The Political Dynamics of Technological Change

Building States with Technology

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A la Tere, l'Àngel i el Joan

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Abstract

In this thesis I analyze the political dynamics of technological change. Firstly, by studying the political causes of the advent of telecommunications, and secondly, by exploring the consequences of different technologies. Regarding the first research agenda - the political determinants of technological adoption - I focus on the arrival of the labor movement as a trigger for greater diffusion. Regarding the consequences, I study the political effect of the telegraph -in chapter 3- and of the censuses and statistical agencies -in chapter 4-. Regarding the effect of the telegraph, the question is whether, where it was implemented, political participation increased. Regarding the censuses and statistical agencies, this thesis explores whether they facilitated the repression of ethnic minorities. These questions are explored using quantitative methods and panel data. The results provide an overview of the causes and effects of a given type of technology: those that are controlled by the state and allow the dissemination of news and information, but not entertainment. These types of technology, first of all, are targeted to areas that are politically relevant, and not just economically. Once implemented, telecommunications facilitate voting in general elections, while censuses and statistical agencies allow for greater assimilation and state repression of ethnic minorities.

Resum

En aquesta tesi analitzo el cicle polític del canvi tecnològic. En primer lloc, estudio els causants polítics de l'arribada de les telecomunicacions, i en segon lloc, exploro les conseqüències de diferents tecnologies. Respecte a la primera pregunta -els determinants polítics de la tecnologia - em centre en l'arribada del moviment obrer com a desencadenant d'una major adopció tecnològica. Pel que fa a les conseqüències, estudio l'efecte polític del telègraf -al capítol 3- i dels cens i agències estadístiques -al capítol 4-. Pel que fa a l'efecte del telègraf, la pregunta és si, allà on es va implementar va augmentar la participació política. Pel que fa als cens i agències estadístiques, aquesta tesi explora si van facilitar la repressió de minories ètniques. Aquestes preguntes s'exploren utilitzant mètodes quantitatius i dades de panell. Els resultats donen una visió general de les causes i els efectes d'un tipus de tecnologia determinat: les que estan controlades per l'estat i permeten la disseminació de notícies i informació, però no entreteniment. Aquest tipus de tecnologies, en primer lloc, estan targetejades en zones que són políticament rellevants, i no només econòmicament. Un cop implementades, les telecomunicacions faciliten el vot en eleccions generals, mentre que els cens i agències estadístiques permeten una assimilació i repressió més gran per part de l'estat a les minories ètniques.

Contents

Chapter 1

INTRODUCTION

The arrival of new technology is considered to be one of the key drivers of economic development (Gordon 2017; Boix 2015; Herranz-Loncán 2007; Boff 1984). Economists have extensively analyzed both the determinants of technological adoption (Nelson 1985; Romer 1990) and its consequences (Solow 1956; Gordon 2017). This dissertation focuses on the determinants and consequences of the arrival of new technology. But rather than concentrating on economics, the question is whether politics, not just demographic and economic factors, can influence and be influenced by technological adoption. One way of putting together the research agenda of this dissertation is by asking the following questions: was the arrival of new technology (and especially XIX century information-based innovations) influenced by political events? And second: once established, did those technologies influence politics?

There is increasing evidence that the arrival of new technology is not exogenous. Economists have long emphasized firm-level inputs (Nelson 1985) and the availability of human capital (Romer 1990) as crucial aspects of the adoption of new technology (the list of economic determinants is extensive and goes far beyond these factors). Human capital stands out as

one of the most decisive inputs predicting higher innovation and technological diffusion (Caselli and Coleman 2001; Comin and Mestieri 2014), since qualified personnel can conceive novel engines and technologies, while also integrating recently available innovations invented elsewhere. Another critical socio-demographic factor is population density, as shown by the iconic work of Herbst (2014) in Africa, where he proves that, in the African Continent, only the most populated regions experienced high levels of infrastructural and technological adoption.

The previous works - perhaps with the exception of Herbst, who also accounts for the importance of colonial legacies - suffers from being ahistorical, while also putting little emphasis on the role of politics in the field of technological adoption and its consequences. As a remedy for this deficit, recent research has started to investigate how political factors can affect the path and speed of technological adoption. The level of democracy (Mokyr 1992; Mokyr and Nye 2007), the quality of institutions (Acemoglu and Robinson 2012; Comin and Mestieri 2014), the preferences and strength of lobbies and their interaction with democratic institutions (Comin and Hobijn 2009), together with international competition for technological power (Milner and Solstad 2021) are political factors affecting the adoption of new technology. The focus of these authors, however, relies on macro-institutional variables that vary across big countries, or even empires. On the other hand, the study of political grievances and their interaction with technology adoption within countries is less well understood. Works by Curto-Grau, Herranz-Loncán, and Solé-Ollé (2012); Do, Nguyen, and Tran (2017) and Jiang and Zhang (2020) explore the political determinants of adoption of new infrastructure in general, but do not focus on technological innovations. Differences in technological adoption within countries can lead to variations in economic performance in sub-national units (Solow 1956; Boff 1984). Therefore, the question of who gains access to new technology and why is important for development.

A second important research question is whether the arrival of new technology brought political consequences. When evaluating the political consequences of innovations, it is important to specify what the new technology is capable of, which social groups have access to it, and to what extent. Focusing on what a new technology can do avoids assuming that new technologies have a uniform impact on an outcome of interest, an error that is often portrayed as technological determinism (Polat 2005). Some innovations are controlled by the elites, like the printing press in the Ottoman Empire (Acemoglu and Robinson 2012). Others are partly accessible by those with less resources, like telecommunications in the XIX century - individuals of all sorts of classes could use the telegraph, for instance, but its cost was easier to assume by those with more resources- and others are non-excludable, like the internet in high-income countries, where most people have access to a laptop or mobile phone and the internet. This dissertation focuses on telecommunications, modern censuses, statistical agencies and yearbooks as the relevant technologies to be explored. The most defining feature of these technologies is that they facilitated the transmission of large amounts of information. Either by avoiding the need for physical movement to send a message, which the telegraph allowed, or by providing reliable and stable sources of information on political groups, as censuses did by providing key information on ethnic minorities. Another characteristic that these technologies had in common is that, in most countries, they were rolled-out by the state (with the exception of telecommunications in the UK and United States). A third commonality is that these technologies transmitted information, not entertainment. Unlike the radio, the TV, the Internet or Artificial Intelligence, whose uses have extended to entertainment, the telegraph mainly focused on transmitting informational and descriptive texts and commercial information. The focus is therefore on how the dissemination of political information - not entertainment - affected crucial outcomes.

Did XIX century telecommunications affect turnout? From a normative point

of view, it is accepted that the extent of individuals' participation in politics is a crucial feature for democracy (Dahl 1971). Classic theories of political participation underline that the availability of time is an essential resource that enhances participation (Verba, Schlozman, and Brady 1995). Being informed about politics is time consuming, thus costly for some individuals. The cost of information increase when individuals also have to travel long distances to be informed, added to the time that it takes to consume the actual information. The arrival of technologies that facilitate the transmission of political information reduced the time of transportation. The expectation should therefore be that, where those technologies became available, political information spread further, potentially increasing turnout.

Some research suggests that modern technologies, such as the Internet, have increased turnout (Chae, Lee, and Kim 2019), but the effect is very small, and well-designed articles have even found a negative association (Falck, Gold, and Heblich 2014). The arrival of the radio is positively associated with turnout (Panagopoulos and Green 2011), which has been confirmed by posterior meta-analysis (Smets and Van Ham 2013), but is largely conditioned by the consumption of news. These technologies transmitted both entertainment and information, but it is difficult to disentangle which of them ultimately influenced turnout. The technologies explored in this thesis, on the contrary, did not disseminate entertainment.

When studying turnout as an outcome, there are important reasons to focus on telecommunications as a relevant set of technologies to be explored. Studying XIX century telecommunications allows to isolate the power of transmitting descriptive information, informative messages and news, while reducing the role of entertainment at its minimum expression. Telecommunications offer a great capacity to transmit messages at the speed of electricity, which significantly enhances efficiency and has transformative potential. Prior to the advent of the telegraph, sending a letter from the northern city of

Luleå to the southern city of Gothenburg in Sweden could take up to 20 days. However, with the introduction of this new technology, the transmission time was reduced to just a few minutes. [1]

Currently, many countries still face limited access to telecommunications services. To use telecommunications, good access to electricity is necessary. Nowadays, approximately 49.4% of the population in Sub-Saharan Africa lacks access to electricity, and internet penetration remains as low as 32% World Bank (11/5/2024). By studying telecommunications, we can examine the ex-ante conditions that facilitated its adoption and understand its political implications. Analyzing these phenomena from the introduction of the technology to its wider implications within a reasonable time frame provides valuable insights and one of the key contributions of this thesis.

Another set of technologies explored in this dissertation are those that relate to the informational capacity of the state: censuses, statistical agencies, and yearbooks. Weber, in his iconic book *Peasants into Frenchmen* was likely among the first to emphasize how important it was for a developed state to have access to unified information about their population (Weber 1976). The anthropologist and political scientist James Scott, in his famous work *Seeing Like a State* (Scott 1999), suggested that the state's performance depended - to a point- on the capacity of public authorities to effectively understand their population. This idea has been reinforced by subsequent works in political science (Lee and Zhang 2017a; Brambor et al. 2020)

What remains less clear is the impact of technological advancements on states' utilization of those technologies. Did the introduction of modern censuses, statistical agencies, and yearbooks during the XIX century contribute

[1] This is based on my own calculations, assuming that an individual could travel a maximum distance of 65 kilometers per day. This distance assumes that the citizens did not have access to the railway, but that they were transported either by horse or on foot, or by maritime transport. Messenger pigeons are not taken into account here due to their unreliability, higher risk and the high costs associated with their training.

to the reduction of ethnic fractionalization? Classical works suggest that ethnic fractionalization is a crucial measure for development (Alesina, Baqir, and Easterly 1999; Alesina et al. 2003), although recent works have started to question this (Wimmer 2016; Singh and Vom Hau 2016). Understanding the origins of diversity, and how state technology can shape it, is crucial for current research exploring hypotheses related with fractionalization and development. Previous research has explored the influence of various factors such as prehistoric human settlement (Ahlerup and Olsson 2012), land quality (Michalopoulos 2012), and climate variability (Cashdan 2001) on subsequent levels of ethnic diversity. Recently, Wimmer (2016) suggested that the absence of a minimum state structure in many countries led to higher levels of ethnic fractionalization. However, the extent to which technological shocks resulting from the introduction of statistical agencies and modern censuses, facilitated by advancements in telecommunications, influenced each country's level of fractionalization remains unexplored. As state authorities usually try to reduce fractionalization (Wimmer 2018), a relevant question is whether these technologies contributed to accomplish this goal.

This dissertation explores the overall political dynamics involved in technological adoption. The first objective involves understanding the political causes of the arrival of informational technology. The second objective is to grasp its implications for individual behavior (analyzing whether new technology can alter the propensity of individuals to vote). The third objective is to see whether new engines can influence the capacity of the state to either assimilate or repress ethnic minorities (contributing to an overall decrease in the levels of fractionalization). Finally, a complementary goal is to bring informational innovations back into the political debate by analyzing their entire political dynamics.

This dissertation is organized in three academic articles, that look at different aspects of the synergies between politics and technological adoption. Chapter

two focuses on the political determinants of technological adoption. Chapter 3 explores how the arrival of telecommunications affected turnout in Europe. Chapter 4 delves into the issue of whether the arrival of censuses, statistical agencies and yearbooks facilitated ethnic assimilation and repression.

The second chapter of this dissertation, corresponding to the first academic article, investigates whether the labor movement accelerated the diffusion of new technology. During the XIX century, when most countries were non-democracies, industrialization and structural change led to the emergence of the labor movement. Like other technologies, telecommunications initially spread in the main economic hubs, where a significant population resided (Herbst 2014), and where human capital was readily available (Comin and Hobijn 2004; Comin and Mestieri 2014).The crucial question is whether areas exposed to the labor movement, with higher incidences of strikes, received more technology. Telecommunications could have potentially facilitated the repression of opposition by monitoring their locations and instantly accessing information on the scale and location of conflicts. Anecdotal evidence suggests that the telegraph and railways were used in the XIX century to repress (Mather 1953). Building on this, chapter 2 is the first to empirically examine the proposition that telecommunications were more likely to emerge in regions where labor conflict was prominent.

The third chapter studies the roll-out of the telegraph and its influence on turnout in national elections. In the 19th century, political participation varied widely across the globe. Most countries were non-democracies and did not hold elections. In many European countries of the XIX century, like Spain, Sweden, or the UK, suffrage was limited to the rich. These countries are often referred to as 'semi-democracies', where elections are held but are not free nor universal (Curto-Grau, Herranz-Loncán, and Solé-Ollé 2012). In such contexts, the incentives for voting in national elections were limited, especially when local affairs had greater importance than national ones (Weber

1976). The United States, for example extended suffrage to a larger portion of its male population, but restricted suffrage based on property or wealth was more common in other countries of the world. How did the arrival of telecommunications affect an elite electorate, consisting of powerful individuals with voting rights? Wang (2020) primarily investigated the role of the telegraph on turnout in the United States, a country where participation rights were much more extended that XIX century Sweden.

The fourth chapter of the dissertation analyzes the political impact of a different set of technologies: modern censuses, statistical agencies and yearbooks. Variation across countries regarding the quality of censuses likely depends on exogenous and endogenous factors. By focusing on the availability of each country's censuses and statistical agencies at the year of a country's independence -when new institutions had to be created and there was significant leeway to decide which institutions should be prioritized-, we treat informational shocks as an exogenous variable. The question is: to what extent were countries that adopted more developed informational technologies early on better able to reduce ethnic and linguistic diversity? The question is not only about the availability of modern censuses, it is also *when* they became available. With an increased capacity to know where minorities lived, it became possible to either eliminate or assimilate them. A related question is: is the negative effect of fractionalization on public goods provision negated once we control for the state's informational capacity? The diversity-deficit hypothesis initially suggested that higher levels of fractionalization were indicative of an inferior provision of public goods (Alesina, Baqir, and Easterly 1999; Alesina et al. 2003). Recent research has indicated that the relationship is endogenous to state capacity (Singh and Vom Hau 2016; Wimmer 2016). Together with Matthias vom Hau, we explore whether the mechanism behind the aforementioned papers lies on informational technologies.

The fourth chapter accompanies the empirical analysis with an in-depth case

study. The case study introduces a comprehensive analysis of two pivotal military campaigns in Argentina during the XIX century: the Desert Campaign (1833-1834) and the Conquest of the Desert (1876-1883). Both shared a common objective: shaping Argentina into a white, European-dominated nation by the systematic eradication of indigenous communities. A critical point was the state's varying levels of knowledge regarding these indigenous groups, which significantly influenced the outcomes of these campaigns. Beyond military strategies, this study delves into the broader societal impacts by examining the pivotal role of informational capacity in the context of mass schooling and the assimilation of European immigrants. Specifically, it scrutinizes state-driven educational initiatives targeted at Italians and Spaniards, revealing a transformation over time due to enhanced information accessibility. This shift enabled a more precise and effective expansion of public education, resulting in a visible reduction of ethnic identification among European migrant populations.

Case selection and geographical coverage

Consequently, when the telegraph arrived in the XIX century, the labor movement was in its infancy. Similarly, the first elections took place in the same period in which the telegraph was expanding. The fact that labor conflict, the roll-out of telecommunications and the first elections occurred in the same broad historical period, makes Sweden a good candidate to explore how these phenomena are related. Additionally, the availability of detailed archives that contain accurate data on the telegraph is rare. Thanks to the Statistical Agency in Sweden, and the BISOS-database (1861-1880), which relies on it, it has been possible to investigate the causes and consequences of the arrival of the telegraph.

The historical context of 19th century Sweden provides an excellent opportunity to study a case of a country that was developing its institutions at a time of rapid technological change. During this period, Sweden was governed

by three successive kings -Oscar I, Charles XV, and Oscar II-, who formed alliances with powerful elites. These elites encompassed the Nobility, the Clergy, and the peasantry, with the latter possessing limited power compared to their counterparts (Verney 1957), despite having a seat in the estamental Parliament, a Parliament where the estates (the nobility, the peasantry, the bourgeoisie, and the clergy) were represented and which was abolished in 1866. When ruler and elites are aligned, scholars often describe this context as conducive to the development of state capacity (Garfias and Sellars 2022). These models, however, are primarily theoretical, and while explorations of similar contexts have occurred, as in the case of 1920-40 Mexico (Garfias et al. 2018), few instances have undergone thorough examination. Focusing on Sweden allows to explore the political dynamics of technological change in a European context characterized by emerging democracies, structural change and what Doner and Schneider (2016) referred to as *institutional coordination* (the capacity of different institutions to work together with the objective of accomplishing certain goals).

Chapter 2 studies 2425 Swedish Municipalities. Focusing on municipalities facilitates capturing the within-variation of small units of analysis. This, when accompanied with the inclusion of municipal fixed effects in the statistical analysis, enables the study to keep each municipality's time-invariant characteristics constant, thus enabling the isolation of the effect of the explanatory variable. By focusing on this strategy, I follow the *dis-aggregation turn* (Snyder 2001), consisting of analyzing the data at the smallest unit of analysis available.

Chapter 3 uses the Swedish electoral districts. Since municipal-level data of turnout was unavailable, it has had to be aggregated at the district level instead. For both municipal and district level data, a major challenge has been to geographically allocate the distinct variables of interest. Both papers required the calculation of distances from municipal centroids to different

events. These events are telegraph location and work stoppage occurrences. Placing events in time and space has been possible thanks to the availability of a shapefile that contained the geometries of each Swedish Municipality for the period between 1866 and 1880. This shapefile was recently put together by Johan Junkka, who constructed it using data from the Swedish National Archive.

His data, however, contained municipalities as geographical units, and not electoral districts, which were needed for the district-level elections analysis in chapter 3. To be able to analyze the data, as part of the contribution in this dissertation, I have created a new shapefile of the Swedish electoral districts in 1872, 1875 and 1878. I have done so by looking at which electoral district each municipality belonged to, and then I have created a shapefile with electoral districts as the standard geometry.

The case selection for the fourth chapter, which corresponds to the third paper, has been straightforward. It includes all countries for which data in our explanatory variable - historical informational capacity - was available. Together with Matthias vom Hau, we have primarily relied on the Brambor et al (2020) database, which includes 86 polities, and to a lesser extent, Lee and Zhang's database (2017) on modern legibility for cross-validation. One drawback of the data is that missing countries could have lower levels of informational capacity and higher levels of diversity, thus partially biasing the results. We rely on the good geographical distribution of the countries available in the STANCE dataset, where there are countries from all continents, of all economic levels, and with a great variation in terms of informational capacity.

Data

For this dissertation I have used micro and macro data. The first two papers contain data at the municipal level (Chapter 2) and district level (Chapter

3). For the fourth chapter I have used existing data at the country-year level, for different indicators. Chapters two and three study the adoption of the telegraph. First as an outcome and then as explanatory variable. In both cases, establishing where each telegraph station was located is a necessary step for the analysis of the data. Before the beginning of this dissertation, there was no dataset including the exact location of telegraph stations and the year of their installation at the sub-national level. During my fieldwork in Sweden in the 2021, I found digitized archives that indicated the exact station locations, as well as the year that they started operating. These archives come from the Swedish Statistical Agency, the (BISOS-database 1861-1880). I have obtained those locations and manually allocated them in a shapefile of Sweden of the XIX century, thanks to the Histmaps project.

With the use of GIS, I computed distances from each Municipality's centroid to its nearest telegraph station. This measure was useful to discern whether each municipality had access to the telegraph or not. Municipalities that were far away from the nearest telegraph station had less access to it, or had none at all. To operationalize the concept of accessible distance, I referred to the research conducted by Bergenfeldt (2014) on transportation options. According to Bergenfeldt, in the absence of electric-based transportation technology, individuals were limited to traveling by foot or horse, covering approximately 65 kilometers in a day. It needs to be emphasized, however, that this distance encompasses the maximum travel distance, not the typical distance covered. Running 65 kilometers in a horse-drawn carriage was likely very uncommon in the XIX century. The decision to maintain the threshold at 65 kilometers is based on the aim to avoid overfitting and to mitigate the variation caused by spill-overs from the telegraph. For instance, the telegraph facilitated quicker connections between postal services, influencing this threshold.

In chapter 2, the emergence of the labor movement is operationalized as

follows: I georeferenced work stoppages from 1863 onwards. Their exact location comes from Molinder, Karlsson, and Enflo (2018)'s data. These data also reveal the type of work stoppage, whether it was a strike or not (most of them were) and whether the strike succeeded.

For the third paper, I have relied on country-level panel data composed of different measures. The main idea is that higher levels of informational technology decreased ethnic and linguistic fractionalization over time. To test this hypothesis, my coauthor Matthias vom Hau and I have used panel data on fractionalization and informational capacity. For our time-varying fractionalization measure, we have relied on the dataset from Dražanová (2020), which shows how fractionalization evolved over time. Our panel dataset for informational capacity comes from the STANCE dataset (Brambor et al. 2020). The latter includes a composed indicator that lists each country's of availability of modern censuses, the presence of statistical offices and the publication of yearbooks. The dataset is available at the country level. We have also used lagged GDP values and geographical data from Wimmer (2016), the years at which each country has engaged in civil wars from Wimmer and Min (2006), population estimates from the World Bank, as well as other data and indicators specified in chapter 4. To cross-check our results, we have used an alternative measure of informational capacity, the legibility score from Lee and Zhang (2017b). This dataset constitutes a very good measure of informational capacity, although its unavailability for deep historical periods such as the XIX century warns us about its possible limitations. The chapter also includes an in-depth case study of Argentina.

Methods

The three articles in this dissertation use the same methodological strategy, the two-way fixed effects as the principal estimator. The two-way fixed effects regression model relies on panel data and the observation of the same units over time. By controlling for each unit itself and holding constant each period

of the panel analysis, the model enables exploring how changes within the same unit over time (e.g., municipalities, electoral districts, or countries) lead to differences in the outcome of interest within that specific unit. This strategy allows to control for confounding variables that are constant across units. In Chapter 2, I use fixed effects for municipalities and years, in Chapter 3 I use fixed effects for elections and years and in Chapter 4 I use them for countries and years.

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Chapter 2

LABOR CONFLICT AND TECHNOLOGICAL ADOPTION: THE CASE OF THE TELEGRAPH

Technological change stands as one of the main drivers of economic growth (Gordon 2017). Over the past decades, an increasing amount of works have started to expand the existing literature on the political determinants of the adoption of new technology. Notable cases are Acemoglu and Robinson (2012); Mokyr (1992) and Milner and Solstad (2021), whose focus is on countries and empires as units of analysis. These works have contributed to better understand the political dynamics of technological adoption by putting the theoretical spotlight on political factors such as the level of democracy (Acemoglu and Robinson 2012; Mokyr 1992), or international competition linked to national security (Milner and Solstad 2021). However, these rather aggregate variables tell us little about the inside story of technological adoption

within - rather than across - countries.

The literature on technological adoption within countries is more limited, and works often do not look at disruptive innovations. Rather, they tend to look at infrastructural developments like roads (Herranz-Loncán 2007; Curto-Grau, Herranz-Loncán, and Solé-Ollé 2012; Do, Nguyen, and Tran 2017; Jiang and Zhang 2020; Burgess et al. 2015)[1]. The works that do not focus on democracies and have some sort of technological innovation as an outcome, use distributive politics as their theoretical anchor. Their research broadly suggests that the ruler's pursuit of stability may drive him to allocate a larger share of infrastructural resources to areas of less conflict, where they have more support to maintain their power (Do, Nguyen, and Tran 2017; Jiang and Zhang 2020; Burgess et al. 2015).

However, the distributive politics framework to explain technological innovation has its limitations. It overlooks the potential capabilities of the new innovations and fails to address how they could benefit those in political power compared to the state's challengers. I suggest that the within dynamics of the regime and the emergence of new social groups -rather than/or in conjunction with the ruler's pursuit of stability- can better explain the adoption of new technology. More specifically, my research aims to answer the research question of whether the emergence of the labor movement conditioned strategic decisions of the elites to place new innovations.

I suggest that in regions where labor strikes, work stoppages, and social unrest were more prominent, the likelihood of new innovations occurring was higher. In this paper, I operationalize *new innovations* with the roll-out of the telegraph, a cutting-edge technology that enabled instant communication. There are, at least, two possible mechanisms linking the emergence

[1]These works also focus on non-democratic regimes, which aligns with the scope of this thesis. There is a large literature on distributive politics in democracies that goes back to canonical works by Cox and McCubbins (1986) and Lindbeck and Weibull (1987). For a review, see Golden and Min (2013)

of the labor movement and technological adoption: repression and *the voice* argument.

The idea that repression is linked to technology is not new. Mather (1953) noted over 70 years ago that railways and telegraph stations tended to appear more prominently in areas with a stronger labor movement. However, he did not test his argument empirically, and technological adoption was not his primary focus of interest. Similarly, Horowitz (2010) demonstrates how terrorist attacks, broadly defined as innovations, were partially instigated by repressive responses of elites to state challengers.

There are two reasons why telecommunications technology - with the telegraph being its clearest expression - could have increased the ruler's capacity for repression. Firstly, the time and cost of transmitting information were drastically reduced compared to previous forms of communication. The police could use the telegraph to coordinate more easily (Morus 2000, p.426). In the event of an uprising, state authorities could send immediate messages that would facilitate its swift repression, as happened with the chartist revolution in the UK during the first half of the XIX century (Solymar 2000). The second crucial aspect is that state authorities could utilize the telegraph for repression to a greater extent than workers could use it for coordination. From the reading of the parliamentary debates where the Bourgeoisie, the Nobility, the Peasantry and the Clergy were present, the state's ultimate control was evident.

The other possible mechanism is *the voice* argument (Hirschman 1972). In the XIX century — as still happens today in different coordinates of the globe — many places were unnoticed by the state. As pointed out by Scott (1999), it takes resources, innovation, and advanced infrastructure to monitor remote areas. Labor conflict could have worked as a way to draw greater attention to otherwise peripheral locations, and those could in turn have become more likely to receive new technology.

Regarding the operationalization of the outcome, there's also a strong case for using the telegraph as the technology under study. Before its advent, horse-drawn carriages and maritime transport were the dominant modes of communication over distance, but their functionalities were far from those offered by the electric telegraph, with far lower speed of transmission and success rates. It is worth noting that telecommunications encompass other technologies such as the telephone and radio. One of the arguments of this dissertation is that telecommunications were more likely to spread to places where there was more social unrest, repression being one of the possible underlying mechanisms behind this observation. The telegraph likely had a more profound impact in this regard compared to radio and telephone as it predates any other telecommunications technology, thereby providing a greater contrast to past means of communication, and, unlike the telephone and especially the radio - which mixed informative and descriptive information with entertainment - the telegraph was primarily used for transmitting concise messages such as news, commercial information, and government messages.

To test the idea that more labor conflict implied better telegraph connection -the most novel part of the argument in the diffusion cycle, although Horowitz (2010)'s work suggests a similar argument, albeit with a completely different operationalization of innovation- I use a panel dataset of the Swedish Municipalities. I employ two empirical strategies. I first explore the data descriptively with a survival analysis that uses technological diffusion as an outcome and the proximity to conflict as an input. I then turn to a hard test of the theory by using a two-way fixed effects with distances to the nearest telegraph station as an outcome and proximity to labor conflict events such as strikes as the main predictor. The municipality and time fixed effects allow to control for each municipal time-invariant characteristic. The controlled characteristics include all sorts of geographical indicators, as well as institutional indicators, such as the coordination among institutions (Doner

and Schneider 2016).

The greatest confounder between technological adoption and conflict is the fact that industrialization could be driving the observed results. Industrialization increases both the presence of the labor movement and, likely, the telegraph. To account for this, I have taken two different measures to at least alleviate the possible bias. The first one has been to control for population density at the municipal level. Since the area of each municipality is accounted by the municipal fixed effects, controlling for population effectively takes population density into account. The municipal fixed-effects control for any historical legacy of industrialization. But new industries may have appeared precisely under the period of study -for instance, if a coal deposit was discovered, or if a transport industry decided to change its location, or to expand to another - biasing the results. If those shocks occurred, we should have observed increases in population density in those areas. Since Sweden was mainly rural, industrial shocks would have fostered the arrival of migrants from different parts of Sweden to work in the industry. In other words, industrialization likely brought population increases. By controlling for population density, industrial shocks are partly accounted for.

A second measure to cope with the absence of industrialization data is the use of secondary sources such as the Parliamentary debates regarding the telegraph expansion in the XIX century and the state reports on the telegraph. In different state reports and parliamentary motions (11, 48 and 118 of the parliamentary statements of 1853) the King mentioned that the places with greater industrial activity had already been connected. While those documents do not provide any explicit reference to the telegraph being a repressive engine, the Monarch mentioned in state report number 11 of 1853 that the telegraph was built in the interest of the state. This reference to state interests in telegraph development, in conjunction with literature emphasizing the telegraph's role in national security (Morus 2000; Goldstein

2001), suggests support for the repressive aspect of state-sponsored technology, as security is one of the key aspects of the state. I delve deeper into these aspects throughout the paper and propose testing this notion in more well-known contexts and technologies. Nonetheless, I consider exploring this research question within a relatively understudied technology - the 19th-century telegraph- thus providing an additional contribution from this paper.

2.1 Repression and technological adoption

Institutionalists have examined two political variables that affect the diffusion of technology. One primarily focuses on the quality of institutions. Studies suggest that democracies (Comin and Hobijn 2004) and countries with more advanced institutions in general (Acemoglu and Robinson 2012; Mokyr 1992) are more likely to embrace new technologies due to fewer barriers to innovation. The underlying idea is that democracies are less susceptible than autocratic regimes to ban technological advancements. Democracies also offer stronger protection of property rights (Mokyr 1992; Mokyr and Nye 2007) and those foster innovation and technological adoption. The second factor influencing macro-level decisions regarding technology adoption is the role, significance, and impact of specific interest groups. For example, unions may oppose the introduction of new technologies that reduce labor demand (Olson 1982). Furthermore, other factors such as international competition (Milner and Solstad 2021), high literacy rates (Caselli and Coleman 2001; Comin and Hobijn 2004), and geographical variables such as population density (Herbst 2014) have been identified as influential in the adoption of new technology. These works, however, focus on countries and empires. If technological change is meant to be the main driver of economic growth (Gordon 2017), the study of technological adoption at units smaller than States requires further attention.

New technologies are argued to diffuse quickly, as argued by the economist Robert Solow, who, in the late 50's, claimed that technological adoption is exogenous (Solow 1956). The empirical reality, however, suggests that adopting new technology takes time, and some places are quicker in adopting given technologies than others. Since the uptake of new technology is expensive, the question of which places are likely to be fast adopters requires thorough consideration. New technology often unfolds first in the main economic hubs. As Herbst illustrated in Africa, population density makes the arrival of new technology more likely. His insights from Africa also travel into XIX century Sweden, as shown in table 2.9, available in the appendix. Population density disproportionately increases the adoption of new technology, as one could expect. Autocrats, in the absence of major external or internal threats, are likely to connect the main economic hubs, those that can make new technology profitable early on.

But often, social unrest can appear without previous notice, and can alter the incentives to place technology in certain locations. The protests and social unrest witnessed during the 19th century can be understood as expressions of opposition directed towards the prevailing regime (Melander et al. 2020, p.5). Moreover, rebellion and popular uprisings are more likely in contexts of low state capacity(Fearon and Laitin 2003; Müller-Crepon, Hunziker, and Cederman 2021), which were common in XIX century continental Europe. In those contexts, population density, human capital and socioeconomic variables may not be the only factors at play, if those who hold power can use technology for purposes other than development.

Telecommunications alleviated rulers' anxiety regarding possible uprisings. In Sweden, the telegraph network was primarily controlled by the State, and workers in the telegraph service were public officials. That guaranteed ultimate control of telegraph stations to the king, preventing any unintended use against his authority. If those in power could use the telegraph to immedi-

ately send information about any eventuality, then plotting against the ruler became a more arduous task. An elucidating example is found in historical work such as Lubrano (1997, p.15), who shows how certain crimes were fought with the arrival of the telegraph. He argues that the telegraph altered the relations of power and control in society, making it easier for state officials to repress. Similarly, Solymar (2000) sustains that the telegraph streamlined the state's ability to gather, command, and call troops, as communication times were shortened considerably. And, as a result, the rebels' chances of success were reduced. With new technology, the speed at which state officials could communicate from one side of the country to another was that of electricity, not horses. Ultimately, the arrival of new technology became more likely where labor conflict was more prominent, because it was in those locations where the monarch had more incentives to increase control and prevent rebellion.

These works are, in fact, not alone in revealing the repressive capacity of the telegraph. Goldstein (2001) -whose principal interest is not technology but repression during the XIX century- suggests that the telegraph was crucial in preventing rebellions. In a different context, the XIX century United States, the telegraph strengthened the overall capacity of the state (Nonnenmacher 2001). Due to different state preferences regarding its implementation, it resulted in differential implementation within the United States.

The concept of technologically enabled repression isn't entirely novel. State infrastructure, incorporating newly arrived technologies, can bolster state capacity and alleviate violence, incentivizing political leaders to invest in them (Mann 1984; Fearon and Laitin 2003). Anecdotal evidence from the UK's Chartists revolution in 1836 implies the telegraph was a tool for repression (Mather 1953). This perspective is echoed by experts studying the telegraph's impact (Solymar 2000; Morus 2000). Research on the XIX century also highlights the role of early telecommunications in repression (Goldstein

2001).

What flows from these works is that technology is often strategically allocated to repress. But technological diffusion was not their outcome of interest -with the exception of Horowitz (2010), whose operationalization of innovation is different from the outcome explored in this paper. Rather, they focused on describing conflict and repression, and how technology was used throughout that process. The idea that more labor conflict made technological adoption more likely is present in their work, but it is not directly hypothesized. Consequently, the argument is also not empirically tested. Additionally, the mechanisms that link conflict and technological adoption are unclear, as well the scope conditions under which conflict leads to more technology.

2.2 Sweden: Historical background and case selection

In Sweden, the emergence of the labor movement arrived later than in other countries that had industrialized earlier than Sweden, such as the United Kingdom. As a consequence, the expansion of telecommunications coincided with the appearance of the labor movement. In addition, few countries have geolocated data on work stoppages in the XIX century, or have public records of when, and where, each telegraph station was installed. Population density information at the municipal level is also rare: that is particularly relevant as population density is one of the few existing tools to control for industrialization shocks. These data exist for Sweden, and the availability of this information make the linkage between emerging conflict and technological adoption suitable for research. Finally, the way in which XIX century innovations unfolded in Sweden resembles the form of technological expansion in Continental Europe, i.e., technological diffusion via the initiative of public authorities rather than private companies. The findings from this paper,

therefore, can apply to contexts other than Sweden.

In Sweden, labor conflict was uncommon in the early 19th century (Molinder, Karlsson, and Enflo 2018). The country's low population density and delayed industrialization contributed to the absence of recorded work stoppages until 1863. Axel Raphael, an economist and historian employed by the Swedish public administration, conducted extensive research on work stoppages for the period 1859 to 1900. The resulting database, available in Molinder, Karlsson, and Enflo (2018), reveals that the first documented work stoppage transpired in the coastal region of Helsingborg. This protest materialized in the form of a strike which lasted five days. The strikers failed to achieve their desired outcomes, resulting in the protesters' ultimate defeat (Molinder, Karlsson, and Enflo 2018).

After the first strike in Helsingborg, subsequent strikes in Stockholm, Gefle, Uddevalla, Trollhättan, Göteborg, and Eskilstuna took place, and again, the protesters' demands were not conceded by the monarch (they fail to achieve their intended objectives). However, a significant turning point emerged in 1869 when the first successful strike was carried out. A strike can be considered successful when protesters achieve all, most, or a significant portion of their demands. In the city of Mondal, located near Göteborg, factory workers organized a protest against reductions in their wages. At the end of the protest, their demands were met, marking the first instance of a triumphant strike. In the five months that followed, a second strike also succeed in accomplishing workers' demands. In general, workers had different success rates when pursuing strike actions. From 1868, strikes also became much more prominent and likely to take place, affecting different sectors of the economy such as dock workers, factory workers, the tobacco industry and miners. In 1879, a significant strike in Sundsvall, a coastal city in Sweden, involved 4000 Sawmill workers -the wood industry was huge in XIX century Sweden. It was the largest strike up to that moment (Molinder, Karlsson,

and Enflo 2018). Despite its ultimate failure -they did not achieve their intended goals-, some scholars have regarded this event as one of the initial instances of substantial collective action in Sweden (Verney 1957, p.193). What these figures tell us -despite some limitations from XIX century data - is that the labor movement was becoming stronger under the period covered in this paper.

The industrial revolution also brought new technology to Sweden. The electric telegraph arrived in 1853. A year prior, King Oscar, a monarch with increasingly diminished power (Verney 1957, p.116), had first founded the Telegraph Agency. The king ordered this agency to prepare a telegraph line that would connect the cities of greatest commercial and political relevance. The director of the Telegraph Agency, Carl Akrell, was influential in deciding where the telegraph should be installed, but the king had the final say on the matter. The construction of the telegraph was marked by the guidelines that the King entrusted to the Agency. The King made it very clear that areas of *economic* but also *political* interest should have a telegraphic connection. What did the king and other parliamentarians mean by *political*? Perhaps it becomes clearer when reading the minutes of the Swedish Parliament of Estates before the 1866 reform, in motions presented by the different States (such as motions 11, 48, and 118 in 1853). After conducting a thorough analysis of all publicly available parliamentary debates whose principal topic of discussion was the telegraph, what *political* meant becomes clearer. To put it simply, the king (and many other parliamentarians of different social groups) viewed the telegraph as a way of increasing state capacity through two means. First, they referred to its capacity to protect the country against external threats. In some debates, they simply pointed out that it *helped the state* (motion 118) without further specifying what that could mean. By reading all the debates and seeing it in perspective, it seems that what they broadly meant is that the telegraph was a tool to improve the capacity of the state to carry out its functions, which the literature in political sciences

refers to as State Capacity.

Historical studies conducted in other countries, such as the United Kingdom, also point out that the telegraph was as a political instrument that could be employed for repressive purposes (Mather 1953). The king, however, was unlikely to overtly characterize the telegraph as a repressive tool, as it would have been counterproductive. Such a declaration would have publicly exposed his intentions, potentially instigating further mobilization. Consequently, an empirical analysis is necessary to ascertain whether conflict entailed an increased adoption of technology as a means of repression. This analysis is particularly relevant given the inherent limitations of qualitative sources from the era and the monarch's lack of incentives to delineate their intentions explicitly.

2.3 Empirical Strategy

To answer the main research question of this paper -whether social unrest accelerated technological diffusion - I have constructed a new dataset. Matching newly geocoded telegraph stations with existing reports on labor conflict for the 1866-1878 period, the result is a panel structure of 2371 municipalities across 13 time periods.

I also adopt two distinct methods to investigate my research question. The first approach encompasses the implementation of a survival analysis utilizing the Cox proportional hazards model. The model unfolds as follows: the survival outcome is defined as the occurrence of an event, in this case, the adoption of the telegraph. This occurrence is regressed on predictors - the one I am interested in is the proximity to the nearest strike or work stoppage.

In the survival analysis , a positive coefficient implies that increasing each municipality's distance to the nearest work stoppage (which actually meant less exposure to conflict, as conflict was further away) increased the likelihood

of getting connected to the telegraph. Conversely, a negative coefficient in the survival model implies that more conflict caused more telegraph adoption.

To put my hypothesis under a second empirical test, I have run a second model with a different method. Instead of a survival analysis, I rely on a two-way fixed effects where the outcome is each municipality's distance to the nearest telegraph station and the explanatory variable is each municipality's distance to the nearest strike. Both variables are regressed using fixed effects for each municipality and year. This strategy effectively controls for every non-time-varying characteristic of municipalities, as well as common shocks that took place in similar periods. Furthermore, in order to control for industrialization, which varies within municipalities, I have included a time varying population indicator, that is meant to account for changes in the industrial activity of each municipality.

$$\delta\tau_{i_t} = \alpha + \beta_1\delta\kappa_{i,t} + \beta_2\pi + \sigma + u_i + \lambda_t + \varepsilon_{i,t}, \tag{2.1}$$

Where i denotes municipalities $(1, 2, \ldots, 2371)$, t denotes years, $\delta\tau_{i,t}$ indicates proximity to the telegraph, $\delta\kappa_{i,t}$ the proximity to the nearest work stoppage, and $\beta_2\pi$ indicates population shocks from 1860 to 1870. U_i are municipal fixed effects and λ_t are time fixed effects for each year. For the variables distance to the telegraph and distance to labor conflict, I have followed the four operationalizations described above.

Both models employed in this study, namely survival analysis and the OLS two-way fixed effects model, utilize a similar operationalization of social unrest. Labor conflict -once municipal-level, time-varying population density estimates are accounted for- does not proxy industrialization, but the arrival of the labor movement. The mechanism linking the emergence of the labor movement and more technology does not necessarily go through the channel of repression as new data would be needed to test the repressive mechanism

more directly. The mechanism of repression is plausible, but others could be at stake, such as the fact that those places got a *voice* (Hirschman 1972), or were *seen* in Scott (1999) terms.

As posited by the theoretical section of this paper, conflict precedes the adoption of technology; therefore, various lags of the explanatory variable have been examined. Notably, the primary results highlight lag periods of two years, reflecting the estimated duration for constructing a new telegraph station. However, robustness checks are conducted using alternative operationalizations with lag periods of 1 and 3 years. In the survival analysis, the explanatory variable is additionally subjected to logarithmic transformation. Given the large distances involved, it's important to understand that reducing distances, like going from 1000 kilometers to 800 kilometers, may not bring significant theoretical proximity to conflict because the distance is still substantial. To address this, I use a logarithmic transformation, which focuses more on relative changes rather than just the kilometer measurements. This approach places equal importance on changes in proximity to conflict that involve going from 1000 to 500 kilometers as going from 60 to 30 kilometers.

In the two-way fixed effects model, the explanatory variable has been operationalized in four different ways. The first operationalization simply captures the crude distance from each municipality's centroid to the nearest strike or work stoppage. If a municipality went from being 140 km away from the closest strike to 100 km, the model estimates a change in the independent variable of 40 units. The second operationalization follows the same procedure, but caps the variable at 65kilometers from the nearest conflict. The objective of this correction is to avoid counting reductions in distances that did not involve a real proximity to conflict. 65 kilometers is the maximum number of kilometers an individual could do in a day by conventional means of transportation, according to the historian (Bergenfeldt 2014). Although

covering this distance in a day was uncommon, setting this threshold avoids suppressing the spill-over effects of telegraph adoption. Even if it took two days to send a message, the telegraph still drastically reduced communication time. The third and fourth operationalization are the logarithm of the first two measures. The rationale is the same as in the survival analysis, the logarithmic transformation gives more relevance to reduction in distances that take place near the event under study.

The dependent variable also varies in the survival analysis and in the two-way fixed effects model. In both cases, it has required the use of GIS to transform the coordinates of telegraph stations available in historical archives to relevant indicators of each municipality's proximity to the telegraph. In the survival analysis, it reflects the survival probability of a municipality, when surviving means not having telegraph access within a range of 30, 20 or 10 kilometers. For the two-way fixed effects -available in table 2.4- the outcome is measured in the same way as the explanatory variable, following the same procedures and standards explained to measure conflict, but with the distance to the nearest telegraph station as the main parameter of interest. This implies measuring the raw distance to the nearest telegraph station in the first operationalization. A second operationalization caps the variable to 65km and the third and fourth use the logarithm of these two measures.

Table 2.1: Descriptive Statistics by Year

Year	Distance to Nearest Telegraph Station (Sensitive to 65km)	Distance to Nearest Telegraph Station	Prox. to Conflict (Sensitive to 65km)	Prox. to Conflict
1866	27.8 km	29.3 km	97.9 km	205.0 km
1867	27.2 km	28.7 km	86.1 km	139.0 km
1868	25.8 km	27.1 km	81.1 km	122.0 km
1869	25.8 km	27.1 km	81.0 km	121.0 km
1870	25.7 km	27.0 km	81.0 km	121.0 km
1871	25.4 km	26.7 km	75.1 km	104.0 km
1872	25.0 km	25.9 km	73.1 km	99.0 km
1873	24.7 km	25.5 km	68.7 km	73.1 km
1874	23.9 km	24.5 km	67.9 km	70.5 km
1875	22.2 km	22.5 km	67.9 km	70.5 km
1876	22.1 km	22.3 km	67.7 km	67.7 km
1877	21.9 km	21.9 km	67.7 km	67.7 km
1878	21.8 km	21.8 km	67.7 km	67.7 km

Note: Unit of analysis - municipalities.

Table 2.1 highlights aggregate distances to the nearest telegraph stations over time (columns 2 and 3) and proximity to the nearest labor conflict (columns 4 and 5). The data reveals significant variation in the explanatory variable, *Proximity to conflict*, both in its raw measure (column 4) and its adjusted version (Column 5). Interpreting this table, we observe that, on average, a Swedish citizen had their nearest telegraph station approximately 29.3 kilometers away in 1866, decreasing to 21.8 kilometers by 1878. However, these findings do not extend to proximity to conflict. This variable accounts for the accumulated number of conflicts, meaning that conflicts occurring in previous years are factored into the count for the *current year*.

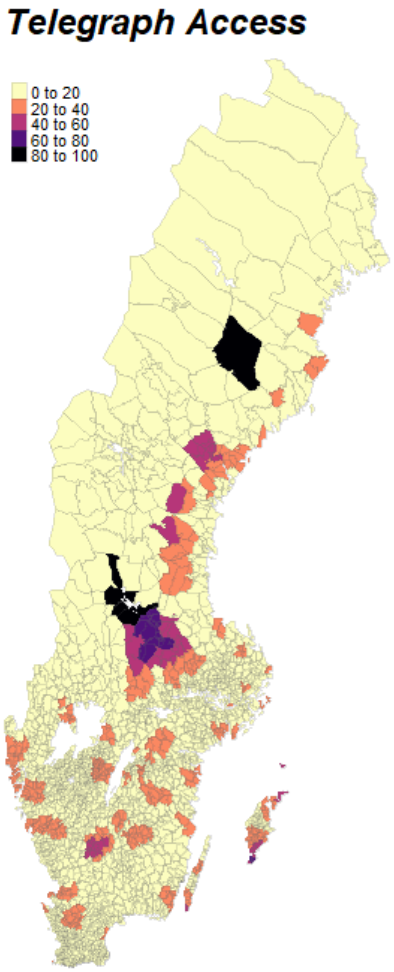

Figure 2.1: Darker colors indicate a significantly improved telegraph connection in 1878 compared to 1866. Places where the telegraph connection did not improve are shown in yellow.

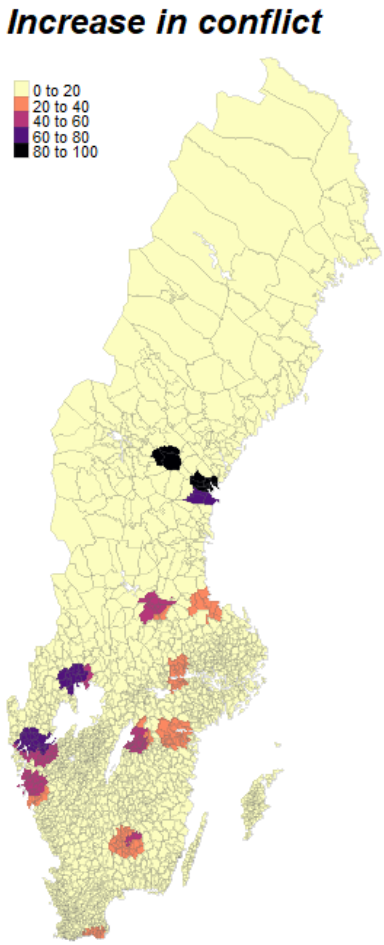

Figure 2.2: Darker colors indicate a significant increase in the proximity to the nearest labor conflict over time. Places where the telegraph connection did not improve are shown in yellow

Figures 1 and 2 provide visual insight into the correlation between conflict and telegraph adoption over time. Figure 1 displays a map depicting the

disparity between the distance to the nearest telegraph station in the latest period (1878) and the earliest period (1866). To illustrate this contrast, I computed the difference in the nearest distance to both the nearest telegraph and labor conflict and standardized that difference on a 0-100 scale. When no differences occurred, this shows in yellow. Darker colors imply greater changes-over time, like shifting from being very far away from the event to becoming close.

2.4 Results

A first exploration of the data suggests that conflict is indeed correlated with technological diffusion in the way that is argued in the paper. The causal test to this proposition can be found in table 2.4, with a two-way fixed effects models and time lags for the explanatory variable. But before that, I introduce a correlational scatter-plot in figure 2.3 and a survival analysis to get a sense about the structure of the data (see table 2.3). After exploring the data, I proceed with the causal test using the two-way fixed effects in table 2.4.

A first exploration of the data suggests that more conflict is correlated with more telegraph connection, as shown in figure 2.3, which shows how municipalities that were further away from the nearest labor conflict were seemingly further away from the telegraph. Despite this initial bi-variate correlation aligning with the theoretical argument of the paper, many confounders and omitted variables could bias the results.

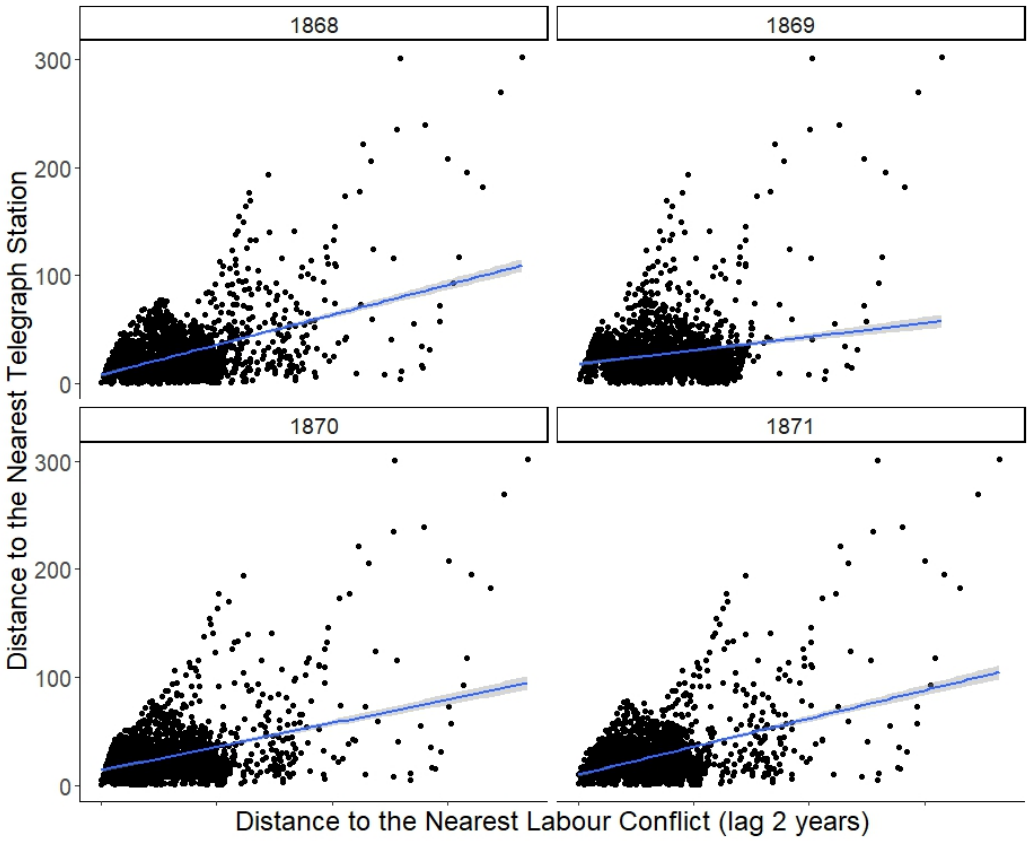

Figure 2.3: Distance to the nearest conflict in two years lag (x); Distance to the nearest Telegraph Station (y)

To gain insights from the data, Table 2.2 displays the top 10 municipalities where the proximity to the nearest conflict increased the most between 1866 and 1867. This table exclusively features *relevant distances*—those within a range of less than 65km in 1867—for the purpose of this visualization exercise. Among these top 10 municipalities—those that notably reduced their proximity to conflict—we note that 40% exhibited an improvement in their telegraph connections.

Notably, Krokstads, the municipality that experienced the most significant increase in conflict proximity, substantially enhanced its telegraph connec-

tion to 33.2km, rendering it accessible within a day's travel. At that time, this municipality had a population of 3142 inhabitants and posed challenges for state officials in terms of monitoring. Primarily reliant on agriculture, akin to much of Sweden, Krokstads also hosted military units such as the indelta soldater (enlisted soldiers) affiliated with the Bohusläns regemente and the indelta båtsmännen (boatmen) associated with the 1st Bohusläns båtsmanskompani

Table 2.2: Municipalities that approximated conflict the most (1866-1867)

Municipality	**Nearest conflict 1866**	**Nearest conflict 1867**	**Telegraph 1867**	**Telegraph 1868**	**Telegraph Improvement**
Krokstads	336 km	44 km	43.7 km	33.2 km	10.5 km
Gesäters	346 km	55 km	46.3 km	42.4 km	3.89 km
Sanne	332 km	41 km	39.9 km	38.9 km	0.98 km
Valbo-ryrs	310 km	19 km	18.2 km	18.2 km	0 km
Torps	308 km	17 km	16.8 km	16.8 km	0 km
Lerdals	340 km	49 km	48.8 km	44.1 km	4.69 km
Hede	322 km	31 km	29.8 km	29.8 km	0 km
Haverstads	352 km	61 km	31.2 km	31.2 km	0 km
Rölanda	351 km	60 km	50.5 km	50.5 km	0 km
Rännelanda	334 km	43 km	42.2 km	42.2 km	0 km

Continuing with the exploratory analysis, Table 2.3 presents the results of the survival analysis model examining the relationship between conflict and the presence of a telegraph within different distances (30km, 20km, and 10km), controlling for changes in the Log Population of each municipality.

As discussed above, the negative coefficients observed in the regression analysis can be interpreted as a positive effect of conflict on technological diffusion. The coefficients are statistically significant at the $p < 0.01$ level, indicating a robust relationship.

The R-squared values indicate the proportion of the variation in the technological diffusion variables that are explained by the log distance to the nearest

Table 2.3: Two-way fixed effects. A negative coefficient indicates that increasing labor conflict yielded better telegraph connection

	Presence of the telegraph within		
	30km	20km	10km
	(1)	(2)	(3)
Log Distance to Conflict (lag 2)	-0.313^{***}	-0.334^{***}	-0.351^{***}
	(0.007)	(0.007)	(0.010)
Log Population	-0.034^{***}	-0.019^{*}	0.152^{***}
	(0.009)	(0.010)	(0.013)
Observations	26,135	26,135	26,135
R^2	0.076	0.069	0.049
Max. Possible R^2	1.000	1.000	0.999
Log Likelihood	−201,664.300	−160,705.400	−88,796.870
Wald Test (df = 2)	$2{,}190.100^{***}$	$1{,}987.880^{***}$	$1{,}454.950^{***}$
LR Test (df = 2)	$2{,}063.483^{***}$	$1{,}862.771^{***}$	$1{,}314.851^{***}$
Score (Logrank) Test (df = 2)	$2{,}180.786^{***}$	$1{,}976.002^{***}$	$1{,}407.876^{***}$
Note:			*p<0.1; **p<0.05; ***p<0.01

conflict lagged in two periods. Each column refers to different operationalizations of the outcome variable, whether the municipality was 30, 20, or 10 kilometers from the nearest telegraph station. The R-squared values for the three models are 0.076, 0.069, and 0.049, respectively. These relatively low values suggest that other unmeasured factors may contribute substantially to the variation in technological diffusion. However, these indicators should not be confounded by the overall effect of social unrest on technological diffusion, as the telegraph had already started its expansion when the first strike occurred in 1863, and there could have been other political grievances that are not accounted for in the model.

To assess the overall significance of the models, several statistical tests have been conducted. The Wald Test, LR Test, and Score (Logrank) Test all yielded highly significant results for each model. These findings indicate that the models as a whole are statistically significant and explain a statistically significant portion of the variation in the adoption of new technology. Despite its statistical significance, there could be omitted variables that refer to the structural factors of municipalities and could thus induce omitted variable bias. To address this issue, the following two-way fixed effects models is better equipped to assess the causal impact of conflict on technological adoption.

Table 2.4 presents the results of the two-way fixed effects model with lagged distances of the explanatory variable. Among the conflict measures, the crude distance to conflict variable (lagged by two years) is statistically significant and positive. This indicates that greater distances to labor conflict are associated with greater distances to the telegraph. Conversely, as proximity to a strike increases over time, the proximity to the telegraph also increases.

The second measure consists of the logarithm of the distance to the nearest strike, again lagged by two periods. The results indicate a positive effect, although it is less precisely estimated. The distance to the nearest conflict,

Table 2.4: Two-way fixed effects. A positive coefficient indicates that increasing labor conflict yielded better telegraph connection

	Distance to the telegraph			
	Crude	Log	Cap 65	Log Cap 65
	(1)	(2)	(3)	(4)
Distance Conflict (lag2)	0.024^{***}			
	(0.003)			
Log Distance to Conflict (lag2)		0.004^{+}		
		(0.003)		
Distance Conflict Cap 65 (lag 2)			0.101^{***}	
			(0.032)	
Log Distance Conflict Cap 65 (lag 2)				0.011^{*}
				(0.006)
Log Population	0.764	0.063^{+}	2.087^{***}	0.077^{*}
	(0.953)	(0.044)	(0.795)	(0.044)
Observations	26,135	26,135	26,135	26,135
R^2	0.002	0.0002	0.001	0.0003
Note:		$^{+}$p<0.2; *p<0.1; **p<0.05; ***p<0.01		

capped at 65 kilometers in column 3, is statistically significant at the 99% confidence level and also predicts more technological adoption when conflict is high. Similarly, its logarithm version is also positive and significant at the 90% confidence level.

To get a sense about the magnitude of the effect, I have considered the log-log results in columns 2 and 4. The average of both estimations is 0.0075. This means that by increasing the proximity to conflict by 50%, the proximity to the actual telegraph distance would increase by 3.75%. The potential size effect, assuming the same hypothetical 50% reduction in conflict distances, ranges from 0.2% at the lower bound to 5.5% at the upper bound.

Regarding the influence of log population on the outcome, the variable behaves counter-intuitively. Increasing the log population decreased the marginal probability of technological adoption (since the outcome measures distances to the telegraph, and higher distances actually mean worse telegraph connection). The reason for this is likely to be associated with the fact that the main economic hubs had already been connected before the first period of my analysis, as shown in table 2.9, available in the appendix.

2.5 Conclusions

Right at the intersection between state-building and technological diffusion, the results of this paper suggest that the diffusion of new innovations within countries often does not follow only economic and geographical criteria, although those are also strong predictors. Controlling for economic and geographical factors through the use of a two-way fixed effects model, the results streamline the idea that newly arrived technology can be more likely to be adopted when repressive incentives exist.

The mechanism that links labor conflict and technological adoption is straightforward. In contexts of non-democracy and state building, autocrats stabilize

the regime through alliances with powerful political elites. The disruption of new social actors with the capacity for uprising can further strengthen the alliances between the ruler and the elites, and it can also -as shown in this paper - increase the incentives to deploy new technologies capable of monitoring the movements of newly emergent groups, like the labor movement. Instead of distributing state-sponsored technology exclusively in economically developed regions, the government can also take political considerations into account. A critical question arises: who benefits the most from this new technology, rebel groups or the government? When the answer favors the government, and the technology can be expanded while impeding its use by rebels, it is likely that the government will strategically deploy these innovations in areas where challengers hold more influence.

This paper, despite not presenting an entirely novel approach to the repressive component of technology, contributes to the existing literature on technological adoption. While it's true that Horowitz (2010), along with Mann (1984) and Mather (1953), have linked the adoption of new technologies (often with significantly different operationalizations) to social unrest, this paper delves into a different sphere: the telegraph, where the state held ultimate control and decision-making power regarding its placement. The telegraph was also different in that it was the first available telecommunications in history -the first that allowed to instantly communicate at the speed of electricity.

The paper also adds - in a cumulative way - evidence to understand how state capacity developed in XIX century Sweden. State capacity was boosted in many European countries during the XIX century, and the expansion of telecommunications was part of this process. While most papers look at taxation as a way of operationalizing state capacity (Garfias and Sellars 2022), or non-innovative infrastructure (Herranz-Loncán 2007; Do, Nguyen, and Tran 2017; Curto-Grau, Herranz-Loncán, and Solé-Ollé 2012), this paper

focuses on the state's distribution of new innovations as a crucial part of state capacity.

There are certain limitations in this paper that deserve attention, and potential future research could help address these issues. Repressive objectives are not often explicitly stated by those in positions of power. It would be unwise and unpopular for any ruler, whether democratic or authoritarian, to openly declare that a technology could be used for repressive purposes. Researchers exploring the repressive use of specific technologies may encounter the challenge of not finding direct statements linking the explained goals with the studied outcome. However, these links can often be inferred from context and supported by data.

In this work, I identify proxies for such statements, such as rulers referring to new technology as a means to *enhance the state* or defend against *external threats* or labeling a technology as of *political interest*. Another concern pertains to the external validity of my findings. To what extent can the case of the telegraph in 19th century Sweden be applied to other contexts? Further research should empirically examine this issue, possibly specifying the conditions under which my findings hold true.

The data of this paper is consistent with the idea that more conflict brought the adoption of new technologies, but the lack of direct statements and the lack of data on industrialization warrant further attention and research. Further research should examine these questions in new contexts -where there is more micro-data available-, to complement this one. In order avoid the error of testing ideas with the same data that have generated them, I suggest some hypotheses for theory building that are plausible after exploring the case of the telegraph in the XIX century.

2.6 Appendix

Table 2.5: Survival analysis with 1 year lag in the explanatory variable. Negative coefficients indicate that more conflict increased telegraph connection

	Presence of the telegraph within		
	30km	20km	10km
	(1)	(2)	(3)
Log Distance Conflict (lag 1)	-0.306^{***}	-0.323^{***}	-0.338^{***}
	(0.006)	(0.007)	(0.010)
Population (logged)	-0.032^{***}	-0.017^{*}	0.150^{***}
	(0.008)	(0.009)	(0.012)
Observations	28,506	28,506	28,506
R^2	0.071	0.063	0.044
Max. Possible R^2	1.000	1.000	0.999
Log Likelihood	−220,536.600	−174,988.300	−96,121.700
Wald Test (df = 2)	$2{,}270.600^{***}$	$2{,}000.090^{***}$	$1{,}467.250^{***}$
LR Test (df = 2)	$2{,}109.896^{***}$	$1{,}847.221^{***}$	$1{,}295.644^{***}$
Score (Logrank) Test (df = 2)	$2{,}266.417^{***}$	$1{,}993.526^{***}$	$1{,}413.210^{***}$
Note:			*p<0.1; **p<0.05; ***p<0.01

Table 2.6: Survival analysis with 3 years lag in the explanatory variable. Negative coefficients indicate that more conflict increased telegraph connection

	Presence of the telegraph within		
	30km	20km	10km
	(1)	(2)	(3)
Log Distance Conflict (lag 3)	-0.014	-0.046^{***}	-0.090^{***}
	(0.009)	(0.009)	(0.012)
I(log(population))	-0.022^{**}	-0.004	0.173^{***}
	(0.009)	(0.010)	(0.013)
Observations	23,764	23,764	23,764
R^2	0.0004	0.001	0.009
Max. Possible R^2	1.000	1.000	0.999
Log Likelihood	$-183,286.100$	$-146,867.300$	$-81,742.380$
Wald Test (df = 2)	8.370^{**}	23.620^{***}	215.700^{***}
LR Test (df = 2)	8.378^{**}	23.414^{***}	209.062^{***}
Score (Logrank) Test (df = 2)	8.368^{**}	23.622^{***}	213.647^{***}
Note:			*p<0.1; **p<0.05; ***p<0.01

Table 2.7: two-way Fixed Effects with 1 year lag. Positive coefficients indicate that increasing conflict led to higher telegraph connection

	Distance to the telegraph			
	Crude	Log	Cap 65	Log Cap 65
	(1)	(2)	(3)	(4)
Distance Conflict (lag1)	0.015***			
	(0.003)			
Log Distance Conflict (lag1)		−0.004*		
		(0.003)		
Distance Conflict Cap 65 (lag 1)			0.065**	
			(0.033)	
Log Distance Conflict Cap 65 (lag 1)				0.006
				(0.006)
Log Population	0.581	0.039	1.551**	0.049
	(0.901)	(0.039)	(0.728)	(0.038)
Observations	28,506	28,506	28,506	28,506
R^2	0.001	0.0001	0.0003	0.0001
Note:				$^{+}$p<0.2; *p<0.1; **p<0.05; ***p<0.01

Table 2.8: two-way Fixed Effects with 3 year lag. Positive coefficients indicate that increasing conflict led to higher telegraph connection

	Distance to the telegraph			
	Crude	Log	Cap 65	Log Cap 65
	(1)	(2)	(3)	(4)
Distance conflict (lag3)	0.002			
	(0.004)			
Log Distance Conflict (lag3)		0.005^{+}		
		(0.003)		
Distance Conflict Cap 65 (lag3)			−0.001	
			(0.032)	
Log Distance Conflict Cap 65 (lag3)				0.007
				(0.006)
Log Population	0.773	0.069	2.212^{**}	0.083^{+}
	(1.288)	(0.059)	(1.074)	(0.059)
Observations	23,764	23,764	23,764	23,764
R^2	0.00003	0.0002	0.0002	0.0002

Note: $^{+}$p<0.2; *p<0.1; **p<0.05; ***p<0.01

Table 2.9: Geographical determinants of technological diffusion in the first available period. Negative coefficients indicate that higher values of the explanatory variable predict higher probability of telegraph connection

	Dependent variable:	
	Distance to Nearest Telegraph Station in 1866	
	(1)	(2)
Log Population Density	-17.325^{***}	-8.394^{***}
	(0.425)	(0.549)
Quality of Land		0.011^{***}
		(0.004)
Elevation		0.134^{***}
		(0.007)
Distance to the Capital		0.182^{***}
		(0.009)
County FE	No	Yes
Observations	2,371	2,359
R^2	0.412	0.679
Adjusted R^2	0.412	0.675
Residual Std. Error	20.625 (df = 2369)	15.201 (df = 2331)
F Statistic	$1{,}660.686^{***}$ (df = 1; 2369)	182.291^{***} (df = 27; 2331)
Note:		*p<0.1; **p<0.05; ***p<0.01

	Year	Sector of Work Stoppage	n	placename
1	1863	Dock workers	1	Helsingborg
2	1865	Stonemason	1	Stockholm
3	1867	Bread farm worker	1	Gefle
4	1867	Dock workers	1	Uddevalla
5	1868	Paper pulp worker	1	Trollhättan
6	1868	Shipyard worker	1	Eskilstuna
7	1868	Shipyard worker	1	Göteborg
8	1869	Bread farm worker	1	Stockholm
9	1869	Factory worker	1	Mölndal
10	1869	Bricklayer	1	Stockholm
11	1869	Carpenters	1	Stockholm
12	1870	Sawmill work	1	Skutskär
13	1871	Painter	1	Stockholm
14	1871	Sawmill work	1	Skutskär
15	1871	Tobacco worker	1	Stockholm
16	1871	Tobacco worker	1	Ystad
17	1871	Workshop worker	1	Motala
18	1872	Miner	1	Falun
19	1872	Glove sewing shoes	1	Helsingborg
20	1872	Kolb., Sackb., Seer	1	Göteborg
21	1872	Mech. workshop work	1	Göteborg
22	1872	Tailor	1	Stockholm
23	1872	Timber worker	1	Lund
24	1872	Tobacco worker	1	Vesterås
26	1873	Steam sloop crew	1	Göteborg
27	1873	Baker	1	Stockholm
28	1873	Mill worker	1	Edsvalla
29	1873	Railway worker	1	
30	1873	Railway worker	1	Forssa-Näsviken
31	1873	Railway worker	1	Växjö
32	1873	Painter	1	Stockholm
33	1873	Cobbler	1	Göteborg
34	1873	Cobbler	1	Sundsvall
35	1873	Stuffer	1	Göteborg
36	1873	Shipyard worker	1	Helsingborg
37	1874	Coal miner	2	Kropp
38	1874	Gas worker	1	Stockholm
39	1874	Railway worker	1	Malmö-Ystad
40	1874	Painter	1	Göteborg
41	1874	Mech. workshop work	1	Norrköping
42	1874	Tailor	1	Göteborg
43	1875	Bread farm worker	1	Gefle
44	1875	Railway worker	1	Uppsala-Gävle
45	1875	Coal miner	1	Kropp
46	1876	Flotation worker	1	Indalsälven
47	1877	Fortification worker	1	Stockholm
48	1877	Railway worker	1	
49	1877	Carpenter	1	Stockholm
50	1878	Dock workers	1	Helsingborg

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Chapter 3

THE TELEGRAPH AND TURNOUT: EVIDENCE FROM SWEDEN

Guillem Amatller Dómine and Johannes Lindvall

Turnout was often low in national elections in Europe in the nineteenth century. In 1870s Sweden, which is the case we're studying in this paper, only 20 percent of eligible voters voted, and only 10 percent of the adult population had the right to vote in the first place. But turnout nevertheless varied greatly within countries. In the Swedish parliamentary election of 1875, turnout was a mere 3 percent in the Orust and Tjörn electoral district, comprising two large islands some 50 kilometers north of Gothenburg, but it was 67 percent in the urban electoral district that comprised the four northern cities of Härnösand, Umeå, Luleå and Piteå. We study one explanation for these varying levels of turnout in the nineteenth-century world: the telegraph. We estimate the effect of the expansion of the electric telegraph network on

electoral turnout using district-level panel data from the Swedish elections of 1872, 1875, and 1878, and we find a positive effect of new telegraph stations on turnout.

The idea is simple: the telegraph, which was one of the quintessential network technologies of the First Industrial Revolution, contributed to higher turnout since it connected local communities to a national communication infrastructure that could be used for political campaigning and that brought political news from the center to the periphery. Outside England, which urbanized early, most people in nineteenth-century Europe lived in the countryside, and many small or middle-sized towns and cities lacked the infrastructural capacity to connect with the capital. As a result, most citizens were anchored in the local, not the national, community, and had little knowledge of national affairs. Where news from the capital was available, however, it made people more aware of national politics and more motivated to vote.

Our work is related to that of Wang (2022), which examines the relationship between telegraph connections and turnout in presidential elections in the United States in 1844–1852, but there are several differences between 1840s United States and 1870s Sweden that warrant attention and that distinguish our work. In 1840s United States, most white men could vote and turnout was already high. In 1870s Sweden, only a small minority of adult men could vote, with turnout remaining low. There are also methodological differences. Wang concentrates on the distance between the voters and the nearest newspaper with a telegraph connection. We instead study a much smaller, elite electorate and therefore want to allow for the possibility that the telegraph *itself* may have influenced local political outcomes. But we also model the interactive effect of telegraph connectivity and the presence of newspapers. We find that the estimated effect of the telegraph was approximately twice as large in districts with newspapers as in districts without newspapers—and the effect in districts without newspapers is less precisely estimated—which

suggests that in Sweden, as in the United States, the telegraph influenced turnout mainly through its effect on journalism and how newspapers reported on politics.

3.1 Electric Telegraphy and Electoral Turnout

Scholars of political participation have identified many different factors that are associated with turnout in legislative elections. At the national level, aggregate turnout is associated with political institutions such as compulsory-voting rules, district magnitude, and electoral laws (for an overview, see Blais 2006). At the individual level, turnout is higher among the well-educated and other groups that are rich in economic and cultural resources (see, for example Verba, Schlozman, and Brady 1995). On an election-by-election basis, finally, turnout is associated with factors such as the closeness and decisiveness of elections: when there's more at stake, people are more inclined to vote (Franklin 2004). Most empirical studies of electoral turnout are based on evidence from the twentieth and twenty-first centuries, but it seems likely that the three *types* of factors we have mentioned here—institutions, individual-level resources, and the closeness and decisiveness of elections—mattered also in the nineteenth century.

Our claim that the arrival of the telegraph increased turnout in national elections in the nineteenth century flows from the idea that voters are more likely to participate if they have a sense of how the outcome of the elections matters to them, as suggested by the literature on the closeness and decisiveness of elections. It also flows from the idea that access to information increases individual-level political efficacy—in turn increasing the propensity to vote—as the literature on individual resources and participation suggests. Since the telegraph connected local communities to a national communication network, it made people more aware of what was at stake in national politics. It also disseminated important political information across national

territories. It has been known for a long time that people who follow the news and are well-informed about politics are more likely to vote in elections, and in the nineteenth century, the telegraph made it much easier for voters far from national capitals to keep themselves informed about current affairs.

Our paper is also relevant for the literature on the political consequences of the telegraph, which was one of the two defining network technologies of the First Industrial Revolution (the other being the railroad; see Cermeño, Enflo, and Lindvall 2021 for a recent analysis of the railroad's political effects in Sweden). With a few exceptions that we mention below, the political consequences of the telegraph have received little detailed attention from scholars, although political scientists such as Finer (1997), Buzan and Lawson (2013) and sociologists such as Michael Mann (1984; 1993) have made the general observation that the arrival of new technology transformed politics in the nineteenth century. The effects of the telegraph globally have been studied by scholars of international relations: Nickles (2003) shows how telegraphy changed diplomacy and Wenzlhuemer (2012) studies the relationship between telegraphy and the *first globalization* of the nineteenth century.

Existing studies of the *domestic* political effects of the telegraph have concentrated on how this new technology influenced the performance of public officials, especially the police and the armed forces. For example, Morus (2000, 426) argues that the telegraph enhanced the strength of the state in the United Kingdom by increasing the ability of police officers to perform their tasks. He tells the story of a criminal who was caught in a railway station thanks to the telegraph. Solymar (2000, 204) makes a similar argument and underlines the importance of the telegraph for campaigns against rebel groups. He exemplifies this phenomenon with the British government's use of the telegraph during the Chartist riots in 1846. Lubrano (1997, 15) examines how the telegraph changed social interactions and reduced barriers to communication, while also underlining how the state relied on the tele-

graph to improve law and order. Goldstein (2001) examines different forms of political repression in the nineteenth century and claims that telegraphy made popular uprisings less likely since the state increased its capacity to anticipate rebellions and assemble and deploy troops. Nonnenmacher (2001) also suggests that the telegraph increased state power.

But the telegraph could also be put to use for political mobilization and campaigning. One example from Sweden, the country we study in this paper, was the national campaign for the major constitutional reform that was adopted by the parliament, the Diet of the Estates, in 1865–1866, a few years prior to the period we study in this paper. As documented by Harvard (2010), the advocates of constitutional reform, which replaced the old estates parliament with a modern, bicameral parliament, used Sweden's new electric telegraph network effectively to influence the editors of local and regional newspapers, which helped sway the members of parliament who were debating the reform bill in the autumn of 1865 (see also Ekman 1966). The concerted effort by the reform campaign to disseminate propaganda via the telegraph network gave decision-makers the impression that there was widespread support for constitutional reform across the country and among different social classes.

More recently, scholars have begun to examine the consequences of the telegraph for national elections. Wang (2022) provided the first paper that addressed the research question we address in this paper—whether the telegraph increased turnout in national elections. Wang demonstrates that the telegraph had such an effect in the United States in the 1840s and early 1850s. His argument and empirical analysis concentrate on the role played by newspapers that were connected to the telegraph and that brought national news to local voters.

Wang's study is concerned with one particular political context: 1840s and early 1850s United States. Our study is designed to demonstrate whether the telegraph had a similarly positive effect on turnout in a very different

context: Sweden in the 1870s. Unusually for the nineteenth century, the United States had already extended suffrage to most men (*white* men) in the 1840s, the period analyzed by Wang, and turnout was already high, having gone up markedly in the Jacksonian period in the 1830s. We instead study the effect of the telegraph in a non-democratic system with low turnout—a system that was much more typical of political regimes in the middle of the nineteenth century, which was when telegraph networks were established and expanded across North America and Europe.

Our first goal is quite simply to determine whether the telegraph had a positive effect on turnout in the non-democratic, low-suffrage, and low-participation environment we study in the paper. Our second goal is to distinguish between the effect of the telegraph in electoral districts with newspapers—which is the only effect studied by Wang—and the effect of the telegraph in electoral districts *without* newspapers. Since the Swedish electorate comprised a relatively small elite—approximately 10 percent of the adult population—we wish to consider the possibility that the press may have played a less decisive role for turnout than it did in the mass-based politics of mid-nineteenth-century United States. We therefore start by considering the effect of the telegraph in itself, instead of only estimating its indirect effect via newspapers. We base the idea that there may have been such a direct effect on the assumption that the small elite electorate of the 1870s was likely to use the telegraph themselves for commercial or official purposes, which exposed them to news from the capital without it being mediated by local newspapers. As we explain below, we study these two different channels by estimating interactive models in which the estimated effect of telegraph connectivity is allowed to vary between districts with and without newspapers.

3.2 Sweden's Telegraph Network in the 1870s

Although Sweden already had an efficient postal network in the early-modern period, communications before the arrival of the telegraph were slow and depended on couriers, horse-drawn buggies, and shipping. Given the size of Sweden's territory and the country's low population density, the introduction of electronic communications that did not depend on a person physically carrying messages over long distances was an epoch-making change: with the help of Morse code, communications became much faster and more effective, although this effect was not immediate. Harvard (2011) has shown that in its infancy, the telegraph technology was often slow and ineffective and prone to breakdowns, which meant that the national telegraph company often had to rely on other forms of communication via land and sea transportation networks. But over time, the telegraph led to fast electronic communications across Sweden's national territory.

The telegraph arrived in Sweden in 1853 with the establishment of a telegraphic connection between the capital, Stockholm, and the city of Uppsala. To implement the new technology, king Oscar I created a new public authority, the Telegraph Agency. By 1854, the Stockholm–Uppsala line had been connected to the southern city of Malmö, and telegraph stations were established in cities and towns such as Västerås, Örebro, Mariestad, Vänersborg, Gothenburg, Halmstad, Helsingborg, Lund, and Grisslehamn. In 1856, Gothenburg was connected to Stockholm, and Öregrund, east of Stockholm, was connected to the town of Haparanda on the Finnish border. Several additional cities were reached by the telegraph before 1860 (BISOS 1851–1917, Telegrafväsendet 1861–1910). Between 1860 and 1872—the period immediately preceding the one we study in the paper—the telegraph network continued to grow, going from 70 stations to 125.

The telegraph also continued to grow in the 1870s. By then the network had reached many smaller towns, not just larger towns and cities. Table

Table 3.1: Distances to the Telegraph, 1872–1878

Year	25th Perc.	Median	Mean	75th Perc.
1872	11.5 km	17.4 km	23.4 km	27.3 km
1875	10.7 km	16.2 km	21.6 km	25.1 km
1878	10.6 km	15.6 km	21.2 km	25.1 km

The table describes the distribution of the distance from the centroid of each Swedish municipality to the location of the nearest telegraph station in 1872, 1875, and 1878.

Unit of analysis: Electoral districts

3.1 describes the distribution of our main explanatory variable—the distance from the center of a municipality to the nearest telegraph station—in 1872, 1875, and 1878. As the Table shows, the addition of new telegraph stations in this period meant that the mean and median distances to the nearest station decreased by approximately 2 kilometers. The period from 1872 to 1875 was key, as 27 new stations were installed. Since we estimate the effect of the telegraph with the help of two-way fixed effects models that control for constant unit-level factors and period-specific trends and shocks, we in effect study the outcomes of these late extensions to the telegraph network in the 1870s in our empirical analysis.

Between 1878 and 1881—after the period we are studying—few new telegraph stations were built, and some smaller telegraph stations were merged into larger ones. In the 1880s, the telephone arrived in Sweden (Rashid 2004), which may have inhibited further investment in new telegraph infrastructure, although, judging from aggregate historical statistics on communications (Comin and Hobijn 2009), telegraph usage did not decrease immediately after the telephone was introduced.

Decisions about which municipalities would receive the telegraph were made by the Swedish Telegraph Agency. In 1852, the government asked Carl

Akrell, later the first director of the public telegraph company, to "draw up a plan for the electric telegraph lines, which should cover the most politically and economically important telegraph stations" (BISOS 1851–1917, Telegrafväsendet 1861–1910, V–VI). Unsurprisingly, the Telegraph Agency decided to begin by wiring the more economically important and densely populated areas. The director of the national Telegraph Agency wrote a technical report each year from 1861 onward, specifying which new stations were constructed and providing other relevant information. They show that after 1860, the network reached beyond the main cities. Decisions about where it would go now often depended on technical considerations. It is possible that political considerations also played a role in some cases—as the Parliament of Estates pressured the government to speed up telegraph connections—but judging from the parliamentary records, members of parliament only managed to influence the government in a few cases in the 1850s (see the minutes of the Swedish parliament, motions 11, 48 and 118 for the year 1853; 111 for the year 1856, and 25 and 37 for the year 1859).

The telegraph was used by different groups of people and for different purposes. Importantly, the use of the telegraph was overwhelmingly private. For small telegraph stations like Landscrona (today Landskrona), the use of the telegraph by public authorities corresponded to 0.16 percent of all telegrams, whereas the use by private individuals, organizations, and firms corresponded to 99 percent (some telegrams were used for meteorological purposes and were not counted as either public or private). Even in municipalities such as Stockholm, where the public administration had much greater weight, the percentage of telegrams used by public authorities was only 1.2 percent; up to 98 percent were private telegrams.

There are no statistics that reveal more precisely what the telegraph was used for. However, in parliamentary debates on the telegraph in 1853 and 1856, the parliamentarians of the four Estates of the Realm emphasized its commercial,

political, and military use when trying to convince the king to invest in the telegraph network. Commercial use is the most cited in these debates, in which parliamentarians emphasized the economic benefits of the telegraph. The nobility, the clergy, and the bourgeoisie also emphasized its political importance. Additionally, the nobility emphasized its military relevance, and a representative of the bourgeoisie said it ought to have benefits for agriculture (Amatller 2022).

3.3 Design and Data

We study electoral participation in Sweden's 175 electoral districts in the elections to the lower house of parliament—the Second Chamber—in 1872, 1875, and 1878. In the beginning of this period, a constitutional reform adopted in 1865–1866 had just abolished the old estates parliament and replaced it with a modern, bicameral legislature. The members of the upper house of parliament, the First Chamber, were not elected but appointed by the county councils, Sweden's regional political assemblies. Incidentally, this was the reform to which we alluded earlier, prior to which the proponents had relied on the telegraph network for the dissemination of propaganda (Harvard 2010).

We concentrate on the elections of 1872, 1875, and 1878 for two main reasons. First of all, 1872 was the first year in which detailed election statistics were kept by Statistics Sweden after the constitutional reform of 1865–1866. Second, as we discussed in the previous section, the telegraph network was still expanding in the 1870s, which lets us study the effects of the telegraph network reaching new parts of the country. By the 1880s, by contrast, few localities remained completely unconnected to the telegraph network. Esaiasson (1990, 72–74) describes the elections of 1872, 1875, and 1878 as relatively "harmless," noting that only 20 percent of eligible voters participated in the elections, that there was relatively little campaigning, that national political

debates did not make much of an impression across the country, and that all three elections were dominated by the issue of national defense. An additional advantage of comparing these three elections, then, is that they were quite similar to each other.

The panel structure of our dataset—elections nested in electoral districts—lets us to concentrate on the within-district variation in our data: our two-way fixed-effects regression analyses effectively analyze the empirical relationship between election-to-election changes in telegraph connectivity and election-to-election changes in electoral turnout.

We calculate district-level electoral turnout by dividing the number of ballots cast in each electoral district by the number of eligible voters in the district. Some districts ran indirect elections (*medelbara val*): the voters chose a group of electors, who then went on to select the district's representative in a second-round vote (for a discussion, see Wallin 1961). In those districts, we concentrate on electoral turnout in the first-round vote (which concerned the selection of the electors). Since the distribution of turnout is skewed, we use the logarithm of the turnout variable in our analyses.

Our main explanatory variable captures the connection to telegraph services in 1872, 1875 and 1878. Conceptually, we are interested in how likely individuals were to access telegraph services. As we have already mentioned, to operationalize this concept, we have computed the distance between each municipality's centroid and the location of the nearest telegraph station in 1872, 1875, and 1878. Shorter distances to the telegraph meant better telegraph connections. We can calculate these values at the municipal level, but since our outcome variable is at the district level and each district includes several municipalities, we have aggregated the municipal-level values to the district level by computing the average distance to the telegraph among all municipalities that made up the electoral district. If a district had two municipalities, for instance, and those municipalities were 10 and 20 kilometers

away from the nearest telegraph station, the value for that district has been set to 15 kilometers.

Table 3.2: Descriptive Statistics

Period	Distance to the Telegraph	Log Ratio of Participation	Eligible Voters	Direct Elections	Population	Distance Nearest conflict
1872	23.4 km	2.88	1.31	55 %	23231	135 km
1875	21.6 km	2.87	1.41	59 %	23948	78 km
1878	21.5 km	2.86	1.47	61 %	24401	75 km

We also calculate three alternative versions of this measure to demonstrate that our findings are robust to changes in the operationalization of telegraph connectivity. One concern with the first, raw measure, which we have already discussed, is that a reduction in the distance to the nearest telegraph station from 20 to 10 kilometers is likely to have resulted in a much more meaningful increase in telegraph connectivity than a reduction from, say, 120 to 110 kilometers. In the nineteenth century, 110 kilometers was much too far to travel to get to a telegraph station. Our three alternative measures all take this concern into account. The second measure sets the over-time variation in the distance to the telegraph to 0 for all municipalities that were on average further than 31 kilometers away from the telegraph connection in the last election in the sample (in 1878). One way of thinking about this adjustment from the perspective of the potential-outcomes framework is that municipalities whose distance to the nearest telegraph station was greater than the 31-kilometer cut-off are assigned to the control group. The 31-kilometer cutoff is somewhat arbitrary, although, like (Cermeño, Enflo, and Lindvall 2021), we base it on the work of Bergenfeldt (2014, 131–133), who argues that in the nineteenth century, people could travel around 60 kilometers per day (so around 30 kilometers return trip). Our third measure therefore tries another cut-off, 65 kilometers (the idea being that people could then get to the telegraph station in a day, but not go back). Our fourth and final measure is the logarithm of the distance to the telegraph. By taking the logarithm, we introduce a different approach to consider the impact of dis-

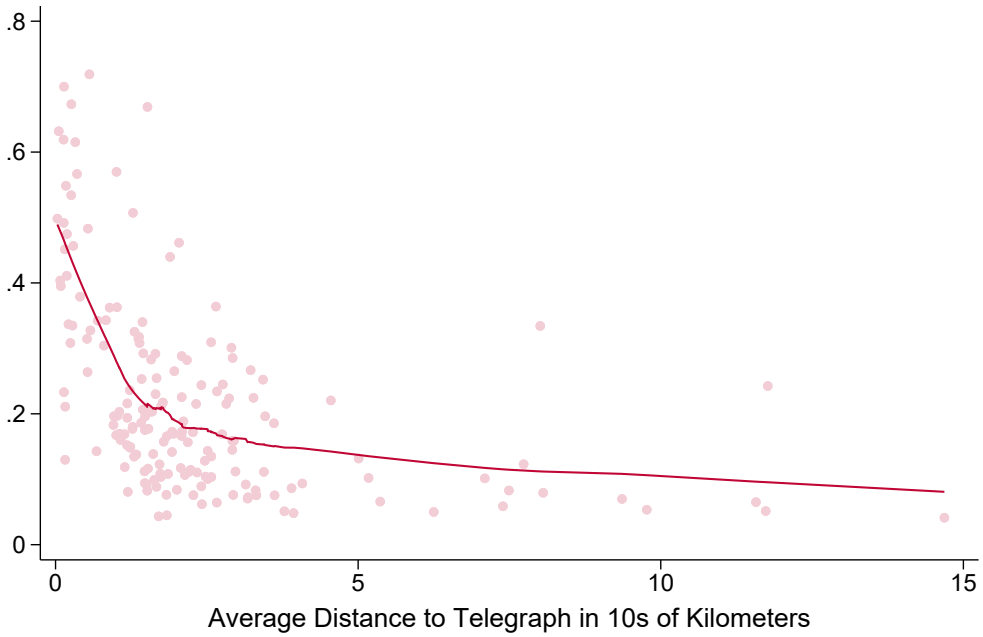

Figure 3.1: The Telegraph and Turnout in 1872

tance on participation. This transformation assigns lower weights to longer distances, emphasizing the significance of increased proximity to the telegraph at shorter distances. However, it does not entirely neglect changes in connectivity that occurred far away from the nearest telegraph station, which could have mattered through different channels, such as the connection with the postal services.

Figure 3.1 describes the relationship between average telegraph connectivity and electoral turnout in all of Sweden's electoral districts in 1872, the first year of our analysis. As the figure shows, there is only a weak linear cross-sectional relationship between telegraph connectivity and turnout at higher values of connectivity, but the relationship gets stronger at lower values, suggesting that it is important to distinguish between short and long distances, as we do, in different ways, with our three alternative measures.

3.4 Main Findings

As we discussed in the previous section, the elections of 1872, 1875, and 1878 are generally considered "harmless" in the historical literature since political debates in parliament did not make much of an impression around the country. That might explain why average turnout across districts fell slightly in the 1870s—from 22.1 percent in 1872 to 21.6–21.7 percent in 1875 and 1878. Turnout fell more in cities than in rural areas. But some cities experienced greater changes than others, and changes went in different directions. Before we turn to the statistical models, let's consider some descriptive evidence to get a feel for the data. Figures 3.2, 3.3 and 3.4 describe the level of turnout in each district—with darker colors representing higher turnout—and the location of each telegraph station. Some electoral districts were city-districts, which covered one or more cities. These city districts are represented on the map by large circles in orange. As the figure shows, the cross-country patterns in participation were quite stable over time, but there is enough change over time to make meaningful the statistical analyses of the within-district variation in turnout we engage with in this paper. The figure also shows that although the telegraph network had reached most of the more populated parts of the country in 1872, new stations were still being added in the ensuing years, which again makes within-district analyses meaningful.

As is evident from the maps in Figures 3.2, 3.3 and 3.4, and Figure 3.1 in the previous section, there is a strong, cross-sectional relationship between telegraph connectivity and turnout: turnout is on average higher in districts near telegraph stations than in districts far away from telegraph stations, especially when one takes into account that turnout was high in the urban telegraph-connected districts along the coasts and in the middle and south of the country. The correlation between our raw effective-distance-to-the telegraph measure and electoral participation is approximately $-.40$. But these bivariate, cross-sectional patterns obviously tell us little about causal

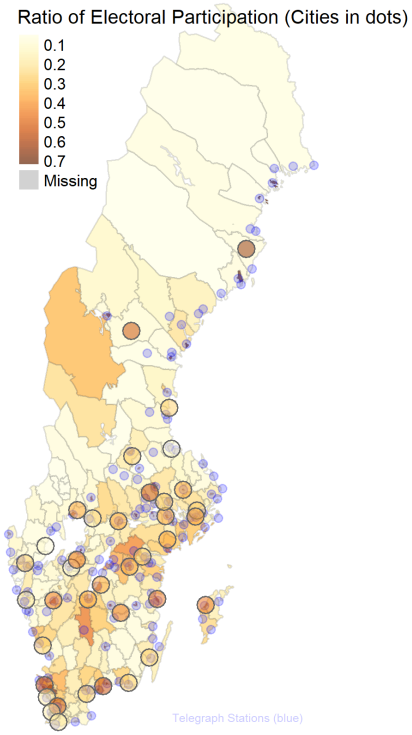

Figure 3.2: Participation and telegraph stations in 1872

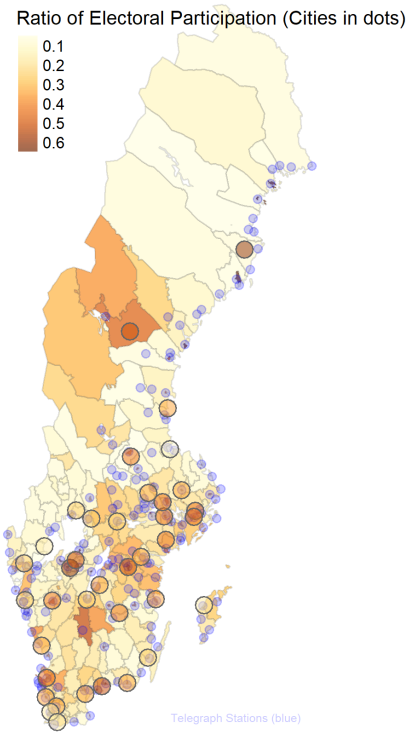

Figure 3.3: Participation and telegraph stations in 1875

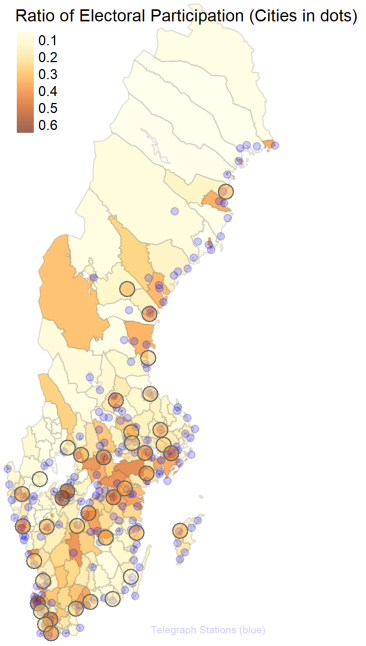

Figure 3.4: Participation and telegraph stations in 1878

effects, since there are all sorts of structural differences between the localities that had and did not have the telegraph. It is much more informative to study changes in turnout *over time* in districts that increased their telegraph connectivity, compared with districts that did not.

Therefore, to estimate the effect of increases in telegraph connectivity on turnout, we estimate simple two-way fixed-effects regressions with the general form:

$$\mathrm{y}_{i,t} = \alpha + \beta_1 \tau_{i,t} + \beta_2 \mathbf{X}_{i,t} + u_i + \lambda_t + \varepsilon_{i,t},$$

where

i denotes electoral districts (1, 2, ..., 175), t denotes elections (1872, 1875, 1878), $y_{i,t}$ is the level of political participation in district i in election t, $\tau_{i,t}$ is each district's telegraph connectivity in election t (our main explanatory variable), $\mathbf{X}_{i,t}$ is a vector of time-varying controls, u_i are district fixed effects, and λ_t are election fixed effects. The quantity of interest is β_1, which is our best estimate of the causal effect of telegraph connectivity (τ) on (logged) electoral participation (y).

In addition to the district and election fixed effects, we include some time-varying controls to test for potential confounders. The first time-varying control is the number of eligible voters. Since voting is a habit—a large literature tells us so (see, for example, Franklin 2004)—we expect this variable to be associated with lower levels of turnout: an increase in the number of individuals who had the right to vote means that new voters entered the electorate, and those new voters were less likely to vote than the voters that have already participated in previous elections. We also control for the prevalent form of the election at the district level: direct or indirect. During the period we're studying, 14 districts changed their elections from indirect to direct and 2 districts changed their elections from direct to indirect.

Building on chapter two, we have also controlled for the increased probability of labor conflict. As seen in the previous chapter, the likelihood of technological adoption increased with the emergence of the labor movement. Although those effects were small and localized, they could have affected both the over-time probability of telegraph adoption, particularly so considering that 1872-1878 was a period with more strikes and lock-downs than preceding periods. The results over-time distribution of this variable at the district level can be observed in table 3.1, and the results that include this variable as a control appear in the appendix, where a new sub-section has been devoted to this issue. The results do not vary with the inclusion of conflict.

Table 3.3 presents the first set of statistical results. Beginning with the first column, here we estimate the effect on turnout of the average distance to the telegraph among the municipalities in the districts (including district and election controls as well as the two time-varying control variables). As the table shows, an increase in the distance to the telegraph is associated with lower turnout, which means that a decrease in the distance to the telegraph—the more common event—is associated with *higher* turnout. When it comes to the control variables, we note that an increase in the number of eligible voters was associated with lower turnout, as expected, whereas the adoption of direct elections—instead of indirect elections—was associated with higher turnout, also as expected.

In the second column, we replace our measure of the raw, average distance to the telegraph with a measure that only records changes in the distance to the telegraph if the distance ended up being lower than 31-kilometers (as discussed above). We find that the estimated effect is greater—as we expected, given that people only began to have meaningful access to the telegraph when it was possible to travel to the telegraph station—but it is also slightly less precisely estimated, which is natural since we are effectively

Table 3.3: Main Results

	Dependent variable:			
	Log Percentage of Participation			
	(1)	(2)	(3)	(4)
Distance in 10 Km	-0.07^{**}			
	(0.03)			
Distance in 10 Km (Sensitive to 30km Cut-Off Point)		-0.11^{*}		
		(0.06)		
Distance in 10 Km (Sensitive to 65km Cut-Off Point)			-0.08^{*}	
			(0.04)	
Log Distance to the Telegraph				-0.11^{+}
				(0.06)
Direct Elections	0.56^{***}	0.57^{***}	0.57^{***}	0.57^{***}
	(0.09)	(0.09)	(0.09)	(0.09)
Eligible Voters (in Thousands)	-0.20^{**}	-0.17^{*}	-0.18^{*}	-0.16^{*}
	(0.10)	(0.10)	(0.10)	(0.10)
District FE	Yes	Yes	Yes	Yes
Period FE	Yes	Yes	Yes	Yes
Observations	523	523	523	523
Adjusted R^2	0.81	0.81	0.81	0.81
Residual Std. Error (df = 335)	0.29	0.29	0.29	0.29
Note:	$^{+}$p<0.2; *p<0.1; **p<0.05; ***p<0.01			

throwing out observations when we disregard all changes in districts that are further away from the telegraph stations. In the third column, we increase the cut-off to 65 kilometers (so we only take into account changes if the distance ended up being lower than 65 kilometers). As one might expect, the estimated coefficient is slightly smaller than when we use the 31 kilometer cut-off. In the fourth column, we include the logarithm of the distance to the telegraph. In this model, the estimate of the coefficient is slightly less precise than in the other models ($p \approx 0.15$). However, when we consider the combined results, we note that they consistently point in the same direction: a decrease in the distance to the telegraph is empirically associated with higher turnout.

With the outcome variable logged, we can interpret the marginal effects in percentage terms. If we interpret the estimate in the first column as a lower bound and the estimate in the second column as an upper bound on the effect of telegraph connectivity, the implication is that each 10-kilometer reduction in the effective distance to the telegraph leads to a 7 to 10 percent increase in electoral turnout (*percent* increase, not *percentage-point* increase). When it comes to the fourth column, the model with the logarithmic transformation of the distance variable, the implication of the statistical findings is that reducing the distance to the telegraph by half was associated with a 5-percent increase in participation.

In Table 3.4, we allow for the possibility that the effect of the telegraph may have varied depending on whether there was a local newspaper in the electoral district. We include the same four different operationalizations of the distance to the telegraph that we relied on in Table 3.3, but we now also include multiplicative interaction terms for the combination of telegraph and the press, multiplying the main explanatory variables with an indicator of whether there was a local newspaper, relying on digitized data on newspapers from the Royal Library of Sweden. We consistently find a negative

Table 3.4: With Newspapers

	Dependent variable:			
	Log Percentage of Participation			
	(1)	(2)	(3)	(4)
Distance in 10 Km	-0.06^{+}			
	(0.04)			
Distance in 10 Km (Sensitive to 30km Cut-Off Point)		-0.08		
		(0.07)		
Distance in 10 Km (Sensitive to 65km Cut-Off Point)			-0.06	
			(0.05)	
Log Distance to the telegraph				0.05
				(0.13)
Distance * Newspapers	-0.07^{*}			
	(0.04)			
Distance (Sens. 65) * Newspapers		-0.06^{+}		
		(0.04)		
Distance (Sens. 30)* Newspapers			-0.07^{*}	
			(0.04)	
Log Distance * Newspapers				-0.19^{+}
				(0.08)
Newspapers (binary)	0.37^{+}	0.32^{+}	0.34^{+}	0.20
	(0.25)	(0.25)	(0.25)	(0.22)
Direct Elections	0.57^{***}	0.57^{***}	0.57^{***}	0.58^{***}
	(0.09)	(0.09)	(0.09)	(0.09)
Eligible Voters (in Thousands)	-0.19^{*}	-0.17^{*}	-0.18^{*}	-0.15^{+}
	(0.10)	(0.10)	(0.10)	(0.10)
District FE	Yes	Yes	Yes	Yes
Period FE	Yes	Yes	Yes	Yes
Observations	523	523	523	523
Adjusted R^2	0.81	0.81	0.81	0.81
Residual Std. Error (df = 333)	0.29	0.29	0.29	0.29
Note:	$^{+}$p<0.2; *p<0.1; **p<0.05; ***p<0.01			

correlation between the distance to the telegraph and turnout in districts without newspapers, but the relationship is much stronger in districts with newspapers, and we can be more confident that the marginal effects—which correspond to the sum of the two coefficients—are actually different from 0 if there was a newspaper around. In other words, there is some indication that the telegraph may have mattered beyond its effects on the press, as suggested by the coefficients in the first three rows (the fourth coefficient is very imprecisely estimated), but, like Wang (2022), we find a strong effect that runs through newspapers, even if we study a very different political context to that studied in Wang's paper.

Again, we can interpret the marginal effects in percentage terms. The sum of the coefficients for the distance variables and the interaction terms varies between -0.13 and -0.19, which implies that *in districts with newspapers*, each 10-kilometer reduction in the effective distance to the telegraph leads to a 12 to 17 percent increase in electoral turnout (again, this is a *percent* increase, not *percentage-point* increase). When it comes to the model with the logarithmic transformation of the distance variable – in our fourth column – it appears that reducing the distance to the telegraph by half was associated with a 10-percent increase in participation.

In the appendix, we expand upon our analysis by exploring other cut-off points. The results, which are available in Table 3.5, reveal that our findings remain consistent regardless of the cut-off point used, whether it be 50, 80 or 100 kilometers. Moreover, we have investigated the specific impact of the telegraph in *rural* districts with and without newspapers. Our analysis, presented in Table 3.7, shows that the telegraph significantly increased participation in rural areas with newspapers. Although it also appears to have had an effect on rural areas without newspapers (see Table 3.7), those results are less precise and depend on the cut-off point chosen. These findings suggest that the telegraph played a vital role in expanding communication

and increasing participation in rural communities during the period under analysis, but this relationship largely depended on newspapers.

3.5 Conclusions

In this article, we have shown that the expansion of the telegraph contributed to higher levels of electoral turnout. We have done so by studying empirically a country, Sweden, that was being reshaped by the twin forces of technological change and the introduction of modern elections and election campaigns, similar to many Western European countries in the second half of the nineteenth century. More generally, we connect the themes of technology and politics by showing how the first modern telecommunications technology mattered for political participation.

In Sweden in 1872, 19 percent of the population lived more than 20 kilometers from the nearest municipality with a telegraph station. This percentage was reduced to 15 percent in 1875 and to just over 13 percent in 1878. Thanks to the panel data we have available, we have been able to determine if turnout increased in electoral districts when municipalities within the districts that were not previously connected to the national telegraph network acquired such connections. Our study stops in 1878, as from then on it becomes increasingly difficult to trace the effect of the telegraph on participation. Far fewer new stations were built in this period, and other new technologies appeared. In particular, the telephone emerged as a more effective technology of communication, political or otherwise. Therefore, from the late nineteenth century onward, it becomes more difficult for scholarship to tease out the effects of different communication technologies.

The only previous study that addresses the same research question we ask in this article is concerned with a different context, 1840s United States (Wang 2020). Our results align with Wang's, but our paper examines a

different context: Sweden in the 1870s. We also allow for the possibility that the telegraph might have had both indirect effects (via journalism and newspapers) and direct effects (via the voters' own use of the telegraph in the cities and towns in which they lived, or to which they traveled).

The main advantage of extending the analysis of the political effects of the telegraph to the Swedish case is that the political context in Sweden was more representative of nineteenth-century political systems than the political context in the United States. In Sweden, voting was reserved for a small elite: as in many other European countries in the final third of the nineteenth century, there were elections, but the franchise was limited. The findings reported in this paper suggest that the telegraph had an effect on turnout not only under conditions of mass politics, as in the United States, but also in non-democratic elections in Europe.

3.6 Appendix

Table 3.5: Different operationalizations of the explanatory variable

	Dependent variable:				
	Log Percentage of Participation				
	(1)	(2)	(3)	(4)	(5)
Distance in 10 Km (Sensitive to 30km Cut-Off Point)	-0.11^{*} (0.06)				
Distance in 10 Km (Sensitive to 50km Cut-Off Point)		-0.09^{*} (0.05)			
Distance in 10 Km (Sensitive to 65km Cut-Off Point)			-0.08^{*} (0.04)		
Distance in 10 Km (Sensitive to 80km Cut-Off Point)				-0.08^{*} (0.04)	
Distance in 10 Km (Sensitive to 100km Cut-Off Point)					-0.08^{*} (0.04)
Direct Elections	0.57^{***} (0.09)	0.57^{***} (0.09)	0.57^{***} (0.09)	0.57^{***} (0.09)	0.57^{***} (0.09)
Eligible Voters (in Thousands)	-0.17^{*} (0.10)	-0.18^{*} (0.10)	-0.18^{*} (0.10)	-0.18^{*} (0.10)	-0.19^{*} (0.10)
District FE	Yes	Yes	Yes	Yes	Yes
Period FE	Yes	Yes	Yes	Yes	Yes
Observations	523	523	523	523	523
Adjusted R^2	0.81	0.81	0.81	0.81	0.81
Residual Std. Error (df = 335)	0.29	0.29	0.29	0.29	0.29
Note:					$^{+}$p<0.2; *p<0.1; **p<0.05; ***p<0.01

Table 3.6: Rural places only

	Dependent variable:					
	Log Percentage of Participation					
	(1)	(2)	(3)	(4)	(5)	(6)
Distance in 10km	-0.07^{**}					
	(0.03)					
Distance in 10 Km (Sensitive to 30km Cut-Off Point)		-0.08				
		(0.06)				
Distance in 10 Km (Sensitive to 50km Cut-Off Point)			-0.07			
			(0.05)			
Distance in 10 Km (Sensitive to 65km Cut-Off Point)				-0.06^{+}		
				(0.05)		
Distance in 10 Km (Sensitive to 80km Cut-Off Point)					-0.07^{+}	
					(0.04)	
Distance in 10 Km (Sensitive to 100km Cut-Off Point)						-0.06^{+}
						(0.04)
Direct Elections	0.48^{***}	0.48^{***}	0.48^{***}	0.48^{***}	0.48^{***}	0.48^{***}
	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)
Eligible Voters (in Thousands)	-0.34^{***}	-0.29^{***}	-0.30^{***}	-0.31^{***}	-0.31^{***}	-0.32^{***}
	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)
District FE	Yes	Yes	Yes	Yes	Yes	Yes
Period FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	412	412	412	412	412	412
Adjusted R^2	0.78	0.78	0.78	0.78	0.78	0.78
Residual Std. Error (df = 266)	0.27	0.27	0.27	0.27	0.27	0.27
Note:						$^{+}$p<0.2; *p<0.1; **p<0.05; ***p<0.01

Table 3.7: Rural places with newspapers (I)

	Dependent variable:					
	Log Percentage of Participation					
	(1)	(2)	(3)	(4)	(5)	(6)
Distance in 10 Km	-0.06^{+}					
	(0.04)					
Distance adj 30km		-0.05				
		(0.07)				
Distance adj 50km			-0.05			
			(0.05)			
Distance adj 65km				-0.05		
				(0.05)		
Distance adj 80km					-0.05	
					(0.05)	
Distance adj 100km						-0.05
						(0.04)
Distance * news	-0.06^{*}					
	(0.04)					
Distance 30km * news		-0.06^{+}				
		(0.04)				
Distance 50km * news			-0.07^{+}			
			(0.04)			
Distance 65km * news				-0.07^{+}		
				(0.04)		
Distance 80km * news					-0.07^{*}	
					(0.04)	
Distance 100km * news						-0.07^{*}
						(0.04)
Newspapers	0.34^{+}	0.31	0.31	0.31^{+}	0.34^{+}	0.34^{+}
	(0.24)	(0.24)	(0.24)	(0.24)	(0.24)	(0.24)
District FE	Yes	Yes	Yes	Yes	Yes	Yes
Period FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	412	412	412	412	412	412
Adjusted R^2	0.79	0.78	0.78	0.78	0.78	0.78
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Residual Std. Error (df = 264)	0.27	0.27	0.27	0.27	0.27	0.27

Note: $^{+}$p<0.2; *p<0.1; **p<0.05; ***p<0.01

Table 3.8: Rural Places With Newspapers (II)

	Dependent variable:	
	Log Percentage of Participation	
	(1)	(2)
Log Distance to the Telegraph	−0.07	−0.001
	(0.15)	(0.15)
Log Distance to the Telegraph With Newspapers		−0.34*
		(0.17)
At Least 1 Newspaper		0.38
		(0.25)
Direct Elections	0.48***	0.49***
	(0.10)	(0.10)
Eligible Voters	−0.29***	−0.28***
	(0.11)	(0.11)
District FE	Yes	Yes
Period FE	Yes	Yes
Observations	412	412
R^2	0.86	0.86
Adjusted R^2	0.78	0.78
Residual Std. Error	0.28 (df = 266)	0.27 (df = 264)
F Statistic	11.16*** (df = 145; 266)	11.11*** (df = 147; 264)
Note:		*p<0.1; **p<0.05; ***p<0.01

Table 3.9: Effect of the telegraph in urban Sweden (Interaction with newspapers not included, as all urban districts except one had newspapers)

	Dependent variable:					
	Log Percentage of Participation					
	(1)	(2)	(3)	(4)	(5)	(6)
Distance in 10km	-0.35^{**}					
	(0.17)					
Distance in 10 Km (Sensitive to 30km Cut-Off Point)		-0.35^{**}				
		(0.17)				
Distance in 10 Km (Sensitive to 50km Cut-Off Point)			-0.35^{**}			
			(0.17)			
Distance in 10 Km (Sensitive to 65km Cut-Off Point)				-0.35^{**}		
				(0.17)		
Distance in 10 Km (Sensitive to 80km Cut-Off Point)					-0.35^{**}	
					(0.17)	
Distance in 10 Km (Sensitive to 100km Cut-Off Point)						-0.35^{**}
						(0.17)
Direct Elections	0.86^{***}	0.86^{***}	0.86^{***}	0.86^{***}	0.86^{***}	0.86^{***}
	(0.27)	(0.27)	(0.27)	(0.27)	(0.27)	(0.27)
Eligible Voters (in Thousands)	0.32^{+}	0.32^{+}	0.32^{+}	0.32^{+}	0.32^{+}	0.32^{+}
	(0.24)	(0.24)	(0.24)	(0.24)	(0.24)	(0.24)
District FE	Yes	Yes	Yes	Yes	Yes	Yes
Period FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	111	111	111	111	111	111
Adjusted R^2	0.53	0.53	0.53	0.53	0.53	0.53
Residual Std. Error (df = 64)	0.31	0.31	0.31	0.31	0.31	0.31

Note: $^{+}$p<0.2; *p<0.1; **p<0.05; ***p<0.01

3.6.1 Main model controlling for labor conflict

Table 3.10: Distance to conflict lagged 1 year

	Dependent variable:			
	Log Percentage of Participation			
	(1)	(2)	(3)	(4)
Distance in 10 Km	-0.07^{**}			
	(0.03)			
Distance in 10 Km (Sensitive to 30km Cut-Off Point)		-0.11^{*}		
		(0.06)		
Distance in 10 Km (Sensitive to 65km Cut-Off Point)			-0.07^{+}	
			(0.04)	
Log Distance to the Telegraph				-0.11^{+}
				(0.07)
Direct Elections	0.56^{***}	0.57^{***}	0.57^{***}	0.57^{***}
	(0.09)	(0.09)	(0.09)	(0.09)
Eligible Voters (in Thousands)	-0.21^{**}	-0.18^{*}	-0.20^{**}	-0.18^{*}
	(0.10)	(0.10)	(0.10)	(0.10)
Average Municipal Distance to Nearest Conflict (lag 1 year)	-0.0004	-0.0004	-0.0004	-0.001
	(0.0004)	(0.0004)	(0.0004)	(0.0004)
Constant	3.14^{***}	3.17^{***}	3.13^{***}	3.06^{***}
	(0.22)	(0.23)	(0.23)	(0.22)
District FE	Yes	Yes	Yes	Yes
Period FE	Yes	Yes	Yes	Yes
Observations	523	523	523	523
Adjusted R^2	0.81	0.81	0.81	0.81
Residual Std. Error (df = 334)	0.29	0.29	0.29	0.29
Note:	$^{+}$p<0.15; *p<0.1; **p<0.05; ***p<0.01			

Table 3.11: Logged distance to conflict lagged 1 year

	Dependent variable:			
	Log Percentage of Participation			
	(1)	(2)	(3)	(4)
Distance in 10 Km	-0.07^{**}			
	(0.03)			
Distance in 10 Km (Sensitive to 30km Cut-Off Point)		-0.11^{*}		
		(0.06)		
Distance in 10 Km (Sensitive to 65km Cut-Off Point)			-0.08^{*}	
			(0.04)	
Log Distance to the Telegraph				-0.10
				(0.07)
Direct Elections	0.56^{***}	0.56^{***}	0.57^{***}	0.57^{***}
	(0.09)	(0.09)	(0.09)	(0.09)
Eligible Voters (in Thousands)	-0.20^{**}	-0.16^{*}	-0.18^{*}	-0.16^{+}
	(0.10)	(0.10)	(0.10)	(0.10)
Log Distance to the Nearest Labor Conflict (1 year lag)	0.02	0.02	0.02	0.02
	(0.04)	(0.04)	(0.04)	(0.04)
Constant	3.01^{***}	3.05^{***}	3.00^{***}	2.92^{***}
	(0.28)	(0.29)	(0.28)	(0.27)
District FE	Yes	Yes	Yes	Yes
Period FE	Yes	Yes	Yes	Yes
Observations	523	523	523	523
Adjusted R^2	0.81	0.81	0.81	0.81
Residual Std. Error (df = 334)	0.29	0.29	0.29	0.29
Note:	$^{+}$p<0.15; *p<0.1; **p<0.05; ***p<0.01			

Table 3.12: Distance to conflict lagged 2 years

	Dependent variable:			
	Log Percentage of Participation			
	(1)	(2)	(3)	(4)
Distance in 10 Km	-0.07^{**}			
	(0.03)			
Distance in 10 Km (Sensitive to 30km Cut-Off Point)		-0.11^{*}		
		(0.06)		
Distance in 10 Km (Sensitive to 65km Cut-Off Point)			-0.07^{+}	
			(0.04)	
Log Distance to the Telegraph				-0.11^{+}
				(0.07)
Direct Elections	0.56^{***}	0.56^{***}	0.56^{***}	0.56^{***}
	(0.09)	(0.09)	(0.09)	(0.09)
Eligible Voters (in Thousands)	-0.21^{**}	-0.18^{*}	-0.19^{*}	-0.17^{*}
	(0.10)	(0.10)	(0.10)	(0.10)
Average Municipal Distance to Nearest Conflict(2 years lag)	-0.0004	-0.0004	-0.0004	-0.0005
	(0.0004)	(0.0004)	(0.0004)	(0.0004)
Constant	3.15^{***}	3.19^{***}	3.15^{***}	3.07^{***}
	(0.23)	(0.24)	(0.23)	(0.22)
District FE	Yes	Yes	Yes	Yes
Period FE	Yes	Yes	Yes	Yes
Observations	523	523	523	523
Adjusted R^2	0.81	0.81	0.81	0.81
Residual Std. Error (df = 334)	0.29	0.29	0.29	0.29
Note:	$^{+}$p<0.15; *p<0.1; **p<0.05; ***p<0.01			

Table 3.13: Logged distance to conflict lagged 2 years

	Dependent variable:			
	Log Percentage of Participation			
	(1)	(2)	(3)	(4)
Distance in 10 Km	-0.07^{**}			
	(0.03)			
Distance in 10 Km (Sensitive to 30km Cut-Off Point)		-0.11^{*}		
		(0.06)		
Distance in 10 Km (Sensitive to 65km Cut-Off Point)			-0.08^{*}	
			(0.04)	
Log Distance to the Telegraph				-0.11^{+}
				(0.07)
Direct Elections	0.56^{***}	0.57^{***}	0.57^{***}	0.57^{***}
	(0.09)	(0.09)	(0.09)	(0.09)
Eligible Voters (in Thousands)	-0.20^{**}	-0.17^{*}	-0.18^{*}	-0.16^{*}
	(0.10)	(0.10)	(0.10)	(0.10)
Log Distance to the Nearest Labor Conflict (2 yearslags)	0.01	0.01	0.01	0.01
	(0.04)	(0.04)	(0.04)	(0.04)
Constant	3.07^{***}	3.10^{***}	3.06^{***}	2.98^{***}
	(0.28)	(0.29)	(0.28)	(0.27)
District FE	Yes	Yes	Yes	Yes
Period FE	Yes	Yes	Yes	Yes
Observations	523	523	523	523
Adjusted R^2	0.81	0.81	0.81	0.81
Residual Std. Error (df = 334)	0.29	0.29	0.29	0.29
Note:	$^{+}$p<0.15; *p<0.1; **p<0.05; ***p<0.01			

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Chapter 4

THE INFORMATION CAPACITY OF STATES, ETHNIC DIVERSITY, AND SOCIAL DEVELOPMENT

Guillem Amatller Dómine and Matthias vom Hau

4.1 Introduction

A large and influential cross-national scholarship in political economy treats ethnic diversity as an exogenous variable. This stands in tension with the widespread agreement in the social sciences that ethnic groups are social constructions and that ethnic identities should be understood as fluid, context-dependent, and historically changing (Laitin and Posner 2001; Chandra 2006). Consequently, a growing body of work has started to endogenize ethnic heterogeneity. Some scholars have sought to link ethnic diversity to differences in prehistoric human settlement (Ahlerup and Olsson 2012), land quality (Michalopoulos 2012), and climate variability (Cashdan 2001). The main problem with these attempts to endogenize diversity is that they focus on static factors and thus remain fundamentally ahistorical. The most notable attempts to address the historically changing nature of ethnic diversity have explored the role of colonialism. Scholars emphasize the ethnic divisions created by colonizers (Acemoglu, Johnson, and Robinson 2001; Engerman and Sokoloff 2005; Dell 2010) and the arbitrary borders left behind by European colonizers (Bleaney and Dimico 2016; Alesina, Michalopoulos, and Papaioannou 2016). Yet, important limitations also remain with these studies. European colonialism was concentrated in certain parts of the world, and it varied in its institutional forms, timing, and duration (Osterhammel 2005).

Other scholars focus on the modern state and suggest that historical state weakness is at the roots of contemporary ethnic diversity (Singh and Vom Hau 2016; Wimmer 2016). This paper builds on but also moves beyond this state-centered approach to endogenize diversity. We draw on the recent "informational turn" in the study of the state (Brambor et al. 2020; D'Arcy and Nistotskaya 2017; Vom Hau, Peres-Cajías, and Soifer 2023; Lee and Zhang 2017a) and propose a novel approach to account for variations in ethnic heterogeneity.

In this paper we treat information capacity—or the capability of states to collect, systematize and analyze information about their populations and territories— as the central aspect of the state (Lee 2020a) and an important determinant of identity outcomes. We argue that states able to gather and organize knowledge about their populations were more effective in physically and culturally eradicating ethnic minorities and/or socializing them into the dominant national identity, resulting in less diversity over time. The 19th century witnessed several technological and scientific advancements that facilitated the collection, transmission, and analysis of information at a large scale. These technologies, including the telegraph, the railways, the telephone, the modern population census, and the development of modern statistics, contributed to the expansion of information capacity. Thus, at least in part due to the arrival of these technologies, states became more effective at making their societies legible (Scott 1999) to them.

We explore the insights and limitations of this argument through a mixed-methods approach, by combining comparative historical case studies of 19th century Argentina and cross-national statistical analysis. The focus on Argentina allows us to move beyond the better-known experience of developed countries. We investigate the historical development of informational capacity in a less well-studied middle-income country, while the emergence of Latin American states more than 200 years ago also facilitates tracing long-term historical processes. Moreover, Argentina sheds light on the historical governance of diversity and the making of an ethnically homogeneous country.

Our analysis of Argentina investigates the role of informational capacity in distinct aspects of diversity governance. We first compare two military campaigns, the Desert Campaign (1833-1834) and the Conquest of the Desert (1876-1883) against indigenous peoples. During both episodes state leaders sought to construct Argentina as a white and European nation through demographic engineering and the violent eradication of Mapuche indigenous

peoples. But differences in the state's knowledge about the size and military capabilities of indigenous groups influenced the extent to which they succeeded. In the Desert Campaign, lack of information capacity facilitated the strategic retreat of indigenous communities to Southern Patagonia, whereas during the Conquest of the Desert the availability of detailed intelligence contributed to the defeat of indigenous forces.

The second aspect we study is the role of informational capacity in the rollout of mass schooling and the assimilation of European immigrants. Here we specifically investigate two state-led schooling campaigns aimed at "Argentinizing" Italians and Spaniards, the first one during the 1870s and 1880s after the initial wave of European mass migration to the country, and the second one around 1900 after the subsequent wave. In the late 19th century, the state did not manage to assimilate European migrants, as informational capacity was low. A generation later, however, the availability of more information about this part of the population facilitated a more targeted and better resourced expansion of public schooling, ultimately propelling the decline of ethnic identification and organization among European migrants.

The statistical analysis explores to what extent our argument that informational capacity shaped diversity is more broadly applicable. In a first step we regress ethnic diversity onto a historical indicator of information capacity. Our findings fit our theoretical expectations. We show a consistently negative and statistically significant association between various measures of information capacity and ethnic and linguistic fractionalization variables across different model specifications. Interestingly, the same does not hold for ethnoreligious diversity, a finding that is probably related to that fact that the reproduction of religious differences cannot be reduced to state-citizen relations, but is structured around the interactions between the state, citizens, and religious organizations. In a second step our statistical analysis directly engages with the scholarship on the so-called "diversity

deficit"(Alesina, Baqir, and Easterly 1999; Alesina et al. 2003; Easterly and Levine 1997); which claims that ethnic heterogeneity dampens the prospects of social development. In line with (Charnysh 2022; Singh and Vom Hau 2016; Wimmer 2016), we argue that the relationship between fractionalization and social development is endogenous to the infrastructural power of the state. What makes our paper different from previous works is our focus on informational shocks, rather than general indicators that account for the presence of the state.

In developing this line of argument, we make three broader contributions. First, while the existing scholarship has primarily focused on the role of information capacity in shaping public goods provision (D'Arcy and Nistotskaya 2017; Lee and Zhang 2017a), taxation(Vom Hau, Peres-Cajías, and Soifer 2023; D'arcy and Nistotskaya 2018), democratization (Brambor et al. 2020), and conflict (Lee 2020b), we present one of the first systematic theoretical efforts and empirical assessments of the processes by which information capacity affects subsequent patterns of ethnic identity. Second, we take the constructedness of diversity seriously, supporting recent scholarship and its view of contemporary ethnic heterogeneity as a legacy of historical stateness (Wimmer 2016). But we also offer a novel perspective that identifies which aspect of state capacity development in the past (i.e., information capacity) is particularly relevant for shaping subsequent patterns of diversity, and which variants of ethnic heterogeneity (i.e., ethnoracial and ethnolinguistic diversity) are more likely and which ones (i.e., ethnoreligious diversity) less likely to be affected.

Our third contribution is to demonstrate how historical differences in state formation led to distinct patterns of ethnic heterogeneity and social development. We concentrate on the specific channel through which state capacity influences diversity, namely informational capacity. Seen in this light, our paper reinforces the call for a broader, historically minded research agenda

that, at its core, asks whether ethnic fractionalization does indeed have a net negative impact on social development.

4.2 Theoretical Framework

4.2.1 Information Capacity and Ethnic Diversity

This article draws on constructivist insights about the historically manufactured nature of ethnicity (Brubaker, Loveman, and Stamatov 2004; Jenkins 1997). From this perspective, by the 19th century almost all territories around the world exhibited some degree of linguistic and/or phenotypical trait diversity (Lieberman and Singh 2012). To identify variations in ethnic diversity, it is crucial to determine whether certain traits have become institutionalized and influence social and political interactions (Wimmer 2008). Ethnic diversity is thus characterized by the extent to which the same ethnic labels and categories are integrated into various institutional structures and act as markers that distinguish different groups based on their perceived descent (Lieberman 2009; Barth 1998).

Furthermore, we build on a neo-Weberian approach to the state (Mann 1984; Skocpol 1979) and focus on state formation—or the development of state capacity—to explain subsequent patters of ethnic diversity (Singh and Vom Hau 2016; Wimmer 2016). We are also inspired by a recent body of work that emphasizes the critical importance of information in the overall capacity of the state. According to this perspective, states often engage in the collection of demographic and geographical data of their societies. This is achieved through various means, such as conducting population censuses, maintaining cadastral records, establishing specialized statistical offices, and publishing statistical yearbooks. These information-gathering technologies play a crucial role, as without them, states encounter significant challenges in carrying out their other activities (Lee and Zhang 2017b).

The creation of statistical agencies and data collection systems certainly relies on some investment of state resources, but this does not mean that information capacity should be treated as endogenous to other aspects of the state, most importantly fiscal capacity. Significant gains in information capacity were often made by small groups of officials who operated on very limited budgets (Vom Hau, Peres-Cajías, and Soifer 2023). The development of information capacity is probably best approached as a "technological shock" that involves the diffusion of new technologies, as exemplified by the rapid spread of modern population census once it was adopted by "early movers" such as Sweden (Brambor et al. 2020). Additionally, information capacity is often derived from the state's appropriation of infrastructures initially set up and managed by non-state actors (Gorski 2003), as for example the birth, marriage, and death registries kept by the Catholic Church. The main focus of this article is on the role of information capacity in shaping ethnic diversity. In the remainder of this section we develop our theoretical framework and argument in two broad steps. First, we detail the mechanisms by which states influence ethnic heterogeneity. We then discuss how those mechanisms relate to information capacity.

4.2.2 How States Reduce Ethnic Diversity

Since the rise of nationalism, most modern states have confronted the challenge of nation-building. Part of this process involves the question of how to govern ethnic differences within its territorial boundaries (Wimmer 2018). When analyzed over the long-run, nation-building has mainly focused on the creation of culturally homogenous nations (Bendix and Lipset 1966; Mann 2005; Bendix 1996; Marx 2003; Quijada 2000). Our theoretical framework therefore starts from the premise that the nation-building policies adopted by the state usually aspire to the reduction of ethnic diversity within its territorial boundaries. There are two key mechanisms through which states seek to reduce ethnic heterogeneity. The first one is socialization, which

refers to processes by which the state influences and shapes individuals' self-identifications and group memberships. Mass schooling constitutes a particularly powerful institution in this regard, whether in the form of explicit nationalist indoctrination (Gellner 1983) or the creation of nationally-defined spaces of interaction (Brubaker 2006). Additionally, public rituals play a role in socialization by creating shared experiences and reinforcing a sense of belonging to a particular community or nation (Kertzer and Arel 2002). These rituals can include national holidays, ceremonies, or symbolic events that promote a common identity and sense of unity among citizens.

The second mechanism is demographic engineering, which captures deliberate efforts by the state to alter population compositions or distributions within its territorial boundaries, often with the aim to create ethnically homogenous populations (Morland 2016; Weiner and Teitelbaum 2001). While Nazi Germany or the genocide in Rwanda constitute extreme cases, demographic engineering encompasses a range of policies aimed at the physical elimination of ethnic groups, most prominently population transfers, forced resettlements, pro-natalist policies, ethnic cleansing, and in extreme cases, genocide (Garrity 2022; Mann 2005). But demographic engineering may also revolve around the deliberate and systematic erasure of a group's cultural heritage and collective identity. This may include the demolition of sacred spaces and group symbols, but also the practice of forced adoption (Carmichael 2003).

4.2.3 How Information Capacity Affects Socialization and Demographic Engineering

The information collected by the state about its population and territory serves multiple purposes. For instance, data obtained through censuses and land cadasters enable the state to design education policies, implement conscription, and streamline tax collection efforts. However, the technological

infrastructure and personnel involved in gathering and organizing this information can also be repurposed. Once officials are trained and engaged in tasks such as conducting population censuses or managing land cadasters, they can readily adapt their skillset to collect and systematize other types of information (Vom Hau, Peres-Cajías, and Soifer 2023). Against this backdrop we argue that information capacity facilitates the state's pursuit of socialization and demographic engineering through a variety of channels.

One concerns the schooling capacity of states, or their ability to provide, regulate, and control the education of their populations. Where states had the capabilities to regularly collect information about the size and location of ethnic minorities, they were better able to expand, adjust, and/or target nationalizing efforts at them. This means that informationally capable states were more likely to accomplish socializing a diverse population into a homogeneous core identity, leading to a decline of diversity over time. By contrast, where states could rely only on limited information capacity, socialization was a less targeted and blunter tool. This, in turn, might have led to grievances and created incentives and political space for minority representatives to mobilize, thereby reinforcing ethnic differences (Petersen 2002).

The aspect of the state that matters most for demographic engineering is coercive capacity. Where states had greater capabilities of enumerating and locating ethnic minorities, they are expected to have been more "effective" at reducing diversity through means such as forced migration, minority resettlement, ethnic cleansing, or even genocidal campaigns. But information capacity is also implicated in minority threat perceptions. Where states regularly collected and analyzed data about society, they were more likely to be seen as powerful, with minorities more inclined—in Hirschman's terms—to choose between the options of *exit* and leaving or *loyalty* and embracing the state-supported identity.

Socialization and demographic engineering require state resources. Seen in

this light, there is also a more indirect channel by which information capacity contributed to ethnic homogenization, namely by facilitating fiscal revenues. Enhanced information capacity empowered rulers to replace tax farmers with fiscal bureaucracies. Knowledge about the whereabouts and assets of subjects also allowed for more intricate and potentially more profitable methods of taxation, whereas states lacking foundational informational resources struggle even with comparatively simpler taxes like customs (Vom Hau, Peres-Cajías, and Soifer 2023). Taken together, we argue that information capacity facilitates the reduction of ethnic diversity. Historically, it became easier for states to eradicate or assimilate ethnic minorities when states had the capacity to collect relevant information on their population. Informationally weak states, on the other hand, were less-well equipped to reduce heterogeneity. In the remainder of this article we subject this argument to an initial empirical test.

4.2.4 Information Capacity, Nation-Building, and Ethnic Diversity in Argentina

Argentina is often portrayed as an ethnically homogeneous country. At a first glance, scientific measures of ethnic diversity appear to confirm this assessment. Different indices of linguistic, ethnic, and cultural fractionalization place Argentina among the least diverse Latin American countries and in the lower bound worldwide. However, the relative homogeneity observed in contemporary Argentina should not be considered merely as a demographic fact but rather as the culmination of a long-term, often turbulent, process of nation-building. Throughout this historical journey, deliberate efforts were made to eliminate ethnic differences and establish a culturally homogeneous country, ultimately shaping the current levels of diversity we observe today. Recent estimates suggest that right before its independence, the indigenous population in Argentina was between 7.5 and 30 percent (Mahoney 2003)). Today, *only* about 2 to 3 percent of the population in Argentina identifies

as indigenous, even after its recent *re-emergence* (Gordillo and Hirsch 2003, p.6). These figures are striking if one also considers that in the late 19th century Argentina turned into a major destination of mass migration. While most immigrants originated from Italy and Spain, substantial migrant populations also arrived from other European countries and the Middle East. They brought with them their distinct languages and religious practices, but today's levels of diversity remain remarkably low. In 1910, about one-third of the population in Argentina was foreign born. In larger cities migrants were in the numerical majority. There is also evidence that migrant communities and their institutions worked tirelessly to preserve and reproduce their distinct cultures and identities (Baily 1999; Devoto 2003).

Our case study seeks to explain the decrease of ethnic diversity in Argentina during the 19th and early 20th century. Our theoretical framework puts the analytical spotlight on the state—and the new informational technologies it could rely on—for exploring the historical constitution of diversity. We argue that the expansion of information capacity facilitated the implementation of eliminatory and assimilationist nation-building strategies, with significant ramifications for subsequent patterns of diversity.

Nation-Building Aspirations and Ethnic Diversity

19th century state authorities sought to construct Argentina as a white and ethnically homogenous nation of European descendants. Regardless of whether the writings of political leaders such Domingo Faustino Sarmiento (1845) and Juan Bautista Alberdi (1852) or state-approved school textbooks published during this period are consulted (Vom Hau 2009, p.131-133), the aspiration was to establish a new and modern society by bringing European migrants to the country. They would constitute the bedrock for the creation of a distinct Argentine national identity. By contrast, official understandings of nationhood represented native indigenous populations as backward and a major internal threat to the construction of a white and homogenous na-

tion. In fact, the Mapuche were framed as "foreigners" that lacked legitimate reasons to reside in Argentina (Delrio et al. 2010, p.148).

These state-sponsored discourses underpinned nation-building policies. After a short initial period of cooperation during the War of Independence, where indigenous soldiers fought alongside insurgent Criollo elites against royalist forces and were recognized as *fellow citizens*, the postcolonial state authorities quickly shifted their stance. They sought the systematic elimination of the indigenous population, branding them as *barbarians* in the name of national progress and unity (Delrio et al. 2010; Gordillo and Hirsch 2003). The policies targeted at indigenous peoples included military campaigns, mass killings, the destruction of indigenous settlements, and their forced relocation and coercion into labor services. The policies applied to European migrants, on the contrary, were assimilationist in their orientation. Throughout the 19th century state leaders promoted migration from Europe (Bastia and Vom Hau 2014).

Entry restrictions or passport requirements were largely absent. Naturalization as an Argentine citizen was easy to obtain, and the children of immigrants had access to unconditional birthright citizenship. The 1876 immigration law further reinforced the notion of European migration as a nation-building tool. It did so by instituting subsidized travel and support for the acquisition of land for migrants from Europe, but not for those from Asia or other Latin American countries. Once European migrants arrived by the millions, state policies sought to nationalize them through a variety of measures, most importantly the expansion of free and compulsory public education and the introduction of nationalizing school curricula that were aimed at turning migrants into Argentines (Bastia and Vom Hau 2014).

The implementation of eradication policies towards indigenous peoples and assimilation policies towards European migrants, however, varied over time, with contrasting consequences for ethnic diversity patterns. We will illustrate

this by comparing two major military campaigns against indigenous peoples, and two concerted efforts to nationalize European migrants.

Extermination Campaigns Targeted at Indigenous People

The Desert Campaign (1833-1834) led by Juan Manuel de Rosas, the former governor of Buenos Aires and later ruler of Argentina, was primarily targeted at the Mapuche and Ranquel in northern Patagonia and the southern Pampas. His army, divided into several columns, pursued several lines of attack. Rosas reported that the campaign led to the death of about 3,200 indigenous peoples, the capturing of 1,200 prisoners, and the destruction of several settlements. But this murderous state violence did not achieve the proclaimed goal of exterminating indigenous communities. Instead, Rosas aborted the campaign in the face of fierce indigenous resistance and coordination problems. Indigenous groups were able to strategically relocate to the south of the country. And the communal institutions, leadership structures, and military capabilities of the Mapuche and Ranquel remained largely intact, contributing to their persistence as culturally distinct ethnic groups.

By contrast, the so-called Conquest of the Desert (1876-1884), a sequence of military campaigns orchestrated by Julio Argentino Roca, came close to the elimination of indigenous peoples and their institutions. After constructing fortresses along strategic points, Roca mounted systematic attacks on the Mapuche and other indigenous groups and their settlements. At least several thousand indigenous people perished, and some researchers estimate that almost half of the indigenous populations in Patagonia was killed (Martínez Sarasola 2011).

Roca's forces did not distinguish between combatants and non-combatants, leading to the repeated slaughter of prisoners and families. And if not killed, indigenous women and children were often sent to work as laborers in other provinces. In fact, the forced displacement and labor services of indigenous

peoples were often combined with the kidnapping of indigenous children, to be renamed with "Christian" names and transferred to non-indigenous families as servants (Delrio et al. 2010, p.140-146). As a consequence, indigenous communities in Patagonia withered away and lost their institutional capacities to maintain their identities and cultural practices.

Assimilation Efforts Targeted at European Immigrants

European mass migration in the 1860s and 1870s instigated significant state efforts to turn these new arrivals and their offspring into Argentines. One initiative was to establish greater control over education. The 1884 National Education Law introduced public primary education under the supervision of the central government and established a national framework for curricula and school programs. To standardize educational content, state leaders established specialized textbook commissions, regulated teacher training programs, and conducted school inspections. Additionally, educational officials paid closer attention to schools operated by immigrant communities. They required monthly reports, introduced standardized exams in Spanish, and implemented a mandatory revalidation process for foreign teaching diplomas (Bertoni 2001, p.24-25, 38-40, 64-77). Both public and migrant community school students were obligated to participate in public parades commemorating national holidays and pay homage to the Argentine flag, which became part of their weekly school routine (Bertoni 2001, p.79, 89-95, 113-120; Spalding 1972, p.42-43). But the intended consequences of these new regulations were limited. With just two percent of the national budget dedicated to education in 1884, access to public schools remained a constant issue, even in major urban areas such as Buenos Aires. And the campaign against ethnic schools lacked bite. During the 1880s, more than 40 percent of Italian school-age children continued to attend schools run by various Italian diaspora organizations (Baily 1999, 114). Not surprisingly, the late 19th century was marked by the persistence of ethnic identifications among European im-

migrants, and their institutions managed to maintain substantial autonomy in the field of education.

A second major wave of European mass migration reached Argentina in the early 20th century. State leaders again responded with a call for *patriotic education*. The new curriculum implemented under Jose Maria Ramos Mejía, who was president of the Consejo Nacional de Educación from 1908 to 1913, included the memorization of "genuinely Argentine" stories and poems, an increase in the number of classroom hours spent on national history, and the frequent celebration of patriotic rituals, such as a daily pledge of allegiance to the national flag (Spalding 1972, p.43). Schools run by immigrant communities were tightly regulated and monitored, their choice of educational contents had to align with the national curriculum (Escudé 1990, p.19). This push to nationalize through schooling was backed up by an enlarged resource base, with 13 percent of the national budget earmarked for education in 1910 (Spalding 1972, p.52). The impact of these measures is apparent. In the beginning of the 20th century ethnic identifications decreased among European migrants and the strength of their institutions declined. For example, only five percent of Italian school-age children attended Italian schools after 1900.

Taken together, the relative ethnic homogeneity that can be observed in contemporary Argentina should be understood as the consequence of a long-run nation-building process with the objective to construct a white and homogeneous nation. In what follows we focus on the development of information capacity and its role in reducing ethnic fractionalization.

Information Capacity in Argentina

During the first decades of postcolonial state formation information capacity remained limited. The Argentine Confederation did not have a specialized statistical office that collected and analyzed numerical information about the demography, social composition and economic activities of its population.

Notably, there are no records of major initiatives to collect such data, like population censuses, centralized land cadasters, or registries. Similarly, there were no efforts to make this knowledge accessible to other parts of the state, such as through the regular publication of statistical yearbooks (Brambor et al. 2020). Echoing this pattern, the historical record left behind by other state agencies involved in the collection and analysis of population-related information does not indicate any systematic record-keeping and dissemination activities. For example, the Ministry of the Interior did not make available any relevant yearbook publications or reports during this period.

The latter half of the 19th century witnessed a significant expansion of information capacity. The establishment of the Mesa Estadística de la Provincia de Buenos Aires in 1853 marked an important first step. Starting from 1854, this institution regularly published the Registro Estadístico, which provided valuable insights into various subjects such as trade and population demographics. Another institution was the Departamento Topográfico, which, in 1864, released the first comprehensive cadastral map encompassing the majority of legally owned territories in the province of Buenos Aires. In 1855, the Argentine Confederation established a statistical office that conducted a census in eight out of the thirteen provinces of the nation.

A National Statistics Office was eventually established in 1864. Comprising a director, three officials, and a concierge, the office operated on a budget of $3,261, which constituted 0.4 percent of the total expenses of the Ministry of Interior. Despite its modest size and perpetual resource challenges, it successfully released seven distinct volumes of the Registro Estadístico de la República Argentina, illustrating that fiscal capacity only played a limited role in the expansion of information capacity. In fact, the work on the Registro enabled the development of continuous trade series starting from 1861. Moreover, this period witnessed the implementation of the first comprehensive population census in 1869, marking a significant milestone in modern

data collection.

During the 1870s and 1880s a national system of statistics began to take shape. While the National Statistics Office itself closed its doors in 1875, some of its responsibilities were assumed by subsequent institutions such as the Oficina Estadística Comercial (1876-1884), the Departamento General de Inmigración (1876-1943), and the Departamento Nacional de Estadística (1884-1894). The enactment of Law 2681 in 1889 played a significant role in solidifying civil marriage and granting the state increased control over parish records documenting baptisms, marriages, and deaths. Similarly, in 1894, the Dirección General de Estadística was established, entrusted with the collection and presentation of statistical data on demographics, trade, economic activity, education, public finances, and transportation.

In tandem with this institutional development, state officials began to systematically collect specific sectoral information. They conducted manufacturing censuses in various provinces and in 1888 implemented the first agrarian census. Likewise, the second nation-wide census in 1895 yielded valuable data on population, manufacturing production, agrarian production, and trade, and 1898 witnessed the creation of a dedicated office responsible for the annual collection of industrial data and sectoral censuses. And the third modern census in 1914 is widely considered to have consolidated the Argentine state's information capacity. This capability to gather and analyze accurate information about its population contributed to the implementation of the official nation-building aspiration—the creation of Argentina as a white and culturally homogeneous nation.

Information Capacity and the Eradication of Indigenous Peoples

The development of information capacity contributed to the pursuit of state projects aimed at physically and culturally eliminating Mapuche peoples. In the Desert Campaign (1833-1834), state forces were often surprised by at-

tacks from indigenous forces . There was a general lack of knowledge about indigenous populations, their locations, the size of indigenous settlements in the Pampas and Patagonia and their military strength. The Departamento Topográfico, in charge of creating official maps and cadastral records, depended on the willingness of private actors such as landowners and settlers to provide and update relevant information (Gautreau and Garavaglia 2012). As a consequence, the state's knowledge about the spatial distribution of its population was extremely limited, which contributed to their initially failed attempts to implement the eradication policies targeted at Mapuche peoples.

Another indication of the state's absence of informational capacity comes from one of the major tools for the recording and sharing of relevant information within the state: The memorias (yearbooks). Those were published by the Ministry of Interior, which included the annual reports sent by provincial governors to central state authorities. The reports were meant to justify policies and actions, but they equally served as a crucial source of information for different state agencies. When reviewing the yearbooks published between the 1830s and 1990s the following patterns stand out for purposes of our argument: up to the 1860s their publication was irregular, and when they were made available almost every year, they barely contained any information about indigenous peoples; indigenous communities are rarely mentioned, and where they are, it is only in very general and imprecise terms, such being described as "numerous" in or "totally absent" from a particular territory.

But the lack of information capacity of the Argentine state during the 1830s also impeded the Desert Campaign through more indirect channels. One is the reuse of information for the mobilization of military capabilities. The absence of a statistical office that produced accurate population censuses and made this data available to the military made the recruitment of soldiers more difficult. Similarly, the lack of census-based information impeded the collection of taxes, with tax yields stagnating for the first decades of the 19th

century (Vom Hau, Peres-Cajías, and Soifer 2023, p.436)

The picture was significantly different during the Conquest of the Desert (1876-1883). In pursuit of its stated goal of eliminating indigenous peoples, this series of military campaigns could draw on more reliable information about the location and size of indigenous communities. From the 1850s onwards, the Departamento Topográfico produced more accurate maps. This was to an important degree related to the standardization of the collection of cadastral information (Gautreau and Garavaglia 2012). Moreover, the information about indigenous peoples included in the yearbooks of the Ministry of Interior became more detailed. Also, the yearbooks referenced the locations of indigenous communities and their ethnicity, and sometimes even offered numerical estimates of their size.

The expansion of information capacity after 1850 supported the eradication of indigenous peoples by enhancing the coercive and fiscal means available to state authorities. The consolidation of national statistics offices during the latter part of the 19th century and the availability of accurate information about Argentina's population provided the backdrop for more targeted campaigns to recruit soldiers and train officers. Another channel was provided by tax resources. The increase in indirect internal taxes was not just driven by the creation of a new tax base and population growth. Rather, the professionalization of statistics officials during the 1870s and 1880s meant that this group not only focused on gathering information but also engaged in their own economic analysis. Most importantly, statistics officials began to collect detailed sectoral information, which enabled the more accurate assessment of collection potential, the calibration of tax rates, and ultimately, the increase of tax revenues available to Roca and his military collaborators Vom Hau, Peres-Cajías, and Soifer (2023, p.437-439)

Information Capacity and the Assimilation of European Immigrants in Argentina

The development of information capacity also played a facilitating role in the assimilation of Italian, Spanish, and other immigrant groups arriving to the country in the late 19th century. Having the necessary tax base to implement the 1884 National Education Law was a major challenge, compared to the resources required for repressing ethnic minorities in previous periods. In this case, National authorities lacked the funds necessary to roll out free and mandatory primary schooling among the hundreds of thousands of recently arrived immigrant families.

Moreover, the development of information capacity was also directly implicated in the persistence of ethnic identifications and institutions among European immigrants. Prior to 1895, there was only little knowledge regarding their characteristics in Argentina. The records of border guards in the port of Buenos Aires provided insights into migrants' entry and exit patterns and their countries of origin (Cook-Martin 2013). Population censuses helped understand their distribution across provinces. However, this information wasn't detailed enough to effectively target new schools. Education authorities lacked data on the concentration of European immigrants in specific neighborhoods and their social characteristics, including education levels. There was also no centralized registry with information on ethnic schools run by immigrant communities. This lack of knowledge led to disproportionate efforts by state officials to regulate or break up densely populated tenements known as *conventillos*. These tenements were considered obstacles to migrant assimilation, even though new arrivals often lived there only temporarily before settling in ethnically defined areas, which played a more central role in maintaining ethnic differences (Devoto 2003, p.266-267; Baily 1999, p.122-138)

This changed at the onset of the 20th century. The consolidation of a na-

tional system of statistics and the routine collection of census-based data contributed to the assimilation of European immigrants. With the second national population census, conducted in 1895, detailed information became available at the much more disaggregated ward level, providing insights into various aspects of immigrant lives. These included their occupational status, literacy rates, school attendance, and home ownership. More fine-grained knowledge about the demographics and living situation of migrants enabled state authorities to specifically target neighborhoods with a high concentration of European migrants for the construction of new public primary schools (Devoto 2003). Similarly, it made possible the creation of teacher training institutes, the so-called escuelas normales in those areas (Fiorucci 2014, p.29). And a registry for civil society associations rendered campaigns against ethnic schools become more effective. Inspectors managed to more frequently visit schools run by immigrant communities in order to ensure compliance with the national curriculum (or find reasons to shut them down). More indirectly, the development of information capacity also facilitated the broad-based implementation of "patriotic education" by expanding fiscal capacity. During the 1890s total tax revenues increased to seven percent of GDP and then maintained this level until 1914 (Ferreres 2005).

In sum, this comparative-historical case study of Argentina has found support for our argument that information capacity sets the stage for the reduction of ethnic diversity. We have shown that the implementation of nation-building strategies concerned with the eradication or assimilation of ethnic minorities are at least in part enabled by the prior development of the state's capacity to collect and analyze accurate information about its population. Information capacity directly facilitates the creation of military and schooling capacities necessary for demographic engineering and socialization, and it indirectly affects them by establishing a greater tax base. The cross-national statistical analysis that follows explores the insights and limitations of this argument for a broader range of cases in a more recent time period.

4.3 Data

We start our empirical analysis by examining whether informational capacity and ethnic diversity are related. To that end, we follow two empirical strategies. First, we estimate a cross-sectional model in which ethnic fractionalization is predicted by an indicator of historical Informational Capacity. Second, we use a two-way fixed effects panel model, incorporating various lags of our informational capacity measure.

Ethnic, Linguistic and Religious Fractionalization

In the cross-sectional model shown in Table 1, we use variables of ethnic, linguistic and religious fractionalization as outcomes (Alesina et al. 2003). Despite the data being old—it relies on the Encyclopaedia Britannica of 2001— it allows us to differentiate between different dimensions of diversity. In our panel, on the contrary, we use a recently published dataset on ethnic fractionalization with a panel structure, the Dražanová (2020) fractionalization index. This measure focuses only on ethnic fractionalization and does not include information in linguistic and religious diversity. But the principal advantage of this dataset is that it varies over time, which allows us to run our two-way fixed effects panel model on fractionalization and informational capacity.

Information Capacity Index and Legibility

Our explanatory variable conceptually captures informational capacity. To operationalize it, we draw on a relatively novel dataset that has been assembled and published by the State-Making and the Origins of the Global Order in the Long 19th Century and Beyond (STANCE) research group at the University of Lund for 86 polities (Brambor et al. 2020). Their information capacity index (infcap_irt) is composed of five component indicators and measures variations on a continuous scale per country year. Specifically,

this index identifies when a state first had a statistical agency and a modern population census and each country's ability to generate reliable yearbooks. For almost all polities included in the STANCE dataset, it provides yearly evidence over long periods of time, from 1789 (or the onset of nation-state formation) until 2015. Although the number of observations is not particularly high, the geographical coverage of the countries included is diverse, with countries from all continents and geographical regions of the world. What the information capacity index provides is a measure of the extent to which states could know crucial features of the population they attempted to govern. Taking an informational approach to state capacity implies a measurement focus on the main information technologies employed by states. A particularly central role is played by the administration of a national census. The frequency, format, geographic coverage, and quality of population censuses help to capture the ability of the states to generate basic knowledge about society within their borders (Soifer 2013; Lee and Zhang 2017b).

As a robustness check, we use Lee and Zhang's (2017a) legibility index score. This original dataset -available for more than 120 countries – constitutes a promising alternative to measure information capacity. It traces variations in the legibility of citizens by concentrating on the quality of population censuses. Specifically, Lee and Zhang draw on demographic techniques to calculate the extent to which the age data included in a population census follows a smooth curve and thus is accurate, or whether the census is characterized by age "heaping" around certain numbers (e.g., 0 and 5). The latter is indicative of limited legibility. To bolster the strength of our argument, we employ legibility scores from Zhang and Lee as robustness checks, taking into account that the data is only available from 1960 onwards.

4.3.1 Operationalization for Cross-Sectional and Panel Models

For the cross-sectional regression analysis, we rely on the information capacity index from STANCE as our preferred data indicator, which is available in Table 1. As a robustness check, we also include the legibility measure from Lee and Zhang (2017a), which can be found in Table A3 of Appendix A. When operationalizing our principal indicator of historical information capacity, we follow two crucial steps. The first step involves calculating the average of the information capacity index -labelled in their original dataset as *infcap_irt*- for the period of 1820-1830. We chose this cut-off point based on the understanding that, prior to 1820, the majority of the world was governed by empires, city-states, and other political institutions (Wimmer and Min 2006). By including the subsequent 10 years, we can include countries that gained independence shortly after 1820, such as Brazil, Bolivia, Ecuador, or Belgium. In our cross-sectional model, the second operationalization examines the degree of informational capacity at each country's year of independence. Since many countries were reported to have 0 informational capacity in the year of their independence, we averaged the values of informational capacity for the following five years, ensuring that we are not capturing a transitional period where no information capacity was reported. A third and fourth operationalization, along with their results, are provided in Table A2 in Appendix A) and involve taking informational capacity in 1820 and at the year of each country's independence, without applying any additional data corrections.

For the two-way fixed effects model, we again utilize the information capacity index as our preferred source. However, since we are conducting a panel model to examine the within-state variation in informational capacity, the periodization of our explanatory variables follows a different logic. We have introduced lags of 10, 20, 30, 40, and 50 years to the informational capac-

ity index. Our theoretical argument posits a time lag between a country's increase in informational capacity and the subsequent reduction in fractionalization. As we lack a specific theoretical expectation regarding the duration of time it takes for informational capacity to impact fractionalization, we have included various lag periods.

4.4 Methods and Statistical Tools

Regarding the methods and statistical tools used, they vary depending on whether we utilize cross-sectional or panel data. For the cross-sectional model, we employ an ordinary least squares (OLS) regression. Specifically, we regress ethnic, linguistic, and religious fractionalization on historical values of informational capacity. To account for potential confounding factors, we include additional controls in the model, such as GDP per capita (1975-1995, from Alesina et al. (2003)), log population (from the World Bank), a dummy variable indicating colonial legacies, and the number of civil wars until 1900 (Wimmer and Min 2006). Further geographical controls are included in the appendix.

The regression model is based on the observation that measuring information capacity of the 1820-1830 period, and then examining ethnic fractionalization values measured in 1990-2000 (over 150 years later), contributes to the exogeneity of information capacity, as the explanatory variable precedes the outcome. Additionally, each country's level of information capacity at its year of independence further reinforces the exogeneity of the measure. When a country gains independence, it typically undergoes significant institutional and structural changes. These changes can be considered exogenous if they are not influenced by factors that could be correlated with ethnic fractionalization 150 years later and are not captured by our list of control variables. We believe it is reasonably plausible to meet this requirement.

For the second regression model, we use a different technique. Taking advantage of the panel structure of our dataset, we evaluate how changes within countries, rather than across them, affected fractionalization. To effectively accomplish this purpose, we include fixed effects for each country and time period. The lags in our explanatory variable allow us to capture the expected result of changes in informational capacity on fractionalization. The lags in the two-way fixed effects models contribute to the sequentiality of the relationship of our variables. We also account for time-varying lagged levels of GDP, population density and the number of civil wars fought in each country. Unlike with population and fractionalization, we have not lagged the civil wars variable, as we expect this variable to influence fractionalization at the moment of its occurrence.

$$\pi = \alpha + \beta_1 \iota_{i,t-n} + \beta_2 X_{t-n} + u_i + \lambda_t + \varepsilon_{i,t} \tag{4.1}$$

Where i denotes countries (1, 2, ..., 61), t denotes years, n indicates the lag (10, 20, 30, 40 years...) , X_{t-n} is a vector of GDP, population and conflict variables, lagged with the same period as the explanatory variable. U_i are Country fixed effects and λ_t are time fixed effects measured in the year of the outcome variable (1945, 1946, ..., 2012)

4.5 Results

Historical information capacity for the 1820-1830 period is negatively associated with ethnic fractionalization and linguistic fractionalization. Once standardized, the size of the effect corresponds to a magnitude of about 0.27 and 0.28 standard deviations of linguistic and ethnic diversity. Similarly, when we measure informational capacity at the year of each country's independence (in the second row) we find similar results: an effect size that reduces ethnic and linguistic fractionalization in a magnitude of 0.2 standard deviations of

these outcomes. When we evaluate the impact of our explanatory variables on religious diversity, the results become much more inconsistent, with different signs depending on the operationalization, and overall, the coefficients are imprecisely estimated. This suggests that past legacies of information capacity likely reduced ethnic and linguistic fractionalization, while the same does not holds true for religious diversity.

Table 4.1: Cross-Sectional model of Ethnic Fractionalization as an outcome

	Dependent variable:					
	Ethnic Fractionalization		Linguistic Fractionalization		Religion	
	(1)	(2)	(3)	(4)	(5)	(6)
Information Capacity Index 1820-30 (Avg)	-0.45^{**}		-0.47^{*}		0.42^{*}	
	(0.22)		(0.24)		(0.23)	
Information Capacity Index at Independence (+5 years agg.)		-0.33^{*}		-0.35^{*}		-0.001
		(0.17)		(0.19)		(0.15)
Constant	0.12	-0.01	0.01	-0.21	-0.22	0.03
	(0.24)	(0.19)	(0.27)	(0.25)	(0.23)	(0.24)
Socioeconomic Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	50	59	47	55	49	58
Adjusted R^2	0.19	0.17	0.08	0.13	0.03	-0.05
Residual Std. Error	0.22 (df = 44)	0.21 (df = 53)	0.23 (df = 41)	0.22 (df = 49)	0.22 (df = 43)	0.22 (df = 52)

Note: $*p < 0.05$; $**p < 0.01$; $***p < 0.001$. Controls Include GDP per capita (1975-90 avg), Log Population, Accumulated Number of Civil wars (1820-1900, from Wimmer and Min, 2006)

The results are robust across different operationalizations. Table A2, available in Appendix A, confirms the negative association between information capacity and ethnic and linguistic fractionalization, and the lack of a clear association with religious diversity, when different operationalization strategies are taken into account. Table A1 reproduces the models in Table 1 but takes on additional geographical controls available in Wimmer (2016) regression models. Despite diminishing the statistical power of the exercise due to the inclusion of a large number of controls, results remain negatively associated with the two principal fractionalization variables (especially so with our 1820-1830 averaged information capacity).

Tables A3 and A4 of the appendix include contemporary, rather than historical, levels of information capacity. We start by using the same data source as before—the information capacity index from STANCE —but we average it for the 1960-1990 period. We proceed with the legibility indicator from Lee and Zhang, using the same periodization. We choose 1960 as our initial starting point because it is the first year for which Zhang and Lee's legibility score is available, and 1990 as our endpoint since we want to make sure that informational capacity precedes any measurement on fractionalization. The effect of the information capacity index remains negatively associated with fractionalization, and its coefficient is twice as big as its historical operationalization. Similarly, the legibility score is negative and statistically associated with ethnic and linguistic fractionalization. Both measures are not statistically significant for religious diversity, suggesting that the link between state capacity and the variety of religious groups is non-existent. We now turn into our preferred model for estimating the effect of information on fractionalization, a panel two-way fixed effects model that captures variations of both variables in time. Table 2 provides the main results.

The average coefficients of the informational capacity—once averaged across different operationalization—is about -0.02 (-0.01 at the lower bound and -0.03 at the upper). The 10-, 20-, 30-, 40- lag of informational capacity are statistically significant and negative, as predicted, but the size of the effect is considerably smaller than the cross-sectional models (of about 1/12 standard deviations of the outcome). This effect -however – only reflects how informational capacity affected fractionalization during the period we have panel data on, from 1940 onwards. That should not be confounded with the overall effect that informational capacity may have had on fractionalization, since the period we are covering experienced overall little variation in our outcome. And yet, part of this variation, can be explained by lagged increments in informational capacity. Our 50 years lag is not statistically significant.

Table 4.2: Panel model of Ethnic Fractionalization as an outcome

	Dependent variable:					
	Ethnic Fractionalization (Dravzanova)					
	(1)	(2)	(3)	(4)	(5)	(6)
	Lag 10	Lag 20	Lag 30	Lag 40	Lag 50	
Information Capacity Index (Lag)	-0.02^{***}	-0.02^{***}	-0.03^{***}	-0.03^{***}	-0.01	
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	
GDP per capita (Lag)	-0.002	0.002	0.01^{*}	0.002	0.02^{***}	
	(0.002)	(0.002)	(0.003)	(0.004)	(0.005)	
Log Population (Lag)	0.0004	-0.0002	0.002	0.001	-0.001	
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	
Accumulated number of years of civil war	-0.002^{***}	-0.003^{***}	-0.003^{***}	-0.004^{***}	-0.01^{**}	
	(0.0002)	(0.0003)	(0.0003)	(0.001)	(0.002)	
Time FE	Yes	Yes	Yes	Yes	Yes	
Country FE	Yes	Yes	Yes	Yes	Yes	
Observations	2,886	2,713	2,129	1,539	948	
F Statistic	25.49^{***}	29.20^{***}	25.59^{***}	16.14^{***}	8.04^{***}	
Number of countries	61	61	61	61	61	
Period covered by the fractionalization data	1945-2012	1945-2012	1945-2012	1945-2012	1945-2012	
Period covered by Inf. Capacity Data	1930-2002	1920-1990	1910-1980	1900-1970	1890-1960	

Note: $*p < 0.05$; $**p < 0.01$; $***p < 0.001$. Each Lag corresponds to 10 years. All the variables are lagged to the number indicated in the column label, except the years of civil war, which indicate the cumulative number of civil wars fought at any given country/year. The models include fixed effects for each country and year

4.6 The Diversity-Deficit Thesis Further Revisited

Wimmer's work suggests that the level of historical stateness explains part of the effect of fractionalization on social development. His work operationalizes stateness as something that countries either have or do not, and it is intended to capture a minimum level of each country's degree of institutionalization. Our approach differs from his in that we are interested in exploring how different levels of informational capacity, and not just the existence of minimum state structure, may have shaped both ethnic fractionalization levels and social development. In the analysis, we suggest a causal effect of informational capacity on fractionalization. We do not, however, aim for the same causal standard in this second empirical attempt. Our aim is not to assert that informational capacity causally, once accounted for, reduces the effect of ethnic diversity on social development in a definitive way. Rather, we suggest that the omitted variable bias identified in Wimmer could go through the channel of informational capacity. Previous research has attempted to further disentangle state capacity across different dimensions. Fiscal capacity is often the most widely used measure (Garfias and Sellars 2022; Queralt 2019, 2015). Many authors believe that taxation is the basic tool for states to accomplish their developmental goals, since any intention of a country requires resources to finance such expenses. However, for taxation to succeed, it requires a basic informational infrastructure(Vom Hau, Peres-Cajías, and Soifer 2023). Furthermore, informational capacity varies across states with similar levels of stateness (as in Wimmer's operationalization) or antiquity (Bockstette, Chanda, and Putterman 2002).

Our argument holds that where states acquired the capability to "read" their populations (Scott 1999), they became more likely to socialize them into the dominant national identity and/or repress their distinct identity expressions. This potentially decreases the likelihood of violent conflict, with

non-dominant ethnic groups rebelling against the state, either because they have been assimilated, eradicated or both. Historical information capacity also matters for subsequent social development in a more direct manner. The effective delivery of public services depends on the state's capabilities to collect relevant and standardized information about its citizens and their activities. For example, states are better able to establish schools and hospitals and train teachers and nurses if they possess prior knowledge about the size, geographic distribution, and basic demographic and socioeconomic characteristics of their citizens, and if this information is standardized and comparable across different local units. Scholars have argued, both theoretically (Rueschemeyer, Huber, and Stephens 1992) and empirically (Brambor et al. 2020) that state information capacity grows rather slowly. Census enumeration and the construction of a professional statistical agency take time, as does the production of systematic demographic and economic information, which in turn facilitate the generation of tax revenues or the planning of public service interventions, such as the expansion of public schools or health care centers. For this correlational exercise, we run an OLS with the log infant mortality as an outcome and the fractionalization variables as explanatory variables. The first regression model starts without any informational capacity variable included in the model. Next to this initial model, we explore how the fractionalization variables vary when we introduce Lee and Zhang's legibility score. Table 3 shows the main results.

When controlling for legibility, the effect of ethnic fractionalization on infant mortality disappears. One should be careful when extracting definitive conclusions from these results, as ethnic fractionalization is still positively associated with higher infant mortality. The magnitude of the coefficient, however, drops by half when controlling for legibility. It is also less precisely estimated, in fact, it becomes statistically insignificant. The same empirical trend is observed for linguistic fractionalization. The size of the effect reduces drastically when controlling for legibility and becomes statistically

Table 4.3: Diversity-deficit thesis revisited with Legibility

	Dependent variable: Log Infant Mortality					
	(1)	(2)	(3)	(4)	(5)	(6)
Ethnic Fractionalization	0.64***	0.28				
	(0.22)	(0.19)				
Linguistic Fractionalization			0.36*	0.11		
			(0.19)	(0.16)		
Religious Fractionalization					-0.31	-0.25
					(0.22)	(0.18)
Legibility (1960-1990, Avg.)		-0.36***		-0.40***		-0.39***
		(0.07)		(0.07)		(0.06)
Constant	4.29***	4.88***	4.75***	5.07***	4.99***	5.23***
	(0.59)	(0.51)	(0.58)	(0.48)	(0.57)	(0.46)
Socioeconomic Controls	Yes	Yes	Yes	Yes	Yes	Yes
Geographical Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	80	80	76	76	78	78
R^2	0.67	0.77	0.65	0.77	0.63	0.77
Adjusted R^2	0.64	0.74	0.61	0.74	0.60	0.74
F Statistic	20.86***	29.37***	17.68***	27.38***	17.34***	28.25***

Note: $*p < 0.05$; $**p < 0.01$; $***p < 0.001$. Controls Include GDP per capita (1975-90 avg), Log Population, Accumulated Number of Civil wars (1820-1900, from Wimmer and Minn, 2006), Dispersion in elevation across regions of country (Michalopoulos), Dispersion in agricultural suitability across regions of the country (Michalopoulos), Average monthly precipitation 1961-1990 in 1,000s of mm (Michalopoulos), Distance from the coast in km (Michalopoulos). Columns 1, 3 and 5 include the baseline model where infant mortality is regressed on Ethnic Fractionalization and its controls. Columns 2, 4 and 6 reproduce the same model, including informational capacity.

insignificant. Drawing conclusions from religious diversity is not possible since religious diversity is not significant in the baseline model. Table 4 proceeds with the same statistical model, but with information capacity index (averaged for the period 1820-1830) as the main explanatory variable.

Table 4.4: Diversity-deficit thesis revisited with STANCE

	Dependent variable: Log Infant Mortality					
	(1)	(2)	(3)	(4)	(5)	(6)
Ethnic Fractionalization	0.67*	0.47				
	(0.36)	(0.32)				
Linguistic Fractionalization			-0.37	-0.21		
			(0.36)	(0.32)		
Religion					-0.62	-0.59*
					(0.37)	(0.32)
Information Capacity Index (1820-1830 Avg.)		-2.24***		-2.18***		-2.34***
		(0.59)		(0.64)		(0.59)
Constant	4.28***	4.41***	4.52***	4.62***	4.19***	4.38***
	(0.85)	(0.74)	(0.87)	(0.77)	(0.88)	(0.76)
Socioeconomic Controls	Yes	Yes	Yes	Yes	Yes	Yes
Geographical Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	49	49	46	46	48	48
Adjusted R^2	0.70	0.77	0.69	0.76	0.70	0.78
F Statistic	16.88***	21.49***	15.54***	18.94***	16.40***	21.62***

Note: $*p < 0.05$; $**p < 0.01$; $***p < 0.001$. Controls Include GDP per capita (1975-90 avg), Log Population, Accumulated Number of Civil wars (1820-1900, from Wimmer and Minn, 2006), Dispersion in elevation across regions of country (Michalopoulos), Dispersion in agricultural suitability across regions of the country (Michalopoulos), Average monthly precipitation 1961-1990 in 1,000s of mm (Michalopoulos), Distance from the coast in km (Michalopoulos)

Higher values of informational capacity are associated with lower infant mortality, as we expected. Interestingly, ethnic fractionalization becomes less relevant in predicting the mortality of infants when we include informational capacity as a control, and it becomes statistically insignificant too. The loss of statistical power could be due to the mechanical inclusion of another variable in the model, given the low number of observations, but as the co-

efficient becomes smaller, and the standard errors remain relatively stable, we take this as an indicator that informational capacity could be a relevant control variable affecting both fractionalization and the provision of public goods. We find a similar finding for linguistic fractionalization. A drawback for our purposes is that the baseline model for linguistic fractionalization is not statistically significant. Thus, we cannot be sure of its potential association. Religious fractionalization, when controlling for informational capacity, becomes significant and negatively associated with infant mortality. This suggests that more religious diversity is not detrimental for development, in fact, it might contribute to it. Although this finding is consistent with our theory, we are cautious about the possibility that the finding travels beyond our sample, given that the standard errors are relatively high and that we do not have a representative sample of countries for this exercise, despite the information capacity index doing a fair job in covering a variety of countries in terms of geographical, institutional and colonial indicators. Tables B1 and B2 in Appendix B show that in our replication model fractionalization is not statistically significant when the proportion of literate adults is our outcome, as an alternative measure of social development. When including our information capacity variables in the model, however, the effect becomes even smaller and less precisely estimated.

4.7 Conclusions

Taken together, our findings provide support for the claim that historical levels of state information capacity shaped subsequent patterns of ethnic diversity. Our results align with Wimmer, but what sets our paper apart is our focus on informational technologies. "Informational shocks" likely played a significant role in shaping ethnic fractionalization by facilitating either the assimilation or eradication of ethnic minorities. States usually try to homogenize the populations they govern by creating a national identity.

Some states fail to do so, while others succeed, and we suggest that this depends on the state's capacity to "read" (Scott 1999) their population.

Seen in this light, our findings emphasize the importance of recognizing information capacity as an important and still underappreciated pillar for the study of ethnic diversity. In fact, it is crucial to treat the effects of information capacity and more general measures of state capacity on ethnic diversity as analytically distinct from each other. The population census and other information technologies play an important role in the (re)construction of ethnic categories and identities (Nobles 2000; Loveman 2014; Lieberman and Singh 2017) while also shape the performance of other state institutions involved in the socialization of citizens, such as schooling.

Another contribution is advancing the research of the diversity-deficit hypothesis. We are not the first in arguing that the observed negative association between fractionalization and social development could suffer from omitted variable bias, the missing control being state capacity. The findings of our second statistical analysis, in which we explore fractionalization coefficients after the inclusion of information capacity variables as controls, suggest that information capacity is a key factor to understand the link between fractionalization and social development outcomes. We thus show that historical information capacity, and not just general indicators of the presence of the state, make the relationship between fractionalization and social development less meaningful.

One crucial implication for future research is the need for more systematic historical data on information capacity at a global scale. The data we primarily relied on for the statistical analysis, the information capacity index developed by the STANCE team, reaches back in time by about 200 years and thus covers where informational shocks took place and when the first modern censuses and statistical agencies appeared. But it only includes data for about 86 polities, some of which no longer exist. One crucial contri-

bution to the study of information capacity and its long-term implications would therefore be the construction of a truly global dataset that expands on existing legibility and information capacity datasets. This would involve tracking historical census data and the prevalence of age heaping in it, the frequency and geographic coverage of subsequent iterations of censuses, and the deployment of other information-gathering technologies such as statistical yearbooks. Another implication of our study concerns nation-building and the deployment of state capacity. Currently our argument rests on the assumption that historically strong states use their capabilities, in one way or another, to reduce ethnic diversity over time. Yet, state capacity (understood as either informational or fiscal capabilities) and state performance (understood as what states actually do with their capacity) should be analytically distinguished from each other (Centeno, Kohli, and Yashar 2017). This point is echoed in recent works on nationalism (Aktürk 2012; Mylonas 2013; Singh and Vom Hau 2016; Wimmer 2018) which treat the deployment of state capacity as crucially shaped by the prevailing nation-building strategy. It is thus not self-evident that a historically strong state produces a decline of ethnic heterogeneity. Rather, the effects of state capacity are crucially mediated by whether states seek to assimilate, accommodate, or exclude ethnic minorities. The nation-building strategy of assimilation is associated with the provision of public services on a universal basis to all citizens without regard to ethnicity—yet often with the implicit aim of establishing congruence between the ethnic boundary markers (e.g., language) of the dominant group and the nation. Accommodation is similarly associated with the inclination to universally provide public goods but is open to providing distinct kinds of public goods to different ethnic groups, in line with those groups' preferences. Finally, exclusion usually limits national membership, either in terms of formal citizenship rights and/or their privileging to one dominant ethnic group and entails the targeting of public goods towards this group. Future research on the potential spuriousness of the relationship between ethnic di-

versity and public goods provision should therefore complement our focus on historical patterns of state capacity with paying close attention to the prevailing nation-building strategy. In sum, our findings represent a promising start and call for a broader, historically minded research agenda. This paper has provided evidence that historical patterns of information capacity shape ethnic heterogeneity and social development. To further advance our understanding of those connections, future research must rigorously examine our argument using micro-data over extended periods. However, a significant obstacle lies in the scarcity of panel data concerning fractionalization and information capacity, especially at both the national and subnational levels. Addressing this data limitation will be essential for achieving more comprehensive and accurate insights into the relationship between information capacity, ethnic diversity, and social development.

4.8 Appendix

4.8.1 Appendix A on Ethnic Diversity as an outcome

Afghanistan	Argentina	Australia	Austria	Belgium	Bolivia	Brazil
Bulgaria	Canada	Chile	China	Colombia	Costa Rica	Cuba
Denmark	Dominican Republic	Ecuador	Egypt	El Salvador	Ethiopia	Finland
Greece	Guatemala	Haiti	Honduras	Hungary	Indonesia	Iran
Italy	Japan	Liberia	Libya	Madagascar	Mexico	Morocco
Myanmar	Nepal	Netherlands	New Zealand	Nicaragua	Norway	Paraguay
Peru	Poland	Portugal	Romania	Russia	Saudi Arabia	South Korea
Spain	Sweden	Switzerland	Thailand	Tunisia	Turkey	United Kingdom
United States	Uruguay	Uzbekistan	Venezuela	Vietnam		

Table 4.5: Available countries for the two-way fixed effects in table 4.3

Table 4.6: A1. Table 1 with extended list of controls

	Dependent variable:					
	Ethnic Fractionalization		*Linguistic Fractionalization*		*Religous Fractionalization*	
	(1)	(2)	(3)	(4)	(5)	(6)
Information Capacity Index 1820-30 (Avg)	−0.40*		−0.39*		0.37+	
	(0.22)		(0.23)		(0.24)	
Information Capacity Year of Independence (+5 years aggr)		−0.13		−0.30		−0.05
		(0.18)		(0.20)		(0.16)
Constant	0.10	0.004	0.06	−0.06	−0.34+	−0.17
	(0.22)	(0.24)	(0.25)	(0.32)	(0.24)	(0.25)
Socio-economic Controls	Yes	Yes	Yes	Yes	Yes	Yes
Extended Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	50	58	47	55	49	57
Adjusted R^2	0.40	0.25	0.19	0.18	−0.003	−0.07
Residual Std. Error	0.19 (df = 40)	0.20 (df = 48)	0.22 (df = 37)	0.21 (df = 45)	0.22 (df = 39)	0.23 (df = 47)

Note: $*p < 0.05$; $**p < 0.01$; $***p < 0.001$. Controls Include GDP per capita (1975-90 avg), Log Population, Accumulated Number of Civil wars (1820-1900, from Wimmer and Minn, 2006), Dispersion in elevation across regions of country (Michalopoulos), Dispersion in agricultural suitability across regions of the country (Michalopoulos), Average monthly precipitation 1961-1990 in 1,000s of mm (Michalopoulos), Distance from the coast in km (Michalopoulos)

Table 4.7: 1820 and Independence operationalization

	Dependent variable:					
	Ethnic Fractionalization		Linguistic Fractionalization		Religion	
	(1)	(2)	(3)	(4)	(5)	(6)
Information Capacity Index (1820)	−0.47**		−0.53**		0.42*	
	(0.22)		(0.23)		(0.23)	
Information Capacity Index (Year of Independence)		−0.36**		−0.36**		(0.15)
		(0.16)		(0.18)		0.03
Constant	0.11	−0.02	0.11	−0.22	−0.18	0.03
	(0.25)	(0.19)	(0.29)	(0.25)	(0.25)	(0.24)
Observations	46	59	43	55	45	58
Adjusted R^2	0.19	0.19	0.08	0.13	0.01	−0.05
Socio-economic Controls	Yes	Yes	Yes	Yes	Yes	Yes
Extended Controls	No	No	No	No	No	No
Residual Std. Error	0.22 (df = 40)	0.21 (df = 53)	0.24 (df = 37)	0.22 (df = 49)	0.22 (df = 39)	0.22 (df = 52)

Note: $*p < 0.05$; $**p < 0.01$; $***p < 0.001$. Controls Include GDP per capita (1975-90 avg), Log Population and the Accumulated Number of Civil wars (1820-1900, from Wimmer and Minn, 2006)

Table 4.8: Current levels of informational capacity

	Dependent variable:					
	Ethnic Fractionalization		Linguistic Fractionalization		Religion	
	(1)	(2)	(3)	(4)	(5)	(6)
STANCE (1960-1990)	-0.92^{***}		-0.88^{***}		0.17	
	(0.29)		(0.28)		(0.26)	
Legibility (1960-1990)		-0.14^{***}		-0.17^{***}		0.02
		(0.03)		(0.04)		(0.04)
Constant	0.78^{***}	0.75^{***}	0.58^{*}	0.61^{**}	-0.12	0.26
	(0.29)	(0.25)	(0.35)	(0.24)	(0.35)	(0.24)
Observations	59	82	55	77	58	79
Adjusted R^2	0.27	0.24	0.18	0.24	-0.05	-0.04
Socio-economic Controls	Yes	Yes	Yes	Yes	Yes	Yes
Extended Controls	No	No	No	No	No	No
Residual Std. Error	0.20 (df = 53)	0.22 (df = 76)	0.21 (df = 49)	0.27 (df = 71)	0.22 (df = 52)	0.24 (df = 73)

Note: $*p < 0.05$; $**p < 0.01$; $***p < 0.001$. Controls Include GDP per capita (1975-90 avg), Log Population, Accumulated Number of Civil wars (1820-1900, from Wimmer and Minn, 2006)

Table 4.9: Current Informational Capacity and Legibility (With Extended Controls)

	Dependent variable:					
	Ethnic Fractionalization		Linguistic Fractionalization		Religion	
	(1)	(2)	(3)	(4)	(5)	(6)
STANCE (1960-1990)	-0.93^{***}		-0.70^{**}		0.04	
	(0.26)		(0.34)		(0.31)	
Legibility (1960-1990)		-0.13^{***}		-0.15^{***}		0.03
		(0.04)		(0.04)		(0.04)
Constant	0.66^{**}	0.58^{**}	0.48^{+}	0.33	-0.20	-0.01
	(0.26)	(0.24)	(0.35)	(0.27)	(0.36)	(0.24)
Observations	58	80	55	76	57	77
Adjusted R^2	0.39	0.33	0.21	0.33	-0.07	0.05
Socio-economic Controls	Yes	Yes	Yes	Yes	Yes	Yes
Extended Controls	Yes	Yes	Yes	Yes	Yes	Yes
Residual Std. Error	0.18 (df = 48)	0.21 (df = 70)	0.21 (df = 45)	0.25 (df = 66)	0.23 (df = 47)	0.23 (df = 67)

Note: $*p < 0.05$; $**p < 0.01$; $***p < 0.001$. Controls Include GDP per capita (1975-90 avg), Log Population, Accumulated Number of Civil wars (1820-1900, from Wimmer and Minn, 2006), Dispersion in elevation across regions of country (Michalopoulos), Dispersion in agricultural suitability across regions of the country (Michalopoulos), Average monthly precipitation 1961-1990 in 1,000s of mm (Michalopoulos), Distance from the coast in km (Michalopoulos)

4.8.2 Appendix B on Social Development as Dependent Variable

Table 4.10: Propoprtion of literacy rate as an outcome — Legibility (1960-1990)

	Dependent variable:					
	Proportion of literacy rate					
	(1)	(2)	(3)	(4)	(5)	(6)
Ethnic Fractionalization	-0.31^{***}	-0.17^{**}				
	(0.09)	(0.08)				
Linguistic Fractionalization			-0.24^{***}	-0.15^{**}		
			(0.08)	(0.07)		
Religion					0.08	0.05
					(0.09)	(0.07)
Legibility (1960-1990)		0.14^{***}		0.14^{***}		0.15^{***}
		(0.03)		(0.03)		(0.03)
Constant	0.87^{***}	0.65^{***}	0.68^{***}	0.56^{***}	0.56^{**}	0.47^{**}
	(0.24)	(0.21)	(0.23)	(0.19)	(0.24)	(0.19)
Observations	80	80	76	76	78	78
R^2	0.66	0.75	0.65	0.75	0.60	0.73
Adjusted R^2	0.63	0.72	0.61	0.72	0.56	0.70
Socio-economic Controls	Yes	Yes	Yes	Yes	Yes	Yes
Extended Controls	Yes	Yes	Yes	Yes	Yes	Yes
F Statistic	20.19^{***} (df = 7; 72)	26.88^{***} (df = 8; 71)	18.06^{***} (df = 7; 68)	25.16^{***} (df = 8; 67)	15.00^{***} (df = 7; 70)	23.72^{***} (df = 8; 69)
Note:						*p<0.1; **p<0.05; ***p<0.01

Note: $*p < 0.05$; $**p < 0.01$; $***p < 0.001$. Controls Include GDP per capita (1975-90 avg), Log Population, Accumulated Number of Civil wars (1820-1900, from Wimmer and Minn, 2006), Dispersion in elevation across regions of country (Michalopoulos), Dispersion in agricultural suitability across regions of the country (Michalopoulos), Average monthly precipitation 1961-1990 in 1,000s of mm (Michalopoulos), Distance from the coast in km (Michalopoulos)

Table 4.11: Proportion of literacy rate as an outcome — Information Capacity Index 1820-1830

	Dependent variable:					
	Proportion of literacy rate					
	(1)	(2)	(3)	(4)	(5)	(6)
Ethnic Fraction.	−0.11	−0.09				
	(0.13)	(0.14)				
Linguistic Fraction.			−0.07	−0.08		
			(0.13)	(0.13)		
Religous Fract.					0.11	0.11
					(0.14)	(0.14)
Inf.Capacity (1820-30)		0.24		0.22		0.23
		(0.25)		(0.27)		(0.26)
Constant	0.80**	0.79**	0.82**	0.81**	0.86**	0.84**
	(0.32)	(0.32)	(0.32)	(0.32)	(0.33)	(0.33)
Observations	49	49	46	46	48	48
R^2	0.57	0.58	0.58	0.58	0.57	0.58
Adjusted R^2	0.50	0.50	0.50	0.49	0.50	0.50
Socio-economic Controls	Yes	Yes	Yes	Yes	Yes	Yes
Extended Controls	Yes	Yes	Yes	Yes	Yes	Yes
F Statistic	7.91*** (df = 7; 41)	7.01*** (df = 8; 40)	7.37*** (df = 7; 38)	6.48*** (df = 8; 37)	7.72*** (df = 7; 40)	6.82*** (df = 8; 39)

Note: *p<0.1; **p<0.05; ***p<0.01

Note: $*p < 0.05$; $**p < 0.01$; $***p < 0.001$. Controls Include GDP per capita (1975-90 avg), Log Population, Accumulated Number of Civil wars (1820-1900, from Wimmer and Minn, 2006), Dispersion in elevation across regions of country (Michalopoulos), Dispersion in agricultural suitability across regions of the country (Michalopoulos), Average monthly precipitation 1961-1990 in 1,000s of mm (Michalopoulos), Distance from the coast in km (Michalopoulos)

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Chapter 5

CONCLUSIONS

In this thesis, I investigate the political dynamics of technological adoption. Current studies have either focused on the political causes of technological change or its consequences. This work is the first to comprehensively examine the entire global process. Information technologies enable the rapid exchange of information at the speed of electricity. How can politics influence the process of technological adoption? Did the introduction of *informational technologies* disrupt electoral outcomes by enhancing political participation? Did the arrival of information-based technologies such as censuses have broader implications in other areas such as ethnic fractionalization and the provision of public goods?

Regarding the first research question, results indicate that the emergence of the labor movement had a small, but positive impact on the speed and intensity of technological adoption. The possible mechanisms outlined in the paper are repression -as the most likely one-, but also the possibility that places where the labor movement became stronger gained *voice* Hirschman (1972). It is improbable that other factors, such as modernization, are confounding the results. This is because the two-way fixed effects methods, combined

with population density time-varying indicators, and time lags, allow for the elimination of the possibility that industrialization processes are confounding the results. A broader lesson from this paper suggests that during times of structural change, when individuals are migrating from rural to urban areas, technological adoption can serve as a means to gather information about political actors emerging from this process. Additionally, in line with classical demographic explanations of technological adoption (Caselli and Coleman 2001; Comin and Mestieri 2014; Herbst 2014), I find that the primary economic hubs are the first to get connected. This is influenced by factors like the affordability of the technology, expected tax returns, and public utility. However, once the main economic hubs are connected, political factors may start to play a secondary role, influencing technological adoption to some extent.

A key contribution of the first paper is the exploration of how the diffusion of technology can be influenced, at least to some extent, within countries rather than solely across countries, by political factors. The existing literature primarily focuses on countries and empires as the unit of analysis (Mokyr 1992; Mokyr and Nye 2007; Acemoglu and Robinson 2012; Comin and Mestieri 2014; Comin and Hobijn 2009; Milner and Solstad 2021). Works that address the political dynamics of innovation within countries often focus on general infrastructural measures, rather than technological innovations (Curto-Grau, Herranz-Loncán, and Solé-Ollé 2012; Herranz-Loncán 2007). The second chapter of my dissertation contributes to better understanding how politics can affect technological adoption 'at home', focusing on the incentives that these technologies bring for repression.

Seen in combination with the other two main chapters, it also helps illustrate the overall sequentiality of technological diffusion within countries in non-fully democratic environments. This sequence goes by demographics - including literacy levels -, followed by pork-barrel considerations and, finally,

other political aspects such as repression.

Chapter 3 delves into the political consequences of the arrival of cutting-edge innovations, like the telegraph. As an outcome, I focus on voter turnout. The results suggest that electoral districts that improved their telegraphic connections during the 1872-1878 period experienced higher turnout rates, all other factors considered. While the impact of current technologies on turnout remains mixed (Chae, Lee, and Kim 2019; Falck, Gold, and Heblich 2014; Polat 2005), only a few articles have explored the effects of technologies unrelated to entertainment, like the telegraph. The telegraph and the telephone did not primarily focus on entertainment; instead, their competitive advantage was based on their capability to transmit information quickly, such as news. While Wang explored a similar research question in a working paper, we focus on 19th century Europe, not the USA. These two contexts are distinct. The USA was already a much more consolidated democracy with high turnout, whereas 19th century Sweden was an economically backward country where only an elite electorate had the right to vote, resulting in low turnout rates. Furthermore, unlike Wang (2020), we do not only support the idea that the effect of the telegraph on turnout went through the spread of news. Instead, we take a broader approach by suggesting that it affected it through commerce and interpersonal correspondence. The main take-away message from the third chapter is the confirmation that the arrival of new technologies -when these technologies are based on transmitting descriptive and informative information rather than entertainment - can foster political engagement and participation, in a variety of contexts.

The third contribution of this thesis is to explore the impact of another set of technologies (broadly understood) on a different set of outcomes. These technologies encompass modern censuses, statistical agencies, and yearbooks (Brambor et al. 2020). They enabled the state to effectively understand its population, as described by Scott (1999) in his canonical book *Seeing Like*

a State. Chapter 4 investigates whether rulers utilized these technologies to monitor, assimilate, and ultimately coerce political groups that deviated from the national identity. The results suggest that this was indeed the case. Countries with greater informational capacity in 1820-1830 and at the time of each country's independence (we measure informational capacity at different times) ultimately reported lower levels of ethnic fractionalization two centuries later, after accounting for relevant confounding factors. Our findings draw inspiration from the study of 19th century Argentina, where the availability of informational technologies allowed the state to coerce the Mapuche indigenous peoples in the 19th century and later assimilate Italian and Spanish migrants. We then extend these findings from our case study to a more comprehensive statistical analysis, utilizing both cross-sectional and panel data.

A broader lesson from chapter 4 is that the arrival of XIX century informational technologies -particularly modern censuses - contributed to reducing ethnic diversity over time. There is increasing consensus that ethnic fractionalization is better understood as a constructed phenomenon (Laitin and Posner 2001; Chandra 2006). What factors can influence the construction of national identities? Our paper suggests that states that are informationally strong are better at providing public goods, which help assimilate ethnic minorities. A darker side of our results point towards the way in which states can more easily repress ethnic minorities or even eliminate them. Taken together, it seems that informational capacity has historically contributed to the reduction of ethnic diversity and increased the capacity of providing better public goods.

The arrival of censuses and statistical agencies, despite their unequivocal beneficial consequences for the development of society (they increased the provision of public goods), also facilitated the repression and assimilation of ethnic minorities. This aligns with more comprehensive accounts of the

introduction of new technology (Johnson and Acemoglu 2023), which indicate that many technological advancements historically have not improved (and can even worsen) the quality of life for those at the bottom.

5.1 The political dynamics of technological adoption: final remarks

In this concluding section, I present pivotal ideas that can potentially advance future research towards achieving a more cohesive understanding of the political diffusion process of technology.

5.1.1 Significant differences in discussing technological diffusion

There are various theories on how technological adoption is influenced by politics, with several factors to consider. I refer here to works where technological adoption is the outcome, and this outcome is explained by political factors.

- **The units of analysis**: A key specification to explain the diffusion of innovations is the level at which the data is analyzed. Many works focus on countries (Mokyr 1992; Mokyr and Nye 2007; Acemoglu and Robinson 2012; Comin and Mestieri 2014; Perkins and Neumayer 2011). A lot is to be gained by incorporating micro-level data, as is also the case with the results presented in this thesis. The unit at which technological developments are analyzed may affect what can be said about the phenomenon under study. Country-level analysis, with the availability of long series of data, may be fruitful for investigating the effects of institutional factors in the promotion of innovations, while micro-level analysis is more suitable to investigate how local events (or factors that vary within countries) can affect the arrival of innovations.

- **The order and sequentiality of determinants of technological adoption**: Technological diffusion tends to follow a sequentiality that is not always considered. This sequentiality comes from the review of

different papers, but the data of this thesis allows for directly testing the whole process. The order is as follows:

- First, demographic variables, particularly population density (Herbst 2014) and literacy levels (Perkins and Neumayer 2011; Caselli and Coleman 2001; Comin and Hobijn 2004), are the principal predictors of technological diffusion. I suggest that these are not only the most important factors but also precede others. That is, before political factors are considered, there is a first diffusion phase that is almost exclusively driven by demographic factors (See table 2.9 in Chapter 2).

- Second, regarding distributive politics and pork-barrel dynamics, it is worth noting that, in non-democracies, once the main geographical points are connected, distributive politics predominate. Most evidence seems to suggest that - ceteris paribus - diffusion tends to concentrate where there is alignment with the regime as a means of reward for loyalty (Do, Nguyen, and Tran 2017; Jiang and Zhang 2020), although this may be context-dependent (Curto-Grau, Herranz-Loncán, and Solé-Ollé 2012). The results of this thesis are consistent with the evidence found by these papers based on the reading of parliamentary debates, where the peasantry, the nobility, and the bourgeoisie all lobbied for more telegraph connectivity, which suggests that new innovations are usually popular across groups. That is somewhat surprising, as there were distributive consequences of the telegraph that did not benefit the peasantry.

- Third, once those factors have been taken into account, technological adoption may become more likely in areas where these technologies may be used for repression (Mather 1953). This thesis shows that places with more conflict received more innovations,

but the channel does not necessarily go through repression. In fact, possible mechanisms linking labor conflict with more technology can go through other channels, such as the fact that places where conflict emerges become *seen* by the state. For state officials, it is often difficult to know and to monitor many parts of a given country as recognized by James Scott (1999). In any case, these factors seem to play a lesser role than demographics or pork barrel, and also tend to come to matter later. They may, however, have a cumulative effect and combined with other factor, become relevant. More data is needed to explore the full potential of political preferences of elites on technological difussion.

5.1.2 Technological Concentration and Inequality

Extensive literature exists on how artificial intelligence, robotization, and computer power have contributed to changes in wage distribution in recent decades (for a review, see Gallego and Kurer (2022)). This dissertation is consistent with the findings and the literature that suggest that technological change is a determinant of inequality, but it does so by adding new elements of analysis to the existing literature.

One of the paradoxes of technological change is that, despite having serious distributive consequences (Autor, Levy, and Murnane 2003; Acemoglu 2011), - these works document an increasing substitution of labor for capital - those who are not benefited by the new technologies seem not to oppose them. In a recent review in the Annual Review of Political Science, Gallego and Kurer expressed that *the mechanisms linking structural change and individual political response(s) (to technological change) are not well understood* (2022). This dissertation offers an exploration of a new case - the arrival of the telegraph in the XIX century Sweden - that at least contributes to the understanding of that link by exploring a historical case. The idea that

emerges from the study of parliamentary debates - where the peasantry was represented - suggests that even those groups that did not benefit from the arrival of the telegraph supported it. Whereas the telegraph benefited the bourgeoisie and the older nobility (those groups that had the right to vote in the first elections of 1872), the peasantry did not. For one thing, literacy rates were likely much lower than those of the bourgeoisie. Second, they did not have the right to vote. While the bourgeoisie could benefit from the telegraph through the facilitation of commerce and the reception of valuable political information, the peasantry paid for such an expensive infrastructural development through taxes without any apparent benefit. And yet, they supported it, as shown in the parliamentary debates, where they agreed with further expanding the telegraph.

Part of the reason for this incongruence - supporting technology despite its distributional consequences not being beneficial - is similar to those found in recent years with automation, robotization, and so on. This dynamic is shifting with the advent of recent technologies like GPT, leading to increased suspicion about its impact (Autor 2022). This skepticism arises because the distributional impacts of artificial intelligence are more apparent now than they were with previous technologies, receiving greater media coverage. The telegraph, too, had distributional consequences in the labor market, including a reduced demand for the traditional postal system, the horse industry, and so on (Cottrell 2011).

Chapter 4 is even more indicative of this phenomenon. The introduction of statistical agencies and new censuses increases the power of the state - and those groups that had access to its resources and technologies - vis-a-vis those who did not have access to it. In certain circumstances, such as XIX century Argentina, innovations may have disadvantaged some groups, and benefited others. The data seems to indicate that this was a generalized phenomena that went beyond Argentina: when states became stronger, ethnic diversity

was reduced through different mechanisms including assimilation, exclusion or repression.

5.1.3 Exogeneity of Technological Change:

On a more methodological note, there is debate about whether new technologies should be treated as exogenous or not. While traditionally treated as exogenous (Solow 1956), technological change is influenced by socio-political variables and socio-demographic factors (but as seen in the previous point, political ones tend to come late and their effect is smaller). When analyzing variables linked to technological change at the country level, controlling for democracy, property rights protection, population density, literacy rates, and other relevant factors is essential. At the sub-national level, technological change may be treated as a shock if identified places have minimal correlation with variables affecting technological change. In those instances, it is preferable to use within small-unit differences over time, embedded in larger units such as states.

This is supported by tables 3.10, 3.11, 3.13, which show how the introduction of a political driver of technological change to an equation where technological adoption is treated as exogenous does not affect the coefficients, and has a minimal impact on the standard errors. When technology is treated as exogenous, literacy and demographic factors must always be included in the models, whereas the omission of political level variables may not bias the results. This, of course, does not mean that political variables do not have an effect. But it is consistent with the data of this thesis that technology may be treated as exogenous, when precise time and unit fixed effects are introduced and time-varying socio-demographic factors are taken into account.

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