CPB Netherlands Bureau for
Economic Policy Analysis

The effects of cycling infrastructure on living, working and commuting

The large-scale construction of separate cycleways in the Netherlands has led to more commuting by bike and more compact cities for living and working. As cycling becomes more attractive, workers on average live closer to their place of work or work closer to home on average, and the working population travels less far on average. Replacing traffic lanes with cycleways in cities is common but does not increase car congestion.

Our results illustrate how changes in infrastructure not only affect traffic flows, travel behaviour and times, but also determine where people live and work in the long term.

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Tijl Hendrich, Nicole Loumeau

Summary

The large-scale construction of separate cycleways in the Netherlands has led to an increase in bicycle commuting. Separate cycleways are cycleways that are physically separated from the roadway. Our research shows that, thanks to these cycleways, the share of cyclists in commuter traffic has increased from around 20% to 25%. This represents an increase of approximately 350,000 cyclists. This is mainly because car commuters have switched to cycling. We drew these conclusions from analyses based on a spatial-economic model that reflects the latest scientific insights. This model is grounded in the observed choice behaviours of Dutch workers.

The cycleways also lead to more compact cities for living and working. In the long term, the presence of cycleways leads to an average 6% decrease in commuting distances across all modes of transport and higher population densities in and around cities. As cycling becomes more attractive, workers choose to live closer to their work places or work closer to home on average, and the working population travels fewer kilometres as a whole.

Cycleways often replace car lanes in cities, but this does not increase car traffic congestion. Replacing car lanes with cycleways in urban areas leads to a decrease in road capacity for cars, because space for infrastructure in these areas is scarce. However, the number of motorists decreases too, as more people choose to bike because cycling becomes more attractive due to the cycleways. These two effects roughly cancel each other out.

An further increase in cycling speed leads to more compact cities and less traffic congestion, mainly because commuters switch from cars to bicycles. Cycling speeds can grow as a result of the increased use of electric bicycles and measures that give cyclists greater priority in traffic, such as at traffic lights. However, it is possible that these measures affect traffic safety.

Our results illustrate how changes in infrastructure influence traffic flows, travel behaviour and travel times, and ultimately determine where people live and work in the long run. Changes in cycling infrastructure lead to significant shifts in where people and businesses settle, and in the square metre prices of homes and offices. This is because individuals make choices regarding living, working and traveling in conjunction with each other: someone looks, for example, at travel time between possible places to live and work. Second, individual choices have collective effects. For example, if many people choose to live in a certain neighbourhood, house prices rise in that area. Accordingly, these long-term effects can propagate into various areas of policy, including mobility and housing market policy.

1 Introduction

Cycling to work is a crucial part of the modern Dutch urban economy. Around 25% of all commuting trips are made by bicycle (KiM, 2023).[1] With an average speed of around 15 km/h, bicycles are an efficient alternative to cars, especially for commuting in and around cities. In 2022, 35% of car trips were shorter than five kilometres, a distance that can also be covered by bicycle. The low costs and absence of congestion make cycling an attractive mode of transport. The presence of extensive and safe cycling infrastructure is an important prerequisite for commuting by bike. Most cyclists are willing to travel up to fifteen kilometres. This maximum distance has increased in recent years, partly due to the rise of electric bicycles.[2]

Existing studies mainly focus on the direct societal effects of increased bicycle use. More cycling is associated with less air pollution and CO_2 emissions, health benefits and safety risks (Schroten et al., 2022; KiM, 2023). The motivation behind existing cycling policies often lies in these types of effects (e.g. Rijksoverheid, 2022).

In the long term,[3] the possibility of cycling to work affects where we live and work, but little is known about these indirect spatial effects.[4] If bicycles were not used for commuting, the Netherlands would probably look different in terms of where people settle and where businesses and jobs were concentrated. These spatial effects of cycling infrastructure may become more important as the total annual distance cycled increases due to the rise of electric bicycles (KiM, 2023).

In this study, we investigate the influence of the large-scale construction of cycleways on the spatial distribution of residents and jobs across the Netherlands. We show that the construction of cycleways has changed this distribution significantly. These changes affect local square metre prices, choice of transportation, commuting times and distances, and congestion. This illustrates how the long-term effects of cycling infrastructure can affect various policy areas: from housing market and mobility policy to spatial planning and climate. We mainly focus on working people and commuting, because commuting decisions are a strong driver of workers' location choices.[5]

We also look to the future. What if cycling to work becomes faster and more attractive due to the further growth of electric cycling and policy measures that prioritise cycling? This publication is based on the CPB discussion paper by Hendrich et al. (2024).

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[1] These are trips made entirely by bicycle and not cycling part way, to the nearest train station, for example.

[2] In 2018, electric bike sales exceeded those of non-electric bicycles for the first time (KiM, 2023).

[3] Typically a period of several decades, see Baum-Snow (2007).

[4] See studies on spatial planning in the area of infrastructure (Van Maarseveen and Romijn, 2015; Brouwers and Ossokina, 2016; Bos and Verrips, 2019), regional development (Hendrich et al., 2023), scenarios for spatial planning (PBL, 2023) and accessibility (Bastiaanssen and Breedijk, 2022).

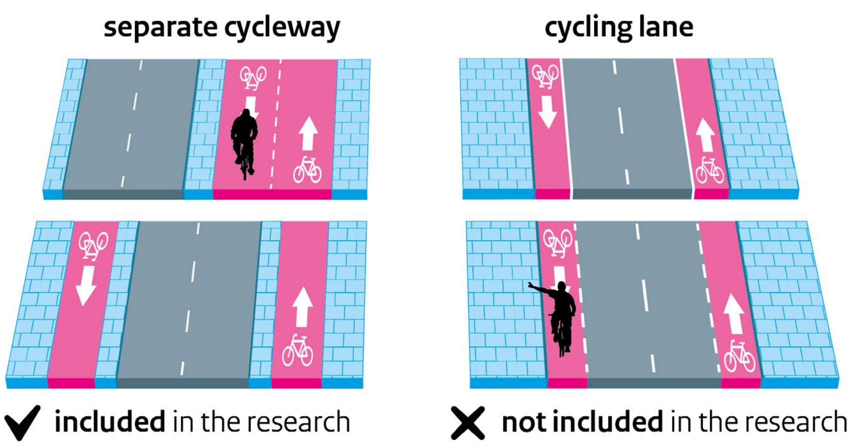
[5] Of course, factors other than travel time are relevant in location choices. These include personal preference, family, leisure activities and amenities in the neighbourhood of residence. Our analysis takes these matters into account implicitly but cannot determine the influence of individual factors.

2 Cycling infrastructure in the Netherlands

The Netherlands is often regarded as a cycling nation. Cyclists formed the majority of traffic in many European cities around 1900 (Bruhèze and Veraart, 1999). Over a century later, the Netherlands has become one of the world's leading cycling countries. Its cycling culture is the result of a combination of factors, including its climate, flat landscape and, most importantly, extensive cycling infrastructure. In the 1970s and 1980s, the large-scale construction of cycleways began, partly in response to protests from pressure groups like *Stop de Kindermoord* ('Stop the Child Murder'), which advocated for better safety and more space on the road (Oldenziel and Bruhèze, 2011). Nowadays, about a quarter of commutes under 15 km are made by bicycle (KiM, 2023).[6]

Dutch cycling infrastructure runs throughout the country and is known for its high quality in terms of design and safety. Car and bicycle traffic share the road in residential areas that have little traffic. On through roads, red cycling lanes separate cyclists from cars with dotted or unbroken lines (Figure 1, right side). Finally, there are separate cycleways on busy roads, which have a clear separation between the road and cycleway (Figure 1, left side). The latter often concerns roads where cars are allowed to drive faster (including provincial roads) and roads that have multiple car lanes. Separate cycleways are also often mandatory cycleways, meaning cyclists are not allowed to cycle on the main road (CROW, 2021).

Figure 1. Schematic showing different types of cycling infrastructure



To ensure the safety and uniformity of its infrastructure, national design guidelines and principles were established in the 1970s. These guidelines are managed by a consortium of stakeholders (CROW, 2021). An important design principle is the separation of different traffic flows by weight and speed. Think of the separation of heavy vehicles and bicycles or the separation of slow and fast traffic.

[6] For distances under 5 km, most commuters (53%) cycle to their work, between 5 and 10 km this is 33%, and between 10 and 15 km the share of bicycle trips further decreases to 16%.

Our research focuses exclusively on separate cycleways. These cycleways are essential for safe bicycle traffic.[7] Their use is often mandatory because cycling on main roads is excessively dangerous (SWOV, 2020). Without cycleways, cyclists would have to take many detours to safely complete their routes.[8] This increases travel time, making commuting by bicycle less attractive. [9]

3 Methodology

To analyse the long-term effects of cycling infrastructure, we use a spatial economic model that employs the latest scientific insights. In Hendrich et al. (2024), we build on the modelling approach proposed by Ahlfeldt et al. (2015). Their approach is innovative because it shows how individuals' choices – regarding living, working and traveling – determine a city's structure. Improvements in infrastructure can result in gains in terms of travel times and influence where people live and work (see box 'Choice modelling'). The approach is therefore suitable for examining how areas (cities, countries) respond to major changes in infrastructure in the long term. This approach is rapidly gaining ground in spatial-economic literature.[10]

In the model, we include the choice behaviour of both workers and businesses. Workers make three decisions: where they live, where they work and what mode of transport they use to travel between these locations. They consider how much they can earn at a work location, how expensive it is to live in a neighbourhood, how large a home they can afford and what amenities surround their residence.[11] When people choose how they commute, they factor in travel time and preference for certain modes of transport. Our analysis shows that, for a given travel time, cycling is largely perceived as more attractive than driving, while public transport is seen as less attractive.[12] Businesses also choose where to establish themselves, looking at the presence of potential employees in the area (labour supply) and the cost of floor space. Businesses prefer to be located close to each other, as this increases opportunities for knowledge exchange and the supply of personnel (agglomeration benefits).[13]

The model describes how workers and businesses respond to each other and influence each other's choices. If many people want to live in a certain neighbourhood, prices per square metre increase. If many businesses establish themselves in a given location, local wages increase, as businesses tend to be more productive when surrounded by peers. In every neighbourhood, businesses and residents compete for floor space.[14] Cycleways ensure that more people cycle to work and fewer drive, resulting in fewer traffic jams. Cycling is slower than driving, but from the observed choices, it appears that people prefer it significantly based on aspects other than travel time. Using the approach of Ahlfeldt et al. (2015), we can take these complex interactions into account, based on actual choice behaviours we see in the data.

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[7] There is academic consensus that cycling lanes are generally less safe than separate cycleways (SWOV, 2020).

[8] The Netherlands has a total of 38,000 kilometres of separate cycleways (CBS, 2022a).

[9] For cycling lanes on the road, such a clear distinction cannot be made. In them, cyclists and cars largely share the same space, causing safety and route choice to depend on the local situation. Consequently, we have excluded cycling lanes from our analysis.

[10] See the recent applications of Tsivanidis (2023), Severen (2023) and Koster (2024).

[11] Our approach differs from earlier spatial-economic models, such as LUCA (Teulings et al., 2018), who assume that dwelling size is the same for everyone and do not explicitly include the location choices of businesses.

[12] These differences can have various causes. Consider movement and flexibility when cycling or crowding and dependence on public transport schedules. We have not investigated these underlying factors further in our research.

[13] There is a general consensus about the existence of these effects (Raspe et al., 2015; Verstraten and Zwaneveld, 2018).

[14] The approach of Ahlfeldt et al. (2015) that we use includes a construction sector, besides workers and businesses, which ensures that the local supply of floor space – for commercial or private use – matches demand. Neighbourhoods can contain both types of floor space and thus combine living and office space.

Our model is based on the observed choices of Dutch employees in 2016.[15] We use the OViN and ODiN surveys (CBS, 2022b) to see which modes of transport Dutch workers choose[16] and CBS microdata for location choices of all Dutch employees. The research population consists of all Dutch people who work eight hours per week or more. We exclude recipients of benefits, pensioners, business owners, temporary workers and the self-employed, as they generally do not have a fixed, unambiguous work location. We use the approximately 12,000 CBS neighbourhoods as our spatial units, covering all of the Netherlands. We choose these small units because of our focus on cycling, meaning that short distance travel is of key importance.

The model also contains virtually all Dutch infrastructure for traveling by car, bicycle, public transport and on foot. Using this infrastructure, we determine travel times for all four modes of transport between all neighbourhoods. The model thus reproduces the distribution of jobs and residents, and the variation in wages and square metre prices across Dutch neighbourhoods in 2016 (the base year). We will examine existing cycling infrastructure in the next chapter to determine its spatial economic effects.

[15] We chose 2016 as the base year because this year is after the 2008 financial crisis but before the Covid-19 pandemic. The Covid-19 pandemic and the resulting increase in working from home can change travel behaviours and location choices in the long term. How this will develop in the long term is still uncertain (PBL, 2021).

[16] We estimate the transport choice based on multiple annual editions of these surveys (2016–2022) to increase the size of the sample population.

Choice modeling

We model the choice of where people live, work and how they travel to their work at the neighbourhood level for all of the Netherlands. How people travel depends on the required travel time and preferences regarding mode of transport, which we derive from observed travel choices in the ODiN survey. Which neighbourhood people live and work in depends on neighbourhood characteristics and personal preferences. 'Work neighbourhood' characteristics include potential wages, a direct result of how productive businesses in a neighbourhood are. 'Residential neighbourhood' characteristics include square metre prices and amenities (e.g. nearby green spaces, restaurants, schools).

Time valuation differs depending on the mode of transport: commuters experience one extra minute of traveling by bicycle differently than one extra minute on the train. We call this the 'opportunity costs' of travel time – the value of the time that one cannot spend on other activities. Our analysis considers four different modes of transport: car, bicycle, public transport and walking. Public transport includes commuting by bus, tram, metro and train. In practice, some commuters combine different modes of transport, but we only focus on the main mode of transport for simplicity. We estimate the differences in time valuation based on observed travel behaviour from the ODiN survey.

The change in the spatial structure of the Netherlands is a direct consequence of how people choose. If we adjust the cycling infrastructure compared to how it is now and remove separate bicycle paths, travel times change because cyclists have to take detours. This makes cycling less attractive than other modes of transport. As a result, people reconsider their mobility and location choices, causing some places to become more attractive. This is reflected in how many people choose a neighborhood to live and work in, which in turn affects wages and square metre prices.

4 Effects of cycling infrastructure in two scenarios

In Hendrich et al. (2024), we show that Dutch cycling infrastructure has a significant influence on the spatial structure of Netherlands. We investigate this by comparing the current situation with two alternative scenarios: one without separate cycleways ('no cycleways') and one in which cycling speeds are higher than the current average ('faster cycling'). In 'no cycleways', we assume that cyclists avoid busier roads in the absence of cycleways, for example by cycling through residential areas. On other, quieter roads, cyclists cycle on the road with car traffic. In the 'no cycleways' scenario, cycling lanes are unaffected.

Effects of cycleways

Having cycleways ('current situation') leads to considerably more bicycle commuting compared to the scenario without cycleways ('no cycleways'). [17] The group of workers who cycle to work increases from 20% to around 25% – an increase of approximately 350,000 cyclists.[18] This increase is mainly due to motorists switching to cycling (4.5% or 85% of the increase) and, to a lesser extent, by workers who previously walked or used public transport. Walking is only an alternative to cycling for very short distances, and public transport is primarily attractive between specific locations if transit stops are sufficiently close.

In the 'current situation' with separate cycleways, cities are more compact for living and working. Average commuting distances in the 'current situation' are 6% lower, and the population density in cities is around 5% higher than in the 'no cycleways' scenario.[19] Figure 2 shows how the population density in the 'current situation' changes compared to 'no cycleways': the increase in cities and decrease in more sparsely populated areas is clearly distinguishable. In cities, square metre prices rise because there is more demand for space. Businesses generally benefit from being established in central locations that have large local labour supplies. We see this reflected in the results: job density in cities increases due to the construction of cycleways, but less strongly than population density.

Separate cycleways lead to more compact cities because the shorter travel time by bicycle makes living in the city more attractive. First, cycling to work becomes more attractive due to decreased travel times. Many motorists therefore switch to bicycles, because workers, beyond travel time, find cycling more attractive than driving. This means that workers that change their mode of transport move significantly closer to their work places, because cycling is slower than driving. In and around cities, this leads to a higher demand for housing and thus to a limited increase in square metre prices (between 0.5 and 1%). Jobs remain concentrated in and around cities. Businesses generally prefer to establish themselves centrally and thus have access to a larger labour supply (agglomeration benefits).

Replacing car lanes with cycleways in urban areas provides less space on the road for cars, without resulting in extra traffic jams or delays on average. Less space for the same number of motorists leads to more traffic jams. However, the cycleways make cycling more attractive, resulting in more workers choosing bicycles and fewer choosing cars. Our results show that these two opposing developments more or less cancel each other out, so traffic jams do not increase on aggregate.

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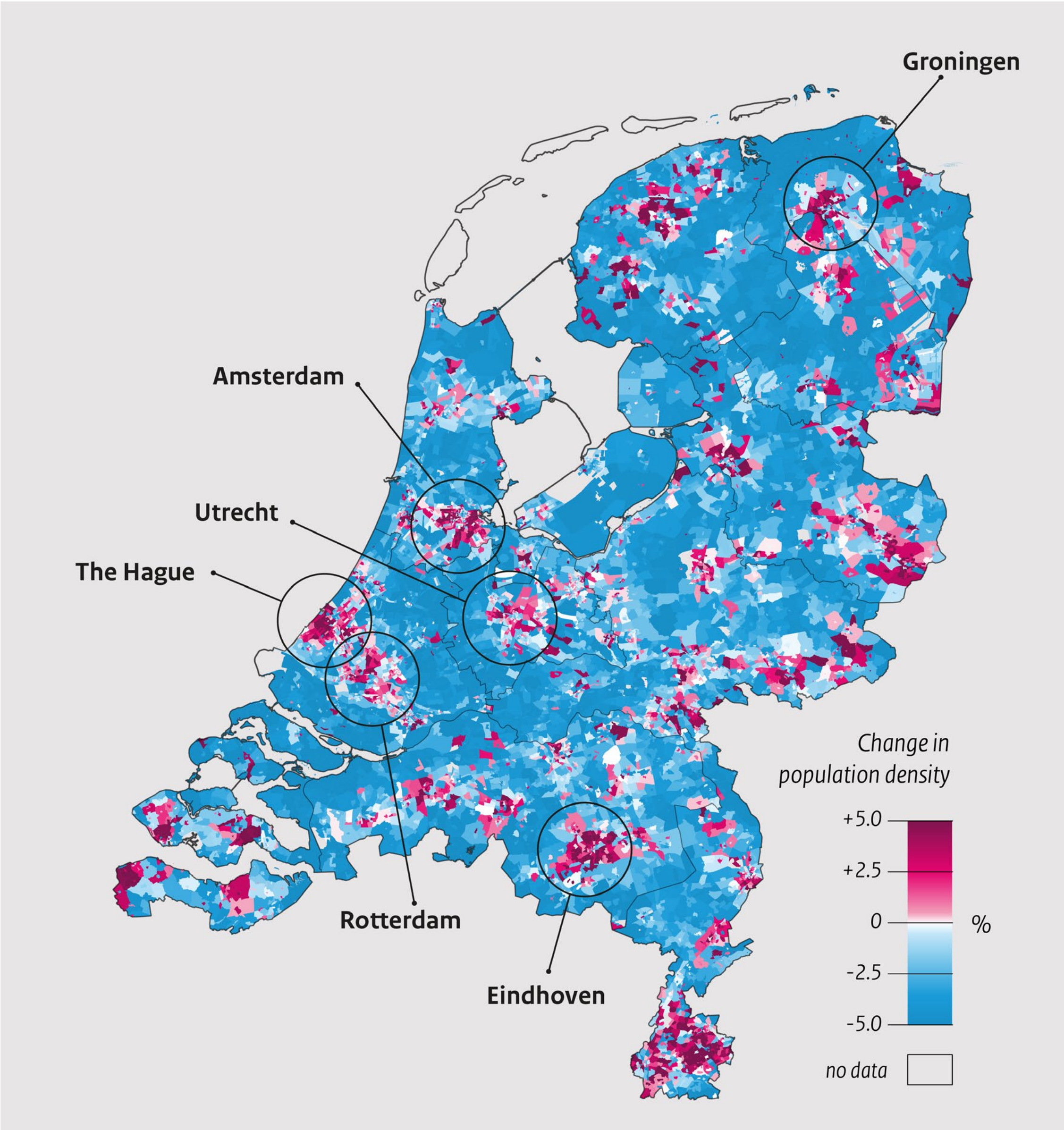
[17] In the 'no cycleways' scenario, the travel time by bicycle is on average 25% higher compared to the current situation, which makes cycling to work less attractive. Whether and the extent to which cycling time increases depends on the location of the residence and work. We assume that cyclists can still use cycling lanes on the road, and that, in densely populated areas, the space of removed cycleways is used for additional traffic lanes for cars. Both scenarios are otherwise equal in all respects.

[18] A rough indication based on the total population of workers in 2016 (7.2 million, link).

[19] This means that the total number of commuting kilometres travelled across all modes of transport decreases by 6% due to the presence of separate cycleways.

Figure 2. Residential density increases significantly in cities (purple) due to the construction of cycleways; it decreases in surrounding areas (blue)



Higher average biking speeds

Higher average cycling speeds (**'faster cycling'**) **lead to more commuting cyclists** (+3%) **compared to the 'current situation'.**[20] This increase comes from a roughly equal share of car, walking and public transport. This shows that cycling is a good choice for both short and relatively long distances. Urban density increases by around 1%, and car congestion decreases slightly by an average of 0.4%. Job densities follow a similar trend, but the effects are smaller. One important assumption is that other factors that determine the attractiveness of cycling, such as safety and comfort, remain the same. We do not investigate these factors any further in the current research.

[20] In the 'faster cycling' scenario, we increase the average cycling speed everywhere by 10%. The cycling network does not change. The space on the road for cars remains the same as in the 'current situation'. We only look at the speed of bicycles and not the potential effects of bicycle facilities on car speeds because these effects strongly depend on local traffic situations.

It is noteworthy that square metre prices also show a slight increase in certain rural areas in the north of the Netherlands. This is likely due to the limited availability of public transport in these areas, making improvements in cycling speed more impactful.

5 Policy implications

A safe increase in the average cycling speed can contribute to further urban densification and fewer traffic jams, especially because cycling becomes more attractive for commuting. Higher average speeds can come about through uncontrolled developments, such as the increased use of electric bicycles, but also through targeted policy measures. The latter includes traffic lights that give cyclists more priority in urban areas, bicycle highways and further separation of traffic flows at and around intersections.[21] Safety is still an important factor, as proven by the discussion on wearing bicycle helmets, for cyclists in general.[22] We have not conducted specific research on traffic safety or the extent to which specific measures can contribute to faster cycling in our study, because these are outside of our expertise and highly location-dependent.

For large infrastructure projects, it can be important to consider the long-term effects on spatial distributions of population and jobs. Our research shows national cycling infrastructure can have considerable effects on spatial shifts. These spatial changes develop over longer periods. and they are less visible than the direct effects of infrastructure interventions, such as travel time. Moreover, indirect effects can affect other policy areas beyond (sustainable) mobility. This includes housing market policy (via changes in square metre prices), spatial planning (via the distribution of living and working), and climate and environmental policy (through changes in car use and traffic jams). Finally, infrastructure and housing are long-term investments, which makes the influence of spatial effects significant. The effects of other types of infrastructure and the need for more local interventions in the Netherlands require further research.[23]

[21] We note that adding more cycleways does not necessarily lead to higher speeds, since the Dutch cycling infrastructure is already very extensive and congestion in bicycle traffic rarely occurs.

[22] See CPB and PBL (2020) and SWOV (2024).

[23] In the scientific literature, there are numerous studies that found significant shifts for other types of infrastructure, for example Donaldson (2018, rail connections in India), Egger et al. (2023, scaling up of Chinese infrastructure), Tsivanidis (2023, rapid bus lines in Bogotá, Colombia) and Koster (2021, high-speed lines in Japan).

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