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ABSTRACT: We study the impact of improved rail access on entrepreneurship rates in England and Wales. We use data from the Census spanning 2001, 2011, and 2021 to analyse self-employment rates in granular geographic areas of around 200 residents. Specifically, we study how they respond to changes in the distance to the nearest train station occurring due to 56 new station openings. We find that all else equal, moving 1 km further away from a station reduces self-employment rates by 0.12 percentage points, with the effect dissipating beyond 7 km. Secondary results suggest that access to rail makes it easier to become self-employed while not making it more attractive compared to employment. Our findings suggest that rail infrastructure improvements can support local entrepreneurship and economic activity, contributing to regional development and reducing economic inequality.

JEL Codes: L26, 018, R11
Keywords: Entrepreneurship, Rail, Self-employment

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1. Introduction

The number of countries implementing policies to promote entrepreneurship has been increasing since the Global Financial Crisis, driven by the desire to enhance economic growth, resilience, and innovation (Lerner, 2020). These policies are often regional, reflecting the understanding that local conditions significantly influence entrepreneurial activities (OECD, 2020). While much attention has been given to policies focusing on access to finance (Beck et al. 2005), tax incentives (Djankov et al. 2010), and education (Martin et al. 2013), the role of transport infrastructure, particularly rail access, in supporting entrepreneurship has been relatively understudied. This is surprising as improving transport infrastructure is one of the most popular regional growth strategies (Adler et al. 2020). Rail systems, in particular, attract large investments that aim to efficiently connect distant locations, thereby reducing transportation costs, improving market accessibility, and facilitating the flow of goods and services. However, despite the substantial evidence on the broader economic benefits of rail systems (Albalate & Bel, 2012; Pogonyi, 2020), the specific impact on entrepreneurship has not been thoroughly examined. This paper seeks to fill this gap by investigating how changes in access to rail affect entrepreneurship rates within local communities.

Theoretically is seems clear that rail access should affect entrepreneurship, but the direction of the net effect of several forces that work against each other is unclear. On the one hand, economic theory posits that enhanced transportation infrastructure should support entrepreneurial activity by lowering logistical costs and broadening access to larger markets, thus fostering business creation and growth (Glaeser et al. 2010). It should also enhance access to knowledge that will support new firm creation (Bahar, Choudhury, Kim, & Koo, 2023). Conversely, increased accessibility may improve employment opportunities, consolidate market saturation and increase property values potentially deterring new entrepreneurial ventures due to heightened competition and (both operational and opportunity) costs. Additionally, the benefits of enhanced transport links may accrue disproportionately to established firms that can more readily capitalize on expanded networks, potentially sidelining startups (Audretsch et al. 2015; Bennett 2019). The ambiguity of the theoretical prediction creates a compelling case for our empirical investigation of the total (net of all positive and negative effects) local effect.

Our primary hypothesis is that being closer to a rail station causes a change in local entrepreneurship rates and the main goal of the paper is to estimate the magnitude and direction of the total effect of rail access on entrepreneurship. To better understand the mechanism, we use our literature review to guide a more detailed examination. First, we explore if changes in entrepreneurship occur at the expense of the number of employees or by shifting unemployment

and economic inactivity rates. Second, we check if the relationship between rail access and entrepreneurship is moderated by local economic conditions, such as pre-existing levels of entrepreneurship, commuting patterns, and urbanisation. Finally, we look at the likelihood that an entrepreneur works from home as a function of the distance to the station and split the effect into an impact on men and women. By empirically exploring these issues, we contribute to the research on the impact of transportation infrastructure, economic development and entrepreneurship policy.

We use a comprehensive dataset from the Census of England and Wales spanning the years 2001, 2011, and 2021. We leverage this longitudinal data to construct a panel of very small areas (around 200 residents) that experienced changes in rail access due to the opening of 56 new stations.[2] We identify the causal effect on entrepreneurship (defined as self-employment) from the *change* in the distance to the closest station conditional on area fixed effects, trends around the new stations and trends followed by places with similar distances to the nearest station that did not receive a treatment. This strategy has the advantage of relying on the easily testable identification assumption that the distance to the newly opened station (or the eventual change in distance) did not determine entrepreneurship before the new stations opened. Indeed, we demonstrate that the intensity of the treatment (change in the distance to the nearest train station) is not correlated either to levels or to changes in entrepreneurship before the treatment.

We find that on average moving further away from a station by 1km reduces the local rate of self-employment by 0.12 percentage points and that the effect disappears around 7km from stations. This means that locations very close to a station have rates around 0.84 percentage points higher (around 10% more entrepreneurs) than locations more than 7km away. Importantly, we find that the effect of rail access on the number of economically active residents is positive as the increase in self-employment is accompanied by a decrease in economic inactivity. The effect is weaker in places where entrepreneurship rates are high or people already work from home, but stronger in places with highly educated residents. Entrepreneurs with better access to stations are less likely to work from home, but this effect is driven mostly by women - possibly because they are more likely to face constraints due to domestic commitments and work from home to avoid long commutes as a result. From a policy perspective, rail improvements could support both entrepreneurship and economic outcomes (such as lower inactivity rates) while reducing inequality.

[2] Stations opened mainly due to local authorities responding to localised population growth, implementing plans to meet pre-existing transportation goals or because of major local development projects such as Cross Rail or Thameslink. There was no UK-wide policy to open new stations.

2. Effects of improving rail access on regions

In developing our hypothesis, we begin by reviewing selected studies on the impact of rail access. We then link these papers to research on determinants of entrepreneurship and note that many factors that determine entrepreneurship are affected by rail access. We then discuss a possible mechanism that could link rail access to entrepreneurship.

2.1. Direct and indirect local effects of rail access

Rail improvements projects are usually very large national or regional investments and their effects have been studied extensively. The most important economic effects have been shown to be increases in employment, income and efficiency of economic production – all leading to increased gross regional product (Chen & Haynes, 2017; Albalate & Bel 2012; Fingleton & Szumilo, 2019). However, these are what we consider "indirect" effects because the direct effect of rail access is simply a reduction in transport cost (including the opportunity cost of time for people).[3]

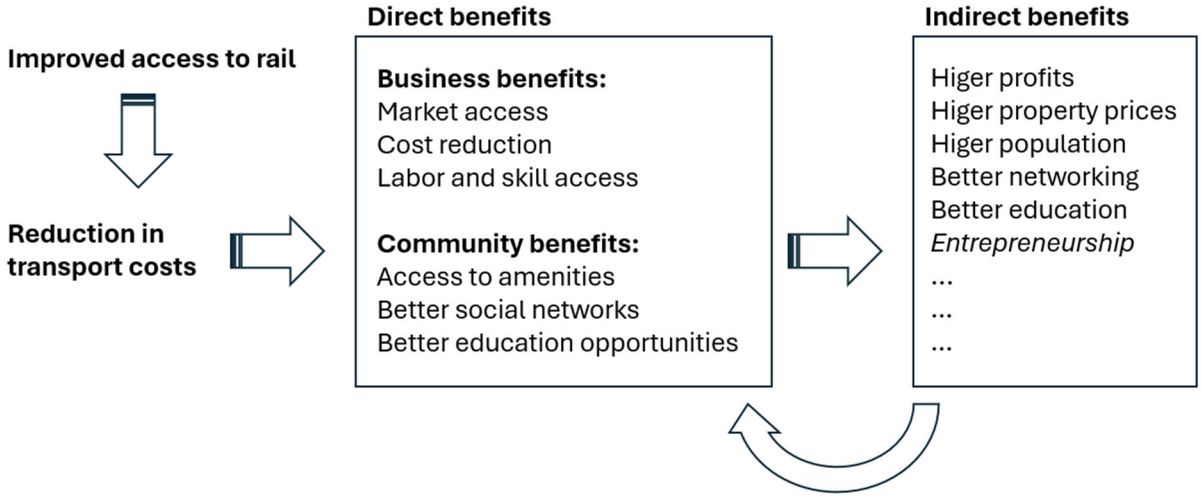
The literature on the impact of railroads on regional and national development is vast. It spans economics, transport studies, regional studies, planning and administrative science, so is too large to review here. Instead, we briefly summarize the economic literature that often discusses employment effects (but seems to ignore self-employment) relevant to our study. It divides the benefits of improved transport costs into three categories. First, they significantly extend market access and allow reaching new customers and suppliers. Studies such as those by Banister and Thurstain-Goodwin (2011) or Donaldson & Hornbeck (2016) highlight how rail connectivity enhances market penetration capabilities, especially for industries reliant on quick delivery times or frequent shipments. Second, Vickerman (2007) underscores that rail developments often lead to a reduction in both direct and indirect transportation costs. These savings enhance overall business efficiency and allow generating higher profits from existing business models and connections. Third, lower transportation costs allow businesses to access better labour by increasing the size of the population within commutable distance (Lin, 2017). Research shows that both size and diversity of the newly accessed labour pool can increase as a result of lower transportation costs. The labour mobility that comes with better access to transportation also leads to knowledge spillovers that further enhance economic outcomes for the newly connected areas (Bai, Jin, & Zhou, 2023).

[3] We acknowledge there may be some amenity value from a newly opened station like better roads or nicer views and revisit this later.

There are also direct effects of transportation cost reduction that are not attributable to businesses but affect local communities. For example, improved access to amenities can make a local area appealing to different types of residents. Indeed, Lee & Tan (2024) show that people from higher social classes tend to live in better-connected areas. Access to education also improves when transportation becomes cheaper so it is not surprising that Kenyon (2011) finds that people who live closer to stations are better educated. Social networking opportunities also improve when travel costs are lower so locations with better transport connections have populations that are better socially connected (Giuffrida et al. 2017). There are also often amenity effects of new stations that can be accompanied by better quality roads, improved security or replace poorly designed buildings.

It is worth noting that benefits to local communities interact with benefits for local businesses. Populations with more education and larger social networks are better both customers and employees. This means that there is a host of outcomes that are indirectly caused by improved access to rail. A good example of this can be an increase in property values. As profits of businesses located close to a station are higher, rents on commercial property go up (Cohen & Brown, 2017). House prices also increase - not only because of an amenity effect but also because local residents are more productive (due to education and network benefits) so earn higher incomes (Gibbons & Machin, 2005). This demonstrates a very complex and nuanced network of causal effects of access to rail.

Figure 1. Causality diagram of the impact of rail access.



Notes: Transportation cost includes the opportunity cost of time for traveling people. "direct" benefits are ones that are affected by lower transportation costs while "indirect" are ones that are affected by the "direct" benefits. The indirect benefits can also affect each other as well as the direct benefits (for example by better education improving entrepreneurship or access to skills).

In **Figure 1** we illustrate how we think rail access affects entrepreneurship. First, it affects transportation costs of goods and people. Based on the literature cited above we list six areas that are directly affected by transport costs (we consider this list as illustrative rather than exhaustive). In turn, these have a plethora of documented downstream effects – for example, better education opportunities (direct benefit) result in higher education levels (indirect benefit). The indirect benefits also interact with each other – for example, higher education levels (indirect benefit) support entrepreneurship (indirect benefit). Finally, indirect benefits can affect areas impacted directly – for example, higher education levels (indirect effect) increase the quality of the labour pool (direct effect). The key point is that entrepreneurship does not depend on transpiration costs directly. Instead, many factors that have been shown to determine entrepreneurship, have also been shown to be affected by rail access.

2.2. Factors that determine entrepreneurship

Given how comprehensive the effect of access to rail is, it is hardly controversial to suggest that it could affect entrepreneurship. Indeed, many of the factors discussed above have been shown to affect the choice to become an entrepreneur.

Market Access: Improved rail connectivity significantly enhances market access, a critical element for startup success and expansion. As highlighted by Buisseret, Cameron, and Georghiou (1995), startups thrive in environments where they can easily reach a broad customer base and engage with diverse markets. Rail developments reduce the spatial barriers to market entry, enabling startups to scale rapidly and efficiently. Prior work using new bridge openings showed that improved connectivity positively affected start-up founding, rail connectivity is expected to produce some of the same effects (Dutta, Armanios, & Desai, 2022). Naturally, market access works both ways and increases competition in the local market which may have a detrimental effect on profitability of local businesses (Laffont & Tirole, 1994).

Cost Reduction: The reduction in transportation costs due to enhanced rail infrastructure can be particularly beneficial for new ventures, which often operate under tight budget constraints. Lower transportation costs for goods and people allow startups to allocate resources more efficiently, potentially making previously unviable startups possible or allowing investing more in innovation and marketing efforts. Audretsch, Keilbach, and Lehmann (2006) note that such cost efficiencies are vital for sustaining new businesses, especially in competitive sectors. At the same time, it is possible that some costs will rise. For example, prices of commercial real estate have been shown to be increased by rail access. While this naturally occurs because these locations become more

productive, it is not clear if this productivity is captured by incoming firms, incumbent local firms or new local firms. In addition, increasing house prices (and rents) may make it costlier to afford a house from which running a business is feasible making starting business from home harder.

Labor Mobility and Skill Access: Access to a skilled and diverse workforce is another key factor driving entrepreneurial success. Improved rail systems expand the geographical range from which businesses can recruit, thus enhancing the match between job requirements and employee skills. This connectivity also supports the agglomeration of knowledge-intensive industries, which rely heavily on human capital, as discussed by Florida et al. (2015). However, it is worth noting that (like market access) labour mobility works both ways and allows firms close to a station recruit from further afield but increases competition for labour by allowing people living close to a station to access jobs located far away. This means that increased labour mobility enhances both employment and self-employment opportunities for the connected population. This could reduce entrepreneurship rates close to stations by offering better employment options than places with poor rail connections. This is especially important for women as reducing commute times makes it feasible for them to balance work and domestic responsibilities more effectively, potentially increasing their economic participation rates (Farré et al., 2023). Furthermore, the option to work closer to home or in more accessible areas might alter the traditional business models that women choose to engage with, potentially leading them to venture into sectors that were previously less accessible due to commuting constraints (Simoes, 2016).

Amenity Effects Enhancing Local Attractiveness: Improved rail access often leads to upgraded local amenities, making areas more attractive for both living and business operations. Improved infrastructures, such as better roads and security, accompany rail developments, enhancing the quality of life. Such amenities attract a wealthier and more educated residents and better businesses, as demonstrated by the increased property values discussed by Mathur and Ferrell (2013).

Education Benefits Leading to a More Skilled Population: The accessibility of educational opportunities is also a crucial benefit of rail access. As transportation becomes less expensive and more efficient, more individuals can access higher education facilities, which likely increases the local skill base. Research by Glaeser et al. (2004) supports the idea that better transport connectivity correlates with higher educational attainment in connected regions.

Social Networks and Entrepreneurship: Reduced transportation costs and improved accessibility also enhance social networking opportunities by facilitating more frequent and diverse

interactions. Putnam (2000) notes that stronger social networks foster a collaborative environment conducive to entrepreneurship by easing information exchange and support systems. Better connectivity supports knowledge spillovers between regions (Bahar, Choudhury, Kim, & Koo, 2023; Bai, Jin, & Zhou, 2023), and enhance startup creation (Dutta, Armanios, & Desai, 2022).

Real Estate Effects on Entrepreneurial Activity: The increase in real estate values in areas with enhanced rail access can influence entrepreneurial activity. For example, increasing house prices stimulated by rail access could provide entrepreneurs with the equity they need to start a business. Szumilo and Vanino (2021) show that house prices can have a significant impact on entrepreneurship. Rail access increases the visibility of emerging business hubs to potential investors, facilitating capital flows into innovative ventures as highlighted by Florida et al. (2012). In addition, higher commercial and residential property values can lead to increased local spending power and provide a wealth effect that supports new business initiatives (Cervero and Kang, 2011).

2.3. Measuring entrepreneurship

Using self-employment as a proxy for entrepreneurship has both strengths and weaknesses that have been discussed extensively in the literature. On the positive side, it aligns with policy goals focused on economic resilience and captures nascent entrepreneurship, including early-stage ventures not yet reflected in firm-level data (Simoes et al., 2016; OECD 2020). Additionally, self-employment data is readily available and consistently measured in the Census, allowing for robust comparisons across regions and time, particularly at the localized level our study focuses on. Moreover, self-employment is strongly associated with innovation and new business creation (Parker, 2018; Wong, Ho, & Autio, 2005), further supporting its validity as a proxy. However, the consensus of the literature discussing the use of self-employment as a measure of entrepreneurship seems to be that it is a valid apporach but only as long as its limitations are acknowledged (Bjuggren et al. 2012). We therefore note that that self-employment is a broad category encompassing diverse activities, from innovative entrepreneurs to individuals in subsistence activities and keep this in mind throughout the paper.

3. Hypothesis and mechanisms

While the literature suggests a strong linkage between rail infrastructure improvements and key determinants of entrepreneurship, it also shows that there are possible effects that could potentially work against each other. In a recent paper, Koster et al. (2023) show that even the effect of rail access on employment is theoretically unclear because the balance of opposing forces can depend

on the characteristics of the treated region. This means that it is not obvious what the total effect of rail connections on entrepreneurship will be. This makes our main hypothesis simple but ambiguous about the direction: rail access affects entrepreneurship rates.

If the hypothesis is true, areas that where rail connections improve should see a change in the share of people who are self-employed. To understand the mechanism behind this effect we can examine shares of the population that prefer alternatives to self-employment namely employment/unemployment[4] or economic inactivity. For example, if labour market access makes starting a business easier and more profitable, we should see people shifting from being employees, unemployed or economically inactive to self-employment. Conversely, if rail access lowers barriers to entry into entrepreneurship but does not make it any more profitable or desirable with respect to employment, good train connections would decrease economic inactivity rates and increase entrepreneurship rates.[5]

Our ability to unpack the mechanism further and isolate individual forces is limited by data availability. Indeed, the complex interplay of different factors makes it unfeasible to provide a definitive answer in a single paper. However, we can perform additional tests with our data to provide further insights into the relationship we study.

First, we test if areas with different characteristics are affected differently by increasing rail access. Interactions of pre-treatment area characteristics with rail access can help uncover which forces drive the total effect. For example, if rail access increases entrepreneurship the most in areas with higher education rates, the effect would be more likely to occur through market access and cost reduction (making self-employment cheaper or more accessible) rather than labour market access (increasing access to a better labour pool).

After considering the extensive margin response – the impact of rail connections on the number of businesses - a natural next step would be to try to examine the intensive margin response – changes in operations of businesses or the types of firms that are opened or closed when rail connections improve. Unfortunately, we do not have any data on firms run by the self-employed, so we need to focus on entrepreneurs and their choices. Guided by the literature on commuting (Delventhal et al. 2022), we focus specifically on the choice of the self-employed to work from

[4] Note that we follow the ONS classification that defines unemployed as participants of the employment market who are searching for employment and are temporarily not employed.
[5] Note that employment would still be preferred to self-employment for the same share of people so the rate of employed and unemployed (looking for employment) would not change (Simones et al. 2016).

home or elsewhere. This choice is an important operational decision that is likely to be affected by changes to transportation cost, so it seems a very intuitive intensive margin response. On the one hand, rail access increases commuting options making work away from home easier. On the other hand, it improves the local area and makes it more productive so working from home may be more attractive. Moreover, given what the literature says about differences in commuting choices and domestic responsibilities between men and women, the impact on choices made by male and female entrepreneurs could be different, as they have different opportunity costs of commuting. When commutes are longer, women are often forced to work from home (including self-employment from home) by their domestic commitments (Cao, Mokhtarian, & Handy, 2009). Women are also much more likely to self-employ in sectors that require in person contact such as education or care work. Therefore, we expect women entrepreneurs to be more likely to work from home when rail connections are poor.

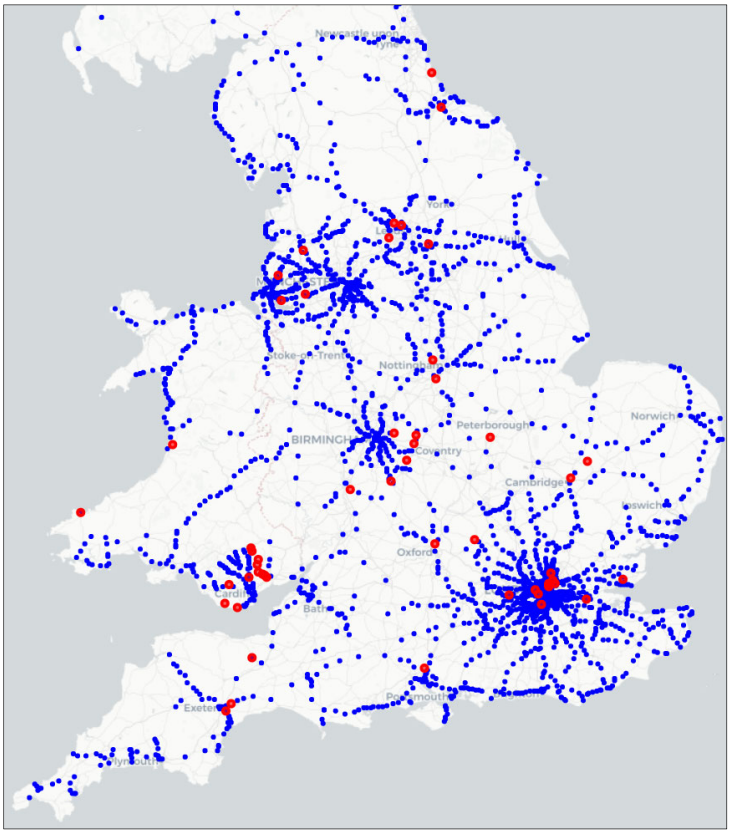
4. Data

The main data comes from the Census in England and Wales in years 2001, 2011 and 2021. It offers data on population and economic activity at very granular level. Our main focus is on Output Areas (OAs) which are the smallest Census geography and have the average population of around 214 working age adults (in 2001). **Table 1** offers summary statistics for all variables we have at this geographical level. Our most important variable is the rate of self-employment which we calculate by dividing the number of self-employed by the population of working age adults. On average there are around 17 self-employed persons in each OA giving a self-employment rate of around 8%. We focus on the rate because access to rail can affect population and we want to control for that effect. Our conclusions hold when we use the number of self-employed rather than the rate. In our regressions we also use other answers to the same census question about being employed, unemployed and economically inactive. For data we could not access at OA level we used slightly larger geographies – LSOAs – that have an average population of around 1,500. This includes variables such as the number of self-employed who work mainly from home as well as the split of this variable by gender. The variables we use at LSOA level are not publicly available and we purchased it from the Office for National Statistics.

We geocode the location of each area using its population-weighted centroid provided by the Office for National Statistics. We match this to geocoded locations of train stations in England and Wales from the Office of Road and Rail in each of the census years. This allows us to create a variable that gives the distance to the nearest station for each location in each of the census years.

We focus on locations that are no further than 10km away from a station.[6] This gives us a three-period panel of Output Areas (or LSOAs).[7] In total, we have 3,745 Output Areas and 724 LSOAs for which the distance to the nearest train station changed in our study period as a result of opening 28 stations between 2001 and 2011 and 26 stations between 2011 and 2021. The average change of this distance was around -1.78km with the maximum being around -9km. Locations of all stations in our data are plotted in **Figure 2**.

Figure 2. Locations of new (red) and existing (blue) stations in England and Wales.



Notes: the figure shows locations of rail stations in England and Wales at the end of 2021. Each blue dot represents a station that existed before 2001 and each red dot represents a station that was opened between 2001 and 2021. It does not include light rail stations or the London Underground.

Summary statistics are available in **Table 1**. The treated sample is relatively representative of the population in terms of the distances to the nearest station as well as other variables – see the comparison to the non-treated sample in **Table 1**. While our identification is based on comparing

[6] The idea behind the 10km radius is that we think that the impact of the treatment beyond that distance will be marginal and are less interested in measuring it. Setting the radius at 10km does not affect our results. Indeed, our results show that there are no effects beyond around 7km.

[7] Boundaries of around 2.6% of all census geographies changed between censuses. We only use geographies that did not change and there appears to be no changes in the sample of areas close to stations opened in our study period (treated locations). The panel is not balanced since a small fraction of OAs (<1%) are suppressed in any given year due to statistical disclosure controls.

locations that are similar (and very close) to each other, the fact that our treatment sample is representative to the population allows us to claim that our conclusions are generalizable.

In our regressions we also use two types of larger geographies to control for common trends shared amongst nearby areas – we call them regions. For the treated areas we use regions defined by a 12km radius around the location of their closest station in 2021. For areas that are not treated, we define regions as Local Authority Districts (local government jurisdictions) which are usually much larger than treated regions. There are 348 government-based regions.

Table 1. Summary statistics.

	2001 treated		2001 non-treated		All years & areas	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
	Output Area (OA)					
N	3,745		162,116		482,098	
Self-employment rate	7.32%	4.89%	8.09%	4.94%	9.06%	4.68%
Distance to nearest station	3.97	2.39	2.35	2.03	2.33	2.02
Working age population	214	40.75	213.4	48.05	232.31	58.85
Total employment	112.8	34.62	112.5	35.21	124.59	40.25
Self-employment	15.7	10.86	17.3	11.16	21.26	12.38
Unemployment	8	6.14	7.2	5.99	8.28	6.43
Economically inactive	72.7	23.82	71.1	29.5	80.74	35.57
Female w. age population	109.5	21.25	108.7	24.31	118.7	30.3
Share with a degree	20.10%	15.13%	19.60%	12.97%		
Share with social class A	20.80%	13.12%	21.60%	12.63%		
Share of single adults	17.30%	9.94%	16.70%	10.57%		
Share working from home	8.20%	4.46%	8.90%	5.07%		
% working <10km from home	79.00%	8.17%	74.70%	11.01%		
% working >60km from home	8.70%	5.96%	11.80%	8.05%		
	Lower Layer Super Output Area (LSOA)					
N	724		30,813		92,875	
Home SE / SE	34.10%	12.92%	33.20%	12.19%	33.60%	11.92%
Home SE Fem / Fem Pop	1.90%	1.76%	2.00%	1.71%	2.60%	1.95%
Home SE Male / Male Pop	3.30%	2.43%	3.70%	2.61%	3.80%	2.62%
Home SE Fem / SE	12.20%	7.60%	11.60%	7.02%	13.50%	6.71%
Distance to nearest station	4.01	2.41	2.34	2.01	2.32	1.99

Notes: "2001 treated" refers to cross-sectional statistics in year 2001 for the geographies for which the distance to the nearest station changed during the study period due to the treatment. "non-treated" presents the rest of the population in 2001. "All years & areas" gives the full sample across all locations and periods.

4.1. Why new stations open in the UK

The need for new train stations (and their location) in the UK is determined through a multi-faceted process involving various stakeholders and key considerations. The process starts with identifying the need for a new station, driven by factors such as population growth and gaps in the current transport network (Network Rail, 2021). Feasibility studies are then conducted to assess

the technical, economic, and environmental viability of the proposed station, considering projected passenger demand, cost estimates, engineering challenges, and environmental impacts. Stakeholder consultation involves local authorities, transport operators, community groups, and businesses, along with public consultations to gather feedback from residents and potential users (Department for Transport, 2020). The proposed station must align with national, regional, and local transport strategies and policies, supporting broader goals such as sustainability and improved accessibility (Network Rail, 2021). A key step is to secure funding, which may come from public and private sources, including government grants, local authority contributions, and private investments.

Once feasibility and funding are confirmed, detailed design work begins, including architectural designs, engineering plans, and environmental assessments. Planning permissions and regulatory approvals must be obtained from relevant authorities (Department for Transport, 2020). Land acquisition and site preparation follow, with construction commencing once all permissions are in place. The final stages involve testing and commissioning to ensure safety and operational efficiency before the station opens to the public. Continuous monitoring and evaluation are conducted to ensure the station meets its objectives and benefits the community and transport network (Network Rail, 2021).

5. Methods

Our objective is to estimate the following equation:

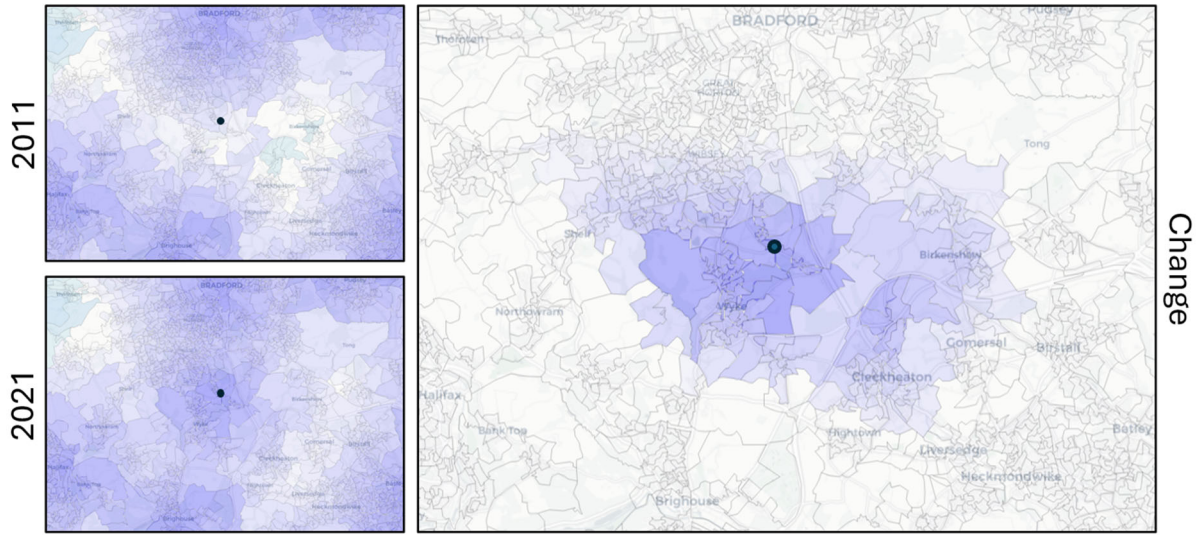
$$Eq.1 \qquad Y_{it} = \alpha + \beta D_{it} + \epsilon_{it}$$

Where Y is the rate of self-employment in area i at time period t, α is a constant, D is the distance to the nearest train station and β is its corresponding coefficient while ϵ is an error term. This equation cannot be reliably estimated with a simple regression for two reasons. First, there are other variables that are likely correlated to both distance to the train station and entrepreneurship including the availability of other types of infrastructure (e.g. buses or broadband), quality of amenities such as schools or office space as well as employment density. Second, high entrepreneurship rates resulting from local factors might cause stations to be build nearby to support their growth.

To address these challenges, we exploit an identification strategy based on the change in the distance to the nearest station that occurs when a new station is opened. This means that we observe a change in the distance to the nearest station and can measure self-employment rates before and after a station is built at different distances to the station. We illustrate the treatment

we exploit in **Figure 3** which shows how opening of a station affected the distance to the nearest station in the surrounding OAs.

Figure 3. Distances to the nearest station around Low Moore station (and change).



Notes: All panels show OAs in the same area of around 10km by 15km around Low More station (denoted by the black dot) opened in April 2017. The left panels colour each OA with a shade of blue where darker denotes shorter distance to the nearest station. The panel on the right uses darker blue to indicate a bigger change in the distance to the nearest station (treatment) between 2021 and 2011. The average treatment in this sample is -1.33km and the biggest reduction in distance is -4.56km.

In simple terms, our identification is based on tracking outcomes in OAs that are not white in the panel on the right and correlating their changes to the change in the distance (denoted by shades of blue). Naturally, we need to control for any factors that could be correlated to our treatment intensity, so in practice, we estimate:

$$Eq.2 \qquad Y_{it} = \alpha + \alpha_i + \alpha_t \times R_i + \beta D_{it} + D_i^{2001} \times \alpha_t + \epsilon_{it}$$

Where α_i is an area i fixed effect and allows us to keep all unobserved time-invariant characteristics of areas constant - including the impact of the distance to nearest station for areas where this distance does not change and the impact of the distance to the point where the new station is built. Adding an area fixed effect to the regression means that variable D_{it} captures changes in distance. Next, $\alpha_t \times R_i$ is a time fixed-effect interacted with a region fixed-effect, capturing time-dynamic unobserved variables that affect entrepreneurship in a region (such as long-term trends, changes in amenities or policy changes). Finally, $D_i^{2001} \times \alpha_t$ is an interaction of the distance to the nearest station in 2001 with the year fixed-effect and captures the fact that places close to stations in 2001 could be following a different trend than places further away. For clarity we note that this fixed-effects panel specification is numerically identical to using a first-difference equation regressing

changes in self-employment to changes in distance to the nearest station but uses a larger sample. The two specifications differ only by precision of estimates.

In **Eq.2** we are effectively, identifying from changes in the distance D that occur due to a new station being opened compared to other areas in the same region. It is worth reiterating that we focus on variation in virtually street-level outcomes conditional on trends in relatively small geographical areas.

5.1. Identification assumptions and placebo tests

At this stage it may seem tempting to add control variables that are typical in the entrepreneurship literature such as education levels or age of residents. However, these are likely affected by our treatment (see **Figure 1**) which means that they are what Angrist and Pischke (2009) call "bad controls" and including them would bias our estimation of β. Instead, we rely on our identifying assumption that, conditional on our fixed effects, our treatment is exogenous (uncorrelated to the outcome or its determinants prior to the treatment). If this is assumption holds, we do not need to include control variables. In practice, the key identification assumption is that without the treatment, outcomes in areas that receive a higher intensity treatment (larger change in distance) are the same as further away. Fortunately, this assumption is testable and we can demonstrate that it holds in our data.

First, we show that the distance to the location of a future station does not matter for self-employment before a station is opened. This suggests that the rate of entrepreneurship in the surrounding area is not a determining factor of a new station's location. In other words, on average the distance to the place where a new station eventually opens does not seem to determine self-employment before a station is opened. We show this in a simple cross-sectional regression in 2001:

$$Eq.3 \qquad Y_{it} = \alpha + R_i + \beta_p D_{it}^{post} \times T_i + D_i^{2001} \times \alpha_t + \epsilon_{it}$$

This specification models self-employment rates as a function of region fixed effects (R_i), distance to the nearest station in 2001 (D_i^{2001}) and distance to the nearest station after the treatment for the treated locations $D_{it}^{post} \times T_i$. Parameter β_p captures the impact of the distance to the newly developed station on self-employment in 2001 (in addition the impact of distance to the nearest existing station captured by D_i^{2001}). β_p is expected to be zero if the distance to the location of a station that will eventually open is not correlated to determinants of entrepreneurship in 2001.

The second way to supports our identification strategy is to show that changes in the distance to the nearest station that will occur in the future do not affect changes in self-employment rates before the new stations are opened. Essentially, this shows that trends in self-employment rates before the treatment are not correlated to the intensity of the treatment received eventually by the treated areas. This is fundamentally a test of parallel pre-trends typical for the difference-in-difference method that our approach is related to.[8] To implement this we estimate **Eq.2** but replace the contemporary distance to the nearest station D_{it} with the value it will take in the future $D_{i(t+1)}$. If areas follow parallel pre-trends, future changes should not correlate to changes in self-employment before stations are opened**.** Naturally, we can only do this for outcomes in 2001 and 2011, using stations that open between 2011 and 2021 as the treatment.

The fact that our identification assumptions are supported by the data means that we identify the treatment effect from variation in the "intensity" of the treatment (in our case the change in the distance to a station) that is unrelated to both levels and changes of the self-employment rate in the absence of the treatment.

5.2. Secondary regressions

We also make several adjustments to **Eq.2** to further examine the relationship between rail access and entrepreneurship. We start by replacing the continuous variable D with a series of dummy variables denoting increasing distance bins of 500m each. Each distance bin denotes the distance to the nearest station after the treatment for areas where the distance has changed. The regression estimates the effect of being moved into each of these bins and allows us to see how far the effect reaches.

Next, we interact D with characteristics of areas before the treatment to understand what kinds of places are affected more/less. We estimate:

$$Eq.4 \qquad Y_{it} = \alpha + \alpha_i + \alpha_t \times R_i + \beta D_{it} + \sum_{n=1}^{9} \beta_n D_{it} X_{ni} + D_i \times \alpha_t + \epsilon_{it}$$

Where X_n is a vector of one of 9 area characteristics we include based on the literature review (denoted by n) measured before the treatment (in 2001) and β_n are their corresponding coefficients.

[8] Technically our main approach is a combination of a method that assumes exogenous treatment intensity with a difference-in-difference approach. This means that in practice we compare differences between areas that receive different levels of treatment before and after the treatment is administered. Note that our estimates are not affected by changes in the control group that have been shown to be problematic for difference-in-difference approaches where treatments occur at different times. This is because we are identifying from changes within very small areas.

Finally, we also replace the outcome in **Eq.2** with other variables. In the first instance we replace it with other measures of economic activity to understand how changes in self-employment interact with employment and inactivity. Next, we look at outcomes related to how likely self-employed men and women are to work from home.

6. Results

In **Table 2** we present results of our main regression. In column (1) we show that higher distance to the nearest train station is negatively correlated to self-employment rates. These results controls for year and OA fixed effects so it exploits *changes* in the distance occurring due to opening of new stations. In column (2) we add LAD trends to allow for different local authority areas to follow different long-term trends in self-employment. This reduces the key estimate slightly but the effect remains strong and negative. In column (3) we control for trends in self-employment around locations that eventually receive a new station. This means that conditional on OA fixed effects and common trends experienced by areas around new stations, places where the distance reduced by more have higher rates of entrepreneurship growth after the stations are opened. The last two columns offer slightly different samples for comparison. Column (4) uses only OAs that are within 12km from the location of a newly opened station. Column (5) includes only OAs where the distance to the nearest station changed in our study period. They have slightly smaller and less precisely estimated coefficients, but they point to the same negative relationship between distance to a station and self-employment rates. Our preferred specification is given in column (3) but we use the lowest estimate in this table (-0.0012) as a conservative estimate of our total effect.

Table 2. Distance to a newly opened station and self-employment rate.

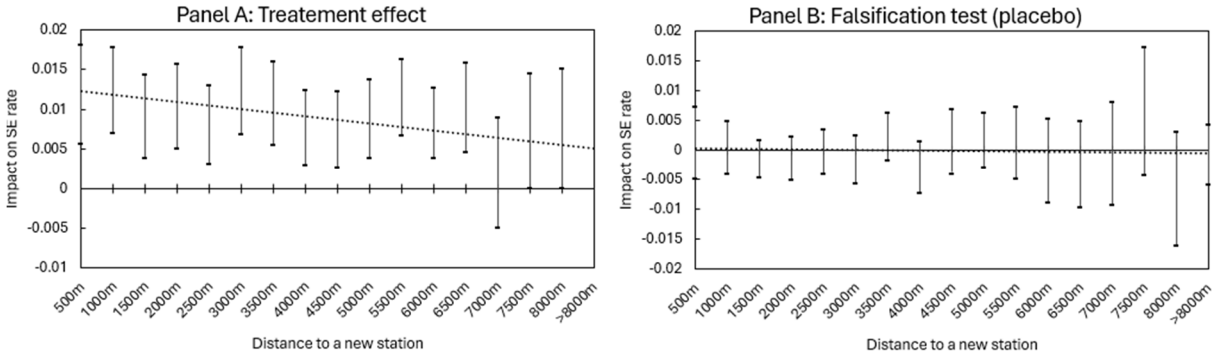
	(1)	(2)	(3)	(4)	(5)
	SE rate	SE rate	SE rate	SE rate	SE rate
Distance	-0.00230***	-0.00147***	-0.00129**	-0.00120*	-0.00138**
	(0.000540)	(0.000361)	(0.000411)	(0.000508)	(0.000426)
N	482120	482120	482098	84588	146011
Area FE	Yes	Yes	Yes	Yes	Yes
Year Fe	Yes				
LAD trend		Yes	Yes		
Station trend			Yes	Yes	Yes
Sample	Full	Full	Full	<12km	Treated

Notes: Standard errors in parentheses, + p<0.10, * p<0.05, ** p<0.01, *** p<0.001. Standard errors are clustered by the identifier of the nearest station in 2021. The outcome in all columns is the number of self-employed over the number of working age population at Output area level. Area FE refers to output area fixed effect, Year FE is a period fixed effect, LAD trend is an interaction of a Local Authority Area (local government) with year, Station trend is the interaction of a fixed effect for being within 12km of the location that eventually turns into a newly opened station interacted with year. Full sample includes all Output Areas in England and Wales, <12km includes all areas within 12km of the location that eventually turns into a newly opened station and Treated includes all areas for which the distance to the nearest station changed between 2001 and 2011.

Next, we investigate a less parametric version of our favourite specification and use 500m bins of distance to the nearest station to test how far the effect reaches. It shows the effect of being moved into a bin at a certain distance from a newly opened station and uses a distance bin of between 8km and 12km away from the same station as a benchmark.

Figure 4 we show that the effect is the strongest on places moved to within 500m of the newly opened station and reduces with distance. The effect is indistinguishable from zero after around 7km (equivalent to a 20min bicycle ride) suggesting that this is the spatial extent of the impact of a new station.

Figure 4. Non-parametric estimation results of the treatment and placebo effects.



Notes: Standard errors at 5% confidence interval are clustered by the identifier of the nearest station in 2021. Specification of Panel A corresponds to column (3) in **Error! Reference source not found.**. Panel B uses the same specification but is limited to years 2001 and 2011 (see column (4) of **Error! Reference source not found.**) and uses the placebo approach discussed in section **5.1**. Data plotted corresponds to coefficients of dummy variables for distance bins of 500m.

6.1. Test of identifying assumptions

The above results are exploiting powerful controls in the form of OA fixed effects and small geography trends. However, to further strengthen our claim that the result is causal we turn to the tests described in section **5.1** and present their results in Error! Reference source not found. in columns (1) to (3) we implement **Eq.3** in different ways. We begin with a specification with no fixed effects in column (1), which shows that nationally new stations were located in places where entrepreneurship rates were higher. However, this effect disappears when we add location fixed effects in column (2) suggesting that focusing on within-region changes is important. In column (3) we check if stations opened between 2001 and 2011 or 2011 and 2021 were placed in areas with different entrepreneurship rates and find that neither set was located in areas with different outcomes. In column (4) we show that future changes in distance to the nearest station do not affect changes in self-employment prior to stations opening. This means that all treated areas follow the same pre-treatment trends. We show this graphically using a non-parametric specification in Panel B of

Figure 4. The figure shows very clearly that the treated areas have identical outcomes in the absence of the treatment. Overall, the table shows that areas located closer to the new stations do not seem to have higher entrepreneurship rates before stations are opened and that areas which receive a stronger treatment do not follow different trend in self-employment before the treatment.

A further robustness check is offered by Panel A of

Figure 4 which provides reassurance that the effect is not driven simply by areas in the closest neighborhood to the station that could be attractive to begin with or benefit from a refurbishment of the area.

Table 3. Placebo test: distance to a unopened station and self-employment rate.

	(1)	(2)	(3)	(4)
	SE. rate	SE. rate	SE. rate	SE. rate
Dist after change	-0.00278***	0.00111		
	(0.000628)	(0.000825)		
Dist in '11			0.000693	
			(0.00146)	
Dist in '21			-0.0000239	
			(0.000683)	
Dist. (t+1)				0.000224
				(0.000535)
N	157874	52182	52182	315716
Sample	'01	'01	'01	'01 & '11
Distance '11 ctr.	Yes	Yes	Yes	
Area FE				Yes
LAD FE		Yes	Yes	Yes
Station FE		Yes	Yes	Yes

Notes: Standard errors in parentheses. + p<0.10, * p<0.05, ** p<0.01, *** p<0.001. Standard errors are clustered by the identifier of the nearest station in 2021. Columns (1)-(3) are cross sectional regressions in 2001 and column (4) is a panel regression using 2001 and 2011. The outcome is the number of self-employed over the number of working age population at Output area level. "Dist after change" is the distance the nearest station in 2021 interacted with a dummy denoting treatment at any point. "Dist in '11" is the distance the nearest station in 2011 interacted with a dummy denoting treatment between 2001 and 2011. "Dist in '11" is the distance the nearest station in 2011 interacted with a dummy denoting treatment between 2001 and 2021. "Distance '11 ctr." is a flag for the regression including distance to the nearest station in 2001 as a control. LAD FE denotes a Local Authority District area fixed effect and Station FE denotes one for the nearest station in 2021.

6.2. Economic activity

In **Table 4. Distance to a newly opened station and economic activity.** we present results of our preferred specification but replace the outcome with other types of economic activity.[9] The results are mostly imprecise and need to be interpreted in this context. Frist, in column (1) we look at total employment. It seems to be positively affected by access to rail (consistent with the effect

[9] At this point, it is worth noting that while the sum of the rates we predict should add up to one, the sum of the estimated effects does not necessarily have to add up to zero because each regression is estimated conditional on regional trends in the outcome variable.

we find on self-employment), but the effect is estimated with a large confidence interval. In column (4) we look at the impact on the rate of people who are employees, and it is estimated with even less precision – suggesting that the impact on the choice to be an employee is far less consistent than on self-employment and could be zero. In column (2) we find no impact on unemployment. In column (3) we show that the impact on the rate of economic inactivity is negative and statistically significant. All in all, the results of **Table 2** and **Table 4** suggest that access to rail seems to have an overall positive impact on total employment but that it comes mainly from increasing self-employment rates. Importantly, as self-employment increases, the rate of economic inactivity reduces suggesting a positive impact on the overall economic participation. Employment and unemployment rates seem to remain unaffected suggesting that the impact on self-employment does not affect the employee job market.

Table 4. Distance to a newly opened station and economic activity.

	(1) Employment r.	(2) Unemployment r.	(3) Inactivity r.	(4) Non-self emp. r.
Distance	-0.00234+	0.000273	0.00231*	-0.00107
	(0.00141)	(0.000297)	(0.00114)	(0.00124)
N	482031	482031	482031	482031
Area FE	Yes	Yes	Yes	Yes
LAD trend	Yes	Yes	Yes	Yes
Station trend	Yes	Yes	Yes	Yes

Notes: Standard errors in parentheses. + p<0.10, * p<0.05, ** p<0.01, *** p<0.001. Dependent variables are employment, unemployment, economic inactivity and non-self-employment (total employment minus self-employment) divided by the working age population. Area FE refers to output area fixed effect, LAD trend is an interaction of a Local Authority Area (local government) with year, Station trend is the interaction of a fixed effect for being within 12km of the location that eventually turns into a newly opened station interacted with year.

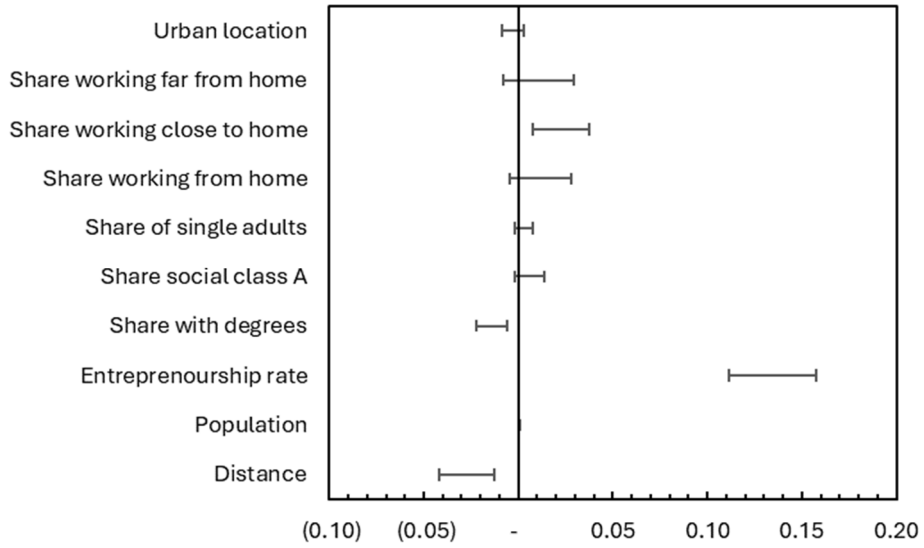
6.3. Rail access and area characteristics

In **Figure 5** we present estimates of coefficients based on **Eq.4**. The impact of distance to a station remains statistically the same and only three interaction terms are statistically significant. The starting entrepreneurship rate stands out as an important factor that reduces the impact of rail access. The effect is large and in extreme (for our sample) cases it reduces the effect to being indistinguishable from zero. This means that in our sample areas with high starting entrepreneurship rates but low treatment intensity (change in distance to the nearest station) do not see any changes in entrepreneurship rates.

The starting share of people working close to home also has a dampening effect on the impact of access to rail while places with a high share of residents with university degrees seem to experience a higher effect. Interestingly, starting values of variables that are usually correlated to entrepreneurship, such as social status, share of single adults living in the area, or being in an urban

setting, do not seem to alter the impact of rail access. Notably, they are insignificant after controlling for starting entrepreneurship rates so the results show that they are not affecting the impact of rail access independently.

Figure 5. Interactions of the distance to a new station effect with area characteristics.



Notes: Results are from a specification that includes area fixed effect, an interaction of a Local Authority Area (local government) with year and an interaction of a fixed effect for being within 12km of the location that eventually turns into a newly opened station interacted with year. Data on characteristics of each variable are from the 2001 Census at Output Area level. Standard errors at 5% confidence interval clustered by nearest station id in 2021.

6.4. Effect on self-employment from home

In **Table 5** we present results at LSOA level with the outcomes focused on the share of entrepreneurs that work from home. In column (1) we replicate the results of **Table 2** (specifically of column (3)) and get a very similar result. It is reassuring that changing the geography does not affect our results. Next in column (2) we show that the share of entrepreneurs that work from home decreases when rail connections improve. This seems to be driven disproportionately by women as in column (3), we show that the share of female entrepreneurs who work from home follows the same trend and find no impact on the share of men. Finally, in column (4) we show that access to rail does not affect the ratio of male to female self-employed. Overall, LSOA results show that improving access to rail increases the share of entrepreneurs in the area and that this extensive margin impact is the same on men and women. However, there is also an intensive margin effect on the choice to self-employ from home that differs between men and women. Access to rail decreases the probability that a self-employed woman living in the treated area is an entrepreneur working from home but has no impact on men.

Table 5. Distance to a newly opened station and self-employment from home.

	(1) SE rate	(2) $\frac{SE\ home}{SE\ total}$	(3) $\frac{SE\ Fem.\ home}{SE\ total}$	(4) $\frac{SE\ Fem.}{SE\ total}$
Distance	-0.00112*	0.00482*	0.00393**	0.000621
	0.000458	0.00234	0.00134	0.00133
N	93096	92875	92875	93073
LSOA area FE	Yes	Yes	Yes	Yes
Distance trend	Yes	Yes	Yes	Yes
LAD trend	Yes	Yes	Yes	Yes
Station trend	Yes	Yes	Yes	Yes

Notes: Standard errors in parentheses clustered by nearest station id in 2021. + p<0.10, * p<0.05, ** p<0.01, *** p<0.001. Dependent variables are (1) population of self-employed over working age population, (2) population of self-employed working from home over population of self-employed, (3) population of self-employed women working from home over population of self-employed and (4) population of self-employed women over the population of self-employed. LSOA area FE refers to Lower Layer Output Area fixed effect, Distance trend is the distance to the nearest station in 2001 interacted with year. LAD trend is an interaction of a Local Authority Area (local government) with year, Station trend is the interaction of a fixed effect for being within 12km of the location that eventually turns into a newly opened station interacted with year.

7. Discussion

The central finding of our study is that improved rail access increases self-employment rates. The effect we measure is a long-term net effect of all mechanisms through which rail access affects entrepreneurship. Importantly, the effect we find is local and exists only within 7km of a station. Since this distance is close to what Gibbons and Machin (2005) call a reasonable daily travel distance the effect seems to be related to the ability to reach a station.

An increase in entrepreneurship rates closer to stations is accompanied by decreasing rates of economic inactivity. Ceteris paribus this means a positive overall economic effect as more people participate in economic production. Interestingly, we find no impact of rail access on the rate of people who are employed or seeking employment (unemployed). This does not necessarily mean that rail access is irrelevant for them as it could be driven by opposing effects counteracting each other to give an average net effect of zero. Indeed, Koster et al. (2022) show that an insignificant overall effect can mask a heterogeneous impact on employment in large and small cities. Combined, the effects of rail access on different types of economic activity seem to suggest a lowering of the entry barriers for entrepreneurship – so some economically inactive residents are replaced by self-employed. However, it does not seem to make it any more attractive compared to being an employee – so the share of people who think they can find employment (employed or seeking employment) remains unchanged. This is important for policy makers because it suggests that improving rail access can at least partially substitute for other local policies that encourage

entrepreneurship and economic development. It is also interesting to note that economic inactivity rates are lowered by providing access to infrastructure which points to an interesting and understudied determinant of economic inactivity.

The idea that rail access reduces barriers to entry into entrepreneurship, seems consistent with the fact that areas where entrepreneurship rates are high to begin with, do not seem to benefit from better rail access. If barriers to becoming self-employed are already low (so entrepreneurship rates are high) lowering them further by improving access to rail should have a smaller effect. Moreover, if the effect is driven simply by lowering barriers to entry into self-employment, we would not expect the effect to be higher in locations that are more urban, have more educated people of higher social standing (after controlling for entrepreneurship rates) – which is consistent with our findings. This suggests a saturation point for infrastructure benefits and means that access to rail is unlikely to complement other local policies that encourage entrepreneurship. At the same time, it is important to note that rail access primarily benefits areas where barriers to entrepreneurship are higher to begin with, rather than amplifying advantages in already privileged areas. This suggests that it could be a useful policy choice for levelling up support for self-employment. However, it does not seem to apply to all inequalities. We find no impact on the ratio of male to female entrepreneurs suggesting that both genders are affected equally. This is important as on average women are only around 31% of entrepreneurs in our data, so for every one female entrepreneur created by rail access, there are around two male ones.

Finally, we look into the impact of access to rail on profiles of businesses run by self-employed in the affected areas. Limited by data and guided by the literature, we focus on the choice to work from home. We find that a smaller share of self-employed women chooses to work from home when access to rail is good but the share of men is unaffected. This could be explained by two mechanisms and in practice is likely determined by some combination of both. First, women who choose to become entrepreneurs when rail access improves are more likely to not do it from home. This suggests that the lower barrier to entry for women is related to the ability to self-employ away from home when travel to clients/suppliers becomes easier. Second, women who were self-employed from home before rail access improves choose to start working elsewhere when commuting options are improved. While the first mechanism is more consistent with the rest of our results, we cannot rule out the second one or even quantify how each one affects our results. However, it is clear that there is an intensive margin effect on women that does not exist for men showing that in the choice to self-employ from home rail access affects both genders asymmetrically.

Finally, it is worth noting that while prior research has sometimes focused on the importance of where the new transport link connects to (Bahar, Choudhury, Kim, & Koo, 2023; Bai, Jin, & Zhou, 2023), our work suggests there is a positive net effect of improved rail access, independently of where the new transport link leads to. This suggests that policies that improve transport links would have positive effects on self-employment regardless of the economic desirability of the places they connect to.

7.1. Limitations and future research

Unpacking the mechanism that drives the effect we report is difficult as we are limited by data availability as well as the empirical design we exploit. For example, our treatment applies to areas rather than people, so we cannot say if access to rail affects choices people make about their economic activity or about their place of residence (people can move between areas). This means that we can speak only to the local impact of access to rail. While this is the main outcome of interest for regional policymakers, we recognise that to be able to say more about the nature of a decision to become an entrepreneur, we would need individual-level data.

Our study focuses on the effects of rail access as these are often the most expensive, ambitious and popular infrastructure projects, but similar mechanisms could be at play with other types of infrastructure improvements, such as highways, airports, and digital connectivity (e.g., broadband internet). Future research should investigate whether these different forms of infrastructure have comparable effects on entrepreneurship and local economic activity. Understanding these dynamics can help in planning comprehensive infrastructure development strategies that foster entrepreneurship and regional growth.

8. Conclusions

Our research underscores the significant impact that improved rail access has on local entrepreneurship, providing clear evidence that proximity to rail stations fosters higher self-employment rates. This relationship is indicative of the broader role that transportation infrastructure plays in economic development. However, the nuanced interplay of factors driving our results calls for further investigation. The precise mechanisms—whether through enhanced market access, cost reductions, or improved labour mobility—warrant deeper exploration.

Furthermore, our results suggest that the impact of infrastructure on entrepreneurship is underappreciated and understudied. While much attention has been given to financial, educational, and regulatory factors, our study suggests that infrastructure access plays an important role in

fostering entrepreneurial activity. Given the popularity of entrepreneurship and infrastructure policies their interactions seem to be important but understudied.

The data constraints of our setting mean that we are limited in what we can say about the impact of access to rail on the way self-employed operate their businesses. However, we can show that the share of entrepreneurs working from home decreases when rail is more accessible. Thus, it is evident that rail access can influence where and how entrepreneurs choose to conduct their business, with potential implications for gender equality in entrepreneurship. We believe that our findings and methods will help other researchers look further into this area.

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