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# The Belle Époque of the railways: the Freycinet plan and its effects on the French population and economy

Olivier Lenoir

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**The Belle Époque of the railways:  
the Freycinet plan and its effects on the  
French population and economy**

Olivier Lenoir

JEL Codes: N73, N94, R40

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The *Belle Époque* of the railways:  
the Freycinet plan and its effects on the French  
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Vincent Van Gogh, *Wagons de chemin de fer*, 1888

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## Abstract

In this paper, I study the impact of the Freycinet plan (1879-1914) on the French population and economy, in the short run. The Freycinet plan was one of the major public works programmes launched by the young Third Republic in 1878-1879, which aimed to massively develop railway connections across the French territory. I first show that, in accordance with the republican ideology at the time, the plan targeted less served and underprivileged areas, therefore contributing to the unification of the French territory. Then, I use a difference-in-differences methodology to assess the impact of the plan on the French population. Since railroad construction is endogenous, I resort to an instrumental variable strategy focusing on the shortest route between the predefined endpoints of each train line. I find that gaining access to the railway thanks to the Freycinet plan is associated with a relative increase in the population of connected municipalities by around 30% after the plan was implemented (in the early Interwar period), a result that withstands a series of robustness checks and is mainly explained by population displacement, from unconnected to connected municipalities. Eventually, I find evidence that additional connected municipalities thanks to the Freycinet plan did increase the GDP of French *départements*, in a non-linear way, but had no effect on farming profits.

JEL codes: N73, N94, R40.

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# Introduction

*“Ah! the clear arrival at the morning dawn!  
The stations, their smell of sunshine and orange,  
Anything on the platforms gets tangled up and messed up,  
This wonderful effort of unstable and distant!”<sup>1</sup>*

When Anna de Noailles was writing, at the beginning of the 20<sup>th</sup> century, the French railway network was experiencing a kind of revolution: after an already rich history during which the major towns had welcomed train stations, along with some small and isolated municipalities which were at the centre of local lines, it was time to unify the territory and give more coherence and density to the network. The young Third Republic (1870-1940) therefore launched a major programme of public works, called the Freycinet plan (1879-1914), named after the Minister of Public Works at the time, Louis Charles de Saulces de Freycinet. In the law of July 17, 1879, which gave birth to the plan, 8,848 km of 181 new train lines of the general interest (i.e. national) network, had to be built. Many other train lines, especially local lines decided by the *conseils généraux* of French *départements*, were also built at the time, but the Freycinet plan is still today retained as one of the major railway policies of the end of the 19<sup>th</sup> century. It constitutes an episode still sometimes mentioned in the media<sup>2</sup>. While the majority of Freycinet lines have been closed during the 20<sup>th</sup> century, there can be some historical backlashes: the *Chemin de fer de la Mure* (Isère), corresponding to Freycinet line number 127<sup>3</sup>, is expected to reopen as a tourist line in the spring of 2021. In this paper, in the vein of the everlasting issue of the economic impacts of railways, I therefore study the effects of the Freycinet plan on the French population and economic development, in the short run.

There are several reasons for my focus on the Freycinet plan. First, it constituted a major watershed in the French railway history, since for the first time the state would build and run its own train lines, after decades of total private ownership, a trend that would eventually lead to the complete nationalisation of the railway network in 1937. Historically, it was also a milestone for the Third Republic because it was one of the means through which republicans aimed at unifying the territory, at rallying rural populations to the republic and at responding to economic issues in the aftermath of the Franco-Prussian War of 1870-1871 (as I will further detail in section 1). It was therefore a major programme, that was largely publicised in the media and also very frequently discussed in the National Assembly, especially due to its increasing cost over time. Until today, the Freycinet plan is often perceived as the source of an excess in public spending, that over-equipped the territory with railways and may have deterred investment in other sectors than the railway industry (e.g. [Le Bris \(2012\)](#)), an idea that however has not been assessed econometrically. Beyond the historic facet of the plan, one important dimension is that it concerned railways of the general interest network and not of the secondary, local, network. This basically means that the lines were expected to have a national value and therefore a larger scope than small and isolated lines often created by municipalities or *départements*. The lines of the Freycinet plan were also essentially exploited by the state or the so-called great railway companies (*grandes compagnies de chemins de fer*), but always monitored by the state ([Gonjo \(1972\)](#)), which insured more reliable traffic and stability, while the majority of smaller private secondary companies disappeared over the period of study ([Protat \(2002\)](#)). Also, the centralisation of the list of the Freycinet lines in the law of July 17, 1879, that I study (cf. section 1.3 for more details) makes it possible to follow exhaustively the scope and extension of the network, while there is no clear enumeration of all the other local lines, due to a dissemination of decisions among local authorities (*conseils municipaux* and *conseils généraux*). This is very useful for the econometric part of this paper.

However, identifying the causal impact of the Freycinet plan on newly connected municipalities is not an easy task. It is first possible to compare “Freycinet municipalities” (considered as “treated”) to control municipalities, before and after the plan was implemented, in a standard difference-in-differences

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<sup>1</sup>Anna de Noailles, “Les voyages”, *L’Ombre des jours*, 1902.

<sup>2</sup>E.g. Mathilde Leclerc, “Il y a 50 ans, le dernier train s’est arrêté en gare de La Flèche”, *Ouest-France*, April 5, 2020; Georges Ribeill, “Les petites gares de province étaient chargées de vécus affectifs forts”, *Le Monde*, August 26, 2018; Aurélien Bellanger, “Les gares désaffectées” in *La Conclusion*, France Culture, February 25, 2019.

<sup>3</sup>Symbol of the modernity of French railways at the turn of the century, this train line was also the first one in the world to be electrified, in 1903, by French engineer René Thury.

framework. Yet, this approach suffers from a common issue in the literature on transportation infrastructure: the arrival of the train in a municipality is clearly not exogenous. To circumvent this problem, following several authors and in particular [Berger and Enflo \(2017\)](#), I instrument the station openings by the location of a given municipality on the shortest route between two predefined train line endpoints in the law of 1879. This approach rests on the assumption that train lines are meant to connect two (or sometimes three or four) towns in the cheapest and most efficient way. By doing so, railway constructions cut through many other municipalities that gain railway access only by virtue of their location on the shortest path between line endpoints. These municipalities were not targeted by state planners, meaning their access to the railway can be deemed “quasi-random” ([Mayer and Trevien \(2017\)](#)).

I first show that gaining railway access thanks to the Freycinet plan is associated with an average increase of about 30% in the population of connected municipalities after the plan was implemented in the 1920s, compared to non-connected municipalities and to the period before 1879, *ceteris paribus*. This result is very robust to several checks that I perform. I also highlight that both isolated and quite landlocked, rural municipalities that gained access to the network, as well as important towns which usually already had prior train connections, benefited from the plan. I suggest that this favourable demographic situation of “Freycinet municipalities” is mainly due to a reorganisation of population patterns across the French territory, from non-connected areas towards the newly connected places. At a local level, I underline that some regions, namely the current Hauts-de-France, Grand-Est and Provence-Alpes-Côte d’Azur, benefited more from the plan than others regarding the evolution of their population. In terms of economic outcomes, at the level of the *département*, I also find evidence that an additional “Freycinet municipality” is associated with an average increase in the *département*’s GDP by 1.1%, *ceteris paribus*. The contribution of railway connections seems however non-linear: the first connections do positively impact GDP, while after 80 connected municipalities, the contribution becomes negative. Moreover, it appears that the Freycinet plan did increase wages, as well as commercial and non-commercial profits, but had no effect on farming profits.

This paper therefore enables me to shed a new light on the contribution of the Freycinet plan to demographic and economic development in France between the beginning of the Third Republic and the Great Depression of 1929. It first speaks to an already wide and rich literature on the effects of railway constructions, but in which the French case in the past has not been much discussed compared to other national contexts (cf. section 2.1). It also provides causal and precise estimates on such impacts, due to the methodology used and to very detailed data stemming from datasets at the municipal level (i.e. the lowest administrative level in France) and/or resting on recent GIS (Geographical Information System) approaches. Finally, it combines both national and local approaches, as well as demographic and economic aspects, and therefore explores various outcomes on which the plan may have had an effect.

The rest of this paper is organised as follows. In the data section, I explain the plurality of datasets I use in the analysis. In section 1, I document the Freycinet plan and how it induced a massive rise in French railway connections after 1879, stressing that it partly redistributed the network towards less served and landlocked areas. In section 2, I focus on the effects of the Freycinet plan on municipal population, detailing the empirical methodology and results, as well as assessing displacement effects and population reorganisation. In section 3, I study the effects of the plan at the local level (regions and *départements*) and concentrate on economic outcomes, in particular *départements*’ GDPs and the components of them. I eventually provide concluding remarks, references and several appendices to which I refer in the course of the analysis.



# Data and variables

## Railway data

The key data in my analysis consist of Geographical Information System (GIS) databases that list and localise train tracks and stations built over time. I first use the dataset of [Martí-Henneberg \(2013\)](#).<sup>4</sup> In the context of the European project called *Inventing Europe*, launched in 2007 and aiming at understanding the role of technology in the history of Europe, [Martí-Henneberg \(2013\)](#) has built a GIS database with all major train lines in Western and Central Europe between 1840 and 2010, at a 10-year interval, by digitalising numerous maps. The 1870 dataset, that I use, gives a picture of the main standard gauge lines in many European countries – excluding narrow and local tracks that might not be comparable across Europe and may only be of limited and very local use (while the aim of the dataset is to focus on the larger topic of European integration). This dataset will therefore enable me to assess the situation of the French railway network at the beginning of the Third Republic in comparison with its neighbouring countries.

Another dataset, which I will thoroughly use during the whole analysis, focuses precisely on the French railway network.<sup>5</sup> [Thévenin, Schwartz, and Sapet \(2013\)](#) had already synthesised a variety of historical sources to build a H-GIS (Historical and Geographical Information System) dataset of the whole French (main and secondary) railway system: maps from the French National Railway Company (SNCF) in the 1940s, from the National Institute of Geographical and Forest Information (IGN), from a database already built by [Cima \(2001\)](#) and books by [Domengie and Banaudo \(1985\)](#). This first project has been complemented by [Mimeur \(2016\)](#), who enriched it in order to build the FRANcE (French Railway Network) database, adding various variables and focusing on the speed of trains as well as the interaction between network and territory. The database contains a total of around 11,000 stations on the period 1827-2001 and covers 56,000 km of railway lines of all sorts (main general network, secondary network, parts of the suburban network, etc.)

I use two sections of this database. On the one hand, I have a dataset with all the railway tracks (from 1827 and 2001), that are geolocalised and associated to their date of opening and closing. Each track is part of a longer line, meaning it is possible to draw maps of the state of the network every year. I will therefore show the evolution of the railway network at different points of French history. On the second hand, I have a dataset with all the train stations opened in French history, again geolocalised and associated to their dates of opening and closing, as well as the municipalities in which they are situated. The stations cover the French metropolitan territory, exclusive of Corsica. This is the dataset I will mostly use in my analysis. I have done very minor modifications in the dataset, because there are some duplicates of stations in some important cities – I have therefore dropped them from the dataset, to avoid over-counting them.

More importantly, the dataset I have does not give any information on the status of the stations considered, and in particular if they welcomed lines of the main and/or the secondary railway network. This is a very important issue since my focus, as I will detail further, is on the 181 lines mentioned in the law of July 17, 1879, that were (at least initially) all meant to be part of the main network (or *réseau d'intérêt général*). The nature of the lines passing through the stations is therefore very important to know because, beyond these main lines, other lines of the secondary network were also massively built on the same period. In order to know whether a station was actually located on one of the 181 “Freycinet” main lines, I relied on a variety of online sources that comprised such a crucial information. Fortunately, there are a lot of enthusiasts about French railway history. In order to know exactly the nature of each line and station on the period of study, I have mainly resorted to:

- *Inventaires ferroviaires de France*, a complete reference for all French *départements* on all the current and some old railway lines and their nature;
- *Géographie des chemins de fer français*, a website by Bernard Cima already mentioned, that gives a quasi-integral map of the French railway network at all points in time, including old and abandoned stations, with information on each of them;

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<sup>4</sup>I thank both Camille Hémet and Miquel-Àngel Garcia-López for having given me access to this data.

<sup>5</sup>I thank Christophe Mimeur for his direct explanation of the dataset and for having personally given me access to it.

- *Archéologie ferroviaire*, an atlas of all railway lines that disappeared and the municipalities across which these lines were passing;
- *Wikisara*, a website initially dedicated to referencing French roads but which also includes a page on the evolution of the 181 lines of the Freycinet plan.

Although the information is consistent across all these sources, which is very reassuring for the robustness of the analysis, I also occasionally completed them with other websites such as *Massif Central Ferroviaire* or *Chronologie des chemins de fer français*. This enables me to know precisely when and where each “Freycinet” station has opened, a key information to the analysis.

## Geographical data

Other important databases include general information on the French territory. In this perspective, I use the GEOFLA dataset, which is published by the IGN (*Institut national de l'information géographique et forestière*) and describes all the delimitations of French municipalities, that are georeferenced in a GIS approach. I use the version of 2013, i.e. the last one before the law of May 17, 2013 that reshaped and considerably reduced the amount of *cantons*. Besides geographical situation, the dataset includes variables on the administrative units the municipality belongs to (*region, département, canton*), its status (basic municipality or local capital city of an administrative unit), its surface and its average altitude. One limitation of the dataset is the fact that it focuses on current municipalities (at least, in 2013) and not on those that prevailed during the Freycinet era. However, since the French Revolution, municipality boundaries have only slightly changed. Only 2% of French municipality boundaries have changed and many of these changes occurred with the reforms of 1831 and 1837 (Motte, Séguy, and Théré (2003)) i.e. prior to my period of analysis. Besides, it is important to note that I exclude from the metropolitan municipalities those of Corsica (because the train station database does not cover this territory, as said before) and of the current *départements* of Haut-Rhin, Bas-Rhin and Moselle, which were annexed by the Prussians after the war of 1870.

I complement this database with other geographical information on water features on the French territory, which are relevant to understand the structure of the train network (e.g. a river might stop the building of a line) and that can also determine growth, as water transportation was important at the time. This data comes from the *Service d'administration nationale des données et référentiels sur l'eau* and is made available by the *Système d'Information sur l'Eau*. More precisely, I have made use of three datasets: the *Masse d'eau plan d'eau* dataset, from which I extracted the localisation of lakes; the *Masse d'eau rivières* dataset, for small and larger rivers (excluding small water streams); the *Masse d'eau côtière* dataset, for coastlines. For all municipalities of the GEOFLA database, I computed the distance between each of these three types of water features and the closest point of the municipality.

## Population data

Population is one of the main dependent variables I use in this paper. Demographic data come from the “Cassini” dataset<sup>6</sup>. A team of researchers of the Laboratory of historical demography (*Laboratoire de démographie historique – CNRS/EHESS*), coordinated by Claude Motte and Marie-Christine Vouloir, has compiled historical population data. The dataset gives the population of each municipality over time, for each year of census. I include data for years between 1861 and 1926, to encompass the whole Freycinet era as well as some years before and after the Plan.

Over my period of study, censuses took place every five years in France (years ending by 1 and 6), with the exception of 1872 that replaced the census of 1871, and the one of 1916 that was not carried out due to World War I. Of course, I cannot rule out that there might be some imprecision in population data due to the change in municipality boundaries over time; however, this should only be a minor issue thanks to the relative persistence of such boundaries after 1861, as I developed before.

---

<sup>6</sup>I thank Lionel Kesztenbaum for having given me access to it.

## Economic and industrial data

In the third section, I also make use of economic data at the level of French *départements*. First, the dataset by [Bazot \(2014\)](#) gives an approximation of Gross Domestic Product (GDP) at the departmental level before World War I. The approximation exploits a combination of agricultural added value (AVA) calculated by [Toutain \(1992\)](#) and Bazot’s collection of non-agricultural value-added (NAVA) thanks to computations based on the *patente* business tax. The dataset therefore gives the GDP for each *département* and successive decades (1840, 1850, 1860, 1869, 1880, 1892, 1900, 1911), except for the Territoire de Belfort.

The measures of economic activity during the Interwar period come from the works of [Monnet, Riva, and Ungaro \(2020\)](#)<sup>7</sup>. Following the same approach of using taxes to compute aggregate revenues, the authors base their computations on the four “schedular” taxes (*taxes cédulaires*) created by the law of July 31, 1917: remuneration, wages, pensions, and life annuities; industrial and commercial profits; farm profits; noncommercial (self-employed) profits. Although the public sector is not included in the estimate, these revenues help approximate again GDP at the level of *départements* for the Interwar period (with a 2-year interval). Therefore, I use the dataset resulting from such GDP approximations, and four types of revenues, to analyse economic activity after World War I. More precisely, I have the GDP for all *départements*, exclusive of the Seine *département* (75); the data for Haute-Saône (70) and Territoire de Belfort (90) are gathered. Besides, I have revenues from the “schedular” taxes for all *départements*, exclusive of the Seine (75), Haute-Saône (70) and Territoire de Belfort (90) *départements*.

I cannot rule out that there might be statistical breaks between both series, before and after World War I. However, both [Bazot \(2014\)](#) and [Monnet et al. \(2020\)](#) compare their measures of GDP with those of [Combes, Lafourcade, Thisse, and Toutain \(2011\)](#), that cover the whole period, and find that they fit quite well. Besides, had there been any important statistical difference between measures of the two periods, these differences would be symmetric to all *départements* and not only to some of them for which data definitions might have changed. Also, in order to make nominal values comparable, I deflate them using the price index of [Lévy-Leboyer and Bourguignon \(1985\)](#) that runs over the whole period and enables me to correct GDP for inflation.

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<sup>7</sup>I thank Éric Monnet for having given me access to this dataset.

# 1 The Freycinet plan: a republican attempt to rebalance the railway network towards less served areas and unify the territory

*“Ideally, the triptych of the town hall, the school and the station should equip a maximum of municipalities! [...] The small provincial railway stations have been places full of very strong emotional experiences.”<sup>8</sup>*

In this section, I give a thorough understanding of the Freycinet plan, from its conception to its actual implementation. After a quick recall of French railway history throughout the 19<sup>th</sup> century (section 1.1), I explain the context of emergence of the Freycinet plan and how important it was in order to redefine the role of the state in industrial policy at the time (section 1.2). Then I precisely describe the plan itself and show its massive contribution to railway coverage in France until 1914 (section 1.3), before highlighting that it did achieve its republican objective of unifying the French territory (section 1.4).

## 1.1 Trains in France until 1879

At the beginning of the Third Republic (1870-1940), France already enjoyed an important railway network, that started with the line going from Saint-Étienne to Andrézieux (23 km), that became operational in 1827. It was also the first train line of continental Europe – which also means that France was lagging behind Great Britain. After many private and local initiatives, consisting essentially in joining neighbouring cities or industrial areas, the law of June 11, 1842 (*Loi relative à l'établissement des grandes lignes de chemin de fer en France*) contributed to formulate ambitions for the French railway network, at a time when the latter only comprised 548 kilometers (compared to 2,521 in Britain). The July Monarchy gave birth to the “century of railways” (Caralp-Landon (1951)), by enacting the construction of long national lines, many of them connecting Paris to other French cities (in the shape of a star, the so-called *étoile de Legrand*). Municipalities would grant land for railroads, the State would build them and private companies would exploit them thanks to long-term concessions. It was the flourishing time for private train companies, with major lines being built (e.g. Paris-Orléans in 1843, Paris-Strasbourg in 1849).

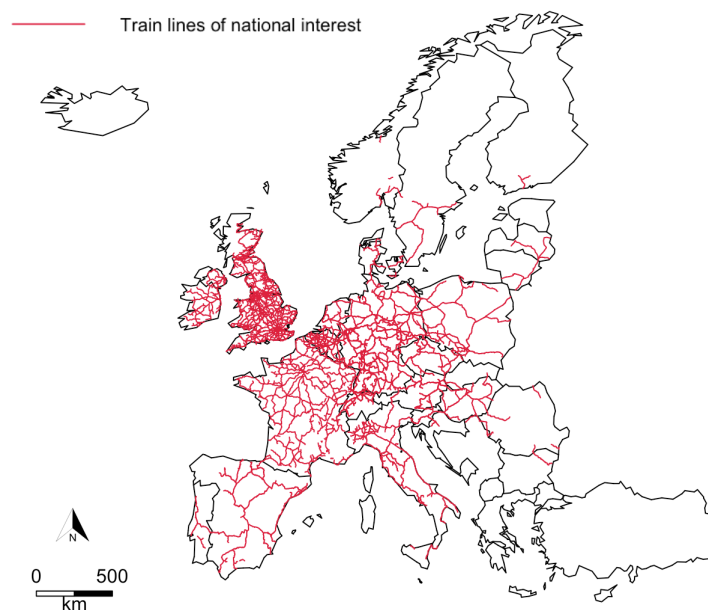
In 1859, the Second Empire reorganised the network and distributed all conceded lines to the six great railway companies (the *grandes compagnies de chemins de fer*), which were (in their abbreviated names): *Compagnie de Paris à Orléans* (PO), *Compagnie des chemins de fer du Midi* (Midi), *Compagnie de l'Est* (Est), *Compagnie du Nord* (Nord), *Compagnie de l'Ouest* (Ouest), *Compagnie Paris-Lyon-Méditerranée* (PLM). It also started to subsidise some companies as it urged them to build less and less profitable train lines to connect less favourable municipalities. In the meantime, private initiatives to construct local lines of the secondary network continued growing.

As a result, in 1870, at the dawn of the Franco-Prussian war and of the Third Republic, the French railway network was complex and already developed. It was dual, with a general interest network (*réseau d'intérêt général*), or shortly national network, exploited by the six *grandes compagnies* under the aegis of the state, and a local interest network (*réseau d'intérêt local*), or secondary network, with small and often irregular lines disseminated on the whole territory. Despite this already rich history, France was still lagging behind many Western European countries.

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<sup>8</sup>G. Ribeill, French historian of railways, interviewed by Julie de la Brosse in “Georges Ribeill : Les petites gares de province étaient chargées de vécus affectifs forts”, *Le Monde*, August 26, 2018.

**Figure 1: European national railway networks in 1870**



Source: Author's map with data from [Martí-Henneberg \(2013\)](#)

Figure 1 shows train lines of national interest, excluding narrow and local tracks, in Western and Central Europe. Clearly, France did have an important network but was far behind its neighbours across the Channel and to its Eastern borders. It was a well-known fact among the French elite at the time, and the Freycinet plan would quickly help France become one of the most train-covered countries in Europe.

## 1.2 The crisis of the French railway system in the 1870s and the context of emergence of the Freycinet plan

**The military context.** It is clear that the military trauma of 1870 created an impulsion to develop further the French railway system. The chaos of the military mobilisation of 1870, during which the Second Empire failed to reconcile the “military element” with the “technical [i.e. railway] element” ([Jacqmin \(1874\)](#)), was deepened by numerous military decisions that overwhelmed the railway network and revealed the disorderly French system. In contrast, republicans in the early Third Republic were convinced that “the defeat of the country, in 1870, was due to the organisation of railways of Prussia” ([Miquel \(1994\)](#)). The Prussian victory was therefore the victory of the Prussian schoolteacher, but also of the Prussian railwayman. Freycinet was himself a collaborator of Gambetta and delegate to War of the government of national Defense (1870-1871). He would soon become the first civilian Minister of War in 1889. Moreover, the Franco-Prussian war destroyed many engineering structures, that had already been only scarcely renovated under the Second Empire. A special commission was established at the National Assembly, that published a report in January 1872. It stated that the pitfalls of the railway system did not relate to equipment but more generally to deficient and lacking fixed structures (especially obsolete stations). Public spending became more and more necessary ([Caron \(1997\)](#)).

**Economic concerns.** Beyond these dimensions, the French railroad system, as well as the French economy as a whole, on the eve of the Freycinet plan, suffered from various difficulties. In one of the pioneer (and rare) works entirely dedicated to the Freycinet plan, [Gonjo \(1972\)](#) has inscribed the latter in the French economic history of the end of the 19<sup>th</sup> century, and not only in railway history. He stated that railway evolutions and reflections before 1878 had to be thought with respect to the broader economic context of the years 1870s. He identified three major features of the time:

- *The economic depression in the metallurgical sector.* It started in 1873 in all capitalist countries but emerged as a public issue in France later, in 1876-1877. Metal prices started to fall and the drop

was reinforced partly by the stopping of metal acquisitions by many train companies, especially in 1876. The metal industry was also facing a reduction in foreign orders due to protectionist measures enacted in many partner countries after 1870.

- *The increasing appeal of industrialists to public support.* For Gonjo, three main claims were formulated by industrialists to the government and involved communication networks (creations and improvements), taxes (rebates) and tariffs (elimination of the import duty imposed on foreign coal). Transports were therefore emphasised by industrialists, since transport costs constituted a large share of cost prices. For liberals and free-traders, the expected reduction in transport costs could also lead to reductions in tariffs that were still protecting the national French industry, the products of which seemed more costly.
- *The railway crisis itself.* Two main issues were raised at the time. On the one hand, train prices were seen as immeasurably complex, due to the variety and monopolistic position of railway companies, and more favourable to foreign than national trade. On the other hand, raising concerns appeared on the necessity to build regional train lines, that were not promoted by great railway companies because regarded as unprofitable. As said above, regional and local lines were essentially forged by small private companies, usually aiming at competing the monopolies of great companies, but that were generally financially unstable. The Philippart affair (1876), named after a Belgian speculator who owned 10 of such lines and went bankrupt in 1876, underpinned the distrust towards regional lines, as well as criticism against the great companies, that left such local lines to unreliable people and businesses. In the words of Caron (1997), Philippart’s failure had three meanings: “It was a victory for the ‘established bank’ and the French high administration, a manifestation of the declining influence of the decentralising notables, a prerequisite for the definition of a republican railway policy.”

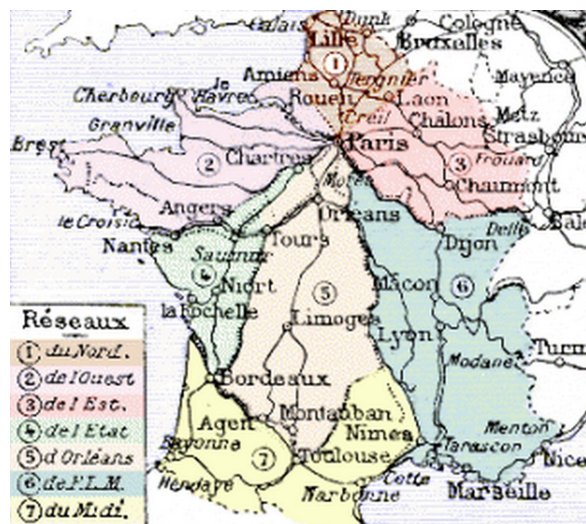
**Towards the “republican compromise”.** There was therefore, in the 1870s, a strong tension between the interests of industrialists and great railway companies regarding the building of new regional and cost-reducing train lines. As Gonjo (1972) puts it, “A way had to be found to reconcile the two opposing groups, rail and industry. Only the state could intervene.” After preliminary measures adopted by Eugène Caillaux in 1874, who conceded 2,056 km of railways to great companies, that already outlined the future approach of the Third Republic, it was time for the “republican compromise” that characterised the Freycinet plan (Caron (1997)).

Opportunist republicans did indeed increasingly oppose the monopolistic power of the *grandes compagnies* and the idea of the purchase of the totality of the railway network was omnipresent in the republican ideology at the time (Thibault (1975)). Already in 1876, Sadi Carnot, engineer of the *corps des Ponts et Chaussées* and future president of the Republic (1887-1894), published a report, for the Public Works section of the Budget commission of the House of Deputies, in which he demonstrated that the state could build railways in a less expensive and quicker manner. He advocated a strengthening of the power of the administration on the works and the exploitation of new train lines. Other deputies (e.g. Waddington, Le Cesne) clearly supported a total repurchase of large strands of the network by the state, which triggered the wrath of all liberals and free-traders, led by Leroy-Beaulieu. Allain-Targé thought that supporters of the great companies constituted the “coalition of all oligarchies led by the Society of Jesus” (Caron (1997)) but rather championed an intermediate solution. It consisted in the repurchase of small lines in strong difficulties and the preservation of the great companies but increasing monitoring of the state on all segments of the railway system, from ticket prices to building and daily exploitation. This proposition gained support in both Houses; the amendment was passed in March 1877 and would constitute the spirit of the Freycinet plan.

**First steps of Minister Freycinet before the plan.** After the crisis of May 16, 1877, opportunist republican Jules Dufaure was charged to form a government and Charles de Freycinet (1828-1923) was appointed Minister of Public Works. A Polytechnician of the *corps des Mines*, elected senator in 1876, he would soon become “one of the most influential politicians of the Third Republic” (Caron (1997)). As soon as he was appointed minister, according to bills voted by the Parliament, he repurchased lines in the West and South-West from ailing small companies, amounting to 2,615 km in total, and gathered them in order to form the State network (*réseau de l’État*) in May 1878. It was the first time in French history that a totally public organisation owned train lines, after half a century of private ownerships.

Figure 2 highlights the division of the territory among the six companies and the *réseau de l'État* (but does not show the numerous small local companies).

**Figure 2: Map of the territory of the great companies and state network around 1900**



Source: Encyclopédie de Brocéliande

However, supported by his party and the government, Freycinet had much larger ambitions. As of January 31, 1878, he organised the *Conseil supérieur des voies de communication* – that thus did not concern only railways –, with 48 members (senior civil servants, members of the government, 16 representatives of the industry and 16 of the farming sector). Already, on January 8, 1878, a “historic” (Léon Say) meeting occurred between Say, Gambetta and Freycinet, that Freycinet described in his *Mémoires*. While Gambetta’s party was favourable to a complete repurchase of the network, contrasting with Say’s liberal opposition to big government, the meeting was a historic compromise. Gambetta said: “We are not declaring war on the companies, we will offer them to be our collaborators. We will work alongside them, we will not work against them.” (Freycinet (1913)).

### 1.3 The Freycinet plan: initial aspects and evolutions

**The birth of the Freycinet plan.** This meeting gave birth to a series of draft proposals, starting from two reports to the President of the Republic made by Freycinet in January 1878. The first programme, amounting to 4 billion francs, was split between 1 billion for rivers, canals and ports and 3 billion for railways (at an estimated cost of 200,000 francs per kilometer). The first railway programme, formulated in June 1878, consisted in classifying in the general interest network 154 new train lines (6,200 km) and 53 already existing local lines (2,500 km). However, during parliamentary studies, many actors impulsed an inflation of the programme: members of the *Conseil général des Ponts et chaussées*, of the *Conseils généraux des départements* or from the Commission of the House of Deputies (Gonjo (1972)). As a result, the Freycinet plan, eventually voted in the summer of 1879, consisted in three laws corresponding to three components:

- Waterways: on August 8, a law was passed to renovate and increase locks and canals on the French territory (1 billion francs).
- Ports: on July 28, a law was voted that fostered investment in 76 French ports (500 million francs).
- Railways: in July 17, a law stated that 181 new train lines had to be built and classified in the general interest network, representing 8,848 km (3.5 billion francs).

Waterways (Miquel (1994)) and ports (Marnot (2016)) are very important dimensions of the Freycinet plan, but I focus here on the railway part, which is the most ambitious. The law of July 7, 1879 therefore gave birth to a brand new railway network, that essentially consisted either in extensions of existing lines, connections between stations that already existed but on different train lines and were not accessible to each other, or the release of new itineraries that were deemed interesting. It is important to note that, beyond the 181 lines of the law above mentioned, Freycinet postponed the examination of additional 94 lines of length 4,152 km and also insisted on including in the general interest network 64 already existing lines of local interest. The repurchasing of them from small private companies would cost 1 billion francs. In total, counting ante-Freycinet lines, the domain of the *grandes compagnies* would reach 18,000 km and the total length of the French railway network would be increased to 42,000 km (Gonjo (1972); Caron (2005)). The initial cost of the Freycinet plan is estimated to be 6 billion francs.

**Developments and issues of the plan.** Two main concerns therefore emerged, that I will not detail completely since they are not the main scope of this paper, but on which it is worth making some remarks.

The first one is the funding of such a massive industrial policy. French public finance was very encouraging in 1879, since new taxes enacted in 1871-1872 yielded massive public funds thanks to the economic rebound of 1877 (Caron (1997)). In this favourable context, and after some technical modifications in the relationships between the Treasury and the Bank of France, it is liberal Léon Say himself, Minister of Finance at the time, who argued that the Freycinet plan would be financed by government bonds. They consisted in the issuance of a 3% amortizable annuity (the so-called *rente à 3% amortissable*). Debt servicing (amortization and interests) would represent additional 50 million francs for each billion of works carried out, over a period of 75 years, until 1953 (Gonjo (1972)). The annuities were not subject to income tax. At the end of the 1870s, the idea was therefore that the Freycinet plan would never be a burden to public finance. History was quite different. First, the two episodes of debt issuance (500 million francs in 1878 and 1 billion in 1881) did not entail a massive enthusiasm in French society and were rather accompanied by massive speculations and tensions in the financial market (Gonjo (1972)). Second, the economic situation was modified as of 1879, with a reduction in tax receipts, and the stock market crash of January 1882 entailed a severe economic depression. Third, the actual cost of the programme had been underestimated and it kept rising, reaching more than 8 billion francs at the end of 1882, which triggered massive criticisms from liberals. At the dawn of the new conventions of 1883 (see below), the funding of the Freycinet plan was therefore in crisis.

The second concern is the relationships between the state and the *grandes compagnies*, that shaped a modern public-private partnership on the period. At the beginning of the plan, Freycinet and other supporters of the plan avoided all major discussions on the exploitation of the new railways, despite many interrogations of deputies of the opposition<sup>9</sup>. It is the state that carried out the first tracks but the distribution of tasks between the state and companies regarding the building of lines and their exploitation was not clear. Many opportunist republicans, around Gambetta, revived the idea of repurchasing the totality of the railway network by the state. Again, this triggered strong oppositions from liberals, and Say refused to participate in Gambetta's "great ministry" (November 1881-January 1882). Freycinet himself, when he became President of the Council after Gambetta (January-August 1882), wanted to maintain at all costs the execution of the public works of his plan, but with less public implication and more private funding (Gonjo (1972)).

Conventions were eventually signed in 1883 between the state and the great companies. They transferred the building and the exploitation of the railways from the state to the great companies. Every year, the state would dedicate one hundred million francs to the execution of the lines. In order for the companies to build such unprofitable lines, many guarantees and financial instruments were created by the state; one of the main ones was the guarantee of interest (*garantie d'intérêt*). With "their complexity and sometimes their darkness", they constituted "a masterpiece of administrative law *à la française*" (Caron (1997)). Subsidies to the railway sector were so important, and the share of railways in the total capitalisation of the French stock market until World War I was so high, that this system may have created shortages of capital and investment in other developing and innovative sectors at the time (Le Bris

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<sup>9</sup>"Again, this is a difficult question. Until then, what do you want me to do? Do you want France not to build railways? You know you can't," answers Freycinet to criticisms in his speech delivered at the House of Deputies on March 14, 1878 (available in the *Journal Officiel* of March 15, 1878).



(2012)). As a result, if the conventions may have constituted a short term victory for the companies, which were maintained and even broadened with a wider network, it was a short victory. In reality, the conventions underlined a strong control of the state and an increasing involvement of governments in the railway network (Gonjo (1972)). The monopolies of the companies were reaffirmed but the conventions of 1883 “imposed burdens on them which deprived the increase in net income of any real elasticity” (Caron (1970)). The repurchase of the ailing *Compagnie de l’Ouest* in 1908 was a symbol of this and a cornerstone towards the total nationalisation and creation of the *Société nationale des chemins de fer français* (SNCF) in 1937.

**Gares et Guerre: a major increase in the railway network.** It is a well-documented fact that, in 1914, the French railway network had reached an apex, with train lines covering major parts of the territory – but also, inevitably, many fragile and unstable lines that would soon be dropped by the SNCF after the crisis of railways of the Interwar period. It has been essentially complex to circumscribe precisely the perimeter of the Freycinet plan and many shortcuts are sometimes made in the literature, that consider that any line built after 1879 is attributable to the plan<sup>10</sup>. As Gonjo (1972) puts it, the plan “was inclined to become a vast policy of expedients, always open to later complementary projects. This character of the programme will contribute to making it extremely difficult to grasp as a whole, and with precaution.”

I have therefore decided to stick to the original 181 new lines presented by Freycinet in the law of July 17; the other ones that had to be built were irregularly decided by further commissions and it is impossible to follow them precisely and to distinguish whether they are part of what Freycinet had thought or not. Besides, the 64 local lines that had to be included in the general interest network were essentially renovated but they were not new lines; they were already existing in 1879, while I am interested in new openings of tracks and stations. Even the strict initial perimeter of the 181 lines has evolved: some lines were eventually not built, many of them experienced a change in the itinerary, some were eventually part of the secondary network. I therefore study 126 lines among these 181 lines, that were actually built as part of the general interest network. Table 11 of Appendix A.1 gives a detailed list of all the 181 lines.<sup>11</sup> To account for all the changes between the initial plan of the 126 lines and what was actually built, I made use of many sources, detailed in the Data section previously, in order to assess the real network built until 1914, not only the theoretical one forged in 1879.

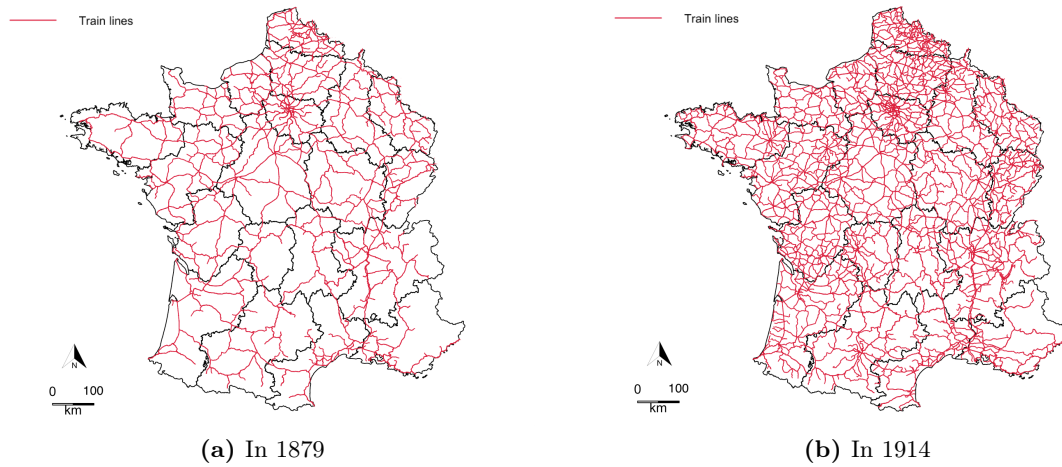
Besides, there is no exact date marking the end of the Freycinet plan, especially due to the strong extension in the timing of railway buildings (that was reasserted by the conventions of 1883). The year 1914, before the turmoil of World War I, is generally regarded as the unofficial end of the plan (and I will stick to it in the rest of the analysis), although some rare tracks were still being built in the 1920s. From the early Third Republic to World War I, the growth of French railways is indeed massive. Figure 3, representing both general and local networks, indeed highlights a very strong increase. Never France will reach again such a high coverage of its territory and, after World War I, the trend will constantly be downward.

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<sup>10</sup>For instance, even before the conventions of 1883, the law of June 11, 1880, extended subsidies to local train lines, exclusive of tramways (Ribeill (2002)).

<sup>11</sup>I do not consider also short lines that spread on the territory of only one or two municipalities, since my identification strategy (cf. section 2.3) requires intermediate municipalities on lines i.e. at least three municipalities. All the reasons of exclusions of lines among the 181 are justified in Table 11 of Appendix A.1.

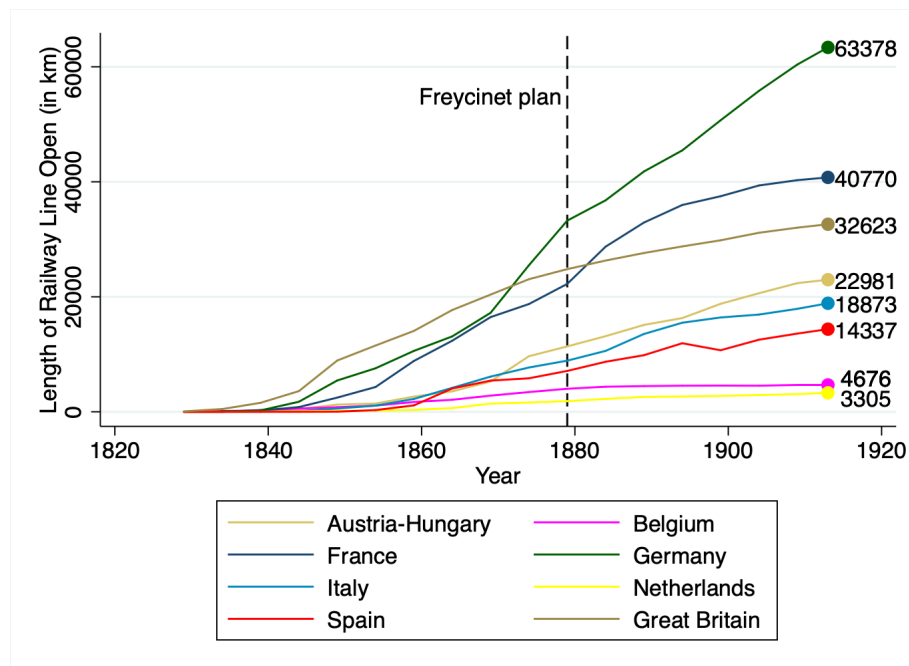
**Figure 3: The evolution of the total French railway network**



General and local interest railway networks. Author's maps with data from [Mimeur \(2016\)](#)

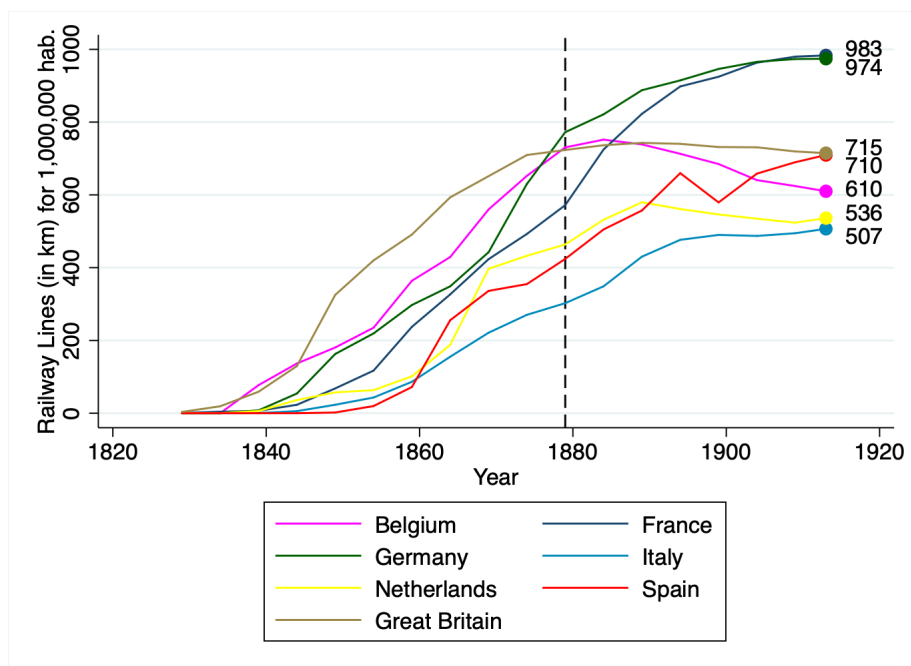
Another feature of the development of the railway at the time is the final catch-up of France over its neighbour across the Channel. Figures 4 and 5 clearly show that the Hexagon (literally speaking, since colonial lines are not included) rapidly caught up its delay on the eve of World War I. 40,770 kilometers of railways were in service in France. In terms of length of open railways for 1,000,000 inhabitants, France had even become the leading country of Western Europe, just before Germany.

**Figure 4: The length of open railway lines in some Western European countries until 1913**



Author's graphs with data from [Mitchell \(1992\)](#)

Figure 5: The length of open railway lines for one million inhabitants of some Western European countries until 1913



Author’s graphs with data from Mitchell (1992) for railway length and the Maddison Project Database (2018) for population. The absence of curve for Austria-Hungary is due to the absence of population data.

#### 1.4 Assessing the location of stations of the plan: did the Freycinet plan succeed in unifying the territory?

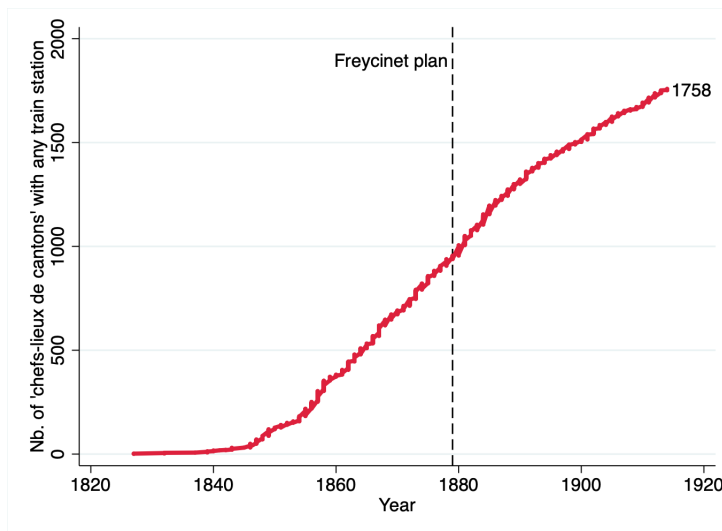
**Connecting the whole territory.** It is clear that the Freycinet plan pursued many objectives in response to the context described above. It was alternately targeting solutions to military disorganisation, the crisis in the metal industry, the collective will of a decrease in transport costs, the strong distrust of great companies, etc. However, it is important to reckon that this plurality of objectives is organised around the republican ideology that it was time to unify the territory and to finally include remote areas in the network – which is therefore also an inclusion in the Republic itself. “The increase in the number of constructions referred to an essentially civilising vision of the usefulness of public works”, in order to restore social cohesion and foster communications across the whole territory (Marnot (2016)). Many parliamentarians gave in to “railway demagoguery”, inhabited by the idea of “a kind of equality of all French people in front of the railways” (Le Bris (2012)). Despite vigorous debates in both Houses of Parliament, the immediate profitability of the new train lines was not the main concern. “Consensus is reached on the objective of opening up the territory to the outside world.” (Houte (2014)). This approach included targeting specifically remote areas which supported opportunist republicans in the general elections of 1876 and 1877: many “electoral districts” had to be satisfied with the new arrival of trains (Colson (1903)). This does not mean that concerns on the state of the French economy at the time were less important. Freycinet said that it was time “to correct the inequalities that have been perpetuated to this day and to care, to a reasonable extent, for the underprivileged regions” (Freycinet (1913)), but this argument was clearly linked to savings in transport costs and was an indirect contribution to economic development (Gonjo (1972)).

One of the main ways to insure a thorough presence of the railway over the whole territory is to serve all administrative levels. Indeed, while the majority of *préfectures* (i.e. the capital cities of French *départements*, the highest administrative level in France at the time, in the absence of the current *régions*) had a train station in 1879, a high number of Freycinet lines had the objective to connect all *sous-préfectures* (i.e. capital cities of *arrondissements*, the administrative level beneath *départements*) and a maximum of *chefs-lieux de cantons* (*cantons* being again the next administrative level). Le Bris (2012)

states that, at the end of the day, only three *sous-préfectures*, Sartène, Barcelonnette and Castellane, did not welcome any train station. Besides, Florac, Puget-Théniers and Yssingeaux were crossed only by narrow-gauge railways.

In order to extend [Le Bris \(2012\)](#)'s work, I focus on French *chefs-lieux de cantons*, counting the number of them that had any train connection over time, until 1914.<sup>12</sup> Figure 6 indeed highlights the rise in connections in the majority of French *chefs-lieux de cantons* from 1879 to 1914 and the increasing connection of the French territory over time thanks to railways. It is clear that the Freycinet plan enabled to pursue a trend already pre-existing throughout the 19<sup>th</sup> century. Eventually, before World War I, 1,758 *chefs-lieux de cantons* had their own train station, which amounts to 67% of them, in the sample described in footnote 12.

**Figure 6: The rising number of French *chefs-lieux de cantons* with any train station until 1914**



Author's graph with data from [Mimeur \(2016\)](#) for train stations and [Gay \(forth.\)](#) for *chefs-lieux de cantons*. The total number of *chefs-lieux de cantons* retained is 2,612, which results from a small reduction in the actual amount at the time (2,862) for reasons developed in footnote 12.

**Landlocked regions.** However, administrative capital cities are not sufficient to understand the comprehensive project of Freycinet to “care, to a reasonable extent, for the underprivileged regions” ([Freycinet \(1913\)](#)). Despite a dense administrative coverage of the French territory, some remote areas remained essentially far from towns. Also, only studying administrative towns would fail to understand the fact that the Freycinet plan entailed railway constructions sometimes in the middle of the countryside, in very rural areas. Indeed, to a certain extent, the Freycinet plan had the ambition to promote the republican ideas of the new regime to rural communities which were still voting for monarchists in the 1870s ([Schnetzler \(1967\)](#)).

This is why, in Table 1, I compare the former and the new network of general interest. In column 1, I give summary statistics for all municipalities that welcomed, for the first time, thanks to the Freycinet plan, between 1879 and 1914, a train station that was crossed by lines of general interest. Column 3 is the same thing for all municipalities that had a station crossed by lines of general interest before 1879. Column 2 gathers municipalities that had such a station before 1879 and that welcomed another one thanks to the Freycinet plan (essentially *préfectures* and major cities at the crossroads of several train

<sup>12</sup>I used the list of *chefs-lieux de cantons* in 1878 compiled by [Gay \(forth.\)](#), who transmitted it to Lionel Kesztenbaum, that I thank. There were initially 2,862 *chefs-lieux* in 1878. Excluding Corsica for the sake of the analysis (cf. Data section), this gave me 2,800 *chefs-lieux*. Besides, all the stations in the dataset of [Mimeur \(2016\)](#) are associated to a given French municipality. However, it may happen that some cities (which are therefore counted as only one municipality) are actually divided in many *cantons*, each time with a specific *chef-lieu*. So as to join both datasets, I have therefore compressed all potential *chefs-lieux* present in the same municipality in order to have only at most one observation per municipality. This therefore reduced the number of *chefs-lieux de cantons* to 2,612 in 1878.

lines). The last column of the table compares columns (1) and (3) and performs a t-test to understand if the difference is statistically significant.

**Table 1: Comparison of municipalities which welcomed stations of the main network during the Freycinet era to municipalities which already had such stations before**

	(1)		(2)		(3)		Diff.
	N	Mean	N	Mean	N	Mean	(1) – (3)
<b>Pop. in 1876</b>	957	1379.84 (1366.80)	29	5639.59 (9866.31)	4014	2753.01 (8002.58)	-1373.17***
<b>Growth of pop. (1851-1876), %</b>	930	-2.19 (20.94)	28	31.30 (84.12)	3849	10.79 (53.64)	-12.98**
<b>Dist. to lake, km</b>	964	95.02 (75.98)	27	93.67 (75.35)	4064	94.56 (64.76)	0.45
<b>Dist. to river, km</b>	964	1.99 (2.23)	27	1.63 (1.70)	4064	2.19 (2.39)	-0.20**
<b>Dist. to coast, km</b>	964	161.09 (106.43)	27	146.47 (99.63)	4064	160.93 (117.94)	0.16
<b>Dist. to important city, km</b>	964	3.14 (4.14)	27	0.65 (1.56)	4064	2.45 (3.79)	0.69***
<b>Altitude, m</b>	964	254.33 (254.15)	27	193.52 (199.25)	4064	185.15 (183.28)	69.18***
<b>Surface, ha</b>	964	2071.61 (1622.83)	27	2873.56 (2178.64)	4064	1968.41 (2145.11)	103.21
<b>Dist. to other station, km</b>	964	8.65 (6.87)	27	0.00 (0.01)	4064	0.00 (0.01)	8.65***

Standard deviations in parentheses. “N” denotes the number of observations for each column and variable. Column 1 consists of municipalities newly connected to the general interest railway network thanks to the Freycinet plan; column 3 of municipalities already connected to this network before 1879; column 2 of municipalities that were connected twice to the general interest network, before and during the Freycinet plan. In the last column, the values displayed for t-tests are the differences in the means across groups (1) and (3). \*\*\*, \*\*, and \* indicate significance at the 1, 5, and 10 percent critical level.

From this table, it is clear that the Freycinet plan targeted less privileged areas, with lower growth potential and more geographical difficulties that had prevented private companies, in the past, to build train lines and stations in these places. Freycinet municipalities were less populated than municipalities already connected to the general interest network, by nearly 1,400 people, in the last census year before the plan (1876), and had experienced over the last quarter of a century (1851-1876) a lower population growth. These differences are statistically significant at the 99% and 95% levels respectively. They were also, on average, further away from important cities by 690 meters and far from existing stations by 8.65 kilometers. Besides, Freycinet municipalities were located closer to rivers, at a higher altitude, meaning it was less easy to build a train line there before. In a nutshell, the Freycinet plan did succeed in connecting more landlocked areas to the railway network. The main issue now is to know whether such complex and remote train connections benefited the – not anymore – landlocked areas.

## 2 The effects of the Freycinet plan on the French population at the beginning of the 20<sup>th</sup> century

*“But behold, there behind me something ugly, blackish, boisterous, foolishly hasty, passes by, quickly, shakes the earth, disturbs this delightful calm with whistles and scrap noises: the railroad.”*<sup>13</sup>

In this section, I study the consequences of the Freycinet plan on the French population in the short run, right after the plan was implemented. I first show that my analysis speaks to different strands of the literature (section 2.1), before developing the two strategies that I will use to assess the plan’s effects on population, namely the difference-in-differences approach (section 2.2) and an instrumental variable strategy (section 2.3). After giving a better understanding of summary statistics regarding treated and control municipalities (section 2.4), I provide the results of the estimation (section 2.5) and perform a series of checks to highlight their robustness (section 2.6). Eventually, I assess to what extent the Freycinet plan entailed displacement effects, by reorganising the French population towards more attractive newly train-connected municipalities (section 2.7).

### 2.1 Contribution to the literature on the effects of railways

**Railways and growth, through a variety of proxies.** My analysis is first and foremost inscribed in a very broad literature in economic history that has tried to assess the contribution of railways to growth. While intuitions on the role of trains to foster growth were frequent throughout the 19<sup>th</sup> and early 20<sup>th</sup> centuries, [Rostow \(1959\)](#) is one of the first to stress the importance of the railroad industry in economic growth. Sketching five stages of growth (traditional society, preconditions for take-off, take-off, drive to maturity, age of high mass consumption), he considered that railways were one key sector of economic take-offs (taking in particular the example of Sweden). However, in the 1960s, various economists called into question the contribution of railways to growth, both regarding the reduction in trade costs they triggered and the share they represented in industrial production. In a very famous article and then a book, at the heart of the New Economic History and cliometrics revolution, [Fogel \(1962\)](#) & [Fogel \(1964\)](#) focused on the importance of building a counterfactual to understand the actual effects of railways. He created a “social saving” methodology, studying transport costs of farming products with and without American railroads from the Midwest to the East and South of the USA at the end of the 19<sup>th</sup> century, and showed that the contribution of railways to aggregate US farming sector was quite small (2.7% of GDP in 1890); transportation with only rivers, canals and wagons, that would have followed their development path, had railroads not existed, would have been only slightly more expensive. [Fishlow \(1965\)](#) also challenged the effects of railroads and resorted to a “social saving” approach; he found larger effects than Fogel but considered that railroad construction rather followed demand than it caused growth. This “social saving” methodology has flourished (e.g. [Hawke \(1970\)](#) and [Leunig \(2006\)](#) in England), with different modifications (e.g. [Donaldson \(2018\)](#) for the Raj) but has been challenged by a series of economists, for instance by [White \(1976\)](#) or [Lebergott \(1966\)](#), who studied transport externalities, and even [Fogel \(1979\)](#) himself. More recently, [Donaldson and Hornbeck \(2016\)](#) have tried to reassess the contribution of railroads to American economic growth, by quantifying their aggregate impact on the agricultural sector in 1890, like [Fogel \(1964\)](#). They mobilised a “market access” approach, stemming from general equilibrium theories, and estimated that removing all railroads in 1890 would have triggered a drop of 60% in the total value of U.S. agricultural land, which amounts to 3.22% of 1890 GDP. [Hornbeck and Rotemberg \(2019\)](#) use the same methodology but to study American manufacturing, in an economy with resource misallocation (i.e. where the value marginal product is higher than the marginal cost) and find that removing railroads would have led to a 25% decrease in 1890 GDP.

Besides, my analysis is more specifically related to numerous and rather recent papers which have tried to estimate impacts of train connections on a variety of outcomes, generally by establishing comparisons between areas newly connected to trains and other non-connected places, or at least focusing on the distance of each area to the railroad. [Banerjee, Duflo, and Qian \(2020\)](#) study transportation infrastructure in China and find that proximity to the latter has a small positive causal effect on GDP per

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<sup>13</sup>Pierre Loti, *Figures et choses qui passaient*, 1898.

capita, but no effect on per capita GDP growth, due to capital mobility. [Tang \(2014\)](#) uses a difference-in-differences strategy to study railroads in Japan: he finds that rail access led to higher average firm capitalization, more capital investment and more efficient resource allocation. Many other outcomes have been carefully analysed, in particular global and sector employment ([Atack, Haines, and Margo \(2008\)](#); [Bogart, You, Alvarez, Satchell, and Shaw-Taylor \(2019\)](#); [Berger \(2019\)](#)). It is important to note that papers on railways are often in the continuation of, and exploit the same strategy as, articles on other means of transportation, such as highways ([Baum-Snow \(2007\)](#); [Michaels \(2008\)](#); [Duranton and Turner \(2012\)](#)) or rural roads ([Asher and Novosad \(2020\)](#)).

**Railway and population.** In this section, I mainly focus on railroad effects on population, which is a major source of interest in economic history due to census data that are, in many countries, among the only local information available in the long run. [Atack, Bateman, Haines, and Margo \(2009\)](#) perform a difference-in-differences analysis and show that railroads had little or no impact on population densities but were the “cause” of midwestern urbanization. In a variety of countries, train connections have also been seen as contributors to population growth, at least at a local level close to the railway, or urbanisation: for instance England and Wales ([Bogart et al. \(2019\)](#)), Prussia ([Hornung \(2015\)](#)), Switzerland ([Büchel and Kyburz \(2020\)](#)), Kenya ([Jedwab, Kerby, and Moradi \(2017\)](#)), Portugal ([Silveira, Alves, Lima, Alcântara, and Puig \(2011\)](#)) or Sweden ([Berger and Enflo \(2017\)](#)). This latter paper is crucial to my analysis, as I will develop further.

Regarding population itself, one major issue concerns spatial reorganisation and displacement effects that railroads may entail. This requires precise local data, which are not always available. [Redding and Turner \(2015\)](#) provide a theoretical and empirical overview of this issue and show, in particular, that when trade costs decrease in a given area compared to another one, the former attracts labour, until real wages are equalised across the territory. In empirical studies, [Bogart et al. \(2019\)](#) find evidence that railroads reduce population in stations’ hinterlands, in the short run. [Berger and Enflo \(2017\)](#) highlight that population growth in towns connected to railways in the first wave of train development in Sweden was made at the expense of other towns far away from the network. [Büchel and Kyburz \(2020\)](#) show highly localised population growth patterns in Switzerland in connected municipalities, while population decreased in towns located at least 2 km away from the train lines. [Heblich, Redding, and Sturm \(2020\)](#) have also shown very recently how much the steam railway has reorganised economic activity, by separating workplace and residence and increasing commuting time in London, on the period 1801-1921.

**French railways and growth.** Beyond these general ideas and studies on the effects of railway building, my paper sheds a new light on French trains themselves, which have been quite rarely studied from an econometric point of view. Indeed, many works on the topic come from a variety of disciplines, in particular history and geography. For historical studies, it is impossible to provide such numerous references here and I refer to [Caron \(1997\)](#) & [Caron \(2005\)](#) for an overview<sup>14</sup>. Very broadly, with a large understanding of numerous case studies on the topic, Caron identifies three major sets of mechanisms to explain the contribution of railways to growth: (i) very large funding made in the railroad sector, both by the government, companies or individual savers, that triggered major investments; (ii) the volume of railroads in total French industry that boosted industrial production and had externalities on many other sectors; (iii) the role railroads had in driving down transport costs, increasing the regularity and speed of trade and exchanges. When necessary in the rest of the analysis, I will make reference to specific works of Caron himself or of other historians he mentions.

Among geographical works on the relationships between railways and (population) growth, [Offner \(1993\)](#) made quite a revolution by debunking the myth of the “structuring effect” of transport infrastructure, underlining the important methodological limitations of any study of these links and suggesting the myth was essentially mobilised to justify railway public policies and funding. Yet, [Schwartz, Gregory, and Thévenin \(2011\)](#) compare the effects of railway construction on rural societies in France and Britain (1850-1914) and find that railways did not completely entail rural exodus; they rather provided them with “a second chance at stability or limited growth”, stimulating farming trade and creating employment, mainly linked to trains themselves, in rural areas. Following the observations of [Pumain \(1982\)](#), [Mimeur, Queyroi, Banos, and Thévenin \(2018\)](#) focus on French municipalities with at least 2,500 inhabitants at

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<sup>14</sup>In *Histoire des chemins de fer en France, 1740-1883 (t.1)*, 1997, the most interesting chapter on the topic is Chapter X (pp 547- 588). In *Histoire des chemins de fer en France, 1883-1937 (t.2)*, 2005, interesting developments can be found at pages 61-63, 76-114, 199-288.

least one time on the period 1860-1910: they find no significant correlations between railway network coverage and population growth, “because the areas that get a better access always had a better growth than those that would never gain access.” However, this approach does not fully take into account the endogeneity of transport network and relies on observational studies.

Eventually, it is important to note that empirical and econometric studies on French railway lines have developed very recently. Many of them pore over recent economic history (after World War II) or even contemporaneous train lines. Mayer and Trevien (2017) study the opening of the French *Réseau Express Régional* (RER) in the Paris region. With a difference-in-differences strategy, they find that it caused a 8.8% increase in employment in the municipalities connected to the network between 1975 and 1990, but no effect on population growth, which can be explained by increased competition for land. Garcia-López, Hémet, and Viladecans-Marsal (2017) also focused on the RER. Using historical instruments and all other non-RER means of transport, they find that proximity to an RER station increases population density and growth, as well as employment density and growth, in particular for factory workers and for highly educated population. Charnoz, Lelarge, and Trevien (2017) study the effects of French high speed trains (*Trains à Grande Vitesse*, TGV) on the internal organisation of multi-plant businesses across the French territory. They find that the TGV has increased production jobs in affiliates, decreased management jobs there (which were transferred to headquarters) and slightly increased operational profit margins. Finally, special mention has to be made Kakpo, Le Gallo, Grivault, and Breuillé (2019) who focused on French local train lines built at the end of the 19<sup>th</sup> century (in the vein of the Freycinet plan, but not amongst the 181 lines of general interest that I consider). With a strategy comparing municipalities connected to the train to municipalities that were not connected although they were meant to be, since planned train lines have not been finished, they find no effect of railway on population in the short run but positive and significant effects in the medium and long run.

## 2.2 First model: a difference-in-differences approach

**Framework of the difference-in-differences strategy.** My data, as well as the set-up of the Freycinet plan, enable me to exploit two sources of variations: (i) the status of each municipality (whether it has been connected to the railway thanks to the plan or not) and (ii) the timing of the plan (before and after it was implemented). These two sources of variation make it possible to resort to a difference-in-differences strategy to measure the effects of the Freycinet plan on population at the municipal level. Both time and treatment group dimensions need however some clarification.

Regarding time, the “Pre-Freycinet” period starts in 1861 in my data, in order to have some variation until 1876, the last census year before the Plan was implemented. Besides, as said above, the Freycinet plan is generally thought to be more or less terminated in 1914, just before World War I. Therefore, the “Post-Freycinet” period in the difference-in-differences strategy consists of years after 1914. However, as demographic and economic trends of the Interwar period have been seriously affected by the Great Depression, I restrain the “Post” to the two census years after World War I but before the crisis of 1929, namely 1921 and 1926. Some specifications in robustness checks also study the effects of stations built over time during the treatment period (in 1891, in 1896, etc.), as I will detail further in section 2.6.

Regarding treatment status, it is very important to precisely define which municipalities can be deemed “treated” i.e. connected to the railway thanks to the Freycinet plan, and which ones belong therefore to the control group. One approach in the literature could have been to include only municipalities in which a station has precisely opened during the Freycinet era (e.g. Tang (2014); Büchel and Kyburz (2020)). However, as some stations have been built in the very close suburb to a larger city, and as any municipality might well benefit from the opening of the station just in its neighbouring city, the latter approach might be too restrictive. This is the reason why it rather may be relevant to base treatment status on the distance of a municipality to the closest station than only on the binary opening, or not, of a station in such a municipality (e.g. Jedwab et al. (2017); Berger (2019)). GIS is very useful for this since it is possible to compute actual distances.

In this respect, one might however be careful, because including in the treatment group municipalities too far away from stations might fail to understand the effect of the Freycinet plan itself which, again, emerged in a country that already had many train lines and in which the network was already somewhat developed in 1879. Indeed, the average distance to a station in the France of 1879 is 5.9 km in my dataset.



Also, for a station to be used thoroughly by the inhabitants and industrialists of a municipality without major commuting problems, the distance they must walk to it should not be too long. All these reasons have made me consider that a municipality is defined as treated if its closest point to the closest Freycinet station is located at no more than 1 km from this station. This will be the general definition I will use in the majority of the analysis. In section 2.6, I will however resort to different definitions and show that results are obviously sensitive to definitions based on the distance to the closest station. As a result, to frame the difference-in-differences strategy, it is necessary to denote:

- $\ln(Pop_{i,j,t})$  the log of population in municipality  $i$  in *département*  $j$  in year  $t$
- $Treat_{i,j}$  a dummy equal to 1 if municipality  $i$  (in *département*  $j$ ) belongs to the group of municipalities connected to the railway thanks to the Freycinet Plan (“treatment group”) and is, as defined, less than 1 km from a Freycinet station
- $Post_t$  a dummy equal to 1 for all years after the end of the Freycinet plan, in the “Post-Freycinet” era (i.e. posterior to 1914)
- $Freycinet_{i,j,t}$  a dummy equal to 1 if, at the end of the Freycinet plan (after 1914), the city has been connected to the railway thanks to the plan. Concretely, it is the interaction of  $Treat_{i,j}$  and  $Post_t$ , such that  $Freycinet_{i,j,t} = Treat_{i,j} * Post_t$
- $\epsilon_{i,j,t}$  the error term

I take the log of population to account for strong disparities in demographic patterns across municipalities (since the dataset covers the universe of municipalities) and therefore discard cases in which outliers would drive all the results. This also allows more straightforward interpretations of coefficients in percentage. The difference-in-differences model can therefore be estimated with an Ordinary Least Squares (OLS) approach and can be written as:

$$\ln(Pop_{i,j,t}) = \beta_0 + \beta_1 * Treat_{i,j} + \beta_2 * Post_t + \beta_3 * Freycinet_{i,j,t} + \epsilon_{i,j,t} \quad (1)$$

The coefficient of interest is  $\beta_3$ , which gives the difference-in-differences estimator. One can refine such a model, accounting both for controls at the level of the municipality in order to discard omitted variable bias, for general time-trends affecting all municipalities at every census year and for shocks that might influence all municipalities in a given French *département* over time, which is the major decision-making administrative unit at the time. Let’s denote:

- $X_{i,j,t}$  a vector of controls at the level of municipality  $i$
- $\delta_j$  *département* fixed effects
- $\delta_t$  year fixed effects (every five years i.e. the years of censuses that finish by 1 or 6)

In my analysis,  $X_{i,j,t}$  includes many geographical variables that may affect a municipality’s population distribution and growth, such as average altitude and total surface of the municipality. As being close to an important city might have spillovers on the growth of a municipality, I also control for the distance of each municipality to the closest city among the 5% most populated before Freycinet era, in 1876 (i.e. with more than 2,569 inhabitants). Besides, it is very important to control for other means of transport that might be (imperfect) substitutes for Freycinet lines, namely other train lines and water transportation means. Controls therefore include the distance of each municipality to the closest lake, river, coastline, and other train stations, either built before the Freycinet era or during it (but obviously not belonging to the 126 retained Freycinet lines)<sup>15</sup>. In this case, the difference-in-differences model simply becomes:

$$\ln(Pop_{i,j,t}) = \beta_0 + \delta_j + \delta_t + \beta_1 * Treat_{i,j} + \beta_3 * Freycinet_{i,j,t} + \beta_4 * X_{i,j,t} + \epsilon_{i,t,j} \quad (2)$$

Eventually, thanks to panel data, it is possible to account for individual heterogeneity, with individual fixed effects, denoted  $\delta_i$ . The fixed effects model will fail to identify the contribution of fixed variables

<sup>15</sup>Throughout the specifications, I also control for the distance of the municipality to the closest endpoint of a Freycinet line, for reasons detailed in section 2.3.

to population (distance to lake, river, coastline, important city, altitude, surface), but will still account for the only variable that evolved over time during the study period, namely the distance to other non-Freycinet train stations. As a result, the estimated equation becomes:

$$\ln(\text{Pop}_{i,j,t}) = \beta_0 + \delta_i + \delta_t + \delta_j + \beta_3 * \text{Freycinet}_{i,j,t} + \beta_4 * X_{i,j,t} + \epsilon_{i,j,t} \quad (3)$$

One major feature of the Freycinet Plan as a treatment is that the treatment period is quite long, starting from 1879 and ending in 1914. In the previous specifications, and following [Berger and Enflo \(2017\)](#) who exclude population data for the years during the treatment period, the censuses I retain therefore relate to years 1861, 1866, 1872, 1876 for the pre-Freycinet era and to years 1921 and 1926 for the post-Freycinet era, as explained above. However, as I have data at the level of each municipality and I know for each year the closest Freycinet station, it is possible to refine the analysis and to progressively include in the treatment group municipalities that have had access to the railway due to the Freycinet plan for all census years, following [Givord \(2010\)](#). This basically means that in 1861-1876 there is zero municipality in the treatment group (since it is the pre-Freycinet era), then in 1881, 1886, 1891, 1896, 1901, 1906, 1911, the treatment group increases in size with municipalities progressively being at less than 1 km from a Freycinet station. In 1921, when the ‘‘Post-Freycinet’’ era starts, the size of the treatment amount is of course the same as that in the previous specifications, but now it is possible to better take into account the progressive aspect of the treatment and its quite long-time span.

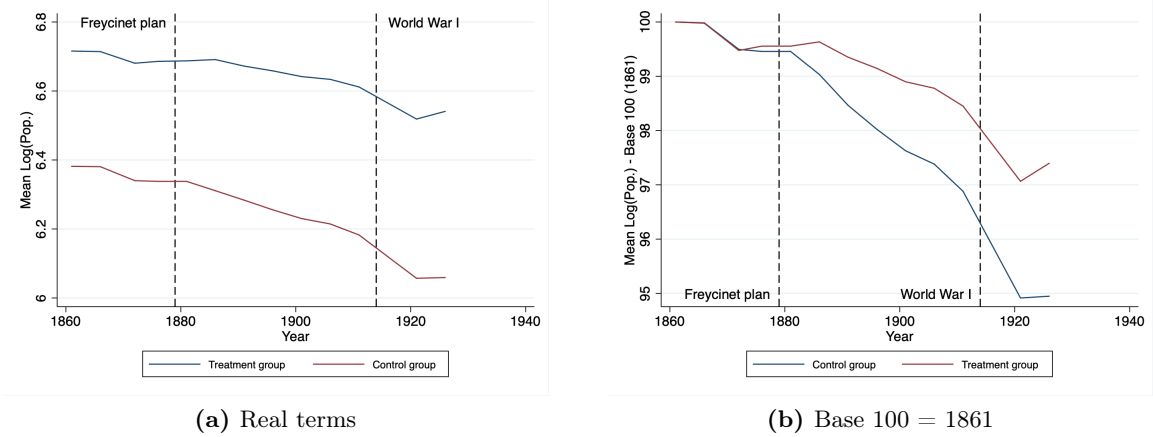
In this case, the  $\text{Freycinet}_{i,j,t}$  variable follows the same logic as defined above and the fixed-effects specification is written exactly the same as in equation (3), but now  $t$  does not only apply to years before 1879 or after 1914.  $\text{Freycinet}_{i,j,t}$  is a dummy equal to 1 as soon as municipality  $i$  in *département*  $j$  is located at a distance of less than 1 km from the closest Freycinet station, and for all the subsequent periods. This basically means that, for instance, if a station opens at 500 m from municipality  $i$  in 1895, then for the observation of census 1896 of this municipality, and until 1926, its treatment status becomes 1. Its ‘‘Post’’ period is therefore 1896-1926 and not only 1921-1926. I will call this specification ‘‘Def-2’’ (standing for ‘‘Definition 2 of variable  $\text{Freycinet}_{i,j,t}$ ’’) in result tables.

**Validity of the difference-in-differences strategy.** In order for the difference-in-differences strategy to be valid, one crucial assumption has to be met: the outcomes of the treated and the control group should have followed the same trend, had the treatment not been implemented. In my analysis, this so-called common trend assumption therefore means that the average log of population of the treated and control groups would have known more or less the same growth rate over time and followed the same periods of increases and decreases. In the absence of counterfactual, the hypothesis is not directly testable but studying pre-treatment trends might be informative, especially to discard the so-called [Ashenfelter \(1978\)](#)’s dip. Figure 7 shows the evolution of the mean log of population for both groups from 1861 to 1926. It is clearly visible that the treatment and control group followed the same trend until 1876<sup>16</sup>. From figure 7(b), it appears also that the observed difference in the average log of population across the treatment and control groups in years 1921-1926 is of 0.23 log points, an important information to be compared to further causal estimations in the next sections.

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<sup>16</sup>It is of utmost importance to note that the outcome of interest is the log of population, hence here I represent the evolution of the mean log of population – and not of the log of the mean of population. Indeed, over the period, the French population increases very slightly, therefore the mean of population increases, and therefore also the log of the mean population (since the log is an increasing function). However, the mean log population decreases as represented on the graph, essentially because the demographic growth is driven by the biggest cities that continue growing, while smaller municipalities experience a demographic decrease (and the median of population drops over time). Because the log function increases very slowly for larger values compared to small values, this means that the massive growth of big cities in absolute terms is considerably reduced by the log function, hence the decreasing pattern between 1861 and 1925 observed here.

**Figure 7: Evolutions of the average log of population across groups**



Source: Author’s graph with population data from Cassini project (CNRS/EHES)

In order to further support the validity of the strategy, placebo tests can be very helpful. Following the advice of [Gertler, Martinez, Premand, Rawlings, and Vermeersch \(2011\)](#) and [Givord \(2010\)](#), I therefore perform a series of placebo tests, using modifications of equation (1):

- On variables on which the treatment should have no effect: the distance of a municipality to the closest lake and the distance to the closest coastline.
- On years prior to treatment: I run twice equation (1), doing as if the “Post-Freycinet” era was only composed of year 1866 and of year 1872.
- Defining control and treatment groups that should clearly be both unaffected by the treatment: I run equation (1) but on a dataset restricted to municipalities at least 30 km far from Freycinet stations; “treated” municipalities are between 30 and 31 km from Freycinet stations, “control” municipalities are further away from at least 31 km.

If my strategy is valid, then all simulated difference-in-differences estimates stemming from these placebo tests should be equal to zero.

### 2.3 Second model: an instrumental variable (IV) approach to solve endogeneity issues on railway location

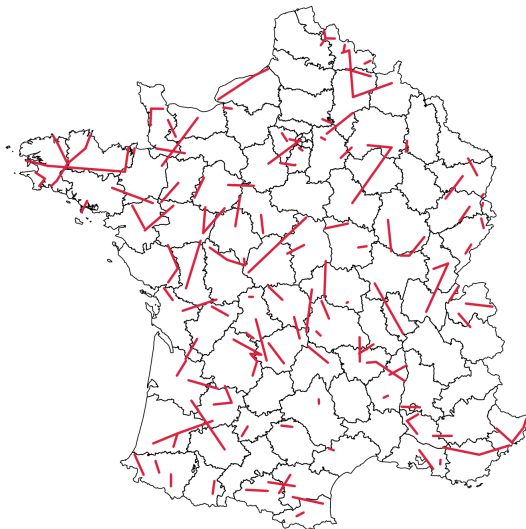
**Framework of the IV strategy.** However, the difference-in-differences strategy described above, estimated by OLS, is valid only if the opening of a station is completely exogenous, which is nearly never the case. Many determinants push for the building of train lines and stations, that may concern geography (e.g. altitude of the area), political issues (e.g. local policymakers interests), pre-existing connectivity of the territory (e.g. distance to the coast). Also, as developed above, the Freycinet plan had the purpose to connect municipalities that were quite landlocked and had lower growth prospects than already connected towns. It is therefore crucial to solve this endogeneity issue and I resort to an instrumental variable approach, in line with [Berger and Enflo \(2017\)](#).

This approach consists in considering that the 181 Freycinet lines (actually, the 126 under study here) were meant to connect endpoints, generally to join already pre-existing other train lines. The law of 1879 is in fact clearly stated in this way; each line has an initial and a terminal point. The purpose was therefore to build the lowest-cost route between two municipalities, meaning almost straight lines, once natural obstacles are taken into account (altitude, water features on the line, etc.). However, by connecting two endpoints (or sometimes, rarely, three or four towns – cf. Table 11 in Appendix A.1 for the precise lines retained), train lines inevitably crossed municipalities between endpoints and the latter gained access to the network accidentally in a way, by virtue of their geographical location. The focus

on transport connection due to the location on least-cost paths is moreover flourishing in the literature (Banerjee et al. (2020); Berger and Enflo (2017); Mayer and Trevien (2017), Büchel and Kyburz (2020)).

As a result, I build straight lines connecting the endpoints of the 126 Freycinet lines under study. Figure 8 maps all these lines. As obviously there is never a completely straight railway line, I build in practice a 10 km buffer zone around each straight line (5 km on each side of the line). I instrument the fact of gaining access to the train thanks to the Freycinet plan by a dummy equal to one if the municipality is located in the buffer zone around the straight line. In this case, two aspects have to be taken into account: (i) it is necessary to exclude from the sample all municipalities that are endpoints, since by definition they are located on the straight lines and the instrument would therefore not be valid to solve the endogenous opening of stations there and (ii) it is important to add controls for geographical obstacles that prevent for the complete building of a line in a straight manner; controls therefore include the already defined geographical features (distance to the closest lake, sea, river, area, altitude).

**Figure 8: The 126 straight lines under study**



Source: Author's map with lines from the law of 1879, corrected for actual railway constructions (cf. Data section).  
Station locations from Mimeur (2016).

Let's denote  $Line_{i,j}$  a dummy equal to 1 if municipality  $i$  (in department  $j$ ) is located in a 10 km buffer zone around a straight line. Equations of subsection 1.1. can therefore be rewritten to account for the instrument and solve the endogeneity issue. In my case, the endogenous variable  $Treat_{i,j}$  appears twice in the specification, since it is also included in  $Freycinet_{i,j,t}$  ( $Treat_{i,j} * Post_t$ ). As a result, according to Wooldridge (2002), it is important to instrument both variables,  $Treat_{i,j}$  and  $Freycinet_{i,j,t}$  by two instruments:  $Line_{i,j}$  as well as the interaction between  $Line_{i,j}$  and  $Post_t$ , that I denote  $Line\_Post_{i,j,t}$ .

Indeed, instrumenting only one of the two endogenous variables would not solve the endogeneity issue and using only one instrument for both variables would lead to an under-identification of the effect of the instrument on the variable (what Wooldridge (2002) calls a "forbidden regression"). In this case, the instrumental variable approach is comprised of two first stages: a regression of  $Treat_{i,j}$  on both instruments and a regression of  $Freycinet_{i,j,t}$  on both instruments. The second stage is eventually composed of both regressors from which only the exogenous part is used. The two-stage least square (2SLS) approach is therefore built as such:

#### First stage regressions

$$Treat_{i,j} = \gamma_0 + \omega_t + \omega_j + \gamma_3 * Line_{i,j} + \gamma_4 * Line\_Post_{i,j,t} + \gamma_5 * X_{i,j,t} + u_{i,j,t} \quad (4)$$

$$Freycinet_{i,j,t} = \zeta_0 + \theta_t + \theta_j + \zeta_3 * Line_{i,j} + \zeta_4 * Line\_Post_{i,j,t} + \zeta_5 * X_{i,j,t} + \mu_{i,j,t} \quad (5)$$

## Second stage regression

$$\ln(Pop_{i,j,t}) = \alpha_0 + \eta_t + \eta_j + \alpha_3 * \widehat{Treat}_{i,j} + \alpha_4 * \widehat{Freycinet}_{i,j,t} + \alpha_5 * X_{i,j,t} + v_{i,j,t} \quad (6)$$

In the specifications with municipal fixed effects, obviously the model becomes simpler since  $Treat_{i,j}$  and  $Line_{i,j}$  are time-invariant, therefore are absorbed by the fixed effects and are omitted in the specifications. In this case, I only have:

## First stage regression

$$Freycinet_{i,j,t} = \zeta_0 + \theta_i + \theta_t + \theta_j + \zeta_4 * Line\_Post_{i,j,t} + \zeta_5 * X_{i,j,t} + \mu_{i,j,t} \quad (7)$$

## Second stage regression

$$\ln(Pop_{i,j,t}) = \alpha_0 + \eta_i + \eta_t + \eta_j + \alpha_4 * \widehat{Freycinet}_{i,j,t} + \alpha_5 * X_{i,j,t} + v_{i,j,t} \quad (8)$$

**Validity of the instrument.** For the instrument to be valid, beyond the exclusion of the endpoints from the sample, two criteria have to be met: the relevance condition and the exclusion restriction.

The relevance condition basically means that there must be a strong correlation between the instrument and the endogenous variable. In my case, it means that I need  $Cov(Treat_{i,j}, Line_{i,j}) \neq 0$  and  $Cov(Freycinet_{i,j,t}, Line\_Post_{i,j,t}) \neq 0$ . The simplest way to assess this condition is to run the first stage regression. Results are provided in Table 2. Being on a straight line is a strong predictor of gaining access to the railway thanks to the Freycinet plan, across all specifications. Indeed, being in a 10-km buffer zone in the Post-Freycinet era increases the likelihood to gain access to the network by around 0.212 percentage points and the result is significant at the 99.9% level (Panel A). More generally, municipalities close to straight lines are more likely to be treated by around 0.200 percentage points (Panel B) and the result is significant at the 99.9% level. In Panel C, I also show that distances to straight lines and distances to Freycinet stations are strongly correlated: a 1-km increase in the distance to a straight line is associated with a 0.53 increase in the distance to a Freycinet station, once controls are accounted for. Very high F-statistics across all models presented reinforce the relevance of the first stage. These results clearly highlight that the relevance condition is met and the instrument cannot be deemed weak.

Besides, the exclusion restriction means that the instrument must not be correlated with the error term of the second stage regression i.e. I need  $Cov(v_{i,j,t}, Line_{i,j}) = 0$  and  $Cov(v_{i,j,t}, Line\_Post_{i,j,t}) = 0$ . This restriction is not testable. As explained above, the IV strategy focuses on intermediate municipalities between two endpoints and considers that these cities have only been almost “accidentally”, “quasi-randomly” (Mayer and Trevien (2017)) connected to the railway, meaning there is no major reason for which a station would have been built on their territory for some economic reason, had they not lied on straight lines. Besides, the exclusion restriction deals with the error term of the second stage regression. It is obvious that being located on a straight line is correlated with being close to a Freycinet line endpoint (with respect to municipalities far away from Freycinet lines) and it could also be correlated to the distance to cities. Distance to cities and endpoints can also predict population growth, since being close to a city is generally associated with more employment, more business, etc. This is why including controls for the distance to cities and the distance to the closest endpoint in the IV regressions is crucial, as these variables are not included anymore in the error term of the second stage regression, which preserves the validity of the exclusion restriction (Berger (2019); Büchel and Kyburz (2020)). Including municipal fixed effects in regressions also reinforces the validity of the instrument, since they will include numerous fixed drivers of population growth that might have remained in the error term of the second stage regression otherwise.

Eventually, in Appendix B.1, to understand the correlations between  $Line_{i,j}$  and pre-existing determinants of population appearing in control variables, I run basic regressions of all covariates on  $Line_{i,j}$ , conditional on *département* fixed effects. Besides distance to city, distance to endpoint and distance to other non-Freycinet train stations, which are mechanically correlated to being on a straight line, there is no significant correlation with all other predictors of population, meaning municipalities on the straight lines did not differ from those not on such lines. In a nutshell, many aspects of the design give indirect evidence for the exclusion restriction.

**Table 2: The impact of being close to a straight line on Freycinet railway connections (including interactions): First stage of IV 2SLS estimates**

	Baseline model			With municipal FE		
	(1) Baseline	(2) Controls	(3) Time FE	(4) Baseline	(5) Time FE	(6) Def-2
<b>Panel A – Dependent variable: Freycinet</b>						
<b>Line (5km) × Post</b>	0.212*** (0.004)	0.213*** (0.004)	0.213*** (0.004)	0.212*** (0.005)	0.212*** (0.005)	0.159*** (0.004)
<b>Line (5km)</b>	0.000 (0.000)	-0.006*** (0.000)	-0.006*** (0.000)			
<b>Post</b>	0.013*** (0.000)	0.015*** (0.000)	0.015*** (0.001)	0.013*** (0.001)	0.009*** (0.001)	0.020*** (0.001)
<b>F-statistic</b>	1397.55	388.905	285.258	1041.608	298.435	149.571
<b>P-value of F-statistic</b>	0.000	0.000	0.000	0.000	0.000	0.000
<b>R-squared</b>	0.166	0.173	0.173	0.180	0.181	0.083
<b>Panel B – Dependent variable: Treat</b>						
<b>Line (5km)</b>	0.213*** (0.003)	0.193*** (0.003)	0.193*** (0.003)			
<b>Line (5km) × Post</b>	-0.001 (0.005)	0.001 (0.005)	0.001 (0.005)			
<b>Post</b>	-0.000 (0.001)	0.010*** (0.001)	0.010*** (0.001)			
<b>F-statistic</b>	3011.371	877.363	643.387			
<b>P-value of F-statistic</b>	0.000	0.000	0.000			
<b>R-squared</b>	0.138	0.160	0.160			
<b>Panel C – Dependent variable: Distance to Freycinet station</b>						
<b>Dist. to straight line</b>	0.835*** (0.002)	0.526*** (0.005)	0.526*** (0.005)			
<b>F-statistic</b>	189228.728	38535.373	24782.660			
<b>P-value of F-statistic</b>	0.000	0.000	0.000			
<b>R-squared</b>	0.651	0.823	0.823			
<b>Controls</b>	No	Yes	Yes	No	Yes	Yes
<b>Year FE</b>	No	No	Yes	No	Yes	Yes
<b>Geographical FE</b>	None	Dep.	Dep.	Mun.	Mun.	Mun.
<b>Observations</b>	202126	202126	202126	202126	202126	440793

Robust standard errors in parentheses. Controls include the distance to the closest lake, river, coastline, train line endpoint, big city, other non-Freycinet train station, as well as the average altitude and total surface of the municipality.

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

## 2.4 Summary statistics: comparing treated and control municipalities

Table 3 compares municipalities in the treatment and control groups, providing means of a series of variables, their standard deviations as well as a t-test in order to know if the difference between the outcomes in both groups is statistically significant. It is important to stress that differences between treatment and control groups do not invalidate the difference-in-differences strategy, which does not need a

perfect homogeneity between groups but only the common trend assumption (i.e. a common evolution of the outcome, not a common initial level), that I have already studied.

Municipalities in the treatment group were more populated than control municipalities in 1876, were closer to rivers, coastlines, to important cities, less elevated and wider in area than control municipalities. As all Freycinet line endpoints have been excluded from the sample, many of them consisting in major cities at the time, or local administrative capital cities, these differences between treatment and control groups are quite instructive: among the universe of remaining municipalities not being endpoints, those that were connected to the train thanks to the Freycinet plan were basically a bit in a better condition and slightly more accessible than the average non-connected rural French municipality belonging to the control group.

Treated municipalities were however further away from pre-existing stations than municipalities in the control group, which is understandable since the Freycinet plan rebalanced the network towards areas excluded from the French railway system at the time. There is finally no statistically significant difference between both groups in terms of distance to the closest lake.

**Table 3: Summary statistics**

	Control		Treatment		Diff.	Total	
	N	Mean	N	Mean	(C) – (T)	N	Mean
<b>Log of pop. (1876)</b>	32273	6.34 (0.86)	1688	6.69 (0.89)	-0.35***	33961	6.36 (0.86)
<b>Dist. to lake, km</b>	32631	104.15 (72.44)	1702	101.78 (76.71)	2.38	34333	104.04 (72.66)
<b>Dist. to river, km</b>	32631	2.69 (2.48)	1702	1.97 (1.91)	0.72***	34333	2.65 (2.46)
<b>Dist. to sea, km</b>	32631	168.59 (119.53)	1702	158.14 (108.92)	10.46***	34333	168.08 (119.04)
<b>Dist. to important city, km</b>	32631	4.17 (4.76)	1702	3.28 (4.22)	0.89***	34333	4.12 (4.74)
<b>Altitude, m</b>	32631	276.57 (296.17)	1702	245.48 (251.12)	31.10***	34333	275.03 (294.18)
<b>Surface, ha</b>	32631	1495.88 (1491.84)	1702	1732.47 (1497.66)	-236.59***	34333	1507.61 (1492.99)
<b>Dist. to other station, km</b>	32631	5.78 (6.49)	1702	8.06 (6.83)	-2.27***	34333	5.90 (6.53)

Standard deviations in parentheses. The values displayed for t-tests are the differences in the means across the groups. \*\*\*, \*\*, and \* indicate significance at the 1, 5, and 10 percent critical level.

## 2.5 Results: the impact of the Freycinet plan on population

Table 4 first gives results of the OLS regressions. The main coefficient of interest is the one associated to *Freycinet*, which is the difference-in-differences estimator. All standard errors are robust and clustered at the municipal level, to account for heteroskedasticity<sup>17</sup>. It appears that getting access to the railway network thanks to the Freycinet plan increased average municipal populations by around 12-14% (0.12-0.14 log points), *ceteris paribus*, in 1921-1926, compared to untreated municipalities and to the years

<sup>17</sup>The Breusch-Pagan/Cook-Weisberg test for heteroskedasticity gives a p-value of almost zero (for specifications [1]-[3]), as well as the Modified Wald test for groupwise heteroskedasticity in fixed effect regression model (for specifications [4]-[5]), meaning one can reject the null hypothesis of constant variance. As a result, it is very important to provide robust standard errors to solve this heteroskedasticity issue. More details on clustering of standard errors are provided in robustness checks, in section 2.6.

prior to the plan. The results are robust to the inclusion of controls, time fixed effects and municipal fixed effects and are always significant at the 99.9% level. The slight increase in the magnitude of the coefficients in specifications with municipal fixed effects<sup>18</sup> shows that there are determinants of population that the covariates used in specifications (1), (2) and (3) do not totally account for. Compared to figure 7(b), this difference represents around 60% of the observed difference in the average log of population across the treatment and control groups in years 1921-1926 (i.e. 0.23 log points). Placebo tests, the results of which are reported in Table 13 of Appendix B.2, also yield non statistically significant coefficients for  $Freycinet_{i,j,t}$ , meaning that the difference-in-differences strategy is valid. Yet, one can observe that the coefficient of Def-2 is clearly lower, which would imply that treatment effects might well depend on the post-treatment period chosen. However, one should not give too much importance to such results, since the OLS does not fully capture the effect of the plan on population. It assumes that train connections are exogenous.

This is why Table 5 rather focuses on IV second-stage estimates, in the continuation of the first-stage results of Table 2<sup>19</sup>. A first glance at Table 5 highlights that getting access to the railway as a consequence of the Freycinet plan, after it was carried out (i.e. in 1921-1926 here), increased average municipal populations by around 30% (0.3 log points), *ceteris paribus*, relatively to non connected municipalities and to the period before the plan (i.e. 1861-1876 census years). Solving the endogeneity issue of station opening with the IV strategy therefore yields estimates that are twice the size of OLS' and are substantially larger than the simple comparison of the average log of population across groups visible in Figure 7(b) for years 1921-1926 (i.e. 0.23 log points). The baseline models are exactly similar whether fixed effects are used, or not. As with the OLS however, models that include municipal and time fixed effects (model [5]), as well as controls for distance to other non-Freycinet station, yield slightly larger estimates. This is consistent with the idea that treated municipalities might have been negatively selected based on the proximity of the municipality to any other railway at the time, already shown in summary statistics (Table 3). The quasi-equality of the IV estimates for specifications [5] and [6] also underlines that the definition of the post-treatment period (and its restriction to the years 1921-1926 in my preferred specifications) does not really matter to assess the effects. The effects emerge very quickly as soon as the stations are built and remain almost stable over time (see section 2.6 for more evidence on this).

In Table 5 (as well as in Table 4), other coefficients than only the ones associated to *Freycinet* might be of interest. It appears that being in the treatment group does not affect population growth in a statistically significant manner, once controls are taken into account. It is clear however that in my sample, there is a general decreasing trend in the mean log population in the first years of the Interwar period (1921-1926, cf. the coefficient associated to *Post*), as Figure 7 has shown. Besides, a higher surface is associated with an increase in population, while being further away from a lake, a river or an important city (or endpoint) by 1 km reduces municipal population, which is coherent with the idea that water features are key to development and that cities induce positive economic spillovers on neighbouring municipalities.

The only matter of circumspection is the coefficient associated to the distance to non-Freycinet stations (built either before or during Freycinet era). On the one hand, it is negative in specifications with departmental fixed effects (specifications [1]-[3]), meaning being close to any non-Freycinet station is positive to population. On the other hand, the municipal fixed effects specifications ([4]-[6]) yield positive estimates: the more the municipality is far from a non-Freycinet station, the higher its population. This seems counter-intuitive, as it would mean a Freycinet station is positive for population growth and a non-Freycinet station is negative. This discrepancy is mainly due to the fact that, here, distance to non-Freycinet stations is clearly endogenous, for the same reason that urged me to instrument *Freycinet* (i.e. stations are not randomly and exogenously distributed on the territory). This means that, as such, the interpretation of the coefficient cannot be deemed causal. It is obviously important to control for other non-Freycinet stations, to discard omitted variable bias and introduce transport substitutes to Freycinet stations in the regressions, but the coefficient is of no relevance in terms of causal interpretation, as a

<sup>18</sup>For all regressions, I have performed an Hausman specification test to discriminate between municipal fixed and random effects. All Hausman tests have yielded very low p-values, usually nearly equal to zero, meaning that I can reject the null hypothesis of preferring random effect models and that fixed effect models are consistent.

<sup>19</sup>I also give in Appendix B.3 reduced form estimates, regressing the log of population on the instrument and control variables. The definition of second stage estimates as the ratio of reduced form estimates on first stage estimates is clearly verified in Table 14.



majority of endogenous controls (Hünermund and Louw (2020)).

Accounting for all controls and varying specifications, Table 5 therefore shows that the Freycinet plan increased treated municipalities' population by around 30% after their connection to the railway, relatively to non-Freycinet municipalities. Compared to the literature, the effect is slightly lower; IV estimates are indeed smaller than in Berger and Enflo (2017) (around 50%) and Büchel and Kyburz (2020) (0.31–0.58 p.p.). However, a higher population of 30% for essentially quite remote towns can be deemed relatively high, all the more so since the context of implementation of the Freycinet plan was clearly not favourable to population growth. As already developed, population increases only slightly on the period and fears of “depopulation” were frequent – and remained until after World War II. From 1876 to 1926, the average log of population of treated municipalities decreased by 0.15 log points (from 6.69 to 6.54), which is very low. The estimate of the effect of the Freycinet plan (around 0.30 log points) is therefore twice the size of the decreasing demographic trend of these municipalities (-0.15). This means that without the plan, these municipalities might have experienced an even sharper decrease in their population.

It is also critical to note that the Freycinet plan started in 1879, at a time where the railway network was already somewhat developed and covered large portions of the French metropolitan territory. Its contribution to population is therefore complementary to already pre-existing railways, while a majority of papers focus on the very first railway lines build in various countries. In this context, finding positive effects, clearly higher than zero and very precise, is noteworthy. Indeed, Kakpo et al. (2019) had found no statistically significant average effect of the other train lines built at the end of the 19<sup>th</sup> century in France and Berger and Enflo (2017) had found no effect of additional railway connection on population once the first wave of train lines building was over.

Table 4: The impact of Freycinet railway connections on municipality populations in the 1920s: OLS estimates

Dependent variable: Log of population						
	Baseline model			With municipal FE		
	(1) Baseline	(2) Controls	(3) Time FE	(4) Baseline	(5) Time FE	(6) Def-2
<b>Freycinet</b>	0.135*** (0.021)	0.124*** (0.015)	0.124*** (0.015)	0.137*** (0.010)	0.141*** (0.010)	0.087*** (0.006)
<b>Treat</b>	0.336*** (0.011)	0.138*** (0.009)	0.138*** (0.009)			
<b>Post</b>	-0.304*** (0.005)	-0.335*** (0.004)		-0.304*** (0.002)		
<b>Dist. to non-Freycinet station</b>		-0.011*** (0.000)	-0.011*** (0.000)		0.004*** (0.000)	0.002*** (0.000)
<b>Dist. to lake</b>		-0.001*** (0.000)	-0.001*** (0.000)			
<b>Dist. to river</b>		-0.014*** (0.001)	-0.014*** (0.001)			
<b>Dist. to coast</b>		-0.001*** (0.000)	-0.001*** (0.000)			
<b>Dist. to important city</b>		-0.031*** (0.000)	-0.031*** (0.000)			
<b>Dist. to endpoint</b>		-0.000*** (0.000)	-0.000*** (0.000)			
<b>Altitude</b>		-0.001*** (0.000)	-0.001*** (0.000)			
<b>Surface</b>		0.000*** (0.000)	0.000*** (0.000)			
<b>Controls</b>	No	Yes	Yes	No	Yes	Yes
<b>Year FE</b>	No	No	Yes	No	Yes	Yes
<b>Geographical FE</b>	None	Dep.	Dep.	Mun.	Mun.	Mun.
<b>Observations</b>	202126	202126	202126	202126	202126	440793
<b>F-statistic</b>	2044.105	2590.757	1912.249	11545.464	4305.751	2506.188
<b>P-value of F-statistic</b>	0.000	0.000	0.000	0.000	0.000	0.000
<b>R-squared</b>	0.032	0.463	0.463	0.366	0.372	0.310

Robust standard errors in parentheses

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Table 5: The impact of Freycinet railway connections on municipality populations in the 1920s: IV 2SLS estimates

Dependent variable: Log of population						
	Baseline model			With municipal FE		
	(1) Baseline	(2) Controls	(3) Time FE	(4) Baseline	(5) Time FE	(6) Def-2
<b>Freycinet</b>	0.317*** (0.057)	0.290*** (0.039)	0.290*** (0.039)	0.317*** (0.014)	0.327*** (0.014)	0.321*** (0.016)
<b>Treat</b>	0.805*** (0.029)	-0.130*** (0.025)	-0.130*** (0.025)			
<b>Post</b>	-0.313*** (0.005)	-0.340*** (0.004)		-0.313*** (0.001)		
<b>Dist. to non-Freycinet station</b>		-0.010*** (0.000)	-0.010*** (0.000)		0.004*** (0.000)	0.003*** (0.000)
<b>Dist. to lake</b>		-0.001*** (0.000)	-0.001*** (0.000)			
<b>Dist. to river</b>		-0.015*** (0.001)	-0.015*** (0.001)			
<b>Dist. to coast</b>		-0.001*** (0.000)	-0.001*** (0.000)			
<b>Dist. to important city</b>		-0.031*** (0.000)	-0.031*** (0.000)			
<b>Dist. to endpoint</b>		-0.000*** (0.000)	-0.000*** (0.000)			
<b>Altitude</b>		-0.001*** (0.000)	-0.001*** (0.000)			
<b>Surface</b>		0.000*** (0.000)	0.000*** (0.000)			
<b>Controls</b>	No	Yes	Yes	No	Yes	Yes
<b>Year FE</b>	No	No	Yes	No	Yes	Yes
<b>Geographical FE</b>	None	Dep.	Dep.	Mun.	Mun.	Mun.
<b>Observations</b>	202126	202126	202126	202105	202105	440773
<b>F-statistic</b>	1905.192	2464.389	1819.458	34070.440	10987.015	9060.229
<b>P-value of F-statistic</b>	0.000	0.000	0.000	0.000	0.000	0.000
<b>R-squared</b>	0.016	0.317	0.318	0.359	0.365	0.294

Robust standard errors in parentheses

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

## 2.6 Discussion of results and robustness checks

From the previous section, my main and most straightforward result is that gaining access to the railroad thanks to the Freycinet plan is associated with a relative average increase of about 30-33% in the population of connected municipalities in the short run, after the plan was implemented (i.e. in census years 1921-1926), compared to non-Freycinet municipalities and to the context prior to the plan (i.e. 1861-1876 census years). This general result is not much affected by the timing of the opening of stations i.e. the result is similar whether I define the post-treatment period as only the years 1921-1926 (when the whole plan is completed) or, for each municipality, as all the years after the municipality welcomed the station. It is now important to understand to what extent my results are robust.

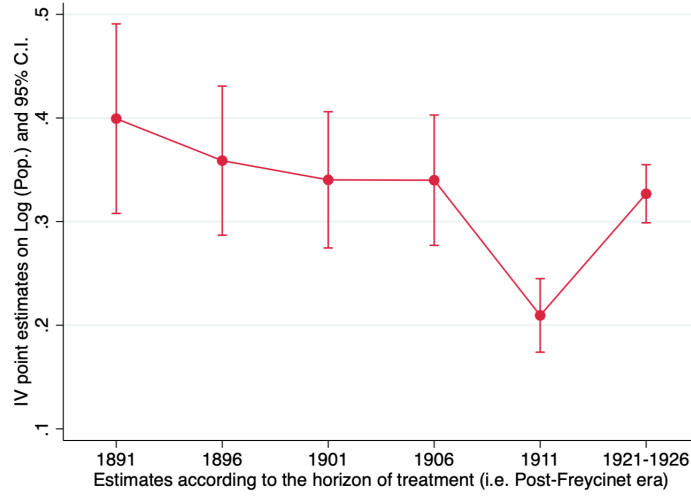
**Differences in post-treatment periods.** One major pitfall of my analysis may be that it aggregates effects of a treatment that spans on quite a long period (from 1879 to 1914). If for instance I expect the effects not to be constant over time but to increase, then studying the impact only in 1921-1926 would combine higher effects for the first treated municipalities (e.g. in 1885) compared to smaller effects for those treated in the end (e.g. in 1913). Also, the period 1921-1926 arrives after World War I, that may have completely reorganised population patterns across the territory. The Def-2 estimate that I use helps solving partly this issue, since the “Post” period is not only 1921-1926 anymore but starts, for each municipality, as soon as it was treated. I find no real differences between the baseline estimates and the Def-2 estimate, meaning the definition of the post-Freycinet period would not matter. However, this Def-2 estimate remains very aggregate: it does take into account the long time-span of treatment effects for early-treated municipalities, but I still only get a unique synthetic estimate, that averages all post-Freycinet periods for all municipalities. It is an average value, that does not say anything about possible very different treatment effects every 5 years, that could compensate each other in the average Def-2 estimate (e.g. if the treatment effects are 0 for the first treated municipalities and 66% for the municipalities treated later, then I would still get a Def-2 estimate around 33%). It is therefore important to assess possibly varying effects during the treatment period.

I therefore run equation (8) every five years (the census years), with the treatment group only composed of municipalities treated until the year of interest<sup>20</sup>. Results are provided in Table 15 of Appendix B.4 and Figure 9 graphs them. For example, taking year 1901: gaining access to the railroad is associated with a relative increase of about 34%, in 1901, in the population of municipalities that were connected thanks to the Freycinet plan until 1901, compared to non-Freycinet municipalities and to the context prior to the plan (i.e. 1861-1876 census years). From Figure 9, it appears that the treatment effect have been very similar over time when I define the post-treatment era every five years, except in 1911, where it was substantially smaller (21%), which explains the very slight decrease in 1921-1926 (33% compared to 34% in 1896-1906). Only the train connections built between 1906 and 1911 had smaller effects on municipality populations; otherwise the treatment magnitude has remained quite constant. It also became more precise, with smaller confidence intervals, essentially because of increasing observations over time. This pattern is actually very coherent with Def-2: the similarity of Def-2 and the baseline IV estimates hinted at the idea of alike effects independently of the post-treatment period, which can clearly be found also in this graph where the post-treatment period is postponed every 5 years.

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<sup>20</sup>I start in 1891 because the size of the treatment group with only stations opened until 1886 would be too small to make any inference.

Figure 9: Progressive effects of the Freycinet plan

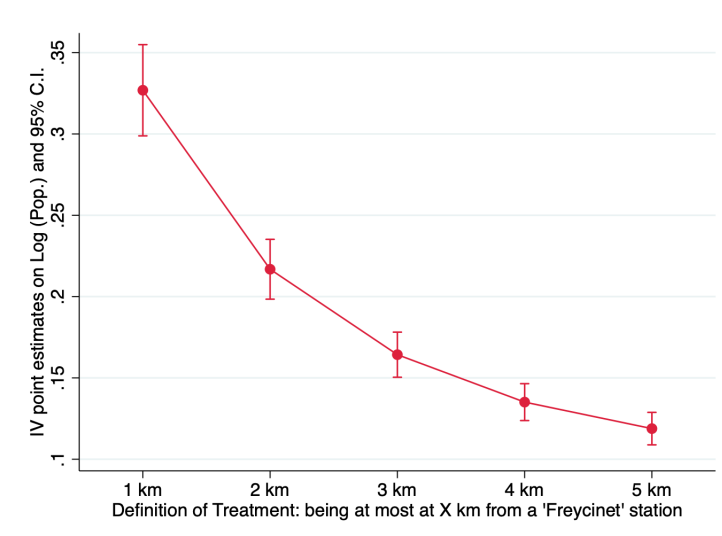


Results of Table 15 of Appendix B.4

**Definition of the treatment.** The previous results depend on the definition of being treated by the Freycinet plan, for the reasons I have developed above: are included in the treatment group all municipalities (except endpoints) of which the closest point to a Freycinet station is located at most at 1 km from this station. It may however be possible to consider that this 1 km distance is quite restrictive, and that inhabitants living at e.g. 3 km from a station might well benefit from it, especially if they had absolutely no station close to them before the plan. In the literature, some authors have indeed defined railway accessibility with broader definitions: for instance [Jedwab et al. \(2017\)](#) use distances of 0-10, 10-20, 20-30 and 30-40 km from trains in Kenya and [Berger \(2019\)](#) uses a 5 km distance in Sweden.

In order to assess the sensitivity of results to definitions of treatment, I run the exact same regressions as defined above, successively basing the inclusion in the treatment group on the fact of being at 1, 2, 3, 4 or 5 km at most from a Freycinet station. I do not extend the analysis to further away than 5 km, since the average distance to a station before the plan is already 5.9 km. For such a strategy to be valid, it is necessary that the common trend assumption is verified for all definitions of treatment. In Appendix B.5 (Figure 17), I give indirect evidence that it seems to be the case, with graphs of pre-trends of population. Result tables are provided in Appendix B.5 (Tables 16-18) for three of the specifications above (namely specifications [3], [5] and [6] of Tables 4 and 5). For the sake of clarity, I only report here a graph of the varying IV estimates along the differences in treatment definitions, in specification [5] (i.e. with municipal and year fixed effects, as well as control variables). As more distant municipalities are included in the treatment group, it is clear that IV estimates decrease.

Figure 10: Comparison of treatment effects according to treatment definitions



Results of Table 17 of Appendix B.5

Mathematically, this is due to the fact that first stage estimates are larger as distance increases (cf. Tables 16-18 in Appendix B.5). They reach almost 0.6 log points when a 5 km definition is retained, compared to around 0.2 log points with the preferred 1 km definition. This is quite normal, since the instrument consists in being at most 5 km from a straight line; hence the instrument mechanically predicts more efficiently the fact of being 5 km from a Freycinet station than being only 1 km away from it. Besides, in terms of interpretation, it already shows that the effects of the plan are higher when municipalities are close to train stations, since they directly benefit from them and can virtually use them on a daily basis, while being slightly further away might refrain a regular use of the network. Section 2.7 will explore further this idea. In any case, even at 5 km from Freycinet station, the effect of the plan remains positive and statistically significant, which supports the idea that the plan did foster population growth in connected municipalities.

**Definition of the instrument.** The definition of the instrument was based on a 10-km buffer zone (i.e. being at most at 5 km from a straight line). As developed above, taking a 10-km buffer zone enables to include several small sinuosities of railways that obviously can never be totally straight (and control variables account for larger movements due to geographical obstacles). However, one may think that building larger buffer zones might capture more Freycinet stations that might have been built a bit further away from straight lines for some reason. This is why I also run the same IV regressions, defining the instrument as being at most at 10 km away from a straight line (i.e. building a 20-km buffer zone). Table 19 in Appendix B.6 gives results for this model, again for specifications [3], [5] and [6]. It appears that a wider buffer zone in the instrument decreases the first stage estimates. As the assumption of the analysis consists in saying that intermediate cities have generally been built very close to straight lines (controlling for geography) in order to minimise railway building costs, it is coherent to see that larger buffer zones, with municipalities 10 km far from straight lines, predict less the opening of Freycinet stations, which therefore have indeed occurred closer to straight lines. As the first stage estimates are smaller with a 20-km buffer zone, mechanically, the second stage estimates are larger, with a magnitude of around 50% more than our most preferred estimates (with a buffer zone of 10 km).

However, as the instrument is quite weak and of small magnitude with a 20-km buffer zone, the larger IV estimates have to be taken with caution. Also, had a station been built 10 km away from the straight line, there may be some reason for it that goes beyond simple geographic obstacles (an important city, an industrial site, etc.) and that would bias our instrument, which rests on the idea that intermediate cities have been “accidentally” connected to the network, only by virtue of their location along straight lines between two endpoints. This is why I stick to my preferred definition of a 10-km buffer zone, which does allow for some small tortuosity of the railway but still preserves a strong correlation with the treatment.

**Clustering of standard errors.** Throughout the analysis, to correct for heteroskedasticity, I cluster standard errors at the level of the municipality, in order to get robust standard errors, following [Bertrand, Duflo, and Mullainathan \(2004\)](#). Such an approach has been widely used in papers resorting to the same kind of strategy as I did, and already mentioned such as [Banerjee et al. \(2020\)](#), [Berger and Enflo \(2017\)](#), [Garcia-López et al. \(2017\)](#). However, some papers consider that municipalities might experience shocks at larger administrative levels, meaning that errors would be correlated for all municipalities in the same district for instance. This approach is carried out by [Berger \(2019\)](#) and [Bogart et al. \(2019\)](#). In France, the major administrative layer is clearly the *département*, inherited from the French Revolution and in which both the *préfet de département* and the *conseil général* had local power, at a time when French *régions* did not yet exist. Many local lines also directly emerged from decisions of various *conseils généraux*. For this reason, I also provide results of Tables 4 and 5 with different standard errors: in Tables 20-21 of Appendix B.7, I give, for each coefficient, point estimates, *département*-clustered standard errors, municipality-clustered standard errors and standard errors with no clustering. There is a clear gradation between these three types of standard errors. However, even when clustering at the level of the *département*, which inflates standard errors, all the results remain statistically significant at the 99.9% level. My results are therefore very robust to different levels of clustering of standard errors.

**Definition of control variables.** In the previous estimations, I mainly based the definition of control variables on distances (to lake, river, seaside, other non-Freycinet station). Introducing distances might be problematic because not totally comparable to the main variable of interest, *Freycinet*, which is a dummy. In Table 22 of Appendix B.8, I therefore run the same regressions but, this time, instead of distances, I define dummies equal to 1 if a municipality is at most at 1 km from the closest lake, river, seaside and other non-Freycinet station. Changing the definition of control variables does not affect very much the magnitude of the difference-in-differences coefficients associated to *Freycinet*, especially in all the fixed-effect models, since the majority of these dummies are time-invariant and therefore are omitted in the FE regressions. The main noteworthy change is that, now, the coefficient associated to non-Freycinet station is in the same direction in all models (having any other train connection is positive for a municipality's population) but specifications with municipal fixed effects considerable reduce the magnitude of such a coefficient. I do not comment too much on this since, here, other stations are only controls and cannot be deemed exogenous.

**Some observations driving the core of the results.** One may think that results are driven by only few specific observations. Indeed, in my analysis, there are two points of vigilance. The first one is big cities. For reasons stated above, endpoints have been excluded from the sample. Many endpoints are actually important cities at the time and/or local administrative capital towns. However, the sample does include some remaining big cities and results might be driven again by only a few of these major municipalities. This is why I restrict the sample only to rural areas (as does [Berger \(2019\)](#)), excluding all cities i.e. all municipalities with more than 2,000 inhabitants in 1876. While the common trend assumption seems verified looking at pre-trends (cf. Figure 18(a) in Appendix B.9), IV estimates (cf. Table 23 in Appendix B.9) are slightly deflated. They however remain statistically significant at the 99.9% level and are very close in magnitude to those of my preferred specifications, meaning the latter are robust to a sample restriction with only rural municipalities.

The second concern is prior train connections. On the one hand, it may be the case that municipalities with already existing train stations before Freycinet era, and getting connection to another new line thanks to the Freycinet plan, might drive up the results, since they would be connected more than once and new connections would reinforce their initial advantage in terms of railway connectivity. On the other hand, municipalities that already had access to the railway before Freycinet era, but did not get any new access thanks to the plan, are included in the control group: as they still benefit from early railway connection, their population growth might still be in an upward trend and therefore the relative impact of the plan for treated municipalities, compared to these control municipalities, might be downward biased.

To circumvent this difficulty, I resort to two strategies. First, I run the same regression on a sample restricted only to municipalities that did not have any access to the railway before Freycinet era (i.e. that were at least at more than 1 km from any station in 1879). The common trend assumption is again necessary to compare both groups and Figure 18(b) of Appendix B.9, with pre-trends, indirectly shows that it seems to be met. Results are provided in Table 23 of Appendix B.9. There is a small reduction in the IV estimates, suggesting that the first interpretation is more likely (municipalities gaining an

additional access to the train due to the Freycinet plan drive up the estimates). However, the results remain of the same magnitude and of the same level of statistical significance. My IV estimates seem therefore robust to a sample restricted to municipalities with no prior train connection.

The second strategy consists in digging further in heterogeneous effects along non-Freycinet stations. The idea is to understand if being connected to the railway thanks to the Freycinet plan has larger effects for municipalities that (i) already had a train station in 1879, or (ii) got another one between 1879 and 1914, not linked to the Freycinet plan. To study this, I build two dummies: *Prior\_station* is equal to 1 if a municipality was within 1 km of any train station before 1879 and *Contemp\_station* (for “Contemporaneous station”) is equal to 1 if the municipality welcomed another station than a Freycinet station on the period 1879-1914. I interact these dummies with my main variable of interest, *Freycinet*.

Table 6 presents the IV results of this estimation, for specifications 3 and 5. Regarding prior stations, it is clear that the Freycinet plan reinforced their already favourable population trend due to prior railways. Indeed, having a prior train connection and getting another one with the Freycinet plan is associated with an increase in the log of population by 0.73 log points ( $0.305 + 0.425$ ) for these municipalities, relatively to non connected municipalities. The effect of the Freycinet plan is more than twice the one of municipalities getting their first train access with the plan and with no prior railway access (0.305), which still remains statistically significant. The fixed-effect model (column [5]) strengthens this relationship, since the coefficient associated to the interaction between *Freycinet* and *Prior\_station* increases slightly and becomes statistically significant at the 99.9% level. Conversely, it appears that municipalities welcoming a station from the Freycinet plan and from another public policy at the same time do not enjoy a higher population than those only having access through the Freycinet plan. Indeed, the coefficient of the interaction between *Freycinet* and *Contemp\_station* is never statistically significant. If any, it seems even that those twice-connected stations (in 1879-1914) have experienced lower population prospects: when including the interaction, the coefficient of *Freycinet* only (which therefore gives the effect of the plan for municipalities with no other new railway access than from the Freycinet plan on the period) increases slightly.

These results, on prior and contemporaneous stations, corroborate the idea that, before the Third Republic, many important towns with huge growth prospects got access to the railway, which allowed them to foster a sustainable growth path even decades later, and which the Freycinet plan reinforced. However, the fact that the coefficient associated to *Freycinet* in Table 6 (in columns [2] and [4], that therefore aggregates the effects for all municipalities connected to railways for the first time thanks to the Freycinet plan, remains statistically significant and of high magnitude, suggests that the Freycinet plan also benefited to these municipalities. Towns with prior train connections do not drive the entirety of the plan’s effects. The plan therefore contributed positively to the population of large and smaller municipalities, with and without prior railway connections. In contrast, other smaller railway programmes under the Third Republic had very limited, even sometimes detrimental, effects on population compared to the broader and more ambitious Freycinet plan.



**Table 6: The impact of Freycinet railway connections on municipality populations in the 1920s: IV 2SLS estimates with interactions between stations of different periods**

Dependent variable: Log of population						
	Spec. 3			Spec. 5		
	(1) No inter.	(2) Prior stations	(3) Contemp. stations	(4) No inter.	(5) Prior stations	(6) Contemp. stations
<b>Freycinet</b>	0.311*** (0.038)	0.305*** (0.034)	0.314*** (0.040)	0.327*** (0.014)	0.307*** (0.012)	0.337*** (0.015)
<b>Freycinet × Prior station</b>		0.425* (0.203)			0.436*** (0.082)	
<b>Freycinet × Contemp. station</b>			0.067 (0.115)			0.088 (0.045)
<b>Controls</b>	Yes	Yes	Yes	Yes	Yes	Yes
<b>Year FE</b>	Yes	Yes	Yes	Yes	Yes	Yes
<b>Geographic FE</b>	Dep.	Dep.	Dep.	Mun.	Mun.	Mun.
<b>Observations</b>	202126	202126	202126	202105	202105	202105
<b>F-statistic</b>	2826.415	2483.066	2386.522	10987.015	12494.348	9019.573
<b>P-value of F-statistic</b>	0.000	0.000	0.000	0.000	0.000	0.000
<b>R-squared</b>	0.370	0.373	0.370	0.365	0.414	0.371

Robust standard errors in parentheses. Spec. 3 and 5 correspond to the models described in section 2.3 (cf. IV equations 4-6 for spec. 3 and equations 7-8 for spec. 5) and visible in Tables 4 and 5. Both specifications include year fixed effects but spec. 3 includes *département* fixed effects while spec. 5 includes municipality fixed effects. Controls include the distance to the closest lake, river, coastline, train line endpoint, big city, other non-Freycinet train station, as well as the average altitude and total surface of the municipality.

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

## 2.7 Assessing displacement effects

As train station areas are attractive, since they are the epicentre of trade networks but also of daily commuting or even migrations, the literature has generally focused on displacement effects resulting from the opening of train stations. In a few words, one key issue is to understand if population growth in Freycinet municipalities is due to an intrinsic process that benefited to the whole French territory or if, as a matter of fact, this growth is mainly the result of the fact that Freycinet municipalities have attracted people from other non-connected municipalities. The latter may therefore have experienced scenarios of depopulation, with people deciding to leave them in order to move to better connected Freycinet municipalities. This issue is quite frequent in the literature on transport infrastructures (e.g. [Chandra and Thompson \(2000\)](#); [Büchel and Kyburz \(2020\)](#); [Berger and Enflo \(2017\)](#); [Garcia-López et al. \(2017\)](#); [Fretz, Parchet, and Robert-Nicoud \(2017\)](#); [Bogart et al. \(2019\)](#)).

Following [Berger \(2019\)](#), I keep the same definition for the treatment group (being at most at 1 km from a Freycinet station) but progressively reduce the control group to include only cities at least at 1, then 2, 3, 5, 10, 20, 40 and 60 km from Freycinet stations<sup>21</sup>. This requires that the common trend assumption is verified for all these definitions of the control group; in Appendix B.10 I produce graphs with pre-trends that show that the condition seems verified (although not directly testable, in

<sup>21</sup>I stop at 60 km because in this case, the control group only includes less than half of the sample (45%) and because being 60 km far away from train connections is quite rare in France, meaning going further away would basically be restricted to very few municipalities and would be of no real meaning to understand the reorganisation effect at the national level.

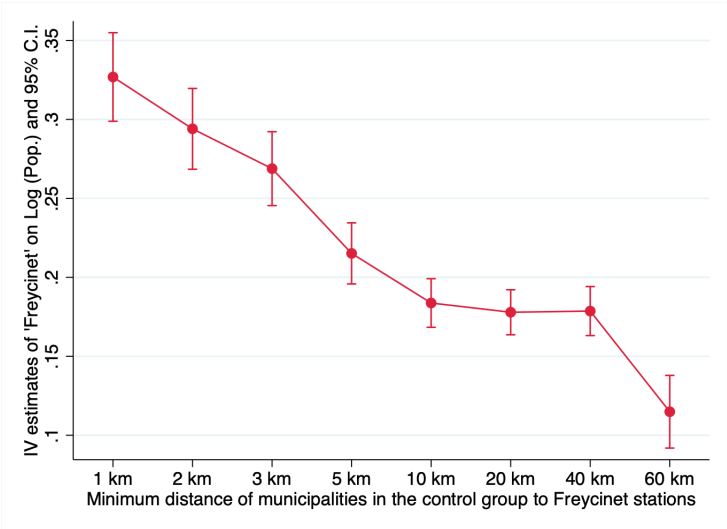
the absence of a counterfactual). If there is a reorganisation of municipal populations close to Freycinet stations, then I would expect the treatment effects to progressively decrease as the distance of the control group increases.

In Table 7, I give the IV results of this strategy. It is clear that treatment effects decrease when the control group is shifted to municipalities further away, across the two retained specifications. For instance, looking at specification 3, *ceteris paribus*, gaining access to the train network thanks to the Freycinet plan has increased the concerned municipalities' population in the post-Freycinet era by 0.290 log points on average, relatively to municipalities located at least 1 km away from Freycinet stations. However, train access effects amount only to 0.240 log points, relatively to municipalities at least 3 km away from Freycinet stations. This suggests that the growth of Freycinet municipalities somewhat happened at the expense of directly close non-connected municipalities.

A more careful look at the results actually shows three processes of gradual reorganisation. Figure 11 clearly highlights this pattern. When the control group includes municipalities at least at 1 km to at least at 5 km from Freycinet stations, IV estimates decrease progressively. Then, from 10 to 40 km, treatment effects seem to have reached a quasi-plateau, with even a slight increase at 40 km. Finally, at 60 km, there is again a strong drop in the coefficient, which however remains positive and statistically significant at the 99.9% level.

This basically means that there has indeed been a reorganisation of municipal populations towards Freycinet stations: newly opened stations have mainly attracted people from close towns. As a result, the Freycinet plan entailed important displacement effects on the French territory.

**Figure 11: Displacement effects: graph of estimates and C.I. of Table 7 (Spec. 5)**



Results of Table 7

**Table 7: Growth versus reorganisation: IV 2SLS estimates when considering control municipalities further and further away from Freycinet-connected municipalities**

Control group?	>1 km	>2 km	>3 km	>5 km	>10 km	>20 km	>40 km	>60 km
<b>Dependent variable: Log of population</b>								
<b>Spec. 3 (Controls, Year &amp; Dep. FE)</b>								
<b>Freycinet</b>	0.290** (0.039)	0.261*** (0.036)	0.240*** (0.033)	0.189*** (0.028)	0.151*** (0.022)	0.152*** (0.020)	0.171*** (0.021)	0.106*** (0.030)
<b>F-stat.</b>	1913.149	1873.901	1826.388	1730.350	1511.527	1037.762	394.566	231.473
<b>P-value of F-stat.</b>	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
<b>R-squared</b>	0.318	0.318	0.319	0.317	0.315	0.302	0.283	0.318
<b>Spec. 5 (Controls, Year &amp; Mun. FE)</b>								
<b>Freycinet</b>	0.327*** (0.014)	0.294*** (0.013)	0.269*** (0.012)	0.215*** (0.010)	0.184*** (0.008)	0.178*** (0.007)	0.179*** (0.008)	0.115*** (0.012)
<b>F-stat.</b>	10987.015	10816.479	10692.650	10222.662	9057.370	6646.892	2075.810	473.521
<b>P-value of F-stat.</b>	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
<b>R-squared</b>	0.365	0.371	0.377	0.385	0.398	0.416	0.346	0.112
<b>Observations</b>	202126	196464	190722	179061	151742	103171	40752	11387

Robust standard errors in parentheses. Spec. 3 and 5 correspond to the models described in section 2.3 and visible in Tables 4 and 5. Both specifications include year fixed effects but spec. 3 includes *département* fixed effects while spec. 5 includes municipality fixed effects. Controls include the distance to the closest lake, river, coastline, train line endpoint, big city, other non-Freycinet train station, as well as the average altitude and total surface of the municipality.

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

### 3 The Freycinet plan and economic development: a local approach

“The train, the poor man’s car. All he needs is to be able to go everywhere.”<sup>22</sup>

#### 3.1 Is population a good indicator of economic development?

Until now, I have been using population as the key variable of interest. Population is *per se* an interesting outcome, since it enables to understand relocations of inhabitants across the territory and the formation of cities or smaller towns over time (for instance, the definition of cities is based on the threshold of 2,000 habitants, cf. Lamarre (1987)). The focus on population is also compelling due to the specific case of France at the time, which was experiencing a demographic stagnation and where fears of depopulation were frequent, as discussed.

Population can also appear as a proxy of economic development, and this idea is one of the underlying messages of the previous analyses. For Pumain (1997), cited in Mimeur et al. (2018), population change can be viewed as an “excellent summary of many functional properties”. Indeed, in economic history, the absence of precise (and digitised) data in the long run at very local levels impedes to study the effects of policies on precise economic information, that are rather frequent in papers on recent issues such as the number of firms in a town, municipal tax revenues, local income per capita, etc. Some authors do have a plurality of variables of interest, either because in some countries local registries provide a lot of data, or because they study more recent eras (e.g. Berger (2019) has data on population and industry share of employment; Bogart et al. (2019) have data on population and occupational growth by economic sector, etc.). In France, only local census data are available and digitised on this period, which might not be enough to fully capture all economic changes in municipalities at the time of the Freycinet plan.

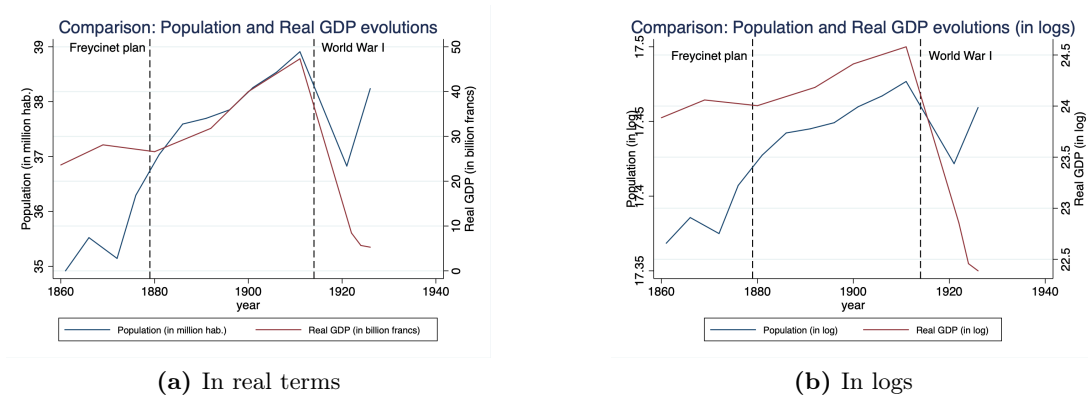
It is obviously not possible nor relevant here to dig into the complex relationships between population and income, but there is a broad consensus on the idea that the Malthusian theory is not valid at the end of the 19<sup>th</sup> century and that population growth and income growth have developed side by side during the two industrial revolutions. Even in early modern times, population shocks could lead to sustained increases in incomes (see Chaney and Hornbeck (2016) for a review). In his paper on the relationship between population growth and economic growth, Peterson (2017) shows that the latter is very controversial. In terms of theoretical arguments, the Malthus model, the Solow model and the model of Mankiw, Romer and Weil predict a negative correlation between population and economic growth. Conversely, endogenous growth models suggest there is a positive relationship between population growth and economic growth. Empirical works on the topic also reach contrary conclusions (e.g. Huang and Xie (2013); Bucci (2015); Kelley and Schmidt (2001); Mierau and Turnovsky (2014)).

As both theory and empirical works highlight contrasting effects but hint at the fact that, at the end of the 19<sup>th</sup> century, population growth did not hamper economic growth, there is a need to understand the precise situation of France to know if population is a good proxy of economic development. I therefore use the *département* GDP measures described in the Data section and stemming from the works of Bazot (2014) and Monnet et al. (2020). In Figure 12, I sketch the evolution of total population and real GDP from 1860 to 1926 in France, in real terms (graph a) and in logs (graph b).

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<sup>22</sup>Jules Renard, *Journal*, 1905.

**Figure 12: The growth of population and real GDP (1860-1926)**



Author’s graphs with population data from the Cassini project and GDP data from Bazot (2014) & Monnet et al. (2020)

It appears that, over the period of the Freycinet plan (1879-1914), population and real GDP followed grossly similar trends, with a rise until 1911 and a severe drop due to World War I. Caron (2005), p. 61, also argues that the slow economic growth between 1883 and the 1890s is due to the very slow population growth. However, the relationship is not completely equivalent, as the growth rate of the log of population seems quite higher. It is also visible that in the pre-Freycinet era, the levels of both variables were very different and that World War I had much more negative consequences on deflated GDP compared to growth.

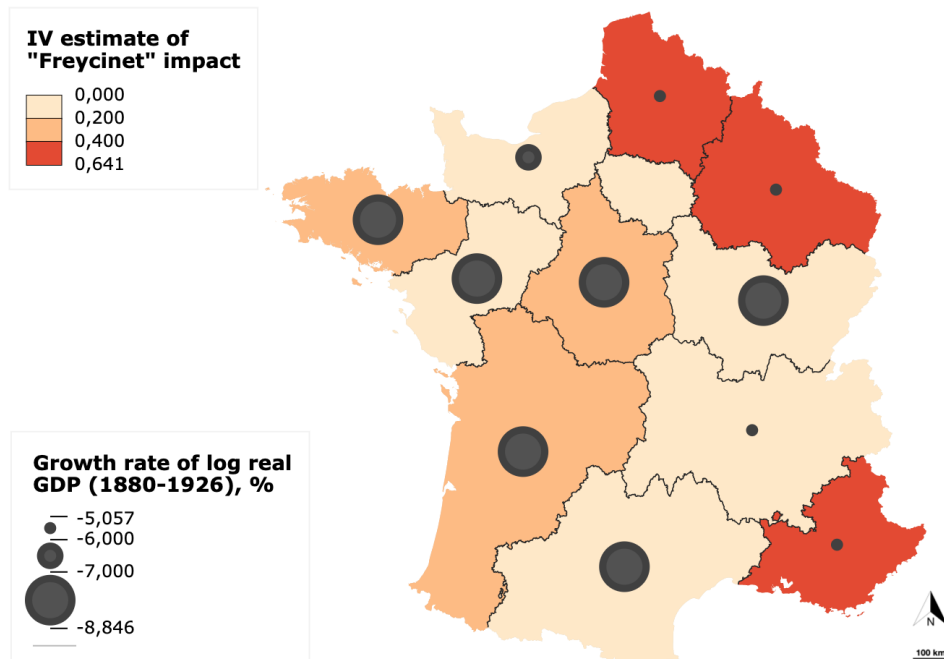
From this analysis, I can conclude that population is a somewhat good proxy of economic growth, at the level of the nation at least, meaning that my conclusions of section 2 might go beyond reflections on population and could be similar for economic outcomes. However, as the relationship between both is not a one match, I remain cautious on this equivalence of interpretations and therefore study the effects of the Freycinet plan on *départements*’ GDP specifically, in the remaining sections of this paper. While population data suggested interpretations linked to displacement effects and reorganisation, the decomposition of GDP across *départements* may also unveil other mechanisms through which the Freycinet plan might have improved the situation of newly served municipalities.

### 3.2 Connecting the railway network, demographics and economic outcomes at the local level: summary statistics

First and foremost, it is possible to assess whether the places where the plan had a major impact on population are also places that have experienced relatively larger economic growth. To do this, I first run equations (3) and (8) for each French region (after the reform of 2015). For such an approach to be valid, it is again necessary that the parallel trend assumption is verified in each region. A look at pre-trends (cf. Figure 20 in Appendix C.1) highlights that the assumption seems plausible in all regions, except maybe Occitanie and Pays de la Loire. I report the results of the estimation in Table 24 of Appendix C.1 and the IV estimates in Figure 13. This figure contrasts the IV results with the evolution of the log of the real GDP between 1880 and 1926<sup>23</sup>. If population is a good proxy for economic outcomes, then important effects of the Freycinet plan on population would also be associated to better economic growth rates.

<sup>23</sup>Note that here, Grand-Est is stripped of the current *départements* of Moselle, Haut-Rhin and Bas-Rhin which were annexed by the Prussians in 1870. Due to lacking GDP data, some *départements* are not accounted for in some regions: the Territoire de Belfort in Grand-Est, Haute-Saône in Bourgogne-Franche-Comté and the Seine *département* in Île-de-France. As the latter is by far the *département* with the highest growth prospects (since it includes Paris), the absence of data for it has led me to exclude the GDP growth rates for the whole Île-de-France region.

Figure 13: Comparison between the impact of the Freycinet plan on French regions' population and the evolution of the log of real GDP

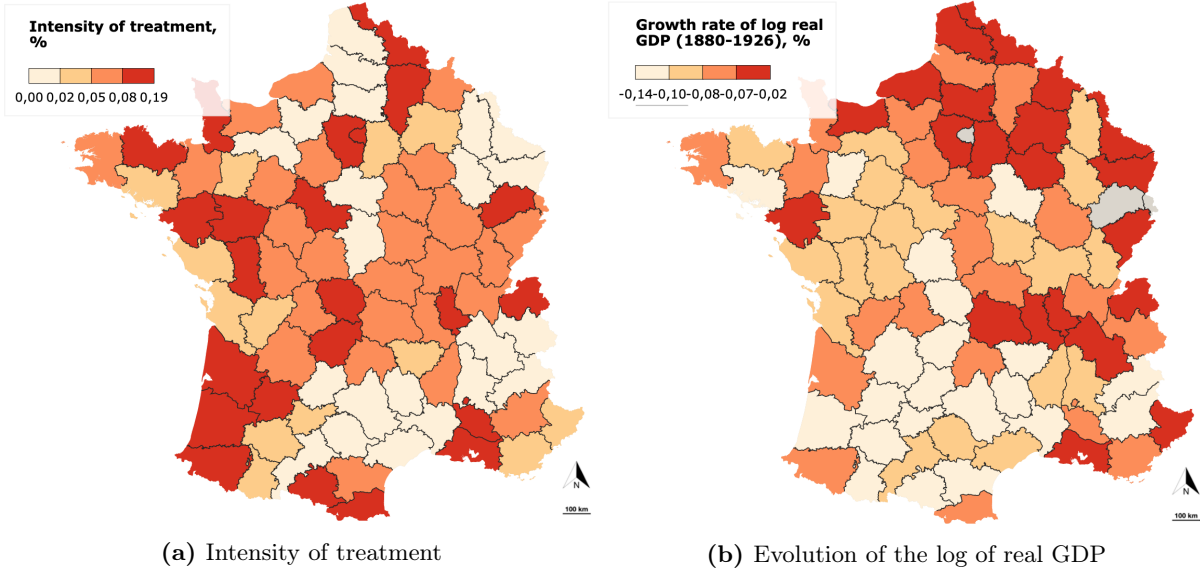


IV estimates of "Freycinet" impact correspond to the values of  $\alpha_4$  of equation (8) for each region. GDP growth rates are computed from the data of Bazot (2014) & Monnet et al. (2020). French region borders after the reform of 2015 are retained. Maps were done with R & Khartis.

From Figure 13, it appears that three regions benefited the most from the Freycinet plan: Hauts-de-France, Grand-Est and Provence-Alpes-Côte d'Azur. These three regions have also enjoyed the highest relative real GDP growth rates over the period 1880-1926, especially because they are located at the borders (and carried out a lot of international trade and welcomed many migrants) and/or in highly industrialised regions at the time. For these regions, there seems therefore to be a high correlation between benefits from the plan and economic growth, although summary statistics cannot make me understand the direction of the relationship at this point. Conversely, for the rest of France, the correlation does not hold that much: regions in which the Freycinet plan had a positive effect on the population between 20% and 40% (Bretagne, Centre-Val-de-Loire and Nouvelle-Aquitaine) all experienced very low and negative GDP growth rates, as much as places where the Freycinet plan only had a small impact (Pays-de-la-Loire, Occitanie, Bourgogne-Franche-Comté). Rhône-Alpes also enjoyed a higher economic growth (relatively to the rest of the territory), although the Freycinet plan had a very small impact there. One needs therefore more information to understand the relationship between both the plan and economic growth.

Looking at data at the level of the *département* also shows correlations that are not very straightforward and clear. In Figure 14, I sketch two maps with, for each *département*, (a) the intensity of the treatment i.e. the number of "Freycinet" municipalities (based on the same definition as above i.e. being at most at 1 km from a Freycinet station) on the total amount of municipalities in the *département* and (b) the evolution of the log real GDP (1880-1926).

**Figure 14: Comparison between the intensity of the treatment and the evolution of the log of real GDP in French *départements***



Intensity of treatment is the number of “Freycinet” municipalities over the total number of municipalities in the *département*. GDP growth rates are computed from the data of [Bazot \(2014\)](#) & [Monnet et al. \(2020\)](#). Values are based on quartiles for each variable. Seine, Haute-Saône & Territoire de Belfort are coloured in grey in map (b) due to missing data. Maps were done with R & Khartis.

Very broadly, the North and East of France have experienced the smallest decline in GDP, while only very few *départements* have been intensely treated by the Freycinet plan (namely Pas-de-Calais and Aisne). The opposite is true for the South-West: this area received many Freycinet stations but suffered from strong economic decline. Apart from this, the center, due south and South-East seem similar among both variables and the correlation appears substantial. These maps therefore hint at the idea that there seems to be an imperfect relationship between Freycinet connections and economic growth, which especially does not hold at high levels of Freycinet connections (intensely served areas experience a decline in growth). It is necessary to go beyond such impressions and to measure exactly the causal effect of the Freycinet plan on economic outcomes.

### 3.3 The Freycinet Plan and economic outcomes of *département*: methodology

To understand the effect of the Freycinet plan on economic outcomes at the level of the *département*, I cannot rely on the dummy I have been using before, that was equal to 1 for each municipality at most 1 km away from a Freycinet station. Now, I rather focus on the amount of such municipalities in each *département*. Therefore, let’s denote:

- $Y_{d,t}$  the outcome of interest of *département*  $d$  in year  $t$ , where  $t$  is equal either to 1911 or 1926. Outcomes of interest include the logs of: GDP, wages, industrial and commercial profits, farm profits, noncommercial profits (see Data section for definitions).
- $Freycinet\_mun_{d,t}$  the amount of municipalities in *département*  $d$  that are considered “treated” according to the previous definition (i.e. being at a maximum of 1 km from the closest Freycinet station) in year  $t$
- $X_{d,t}$  a vector of controls at the level of *département*  $d$  in year  $t$
- $\epsilon_{d,t}$  the error term

The definitions of control variables have also changed. They are based on the same logic as in section 2 but are redefined at the level of the *département*. They consist, in each *département* in the number of coastal municipalities, the number of municipalities close to lakes, the number of municipalities close to rivers, the number of municipalities already served by railways before the Freycinet plan, the number of municipalities served by railways between 1879 and 1914 but not thanks to the Freycinet plan, the total surface of the *département* and eventually its average altitude. The estimated model is therefore:

$$Y_{d,t} = \beta_0 + \beta_1 * Freycinet\_mun_{d,t} + \beta_2 * X_{d,t} + \epsilon_{d,t} \quad (9)$$

The coefficient of interest is  $\beta_1$  which gives the marginal effect of one additional station in the *département* on the outcome of this *département* in 1911 or 1926, *ceteris paribus*.

However, for the same reasons than explained in section 2.3, the number of municipalities connected to the railway due to the Freycinet plan cannot be deemed exogenous. This is why I also make use of the instrumental variable approach described in section 2.3. Now, the estimation is made at the level of the *département* and not the municipality anymore. This is why, to instrument  $Freycinet\_mun_{d,t}$ , I likewise use the number of municipalities that were located on a straight line between two endpoints (specifically, at a maximum of 5 km from such straight lines). Denoting  $Lines\_mun_d$  the amount of municipalities located at most 5 km away from a straight line, the model becomes:

#### First stage regression

$$Freycinet\_mun_{d,t} = \zeta_0 + \zeta_1 * Lines\_mun_d + \zeta_2 * X_{d,t} + \mu_{d,t} \quad (10)$$

#### Second stage regression

$$Y_{d,t} = \alpha_0 + \alpha_1 * \widehat{Freycinet\_mun}_{d,t} + \alpha_2 * X_{d,t} + \epsilon_{d,t} \quad (11)$$

For this strategy to be valid, as in section 2.3, I also need to exclude from  $Freycinet\_mun_{d,t}$  and  $Lines\_mun_d$  all the connected municipalities that are themselves endpoints, because the latter have been targeted by the plan and, by definition, are located on the straight lines. Including them would break the exclusion restriction of the instrument. Consequently, in all table results, for the OLS and for the IV,  $Freycinet\_mun_{d,t}$  and  $Lines\_mun_d$  refer to the number of Freycinet municipalities and the number of municipalities on straight lines, always exclusive of endpoint municipalities.

Besides the exclusion restriction (cf. section 2.3 for longer discussions), the first stage needs to be strong i.e.  $Lines\_mun_d$  needs to predict well  $Freycinet\_mun_{d,t}$ . Table 8 reveals that it is clearly the case. An additional municipality on a straight line increases the average number of Freycinet municipalities by 0.320 in 1911 and 0.324 in 1926, *ceteris paribus*. The results are statistically significant at the 99% level and the models fit well, with very high R-squared and F-statistics. Again, as in section 2, it appears that the instrumental strategy is valid and the instrument cannot be deemed weak.



**Table 8: The impact of straight-line municipalities on Freycinet railway connections: First stage statistics**

Dependent variable: Nb. of Freycinet municipalities		
	(1) In 1911	(2) In 1926
<b>Nb. of municipalities on straight lines</b>	0.320*** (0.032)	0.324*** (0.030)
<b>Observations</b>	85	83
<b>F-statistic</b>	40.464	58.942
<b>P-value of F-statistic</b>	0.000	0.000
<b>R-squared</b>	0.815	0.836

Robust standard errors in parentheses. Controls include, in each *département*, the number of coastal municipalities, the number of municipalities close to lakes, the number of municipalities close to rivers, the number of municipalities already served by railways before the Freycinet plan, the number of municipalities served by railways between 1879 and 1914 but not thanks to the Freycinet plan, the total surface of the *département* and eventually its average altitude.

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

Eventually, when applicable, it is also interesting to dig into non-linear effects of the number of Freycinet municipalities. Indeed, it is conceivable that the first connected municipalities induced a positive shock on GDP, as they opened new markets and could have benefited to many municipalities, while additional train connections may have had only lower contributions and could even have led to congestion effects. To understand this, I add to the previous regressions the squared term of  $Freycinet\_mun_{d,t}$ , and therefore the squared instruments as well (still excluding endpoints from the total), as such:

#### First stage regressions

$$Freycinet\_mun_{d,t} = \zeta_0 + \zeta_1 * Lines\_mun_d + \zeta_2 * Lines\_mun_d^2 + \zeta_3 * X_{d,t} + \mu_{d,t} \quad (12)$$

$$Freycinet\_mun_{d,t}^2 = \zeta_0 + \zeta_1 * Lines\_mun_d + \zeta_2 * Lines\_mun_d^2 + \zeta_3 * X_{d,t} + \mu_{d,t} \quad (13)$$

#### Second stage regression

$$Y_{d,t} = \alpha_0 + \alpha_1 * \widehat{Freycinet\_mun}_{d,t} + \alpha_1 * \widehat{Freycinet\_mun}_{d,t}^2 + \alpha_3 * X_{d,t} + \epsilon_{d,t} \quad (14)$$

### 3.4 The Freycinet Plan and economic outcomes of *département*: results

Table 9 provides the results of the estimation of equation (11) (with the results of the OLS i.e. equation [9] below)<sup>24</sup>. Commenting upon the IV results, it appears that Freycinet municipalities did contribute to real GDP some years after the implementation of the Plan. Indeed, while they had no statistically significant effect on local real GDP in 1911, it appears that an additional Freycinet municipality in a *département* has increased real GDP in 1926 by an average of 1.1% (i.e. 0.011 log points), *ceteris paribus*. The result is statistically significant at the 99% level. Similarly to what I had identified in section 2.6, it appears that prior stations had larger effects than contemporaneous non-Freycinet stations; however as these variables are here endogenous I should not comment upon them too much. In

<sup>24</sup>The associated reduced form estimates are provided in Appendix C.2, regressing the number of municipalities on straight lines (excluding endpoints) on the outcomes of interest. The definition of second stage estimates as the ratio of reduced form estimates on first stage estimates is clearly verified in Table 25.

any case, the positive impact of the Freycinet plan that was visible in municipal populations (cf. section 2) is reflected in economic output of French *départements*, suggesting the plan was favourable both to economics and demographics, at least some years after its implementation.

**Table 9: The impact of Freycinet railway connections on *départements*' GDPs and their components**

	IV 2SLS estimates					
	Real GDP (log)		Components of GDP (log)			
	(1) In 1911	(2) In 1926	(3) Comm. profits	(4) Farming profits	(5) Wages	(6) Non comm.
<b>Nb. of Freycinet municipalities</b>	0.005 (0.003)	0.011*** (0.004)	0.011** (0.005)	0.002 (0.005)	0.012** (0.005)	0.010*** (0.004)
<b>Total surface</b>	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)
<b>Average altitude</b>	-0.001** (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.002*** (0.000)	0.000 (0.000)	-0.001** (0.000)
<b>Nb. of coastal municipalities</b>	0.014 (0.009)	0.027** (0.011)	0.021* (0.012)	0.039* (0.020)	0.027** (0.012)	0.026** (0.012)
<b>Nb. of lake municipalities</b>	0.023 (0.018)	0.021 (0.022)	0.029 (0.026)	0.001 (0.027)	0.009 (0.029)	0.013 (0.019)
<b>Nb. of river municipalities</b>	-0.002 (0.002)	-0.001 (0.002)	-0.001 (0.002)	0.004** (0.002)	-0.001 (0.002)	-0.001 (0.002)
<b>Nb. of municip. with prior stations</b>	0.013*** (0.002)	0.017*** (0.002)	0.016*** (0.003)	0.014*** (0.003)	0.021*** (0.003)	0.016*** (0.002)
<b>Nb. of municip. with contemp. stations</b>	-0.000 (0.002)	0.002 (0.003)	0.003 (0.003)	-0.004 (0.003)	0.004 (0.003)	0.002 (0.002)
<b>F-statistic</b>	10.865	16.159	10.409	16.483	14.136	16.834
<b>P-value of F-statistic</b>	0.000	0.000	0.000	0.000	0.000	0.000
<b>R-squared</b>	0.494	0.577	0.516	0.584	0.542	0.597
	OLS estimates					
<b>Nb. of Freycinet municipalities</b>	0.008** (0.004)	0.009** (0.004)	0.009** (0.004)	0.005 (0.005)	0.011** (0.005)	0.009** (0.004)
<b>Controls</b>	Yes	Yes	Yes	Yes	Yes	Yes
<b>Observations</b>	85	83	83	83	83	83

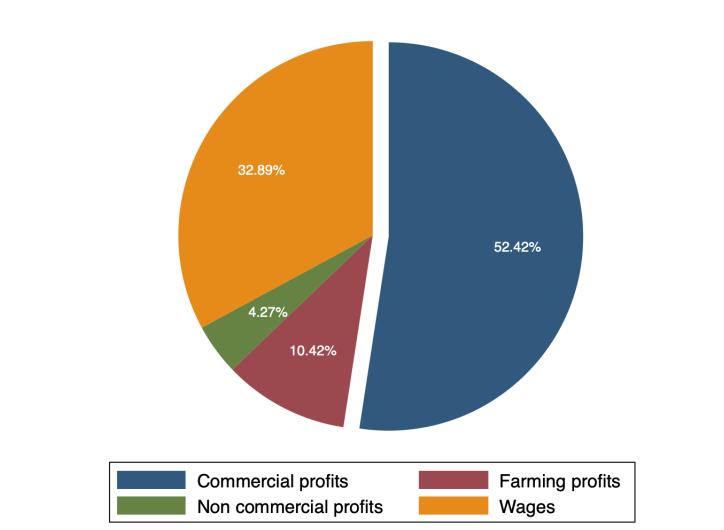
Robust standard errors in parentheses

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

Table 9 also gives more insight on the composition of GDP, in 1926. In their measures of activity

indices at the level of *départements* for the Interwar period, [Monnet et al. \(2020\)](#) use a revenue approach, adding incomes of all sources at the time (cf. Data section for more details). Figure 15 shows that commercial profits and wages constitute the core of GDP in 1926, well before farming and non commercial profits.

**Figure 15: Decomposition of nominal GDP in 1926**



Source: Author's graph with data from [Monnet et al. \(2020\)](#)

Columns (3)-(6) of Table 9 grind on this rich decomposition<sup>25</sup>. It appears that additional Freycinet municipalities had a positive and statistically significant effect on commercial profits, non-commercial profits and wages in 1926. An additional Freycinet municipality in a *département* has increased, *ceteris paribus* and on average, nominal commercial profits by 1.1%, wages by 1.2% and non-commercial profits by 1.0%. However, it had no effect on farming profits, while the model fits well the data, with a high R-squared (0.584) and F-statistic (16.483). This highlights that the Freycinet plan can be seen as a clear industrial policy ([Gonjo \(1972\)](#)), that contributed to the growth of the secondary and tertiary sectors, while leaving the primary sector quite unaffected. Actually, one may have thought of two contrasting potential effects of the plan on the farming industry: on the one hand, farmers may have also benefited from a decrease in transportation costs that helped them send more products at a lower price without penalising their margins; on the other hand, the plan disrupted the country-side with railway building and fostered population and urban growth (cf. section 2) and, to some extent, rural exodus. The absence of statistically significant effect of the plan on farming profits therefore seems to shed light on the fact that both contrasting effects were at work and are hard to disentangle.

Besides, Table 10 gives the results of equation (14), focusing on non-linear effects. To understand them, it is firstly basically very important to know if it is relevant to include squared terms in the regression. For this reason, I perform a joint significance test for  $Freycinet\_mun_{d,t}$  and  $Freycinet\_mun_{d,t}^2$  for all models and report the resulting p-value at the bottom of Table 10. It appears that p-values are lower than the critical value of 5% only for columns (2), (3), (5) and (6), meaning it is relevant to comment only upon the effect of the Freycinet plan, in 1926, on real GDP, commercial profits, wages and non-commercial profits.<sup>26</sup>

Across all the four outcomes retained, the pattern is exactly the same: the first Freycinet municipalities contribute positively to the *départements*' GDP, commercial profits, wages and non-commercial profits in 1926, *ceteris paribus*, as the positive coefficients associated to  $Freycinet\_mun_{d,t}$  highlight.

<sup>25</sup>Note that, compared to GDP which is deflated using the price indices of [Lévy-Leboyer and Bourguignon \(1985\)](#), the components of GDP here are expressed in nominal terms.

<sup>26</sup>I also ran such tests for higher order polynomials, namely  $Freycinet\_mun_{d,t}$  to the power of 3 and 4, but no tests yielded any sufficiently low p-values for the inclusion of such terms to be relevant. As a result, I stick to quadratic effects with squared terms.

Then, negative signs on the squared terms indicate that as the number of Freycinet municipalities increases in the *département*, the returns to an additional municipality decrease. This is clear evidence of congestion effects due to the very high number of stations built due to the Freycinet plan, at a time when the French railway system reached an apex. As a matter of fact, it is possible to compute the turning point for each outcome, by dividing the coefficient of  $Freycinet\_mun_{d,t}$  by twice the coefficient of  $Freycinet\_mun_{d,t}^2$  in absolute terms. The computation shows that the congestion effects start at 80 Freycinet municipalities for the log of real GDP in 1926, at 67 for the log of commercial profits, at 83 for the log of wages and at 79 for the log non-commercial profits.

**Table 10: The impact of Freycinet railway connections on *départements*' GDP: non-linear effects**

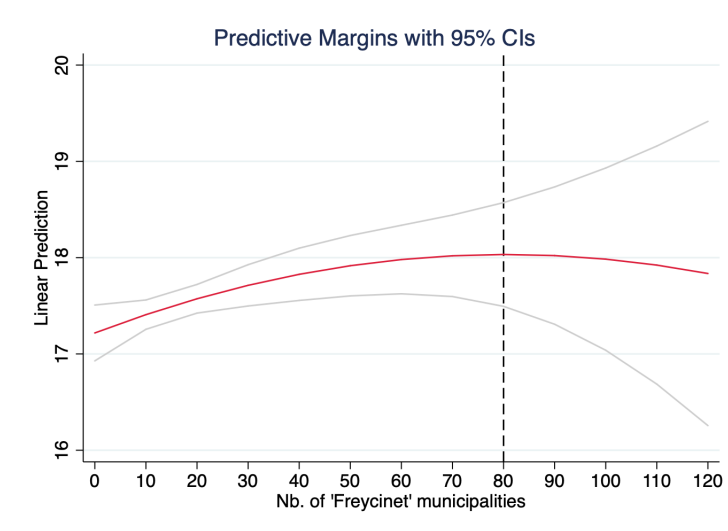
IV 2SLS estimates						
	Real GDP (log)		Components of GDP (log)			
	(1) In 1911	(2) In 1926	(3) Comm. profits	(4) Farming profits	(5) Wages	(6) Non comm.
<b>Nb. of Freycinet municipalities</b>	0.00123 (0.01034)	0.02027* (0.01135)	0.02499** (0.01198)	-0.01302 (0.01369)	0.02094* (0.01217)	0.01886 (0.01204)
<b>Nb. of Freycinet municipalities squared</b>	0.00005 (0.00011)	-0.00013 (0.00012)	-0.00019 (0.00013)	0.00021 (0.00014)	-0.00013 (0.00012)	-0.00012 (0.00013)
<b>Controls</b>	Yes	Yes	Yes	Yes	Yes	Yes
<b>Observations</b>	85	83	83	83	83	83
<b>P-value of Joint-F-stat.</b>	0.07808	0.00770	0.02124	0.08256	0.01723	0.02863
<b>R-squared</b>	0.49153	0.57842	0.51726	0.58332	0.54493	0.59292

Robust standard errors in parentheses. Controls include, in each *département*, the number of coastal municipalities, the number of municipalities close to lakes, the number of municipalities close to rivers, the number of municipalities already served by railways before the Freycinet plan, the number of municipalities served by railways between 1879 and 1914 but not thanks to the Freycinet plan, the total surface of the *département* and eventually its average altitude.

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

Eventually, Figure 16 illustrates the pattern described in the previous table, for the log of real GDP in 1926. It graphs predicted values for GDP according to the number of Freycinet municipalities (with all the controls included). The turning point at 80 seems clear, with an increasing pattern and then a decreasing direction, although with a less steep slope and more imprecise measures. This hints at the idea that the French territory was over-equipped in railways at the end of the Freycinet era, a situation that had negative consequences on its growth prospects [Le Bris \(2012\)](#).

Figure 16: Quadratic effects of Freycinet municipalities on the log of real GDP in 1926



## Conclusion

In this paper, I have studied the structure and the impact of the Freycinet plan (1879-1914) on French municipalities. I have first shown that the plan entailed a massive increase in the volume of railways in France, making it become the second country in Europe, behind Germany, in terms of total length of open railway lines in 1913. In particular, France overcame its strategic disadvantage with respect to Great Britain. In line with the republican ideology at the time, the plan had the objective to bring the train to remote areas (compared to previous railway connections) and this objective was indeed fulfilled. On average, “Freycinet municipalities” had much lower growth prospects and higher natural disadvantages compared to municipalities with prior railway connections.

Targeting these municipalities, The Freycinet plan also made them enjoy larger populations, relatively to non-Freycinet municipalities. Indeed, in my preferred specification, thanks to a difference-in-differences and instrumental variable strategy, I find that, *ceteris paribus*, gaining railway access thanks to the Freycinet plan is associated with an average relative increase of about 30% in the population of newly connected municipalities, after the plan was implemented in the 1920s, compared to non-Freycinet municipalities and to the period before 1879. The result is robust to many specifications and sample restrictions. Three main results can also be extracted from the analysis. First, the effect of the plan was somewhat similar over time, for municipalities connected at the very beginning of the plan (in the 1880s) similarly to municipalities connected later (e.g. in the 1890s), except for those connected in the late 1900s. Second, the plan reinforced the advantage of towns which already had train connections before 1879 and gained new ones with the Freycinet plan, but also benefited to many more rural and smaller municipalities connected for the first time. Third, the relative population superiority of Freycinet municipalities can be explained – at least partly – by the fact that they attracted people from other non-Freycinet municipalities, due to reorganisation patterns of population across the territory.

The Freycinet plan also had local effects. It is clear that not all regions benefited massively from it. Some regions enjoyed higher effects on their population relatively to others, in particular Hauts-de-France, Grand-Est and Provence-Alpes-Côte d’Azur, which also experienced the highest economic growth rates on the period (1880-1926). Moreover, the Freycinet plan contributed to French *départements*’ economic outcomes. On average, an additional Freycinet municipality in a *département* increased the log of real GDP in 1926 by 1.1%, *ceteris paribus*. In particular, the Freycinet plan had positive and statistically significant effects on commercial and non-commercial profits, as well as on wages, but no effects on farming profits. However, these effects were non-linear: the first train connections had positive effects on these outcomes while at some point, the effect became negative, due to congestion effects.

If these results highlight a positive contribution of the Freycinet plan to economic development and French GDP at the beginning of the 20<sup>th</sup> century, they do not tell us what the picture would have been without the increasing railway density that the Freycinet plan brought – and neither how much the contribution of these new railways represents in the aggregate French GDP at the time. In the same perspective, the effects I have studied on population specifically are relative effects, for the Freycinet “treated” municipalities compared to control municipalities. It does not fully take into account potential spillovers from treated to control municipalities (despite other definitions of treatment in section 2.6 and the study of displacement effects in section 2.7). It therefore remains a question for future research to assess the aggregate impact of Freycinet train constructions (and more generally all French railways) on the total French GDP at the time.

Counterfactual analysis can be really useful for this. As an opening towards new research areas, I therefore describe what this kind of approach could be. [Donaldson and Hornbeck \(2016\)](#) and [Hornbeck and Rotemberg \(2019\)](#) have framed a very interesting market-access approach to understand the contribution of railroads to American output in 1890 (i.e. the same year as in [Fogel \(1964\)](#)), studying respectively agricultural land and manufacturing at the county level. The market access approach is common in both articles: the idea is basically that railroads increased the market access of all counties as they were built, compared to the initial situation (in 1860 or 1870 in the papers) where waterways and wagons were the main means of transportation. Even if a county did not welcome new railways, its market access may have increased for instance if another county with which it traded a lot enjoyed better railway connections (due to spillover effects); for that reason a county’s market access aggregates virtually all direct and indirect effects of increased railway construction. The authors therefore regress the changes in market access on

the changes in either the value of agricultural land in counties (Donaldson and Hornbeck (2016)) or the change in the county total productivity of the manufacturing sector (Hornbeck and Rotemberg (2019)) and find positive and significant associations (let's call "A" the estimated coefficient). Then, they compute the market access of all counties in 1890 without railroads (i.e. with only waterways and wagons), which is their counterfactual situation. Next, they compute the difference between this counterfactual market access and the actual market access of counties in 1890 with railroads (let's call this difference "B"). As a result, if I take the example of Donaldson and Hornbeck (2016), the decrease in the total value of US agricultural land is simply equal to  $100-(A \times B)\%$ . They then express the value of this loss in dollars and relate it to the actual GDP in 1890, which gives them the contribution of railroads to the GDP.

Applying such a method to the French case could indeed yield very interesting insights on the role that railroads played in French output and growth. It would be first necessary to find convincing measures of market access, which requires, in the simplified form used by the authors, population data (which I already used) but also transportation length and prices from one locality to another on each means of transportation (railroad, waterways and wagons)<sup>27</sup>. Data on local agricultural land values and/or manufacturing output and inputs (land, capital, labour, raw materials) would also be necessary. It would be important as well to define the proper administrative level of analysis, since it is generally possible to get such data at the level of the *département* in France, but this level seems already too large to get precise and convincing results. Conversely, municipalities appear too numerous to make it possible to digitise such a variety of data. In Table 26 of Appendix C.3, I therefore summarise the (minimum) data and variables I consider necessary to implement Donaldson and Hornbeck (2016)'s and Hornbeck and Rotemberg (2019)'s approaches to the French case (or basically to any other country). This methodology should yield original and appealing results to better understand the contribution of railroads to the French economy and growth, beyond the results I have already brought to light in this paper about the Freycinet plan.

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<sup>27</sup>More complex forms of market access also require at least a measure of trade elasticity.

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# Appendices

## A Appendix to section 1

### A.1 General information on the Freycinet plan

Table 11: List of initially planned v. eventually retained lines of the Plan Freycinet

Line nb	Initial itinerary (Law of July 17, 1879)	Status	Finally retained itinerary
1	Armentières à Lens, par Don	1	Armentières à Lens, par Don (Sainghin-en-Weppes)
2	Armentières à Tourcoing et à Roubaix	4	
3	Roubaix à la frontière belge, vers Audenarde	5	
4	Valenciennes à Denain et Louches, par ou près Trith-Saint-Léger	1	Valenciennes à Louches (Rœulx)
5	Denain à Saint-Amand	1	Denain à Saint-Amand-les-Eaux
6	Don à Templeuve	1	Don (Sainghin-en-Weppes) à Templeuve
7	Lille (la Madeleine) à Lannoy, par le Breucq, l’Empempont et Ham	3	
8	Ormoy à la vallée de l’Ourcq, par ou près Betz	1	Ormoy-Villers à Mareuil-sur-Ourcq

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Table 11 – Continued from previous page

Line nb	Initial itinerary (Law of July 17, 1879)	Status	Finally retained itinerary
9	D'un point de la ligne de Villers-Cotterets à Château-Thierry à une station à établir sur la ligne de Paris à Avricourt, entre les stations de Trilport et Changis	1	Trilport à Bazoches
10	Hirson à Busigny, avec embranchement de ou près Wimy à Guise	1	Hirson à Busigny
11	Solre-le-Château à Avesnes	1	Solre-le-Château à Avesnes-sur-Helpe
12	Valenciennes à Laon, par ou près le Cateau	1	Valenciennes à Laon
13	Laon à Mézières, par ou près Rozoy (Aisne)	1	Laon à Tournes
14	D'un point à déterminer sur la ligne de Mézières à Hirson, par Rocroy, à la frontière belge, vers Chimay	4	
15	Soissons à Réthel, par la vallée de l'Aisne	4	
16	Montmédy à Stenay ou à Dun	3	
17	Baroncourt à Étain	3	
18	Revigny à Saint-Dizier	1	Revigny-sur-Ornain à Saint-Dizier
19	Melun à la Ferté-sous-Jouarre, par ou près Rozoy et Coulommiers	4	
20	Esbly à un point à déterminer sur la ligne de Gretz à Coulommiers, entre Faremoutiers et Coulommiers	2	Esbly à Crécy-la-Chapelle
21	Laon à ou près Château-Thierry	3	
22	Provins à Esternay, par ou près Villiers-Saint-Georges	1	Provins à Esternay
23	Fère-Champenoise à Vitry-le-François	1	Fère-Champenoise à Vitry-le-François
24	Avallon à Bourges, par ou près Clamecy, Cosne et Sancerre (entraînant la suppression de Chatel-Censoir à Sermizelles)	2	Clamecy à Cosne-Cours-sur-Loire
25	Cosne à Saint-Sauveur	4	
26	Auxerre à Vitry-le-François, par ou près Saint-Florentin, Troyes et Brienne	1	Auxerre à Vitry-le-François
27	Gerbéviller (Meurthe-et-Moselle) à Bruyères (Vosges)	1	Gerbéviller à Bruyères
28	Jussey à la ligne d'Épinal et à Aillevillers	2	Jussey à Darnieulles
29	Prolongement de la ligne de Remiremont à Saint-Maurice-sur-Moselle jusqu'à Bussang	1	Saint-Maurice-sur-Moselle à Bussang
30	Bas-Évette (Belfort) à Giromagny	1	Évette-Salbert à Giromagny
31	Lure à Loulans-les-Forges, par Villersexel	1	Lure à Montbozon
32	Raccordement entre la ligne de Ceinture de Paris (rive gauche) et la ligne de Paris à ou près Auneau	3	
33	Raccordement entre la ligne de Ceinture de Paris (rive gauche) et celle du pont de l'Alma à Courbevoie	5	
34	Raccordement entre la ligne de Grande-Ceinture, à Saint-Germain-en-Laye, et la gare actuelle de Saint-Germain	5	
35	Raccordement entre la ligne de Grande-Ceinture, près l'Étang-la-Ville, et la ligne de Paris à Versailles (rive droite), vers Saint-Cloud	1	Saint-Cloud à Saint-Nom-la-Bretèche
36	Rambouillet à un point à déterminer sur la ligne de Pontoise à Gisors, entre Ws-Marines et Chars, en passant par un point à déterminer entre Mantes et Meulan	2	Plaisir-Grignon à Épône-Mézières
37	Palaiseau à Épinay-sur-Orge	1	Palaiseau à Épinay-sur-Orge
38	Paris (gare spéciale) à ou près Auneau	2	Paris à Chartres
39	De la limite des départements de Seine-et-Oise et d'Eure-et-Loir, près Auneau, à Melun, par ou près Étampes	2	Étampes à Auneau
40	Eu à Dieppe	1	Eu à Dieppe
41	Dieppe au Havre	1	Dieppe au Havre

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Table 11 – Continued from previous page

Line nb	Initial itinerary (Law of July 17, 1879)	Status	Finally retained itinerary
42	Pont-Audemer à la ligne de Pont-l'Évêque à Honfleur	1	Pont-Audemer à Quetteville
43	Pont-Audemer à Port-Jérôme, avec bac à vapeur sur la Seine	3	
44	Raccordement, entre Quévilly et Sotteville, des chemins de fer d'Orléans à Rouen et de Paris à Rouen	5	
45	Raccordement, près Elbeuf, des lignes d'Orléans à Rouen et de Serquigny à Rouen	5	
46	Vire à Saint-Lô	1	Vire à Saint-Lô
47	Fougères à Vire et à un point à déterminer entre Bayeux et Caen	2	Fougères à Caen
48	Cherbourg à Beaumont-Hague (Manche)	3	
49	Carentan à la ligne de Sottevast à Coutances	1	Carentan à La-Haye-du-Puits
50	Coutances à Regnéville	1	Coutances (La-Haye-du-Puits) à Regneville
51	De la limite de la Manche, vers Avranches, à Domfront (Orne)	1	Pontaubault à Domfront
52	Sablé à Sillé-le-Guillaume	1	Sablé-sur Sarthe à Sillé-le-Guillaume
53	Connerré à Courtalain	1	Connerré (Beillé) à Courtalain (Saint-Pellerin)
54	Niort à Montreuil-Belley, avec embranchement sur Moncontour	1	Niort à Montreuil-Belley
55	Benet à la ligne de Niort à Ruffec	3	
56	De la limite de la Sarthe (vers la Flèche) à Saumur et raccordement des gares de Saumur	1	La Flèche à Saumur
57	Saumur à Château-du-Loir, par ou près Noyant et Château-la-Vallière, avec raccordement de Savigny à la ligne de Château-du-Loir à Saint-Calais	1	Saumur à Château-du-Loir
58	Tours à Savigny, avec raccordement à la ligne de Vendôme à Pont-de-Bray, entre Vendôme et Montoire	1	Tours à Savigny-sur-Braye
59	Saint-Aignan, par Contres, vers Blois	1	Saint-Aignan (Noyers-sur-Cher) à Blois
60	Nantes à Segré	1	Nantes à Segré
61	Beslé à ou près la Chapelle-sur-Erdre, par Blain	1	Beslé (Guéméné-Penfao) à la Chapelle-sur-Erdre
62	Pouancé (Maine-et-Loire) à un point à déterminer sur la ligne de Paris à Rennes, entre Laval et le Genest, par ou près Craon	1	Pouancé à Laval
63	Raccordement, à Pontorson, des lignes de Saint-Lô à Lamballe et de Fougère à la baie du Mont-Saint-Michel	5	
64	Miniac à la Gouesnière, par Châteauneuf (Ille-et-Vilaine)	1	Miniac à la Gouesnière
65	La Brohinière à Dinan (Côtes-du-Nord) et Dinan à Dinard (Ille-et-Vilaine)	1	La Brohinière (Montauban-de-Bretagne) à Dinan
66	Châteaubriant à Ploërmel, par ou près Bain et Messac	1	Châteaubriant à Ploërmel
67	Auray à Quiberon (Morbihan)	1	Auray à Quiberon
68	Saint-Brieuc au Légué (Côtes-du-Nord)	5	
69	Guingamp à Paimpol (Côtes-du-Nord)	1	Guingamp à Paimpol
70	Carhaix à Guingamp, par Callac	1	Carhaix à Guingamp
71	La Brohinière à la ligne de Châteaulin à Landerneau, par Loudéac et Carhaix	1	La Brohinière (Montauban-de-Bretagne) à Châteaulin
72	Concarneau à Rosporden (Finistère)	1	Concarneau à Rosporden
73	Carhaix à ou près Quimperlé et Carhaix à ou près Morlaix	2	Morlaix à Rosporden, par Carhaix
74	Morlaix à Roscoff (Finistère)	1	Morlaix à Roscoff
75	Brest au Conquet (Finistère)	4	
76	Châteaulin à Camaret (Finistère)	1	Châteaulin à Camaret

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Table 11 – Continued from previous page

Line nb	Initial itinerary (Law of July 17, 1879)	Status	Finally retained itinerary
77	Quimper à Douarnenez (Finistère) et Quimper à Pont-l'Abbé (Finistère)	1	Douarnenez à Pont-l'Abbé, par Quimper
78	D'un point entre Machecoul et la Roche-sur-Yon à ou près Challans au goulet de Fromentine (Vendée)	4	
79	Velluire à Parthenay, par Fontenay-le-Comte et Breuil-Barret à Fontenay-le-Comte à Cholet	2	Velluire à Saint-Christophe-du-Bois, par Breuil-Barret
80	Surgères à Marans	1	Surgères à Marans
81	Saint-Laurent-de-la-Prée au fort d'Enet (Charente-Inférieure)	5	
82	Saint-Jean-d'Angély à Civray, avec embranchement sur Cognac, par Matha	1	Saint-Jean-d'Angély à Civray
83	Saujon (Charente-Inférieure) à un point de la ligne de Tonnay-Charente à Marennes	4	
84	Barbezieux à un point à déterminer entre Montendre et Cavignac	1	Barbezieux à Saint-Yzan-de-Soudiac
85	Bordeaux (gare spéciale) ou près Cavignac (Gironde)	2	Bordeaux à Cavignac
86	La Sauve à Eymet, par ou près Targon, Sauveterre, Monségur et Duras	1	La Sauve à Eymet
87	Libourne à ou près Langon	3	
88	De la gare de Moulis (ligne du Médoc) au port de Lamarque	3	
89	Châtelleraut à Tournon-Saint-Martin (Indre)	1	Châtelleraut à Tournon-Saint-Martin
90	Loudun à Châtelleraut	1	Loudun à Châtelleraut
91	Preuilly à Tournon-Saint-Martin (Indre)	1	Preuilly-sur-Claise à Tournon-Saint-Martin
92	Le Blanc à Argent	1	Le Blanc à Argent-sur-Sauldre
93	Issoudun à Bourges, par Saint-Florent	1	Issoudun à Bourges
94	Le Dorat à Magnac-Laval (Haute-Vienne)	1	Le Dorat à Magnac-Laval
95	Confolens à Bellac	3	
96	Ruffec à Excideuil	1	Ruffec à Roumazières-Loubert
97	Nontron à ou près Sarlat, en passant par ou près Thiviers, Villiac et Condat, avec embranchement d'Hautefort à un point à déterminer entre Objat et Brives (entraînant la suppression de la ligne de Nontron à Périgueux)	1	Nontron (Saint-Pardoux-la-Rivière), Saint-Aulaire, Hautefort, Terrasson-Lavilledieu, Sarlat-la-Caneda
98	Bussière-Galant à ou près Saint-Yrieix (Haute-Vienne)	1	Bussière-Galant à Saint-Yrieix-la-Perche
99	Limoges à Brive, par Uzerche, avec raccordement par la vallée de la Vézère et Treignac avec la ligne de Limoges à Meymac	2	Limoges à Brive
100	Uzerche à Aurillac, par ou près Tulle et Argentat	2	Uzerche à Argentat
101	D'un point à déterminer sur la ligne de Châteauroux à Limoges, entre Forgevieille et Eguzon, à ou près Guéret	1	Saint-Sébastien à Guéret
102	Felletin à Bort, par Ussel	2	Felletin à Ussel
103	Felletin à Bourgneuf	3	
104	Montluçon à Eygurande, par ou près Evaux et Auzances	1	Montluçon à Eygurande (Merlines)
105	Lavaud-Franche à la ligne de Montluçon à Eygurande, par ou près Chambon	3	
106	Saint-Éloi au col de Vauriat et raccordement du col de Gouttières à la ligne de Montluçon à Eygurande	2	Saint-Éloy-les-Mines à Volvic
107	Sancoins à ou près Lapeyrouse, par ou près Montmarault	1	Sancoins à Lapeyrouse
108	Bort à Neussargues (Cantal)	1	Bort-les-Orgues à Neussargues-Moissac
109	Laqueuille au Mont-Dore, par la Bourboule	1	Laqueuille (Saint-Julien-Puy-Lavèze) au Mont-Doré

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Table 11 – Continued from previous page

Line nb	Initial itinerary (Law of July 17, 1879)	Status	Finally retained itinerary
110	Villeneuve-sur-Lot à Tonneins et à Falgueyrat	1	Falgueyrat (Plaisance) à Tonneins, par Villeneuve-sur-Lot
111	Cahors à ou près Moissac	3	
112	Nevers à Tamnay (Nièvre)	4	
113	Tamnay à Château-Chinon	1	Tamnay-en-Bazois à Château-Chinon (campagne)
114	De Châtillon-sur-Seine à ou près Montchanin, par ou près les Laumes et Épinac	2	Épinac à Pouillénay
115	Chagny, par Seurre, à un point à déterminer sur la ligne de Dôle à Dijon	1	Chagny à Villers-les-Pots, par Allerey-sur-Saone
116	Vichy à Cusset	1	Vichy à Cusset
117	Givors à Paray-le-Monial, par ou près l'Arbresle	1	Givors à Paray-le-Monial
118	Paray-le-Monial à un point à déterminer entre Saint-Martin-d'Estréaux et la Palisse	3	
119	Champagnole à ou près Ambérieu, par la Cluse, avec embranchement sur Morez et embranchement de Verges à Jeurre	2	Champagnole à Ambérieu-en-Bugey
120	Lons-le-Saunier à Champagnole	1	Lons-le-Saunier à Champagnole
121	De la ligne de Lyon à Genève à Gex et à Divonne	1	Collonges-Fort-l'Écluse à Divonne-les-Bains
122	Gilley (Doubs) à Pontarlier	1	Gilley à Pontarlier
123	Voujeaucourt (Doubs) à Saint-Hippolyte	1	Voujeaucourt à Saint-Hippolyte
124	Saint-Hippolyte à la ligne de Besançon à Morteau	4	
125	La Roche à Saint-Gervais et à Chamonix (Haute-Savoie)	1	La Roche-sur-Foron à Chamonix
126	Albertville à Annecy	1	Albertville à Annecy
127	La Mure (Isère) à la ligne de Grenoble à Gap	1	La Mure à Saint-Georges-de-Commiers
128	Savines (Hautes-Alpes) à Barcelonnette	3	
129	Nyons à la ligne de Lyon à Marseille, par Valréas	1	Nyons à Pierrelatte
130	Vaison à Orange	1	Vaison-la-Romaine à Orange
131	Traversée du Rhône à Avignon	5	
132	Volx à Apt, avec embranchement sur Forcalquier	1	Volx à Apt
133	Sorgues à Saint-Saturnin (Vaucluse)	3	
134	L'Isle à Orange, par Carpentras	1	L'Isle-sur-la-Sorgue à Orange
135	Valdonne (Bouches-du-Rhône) à la ligne de Carnoules à Aix	1	Valdonne (Peypin) à La Barque (Fuveau)
136	Salon à la Calade, par Lambesc	1	Salon à la Calade (Marseille)
137	Digne à Draguignan, par ou près Castellane	3	
138	Digne à la ligne de Savines à Barcelonnette	3	
139	Draguignan à Cagnes, par Grasse	2	Draguignan à Cagnes-sur-Mer
140	Draguignan à Mirabeau, par Barjols	1	Draguignan à Mirabeau
141	Nice à Puget-Théniers	1	Nice à Puget-Théniers
142	Nice à Coni, par la vallée du Paillon, le contrefort de Braous, Sospel, le contrefort de Broïs et Fontan	1	Nice à Tende, par Breil-sur-Roya
143	Ajaccio à Propriano (Corse)	3	
144	Ponte-Leccia à Calvi (Corse)	5	
145	Cazamozza à Bonifacio (Corse)	5	
146	Ambert à la ligne du Puy à Saint-Georges-d'Aurac	1	Ambert à Darsac (Vernassal)
147	D'un point à déterminer sur la ligne d'Issoire à Neussargues à un point à déterminer, dans la direction de Saint-Étienne, sur la ligne de Montbrison à Monistrol	2	Sembadel à Saint-Bonnet-le-Château

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Table 11 – Continued from previous page

Line nb	Initial itinerary (Law of July 17, 1879)	Status	Finally retained itinerary
148	Saint-Étienne, par ou près Pélussin et Annonay, à la rive droite du Rhône, à un point à déterminer entre Serrières et Sarras	3	
149	Largentière à l'embranchement d'Aubenas	1	Largentière à Saint-Sernin
150	La Voulte-sur-Rhône à Yssingaux, par ou près le Cheylard (Ardèche)	1	La Voulte-sur-Rhône à Yssingaux
151	Tournon (Ardèche) à la ligne de la Voulte à Yssingaux	1	Tournon-sur-Rhône au Cheylard
152	Yssingaux à la ligne du Puy à Saint-Étienne	1	Yssingaux à Lavoûte-sur-Loire
153	Anduze à un point de la ligne de Rodez à Millau, entre Séverac-le-Château et Millau, avec embranchement sur Florac	3	
154	Montpellier à Ganges	3	
155	Espalion à la ligne de Rodez à Séverac-le-Château	1	Espalion à Bertholène
156	Estréchoux (Hérault) à Castanet-le-Haut	1	Saint-Étienne-Estréchoux à Saint-Génies-de-Varensal
157	Lunas à Lodève	3	
158	Saint-Chinian à ou près Saint-Pons	3	
159	Carmaux à un point à déterminer entre Vindrac et Laguéprie	1	Carmaux à Vindrac-Alayrac
160	La Bastide-Rouairoux (Tarn) à Bize (Aude)	3	
161	Agde à la mer	3	
162	Saint-Girons à Foix	1	Saint-Girons (Saint-Lizier) à Foix
163	D'un point à déterminer entre Pamiers et Saint-Antoine-de-Foix à un autre point à déterminer entre Limoux et Quillan	1	Pamiers à Limoux
164	Lavelanet (Ariège) à la ligne de Castelnaudary à Carcassonne	1	Lavelanet à Bram
165	Quillan à Rivesaltes (Pyrénées-Orientales)	1	Quillan à Rivesaltes
166	Prades à Olette (Pyrénées-Orientales)	1	Prades à Olette
167	Vicdessos à Tarascon (Ariège)	4	
168	Saint-Girons à Seix (Ariège)	3	
169	Ligne de ceinture de Toulouse	3	
170	Castelsarrasin à Lombez	2	Castelsarrasin à Beaumont-de-Lomagne
171	Auch à Lannemezan	3	
172	Lannemezan à Arreau (Hautes-Pyrénées)	1	Lannemezan à Arreau
173	Chaum (Haute-Garonne) à la frontière espagnole, au Pont-du-Roy	4	
174	Auch à Bazas, passant par ou près Eauze	2	Auch à Bazas
175	Saint-Sever à Pau, à Dax et à Mont-de-Marsan	2	Hagetmau à Dax, par Mont-de-Marsan
176	Vic-en-Bigorre à la ligne de Saint-Sever à Pau	3	
177	Nérac à Mont-de-Marsan, par ou près Mézin, Sos et Villeneuve-de-Marsan	1	Nérac à Mont-de-Marsan
178	Oloron à Bedous (Basses-Pyrénées)	1	Oloron-Sainte-Marie à Bedous
179	Oloron à la ligne de Puyoô à Saint-Palais, par la vallée du gave d'Oloron	4	
180	Saint-Martin-Autevielle à Mauléon	1	Saint-Martin-Autevielle à Mauléon-Licharre
181	Bayonne à Saint-Jean-Pied-de-Port, avec embranchement d'Ossés à Saint-Étienne-de-Baïgorry	1	Bayonne à Saint-Jean-Pied-de-Port

*Continued on next page*



Table 11 – Continued from previous page

Line nb	Initial itinerary (Law of July 17, 1879)	Status	Finally retained itinerary
<p>This table reports all the 181 lines present in the law of July 17, 1879, giving birth to Freycinet plan, in column 2. Column 3 gives the eventual status of the line at the time (not today): 1 means the line has been (completely or nearly completely) built as mentioned in the law; 2 means the line has been partially built compared to the law; 3 means the line has not been built; 4 means the line has been built, either completely or partly, but only as part of the secondary local railway network; 5 means the line has been built, either completely or partially, but has not been retained in the analysis for another reason. Other reasons include: the line only connects two municipalities, two parts of the municipality, a municipality at the border with the neighbouring country or municipalities in Corsica (all these cases are unused in my strategy). As a result, only lines having status 1 or 2 have been considered in the analysis. Column 4 gives the actual itinerary of the 126 considered lines used to construct the straight lines described in section 2.3, which can be different from column 2 if the name in column 2 is unclear or refers to a place not yet decided at the time of the law; if status is 2; or if a minor simplification has been made from column 2.</p>			

## B Appendix to section 2

### B.1 Indirect justification of the exclusion condition of the IV strategy

Table 12: Correlations between the instrument (Line) and many covariates

Covariate	(a) Dist. to lake	(b) Dist. to river	(c) Dist. to coast	(d) Altitude	(e) Surface	(f) Dist. to city	(g) Dist. end- point	(h) Dist. to other station
Effect of each covariate on instrument Line (5km)								
Effect on Line	-0.001 (0.000)	-0.007 (0.004)	0.001 (0.000)	-0.000 (0.000)	0.000 (0.000)	-0.008*** (0.001)	-0.000*** (0.000)	0.004** (0.001)
Observations	446355	446355	446355	446355	446355	446355	446355	446355

Robust standard errors in parentheses. All specifications include *département* fixed effects.

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

## B.2 Justification of the difference-in-differences design: Placebo tests

Table 13: OLS results of placebo tests

Dep. variable	Dist. to lake	Dist. to sea	Log of population		
	(1) Usual	(2) Usual	(3) Post =1866	(4) Post =1872	(5) Mun. > 30km
<b>Freycinet</b>	-0.069 (0.409)	-0.004 (0.457)	0.006 (0.022)	0.001 (0.020)	-0.001 (0.025)
<b>Treat</b>	-0.717*** (0.165)	-2.275*** (0.184)	0.152*** (0.017)	0.154*** (0.012)	-0.028* (0.014)
<b>Post</b>	-0.170 (0.087)	-0.011 (0.097)	-0.004 (0.005)	-0.034*** (0.004)	-0.378*** (0.007)
<b>Controls</b>	Yes	Yes	Yes	Yes	Yes
<b>Year FE</b>	No	No	No	No	No
<b>Geographical FE</b>	Dep.	Dep.	Dep.	Dep.	Dep.
<b>Observations</b>	446355	446355	66564	99780	55214
<b>F-statistic</b>	4142.085	3784.822	530.544	807.934	800.916
<b>P-value of F-statistic</b>	0.000	0.000	0.000	0.000	0.000
<b>R-squared</b>	0.922	0.964	0.454	0.455	0.438

Robust standard errors in parentheses. Controls include the distance to the closest lake, river, coastline, train line endpoint, big city, other non-Freycinet train station, as well as the average altitude and total surface of the municipality. See section 2.2. for more information on the specifications.

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

### B.3 Intent-to-Treat/Reduced Form results (impact on population)

Table 14: The impact of being on a straight line on municipality populations:  
Intent-to-Treat/Reduced Form estimates

Dependent variable: Log of population						
	Baseline model			With municipal FE		
	(1) Baseline	(2) Controls	(3) Time FE	(4) Baseline	(5) Time FE	(6) Def-2
<b>Line × Post (5km)</b>	0.067*** (0.012)	0.062*** (0.008)	0.062*** (0.008)	0.067*** (0.005)	0.069*** (0.005)	0.051*** (0.004)
<b>Line (5km)</b>	0.171*** (0.006)	-0.027*** (0.005)	-0.027*** (0.005)			
<b>Post</b>	-0.309*** (0.005)	-0.337*** (0.004)		-0.309*** (0.002)		
<b>Controls</b>	No	Yes	Yes	No	Yes	Yes
<b>Year FE</b>	No	No	Yes	No	Yes	Yes
<b>Geographical FE</b>	None	Dep.	Dep.	Mun.	Mun.	Mun.
<b>Observations</b>	202126	202126	202126	202126	202126	440793
<b>F-statistic</b>	1940.502	2469.520	1823.300	11395.539	4265.746	2488.930
<b>P-value of F-statistic</b>	0.000	0.000	0.000	0.000	0.000	0.000
<b>R-squared</b>	0.031	0.461	0.462	0.365	0.371	0.309

Robust standard errors in parentheses. Controls include the distance to the closest lake, river, coastline, train line endpoint, big city, other non-Freycinet train station, as well as the average altitude and total surface of the municipality.

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

## B.4 Robustness check: effects on municipality populations when varying the post-treatment era

Table 15: The impact of Freycinet railway connections on municipality populations: different post-treatment periods (IV 2SLS estimates)

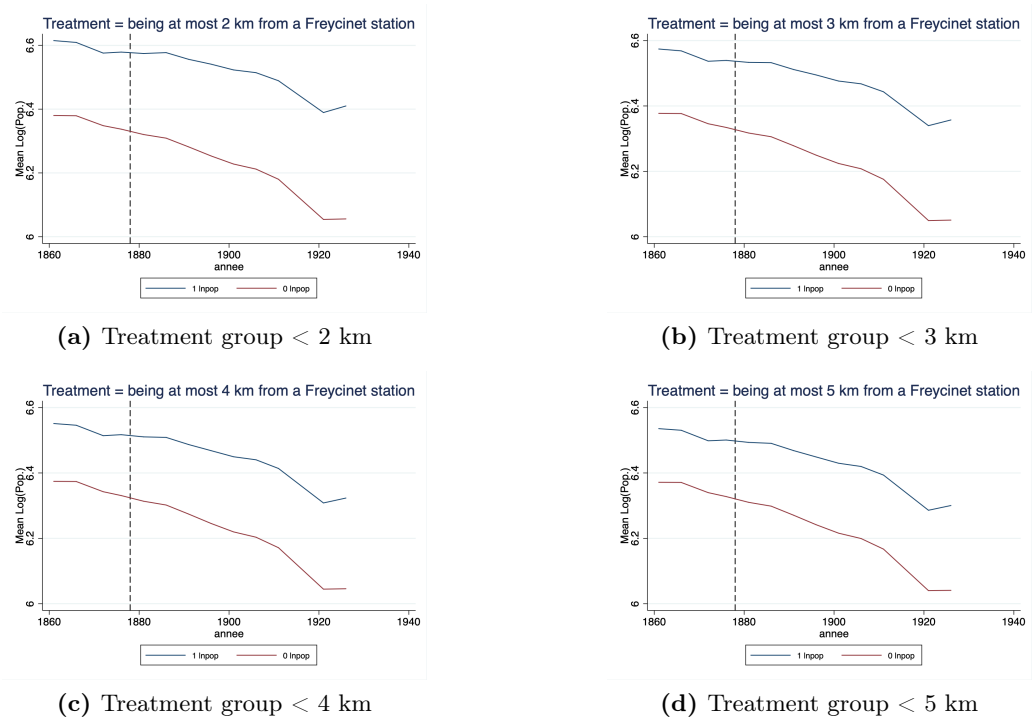
Post period =	Dependent variable: Log of population					
	(1) 1891	(2) 1896	(3) 1901	(4) 1906	(5) 1911	(6) 1921-26
<b>Freycinet</b>	0.399*** (0.047)	0.359*** (0.037)	0.340*** (0.034)	0.340*** (0.032)	0.209*** (0.018)	0.327*** (0.014)
<b>Controls</b>	Yes	Yes	Yes	Yes	Yes	Yes
<b>Year FE</b>	Yes	Yes	Yes	Yes	Yes	Yes
<b>Geographical FE</b>	Mun.	Mun.	Mun.	Mun.	Mun.	Mun.
<b>Observations</b>	167718	167718	167718	167715	167714	202105
<b>F-statistic</b>	1995.271	2439.208	2714.823	2737.647	3304.280	10987.015
<b>P-value of F-statistic</b>	0.000	0.000	0.000	0.000	0.000	0.000
<b>R-squared</b>	0.094	0.140	0.173	0.184	0.227	0.365

Robust standard errors in parentheses. The specification retained is specification 5, corresponding to the model described in section 2.3 (cf. IV equations 7-8) and visible in Table 5. Spec. 5 includes year fixed effects, controls and municipality fixed effects. Controls include the distance to the closest lake, river, coastline, train line endpoint, big city, other non-Freycinet train station, as well as the average altitude and total surface of the municipality.

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

**B.5 Robustness check: effects on municipality populations with different definitions of the treatment**

**Figure 17: Evolution of mean log population**



**Table 16: The impact of Freycinet railway connections on municipality populations in the 1920s: variations according to the definition of the treatment (Specification 3)**

Def. of Freycinet?	(a) 1 km	(b) 2 km	(c) 3 km	(d) 4 km	(e) 5 km
<b>OLS estimates</b>					
<b>Dependent variable: Log of population</b>					
<b>Freycinet</b>	0.124*** (0.015)	0.099*** (0.013)	0.088*** (0.011)	0.082*** (0.010)	0.076*** (0.009)
<b>F-statistic</b>	1912.249	1874.801	1855.807	1844.535	1841.564
<b>P-value of F-statistic</b>	0.000	0.000	0.000	0.000	0.000
<b>R-squared</b>	0.463	0.463	0.462	0.462	0.462
<b>IV 2SLS estimates</b>					
<b>Dependent variable: Log of population</b>					
<b>Freycinet</b>	0.290*** (0.039)	0.193*** (0.026)	0.146*** (0.020)	0.120*** (0.016)	0.106*** (0.014)
<b>F-statistic</b>	1819.458	1821.774	1822.440	1822.761	1822.950
<b>P-value of F-statistic</b>	0.000	0.000	0.000	0.000	0.000
<b>R-squared</b>	0.318	0.318	0.319	0.319	0.319
<b>First stage - IV 2SLS estimates</b>					
<b>Dependent variable: Freycinet</b>					
<b>Line (5km) × Post</b>	0.213*** (0.004)	0.320*** (0.004)	0.422*** (0.005)	0.513*** (0.005)	0.584*** (0.004)
<b>Post</b>	0.015*** (0.001)	0.025*** (0.001)	0.036*** (0.001)	0.049*** (0.001)	0.066*** (0.002)
<b>Line (5km)</b>	-0.006*** (0.000)	-0.010*** (0.000)	-0.014*** (0.000)	-0.020*** (0.001)	-0.026*** (0.001)
<b>F-statistic</b>	285.258	512.080	824.401	1257.491	1824.061
<b>P-value of F-statistic</b>	0.000	0.000	0.000	0.000	0.000
<b>R-squared</b>	0.173	0.257	0.335	0.401	0.447
<b>Observations</b>	202126	202126	202126	202126	202126

Robust standard errors in parentheses. Specification 3 corresponds to the model described in sections 2.2 and 2.3 (cf. OLS equation 2 and IV equations 4-6) and visible in Tables 4 and 5. Spec. 3 includes year fixed effects, controls and *département* fixed effects. Controls include the distance to the closest lake, river, coastline, train line endpoint, big city, other non-Freycinet train station, as well as the average altitude and total surface of the municipality. See section 2.6 for more details on the table.

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Table 17: The impact of Freycinet railway connections on municipality populations in the 1920s: variations according to the definition of the treatment (Specification 5)

Def. of Freycinet?	(a) 1 km	(b) 2 km	(c) 3 km	(d) 4 km	(e) 5 km
<b>OLS estimates</b>					
<b>Dependent variable: Log of population</b>					
<b>Freycinet</b>	0.141*** (0.010)	0.114*** (0.008)	0.104*** (0.006)	0.095*** (0.007)	0.089*** (0.006)
<b>F-statistic</b>	4305.751	4306.364	4322.976	4326.398	4327.805
<b>P-value of F-statistic</b>	0.000	0.000	0.000	0.000	0.000
<b>R-squared</b>	0.372	0.372	0.372	0.372	0.373
<b>IV 2SLS estimates</b>					
<b>Dependent variable: Log of population</b>					
<b>Freycinet</b>	0.327*** (0.014)	0.217*** (0.009)	0.164*** (0.007)	0.135*** (0.006)	0.119*** (0.005)
<b>F-statistic</b>	10987.015	11051.509	11099.557	11113.957	11116.845
<b>P-value of F-statistic</b>	0.000	0.000	0.000	0.000	0.000
<b>R-squared</b>	0.365	0.369	0.371	0.372	0.372
<b>First stage - IV 2SLS estimates</b>					
<b>Dependent variable: Freycinet</b>					
<b>Line (5km) × Post</b>	0.212*** (0.005)	0.320*** (0.006)	0.422*** (0.007)	0.513*** (0.007)	0.583*** (0.006)
<b>Post</b>	0.009*** (0.001)	0.016*** (0.001)	0.025*** (0.001)	0.038*** (0.001)	0.053*** (0.002)
<b>F-statistic</b>	298.435	531.504	844.926	1277.737	1834.301
<b>P-value of F-statistic</b>	0.021	0.012	0.015	0.024	0.028
<b>R-squared</b>	0.181	0.269	0.351	0.418	0.466
<b>Observations</b>	202126	202126	202126	202126	202126

Robust standard errors in parentheses. Specification 5 corresponds to the model described in sections 2.2 and 2.3 (cf. OLS equation 3 and IV equations 7-8) and visible in Tables 4 and 5. Spec. 5 includes year fixed effects, controls and municipality fixed effects. Controls include the distance to the closest lake, river, coastline, train line endpoint, big city, other non-Freycinet train station, as well as the average altitude and total surface of the municipality. See section 2.6 for more details on the table.

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

**Table 18: The impact of Freycinet railway connections on municipality populations in the 1920s: variations according to the definition of the treatment (Specification 6)**

Def. of Freycinet?	(a) 1 km	(b) 2 km	(c) 3 km	(d) 4 km	(e) 5 km
<b>OLS estimates</b>					
<b>Dependent variable: Log of population</b>					
<b>Freycinet</b>	0.087*** (0.006)	0.073*** (0.005)	0.067*** (0.005)	0.061*** (0.004)	0.058*** (0.004)
<b>F-statistic</b>	2506.188	2508.472	2515.706	2515.526	2516.594
<b>P-value of F-statistic</b>	0.000	0.000	0.000	0.000	0.000
<b>R-squared</b>	0.310	0.310	0.311	0.311	0.311
<b>IV 2SLS estimates</b>					
<b>Dependent variable: Log of population</b>					
<b>Freycinet</b>	0.321*** (0.016)	0.199*** (0.010)	0.146*** (0.007)	0.118*** (0.006)	0.103*** (0.005)
<b>F-statistic</b>	9060.229	9198.664	9261.191	9284.100	9294.258
<b>P-value of F-statistic</b>	0.000	0.000	0.000	0.000	0.000
<b>R-squared</b>	0.294	0.303	0.307	0.308	0.309
<b>First stage - IV 2SLS estimates</b>					
<b>Dependent variable: Freycinet</b>					
<b>Post</b>	0.020*** (0.001)	0.028*** (0.001)	0.039*** (0.001)	0.053*** (0.001)	0.069*** (0.002)
<b>Line (5km) × Post</b>	0.159*** (0.004)	0.257*** (0.005)	0.349*** (0.006)	0.432*** (0.006)	0.496*** (0.006)
<b>F-statistic</b>	149.571	265.820	422.348	637.337	911.893
<b>P-value of F-statistic</b>	0.037	0.014	0.015	0.021	0.022
<b>R-squared</b>	0.083	0.143	0.202	0.254	0.296
<b>Observations</b>	440793	440793	440793	440793	440793

Robust standard errors in parentheses. Specification 6 corresponds to the model described in sections 2.2 and 2.3 (cf. OLS equation 3 and IV equations 7-8) and visible in Tables 4 and 5. Spec. 6 includes year fixed effects, controls and municipality fixed effects but uses what has been coined “Definition 2” of treatment (see section 2.2) i.e. it also includes years during treatment period (1879-1914). Controls include the distance to the closest lake, river, coastline, train line endpoint, big city, other non-Freycinet train station, as well as the average altitude and total surface of the municipality. See section 2.6 for more details on the table.

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$



## B.6 Robustness check: effects on municipality populations with different definitions of the instrument

Table 19: The impact of Freycinet railway connections on municipality populations in the 1920s: IV 2SLS estimates according to the definition of the instrument

	Spec. 3		Spec. 5		Spec. 6	
Buffer zone?	(1) 10 km	(2) 20 km	(3) 10 km	(4) 20 km	(5) 10 km	(6) 20 km
<b>First stage - Dependent variable: Freycinet</b>						
<b>Line × Post</b>	0.213*** (0.004)	0.152*** (0.002)	0.212*** (0.005)	0.151*** (0.004)	0.159*** (0.004)	0.114*** (0.003)
<b>Post</b>	0.015*** (0.001)	0.005*** (0.001)	0.009*** (0.001)	-0.001 (0.001)	0.020*** (0.001)	0.012*** (0.001)
<b>Line</b>	-0.006*** (0.000)	-0.004*** (0.000)				
<b>F-statistic</b>	285.258	271.263	298.435	284.867	149.571	142.837
<b>P-value of F-statistic</b>	0.000	0.000	0.021	0.013	0.038	0.031
<b>R-squared</b>	0.173	0.140	0.181	0.150	0.083	0.072
<b>Second stage - Dependent variable: Log of population</b>						
<b>Freycinet</b>	0.290*** (0.039)	0.389*** (0.046)	0.327*** (0.014)	0.415*** (0.017)	0.321*** (0.016)	0.409*** (0.019)
<b>Treat</b>	-0.130*** (0.025)	-0.189*** (0.032)				
<b>F-statistic</b>	1819.458	1815.530	10987.015	10872.168	9060.229	8848.261
<b>P-value of F-statistic</b>	0.000	0.000	0.000	0.000	0.000	0.000
<b>R-squared</b>	0.318	0.316	0.365	0.357	0.294	0.279
<b>Controls</b>	Yes	Yes	Yes	Yes	Yes	Yes
<b>Year FE</b>	Yes	Yes	Yes	Yes	Yes	Yes
<b>Geographical FE</b>	Dep.	Dep.	Mun.	Mun.	Mun.	Mun.
<b>Observations</b>	202126	202126	202126	202126	440793	440793

Robust standard errors in parentheses. Spec. 3, 5 and 6 correspond to the models described in section 2.3 (cf. IV equations 4-6 for spec. 3 and equations 7-8 for spec. 5 and 6) and visible in Tables 4 and 5. Both specifications include year fixed effects but spec. 3 includes *département* fixed effects while spec. 5 and 6 include municipality fixed effects. Spec. 6 uses what has been coined “Definition 2” of treatment (see section 2.2) i.e. it also includes years during treatment period (1879-1914). Controls include the distance to the closest lake, river, coastline, train line endpoint, big city, other non-Freycinet train station, as well as the average altitude and total surface of the municipality. See section 2.6 for more details on the table

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

## B.7 Robustness check: effects on municipality populations with different levels of clustering of standard errors

Table 20: The impact of Freycinet railway connections on mun. populations in the 1920s: OLS estimates & comparison of standard errors according to the type of clustering

	Dependent variable: Log of population					
	Baseline model			With municipal FE		
	(1) Baseline	(2) Controls	(3) Time FE	(4) Baseline	(5) Time FE	(6) Def-2
<b>Freycinet</b>	0.135 (0.024) (0.021) (0.019)	0.124 (0.025) (0.015) (0.014)	0.124 (0.025) (0.015) (0.014)	0.137 (0.024) (0.010) (0.004)	0.141 (0.024) (0.010) (0.004)	0.087 (0.015) (0.006) (0.002)
<b>Treat</b>	0.336 (0.039) (0.011) (0.011)	0.138 (0.029) (0.009) (0.009)	0.138 (0.029) (0.009) (0.009)			
<b>Post</b>	-0.304 (0.017) (0.005) (0.004)	-0.335 (0.018) (0.004) (0.003)		-0.304 (0.017) (0.002) (0.001)		
<b>Dist. to non-Freycinet station</b>		-0.011 (0.002) (0.000) (0.000)	-0.011 (0.002) (0.000) (0.000)		0.004 (0.002) (0.000) (0.000)	0.002 (0.001) (0.000) (0.000)
<b>Dist. to lake</b>		-0.001 (0.001) (0.000) (0.000)	-0.001 (0.001) (0.000) (0.000)			
<b>Dist. to river</b>		-0.014 (0.005) (0.001) (0.001)	-0.014 (0.005) (0.001) (0.001)			
<b>Dist. to coast</b>		-0.001 (0.001) (0.000) (0.000)	-0.001 (0.001) (0.000) (0.000)			
<b>Dist. to important city</b>		-0.031 (0.003) (0.000) (0.000)	-0.031 (0.003) (0.000) (0.000)			
<b>Dist. to endpoint</b>		-0.000 (0.000) (0.000) (0.000)	-0.000 (0.000) (0.000) (0.000)			
<b>Altitude</b>		-0.001 (0.000) (0.000) (0.000)	-0.001 (0.000) (0.000) (0.000)			
<b>Surface</b>		0.000 (0.000) (0.000) (0.000)	0.000 (0.000) (0.000) (0.000)			
<b>Controls</b>	No	Yes	Yes	No	Yes	Yes
<b>Year FE</b>	No	No	Yes	No	Yes	Yes
<b>Geographical FE</b>	None	Dep.	Dep.	Mun.	Mun.	Mun.
<b>Observations</b>	202126	202126	202126	202126	202126	440793

For each variable, the first figure in brackets is the standard error clustered at the level of the *département*, the second one is the robust standard error (i.e. clustered at the level of the municipality) and the third one is the basic standard error with no clustering. See section 2.6 for more details on the table.

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

**Table 21: The impact of Freycinet railway connections on mun. populations in the 1920s:  
IV 2SLS estimates & comparison of standard errors according to the type of clustering**

	Dependent variable: Log of population					
	Baseline model			With municipal FE		
	(1) Baseline	(2) Controls	(3) Time FE	(4) Baseline	(5) Time FE	(6) Def-2
<b>Freycinet</b>	0.317 (0.084) (0.057) (0.053)	0.290 (0.087) (0.039) (0.039)	0.290 (0.087) (0.039) (0.039)	0.317 (0.083) (0.014) (0.012)	0.327 (0.082) (0.014) (0.012)	0.321 (0.081) (0.016) (0.011)
<b>Treat</b>	0.805 (0.170) (0.029) (0.031)	-0.130 (0.095) (0.025) (0.027)	-0.130 (0.095) (0.025) (0.027)			
<b>Post</b>	-0.313 (0.018) (0.005) (0.005)	-0.340 (0.019) (0.004) (0.004)		-0.313 (0.018) (0.001) (0.001)		
<b>Dist. to non-Freycinet station</b>		-0.010 (0.002) (0.000) (0.000)	-0.010 (0.002) (0.000) (0.000)		0.004 (0.002) (0.000) (0.000)	0.003 (0.001) (0.000) (0.000)
<b>Dist. to lake</b>		-0.001 (0.001) (0.000) (0.000)	-0.001 (0.001) (0.000) (0.000)			
<b>Dist. to river</b>		-0.015 (0.005) (0.001) (0.001)	-0.015 (0.005) (0.001) (0.001)			
<b>Dist. to coast</b>		-0.001 (0.001) (0.000) (0.000)	-0.001 (0.001) (0.000) (0.000)			
<b>Dist. to important city</b>		-0.031 (0.003) (0.000) (0.000)	-0.031 (0.003) (0.000) (0.000)			
<b>Dist. to endpoint</b>		-0.000 (0.000) (0.000) (0.000)	-0.000 (0.000) (0.000) (0.000)			
<b>Altitude</b>		-0.001 (0.000) (0.000) (0.000)	-0.001 (0.000) (0.000) (0.000)			
<b>Surface</b>		0.000 (0.000) (0.000) (0.000)	0.000 (0.000) (0.000) (0.000)			
<b>Controls</b>	No	Yes	Yes	No	Yes	Yes
<b>Year FE</b>	No	No	Yes	No	Yes	Yes
<b>Geographical FE</b>	None	Dep.	Dep.	Mun.	Mun.	Mun.
<b>Observations</b>	202126	202126	202126	202105	202105	440773

For each variable, the first figure in brackets is the standard error clustered at the level of the *département*, the second one is the robust standard error (i.e. clustered at the level of the municipality) and the third one is the basic standard error with no clustering. See section 2.6 for more details on the table.

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

## B.8 Robustness check: effects on municipality populations with other definitions of control variables

Table 22: The impact of Freycinet railway connections on municipality populations in the 1920s: other definition of controls

Dependent variable: Log of population						
	OLS estimates			IV 2SLS estimates		
	(1) Spec. 3	(2) Spec. 5	(3) Spec. 6	(4) Spec. 3	(5) Spec. 5	(6) Spec. 6
<b>Freycinet</b>	0.143*** (0.015)	0.138*** (0.010)	0.086*** (0.006)	0.351*** (0.038)	0.321*** (0.014)	0.315*** (0.016)
<b>Treat</b>	0.173*** (0.009)			-0.080*** (0.024)		
<b>Other station</b>	0.391*** (0.005)	0.026*** (0.005)	0.017*** (0.003)	0.384*** (0.005)	0.027*** (0.003)	0.018*** (0.001)
<b>Lake city</b>	0.246*** (0.027)			0.245*** (0.028)		
<b>River city</b>	0.069*** (0.003)			0.074*** (0.003)		
<b>Seaside city</b>	0.611*** (0.034)			0.611*** (0.035)		
<b>Dist. to important city</b>	-0.031*** (0.000)			-0.031*** (0.000)		
<b>Dist. to endpoint</b>	-0.000*** (0.000)			-0.000*** (0.000)		
<b>Altitude</b>	-0.001*** (0.000)			-0.001*** (0.000)		
<b>Surface</b>	0.000*** (0.000)			0.000*** (0.000)		
<b>Controls</b>	Yes	Yes	Yes	Yes	Yes	Yes
<b>Year FE</b>	Yes	Yes	Yes	Yes	Yes	Yes
<b>Geographical FE</b>	Dep.	Mun.	Mun.	Dep.	Mun.	Mun.
<b>Observations</b>	202126	202126	440793	202126	202105	440773
<b>F-statistic</b>	2907.098	3989.277	2350.372	2779.816	10058.126	8622.916
<b>P-value of F-statistic</b>	0.000	0.000	0.000	0.000	0.000	0.000
<b>R-squared</b>	0.494	0.370	0.310	0.357	0.364	0.294

Robust standard errors in parentheses. Spec. 3, 5 and 6 correspond to the models described in section 2.3 (cf. IV equations 4-6 for spec. 3 and equations 7-8 for spec. 5 and 6) and visible in Tables 4 and 5. Both specifications include year fixed effects but spec. 3 includes *département* fixed effects while spec. 5 and 6 include municipality fixed effects. Spec. 6 uses what has been coined “Definition 2” of treatment (see section 2.2) i.e. it also includes years during treatment period (1879-1914). See section 2.6 for some details on the table.

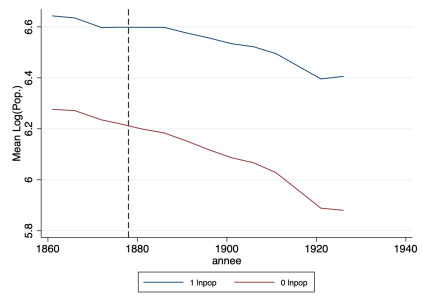
\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

**B.9 Robustness check: effects on municipality populations with sample restrictions**

**Figure 18: Evolution of mean log population**



**(a)** Sample with no cities (> 2,000 hab)



**(b)** Sample excluding municipalities with prior train connections

**Table 23: The impact of Freycinet railway connections on municipality populations in the 1920s: sample restrictions**

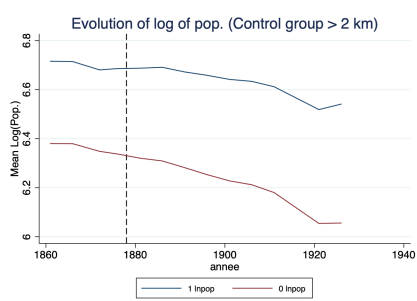
Dependent variable: Log of population						
No access to railway before Freycinet era						
	OLS estimates			IV 2SLS estimates		
	(1) Spec. 3	(2) Spec. 5	(3) Spec. 6	(4) Spec. 3	(5) Spec. 5	(6) Spec. 6
<b>Freycinet</b>	0.146*** (0.014)	0.148*** (0.008)	0.093*** (0.005)	0.305*** (0.034)	0.307*** (0.012)	0.307*** (0.013)
<b>Observations</b>	156502	156502	341249	156502	156487	341235
<b>F-statistic</b>	2345.323	5919.145	3275.457	2206.003	15958.194	13049.590
<b>P-value of F-statistic</b>	0.000	0.000	0.000	0.000	0.000	0.000
<b>R-squared</b>	0.523	0.551	0.469	0.362	0.545	0.453
No cities (>2,000 hab.) in 1876						
	OLS estimates			IV 2SLS estimates		
<b>Freycinet</b>	0.118*** (0.014)	0.131*** (0.010)	0.081*** (0.006)	0.285*** (0.037)	0.310*** (0.015)	0.309*** (0.017)
<b>Observations</b>	186823	186823	407233	186823	186822	407233
<b>F-statistic</b>	1950.266	4727.323	2633.832	1872.010	12520.738	10410.431
<b>P-value of F-statistic</b>	0.000	0.000	0.000	0.000	0.000	0.000
<b>R-squared</b>	0.444	0.427	0.360	0.303	0.421	0.346
<b>Controls</b>	Yes	Yes	Yes	Yes	Yes	Yes
<b>Year FE</b>	Yes	Yes	Yes	Yes	Yes	Yes
<b>Geographical FE</b>	Dep.	Mun.	Mun.	Dep.	Mun.	Mun.

Robust standard errors in parentheses. Spec. 3, 5 and 6 correspond to the models described in section 2.3 (cf. IV equations 4-6 for spec. 3 and equations 7-8 for spec. 5 and 6) and visible in Tables 4 and 5. Both specifications include year fixed effects but spec. 3 includes *département* fixed effects while spec. 5 and 6 include municipality fixed effects. Spec. 6 uses what has been coined “Definition 2” of treatment (see section 2.2) i.e. it also includes years during treatment period (1879-1914). Controls include the distance to the closest lake, river, coastline, train line endpoint, big city, other non-Freycinet train station, as well as the average altitude and total surface of the municipality. See section 2.6 for more details on the table.

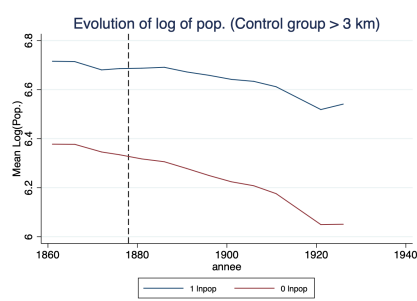
\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

## B.10 Evolution of the mean log of population when progressively reducing the size of the control group

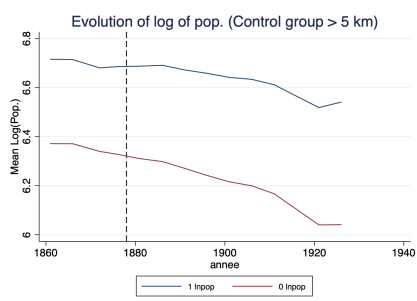
Figure 19: Evolution of mean log population



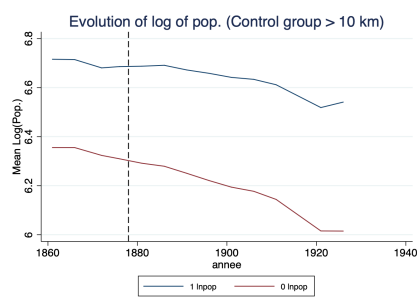
(a) Control group > 2 km



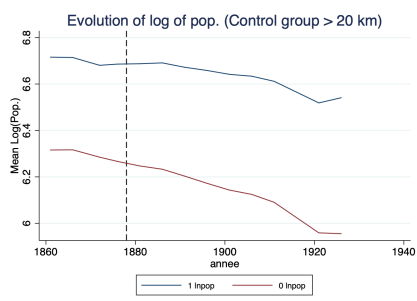
(b) Control group > 3 km



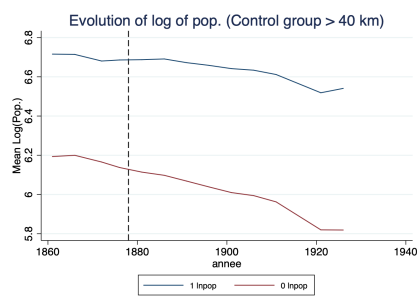
(c) Control group > 5 km



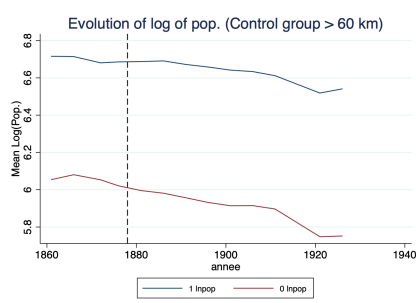
(d) Control group > 10 km



(e) Control group > 20 km



(f) Control group > 40 km

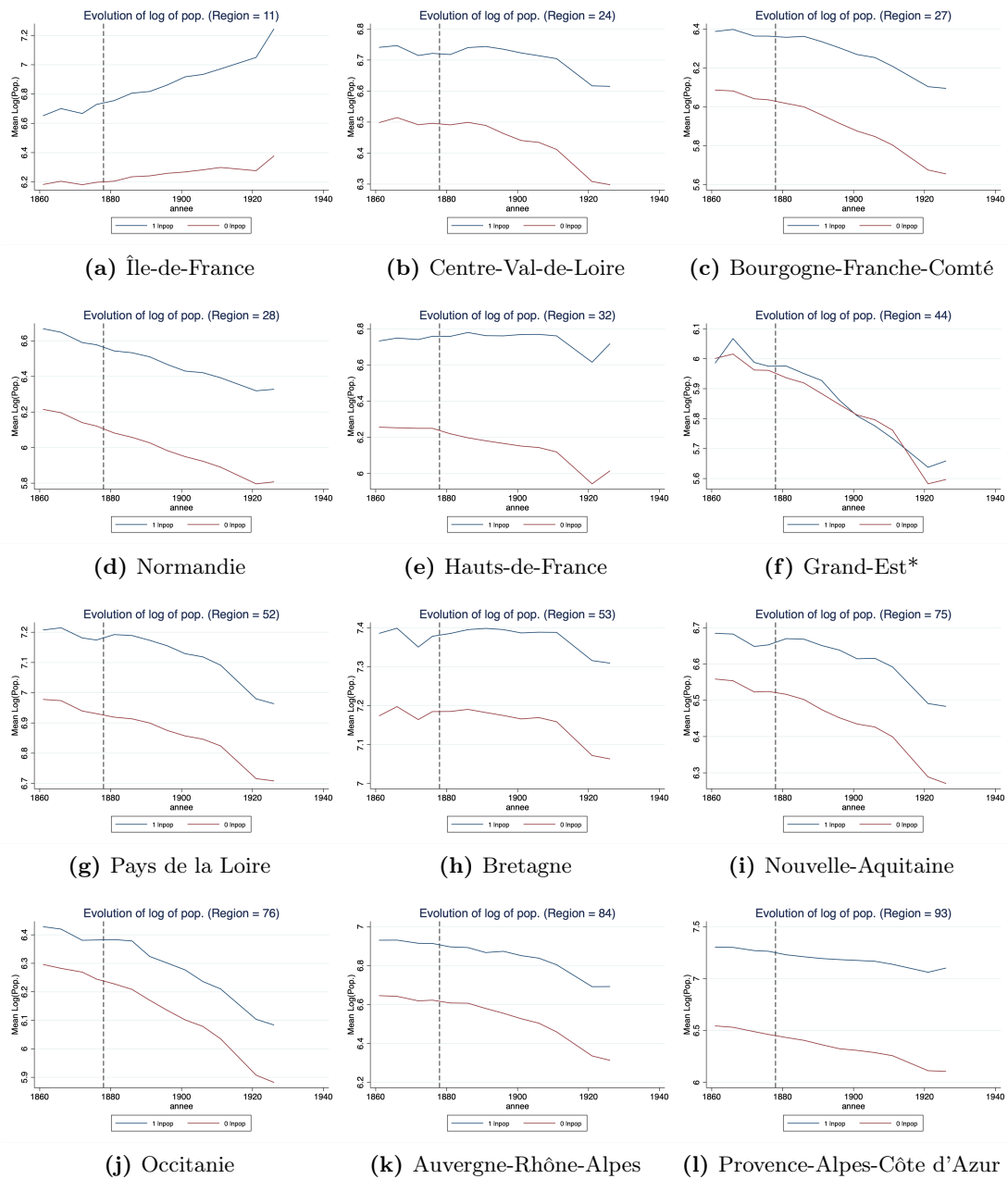


(g) Control group > 60 km

## C Appendix to section 3 and conclusion

### C.1 Effects on population in each French region

Figure 20: Evolution of mean log population



\* Region Grand-Est excludes the territories of the current *départements* of Moselle, Haut-Rhin and Bas-Rhin that were annexed by the Prussians in 1870.



**Table 24: The impact of Freycinet railway connections on municipality populations in the 1920s: regional effects**

	Dep. variable: Log of pop.		
	OLS	IV 2SLS	Obs.
<b>Hauts-de-France</b>	0.220*** (0.039)	0.551*** (0.049)	22818
<b>Grand-Est</b>	0.041 (0.027)	0.641*** (0.083)	19754
<b>Île-de-France</b>	0.351*** (0.065)	0.073 (0.084)	7495
<b>Bretagne</b>	0.070*** (0.024)	0.281*** (0.048)	7273
<b>Normandie</b>	0.076*** (0.029)	0.092* (0.049)	19213
<b>Pays de la Loire</b>	0.020 (0.019)	0.092*** (0.030)	8787
<b>Occitanie</b>	0.073** (0.035)	0.007 (0.042)	26549
<b>Nouvelle-Aquitaine</b>	0.082*** (0.011)	0.206*** (0.022)	26517
<b>Provence-Alpes-Côte d'Azur</b>	0.185*** (0.064)	0.558*** (0.181)	5504
<b>Auvergne-Rhône-Alpes</b>	0.089*** (0.023)	0.120*** (0.034)	24463
<b>Bourgogne-Franche-Comté</b>	0.116*** (0.020)	0.102*** (0.033)	22792
<b>Centre-Val de Loire</b>	0.074*** (0.023)	0.399*** (0.067)	10940

Robust standard errors in parentheses. Equations (3) [OLS] and (8) [IV 2SLS] are estimated for each French region (after the reform on 2015) and the coefficients associated to the variable “Freycinet” of these equations are reported. Controls include the distance to the closest lake, river, coastline, train line endpoint, big city, other non-Freycinet train station, as well as the average altitude and total surface of the municipality.

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

## C.2 Intent-to-Treat/Reduced Form results (impact on GDP)

**Table 25: The impact of the number of municipalities on straight lines on *départements*' GDP: Intent-to-Treat/Reduced Form estimates**

	IV 2SLS estimates					
	Real GDP (log)		Components of GDP (log)			
	(1) In 1911	(2) In 1926	(3) Comm. profits	(4) Farming profits	(5) Wages	(6) Non comm.
<b>Number of municipalities on straight lines</b>	0.002 (0.001)	0.004*** (0.001)	0.004** (0.001)	0.001 (0.002)	0.004** (0.002)	0.003** (0.001)
<b>Controls</b>	Yes	Yes	Yes	Yes	Yes	Yes
<b>Observations</b>	85	83	83	83	83	83
<b>F-statistic</b>	10.838	17.576	11.115	16.323	15.322	17.788
<b>P-value of F-statistic</b>	0.000	0.000	0.000	0.000	0.000	0.000
<b>R-squared</b>	0.479	0.581	0.526	0.581	0.540	0.598

Robust standard errors in parentheses. Controls include, in each *département*, the number of coastal municipalities, the number of municipalities close to lakes, the number of municipalities close to rivers, the number of municipalities already served by railways before the Freycinet plan, the number of municipalities served by railways between 1879 and 1914 but not thanks to the Freycinet plan, the total surface of the *département* and eventually its average altitude.

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

### C.3 Required variables to study more deeply the aggregate impact of railroads on output

**Table 26: Minimum data required to measure the aggregate impact of railroads on GDP with a market access approach**

Variables to build	Required data
<b>Market access</b>	
<i>Simplified form</i>	Price per km of the use of each transportation mode Distance of the shortest route from each locality to all the others, by each transportation mode (wagon, waterway, railroad) Total population in each locality
<i>Complex form (additional data)</i>	Measure of trade elasticity Measure of the proportionality between consumer and firm market access
<b>Agricultural land</b>	Value of agricultural land in each locality
<b>Manufacturing</b>	Annual value of manufacturing output by locality (decomposed in price and volume) Annual cost of production factors by locality (labour, capital, land, raw materials) Industry cost shares (i.e. Cobb-Douglas superscript values)
<b>Controls and most important robustness checks</b>	Longitude and latitude of each locality Distance of each locality to the closest railroad Possible developments of other means of transportation in the absence of railroads Possible estimates of population in the absence of railroads

This table synthesises all the required data, to the eyes of the author, that can be deemed necessary to implement an approach similar to [Donaldson and Hornbeck \(2016\)](#) and [Hornbeck and Rotemberg \(2019\)](#) in another country. See Conclusion for further details.