. For the more accurate evaluation of such investment, more empirical justification by researchers and consultants (e.g., from the field of local development), is hence necessary.

Accordingly, the purpose of this chapter is to offer guidance about how to identify and evaluate the aforementioned theoretical advantages of investments into infrastructure.

- First, we give an overview of the recent economic literature about the economic importance of infrastructure.
- Second, we define the basis on which the wider spatial effects of infrastructure investment can be captured.
- In the following, we focus our discussion on the case of investment in the German motorway road network known as the *Autobahn*. For two different (economic) stages of the current and early construction of the major road network, we discuss the market access and local economic development that followed such road investment.

Although the focus in this chapter is road infrastructure, we do not wish to diminish the importance of other types of infrastructural development – especially in developing countries (e.g., Dinkelman (2011) for electrification in South Africa).

2 Empirical evidence about urbanization and transport infrastructure

A striking element of economic development worldwide is the growth in the urban population (see Desmet and Henderson (2015) for an introduction). Rapid urbanization in the developing world has attracted recent attention in regional and urban economics (Glaeser and Henderson 2017) by stressing the importance of distance in this process. Patterns of urbanization are partly determined by so-called "first nature" fundamentals; i.e., factors such as access to waterways, whether such processes involve the regional capital, and path dependency (related to the country's history). However, the existence of booming and declining cities can also be attributed to forces of agglomeration and dispersion ("second nature" factors), which also play a role in shaping spatial structure (see Combes and Gobillon (2015) for a review). The advantages of agglomerations can be summarized as the sharing of inputs and common infrastructure, better matching of jobs and workers, as well as knowledge spillovers and learning effects between workers and firms (Duranton and Puga 2004). In developing countries, close proximity to labor supply and demand are the main drivers, despite the lack of sufficient infrastructure. The dispersion and agglomeration forces of spatial economic activity significantly depend on the transportation of people and goods (see Redding and Turner 2015), of which the transportation of people is much more expensive. One reason for patterns of urbanization may be a lack of infrastructure and the resultant failure to bring economic growth to distant regions.

Transport infrastructure is the binding thread in local development and in place-based policies (see Duranton and Venables 2018). Related investments can have direct effects (e.g., on construction) and wider indirect economic effects. The latter are economically more important but very diverse. For instance, improvements in transport infrastructure can stimulate regional economic development in rural areas, along with population growth and changes in industry structure or commuter flows. In the past ten years there has been a vibrant discussion about these impacts in regional and urban economic research, often with special emphasis on developing countries (Redding and Turner 2015).

Any meaningful evaluation of the effects of infrastructural investment is aggravated by the complex system of centrifugal and centripetal forces. For instance, the reduction in transport-related costs following the opening of a road may significantly depend on the specific history and the spatial economic system of associated cities. Due to this complexity, the ideal starting point for any discussion is a sound review of empirical evidence from different countries at different stages of economic development. Better transport infrastructure per se can stimulate growth due to improvements in the accessibility of a region; however, it can also hinder growth, or harm the local economy. This is the so-called "two-way roads problem" (see Cheshire *et al.* 2014) that was described by late-nineteenth century German engineer and spatial economist Wilhelm Launhardt in the statement that the best protection of an underdeveloped region is a bad road (Möller and Zierer 2018). For instance, a new road can help establish new trade links

with other regions, which will not necessarily be advantageous for all locals (see also Baum-Snow *et al.* 2018).

In any discussion about the advantages of infrastructure investment it is very important to discuss causal relationships. In order to estimate the so-called "treatment effect," the effective direction of causation needs to be carefully considered. In a nutshell, the availability of infrastructure – or its construction – may be either the cause or effect of economic developments. Baum-Snow and Ferreira (2015) have established a framework which summarizes identification strategies for causal inference in local development. Furthermore, Duranton and Venables (2018) have designed place-based policy framework to empirically evaluate such investments. A large part of the literature focuses on current and past road infrastructure (e.g., Michaels 2008; Baum-Snow 2007; Duranton and Turner 2012; Duranton *et al.* 2014) or railroads (Donaldson and Hornbeck 2016) in the USA. Another part of the literature discusses the effects of infrastructure in newly developed economies (Donaldson 2018; Ghani *et al.* 2016; Baum-Snow *et al.* 2017) and developing countries (Storeygard 2016; Jedwab and Moradi 2016). For Germany, Heuermann and Schmieder (2018) investigate the effects of the rail network on workers' mobility, while Möller and Zierer (2018) examine the impact of the autobahn network on regional employment levels and wages.

A common method is the parallel analysis of historic plans and the actually developed transport networks which are still in use today. The original plans may have promoted different objectives than those of current investments. Another method is the so-called "straight-line-approach" which is favored for identifying the causal effects of infrastructure in regions situated in between two major cities.

Investment into roads and rails has been a dominant factor in the budgets of developing countries and international aid organizations. In order to provide a more thorough introduction to local development analysis, we discuss several cases from different countries more in detail.

- Agrawal *et al.* (2017) examined how roads can facilitate local knowledge flows, hence innovation activity. The stock of planned highways and rails tracks in the USA spur regional growth due to the inflow of new workers. Policy makers may conclude that transport infrastructure can also serve to facilitate innovation spatially.
- Ghani *et al.* (2016) investigated the effects of large-scale highway infrastructure on the growth of the manufacturing sector (e.g., productivity increases and entry costs) along newly established roads in India. The authors also included a cost-benefit calculation in their conclusion.
- Also focused on highways, Banerjee *et al.* (2012) assessed the impact of access to transportation networks on regional GDP growth in China. They also incorporated a highway system that connects major historic cities.

- Focusing on Sub-Saharan Africa, Storeygard (2016) used exogenous variation in transport costs (i.e. oil prices) to shed light on the short-term development of more or less accessible regions in the hinterland in different African cities.
- With respect to railways, Jedwab *et al.* (2017) discussed the effects of railways constructed by European settlers or Asian traders in Kenya. The city structure established by the investments into transport infrastructure did not vanish after independence. Hence, infrastructure is considered crucial for the spatial economy and has long-lasting effects.
- In another publication about Ghana, Jedwab and Moradi (2016) confirmed that the original colonial railroad network created a spatial structure, which persists after the development of road transportation.

When analysing local development with regard to transport infrastructure, a review of causes and outcomes is a necessity, and should always mark the starting point.

3 The concept of market potential

Every region is embedded in a spatial structure with several neighboring regions or cities. Dispersion and agglomeration forces relate to two fundamental principles of regional economics: population density, and distance. In chapter "Theories in Regional Economics in the light of Local Development" the concept of market potential is introduced. Market potential can also be described through the decrease in spatial economic interaction across space, usually referred to as "distance deterrence". Empirical examples of spatial economic interaction are commuting between cities or regions, as well as trade in intermediate goods in manufacturing (both sharply and spatially decline with distance). For instance, research has shown that for one additional minute of driving time, the number of commuters declines by 1.8% (Ahlfeldt *et al.* 2018). Around 95% of commuters' workplaces are located within 60 minutes of their residence.

However, distance in our context means economic distance, which, in contrast to physical distance, can be influenced by infrastructure and transport technology.[1] The concept of market potential is an excellent starting point from which to obtain a feeling about how regional and potential economic mass can differ, and how changes in transport infrastructure impact distance deterrence, hence mass. An alternative representation of market potential can be defined as follows (see Harris 1954):

$$\text{Market Potential}_{rt} = \sum_{\substack{j=1 \\ r \in J}}^{J} L_{jt} \mathrm{f}(d_{rj}) = L_{rt} + \sum_{\substack{j=1 \\ j \neq r}}^{J} L_{jt} \mathrm{f}(d_{rj})$$

where L can be any economic variable (e.g., population or GDP), in any region j. The spatial decay function $f(d_{rj})$ depends negatively on the distance between region r and j. Here, transport infrastructure is implicitly recognized since it affects the physical distance between two regions. We can separate the equation into "Local Market" (L_{rt}) and

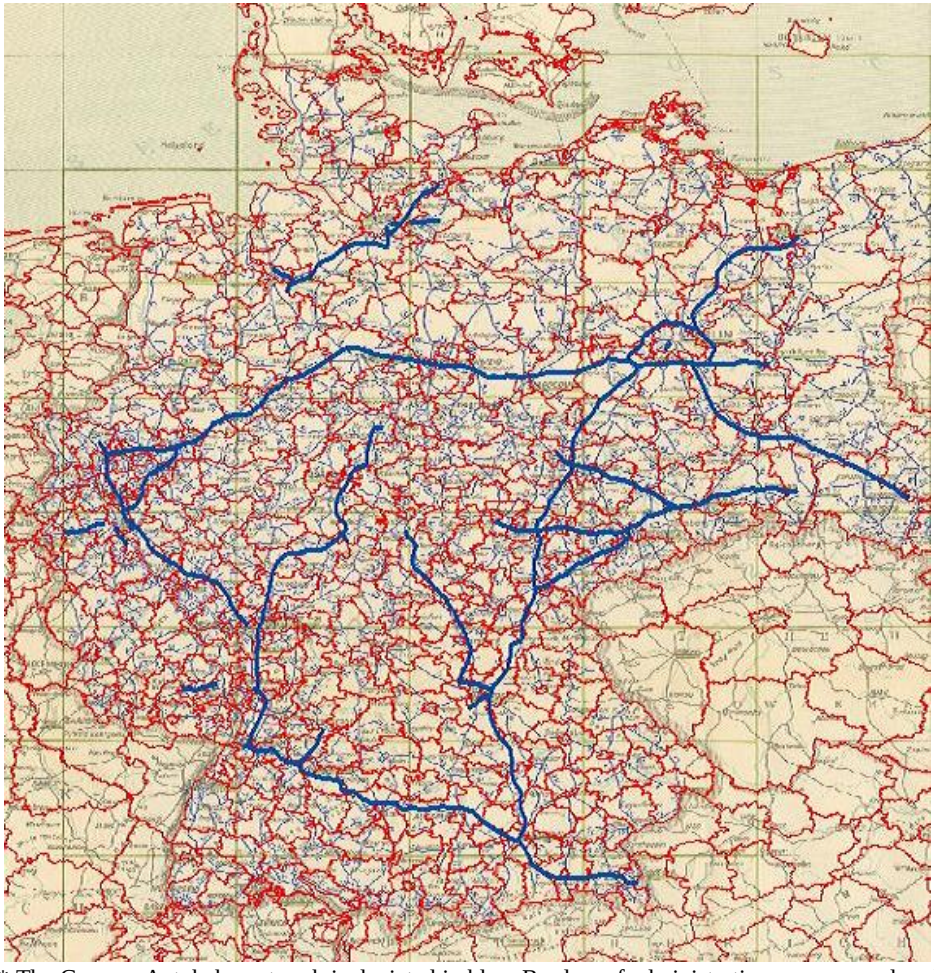
"Potential Market" $\sum_{\substack{j=1 \\ j \neq r}}^{J} L_{jt} \mathrm{f}(d_{rj})$ segments. While the first part is the local value of a region, the second part of the equation refers to the distance or travel-time discounted potential market that may be reached from location r at time t. It thus accounts for the influences of neighboring regions, which represent potential or accessible markets.

Access to other markets measured by market potential works in both directions. On the one hand, a greater potential market increases economic opportunities, while on the other hand it also can increase competition. With the use of market potential, only the net effect of these opposing effects are observable. For empirical analyses it may be favorable to limit the regional catchment to a specified distance (e.g., 60 minutes' travel time, or 100 km). In some cases the decay leads to implausible results if it is not limited.

4 Case study: the Autobahn network in Germany

In the following we discuss a comparative case involving the German highway system. The so-called autobahn was initially planned before the Second World War and was strongly influenced by the division of Germany. From the 1970s onwards, the German Federal Highway Development Act planned the future road network 10 to 15 years in advance. The comparative aspect in this case involves the different approaches to analysing transport infrastructure in a highly developed country. In first section the long-term effects of general road infrastructure will be discussed. Afterwards, in second section, current road investment in an established network is the focus.

Figure 1: German Autobahn network in 1937



* The German Autobahn network is depicted in blue. Borders of administrative areas are colored red. German territory changed after the Second World War, hence the map differs from the one included in the next section.
Source: Möller and Zierer (2018).

4.1 Early infrastructural investment with long-term effects

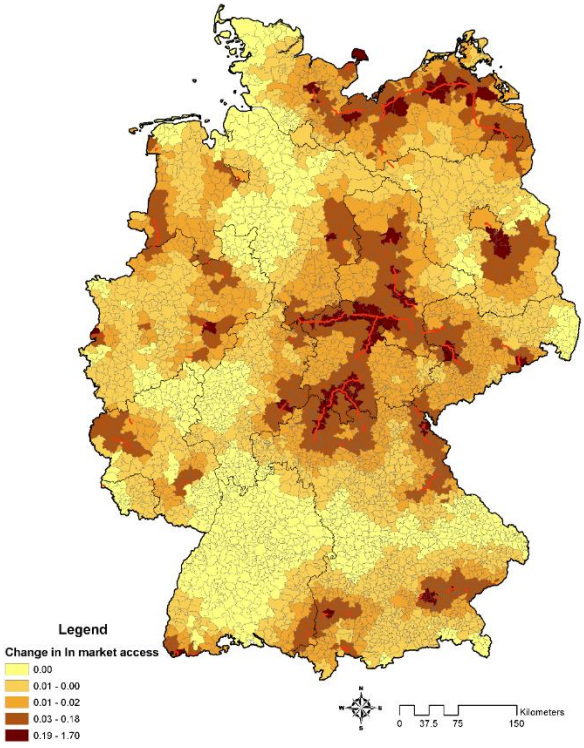
The approach in Möller and Zierer (2018) is in line with the increasing number of studies that used early infrastructure investment ("second nature" advantages) to identify the causal effect of transport infrastructure on population growth and economic outcomes at the regional level. The former authors build on the approach of Duranton and Turner

(2012) by using the historical plan for autobahns and railway tracks in Germany prior to the Second World War. In Figure 1, segments of the autobahn are depicted. The network mainly connects major cities on a West-East axis from the Rhein-Ruhr area to Berlin. On the South-North axis it connects Munich, Nuremberg, Stuttgart and Frankfurt. The network had a total length of more than 3600 km. At that time, driving was still a privilege, which is why the autobahn was mainly established for military purposes.

In order to identify the regional effects of transport infrastructure Möller and Zierer (2018) utilize the "inconsequential units approach". This means that a region only gets the "treatment" of being connected to the road or rail network if it is located between major cities or hubs. For instance, due to high construction costs railroads were usually built in the form of a straight link between major hubs (see e.g., Hornung (2015) for Prussia). The model assumes that the regions that lie in between major hubs were connected to the network independent of their previous economic importance and, likewise, their growth may have been attributable to rail or road development "treatment" independent of earlier economic performance.

In comparison to the situation in the USA (Duranton and Turner 2012), for Germany Möller and Zierer (2018) found a slightly smaller positive effect for (historic) investment in the length of regional autobahn on the future employment growth of particular regions. The authors compiled a database of regions of Germany containing historical autobahn lengths and employment data per region. They found that a one-standard-deviation increase in the growth of autobahn length between 1937 and 1994 led to employment growth of between 2.7 and 3.4%, and to a wage bill increase of between 3.0 and 3.7% over the period from 1994 to 2008. Compared to Germany, the employment elasticity of express highway length appears to be considerably larger for US regions for several reasons, including car use, fuel taxes, and car use habits. The increase in regional accessibility has a positive effect on labour markets but, according to this study, the development of regional roads has a greater impact on the development of regional labor markets as opposed to the development of interregional roads.

Figure 2: Investments into the Autobahn Network: Change in Market Access in Germany



* Only road segments open to traffic are depicted.
Source: Ahlfeldt et al. (2018).

4.2 Current road investment and changes in market access

In line with previous arguments, we look at the case of investment into the German autobahn network between 1999 and 2015. With a total length in 2015 of about 12,950 km, the German autobahn ("interstate highway") system is one of the densest in the world. It is well known worldwide for having parts with no speed limits. In Figure 2, we depict the road elements that were opened between 1999 and 2015. After German reunification, one major goal was to equalize and foster sustainable economic development in the former states of the German Democratic Republic. Such investments were financed by a special levy, the so-called solidarity tax (*Solidaritätszuschlag*), which is why we see some of the highest increases in market access in the East.

The analysis of Ahlfeldt *et al.* (2018) uses changes in transport-induced labour market access over time to evaluate the impact of effective density on local productivity and the

demand for and supply of labour. This contrasts with the method used by Möller and Zierer (2018), which evaluates the economic success or failure of current road investment. In order to evaluate the effects of road investment, Ahlfeldt *et al.* (2018) built a complete theoretical economic model which incorporates many agents of the spatial economy. This model is built both on the demand side of labour (i.e. firms seeking workers) and on the supply side (i.e. on workers offering manpower), as well as the equilibrium where demand and supply meet. In a nutshell, Ahlfeldt *et al.* (2018) estimate the labour market effects of transport improvements using a framework that allows wage and quantity responses to interact both ways. Agglomeration forces and location fundamentals are separated by taking into consideration the variation in bilateral transport costs: i.e., by allowing all stakeholders to optimize their spatial economic behavior. The theoretical background of the model requires deep understanding of urban economic theory and makes a significant demand on data. The analysis of Ahlfeldt *et al.* (2018) is an excellent example of how to start an analysis of recent road investment in the light of the increasingly detailed spatial data that is available (e.g., from administrative sources, including high precision geo-spatial data). The authors' work is also a good example of how the stress may be placed on the importance of the wider economic effects of transport infrastructure. "Pure" improvements in market access do not necessarily prove the success of an investment, but rather demonstrate the changes that have been induced in the spatial economy. The sophisticated equilibrium model demonstrates how improvements in transport infrastructure increase the likelihood that workers will be better matched with new employers. With this approach, the former provides evidence about the relevance of agglomeration economies as drivers of urban productivity and the unequal spatial distribution of economic activity.

5 Conclusion

Investment in public infrastructure has wider economic effects not in the short- but in the long term. We stress that sustainable and reliable infrastructure is a necessity for promoting local development within and across countries. In our examples of transport infrastructure, (early) investment induces an increase in the trade, urbanization, etc. of a country. In general, investment into infrastructure undoubtedly has an overall positive economic effect, although this are significantly context dependent. High investment costs in the short term might be a limiting factor, as outcomes only become visible in the long term. There are also numerous examples of large investments into infrastructure which have not proven to be profitable (e.g., infrastructure for the Olympic Games). The policy implication of this chapter is that a historical perspective should be employed when assessing the impacts of investment into infrastructure, as well as a comparison of current best practices in other countries with a similar history or countries at a similar state of economic development. In this chapter we have employed an economist's perspective, but it is important to involve all stakeholders in decision-making (e.g., city planners, local authorities, and the local community), as the consequences of such activity have effects that last for decades.

Notes:

[1] In contrast, Haller and Heuermann (2016) find that spatial spillovers in the job search market might be best described by direct physical distance.

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