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Abstract

How do reductions in interaction costs shape the diffusion of social movements? In this paper, I use a natural experiment from Swedish history to answer this question. During the thirty-year period 1881-1910, Swedish society underwent two transformative developments: the large-scale roll-out of a national railway network and the nascence of grassroots social movements which came to dominate economic, social and political spheres well into the twentieth century. Using exogenous variation in railway access arising from initial plans for the network, I show that well-connected municipalities were more likely to host a local movement and subsequently saw more rapid membership growth and a greater number of distinct organisations. The mobility of individuals is key: results are driven by passenger arrivals into connected municipalities, not freight arrivals. I implement a market access framework to show that, by reducing least-cost distances between municipalities, railways intensified the influence exerted by neighbouring concentrations of membership, thereby enabling social movement spread.

Keywords: social movements, railways, collective action, interaction costs, market access
JEL Codes: D71, D83, N33, N73, O18, R40, Z13

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1 Introduction

Social movements can be powerful forces for change. In the context of European democratisation, grassroots pressure on elites was instrumental to an extension of the franchise (Aidt and Jensen (2014), Aidt and Franck (2015)). Collective action has the power to end absolutist monarchies, as in Denmark during the upheavals of 1848, and topple economic systems, as in the case of the abolition of Austrian and Hungarian serfdom (Stearns, 1974). More recently, grassroot-level political organisation was crucial for the successes of the U.S. Civil Rights Movement (Morris, 1986) and for popular mobilisation during the Arab Spring (Beinin and Vairel, 2013).

Despite the importance of social movements in shaping societal, political and economic developments, many questions remain open about the nature of their evolution and spread. In theories of collective behaviour, the organisation of individuals with mutual interests is key (Olson (1965), Tilly (1978)), and relies on information about the actions of others (Granovetter (1978), Jackson and Yariv (2007)). Facilitating communication between agents in such models, however, need not necessarily lead to better mobilisation outcomes (Gould (1993), Hassanpour (2014)). The question therefore naturally arises: how do reductions in the cost of interactions between individuals shape the spread and growth of a movement, and what are the mechanisms underlying this social contagion of ideas?

These are questions which I seek to answer in this paper, taking a natural experiment from Swedish history as a testing ground. In the period 1881-1910, the large-scale roll-out of a national railway network radically transformed Swedish society (Heckscher, 1907), with the total length of the network increasing from 6,000 kilometres in 1881 to 14,000 in 1910 (Kungliga järnvägsstyrelsen, 1956). At the same time, nascent social movements emerged which came to define the Swedish economic, social and political fabric at least until the Second World War (Lundkvist, 1977). These movements included a rich network of leftist organisations and labour unions, as well as free churches and temperance movements. Uniting these disparate organisations was a shared objective of democratisation by way of extensions to the comparatively narrow Swedish franchise. By 1910, their combined membership was 700,000 from a population of approximately 5.5 million (Andrae and Lundkvist, 1998). Combining these concurrent developments, I study how the large decrease in travel costs granted by the railway system facilitated the diffusion of these movements.

I use rich historical data, combined from several sources, to construct a panel covering more than two thousand municipalities over the thirty-year period 1881-1910. I reconstruct the Swedish railway network and measure each municipality's access to rail each year based on historical railway maps. I combine this with detailed data on social movements from the Swedish Social Movements Archive (Andrae and Lundkvist, 1998), covering the yearly presence and membership of various groups in each municipality. Finally, I supplement these data with full-count population censuses, data on telegraphs and the postal service, as well as a host of geographical data.

Equipped with this dataset, I estimate the causal effect of improved railway access on the spread of social movements. I implement an instrumental variables strategy in which I use proximity to initial proposals for the railway network to instrument for actual proximity to rail.[1] I document the crucial role played by improvements in transportation infrastructure in shaping the diffusion of social movements on both extensive and intensive margins. Following a reduction in the distance between a municipality and the railway network, the probability that a movement spreads to the municipality increases, membership numbers rise and there is an increase in the number of distinct organisations active in the municipality.

To explore the mechanisms underlying this result, I operationalise a "market access" framework inspired by Donaldson and Hornbeck (2016). The movement membership in a given municipality can be thought of as a travel cost-weighted function of movement membership in other municipalities. I show that as travel costs decrease due to railway expansion, access to and influence from social movements in nearby municipalities intensifies, which facilitates diffusion. I supplement this analysis with station-level data to demonstrate that the spread of social movements is predicted by passenger arrivals in a municipality but not by freight arrivals. The social mobilisation therefore is one driven by the mobility of individuals, and not by local economic activity more broadly. I use data on religious and occupational structure to rule out alternative mechanisms related to the demand for social movements, and data on the telegraph system and postal service to show that competing supply-side channels cannot explain away my proposed mechanism.

This paper speaks to a recent literature exploring the impact of technology on social interactions, in particular in the process of political mobilisation. Most closely related to my study, due to its contemporaneous historical setting, is recent work by García-Jimeno, Iglesias and Yildirim (2018), who document the role of information diffusion in shaping collective action during the U.S. Temperance Crusade of 1873-1874. García-Jimeno, Iglesias and Yildirim (2018) is part a broader family of papers exploring how technology shapes protest activity, which includes key contributions by Acemoglu, Hassan and Tahoun (2018), Manacorda and Tesei (2020) and Enikolopov, Makarin and Petrova (forthcoming). These papers rely on protest data as measures of political engagement. An advantage of my setting is the use of actual membership numbers in grassroots organisations to capture the latent support for political change from which more extreme political action could potentially emerge. Protests are also, naturally, shorter-term events, whereas I am able to capture a longer-run process of the build-up of support for democratisation. Related work on the effect of technology on political participation in elections (Falck, Gold and Heblich (2014), Campante, Durante and Sobbrio (2017)) can take a similarly long view, but presupposes the existence of democratic elections.[2]

[1] This instrument was first used in the Swedish setting by Berger and Enflo (2017), and is explained at length in Section 4 below.

[2] A parallel strand of research on the effect of technology on political unrest considers improvements not in the technology used in political coordination, but in the use of labour-saving technology in modes of production. The labour-displacing effects of new technology may result in unrest as a result of backlash by the displaced. Examples using historical settings include Enflo, Karlsson and Molinder (2019*a*) and Caprettini and Voth (forthcoming).

More broadly, I contribute to a literature seeking to understand the emergence of grassroots demands for democracy. The threat of revolution has been shown both theoretically and empirically to be an important predictor of the transition to democracy (Acemoglu and Robinson (2000, 2001), Aidt and Jensen (2014), Aidt and Franck (2015)). The successful coordination of individuals with shared objectives is key to the credibility of such threats. Demands for representation may have long historical roots (Bentzen, Hariri and Robinson (2019)) or be inspired by interactions with already-democratised societies (Markoff (2015), Stegmann (2019)). In any case, to mount sufficient pressure on the political elite, fledgling democratisation movements need to solve the collective action problems described by Olson (1965) and identified experimentally by Cantoni, Yang, Yuchtman and Zhang (2019). The contribution of this paper is to demonstrate that the spatial dimension of large-scale social mobilisation depends on the mobility of individual actors. Railways enabled such mobility and thereby unleashed the grassroots movements pushing for Swedish democratisation.

My emphasis on personal interactions for the transmission of ideas resonates with work across a number of fields. Cross-country productivity studies highlight the role played by tacit knowledge transmission as people migrate (Andersen and Dalgaard (2011), Bahar and Rapoport (2018)). Face-to-face interactions have similarly been shown to matter for innovation (Andersson, Berger and Prawitz (2020), Catalini, Fons-Rosen and Gaulé (forthcoming)) and for overcoming search and contracting frictions (Startz (2018)). An early observer of the transformative effect of Swedish railways, Heckscher (1907) predicted that the ease of in-person interaction unlocked by rail travel would have effects not attainable by existing communication technologies. Here, I document that grassroots coordination was one such effect.

The technology shock I exploit in this paper stems from an expansion of transportation infrastructure, the study of which has a long-standing tradition in economics and quantitative economic history. Railways have been particularly well-studied, at least since the path-breaking work of Fogel (1964) and Fishlow (1965).[3] Recent work has revisited the central question of the impact of railways on the U.S. economy (Donaldson and Hornbeck (2016), Perlman (2016), Katz (2018), Hornbeck and Rotemberg (2019)). Railways have been shown to have long-lasting effects, across a wide range of geographical settings and time periods, by reorganising economic and demographic structures (Hornung (2015), Berger and Enflo (2017), Jedwab, Kerby and Moradi (2017), Bogart, You, Alvarez-Palau, Satchell and Shaw-Taylor (2018), Donaldson (2018), Berger (2019)). While the focus of this paper is on railways, both pre- and post-railway innovations in transportation technology have had far-reaching effects on the spatial organisation of economic activity (Baum-Snow (2007), Bogart, Satchell, Alvarez-Palau, You and Shaw-Taylor (2017), Pascali (2017), Campante and Yanagizawa-Drott (2018), Flueckiger, Hornung, Larch, Ludwig

[3]Fogel (1964) introduced a social savings methodology to argue that railways only had a moderate effect on the U.S. agricultural sector. Using a different conceptualisation of social savings, Fishlow (1965) reaches a more optimistic conclusion. Concretely, Fogel (1964) compared the U.S. economy with railways to a counterfactual of extended canal and road networks, whereas Fishlow (1965) used existing alternatives in the ante-bellum period as the counterfactual.

and Mees (2019)). One of the contributions of this paper is to extend the economic geography framework to explore questions related to the spatial patterns of political mobilisation.

Finally, given the historical setting of my paper, I contribute to the literature on the political and economic history of Sweden around the turn of the twentieth century. Both sides of my relationship of interest feature heavily in this literature. Eli Heckscher studied the economic impact of Swedish railways already in the early twentieth century (Heckscher (1906, 1907)), and the topic has received renewed interest in recent years (Schön (2012), Berger and Enflo (2017), Berger (2019), Andersson, Berger and Prawitz (2020)). Further, the grassroots movements I study have received considerable attention, to explain both their success in mobilising (Hedström (1994), Sandell and Stern (1998), Hedström, Sandell and Stern (2000), Pettersson-Lidbom and Tyrefors (2014), Karadja and Prawitz (2019)) and their subsequent political impact (Bengtsson and Molinder (2018), Bengtsson (2019), Enflo, Karlsson and Molinder (2019*b*)). My contribution is in the intersection of these strands of the literature. By using the shock of railway expansion to generate time-varying connectedness measures, I show that the reduced interaction costs granted by greater ease of travel were key to the success of the Swedish grassroots movements.

In this paper, I contribute to the body of work assessing the role of technology in shaping social interactions. I do so in a setting that exploits the transformative historical impact of railways in Sweden. The same reductions in effective distances between locations that drove the spatial patterns of economic growth also triggered greater intercommunication between formerly distant places. This increase in connectedness promoted the diffusion of ideas and fundamentally shaped the interactions between formerly disparate groups, enabling grassroots associations to organise in pursuit of democratisation. Operationalising the particular setting of late-nineteenth century Sweden in a well-identified econometric framework, I document these effects in the salient case of the rise to prominence of Swedish grassroots social movements.

2 Historical Background

2.1 Social Movements in Sweden

Throughout the nineteenth and early twentieth centuries, social movements were an important part of the Swedish social and political fabric. From humble beginnings as local grassroots organisations in the middle of the 1800s, various temperance movements, free church associations, labour unions and leftist parties had grown into potent social forces before the First World War. By 1910, combined membership in these organisations totalled around 700,000, a sizeable figure relative to the total Swedish population of 5.5 million.

These movements played a crucial role in the Swedish democratisation process. Free church and temperance organisations were early to voice grassroots demands for representation and an extension of the franchise. By the beginning of the twentieth century, a significant proportion of the second chamber of parliament were free church or temperance members (Möller, 2015). These groups exhibited significant engagement by women, and were particularly key for the introduction of female suffrage in 1919. Labour organisations such as the unionist movement and early social democratic party organisations also increasingly came to demand extensions of the franchise (Lundkvist, 1977). Widespread engagement in grassroots movements around the turn of the twentieth century predicts the rapid subsequent rise in voter turnout (Bengtsson and Molinder, 2018) and decline in industrial conflicts (Enflo, Karlsson and Molinder, 2019*b*).

An important facet of Swedish social movements in this period is that, while the movements themselves were national in scope, membership tended to be local. That is, local branches could be set up with relative ease, and associations with just a handful of members were relatively common. This means that local engagement can be well-measured by the local presence of or membership in various movements. I discuss measurement in more detail in Section 3 below.

2.2 The Swedish Railway Network

Swedish transportation infrastructure underwent rapid change in the second half of the nineteenth century. Traditionally, transport had taken place on primitive roads and highly seasonal waterways (Heckscher, 1954). Unpredictable and fragmented pre-railway transportation networks meant that transshipment was frequent and costs were often prohibitively high (Heckscher, 1907). The introduction and rapid roll-out of a national railway network therefore dramatically changed Swedish transportation by offering a faster, higher-frequency option at a lower cost.

Swedish railway construction started relatively late, and the state viewed itself as having a crucial role to play in directing the expansion of the network. To this end, several proposals were made for a "master plan" for the roll-out of rail. The first was put forth in 1845 by Count Adolf von Rosen, who proposed a main trunk line connecting the two largest cities (Stockholm and Gothenburg), with extensions and branches for a national network.

After von Rosen failed to raise enough funds to begin construction, the parliament of 1853/1854 decided that construction of the main trunk lines would be state-financed. A second proposal was made by Colonel Nils Ericson, who was given "dictatorial powers" to route the main lines (Kungliga järnvägsstyrelsen (1906), see Berger and Enflo (2017) for a discussion).[4] These plans aimed to connect major cities and avoided the coast due to military concerns. Despite the significant powers bestowed upon Ericson to draw the plans, they were ultimately rejected in the parliament of 1857. As such, both

[4]This meant that the main trunk lines were constructed relatively quickly, in contrast to transportation infrastructure projects elsewhere. See, for example, Bogart (2018).

main proposals ultimately failed. Even so, they greatly informed eventual railway construction.[5]

Railway construction began in 1855, and the first short lines were operational by 1856 (Heckscher, 1954). Following a railway boom in the 1870s, the largest cities in the southern half of the country were connected by 1880. Nevertheless, several economic centres remained unconnected (Berger and Enflo, 2017). Throughout the remainder of the nineteenth and the beginning of the twentieth centuries, there were additional periods of rapid expansion. By the eve of the First World War, the railway network connected all the major population centres, including those in the northern parts of the country. This massive expansion is best summarised in the growth of aggregate railway line length: over the period 1856-1910, the total combined length of the network increased from 66 to 13,829 kilometres.

2.3 Railways and the Spread of Social Movements

The large-scale expansion of the railway network had far-reaching effects. Writing in 1906, Eli Heckscher mused on the profound social impact of the large increase in mobility granted by the railway:

> "Travel has been extended to infinitely wider strata of the population ... in contrast with the past, transport has an apparent democratising effect in the present." [6]

One facet of the "democratising effect" of rail is the facilitation of the spread of ideas and popular engagement with them. Hedström (1994) notes the crucial role of distance between actors in the diffusion of Swedish trade unionism, and Hedström, Sandell and Stern (2000) stress the importance of the existence of "mesolevel" networks between disparate groups of actors for the geographic spread of early social democracy. In particular, the ability of individual actors to travel was key in spreading the word of new ideas and movements:

> "The channels of communication for the new [ideas] were primarily personal visits by colporteurs, preachers, agitators and others." [7]

In the Swedish case, the expansion of the railway network reduced effective distances, increased the mobility of individuals and facilitated the formation of mesolevel networks, and enabled the spatial diffusion of involvement in social movements. It is my objective in the remainder of the paper to obtain causal estimates of the impact of rail on the spread and diffusion of social movements, and to explore the mechanisms through which this effect operates.

[5] These plans can therefore be used as instruments for actual railways, as in Berger and Enflo (2017). I discuss this instrumental variables strategy in depth in Section 4 below.

[6] Quotation from Heckscher (1906). Author's translation. Original text: "resandet har utsträckts till oändligt vidare kretsar af folket ... I motsats mot förr verka transportmedlen i nutiden uppenbarligen demokratiserande."

[7] Quotation from Lundkvist (1977). Author's translation. Original text: "Kommunikationskanalerna för det nya var främst pesonliga besök av kolportörer, predikanter, agitatorer och andra."

3 Data

The main data set used in this paper is a panel covering 2,277 Swedish municipalities over the thirty-year period 1881-1910, for a total of 68,310 municipality-year observations. Data on key variables of interest are compiled from a number of sources.

3.1 Data from the Swedish Social Movements Archive

Main outcomes of interest are constructed using the Swedish Social Movements Archive (Andrae and Lundkvist, 1998). The archive is the output of a research project that documents the history of four main social movements: temperance organisations, free churches, unions and left party organisations.[8] For each organisation, the archive details the municipality where it was seated, its year of foundation and (if applicable) its year of dissolution. In addition, the archive documents the number of members in each organisation at the end of each year. From this data, I first construct an organisation-year panel that I then collapse to a municipality-year panel for my analysis. For each municipality, therefore, I can observe which of the four movement types were present in any given year, their membership figures and the total number of distinct organisations.

I report summary statistics for the social movement data in Panels A and B of Table 1 and show aggregate time series of the spread of and membership in each movement type in Figure 1. Social movements (of any type) are present in roughly half of municipality-year observations, and this is driven primarily by temperance and free church organisations. Figure 1 illustrates this pattern: temperance and free church organisations were already relatively well established at the start of my sample period, whereas the establishment and diffusion of unions and left party organisations began in earnest in the second half of the 1890s.

Panel B of Table 1 reports social movement summary statistics conditional on movement presence. This panel illustrates two things. First, there is significant heterogeneity in movement size across municipalities. Some municipalities have movements with only a handful of members, whereas the larger municipalities can have memberships in the tens of thousands. Similarly for the number of organisations: in some municipalities a movement type is represented by only one organisation, while in other municipalities many different organisations are active within the same movement type. Second, the panel demonstrates that unions and left parties tend to be larger, on average, than temperance and free church organisations.

[8]These left party organisations formed the backbone of the fledgling Social Democratic Party, which was founded in 1889 and became a dominant political force in the early twentieth century.

3.2 Data on the Swedish Railway Network, 1881-1910

The main treatment variables in this paper are measures of proximity to the railway. To this end, I construct yearly measures of the distance from each municipality to the completed railway network. For each year, I digitise the railway network from maps published in historical accounts by Statistics Sweden (Statistiska Centralbyrån, various years). I then calculate the geodesic distance from the main settlement in each municipality to the nearest completed railway line in each year. The location of the main settlement is a better indicator of where the mass of the population is located than, for example, the centroid of the municipality in computing measures of railway access.

In Figure 2, I show the extent of the network at the beginning (1881) and end (1910) of my sample period. I report measures of railway access in Panel C of Table 1 and in Figure 3. The median distance to rail is decreasing steadily throughout the sample period, while the proportion of municipalities within a reasonable distance of rail is increasing. Aggregate measures disguise substantial heterogeneity: the distance from rail varies from 0 kilometres (for municipalities on a railway line) to over 600 kilometres (for remote northern municipalities before the northward extension of the network).

For the majority of my analysis, I employ an instrumental variables strategy exploiting proximity to initial railway plans to instrument for proximity to realised railway lines. This strategy is inspired by Berger and Enflo (2017) and I collect data on the railway plans from an official publication celebrating the centenary of the Swedish railway (Kungliga järnvägsstyrelsen, 1956). As with the constructed railway lines, I digitise the railway plans and then compute the distance to these plans for each municipality. Maps of the railway plans and their relationship to realised lines are shown in Figure 4, and the mean distance to the plans is reported in Panel C of Table 1. I discuss the construction of the instrument in more detail in Section 4 below.

In my exploration of the mechanisms underlying the positive effect of railway access on social movement diffusion (see Section 6), I additionally employ station-level data on passenger and freight arrivals at state-operated stations.[9] Using the same historical documents of Statistics Sweden (Statistiska Centralbyrån, various years), I identify stations associated with the municipalities in my sample and digitise yearly arrivals of passengers and freight. Summary statistics are reported in Panel C of Table 1.

3.3 Other Data

I collect additional data from various sources. I make use of the full-count censuses of 1880, 1890, 1900 and 1910 (Riksarkivet and Minnesota Population Center, various years) to construct a range of control variables. In particular, I have data on population numbers and other demographic characteristics of the municipality (such as the share of female inhabitants, the average age of inhabitants and the share

[9] The state operated the main trunk lines as well as key branch lines, while private firms operated remaining branch lines. While my measures for proximity to rail are available for the entirety of the network, the station-level results rely on data from the subset of state-operated stations.

of married individuals). Additionally, I construct measures of occupational structure by classifying individuals in employment into ten broad ISCO categories. I report summary statistics in Panel D of Table 1. Since censuses are decadal, some interpolation is necessary for non-census years. In my baseline results, I consider variables to be fixed in between census years.[10]

To explore potential alternatives to the main mechanism I propose in Section 6, I use additional data on telegraphs and the postal service. These are also hand-digitised from historical publications of Statistics Sweden (Statistiska Centralbyrån, various years). In particular, I track the opening and closing dates of telegraph stations and the number of incoming telegrams processed at these stations. For the postal service, I collect information on the volume of newspapers and printed matter, as well as the total volume of post, dispatched each year from 244 main post stations.

Lastly, I use topographical data from NASA (2009) and land cover data from Natural Earth (various years) to construct various geographical controls, including elevation, distance to coast, distance to nodal municipalities in the railway network and distance to the capital (Stockholm).

4 Empirical Framework

My main relationship of interest is the effect of railway access on the proliferation and growth of social movements. However, railway connectivity is likely to be determined endogenously with social movement outcomes. Bias arising from reverse causality and omitted variables would therefore preclude a causal interpretation of estimates from a simple ordinary least squares (OLS) regression. Hence, I propose an instrumental variables (IV) framework in which I instrument for actual distance to the railway network using distances to initial railway plans. This instrument was first used for the Swedish setting by Berger and Enflo (2017).

In particular, I regress a social movement outcome Y_{it} on the distance to the nearest railway as measured in the previous period, $\mathrm{RailDist}_{i,t-1}$:

$$\mathrm{Y}_{it} = \alpha_i + \gamma_t + \phi\,\mathrm{RailDist}_{i,t-1} + \beta\,\mathrm{X}_{it} + \epsilon_{it} \tag{1}$$

A one-lag structure for the effect of railway connectedness on social movement outcomes is intuitive in this setting for two reasons. First, the historical data I use to calculate distances to the railway show the extent of the network at the end of a given year. This means that railway lines constructed near the end of the calendar year are likely to affect social movement outcomes only in the following year. Second, the administrative steps needed to set up and expand a local organisation mean that there is a natural lag in the response of social movement outcomes to railway connectivity.

[10] I demonstrate in Section 5 that my results are robust to other interpolation regimes, such as linear interpolation or interpolation assuming a fixed growth rate.

The vectors α_i and γ_t are municipality and year fixed effects, respectively, and X_{it} is a vector of controls described as they are introduced in the analysis below. The coefficient of interest is ϕ, which captures the effect of distance to rail on a given social movement outcome.

As a concrete example, suppose Y_{it} is an indicator taking a value of one if any social movement is present in municipality i in year t. Suppose further, as indeed will be the case throughout the paper, that $\text{RailDist}_{i,t-1}$ is the inverse hyperbolic sine transformation of the distance (in kilometres) to the nearest part of the railway network.[11] The estimated coefficient ϕ would then capture the increase in the probability that any movement is present that would result from a doubling of the distance to the railway. Theoretically, I expect to find $\phi < 0$. If railways facilitate transportation and interactions between people, then greater access to rail (that is, lower distance to rail) should cause movements to proliferate.

Estimation of equation 1 by OLS is unlikely to yield a causal estimate of the effect of rail on social movements for three main reasons. First, reverse causality may generate a spurious relationship between Y_{it} and $\text{RailDist}_{i,t-1}$. Recall from Section 2 that railway construction was an elite endeavour in this period. Such elites may therefore have strategically routed railway lines to dampen the proliferation of the grassroots organisations I study, which would bias towards zero any estimates from an OLS regression. Second, independent of reverse causality, there may be underlying omitted variables driving both social movement activity and railway expansion. If these omitted factors are time-varying, they will not be absorbed by municipality fixed effects. As a concrete example, some municipal leaders are more connected to the political elite than others. They may therefore want to suppress local engagement in social movements and simultaneously be better-connected to the elites directing railway construction. This would cause a spurious negative relationship between railway connectivity and social movement outcomes even in the absence of a causal impact, and potentially obscure a positive effect of railway access on social movement spread. Finally, since data on the railway network come from the digitisation of historical maps (as detailed in Section 2), measurement error may be a concern. Errors arising from the digitisation process are likely to be classical, and will bias coefficient estimates towards zero. Such bias would make it more difficult to identify an effect, if it exists.

The three concerns outlined above all suggest the use of an instrument to generate exogenous variation in actual distance to rail. This variation can be used to obtain causal estimates of ϕ in equation 1. In particular, I propose to use an instrument exploiting the particular history of railway building in Sweden. The essence of the instrument is to use proximity to initial plans of the railway network to predict proximity to the realised network. For historical background on the railway plans, see Section 2 above. The precise definition of the instrument as well as a discussion of its validity is provided below.

[11] I use the inverse hyperbolic sine rather than the natural logarithm to allow for zero distances. The interpretation of the estimated coefficients is similar to that of the natural logarithm. See Burbidge, Magee and Robb (1988) and Bellemare and Wichman (2020) for details. Robustness checks using the natural logarithm and an indicator for railway access (defined as having a railway line within 10 kilometres) are discussed in Section 5 and reported in Table B1 in Appendix B.

Formally, RailDist_{it} is instrumented in a first stage equation given by:

$$\text{RailDist}_{it} = \alpha_i + \gamma_t + \sum_d \delta_d \, \text{PlanDist}_i \times \mathbb{1}\{\text{decade} = d\}_t + \beta \, \text{X}_{it} + \nu_{it} \tag{2}$$

The terms α_i, γ_t and X_{it} are municipality fixed effects, year fixed effects and a vector of controls as before. RailDist_{it} is the presumably endogenous distance to the railway network that needs to be instrumented. The variable PlanDist_i is the time-invariant distance to the planned railway network.[12] To use this distance in a panel framework, I interact it with decade fixed effects $\mathbb{1}\{\text{decade} = d\}_t$, taking 1881-1890 as the base decade.[13] The estimated first stage coefficients δ_d should therefore be thought of as the change in the elasticity between planned and realised railway network expansion as the network develops.[14]

4.1 The Railway Plan Instrument

As discussed in Section 2 above, two main network plans were proposed before railway construction began (the von Rosen plan in 1845 and the Ericson plan in 1854). While these plans were both ultimately abandoned, they are still good predictors of where eventual construction took place. Maps of these plans and their relation to the realised network are presented in Figures 4b and 4c.

Notably, neither plan made provisions for northward railway expansion, with the drawback that the plans will be relatively worse predictors for actual railways in the northern parts of the country. To overcome this drawback, I make use of the "nodal" destinations targeted in the proposals and construct a set of straight lines connecting these destinations, as shown in Figure 4d.[15]

Based on these three counterfactual railway networks, I define my instrument PlanDist_i in the following way:

$$\text{PlanDist}_i = \min\{\text{Dist. von Rosen}_i, \text{Dist. Ericson}_i, \text{Dist. Nodal Lines}_i\}$$

That is, the instrument is the distance of municipality i to the nearest of the three counterfactual railway networks.

4.2 Identifying Assumptions

For the two-stage least squares framework described by equations 1 and 2 to produce causal estimates of ϕ, the instruments $\sum_d \delta_d \, \text{PlanDist}_i \times \mathbb{1}\{\text{decade} = d\}_t$ need to satisfy a number of validity conditions.

[12] I will take the inverse hyperbolic sine transformation of this distance throughout.
[13] The remaining two decades are therefore 1891-1900 and 1901-1910.
[14] See Andersson, Berger and Prawitz (2020) for a similar instrument in a panel setting.
[15] The nodal destinations are Stockholm, Gothenburg, Malmö, Östersund and Korsvinger. In all specifications, I control for the distance to these nodal destinations. Additionally, I report robustness checks dropping the nodal destinations (and other municipalities near the nodal destinations) in Table B3 in Appendix B.

First, the instruments need to be relevant. That is, PlanDist_i needs to predict RailDist_{it}, and this effect needs to vary between decades for the time-varying instrument to have bite. In Figure 5, I report the relationship between actual and planned distance to railway in select years. As expected, the effect is strongly positive in each year, but diminishing over time. A diminishing effect is intuitive: as the network expands, more marginal locations are connected, which weakens the predictive power of the early plans.

Second, the instrument needs to be uncorrelated with the error term in equation 1 (ϵ_{it}) to satisfy the exclusion restriction. In other words, proximity to the railway plans should predict social movement outcomes only via the channel of actual railway access. This condition intuitively seems to be satisfied in this case, given that the proposals were drawn strategically to connect major cities. Proximity to planned railways which were never built should therefore be uncorrelated with social and political outcomes decades later.[16]

Third, potential outcomes and potential treatments need to be conditionally independent of the instrument. The history of Swedish railway construction is once again helpful here, since municipalities were not targeted for their potential for flourishing social engagement. In most specifications, however, I control richly for geographical and demographic characteristics to guarantee (at a minimum) conditional independence.

The final requirement for a valid instrument is monotonicity (or "no defiers"). This condition intuitively seems to be satisfied, since proximity to a planned railway line is unlikely to cause some municipalities to be further away from realised rail than would have been the case if they were distant from the planned line.

5 Main Results

Using the identifying framework described in Section 4 above, I now present results demonstrating the causal impact of railway access on the proliferation and growth of social movements. Before formally estimating instrumental variables regressions, I provide some illustrative correlational evidence. Figure 6 presents maps showing the spatial relationships between railway expansion and social movement presence and membership. At the beginning of the sample period, in 1881, both rail and social movements were relatively sparsely distributed. Nevertheless, the spatial patterns can be seen clearly: connectedness with the railway network is associated with a higher density of social movements. After a decade of railway expansion, in 1890, the relationship becomes even more striking. Social movements spread along the completed railway network, suggesting a key role for rail in the diffusion of these movements.

[16] I test for this directly by regressing social movement outcomes prior to railway construction on the distance to the railway plan, and find that proximity to the railway plan is not predictive of social movement outcomes in the absence of actual railway construction. Concretely, I run OLS regressions of the form $\text{Y}_i = \delta \, \text{PlanDist}_i + \beta \, \text{X}_i + \eta_i$, using the first year of the sample only (1881), and only for subsamples of municipalities which were far from already constructed railways. Results are reported in Table 3, and support the exclusion restriction of the instrument. See Section 5 for a longer discussion of these checks.

Additionally, I present correlational evidence separately by movement type in Figure 7. Starting with Figure 7a, distance to the railway network is negatively correlated with the probability of movement presence, and consistently so across all movement types. Figure 7b demonstrates a similar negative relationship between distance to rail and membership. In this sense, railway access is crucial on both the extensive and intensive margins of social movement proliferation. Finally, in Figure 7c I report correlations between access and the number of distinct organisations active in a municipality. The negative relationship presented in this figure suggests that, in addition to larger total membership, proximity to rail also increases the local variety of active groups. These results together suggest that railways were key to the mobilisation of social movements. In the following section, I investigate this relationship more formally.

5.1 Instrumental Variables Results

I begin by estimating equations like equation 1, in which social movement outcomes are regressed on distance to the railway. As discussed, however, estimating this equation by OLS is unlikely to yield causal estimates of ϕ. I therefore use an instrumental variables framework and estimate equations 1 and 2 using two-stage least squares.

I display the first-stage relationship graphically in Figure 5, and report results from a more formal estimation of the first-stage equation 2 in Table 2. In column 1, I report a relatively parsimonious specification which includes municipality and year fixed effects in addition to the instruments $\text{PlanDist}_i \times \mathbb{1}\{\text{decade} = 1891 - 1900\}_t$ and $\text{PlanDist}_i \times \mathbb{1}\{\text{decade} = 1901 - 1910\}_t$. This leaves 1881-1890 as the baseline decade. I also control for important time-invariant geographical characteristics interacted flexibly with year fixed effects. These controls capture determinants of the original railway plan proposals, and are therefore key to ensuring the (conditional) independence of the instruments.[17] Lastly, I control for the initial presence of social movements in the municipality, interacted with year fixed effects. Since I am interested in the effect of railway expansion on the spread of social movements, this allows me to abstract away from the effect of where they initially appeared. As expected, the coefficients for the ensuing decades are negative and highly statistically significant.[18] The negative effects should be interpreted as the change in the elasticity between the distances to realised and planned railways over time.

In columns 2 and 3, I introduce different controls to the specification to probe the stability of the estimated coefficients. In column 2, I introduce baseline demographic characteristics interacted with year

[17] In particular, I include: distance to the capital (Stockholm), distance to the nodal destinations targeted by the military plans, elevation and distance to the ocean. All variables have been transformed using an inverse hyperbolic sine transformation. As an additional robustness check, check sensitivity to completely dropping nodal destinations and municipalities near these destinations in Table B3 in Appendix B.

[18] Throughout, standard errors are clustered on the level of the municipality.

fixed effects.[19] Lastly, in column 3, I add a control for contemporaneous population.[20] The estimated coefficients remain stable and highly significant throughout the successive inclusion of richer sets of controls.

The first-stage results in Table 2 show that the instrument satisfies the relevance condition. I now provide evidence that the validity condition also appears to be satisfied. That is, the railway plan instrument affects social movement outcomes only through the proposed treatment (railway connectedness). To this end, in Table 3, I investigate the relationship between distance to the railway plan and pre-railway social movement outcomes. In the cross-section of municipalities in my first sample year (1881), I isolate those far from already constructed railways.[21] For this subsample, I regress my three main social movement outcomes (an indicator for the presence of any movement, total membership numbers and the number of distinct organisations) on distance to the railway plans. I find that, for these not-yet-connected municipalities, proximity to the railway plans has no impact on social movement outcomes. This is reassuring, since it suggests that the plans were not systematically drawn taking municipalities' potential for social movement development into consideration.

Having established that the proposed instruments appear to be valid and exhibit a strong first stage, I now discuss the main OLS and instrumental variables results. Beginning with an exploration of the extensive margin of diffusion in Panel A of Table 4, I take an indicator for the presence of any social movement as the outcome. The table takes the following structure: in columns 1, 2 and 3, I report OLS results gradually adding richer sets of controls, and I report the same specifications using a two-stage least squares instrumental variables (IV) framework in columns 4, 5 and 6. Controls are introduced in the same succession as for the first-stage results in Table 2 above. The OLS results in columns 1, 2 and 3 are suggestive of the expected negative relationship between distance to railway and social movement presence. Coefficients are negative and statistically different from zero throughout all specifications, suggesting that less well-connected municipalities (further from the railway) are less likely to see the development of local social movements.

For reasons discussed above, however, these estimates are likely biased towards zero, so I now turn to the IV results reported in columns 4, 5 and 6 of Panel A. The consistent negative relationship remains. Taking the richest specification in column 6, the estimated coefficient implies that doubling the distance to the railway reduces the probability of social movement presence by 9 percentage points. This is a sizeable effect compared to the unconditional outcome mean of 0.51, suggesting that proximity to rail

[19]These are baseline characteristics in the sense that they are constructed using the 1880 census, the year prior to the start of my sample period. These include: the size of the adult population, the average age, the share of married inhabitants, the share of female inhabitants, the share of employed inhabitants and employment shares in 10 major ISCO groups.

[20]Since censuses were conducted every ten years, some interpolation between census years is necessary. In my baseline estimates, I hold population fixed in between census years. I show in Table B2 in Appendix B that results are robust to interpolating population numbers using either linear or constant growth rate interpolations instead. Throughout, I will use the inverse hyperbolic sine transformation of population.

[21]I use 5 and 10-kilometre cutoffs as relevant definitions of "far from" constructed railways.

is an important driver of the extensive margin of diffusion. A back-of-the-envelope calculation suggests that, over the period 1881 to 1910, 10.7 percent of the extensive margin of social movement diffusion can be explained by improvements in railway access.[22]

In Panels B and C, I present evidence for the impact of rail on intensive margins of proliferation. First, in Panel B, I explore the effect of railway connectedness on the number social movement members in a municipality. Consistently across the OLS and IV results, I find that distance to the railway network negatively impacts membership numbers. Importantly, this results holds even when controlling for population, which means that membership growth is not a mechanical result of population growth.

Additionally, in Panel C I report estimates of the impact on the number of distinct organisations. This measure captures the level of diversity of representation offered by social movements. A greater number of organisations indicates a weakly better match between individual and organisation preferences. Consistent with previous results, I find that proximity to rail fostered a larger variety of local organisations. Increasing the distance to the nearest railway line is associated with a reduction in local richness of representation. Using the same back-of-the-envelope calculation as above, improvements in railway connectedness explain around 9.5 and 10.8 percent of the growth of membership and the number of organisations, respectively, over the period 1881 to 1910.[23]

5.1.1 Comparing OLS and IV results

Throughout the reported results, a striking feature is that the IV results are consistently larger than those from the OLS. This is to be expected for two main reasons. First, as discussed above, the IV estimations solves problems of endogeneity and of measurement error that bias the OLS results towards zero.

Second, the instrumental variables framework estimates an effect similar to the local average treatment effect of the "compliers".[24] That is, the estimated effect of rail on social movement outcomes obtained from the IV comes from those municipalities which were proximate to the constructed railway network only by virtue of being close to the planned routes, but would not have been close to rail otherwise. It is probable that the treatment effect for municipalities which were connected "by accident" is greater than for municipalities which would have received network access regardless of proximity to planned routes. In a sense, it is also the effect of such accidental connectivity which is most interesting to study if we are interested in causal estimates, since it is the most plausibly exogenous source of variation

[22] Using the formula: $\frac{\hat{\phi} \times \Delta \text{RailDist}_{1881-1910}}{\Delta \text{Y}_{1881-1910}} = \frac{0.093 \times (2.73-1.99)}{(0.759-0.121)} \approx 10.7\%$. The coefficient $\hat{\phi} = 0.093$ is from column 6 of Panel A in Table 4, $\Delta \text{RailDist}_{1881-1910} = (2.73 - 1.99)$ is the change in average IHS distance to the railway between 1881 and 1910 and $\Delta \text{Y}_{1881-1910} = (0.759 - 0.121)$ is the change in the proportion of municipalities with social movement presence over the same period.

[23] For membership: $\hat{\phi} = 0.467$ (column 6, Panel B, Table 4) and $\Delta \text{Y}_{1881-1910} = (4.18 - 0.545)$. For the number of organisations: $\hat{\phi} = 0.190$ (column 6, Panel C, Table 4) and $\Delta \text{Y}_{1881-1910} = (1.41 - 0.113)$.

[24] The strict interpretation of local average treatment effects applies to binary treatments and instruments. Here, the treatments and instruments are continuous, and as such the interpretation of the effect is slightly more complicated, though similar.

in railway access.

5.2 Discussion

Across a range of correlational and causal evidence, I have demonstrated the crucial role played by transportation infrastructure in enabling the diffusion of social movements along both intensive and extensive margins. Not only is railway access causally predictive of the entry of social movements into a municipality, it also drives the growth of membership in these movements. In addition, railway proximity fosters diversity of local representation, as measured by the number of distinct organisations. In the following section, I probe the mechanisms underlying these results. In particular, building on the market access literature, I claim that by reducing effective distances between municipalities, the expansion of the railway network facilitated a social contagion of ideas. I then make use of station-level data on passenger and freight flows to show that the mobility and movement of individuals appears to be a key driver in this process. Finally, I provide evidence to rule out other competing demand- and supply-side mechanisms.

6 Mechanisms: Social Movement "Market Access" and Individual Mobility

Having established that proximity to the railway network drives the diffusion of social movements, I now explore the mechanisms which underlie this effect. The historiography of Swedish grassroots social movements in this period, described in Section 2 above, highlights the mobility of individual actors as a driver of movement proliferation. Newly established railway connections reduce effective distances between municipalities, allowing individual preachers and agitators to travel more widely, and thereby enable the spread of social movements from one municipality to the next.

6.1 Social Movement "Market Access"

I employ a conceptual framework akin to the "market access" measure of Donaldson and Hornbeck (2016) to estimate the effect of connecting municipalities to existing hotbeds of social movement activity.[25] A general market access measure for municipality i in year t is defined as the least-cost path weighted average of some outcome M_{jt} in other municipalities j:

$$\text{MarketAccess}_{it} = \sum_{j \neq i} \text{Cost}_{ijt}^{-\theta} \times \mathrm{M}_{jt}$$

[25] The concept of market access of course has a longer tradition in several disciplines. Key contributions include Harris (1954), Redding and Venables (2004), Hanson (2005) and Redding and Sturm (2008).

Here, Cost_{ijt} is a resistance term, capturing the cost associated with the least costly path between municipalities i and j in year t. Further details on the calculations of these costs are provided in Appendix A. The parameter θ is set to 1 by convention. Different interpretations of market access are possible, depending on the variable chosen for M_{jt}.

Given my setting, I set $\text{M}_{jt} = \text{Membership}_{jt}$. That is, MarketAccess_{it} is a least-cost path weighted average of movement memberships in all other municipalities. This measure of market access relates very closely to the peer effects literature, and is therefore ideal for capturing the spatial contagion of membership. Essentially, every municipality is a "peer" of every other municipality, where the strength of the connection is determined by the transportation infrastructure linking them. The term $\text{Cost}_{ijt}^{-\theta} \times \text{Membership}_{jt}$ captures the access to and influence from the movement membership in municipality j on municipality i in year t. As the effective cost falls or the membership in j grows, a greater peer effect is exerted on i by j, thereby increasing the probability of contagion.

To empirically estimate the effect of gaining access to municipalities with active social movements on subsequent movement spread, I operationalise the market access measure within my instrumental variables framework. The relevant second stage becomes:

$$\text{Y}_{it} = \alpha_i + \gamma_t + \kappa \, \text{MarketAccess}_{i,t-1} + \beta \, \text{X}_{it} + \epsilon_{it} \tag{3}$$

Where $\text{MarketAccess}_{i,t-1}$ is defined as above. Since market access is endogenous to social movement outcomes, I instrument for it in a first stage given by:

$$\text{MarketAccess}_{it} = \alpha_i + \gamma_t + \sum_d \delta_d \, \text{PlanDist}_i \times \mathbb{1}\{\text{decade} = d\}_t + \beta \, \text{X}_{it} + \nu_{it} \tag{4}$$

The roll-out of the railway network provides me with variation in the MarketAccess_{it} measure over time, even in the absence of changes in membership. As the network expands, connectivity between municipalities improves. To illustrate, Figure 8 shows how least-costs to Stockholm decreased over the sample period. Similar maps can be drawn for the least-costs to each of the 2,277 municipalities in my sample. In Figure 9, I document that these improvements in connectedness asymmetrically affected initially worse-connected municipalities. While costs fell by over 20 percent from 1881 to 1910 in the top quartile of municipalities (as measured by initial average travel costs across all destinations), they fell by close to 40 percent in the bottom quartile over the same period. This asymmetry speaks to the two potential channels of transmission for social movements noted by McAdam (2003): diffusion (spread along existing network ties) and brokerage (spread along newly created network ties). The wider geographical reach of the railway network and asymmetric fall in travel costs seems to favour the "brokerage" interpretation.

In Table 5, I summarise the impact of changes in social movement "market access" on my three key social movement outcomes. Columns 1 and 2 provide OLS and IV estimates of the effect of market access on the extensive margin of movement spread. Throughout, I include the richest set of controls from previous regressions. The results support the proposed mechanism: as access to existing movement membership elsewhere improves, the likelihood that the movement spreads increases. In columns 3 to 6, I present results yielding a similar interpretation for the effect of market access on membership and the number of distinct organisations. The broad patterns are evident: by reducing effective distances between municipalities, railways connect social movement organisations to new potential audiences. This, in turn, increases the probability that the movement spreads to new locations and subsequently sees more rapid growth.

6.2 Station-Level Results: The Importance of Individual Mobility

To support the claim that the movement of individuals drives the grassroots mobilisation in social movements, I use station-level data to demonstrate that an increase in the number of passenger arrivals in a municipality is associated with heightened social movement presence and growth. Crucially, the same relationship does not hold for freight arrivals, which dispels concerns that the diffusion effect I document is simply an artefact of increased local economic activity. Rather, the effect of passenger arrivals on social movement spread is indicative of the key role of individual mobility in spreading socially salient ideas.

As detailed in Section 3 above, I use data on the number of passengers and the volume of freight arriving at each station in each year, and match the station data to the municipalities in my main sample. I create a balanced panel of the subset of municipalities which at some point in the thirty-year period 1881-1910 had a local railway station. I then estimate OLS regressions of the form:

$$\mathrm{Y}_{it} = \alpha_i + \gamma_t + \lambda \, \mathrm{Arrivals}_{i,t-1} + \beta \, \mathrm{X}_{it} + \epsilon_{it} \tag{5}$$

The variable $\mathrm{Arrivals}_{i,t-1}$ is either the number of passengers or the volume of freight arriving into municipality i in year $t-1$ (or both included together). Since my municipality-year panel is balanced, a municipality will by definition have zero passenger and freight arrivals prior to the construction of a station. To abstract away from the effect of the construction of a station *per se*, I control for the presence of a station in all regressions. The coefficient of interest, λ, therefore captures the effect of an increase in passenger or freight arrivals on the social movement outcome of interest, Y_{it}. If the movement of individuals is key to the spread of social movements, then we expect $\lambda > 0$ for passenger arrivals but $\lambda = 0$ for freight arrivals.

I report results of this exercise in Table 6. Each set of three columns takes as the dependent variable one of the social movement outcomes. In columns 1 to 3, I explore the effect of passenger and freight arrivals on the presence of any social movement organisation in the municipality. The estimated coefficient reported in column 1 suggests that a doubling of the number of passenger arrivals in a municipality is associated with a 4.4 percentage point increase in the probability that a social movement organisation is present there. Interestingly, there is no analogous effect of freight arrivals, as shown in column 2. When both passenger and freight arrivals are included in column 3, the effect of passenger arrivals clearly dominates.

The remainder of the table repeats the exercise for the two other social movement outcomes, and a very similar pattern emerges. Movement membership and organisational density both depend positively on passenger arrivals, but not on freight arrivals. Throughout, the coefficients on passenger arrivals are statistically and economically different from those on freight arrivals.

Taken as a whole, these results underscore the crucial role of the mobility of individuals in the spread and growth of popular movements. Viewed together with the market access results above, a salient mechanism explaining the impact of railway access on social movement proliferation is revealed. By reducing least-cost distances between places, the railway network facilitated the spread of the movement from one municipality to the next by enabling individuals to travel and share their ideas.

6.3 Ruling Out Alternative Mechanisms

So far, I have shown that railways appear to foster social movement spread spread and growth by allowing municipalities to gain access to existing concentrations of membership (social movement "market access") and by enabling greater flows of people into these municipalities. I now provide supporting evidence to rule out a number of competing demand- and supply-side mechanisms. The results of this exercise are reported in Table 7.

First, I consider two alternative demand-side mechanisms which may respond to improvements in railway connectedness and subsequently shape demand for social movements. The temperance and free church organisations were predominantly religiously motivated and largely of a Lutheran denomination. Therefore, the share of Lutherans in a municipality can plausibly affect demand for these types of organisations. In column 1 of Table 7, I report the baseline OLS estimate of the effect of market access on the three main social movement outcomes. Column 2 then introduces an additional control for the contemporaneous share of Lutherans in the municipality, which leaves coefficients practically unchanged. This is not surprising, given the dominance of Lutheranism in Sweden in this period. There is very little variation in religious affiliation that could explain away the effects I document.

More interesting as a potential alternative demand-side mechanism is a municipality's occupational structure.[26] If railways foster local industrialisation, this may in turn drive demands for trade unions and workers' party organisations as labour organises. To account for this possibility, I add controls for the

[26] Indeed, Berger (2019) shows that railways spurred rural industrialisation, with local occupational structure changing in favour of industrial employment as a result of gaining railway access.

contemporaneous share in ten major ISCO groups to the baseline specification. Results are reported in column 3, and show that controlling for occupational structure indeed attenuates my estimates somewhat. Estimates remain significantly different from zero, however, and are statistically indistinguishable from the baseline coefficients. Changing occupational structure therefore explains only a small part of the effects I document.

Second, I investigate two broad strands of alternative supply-side mechanisms. The first relates to the concurrent development of the Swedish telegraph network. Although there are notable exceptions to the rule (particularly in northern Sweden), telegraph construction broadly followed railway expansion (Schön, 2012). Better telegraph communications, in turn, could solve collective action problems in social movement mobilisation (García-Jimeno, Iglesias and Yildirim, 2018). By using telegraph station-level data on opening and closing dates and the volume of telegrams received, I construct measures both for the proximity to the nearest operating telegraph station and for the number of telegrams processed there. I include these as controls in columns 4 and 5, respectively. Their inclusion only marginally changes the baseline estimates. This is not surprising, given that my results capture the expansion of social movements into new municipalities. On this margin, the face-to-face interaction between individuals cannot easily be replaced by other forms of communication, though improved telegraph communications plausibly improve coordination once local organisations have been established.

The second alternative supply-side mechanism is related to the first, in that it speaks to a competing channel of information transmission. In this period, the postal service relied heavily on railway transportation for its deliveries. It is therefore conceivable that the effect of railway connectedness on social movement outcomes is explained by the increased ability to disseminate the written word, not by the movement of people.[27] To investigate this mechanism, I use post station-level data to measure the volume of newspapers and other printed matter sent from each station each year. I then construct additional market access measures capturing municipalities' potential exposure to circulated post, with s denoting post stations:

$$\text{PostalMarketAccess}_{it} = \sum_{s} \text{Cost}_{ist}^{-1} \times \text{PostalVolume}_{st}$$

In particular, I calculate a measure each for newspapers, other printed matter and for total postal flows. I then include these measures as additional controls in columns 6 to 8 of Table 7. Across all outcomes and all specifications, results remain similar to the baseline. In fact, in some cases the magnitudes of the coefficients are somewhat larger, though not statistically different from the baseline coefficients. This suggests that accounting for improved access to the postal service, granted by railway expansion, cannot explain away the main result. These findings, in combination with the station-level results

[27] Perlman and Sprick Schuster (2016), for example, show that the roll-out of Rural Free Delivery facilitated information transmission and shaped political engagement in the early twentieth-century United States.

presented above, strengthen an interpretation which highlights the movement of individuals and their face-to-face interaction as the key mechanism through which railways foster social movement spread.

7 Concluding Remarks

In this paper, I document the impact of improvements in transportation technologies on the diffusion of engagement in social movements. In particular, I exploit a formative episode from Swedish history to estimate the causal effect of proximity to the newly rolled-out railway network on the spread of key grassroots associations. Rail is instrumental for both extensive and intensive margins of growth: municipalities near the network are more likely to host a movement of any type, exhibit larger membership numbers and establish a greater number of distinct organisations. Increased connectedness is therefore predictive not only of extensive- and intensive-margin proliferation, but also of potentially better-aligned matches between individual and group preferences.

I provide evidence that these effects are driven by a social mobilisation underpinned by individual mobility. Using a "market access" approach, I show that railway expansion reduced effective least-cost distances between municipalities. For a given municipality, these reductions intensified the influence exerted by movement memberships in neighbouring municipalities, thereby enabling social movement spread. These effects cannot be explained away by alternative demand- and supply-side mechanisms, and I use station-level data to demonstrate that the arrival of passengers into a municipalities with railway access, not the arrival of freight, predicts social movement outcomes.

This paper speaks to the two long-standing literatures on social movements and transportation infrastructure, and adds to the small but growing recent intersection between these two bodies of work by highlighting the role played by interaction costs in shaping social phenomena. By combining a unique historical episode with a well-identified econometric framework, I shed light on the role of individual mobility and interaction in the spatial diffusion of ideas. I thereby contribute to our understanding of popular engagement in social movements and how technology aids and shapes such engagement.

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Tables

Table 1: Summary statistics

	Obs.	Mean	St. Dev.	Min.	Max.
Panel A. Social movement summary statistics					
Any movement present	68310	0.49	0.50	0	1
Temperance movement present	68310	0.37	0.48	0	1
Free church present	68310	0.33	0.47	0	1
Union present	68310	0.06	0.24	0	1
Left party present	68310	0.03	0.16	0	1
Total membership	68310	141.75	995.87	0	83570
Temperance movement membership	68310	57.52	209.74	0	9520
Free church membership	68310	51.39	251.61	0	12287
Union membership	68310	19.45	371.68	0	36018
Left party membership	68310	13.39	307.86	0	30327
Panel B. Social movement summary statistics conditional on movement presence					
Total membership	33739	287.00	1402.25	1	83570
Temperance movement membership	25088	156.62	322.89	1	9520
Free church membership	22689	154.73	417.87	1	12287
Union membership	4078	325.82	1488.22	1	36018
Left party membership	1883	485.69	1791.81	3	30327
Total number of organisations	33739	3.74	7.20	1	247
Number of temperance organisations	25088	2.57	3.84	1	117
Number of free churches	22689	1.80	1.41	1	28
Number of unions	4078	4.59	8.66	1	135
Number of left parties	1883	1.10	0.35	1	5
Panel C. Railway summary statistics					
Distance to rail (km)	68310	11.80	31.20	0	677
Rail within 5 km	68310	0.48	0.50	0	1
Rail within 10 km	68310	0.71	0.45	0	1
Rail within 20 km	68310	0.88	0.33	0	1
Distance to railway plan (km)	2277	34.03	59.85	0	538
Arriving passengers (thousands)	5190	33.22	100.10	0	2260
Arriving freight (thousands of tons)	5190	15.05	66.47	0	1381
Panel D. Census summary statistics					
Total population	9108	2223.68	6470.10	90	323407
Adult population	9108	1262.60	4207.29	57	223990
Share female	9108	0.51	0.02	0	0.59
Average age	9108	29.78	2.27	22	39.59
Share married	9108	0.34	0.03	0	0.50
Share ISCO 1 (managers)	9108	0.01	0.01	0	0.15
Share ISCO 2 (professionals)	9108	0.02	0.01	0	0.45
Share ISCO 3 (technicians)	9108	0.01	0.02	0	0.33
Share ISCO 4 (clerical)	9108	0.01	0.01	0	0.14
Share ISCO 5 (service & sales)	9108	0.14	0.05	0	0.43
Share ISCO 6 (agriculture)	9108	0.51	0.16	0	0.97
Share ISCO 7 (craftsmen)	9108	0.10	0.07	0	0.64
Share ISCO 8 (plant & machine)	9108	0.04	0.06	0	0.74
Share ISCO 9 (elementary)	9108	0.08	0.09	0	0.81
Share ISCO 10 (armed forces)	9108	0.02	0.03	0	0.80

Note: Summary statistics for key variables. **Panel A** contains summary statistics for social movement outcomes for the complete municipality-year panel (2,270 municipalities, 30 years). The variable "Any movement present" is an indicator equal to one if any social movement is present in the municipality-year. The following four variables are indicators for the presence of particular social movements: temperance movements, free churches, unions and left parties. "Total membership" is the combined membership across all movement types, and the following four variables decompose this total into membership in the four different movements. **Panel B** contains summary statistics for the subset of municipality-years where at least one social movement is present. The first five variables capture the total membership as well as membership in individual movement types, conditional on movement presence. The second set of five variables captures the total number of organisations overall as well as within each movement type, conditional on movement presence. **Panel C** contains railway summary statistics. "Distance to rail" is a measure of geodesic distance (in km) from the seat of the municipality to the nearest completed railway line. The following three variables are indicators for whether a municipality is within 5, 10, or 20 km of a railway line in a given year. Finally, the variable "Distance to railway plan" is the time-invariant distance from a municipality to the military railway plans described in the text. "Arriving passengers" and "Arriving freight" are station-level variables measuring (in thousands) the number of arriving passengers and tons of freight in each station-year. **Panel D**, lastly, provides municipality-year summary statistics from census data. The variables "Total population" and "Adult population" are the total number of inhabitants and adult inhabitants residing in the municipality at the time of each census. "Share female" is the share of female inhabitants. "Average age" is the simple average age of inhabitants. "Share married" is the share (out of total population) of married individuals. The "Share ISCO" variables summarise the proportion of employed individuals working in major ISCO groups. Censuses were conducted in 1880, 1890, 1900 and 1910. Values outside of these years are interpolated assuming constant rates of change between census years.

Table 2: First stage: proximity to railway plans and railway access

	Dependent variable: IHS(distance to railway)		
	(1)	(2)	(3)
IHS(distance to railway plans) × 1890	-0.118***	-0.133***	-0.130***
	(0.009)	(0.010)	(0.009)
IHS(distance to railway plans) × 1900	-0.147***	-0.146***	-0.140***
	(0.012)	(0.013)	(0.013)
Observations	68310	68310	68310
Municipalities	2277	2277	2277
Clusters	2277	2277	2277
Outcome mean	2.324	2.324	2.324
Mun. FE	Y	Y	Y
Year FE	Y	Y	Y
Init. movem. pres. × Year FE	Y	Y	Y
Geogr. chars. × Year FE	Y	Y	Y
Baseline chars. × Year FE		Y	Y
Population controls			Y

Note: First stage regressions of the form: $\text{RailDist}_{it} = \alpha_i + \gamma_t + \sum_d \delta_d \, \text{PlanDist}_i \times \mathbb{1}\{\text{decade} = d\}_t + \beta \, \text{X}_{it} + \nu_{it}$. The dependent variable is the inverse hyperbolic sine transformation of the distance to the nearest constructed railway line. 1880 is the omitted decade. Standard errors clustered by municipality in parentheses. *, ** and *** indicate significance at the 10, 5 and 1 percent levels, respectively. Initial social movement presence is an indicator for the presence of any social movement in the first sample year (1881) interacted with year fixed effects. Geographical characteristics are: distance to the capital (Stockholm), distance to nodal towns, distance to coast, elevation (all transformed using an inverse hyperbolic sine transformation) interacted with year fixed effects. Baseline characteristics are demographic characteristics in the baseline 1880 census (adult population, average age, share married individuals, share females, share employed, and employment shares in 10 major ISCO groups) interacted with year fixed effects. Population controls is the inverse hyperbolic sine transformation of the contemporaneous adult population.

Table 3: Instrument validity: distance to railway plans and pre-railway social movement outcomes

	Dependent variable					
	Movement presence		IHS(membership)		IHS(no. organisations)	
Distance cut-off:	5km (1)	10km (2)	5km (3)	10km (4)	5km (5)	10km (6)
IHS(distance to railway plans)	0.001 (0.008)	-0.007 (0.012)	0.019 (0.035)	-0.010 (0.052)	0.003 (0.007)	-0.003 (0.011)
Observations	1495	985	1495	985	1495	985
Municipalities	1495	985	1495	985	1495	985
Outcome mean	0.115	0.120	0.506	0.534	0.108	0.115
County FE	Y	Y	Y	Y	Y	Y
Geogr. controls	Y	Y	Y	Y	Y	Y
Baseline controls	Y	Y	Y	Y	Y	Y

Note: OLS regressions of the form: $\text{Y}_i = \delta\text{PlanDist}_i + \beta\text{X}_i + \eta_i$, using the first year of the sample only (1881). Different columns use different subsamples of municipalities: those further than 5 and 10 kilometres from the constructed railway in 1881, respectively. Columns 1-2: the dependent variable is an indicator equal to 1 if any movement organisation is present in the municipality. Columns 3-4: the dependent variable is the inverse hyperbolic sine of total movement membership. Columns 5-6: the dependent variable is the inverse hyperbolic sine of the number of organisations. Robust standard errors in parentheses. *, ** and *** indicate significance at the 10, 5 and 1 percent levels, respectively. Geography controls are: distance to the capital (Stockholm), distance to nodal towns, distance to coast, elevation (all transformed using an inverse hyperbolic sine transformation). Baseline controls are demographic characteristics in the baseline 1880 census (adult population, average age, share married individuals, share females, share employed, and employment shares in 10 major ISCO groups).

Table 4: Main results: railway access and social movement outcomes

	Dependent variable: see panel headings					
	OLS			IV		
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A. Dependent variable: movement presence						
IHS(distance to railway)$_{t-1}$	-0.019***	-0.016***	-0.013**	-0.099***	-0.109***	-0.093**
	(0.006)	(0.006)	(0.006)	(0.036)	(0.038)	(0.039)
Observations	66033	66033	66033	66033	66033	66033
Municipalities	2277	2277	2277	2277	2277	2277
Clusters	2277	2277	2277	2277	2277	2277
Outcome mean	0.507	0.507	0.507	0.507	0.507	0.507
K-P F-stat				92.94	102.6	102.2
Panel B. Dependent variable: IHS(membership)						
IHS(distance to railway)$_{t-1}$	-0.105***	-0.087***	-0.055*	-0.549***	-0.654***	-0.467**
	(0.031)	(0.030)	(0.028)	(0.193)	(0.195)	(0.197)
Observations	66033	66033	66033	66033	66033	66033
Municipalities	2277	2277	2277	2277	2277	2277
Clusters	2277	2277	2277	2277	2277	2277
Outcome mean	2.680	2.680	2.680	2.680	2.680	2.680
K-P F-stat				92.94	102.6	102.2
Panel C. Dependent variable: IHS(no. organisations)						
IHS(distance to railway)$_{t-1}$	-0.041***	-0.032***	-0.016*	-0.213***	-0.280***	-0.190***
	(0.012)	(0.011)	(0.010)	(0.076)	(0.066)	(0.065)
Observations	66033	66033	66033	66033	66033	66033
Municipalities	2277	2277	2277	2277	2277	2277
Clusters	2277	2277	2277	2277	2277	2277
Outcome mean	0.814	0.814	0.814	0.814	0.814	0.814
K-P F-stat				92.94	102.6	102.2
Mun. FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Init. movem. pres. × Year FE	Y	Y	Y	Y	Y	Y
Geogr. chars. × Year FE	Y	Y	Y	Y	Y	Y
Baseline chars. × Year FE		Y	Y		Y	Y
Population controls			Y			Y

Note: OLS and IV regressions of the form: $Y_{it} = \alpha_i + \gamma_t + \phi \, \text{RailDist}_{i,t-1} + \beta \, X_{it} + \epsilon_{it}$. Dependent variables are defined as follows. Panel A: indicator equal to 1 if any movement organisation is present in the municipality. Panel B: inverse hyperbolic sine of total movement membership. Panel C: inverse hyperbolic sine of number of organisations. Standard errors clustered by municipality in parentheses. *, ** and *** indicate significance at the 10, 5 and 1 percent levels, respectively. Initial social movement presence is an indicator for the presence of any social movement in the first sample year (1881) interacted with year fixed effects. Geographical characteristics are: distance to the capital (Stockholm), distance to nodal towns, distance to coast, elevation (all transformed using an inverse hyperbolic sine transformation) interacted with year fixed effects. Baseline characteristics are demographic characteristics in the baseline 1880 census (adult population, average age, share married individuals, share females, share employed, and employment shares in 10 major ISCO groups) interacted with year fixed effects. Population controls is the inverse hyperbolic sine transformation of the contemporaneous adult population.

Table 5: Mechanisms: social movement market access and social movement outcomes

	Dependent variable					
	Movement presence		IHS(membership)		IHS(no. organisations)	
	OLS (1)	IV (2)	OLS (3)	IV (4)	OLS (5)	IV (6)
IHS(market access)$_{t-1}$	0.052***	0.762**	0.209***	3.433**	0.060***	1.217**
	(0.014)	(0.333)	(0.067)	(1.625)	(0.022)	(0.518)
Observations	66033	66033	66033	66033	66033	66033
Municipalities	2277	2277	2277	2277	2277	2277
Clusters	2277	2277	2277	2277	2277	2277
Outcome mean	0.507	0.507	2.680	2.680	0.814	0.814
K-P F-stat		18.17		18.17		18.17
Mun. FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Init. movem. pres. × Year FE	Y	Y	Y	Y	Y	Y
Geogr. chars. × Year FE	Y	Y	Y	Y	Y	Y
Baseline chars. × Year FE	Y	Y	Y	Y	Y	Y
Population controls	Y	Y	Y	Y	Y	Y

Note: OLS and IV regressions of the form: $\mathrm{Y}_{it} = \alpha_i + \gamma_t + \kappa \mathrm{MarketAccess}_{i,t-1} + \beta \mathrm{X}_{it} + \epsilon_{it}$, where $\mathrm{MarketAccess}_{it} = \sum_{j \neq i} \mathrm{Cost}_{ijt}^{-1} \times \mathrm{Membersip}_{jt}$ and Cost_{ijt} is the least-cost between municipalities i and j in year t. See text for details. Dependent variables are defined as follows. Columns 1-2: indicator equal to 1 if any movement organisation is present in the municipality. Columns 3-4: inverse hyperbolic sine of total movement membership. Columns 5-6: inverse hyperbolic sine of number of organisations. Standard errors clustered by municipality in parentheses. *, ** and *** indicate significance at the 10, 5 and 1 percent levels, respectively. Initial social movement presence is an indicator for the presence of any social movement in the first sample year (1881) interacted with year fixed effects. Geographical characteristics are: distance to the capital (Stockholm), distance to nodal towns, distance to coast, elevation (all transformed using an inverse hyperbolic sine transformation) interacted with year fixed effects. Baseline characteristics are demographic characteristics in the baseline 1880 census (adult population, average age, share married individuals, share females, share employed, and employment shares in 10 major ISCO groups) interacted with year fixed effects. Population controls is the inverse hyperbolic sine transformation of the contemporaneous adult population.

Table 6: Mechanisms: station-level arrivals and social movement outcomes

	Dependent variable								
	Movement presence			IHS(membership)			IHS(no. organisations)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
IHS(passenger arrivals)$_{t-1}$	0.044*		0.050**	0.331***		0.379***	0.111**		0.112**
	(0.023)		(0.025)	(0.125)		(0.131)	(0.048)		(0.052)
IHS(freight arrivals)$_{t-1}$		0.007	-0.008		0.048	-0.060		0.031	-0.001
		(0.012)	(0.013)		(0.068)	(0.068)		(0.027)	(0.027)
Observations	5017	5017	5017	5017	5017	5017	5017	5017	5017
Municipalities	173	173	173	173	173	173	173	173	173
Clusters	173	173	173	173	173	173	173	173	173
Outcome mean	0.738	0.738	0.738	4.461	4.461	4.461	1.559	1.559	1.559
Mun. FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Init. movem. pres. × Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Geogr. chars. × Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Baseline chars. × Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Population controls	Y	Y	Y	Y	Y	Y	Y	Y	Y

Note: OLS regressions of the form: $\mathrm{Y}_{it} = \alpha_i + \gamma_t + \lambda\,\mathrm{Arrivals}_{i,t-1} + \beta\,\mathrm{X}_{it} + \epsilon_{it}$. Dependent variables are defined as follows. Columns 1-3: indicator equal to 1 if any movement organisation is present in the municipality. Columns 4-6: inverse hyperbolic sine of total movement membership. Columns 7-9: inverse hyperbolic sine of number of organisations. Standard errors clustered by municipality in parentheses. *, ** and *** indicate significance at the 10, 5 and 1 percent levels, respectively. Initial social movement presence is an indicator for the presence of any social movement in the first sample year (1881) interacted with year fixed effects. Geographical characteristics are: distance to the capital (Stockholm), distance to nodal towns, distance to coast, elevation (all transformed using an inverse hyperbolic sine transformation) interacted with year fixed effects. Baseline characteristics are demographic characteristics in the baseline 1880 census (adult population, average age, share married individuals, share females, share employed, and employment shares in 10 major ISCO groups) interacted with year fixed effects. Population controls is the inverse hyperbolic sine transformation of the contemporaneous adult population. In all regressions, I control for the presence of a station in the municipality.

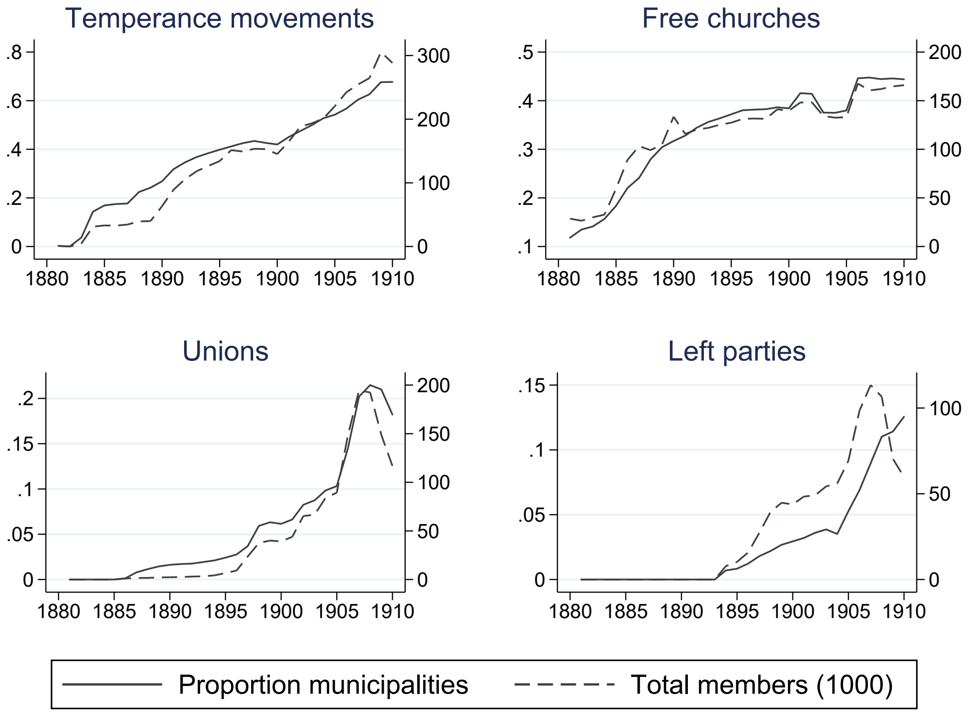
Table 7: Alternative mechanisms: ruling out other demand- and supply-side factors

	Dependent variable: see panel headings							
		Alternative mechanism						
	Baseline	Demand-side		Supply-side				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A. Dependent variable: movement presence								
IHS(market access)$_{t-1}$	0.052***	0.052***	0.047***	0.052***	0.051***	0.055***	0.072***	0.072***
	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)	(0.017)	(0.016)	(0.017)
Panel B. Dependent variable: IHS(membership)								
IHS(market access)$_{t-1}$	0.209***	0.209***	0.175***	0.209***	0.210***	0.251***	0.351***	0.330***
	(0.067)	(0.067)	(0.067)	(0.067)	(0.067)	(0.082)	(0.077)	(0.082)
Panel C. Dependent variable: IHS(no. organisations)								
IHS(market access)$_{t-1}$	0.060***	0.060***	0.048**	0.061***	0.062***	0.078***	0.118***	0.098***
	(0.022)	(0.022)	(0.022)	(0.022)	(0.022)	(0.027)	(0.025)	(0.027)
Additional controls	None	Share Lutheran	Employment structure	Dist. nearest teleg. station	No. telegrams received	Access to newspapers	Access to print	Access to post
Observations	66033	66033	66033	66033	66033	66033	66033	66033
Municipalities	2277	2277	2277	2277	2277	2277	2277	2277
Clusters	2277	2277	2277	2277	2277	2277	2277	2277
Mun. FE	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y
Init. movem. pres. × Year FE	Y	Y	Y	Y	Y	Y	Y	Y
Geogr. chars. × Year FE	Y	Y	Y	Y	Y	Y	Y	Y
Baseline chars. × Year FE	Y	Y	Y	Y	Y	Y	Y	Y
Population controls	Y	Y	Y	Y	Y	Y	Y	Y

Note: OLS regressions of the form: $Y_{it} = \alpha_i + \gamma_t + \kappa \, \text{MarketAccess}_{i,t-1} + \beta \, X_{it} + \epsilon_{it}$, where $\text{MarketAccess}_{it} = \sum_{j \neq i} \text{Cost}_{ijt}^{-1} \times \text{Membersip}_{jt}$ and Cost_{ijt} is the least-cost between municipalities i and j in year t. See text for details. Panel A: indicator equal to 1 if any movement organisation is present in the municipality. Panel B: inverse hyperbolic sine of total movement membership. Panel C: inverse hyperbolic sine of number of organisations. Standard errors clustered by municipality in parentheses. *, ** and *** indicate significance at the 10, 5 and 1 percent levels, respectively. Initial social movement presence is an indicator for the presence of any social movement in the first sample year (1881) interacted with year fixed effects. Geographical characteristics are: distance to the capital (Stockholm), distance to nodal towns, distance to coast, elevation (all transformed using an inverse hyperbolic sine transformation) interacted with year fixed effects. Baseline characteristics are demographic characteristics in the baseline 1880 census (adult population, average age, share married individuals, share females, share employed, and employment shares in 10 major ISCO groups) interacted with year fixed effects. Population controls is the inverse hyperbolic sine transformation of the contemporaneous adult population. Additional controls described in main text.

Figures

Figure 1: Social movements over time



Note: Summary graphs showing the presence of and membership in four different social movements over the sample period 1881-1910. Solid line (left axis) shows the proportion of municipalities with a given movement type present. Dashed line (right axis) shows the total national membership (in thousands) of a given movement type.

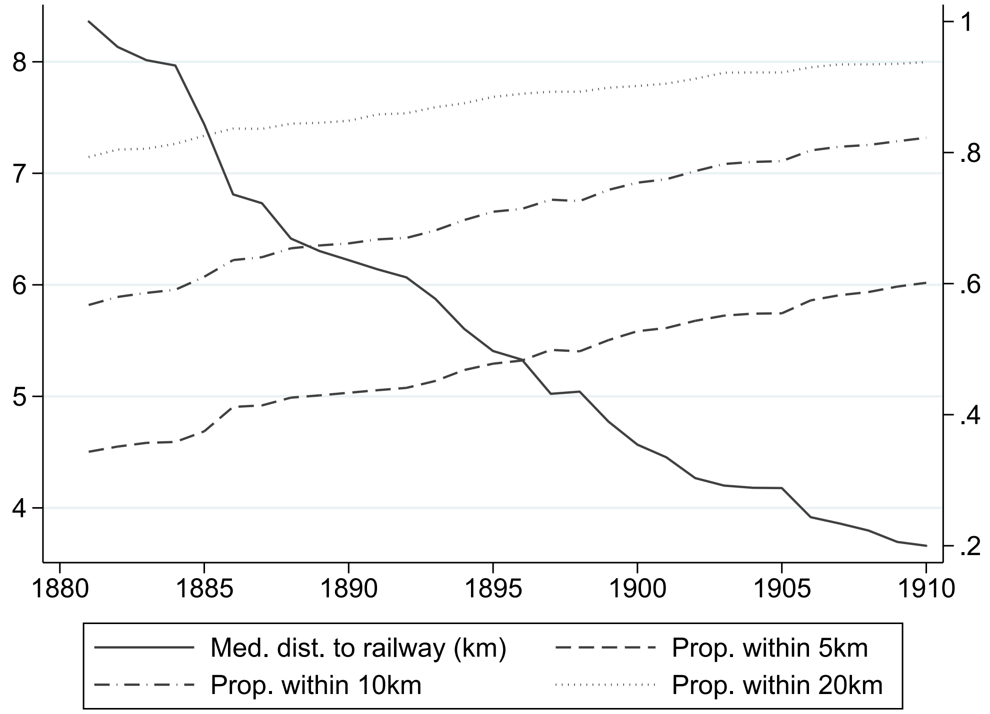
Figure 2: Railway network expansion, 1881-1910

(a) 1881

(b) 1910

Note: Maps showing the extent of the Swedish railway network at the start (1881) and end (1910) of the sample period. These years are chosen to show the full extent of railway expansion over this period. The main analysis exploits year-on-year expansions of the railway network.

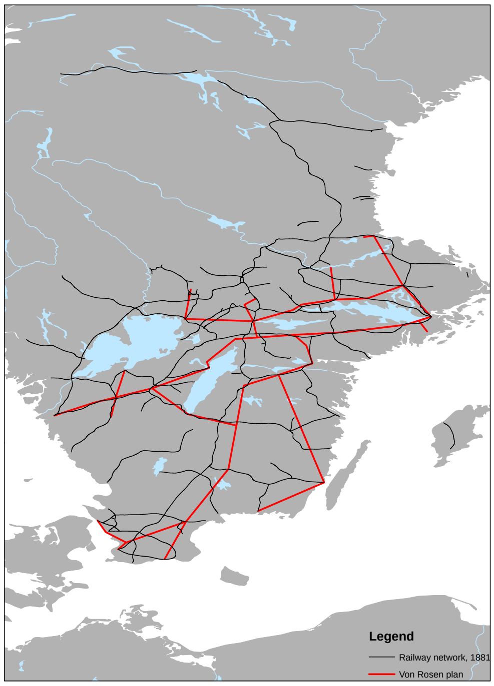
Figure 3: Railway access over time



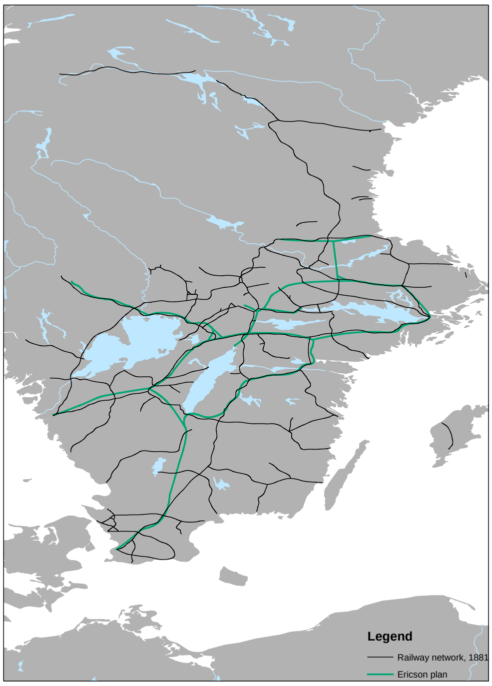
Note: Summary graphs showing railway access over the sample period 1881-1910. Solid line (left axis) shows the median distance (in km) to rail in each year. Dashed lines (right axis) respectively show the proportion of municipalities within 5, 10 and 20 km of rail in each year.

Figure 4: Military railway plan instruments and actual railways, 1881

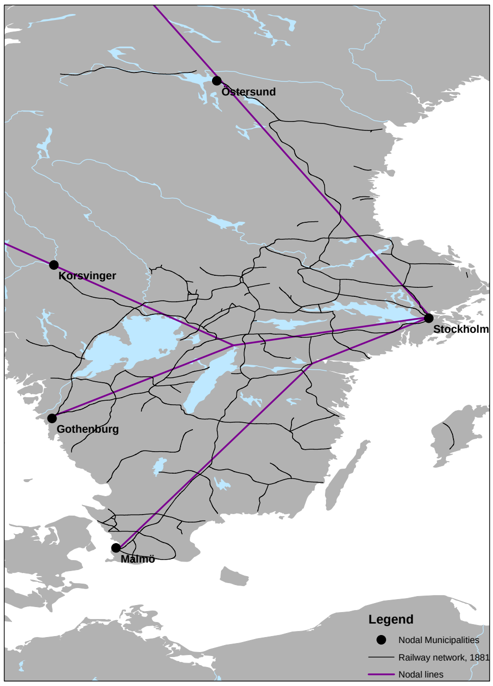
(a) Actual



(b) Von Rosen plan



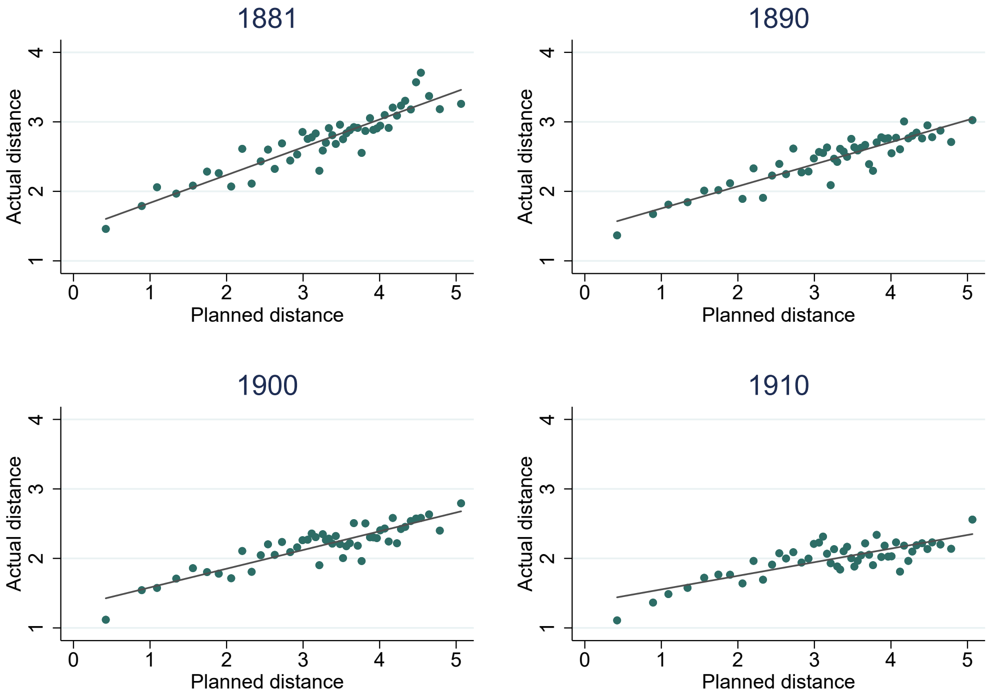
(c) Ericson plan



(d) Nodal lines

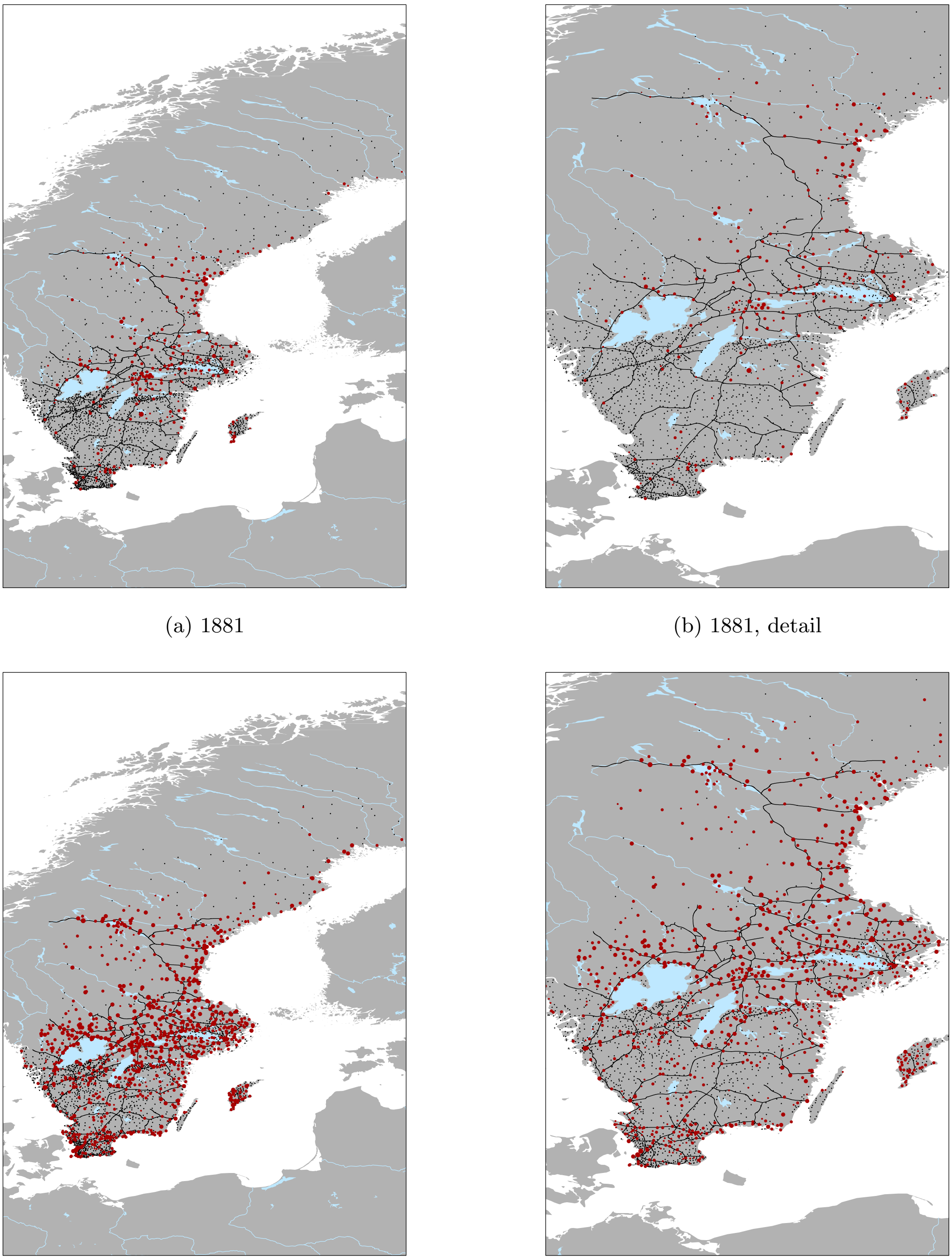
Note: Maps showing the spatial relationship between the actual railway network as of 1881 and the three counterfactual railway networks used in constructing my instrumental variable. See text for details.

Figure 5: First stage relationship over time



Note: Conditional correlations between proximity to railway and proximity to the counterfactual railway networks used in constructing my instrumental variable. Shown for select years. See text for details. All variables have been residualised with county fixed effects as well as controls for longitude and latitude. All distances have been transformed using an inverse hyperbolic sine transformation.

Figure 6: Spatial relationship between railways and social movements



(a) 1881

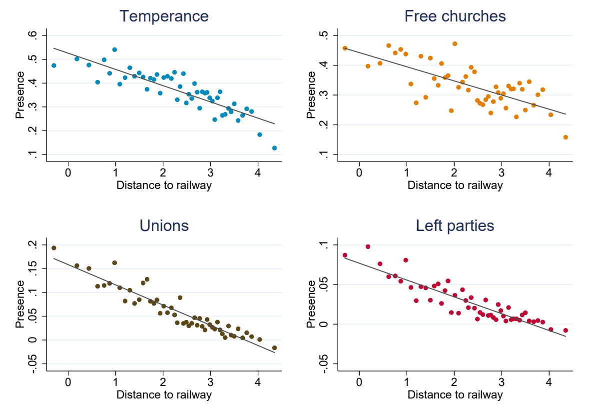
(b) 1881, detail

(c) 1890

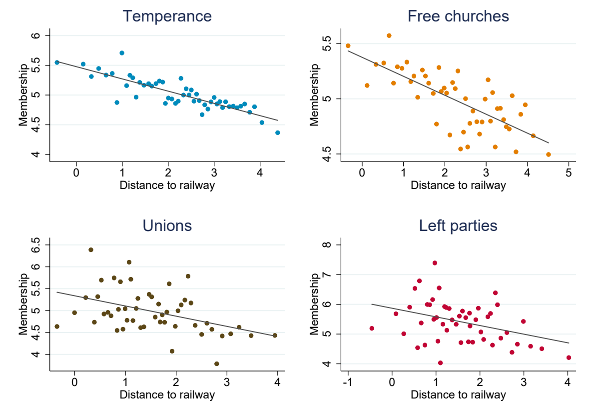
(d) 1890, detail

Note: Maps showing the spatial relationship between social movement presence and membership and railway access in two selected years. Black dots denote municipalities. Red circles denote municipalities with social movement presence. The size of the circle indicates absolute membership numbers.

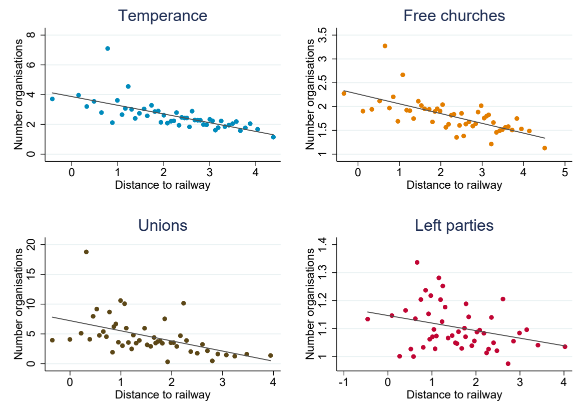
Figure 7: Correlations between railway access and social movement outcomes



(a) Presence



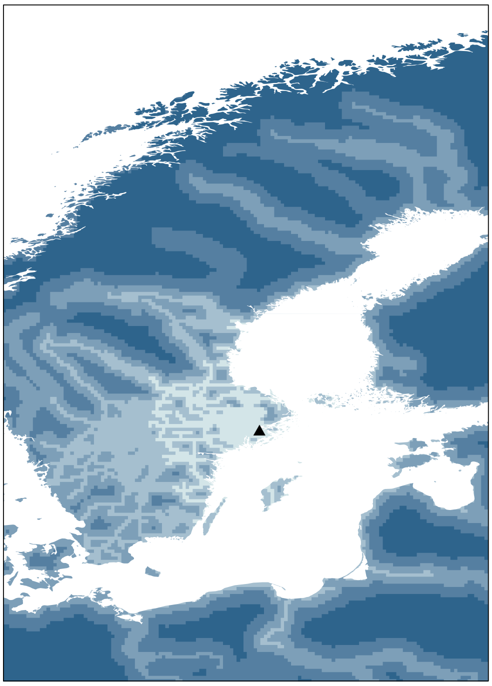
(b) Membership



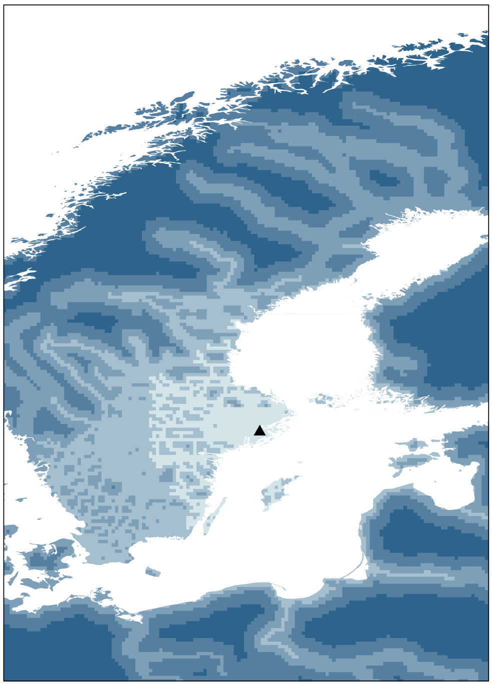
(c) Number of organisations

Note: Conditional correlations (binned scatterplots) between social movement outcomes by type and railway access. All variables have been residualised with county fixed effects as well as controls for longitude and latitude. The "distance to railway" and "membership" variables have been transformed using an inverse hyperbolic sine transformation.

Figure 8: Least costs to Stockholm over time



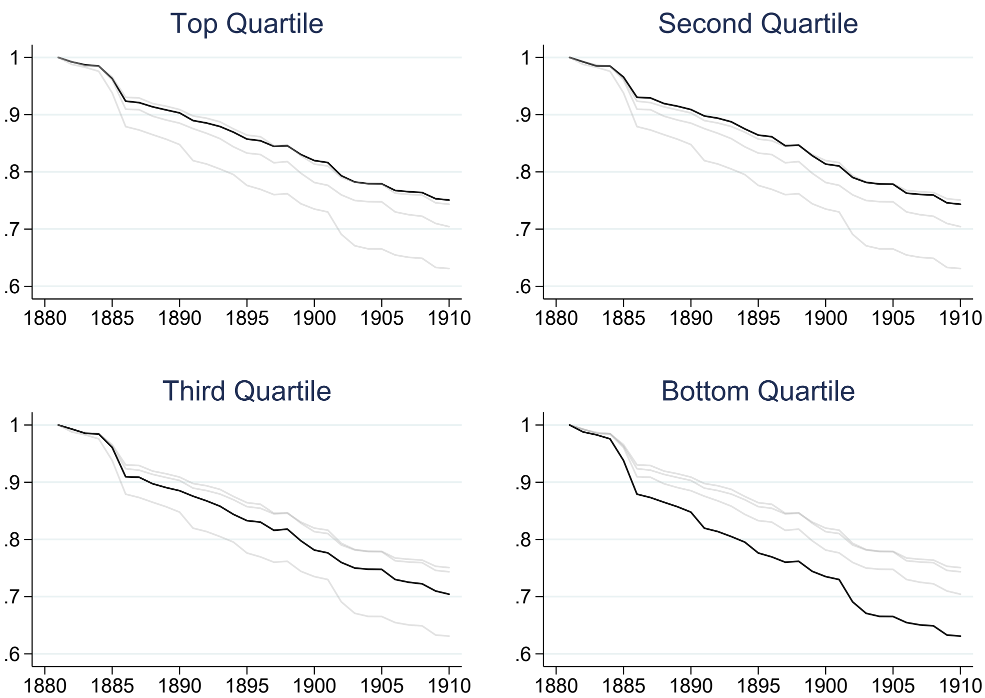
(a) 1881



(b) 1910

Note: Maps showing least costs to Stockholm at the start (1881) and end (1910) of the sample period. Logarithmic scale: a darker colour is twice as costly as the nearest lighter colour. See text and Appendix A for details on the construction of the least cost measures.

Figure 9: Least cost reductions over time



Note: Graphs showing the reductions in average least costs over time in relation to initial average least cost (cost normalised to 1 in 1881). Municpalities split according to initial cost as of 1881: the top quartile contains municipalities with the lowest average cost (i.e. the most connected municipalities), the second quartile those with the second lowest average cost, and so on.

Appendix A: Calculating Least Costs

Key to the discussion of "market access" in Section 6 above is the use of time-varying least costs between municipalities, Cost_{ijt}. This Appendix provides a sketch of the calculation of these cost terms.

The cost terms Cost_{ijt} are allowed to vary by year, t. Indeed, within- as well as between-variation in the least costs is crucial for identification in a panel framework. Variation in these terms comes from the expansion of the railway network, which reduces effective travel costs asymmetrically across municipalities.

Each year, therefore, one can calculate least costs using the following algorithm:

1. Divide Sweden into a $0.1° \times 0.1°$ grid.
2. Assign a cost to each grid cell using the following criteria: [28]
   - If the cell contains a major body of water (coast, river, lake), assign a cost of 0.49.
   - If the cell does not contain water, but contains railway, assign a cost of 0.63.
   - If the cell contains neither water nor railway, assign a cost of 23.1.
3. Construct a cost raster using the full grid of costs. See Figures A1a and A1c for examples.
4. For each of the 2,277 municipalities in the sample, calculate the travel cost to that municipality from every other municipality. This is a minimisation problem over the least cost surface which picks the optimal route. See Figures A1b and A1d for examples of least costs to Stockholm.

Each year, this results in over 5 million pairwise least cost terms, which can be collected in a cost matrix:

$$\mathbf{C}_t = \begin{bmatrix} \text{Cost}_{11}^{-\theta} & \text{Cost}_{12}^{-\theta} & \dots & \text{Cost}_{1n}^{-\theta} \\ \text{Cost}_{21}^{-\theta} & \text{Cost}_{22}^{-\theta} & \dots & \text{Cost}_{2n}^{-\theta} \\ \vdots & \vdots & \ddots & \vdots \\ \text{Cost}_{n1}^{-\theta} & \text{Cost}_{n2}^{-\theta} & \dots & \text{Cost}_{nn}^{-\theta} \end{bmatrix}_t$$

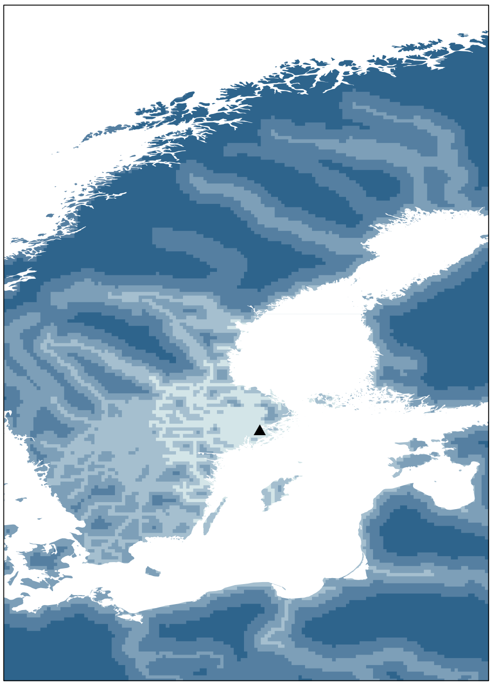
The sequence of cost matrices can then be used in various "market access"-style calculations.

[28] These cost parameters follow Donaldson and Hornbeck (2016), who in turn follow Fogel (1964). Perlman (2016) also uses the same cost values.

Figures for Appendix A

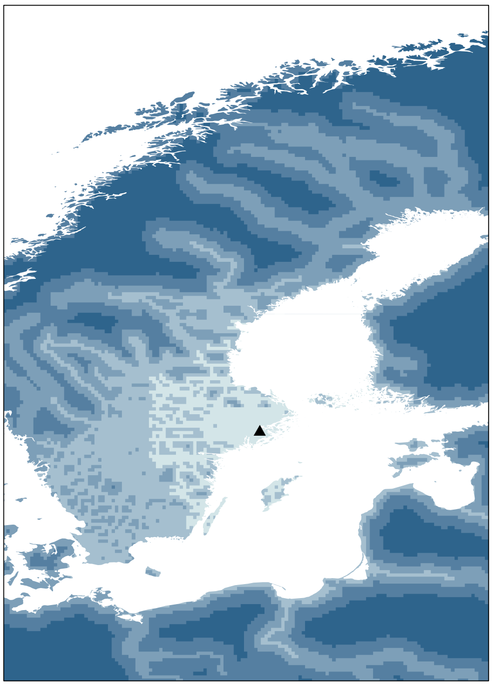
Figure A1: Calculating least costs

(a) Cost raster, 1881



(b) Least costs to Stockholm, 1881

(c) Cost raster, 1910



(d) Least costs to Stockholm, 1910

Note: Maps showing the construction of least cost maps and the cost raster used in this construction for the start (1881) and end (1910) of the sample period. See main text and the text in this appendix for details.

Appendix B: Additional Tables

Table B1: Robustness to different treatment definitions

	Definition of *distance to rail* variable					
	IHS(distance to rail)		ln(1 + distance to rail)		$\mathbb{1}$\{rail within 10km\}	
	OLS (1)	IV (2)	OLS (3)	IV (4)	OLS (5)	IV (6)
Panel A. Dependent variable: movement presence						
Distance to rail_{t-1}	-0.013**	-0.093**	-0.017**	-0.099**	0.034**	0.325**
	(0.006)	(0.039)	(0.007)	(0.042)	(0.013)	(0.144)
Panel B. Dependent variable: IHS(membership)						
Distance to rail_{t-1}	-0.055*	-0.467**	-0.075**	-0.498**	0.119*	1.695**
	(0.028)	(0.197)	(0.033)	(0.210)	(0.063)	(0.733)
Panel C. Dependent variable: IHS(no. organisations)						
Distance to rail_{t-1}	-0.016*	-0.190***	-0.023**	-0.203***	0.019	0.719***
	(0.010)	(0.065)	(0.011)	(0.069)	(0.021)	(0.248)
Observations	66033	66033	66033	66033	66033	66033
Municipalities	2277	2277	2277	2277	2277	2277
Clusters	2277	2277	2277	2277	2277	2277
K-P F-stat		102.2		109.5		51.68
Mun. FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Init. movem. pres. × Year FE	Y	Y	Y	Y	Y	Y
Geogr. chars. × Year FE	Y	Y	Y	Y	Y	Y
Baseline chars. × Year FE	Y	Y	Y	Y	Y	Y
Population controls	Y	Y	Y	Y	Y	Y

Note: OLS and IV regressions of the form: $\text{Y}_{it} = \alpha_i + \gamma_t + \phi \text{ DistRail}_{i,t-1} + \beta \text{ X}_{it} + \epsilon_{it}$. Columns 1 and 2 report baseline results using the inverse hyperbolic sine transformation of distance to rail. Columns 3 and 4 use the natural logarithm (using 1 + distance to allow for zero distances). Columns 5 and 6 use an indicator equal to one if the municipality is within 10 kilometres of the railway. Dependent variables are defined as follows. Panel A: indicator equal to 1 if any movement organisation is present in the municipality. Panel B: inverse hyperbolic sine of total movement membership. Panel C: inverse hyperbolic sine of number of organisations. Standard errors clustered by municipality in parentheses. *, ** and *** indicate significance at the 10, 5 and 1 percent levels, respectively. Initial social movement presence is an indicator for the presence of any social movement in the first sample year (1881) interacted with year fixed effects. Geographical characteristics are: distance to the capital (Stockholm), distance to nodal towns, distance to coast, elevation (all transformed using an inverse hyperbolic sine transformation) interacted with year fixed effects. Baseline characteristics are demographic characteristics in the baseline 1880 census (adult population, average age, share married individuals, share females, share employed, and employment shares in 10 major ISCO groups) interacted with year fixed effects. Population controls is the inverse hyperbolic sine transformation of the contemporaneous adult population.

Table B2: Robustness to different population interpolations

	Population interpolation					
	Fixed between census years		Linear interpolation		Constant growth rate interpolation	
	OLS	IV	OLS	IV	OLS	IV
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A. Dependent variable: movement presence						
IHS(distance to railway)$_{t-1}$	-0.013**	-0.093**	-0.011*	-0.090**	-0.011*	-0.090**
	(0.006)	(0.039)	(0.006)	(0.040)	(0.006)	(0.039)
Panel B. Dependent variable: IHS(membership)						
Distance to rail$_{t-1}$	-0.055*	-0.467**	-0.034	-0.440**	-0.035	-0.441**
	(0.028)	(0.197)	(0.028)	(0.199)	(0.028)	(0.199)
Panel C. Dependent variable: IHS(no. organisations)						
Distance to rail$_{t-1}$	-0.016*	-0.190***	-0.007	-0.178***	-0.007	-0.178***
	(0.010)	(0.065)	(0.010)	(0.065)	(0.010)	(0.065)
Observations	66033	66033	66033	66033	66033	66033
Municipalities	2277	2277	2277	2277	2277	2277
Clusters	2277	2277	2277	2277	2277	2277
K-P F-stat		102.2		101.4		101.3
Mun. FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Init. movem. pres. × Year FE	Y	Y	Y	Y	Y	Y
Geogr. chars. × Year FE	Y	Y	Y	Y	Y	Y
Baseline chars. × Year FE	Y	Y	Y	Y	Y	Y
Population controls	Y	Y	Y	Y	Y	Y

Note: OLS and IV regressions of the form: $\text{Y}_{it} = \alpha_i + \gamma_t + \phi \, \text{DistRail}_{i,t-1} + \beta \, \text{X}_{it} + \epsilon_{it}$. Columns 1 and 2 report baseline results using population numbers fixed between census years. Columns 3 and 4 interpolate population numbers linearly between census years. Columns 5 and 6 interpolate population numbers between census years using a constant growth rate. Dependent variables are defined as follows. Panel A: indicator equal to 1 if any movement organisation is present in the municipality. Panel B: inverse hyperbolic sine of total movement membership. Panel C: inverse hyperbolic sine of number of organisations. Standard errors clustered by municipality in parentheses. *, ** and *** indicate significance at the 10, 5 and 1 percent levels, respectively. Initial social movement presence is an indicator for the presence of any social movement in the first sample year (1881) interacted with year fixed effects. Geographical characteristics are: distance to the capital (Stockholm), distance to nodal towns, distance to coast, elevation (all transformed using an inverse hyperbolic sine transformation) interacted with year fixed effects. Baseline characteristics are demographic characteristics in the baseline 1880 census (adult population, average age, share married individuals, share females, share employed, and employment shares in 10 major ISCO groups) interacted with year fixed effects.

Table B3: Robustness to dropping targeted municipalities

	Sample					
	Full		Dropping nodes		Dropping municipalities <10km from nodes	
	OLS (1)	IV (2)	OLS (3)	IV (4)	OLS (5)	IV (6)
Panel A. Dependent variable: movement presence						
IHS(distance to railway)$_{t-1}$	-0.013**	-0.093**	-0.013**	-0.091**	-0.012**	-0.089**
	(0.006)	(0.039)	(0.006)	(0.040)	(0.006)	(0.039)
Panel B. Dependent variable: IHS(membership)						
Distance to rail$_{t-1}$	-0.055*	-0.467**	-0.054*	-0.458**	-0.047*	-0.455**
	(0.028)	(0.197)	(0.028)	(0.200)	(0.028)	(0.199)
Panel C. Dependent variable: IHS(no. organisations)						
Distance to rail$_{t-1}$	-0.016*	-0.190***	-0.017*	-0.194***	-0.015	-0.194***
	(0.010)	(0.065)	(0.010)	(0.065)	(0.010)	(0.064)
Observations	66033	66033	65917	65917	64902	64902
Municipalities	2277	2277	2273	2273	2238	2238
Clusters	2277	2277	2273	2273	2238	2238
K-P F-stat		102.2		102.4		105.4
Mun. FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Init. movem. pres. × Year FE	Y	Y	Y	Y	Y	Y
Geogr. chars. × Year FE	Y	Y	Y	Y	Y	Y
Baseline chars. × Year FE	Y	Y	Y	Y	Y	Y
Population controls	Y	Y	Y	Y	Y	Y

Note: OLS and IV regressions of the form: $\mathrm{Y}_{it} = \alpha_i + \gamma_t + \phi\,\mathrm{DistRail}_{i,t-1} + \beta\,\mathrm{X}_{it} + \epsilon_{it}$. Columns 1 and 2 report baseline results using the full sample. Columns 3 and 4 drop targeted ("nodal") municipalities. Columns 5 and 6 drop all municipalities within 10 kilometres of targeted ("nodal") municipalities. Dependent variables are defined as follows. Panel A: indicator equal to 1 if any movement organisation is present in the municipality. Panel B: inverse hyperbolic sine of total movement membership. Panel C: inverse hyperbolic sine of number of organisations. Standard errors clustered by municipality in parentheses. *, ** and *** indicate significance at the 10, 5 and 1 percent levels, respectively. Initial social movement presence is an indicator for the presence of any social movement in the first sample year (1881) interacted with year fixed effects. Geographical characteristics are: distance to the capital (Stockholm), distance to nodal towns, distance to coast, elevation (all transformed using an inverse hyperbolic sine transformation) interacted with year fixed effects. Baseline characteristics are demographic characteristics in the baseline 1880 census (adult population, average age, share married individuals, share females, share employed, and employment shares in 10 major ISCO groups) interacted with year fixed effects. Population controls is the inverse hyperbolic sine transformation of the contemporaneous adult population.