The Telegraph and Modern Banking Development, 1881—1936*

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Abstract

The telegraph was introduced to China in the late 19th century, a time when China also saw the rise of modern banks. Based on this historical context, this paper documents the importance of information technology in banking development. We constructed a data set on the distributions of telegraph stations and banks across 287 prefectures between 1881 and 1936. The results show that the telegraph significantly expanded banks' branch networks in terms of both number and geographic scope. The effect of the telegraph remains robust when we instrument it using proximity to the early military telegraph trunk.

Keywords: information technology; telegraph; bank; finance; modern China
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1. Introduction

Banks are instrumental to economic development (Levine, 1997). It is thus essential to understand the historical development of banking industries. Existing research focuses mainly on the roles of law, institutions, culture and ethnicity in shaping banking development (Caprio et al., 2007; Grosjean, 2011; Calomiris and Carlson, 2016; Pascali, 2016; D'Acunto et al., 2018).[1] Another potential growth engine for banking is information technology. Banking is an information-sensitive industry. In the absence of rapid information flow, banks are confronted with information asymmetry, communication costs and agency problems. This leads banks to build their business upon local, soft informational advantages and hence restricts the scale economies of banking (Petersen and Rajan, 2002; Mian, 2006; Sufi, 2007; Agarwal and Hauswald, 2010; Hollander and Verriest, 2016).

Innovation in information technology (e.g., telecommunications, computer, and internet) mitigates the information costs arising from distance barriers, which enables banks to expand their businesses on a broader geographical scale. By virtue of real-time information, banks are now able to track the market and communicate with their branches and customers in distant areas in a timely fashion (Calomiris, 2002; Petersen and Rajan, 2002; Berger, 2003; Frame et al., 2018). However, empirical evidence remains scant on how information technology affects banking development. This is in part due to the difficulty of gauging the operation of multi-dimensional information technologies, let alone the reciprocal relation between information technologies and banking development (Berger, 2003; Liberti and Petersen, 2019).[2]

This study examines the effect of information technology on the rise of modern banking in the historical context of China. We focus on the telegraph, which in the mid-19th century constituted a truly revolutionary advance in information technology. Compared to the traditional courier channels of ships and horses, the telegraph sharply improved the efficiency of long-distance communications, shortening the transit time from months to hours. Moreover, the telegraph fostered modern financial instruments such as telegraphic transfer and settlement. The telegraph thus largely reduced the time and operation costs of banking. Coming before the invention of radio broadcasting (1920s), television (1930s), and the internet-based, multi-dimensional information channels of recent decades, the telegraph in the 19th century presents a singular 'FinTech' that allows us to better capture the effect of information technology on

[1] See also D'Acunto (2017) for a survey on the importance of history in financial development.

[2] For instance, Bircan and de Haas (2020) show that Russian firms' technology adoption is subject to the availability of lending from banks. See also Amore et al. (2013), Chava et al. (2013), and Nanda and Nicholas (2014), among others.

banking.

Modern China (circa 1881–1936) provides us a unique context to examine the role of the telegraph in banking development. Unlike Europe, where the invention and application of the telegraph were (endogenously) driven by business demand, China passively received the technology as part of the forced opening up to Western powers after 1842. To aid the warfare with Western powers and to strengthen state capacity, the imperial government of China built telegraph lines primarily for military and administrative purposes rather than for business initiatives. A national telegraph network was in place before the first modern Chinese banks were established in 1897. In subsequent decades, China saw the expansion of modern banks, with the number growing from a trivial figure in the late 1890s to 259 (with 1,926 branches) by 1936. This historical setting largely mitigates the feedback effect of banking development on telegraph construction. Accordingly, our study focuses on the effect of the early adoption of the telegraph (before 1897) on banking development.

Drawing upon over 1,600 local gazetteers[3], we manually collected information on the locations of all the telegraph stations and banks (and branches) established in China between 1880 and 1936. They covered all the 287 prefectures (of the 18 provinces) in China proper[4]. We exclude the post-1936 period because of the social unrest consequent upon the Second Sino-Japanese War (1937–1945). We first examine the overall impact of the telegraph on banking development at the prefectural level. Banking development is measured by the total number of banks (both headquarters and branches) and their annual growth. To disentangle the effect of the telegraph from other local correlates, we control for population size, the number of treaty ports (as a proxy for the overall Western influence), and geographic factors (distance to coast, and land area). The OLS estimations show a significantly positive effect of the telegraph on banking development. The presence of an additional telegraph station in 1896 increased the annual average growth of the number of banks by 0.091 between 1897 and 1936. By 1936, an additional telegraph station increased the number of banks by 3.622.

The distributions of telegraph stations and banks may be subject to unobserved local correlates. To address this concern, we employ an instrumental variable approach. The instrumental variable is based on the historical fact that most of the early telegraph lines were built for military purposes. This military system of

[3] Local gazetteers were records of the history, economy, and governance of an administrative unit; during the Qing dynasty, they were compiled periodically by county, prefectural and provincial authorities with the cooperation of local gentry, usually at the behest of the central government. They are widely used as sources for the study on Chinese history.

[4] China proper refers to that territory included under the regular county-province administration; it excludes some frontier and other areas that had alternate forms of administration.

communication can be deemed as the early trunk telegraph lines of China. Over time, the branch lines were extended from the trunk to nearby regions. Accordingly, we use the shortest distance from a prefecture to the hypothetical military trunk line as the instrumental variable of the distribution of telegraph stations. We use the hypothetical trunk line in order to mitigate the possibly endogenous path of the actual line. The hypothetical trunk line is constructed by connecting the 21 military centers in the Qing dynasty, following the path of the least construction cost.

The distance to the hypothetical military trunk line is arguably orthogonal to banking development, in that the regional distribution of the military centers had consolidated in the late 17th century—two centuries before China's modern transition—and this distribution was based on military considerations rather than financial ones. Moreover, the imperial military system was abolished with the collapse of dynastic rule in 1912, a time when modern banks had just started to flourish. To further allay the concern that the 21 military centers were located at prefectures of economic or political importance, we remove these military prefectures from the analysis. The instrumented results are consistent with those of OLS although they indicate a greater effect of the telegraph on banking development.

While the telegraph promoted banking, it would also have promoted trade, commerce and production, which in turn would increase the demand for banking. It is thus necessary to know the extent to which the effect of the telegraph on banks is driven by general economic development (rather than being a direct effect of the telegraph itself). To test this, we employ the number of industrial establishments, membership numbers of chambers of commerce, and commercial tax revenue in the 1930s to proxy for economic development. While economic development may explain up to 49% of the telegraph effect on banks, the direct effect of the telegraph on banks remains significantly positive and salient in magnitude, suggesting the specific importance of information technology in banking.

Another concern is whether the telegraph effect is driven by other forms of communication infrastructure. We compared the telegraph with the presence of the other two major types of communications in China—the imperial postal routes and the railways—in terms of their impacts on banks. It is the telegraph rather than the imperial postal routes that promoted banking development. Moreover, the telegraph effect is not driven by the presence of railways. The positive effect of the telegraph on banks is reaffirmed by our panel data estimations, in which we allow for the yearly change in the number of telegraph stations and banks between 1897 and 1936.

A primary mechanism by which the telegraph promoted banking development is the expansion of the branch network. We find that banks were more likely to open branches in prefectures connected by telegraph. With the expansion of telegraph lines,

banks expanded their branch networks to distant areas. Moreover, by analyzing the branch network of each bank, we find that the telegraph increased the overall presence of the branches rather than simply redistributed their geographic locations. These results indicate that the telegraph expanded the branch network in terms of both the number of branches and the geographical coverage.

Our analyses are premised on the assumption that the telegraph increased inter-regional information flow. Drawing upon textual analysis of *Shen Bao* (Shanghai News), the largest national newspaper at the time, we gauge inter-regional information flow by enumerating the frequency of county names reported in the newspaper. The frequency of newspaper reports on prefectures connected by the telegraph was significantly greater than for their unconnected counterparts, suggesting improved information transparency in the former. This, in turn, increased the number and growth of banks.

Our findings indicate that the telegraph as a revolutionary advance in information technology promoted the early development of modern banks. This echoes the importance of information technology in shaping banking or financial development in contemporary time (see the survey by Frame et al., 2018). Most studies focus on the role of information technology in expanding banks' lending business (Petersen and Rajan, 2002), fostering financial services competition (Hauswald and Marguez, 2003; Degryse and Ongena, 2005), reducing agency costs (Berger and DeYoung, 2006) and shaping productivity and structural change (Wilhelm, 1999; Berger, 2003), among others. There is little quantitative evidence on how information technology affected the expansion of banks' branch networks. Our findings suggest that, not merely did information technology increase the number of bank branches, but it also expanded their presence on a greater geographic scope.

Our study also complements the literature on banking or financial history (e.g., Goetzmann and Rouwenhorst, 2005; Temin and Voth, 2013; Pascali, 2016; D'Acunto, 2017; Koudijs et al., 2019). In particular, our findings are consistent with studies on the importance of modern communications or transportation in the development of modern banks in the historical context of the U.S. (Atack et al., 2014) and of Japan (Mitchener and Ohnuki, 2009). Moreover, our findings also coincide with Peter Koudijs's (2016) study on financial market volatility in the absence of modern information technology: when information flow was handled by sailboats in the 18th century, frequent interruptions due to adverse weather led to fluctuations of stock prices on the Amsterdam exchange.

More broadly, our study provides fresh evidence to the literature on the economic impacts of information and transportation technology (Roller and Waverman, 2001; Dittmar, 2011; Pascali, 2017; Donaldson, 2018; Steinwender, 2018; Hjort and Poulsen,

2019). In the historical context of China, our findings suggest that financial modernization could also be stimulated by the introduction of modern technology even in a traditional Confucian culture in which capitalism, according to Max Weber (1953), could not form endogenously. This coincides with the studies on the important role of the Western influence in driving China's financial and economic modernization (Goetzmann et al., 2007; Jia, 2014; Bai and Kung, 2015).

2. Historical background

2.1. The introduction of the telegraph to China

After being defeated by the British in the First Opium War (1839–1842), China was forced to open up to the Western powers. Western technologies began to be introduced to China. In order to facilitate communication, Europeans began to propose the construction of a telegraph in China from the 1860s but progress was hampered by the Qing authorities, who were afraid of losing sovereignty. It was not until 1873 when the first telegraph line was (secretly) connected to mainland China from Hong Kong by the Danish Great Northern Telegraph Company.

From the 1880s, after having recognized the superiority of telecommunications in military and administrative affairs relative to the traditional courier route, the Qing authorities began to develop a telegraph network. In a memorial[5] to the Qing emperor in 1880, Li Hongzhang (1826–1901), one of the most powerful statesmen in China at the time, stated, "During times of combat, foreign countries equipped with a telegraph system could transmit military information much faster than China could; the advantage of using the telegraph is obvious" (Institute of Modern History, Academia Sinica, 1957, pp. 262–263). Thereafter, the telegraph network underwent sustained expansion (Fig. A.1 in Appendix).

A unique feature of telegraph construction during the late Qing period (circa 1880–1900) is that most lines were erected primarily for military purposes. In 1881, the Qing government erected the first telegraph line to link Tianjin (the fortress defending Beijing) and Songjiang prefecture (Shanghai) for the coordination of defense works. They extended the wire to Fuzhou and Guangzhou in 1883 in order to better control the south and southeastern coast—the frontier facing the British naval presence in the South China Sea. Likewise, because of the Sino-French War on the southwestern border of China, the Qing government built the telegraph line that connected the imperial capital to Yunnan province in 1884. Later, to coordinate the communication

[5] The term 'memorial' refers to a wide range of documents addressed to the emperor, usually, but not always necessarily, submitted by officials.

of military affairs, the telegraph was connected to China's central military center at Wuchang. In the early 1890s, the telegraph entered China's northwestern military frontier at Xi'an and Lanzhou. More details of this process are summarized in Online Appendix B.

Within only a few decades, the national telegraph trunk network had taken shape (Fig. 1). Of a total of 67 telegraph lines built between 1882 and 1896, 62.7% were built for military and administrative purposes, while only one line was indicated for business use (Fig. A.1 in Online Appendix A). The proportion of non-military telegraph lines increased after 1911 as the Republic of China government attached great importance to economic modernization (Cheng, 2003). These were mainly short-distance lines built as extensions of existing circuits to peripheral areas. By 1936, more than 1,000 telegraph stations had been built; they covered 94% of the prefectures in China proper with regional variations in terms of number (Fig. 1).

There is no doubt that the telegraph sharply reduced information costs in long-distance trade and communication in China. Previously, letters were delivered along the imperial postal routes by means of boats and horses. On average, it took a month for a letter to be delivered from Guangzhou (in south China) to the imperial capital Beijing in the north (Baark, 1997). The telegraph shortened the time to hours. Indeed, local officials took advantage of the telegraph to submit memorials in a timely fashion to the emperor, reporting the incidence of crop failures and local unrest, and applying for relief and assistance from the court. Although the telegraph lines were originally laid for military or administrative purposes, they were also used in business communications. This is because the merchants also contributed to the construction of the telegraph. Moreover, the Qing government increased fiscal revenue by opening the telegraph to merchants (Xia, 2012).

2.2. The rise of modern banks in China

Before the emergence of modern banks, China's financial market was dominated by two types of traditional financial institutions, namely *qianzhuang* (money houses) and *piaohao* (draft banks). Qianzhuang were local banks that primarily provided small loans and money exchange services. The credit business was based on soft information and personal reputation (Huang, 2005). Unlike qianzhuang, piaohao mainly operated inter-regional remittance. They primarily served the needs of long-distance trade and government money transfer (Zhang, 1957; Huang, 1990).

Modern banks emerged in China after the 1840s under Western influence. After the Oriental Bank, a British-Indian joint venture, opened a branch in Hong Kong in 1845 (Chen, 2011), foreign banks gradually expanded their business in China's treaty

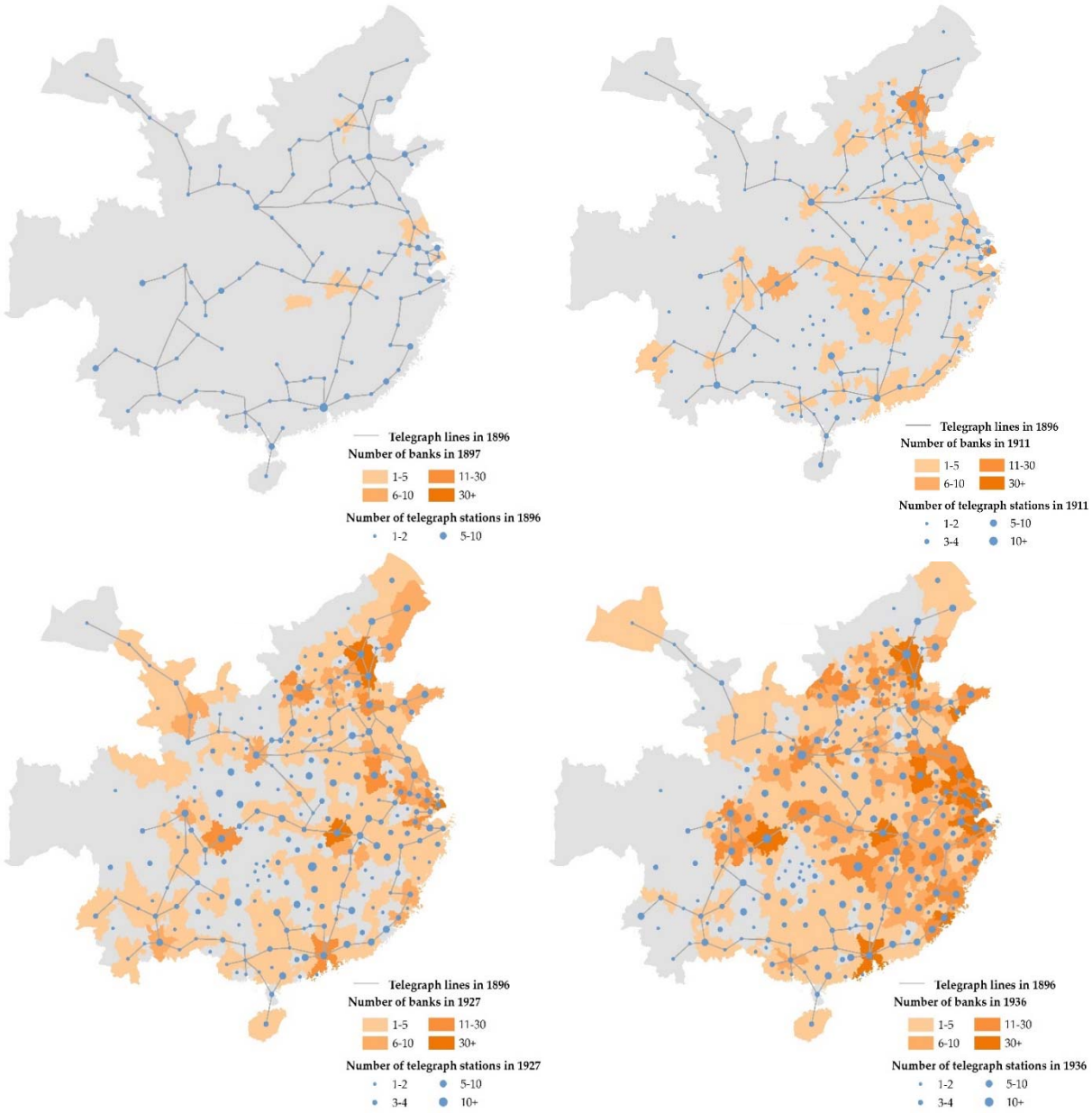

Fig. 1. Distributions of telegraph stations and modern Chinese banks. This figure shows a map of telegraph lines and stations in 1896 as well as the distribution of modern Chinese banks in 1897 when the first modern Chinese bank was established; in 1911 when the Qing dynasty fell; in 1927, the start of the golden age of the modern bank; and in 1936 on the eve of the Second Sino-Japanese War.

ports. The year 1897 witnessed the birth of the first Chinese domestic modern bank, the Imperial Bank of China (IBC). Thanks to the New Policies (circa 1901–1911), the imperial authority in its final decade began to promote the establishment of new banks in the Western style. Modern banks were further promoted under the succeeding Republican government, which fully recognized their importance in economic modernization. The Minister of Finance, Chen Jintao (1870–1939), announced, "The wealth of a county relies on its industry, and the lifeblood of industry relies on finance.

We will take it as our obligation to promote modern banks" (Cheng, 2003, p. 39). The institutional environment was significantly improved upon the issuance of the company law in 1914 (*gongsi tiaoli*) and the establishment of a central bank, the Bank of China, in 1912 (Kirby, 1995; Yeh, 1995).[6]

Different from the traditional banks, the modern banks had limited liability and adopted modern or Western-style administrative systems; this included, for example, regular meetings of shareholders, a separate board of directors, balance sheets did according to international standards, and collateral loans, among others (Sheehan, 2003).[7] There were basically three forms of modern banks in China: official (or government) banks, private banks, and foreign banks.[8] Private banks were banks owned by Chinese businessmen. The number of foreign banks remained trivial compared with that of Chinese banks. After 1920, private banks outnumbered official banks and were eight times as numerous as foreign banks.

2.3. The role of the telegraph in modern banking

Historical narratives suggest the importance of the telegraph in promoting modern bank development. This is mainly because the telegraph improved the informational environment in which banks operated. First, the fast-cum-convenient telegraph lowered the entry cost of banks by mitigating inter-regional information asymmetry. This enabled banks to enter 'shadowy' areas that had been dominated until then by traditional financial institutions. By virtue of telecommunication, banks acquired an informational advantage in competing with incumbent institutions that relied on soft information from local acquaintance networks.[9] Indeed, modern banks gradually crowded out their traditional counterparts, expanding from several treaty ports to most inland areas of China proper by 1936.[10]

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[6] The Republican government also attempted to end chaos in the monetary regime. In 1933, the Republican government issued the *yuan* (Chinese dollar) as a new currency and officially established a single monetary standard (Ma, 2012).

[7] The early modern Chinese banks all followed the model of Western banks. For instance, the administrative structure of IBC replicated that of HSBC (The Hongkong and Shanghai Banking Corporation Limited) (Cheng, 2003).

[8] In addition, some banks were private banks under government supervision (*guandu shangban*) or Sino-foreign joint ventures (*zhongwai hezi*).

[9] For instance, the money houses mainly provided loans to customers who had a good reputation and whose integrity was recognized in local communities, and relied on lineage solidarity to enforce lending contracts. Accordingly, the money houses usually restricted their business to a small local network of acquaintances (Hu et al. 2017).

[10] The numbers of piaohao plummeted after 1911 and they vanished in the 1930s (Huang, 1990), whereas qianzhuang shrank to only a few big cities (Shanghai and Hankou) before they finally withdrew from the market in the 1940s (Zhang, 1989). Unfortunately, there are no systematic

Second, the telegraph also facilitated information exchange and business dealings between bank headquarters and their branches. Let us take the foreign exchange transaction as an example. China's monetary system was on the silver standard before 1935. HSBC maintained a daily adjustment of the exchange rates according to the change in the price of silver in London and New York. Every morning, the managers headquartered in Shanghai telegraphed the real time exchange rates to their branches in Hankou and Tianjin. Likewise, the Bank of Communications and the Bank of Shanghai set a telegraph terminal in their head offices in order to gauge the fast-changing exchange market with minimal delay (Song, 2014). Beyond the time advantage, the telegraph also brought banks new transaction instruments that greatly facilitated their dealings with branches and customers. For example, the telegraphic transfer gradually replaced mail transfer as the primary means of remittance and settlements among Chinese banks in the early 20$^{\text{th}}$ century (Song, 2014).

A related contribution of the telegraph was helping banks overcome the agency problem and accordingly improve administrative efficiency. Thanks to real time information, banks could effectively monitor their branches in distant areas.[11] This administrative advantage of the telegraph was well recognized by Chinese bankers at the time. For example, Kincheng Bank (headquartered in Tianjin) required its branches to report information on daily capital flows by telegraph to support the manager's timely decision-making. To some extent, this facilitated the expansion of Kincheng Bank. By the 1930s it had become one of the 'big four' northern banks in the Republic of China, with 43 branches covering 12 provinces (Zhongguo Renmin Yinhang, 1983).[12]

Apart from the direct information effect, the telegraph may also have influenced banking expansion through stimulating real economic activities. Before the telegraph era, China's long-distance trade (especially grains, cotton, silks and teas) had long

records on the distribution of these traditional financial institutions over time.

[11] Chinese traditional banks had long been confronted with the agency problem. For example, piaohao operated many branches for remittance business. Due to information friction and communication costs between the headquarters (in Shanxi Province) and the branches scattered in other provinces, the branch managers usually had great decision-making powers with regards to branch affairs. In order to avoid shirking and fraud among employees, the piaohao owners only employed people who were members of their own lineage or who were fellow townsmen as branch managers. The small size of the human capital pool thus restricted the development of piaohao (Huang, 1990).

[12] Likewise, Sheng Xuanhuai (1844–1916), the founder of IBC, valued the telegraph because it allowed headquarters to monitor the branches in a timely manner. In the General Charter for the Branches of IBC issued in 1897, all the IBC branches were asked to report to headquarters immediately via the telegraph when they issued exchange bills. In the same vein, all transactions valued at more than 50,000 silver taels (*liang*, or Chinese silver dollars) had to be reported to headquarters for approval (Chen et al., 2000, p. 89).

been subject to information friction. Such trade was conducted mostly in a regional pattern and only at a small volume (Rozman, 1981). Modern communications expanded the information network and improved economic integration.[13] Growing trade and commercial activities thus boosted the demand for inter-regional remittance, settlements and lending (Rawski, 1989).

Meanwhile, the telegraph also facilitated China's industrialization. Like modern banks, industrial firms represented a major force in China's economic modernization from the 1840s. These modern firms operated in a broader market and through wider logistical networks, and hence relied on modern communications to track markets and transactions in a timely manner. Historical narratives indicate that information had become an integral part of industrial production, so much so that firms had to locate their factories in places with convenient telegraph access (Rawski, 1989). [14] Industrialization undoubtedly stimulated financial demand. In order to purchase new machines and raw materials and to expand production, the firms relied on bank loans.[15]

In a nutshell, the prosperity of the real economy gave an impetus to banking development. That is why from the 1910s China saw a boom in commercial banks targeting specific economic sectors; these included, for example, industrial banks, agricultural banks, and banks that specialized in the trade of salt, coal, and silk, among others (Lee, 1941).

Fig. 1 depicts the distributions of telegraph lines (and stations) in 1896 and modern banks in China proper over the time points of 1897, 1911, 1927 and 1936. The spatial expansion of banks coincides with that of telegraph lines. The number of banks was greater in prefectures where there were more telegraph stations.

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[13] For example, Yining County of Jiangxi Province was well-known for high-quality tea production, but was located quite far (360 km) from the nearest trade port (Jiujiang). By mail, it took a week for the tea merchants of Jiujiang to obtain price information from Yining. Tea merchants thus often suffered from profit loss due to such price information friction. This situation did not change until 1901 when the telegraph was connected to Yining. The tea market of Yining became unprecedentedly prosperous (*Dongfang Zazhi* [The Eastern Miscellany], March 11, 1904).

[14] For instance, Shenxin Cotton Mills (Shenxin Shachang) moved from Wuxi (Jiangsu Province) to Shanghai because Shanghai was an important telegraph node in China (Cochran, 2000).

[15] The collaboration between the Nanyang Brothers Tobacco Company and the Bank of Communications represents a good example. The Company had a broad tobacco supply network in China. It entrusted the Bank of Communications to deal with the remittances with the tobacco suppliers in different provinces. Moreover, during the tobacco harvest seasons (March and November), the Company usually asked for loans from the Bank of Communications for procurement purposes (*Jiaotong Yinhang Shiliao* [Historical Materials on the Bank of Communication], 1995, p. 186).

3. Data

Our sample covers 287 prefectures found in the 18 provinces of China proper (Fig. 1). The period of regression analysis begins in 1897, the year when the first modern Chinese bank was established. It ends in 1936, just before the Second Sino-Japanese War broke out. Prefectural boundaries changed throughout the period. Using ArcGIS, we traced the change of administrative boundaries and matched the counties from different periods to the prefectural boundaries of the 1911 base map.[16] The 1911 base map is taken from the Harvard China Historical Geographic Information System (CHGIS, version 6).

3.1. Modern banks

Data of modern banks were obtained mainly from the local gazetteers compiled by county, prefectural, and provincial governments between 1933 and 2018. The gazetteers provide the most systematic records of banks (and their branches) at the county level. For each bank, there are records on the location, year of establishment, and year of closure.[17] In addition, we cross-checked all the banks between the gazetteers and other sources on modern banks and complemented the banks that are missing in the gazetteers. These sources mainly include the statistical yearbooks on banks in China and books on the history of national banks and local banks compiled during middle years of the Republican era (circa 1920–1937) (see Online Appendix D.1).

We aggregated the number of modern Chinese banks to the prefectural level on an annual basis (henceforth, number of banks) as our principal measure. We organized the data at the prefectural level simply because most other control variables are not available at the county level. For robustness, we also used county level estimations while controlling for prefectural covariates or prefectural fixed effects. We combined the numbers of headquarters and of branches to examine the overall banking development. Foreign banks were excluded in our main analysis as their distribution and business were mainly directed by foreign countries. There were striking variations

[16] The historical changes in administrative boundaries are based on Fu et al. (2013), Fu and Zheng (2007) and Guan (1955).

[17] There were 2,059 counties in China proper in 1911 based on CHGIS (version 6). Due to changes in administrative boundaries, only 1,523 counties are identified throughout our sample period. To confirm the accuracy and completeness of the records, we cross-checked each bank in county gazetteers with that of municipal gazetteers, provincial gazetteers, and specialized volumes of such gazetteers focused on finance in a given area. The total list of 1,646 gazetteers is available in Online Appendix D.4.

in the distribution of banks (Fig. 1). By 1936, Shanghai already had 229 banks, whereas there were still 80 prefectures without any banks at all.

3.2. Telegraph

Data on the telegraph was mainly collected from local gazetteers and *Jiaotongshi Dianzhengbian* (History of Transportation: Telecommunications) compiled by the Ministry of Communications in 1931 (see Online Appendix D.2 for a complete list of these historical sources). These sources provide systematic records on the location and year of establishment of each telegraph station. We aggregated the number of telegraph stations at the prefectural level on an annual basis (henceforth, telegraph).

In the cross-prefectural regressions that examine the effect of the early adoption of the telegraph on subsequent banking development, we use the total number of telegraph stations that a prefecture had built by 1896 (the year before the first modern bank emerged in China). In the panel data regressions, we use the annual number of existing telegraph stations in each prefecture as the measure. In addition, to capture the effect of prefecture size on access to the telegraph, we also used the telegraph density as measured by the number of stations per 1,000 square meters (telegraph density) as an alternative measure.

3.3. Control variables

The erection of the telegraph in a prefecture was affected by local characteristics that may also bear upon banking development.

First and foremost is the population size. The markets for both the telegraph and banks should be large in populous areas. To control for the possible effect of population size, we constructed prefectural population data based on Cao (2001). In the regression analysis, we take the natural logarithm of the population to mitigate the outliers.

China's modernization originated in the mid-19th century following its forced opening-up to the West. The telegraph-banking nexus thus may have been driven by the overall Western influence. Given that this influence was primarily channeled through the designated treaty ports, we control for the distribution of treaty ports. Specifically, we use the number of treaty ports in 1896 in the following cross-prefectural regressions, and the actual number of treaty ports in each year in the panel regressions.

In addition, we also control for two geographic factors that may be correlated with the distribution of the telegraph and banks. First, given that both telegraph stations and banks were concentrated close to coastal China, we control for a prefecture's shortest (great circle) distance to the coastline (in kilometers). Secondly,

we control for a prefecture's land area (in 1,000 km^2); that captures the effect of the size of territory on the telegraph and banking. Descriptive statistics of all the variables are reported in Table A.1 in Appendix. In the regressions, we take the natural logarithm of these control variables to mitigate the possible bias from extreme values.

4. The effect of the telegraph on banking development

To assess the effects of the telegraph on China's modern banking development, we first examine whether more banks would be opened in prefectures that had more telegraph stations before 1897—the first year of modern Chinese banks. The regression specification is:

$$Banks_i = \alpha + \beta \times Telegraph_i + \gamma \times \mathbf{X}_i + \varepsilon_i, \quad (1)$$

where $Banks_i$ denotes the number of modern Chinese banks (both headquarters and branches) in prefecture i in the year 1911 or 1936. The number of banks in 1911 measures the early developmental level of banks across prefectures. We choose 1911 simply because it was the last year of China's imperial rule; this restricts the analysis within a similar institutional environment. The number of banks in 1936 measures the developmental level of banks in the long run.[18] Beyond the developmental level, we also examine whether the telegraph shaped the growth of banks. Specifically, we employ the average annual increment of the number of banks in each prefecture between 1897 and 1936 to measure bank growth.

The main explanatory variable is $Telegraph_i$, which denotes the number of telegraph stations that had been built in prefecture i by 1896. Given that modern Chinese banks emerged in 1897, our measure of the telegraph in 1896 can mitigate reverse causality. $\mathbf{X}_i$ refers to a vector of control variables. These variables include the logarithm of population size (in 10,000s) in 1880, the number of treaty ports in 1896, and the geographic factors of the distance to the coast and the land area at the prefectural level.

We report the heteroskedasticity-robust standard errors. In order to check the potentially spatial correlation among the residuals, we also cluster the standard errors within a circle that basically covers all adjacent prefectures. Given that the average 'radius' of each prefecture (from the prefectural seat to the prefectural border) is 69 kilometers in our sample, we use a distance of three times the radius (207 kilometers) to approximately cover all the adjacent prefectures. Within the 207-kilometer radius,

[18] We also chose the number of banks at other time points and found the results are consistent with those of 1911 and 1936.

we calculate the bilateral spatial correlation between the local prefecture and its adjacent prefectures following the method in Colella et al. (2019). We also use alternative radii to check the robustness of the 207 kilometers. These alternatives range from 76 kilometers (the average distance between two adjacent prefectural seats) to 345 kilometers (the distance covering the next ring of a prefecture's adjacent prefectures). The results show that the effect of the telegraph is unlikely to be affected by spatial correlation, and hence we do not report them separately.

The regression results in Table 1 show that the number of telegraph stations in 1896 had a significantly positive impact on the number of modern Chinese banks established thereafter. Columns 1 and 2 examine the effect of the telegraph on the number of banks in 1911. Column 1 reports the OLS results without any control variables. An additional telegraph station is associated with an increase in modern Chinese banks by 0.616 (or 121% when evaluated by the mean number of banks, 0.51). The effect of the telegraph remains significantly positive after the inclusion of the population size, treaty ports, and geography, though the magnitude of coefficient decreases to 0.366 (column 2).

Table 1. The effect of the telegraph on modern Chinese banks: OLS results.
This table reports the results from the cross-sectional regressions at the prefectural level. The main independent variable, telegraph in 1896, refers to the prefectural number of telegraph stations that had been built by 1896 (the year before the first modern Chinese bank appeared). The average growth of banks is measured by the average annual growth of the number of banks between 1897 and 1936 (columns 5–6). Geographic controls include distance to coast (log) and land size (log). Heteroskedasticity-robust standard errors are reported in parentheses. *, **, and *** indicate significance at 10%, 5% and 1%, respectively.

	Number of banks in 1911		Number of banks in 1936		Average growth of banks, 1897–1936	
	1	2	3	4	5	6
Telegraph in 1896	0.616***	0.366*	6.608***	3.622**	0.165***	0.091**
	(0.171)	(0.210)	(1.157)	(1.503)	(0.029)	(0.038)
Population in 1880 (log)		0.238***		3.369***		0.084***
		(0.087)		(1.085)		(0.027)
Treaty ports in 1896		1.690**		17.466*		0.437*
		(0.730)		(9.053)		(0.226)
Geographic controls		Yes		Yes		Yes
Observations	287	287	287	287	287	287
R^2	0.127	0.222	0.115	0.226	0.115	0.226

Early adoption of the telegraph (1896) had a long-lasting positive effect on the number of banks 40 years later (columns 3 and 4, Table 1). This time, an additional telegraph station would increase the number of banks by 3.622 (column 4). This is translated to an increase in banks of 47.6% when evaluated by the mean number of banks in 1936 (7.61) —a substantial marginal effect. Last but not least, the telegraph also had a significantly positive effect on the growth of banks from their genesis to

1936 (columns 5 and 6). An additional telegraph station in 1896 caused an increase of an average of nearly 0.1 more banks per year.

4.1. Instrumented evidence

The observed positive effect of the telegraph on banking may not be causal, simply because of the possibility that the distributions of both the telegraph and the banks were subject to other unobserved factors at the prefectural level. To identify the causality, we employ an instrumental variable approach. The instrumental variable is used to predict the distribution of telegraph across prefectures but has no direct effect on banking development.

The instrumental variable for the distribution of telegraph stations is a prefecture's shortest distance to the military telegraph trunk lines that had been built before the emergence of modern banks in 1897. As introduced in Section 2.1, in order to strengthen defenses and internal administration, the Qing authorities constructed the military telegraph network between the 1880s and the 1890s (Fig. 2). To some extent, this became the early 'trunk' of China's telegraph. Later, short-distance lines were built as extensions of existing circuits to peripheral areas. As a result, prefectures close to the trunk were more likely to be connected to the telegraph.

To rule out the possible effect of local economic fundamentals on the location of the telegraph trunk lines,[19] we constructed a hypothetical military telegraph trunk network (HMTN), and use a prefecture's shortest distance to the hypothetical trunk as the instrumental variable (henceforth, distance to HMTN). The HMTN is constructed as follows.

To begin with, we define 21 military centers in the late Qing period (Fig. 2). Eight of them were the cities where governors-general were stationed: Baoding, Jiangning, Fuzhou, Guangzhou, Yunnan Fu, Chengdu, Wuchang, and Lanzhou. The other thirteen centers were not residences of governors-general but were important cities in the country's military-cum-administrative affairs. They were Beijing (the imperial capital); Yongping, Taiyuan, Kaifeng and Ji'nan (the garrisons defending the imperial capital); Tianjin, Dengzhou and Songjiang (the key naval fortresses defending the coast); Xi'an and Jiujiang (important fortresses defending the northwestern frontier and the Yangtze River, respectively); and Yongchang, Taiping and Lianzhou (the fortresses defending the southwestern border).

Then we link the military centers along the path that entails the least construction

[19] For example, the Qing government raised funds from merchants to finance telegraph construction. As a result, the telegraph would be connected to the cities where merchants donated to the government's telegraph projects (Sun, 2007; Xia, 2012).

cost. Between two military centers, the least construction cost path is calculated based on the topographical and hydrological indices that are scaled in 1km × 1km grid cells. The data on topography and hydrology are obtained from the Shuttle Radar Topography Mission (SRTM) (see Online Appendix C for details). As shown in Fig. 2, the distribution of the HMTN was basically consistent with that of the actual trunk lines.

Fig. 2. Hypothetical military telegraph trunk network. This figure shows the map of 1896 telegraph lines and the hypothetical military telegraph trunk network (HMTN). The trunk includes 21 nodes (military centers). We link these military centers along the least construction cost path. We number the network nodes according to the schedule of trunk line construction.

The distance to HMTN is arguably orthogonal to banking development. The 21 military centers had been in place since the late 17$^{\text{th}}$ century—two centuries before China's modern transition—and their distribution was determined by military

purposes rather than financial development. However, some military centers were located in places that were already big cities at the time, such as Shanghai (Songjiang), Beijing (Shuntian), Tianjin and Guangzhou, among others. These military centers may also capture the direct effect of big cities on banking development. To rule out this possibility, we exclude all the 21 military centers in the following regression analyses. In addition, to the extent that the political-economic importance of big cities may permeate their surrounding areas,[20] we further drop the 102 prefectures adjacent to the 21 military centers for robustness.

We formally examine the effect of the distance to HMTN on the distribution of the telegraph in Table A.1 in Online Appendix A. Indeed, the distance to the trunk has a significantly negative effect on the number of telegraph stations in 1896 (column 1). A 10% (or eight kilometers) increase in the distance away from the HMTN would reduce the number of telegraph stations by 1.47.[21] The reduced-form estimations suggest that the distance to HMTN has a significantly negative effect on the number and growth of banks (columns 2, 4 and 6). However, after controlling for telegraph, we find that the effect of the distance to HMTN on banks disappears (columns 3, 5 and 7). This suggests that our instrumental variable affects banking development mainly through the channel of the telegraph. Of course, this result should be interpreted with caution in the sense that the endogenous telegraph may bias the estimate on the distance to HMTN. For this reason, we consider the results on the exclusion restriction as suggestive rather than conclusive.

We employ the Two-Stage Least Squares (2SLS) method to estimate the instrumented effect of the telegraph on banking development. We first use the distance to HMTN to predict the number of telegraph stations in 1896, before using telegraph stations in 1896 to predict the number and growth of banks (Eq. (2)).

$$\begin{aligned} Banks_i &= a_1 + \beta_1 \times Telegraph_i + \gamma_1 \times \mathbf{X}_i + \varepsilon_{1i}, \\ Telegraph_i &= a_2 + \beta_2 \times Distance_i \quad + \gamma_2 \times \mathbf{X}_i + \varepsilon_{2i}, \end{aligned} \tag{2}$$

We find that the instrumented telegraph has a significantly positive effect on the number of banks in 1911 (column 1, Panel A of Table 2). The effect remains robust to the inclusion of control variables (column 2). The instrumented effect of the telegraph on banks is sustained until 1936 (columns 3 and 4). Moreover, it has a

[20] For instance, the average urbanization rate of the adjacent prefectures in 1910 is 7.12%, which was slightly higher than the 6.34% of the other non-adjacent prefectures, although the difference is not statistically significant.

[21] In addition, the distance to HMTN can still predict the distribution of the telegraph in 1936 (not reported), suggesting the important role of the telegraph trunk in shaping the long-term expansion of the telegraph in China.

significantly positive impact on bank growth from 1897 to 1936 (columns 5 and 6). In terms of the magnitude, an additional telegraph station in 1896 would increase the number of banks by 5.677 in 1936 (column 4).

To rule out the spillover of the big city effect from military centers to surrounding areas, we further drop all the 102 prefectures adjacent to the 21 military centers (Panel B of Table 2). The results show that the effect of the telegraph on banks remains robust and, more importantly, changes little in magnitude relative to that obtained without dropping the adjacent prefectures (Panel A). This suggests that the telegraph effect is unlikely to be driven by large cities.

Table 2. The effect of the telegraph on modern Chinese banks: instrumented results. This table reports the 2SLS estimates at the prefectural level. The 21 military centers (telegraph nodes) are excluded. Panel B further excluded the 102 prefectures adjacent to the 21 telegraph nodes. In Panels A and B, telegraph in 1896 is instrumented by the log distance to HMTN, i.e., a prefecture's shortest distance (in kilometers) to the hypothetical military telegraph trunk line. Panel C uses the log distance to MSTN, i.e., a prefecture's shortest distance (in kilometers) to the hypothetical telegraph trunk lines that are constructed based on the Minimum Spanning Tree Network, as the alternative instrument of the telegraph. Controls include population in 1880 (log) and the number of treaty ports in 1896, distance to coast (log), and land size (log). Heteroskedasticity-robust standard errors in parentheses. *, **, and *** indicate significance at 10%, 5% and 1%, respectively.

	Number of banks in 1911		Number of banks in 1936		Average growth of banks, 1897–1936	
	1	2	3	4	5	6
	Panel A. Distance to HMTN as the instrument					
Telegraph in 1896	0.525***	0.394**	8.210***	5.677***	0.205***	0.142***
	(0.188)	(0.191)	(1.810)	(1.858)	(0.045)	(0.046)
K. P. F-statistic	28.893	24.239	28.893	24.239	28.893	24.239
Observations	266	266	266	266	266	266
	Panel B. Distance to HMTN as the instrument; prefectures adjacent to the military centers are excluded					
Telegraph in 1896	0.578**	0.281	9.293***	6.361***	0.232***	0.159***
	(0.245)	(0.209)	(2.274)	(2.409)	(0.057)	(0.060)
K. P. F-statistic	18.713	14.024	18.713	14.024	18.713	14.024
Observations	164	164	164	164	164	164
	Panel C. Distance to MSTN the instrument					
Telegraph in 1896	0.356	0.148	9.788***	7.662**	0.245***	0.192**
	(0.233)	(0.259)	(2.455)	(2.998)	(0.061)	(0.075)
K. P. F-statistic	18.559	10.630	18.559	10.630	18.559	10.630
Observations	266	266	266	266	266	266
Controls		Yes		Yes		Yes

Compared with the OLS estimates that also excluded the 21 military centers (columns 1, 3 and 5, Panel C of Table A.2 in Online Appendix A), the instrumented estimates become 1.79-2.14 times of the OLS ones. This raises the concern of whether

the local average treatment effect of the telegraph, which is captured by the distance to HMTN, is significantly greater than the average population effect of the telegraph. Stated differently, the effect of the telegraph on banks might be much greater in prefectures close to the HMTN than that of the whole sample, and this may inflate the instrumented effect of the telegraph. In Table A.2 in Online Appendix A, we find that the effect of the telegraph on banks in prefectures close to the HMTN (e.g., within 50 km or 100 km) is slightly (but not significantly) greater than that of the whole sample, suggesting that the large local average treatment effect is not a serious concern. Moreover, the Kleibergen and Paap F-statistic (24.239) suggests that the distance to HMTN is unlikely to be a weak instrument for the telegraph (Kleibergen and Paap, 2006).

The instrumented results remain robust when we use the log density of telegraph stations and the log density of banks (per 1,000 square meters) as alternative measures (Table A.3, Online Appendix A). Given the large share of zero values in the dependent variable, we also use IV-Tobit or IV-Poisson estimations and obtain results consistent with that of the 2SLS estimations (Table A.4, Online Appendix A).

The results remain consistent when we use county level data.[22] Our sample prefectures are composed of 1,501 counties after the 21 military centers (nodes at the county level) were excluded. Given that a county had at most one telegraph station in our sample, the telegraph is now a dummy variable indicating whether a county had telegraph in 1896. The control variables are the same as those of the prefectural estimations, except that population size and treaty ports have only prefectural variations. To address the endogenous distribution of the telegraph, we use a county's shortest distance to the HMTN as the instrument. Both OLS and instrumented estimations show a significantly positive effect of the telegraph on the number and growth of banks.[23] The results are robust to the inclusion of controls and the prefectural fixed effects. Moreover, the magnitude of the coefficient of the telegraph is very close to that of the prefectural estimations (Table A.5, Online Appendix A).

The HMTN can correct the endogenous path of telegraph lines that were intentionally connected to cover prosperous regions. But this only addresses the endogenous path between two military centers. At the national level, this method may

[22] The county data are more precise in identifying the locations of banks and telegraph stations. The drawback is that there is a large share of zero values; 88.61% of counties had no telegraph in 1897 and 96.54% had no banks in 1911. Moreover, population and treaty ports have only the prefectural variations.

[23] The only exception is the results in 1911. A possible reason is that only a very small portion (3.46%) of counties had banks in this year, which renders the effect of the telegraph statistically insignificant.

not correct the possibly endogenous formation of the whole telegraph trunk system.[24]

To address this concern, we design an optimal trunk network from the perspective of the minimum construction cost of the whole telegraph network of China. Specifically, we assume that the late Qing government would have been likely to lay the telegraph trunk lines with the sole policy objective of connecting major wire destinations with minimum construction costs. We first calculate the bilateral least cost path between each pair of military centers following the method used in constructing the HMTN. Based on the bilateral least cost paths, we apply the Greedy Algorithm (Kruskal, 1956) to generate the Minimum Spanning Tree Network (hereafter, MSTN) as the optimal trunk of the whole telegraph system (Fig. A.2 in Appendix A). The details are given in Online Appendix C.

Using the distance to MSTN as the instrumental variable further brings out the positive effect of the telegraph on banking development (Panel C of Table 2). Moreover, the marginal effect of the telegraph on banks is very similar to that of the HMTN. The only exception is that the instrumented effect of the telegraph on the number of banks in 1911 is not statistically significant. A possible reason is that the MSTN is calculated based on the overall least construction cost of the national telegraph network rather than the more precise local construction cost for each line. As a result, the MSTN may not produce a first stage fit as strong as that of the HMTN.

4.2. The telegraph and economic development

Not merely did the telegraph promote banking, it also stimulated real economic activities. As suggested by the historical narratives reviewed in Section 2.3, modern communications also spurred trade, commercialization, industrialization and thus overall economic development. This would have increased the demand for banking services, in particular inter-regional remittance, settlement, and lending, among others. Against this background, it is necessary to know the extent to which the effect of the telegraph on banking is explained by general economic development.

To formally test the channel of economic development, we employ several proxies for it. The first is the number of industrial establishments. Industrialization had been a principal force of China's economic modernization since the 1840s. Most industrial

[24] This is the case for the Yunnan-Chengdu-Wuchang line (Fig. 2). As noted in historical records, there was an urgent need to connect Yunnan and Wuchang to convey military intelligence regarding the frontier to the capital. Sheng Xuanhuai, who was in charge of telegraph construction, explicitly stated in his memorials that, since there was little commerce in remote frontier cities, it would be better if the line went across Sichuan province where trade flourished, and business newspapers had marketability (Xia, 2012; see also Online Appendix B for details).

establishments relied heavily on modern communications to access real time information. Meanwhile, they also had a great demand for bank loans (Cheng, 2003). The data is obtained from *Zhongguo jingji nianjian* (China Economic Yearbook) of 1934. It lists all existing industrial establishments (irrespective of their size) based on the first economic census conducted by the Ministry of Industry in 1932 to 1934.

The second measure pertains to trade or commerce, which is proxied by the membership numbers of the chambers of commerce (*shanghui*) of each prefecture in 1935. The chambers of commerce were self-governing associations founded and run by merchants. The size of the chambers could reflect the strength of local merchants and commercial prosperity. The data is obtained from surveys on civil organizations conducted by the KMT Central Executive Committee and the Ministry of the Interior in 1935. To fully gauge commercial prosperity, we also use commercial tax revenue as an additional measure, although the data has only provincial variations between 1931 and 1935. The data are obtained from *Zhongguo jingji nianjian xubian* (Supplement to China Economic Yearbook) in 1935 and *Caizheng nianjian* (Fiscal Yearbook) in 1936. The three economic variables are measured in logarithm in order to alleviate the effect of extreme values. Appendix D.3 introduces specific sources of each economic measure.

To distinguish the effect of the telegraph on banking from economic development, we control for the above economic measures together with the telegraph in regressions (Table 3). Their respective effects on banks are examined in columns 1-3. Then we control for them simultaneously to test their joint effects (column 4). Given the high correlation among the three economic measures,[25] we also take their first principal component as a single proxy for general economic development (column 5). The results show that economic development had a positive impact on the number of banks in 1936. In terms of magnitude, the three economic measures jointly mitigate the effect of the telegraph on banks by 40%, in which industrial establishments play a dominant role (column 4). When we control for the principal component of economic measures, the effect of the telegraph on banks is mitigated by 28.61%.[26]

A caveat to the above analysis is that the telegraph effect might be over-estimated due to possible measurement error in economic development. While the three economic measures capture industrialization and commercialization, they may omit the development of some other economic sectors driven by the telegraph. Thus, it is necessary to assess whether the effect of the telegraph on banks would be explained

[25] The correlation coefficients among the three economic variables range from 0.28 to 0.41; all are significant at the 1% level.

[26] There are no systematic records on economic performance between 1897 and 1936, so we cannot examine the effect of economic development on bank growth in this setting.

by these potentially unobserved economic factors. Based on Oster (2019), we use the selection of economic observables to estimate the possible effect of economic unobservables.[27] The results show that the effect of unobservables needs to be 3.4 to 7.1 times greater than that of the observables to completely explain away the effect of the telegraph on banks (Table 3). The chance that this was the case is slim, based on the reasoning that China's modern economic growth in the early 20th century was primarily manifested in industrialization and commercialization (our observables). In other words, relative to industrialization and commercialization, other economic sectors are unlikely to have had such a much greater effect on modern banks.

A related concern is that our economic variables themselves are endogenous, which would also bias the estimate on the effect of the telegraph on banks. To address this concern, we employ Dippel et al.'s (2020) causal mediation analysis, a method designed to disentangle the direct effect of the treatment variable from its indirect effect through an intermediate variable. The causal effect of the intermediate variable can be identified in a system of equations with a single instrumental variable. In our context, the effect of economic development (intermediate variable) can be identified by two regressions of 2SLS. One regresses economic development on the telegraph that is instrumented by the distance to HMTN, whereas the other regresses banks on economic development (instrumented by the distance to HMTN) and the telegraph. The magnitude of the intermediary effect is the product of the coefficients of the telegraph in the above two regressions.[28] As this method can only deal with a single endogenous intermediate variable, we focus on the principal component measure of economic development. The results show that economic development may absorb up to 49% of the effect of the telegraph on banks (Panel B of Table 3).

Nevertheless, the direct effect of the telegraph on banks remains significantly positive and still accounts for a majority of variation in banks, suggesting the pivotal role of information technology in banking development at the time.

Another way to confirm the telegraph effect net of economic development is to examine whether the telegraph impacted economic development through affecting the foundation of banks. Given the predominant role of industrial establishments in China's economic modernization, we first use the number of industrial establishments in 1934 as the outcome variable. The results show that the telegraph has a significantly

[27] That is, we calculate the Oster delta statistic by comparing the coefficient of telegraph controlling only for baseline observables (population size, treaty ports, distance to coast and land size) to the coefficient of telegraph after further controlling for the economic observables (industrial establishments, chambers of commerce and commercial tax revenue). According to the rule of thumb suggested by Oster (2019), if the delta is greater than one or smaller than zero, the unobservable is unlikely to explain away the effect of the treatment variable (telegraph).

[28] Stata codes for the causal mediation analysis are provided in Dippel et al. (2019).

positive effect on the number of industrial establishments. However, this effect shrinks by 44% and turns insignificant after we control for the number of banks in 1934 (columns 1 and 2, Table A.6, Online Appendix A). When using the principal component of economic development as the outcome variable, the effect of the telegraph on it dropped by 16% after controlling for banks (columns 3 and 4). These results suggest that the foundation of banks actually played a substantial role in directing the effect of the telegraph on economic development, and thus add more credence to the importance of the telegraph in banking development.

Table 3. The telegraph and economic development.
This table examines the extent to which the effect of the telegraph on banks could be explained by economic development. Economic development is measured by the log number of industrial establishments in 1934, log membership numbers of chambers of commerce in 1935, log commercial tax revenue in 1931-1935, and their first principal component. Baseline controls include log population in 1880, log number of treaty ports in 1896, log distance to coast, and log land size. Panel A examines the effect of the telegraph after controlling for economic development. Telegraph in 1896 is instrumented by the log distance to HMTN. Oster delta assesses the likelihood that the telegraph effect could be fully explained by unobserved factors based on Oster (2019). Panel B reports the results of the causal mediation analysis based on Dippel et al. (2020). % telegraph effect mitigated by economic development is calculated based on the coefficient of telegraph without economic controls (5.677). Heteroskedasticity-robust standard errors in parentheses. *, **, and *** indicate significance at 10%, 5% and 1%, respectively.

	Number of banks in 1936				
	1	2	3	4	5
	Panel A. Economic controls				
Telegraph in 1896	3.454**	5.504***	5.309***	3.407**	4.053**
	(1.741)	(1.820)	(1.801)	(1.706)	(1.644)
Industrial establishments in 1934	1.911***			1.915***	
	(0.403)			(0.421)	
Chambers of commerce in 1935		0.188		-0.056	
		(0.149)		(0.146)	
Commercial tax revenue in 1931-1935			0.825**	0.209	
			(0.406)	(0.371)	
Principal component					2.151***
					(0.470)
% telegraph effect mitigated by economic development	39.16%	3.05%	6.48%	39.99%	28.61%
Oster delta	3.503	[<0]	[<0]	3.423	7.094
Baseline controls	Yes	Yes	Yes	Yes	Yes
Observations	266	266	266	266	266
	Panel B. Causal mediation analysis				
Direct effect of telegraph					2.906***
					(0.872)
Indirect effect of telegraph via economic development (principal component)					2.771
					(2.175)
% telegraph effect mitigated by economic development					48.8%
Baseline controls					Yes
Observations					266

4.3. Panel data evidence

The aforementioned analysis documents a positive effect of the early adoption of the telegraph (by 1896) on subsequent banking development. But the number of telegraph stations kept growing past 1896 (Fig. A.1 in Appendix A). To gauge the temporal variation in the number of telegraph stations, we employ the panel data regression:

$$Banks_{i,t} = a + \beta \times Telegraph_{i,t\text{-}1} + \gamma \times \mathbf{X}_{i,t\text{-}1} + pref_i + year_t + \varepsilon_i, \quad (3)$$

where $Banks_{i,t}$ refers to the number of banks in each prefecture in each year between 1897 and 1936. $Telegraph_{i,t\text{-}1}$ is the number of telegraph stations in each prefecture in the previous year. $\mathbf{X}_{i,t\text{-}1}$ include population size and the number of treaty ports in the previous year. For population data, Cao (2001) estimated the population size of all Chinese prefectures for the time points of 1880, 1910, and 1953. We estimated the annual population size between these time points using linear interpolation. Prefecture fixed effects ($pref_i$) capture the unobserved, time-invariant prefectural factors, and year fixed effects ($year_t$) capture the common shocks faced by all prefectures. After controlling for the prefectural and year fixed-effects, we examine the effect of telegraph expansion on banking growth in a difference-in-differences setting. We clustered the standard errors at the prefectural level.

The results show that the number of telegraph stations has a significantly positive impact on the number of banks (columns 1–2, Table 4). The effect of the telegraph remains significant after we control for the prefectural population and the distribution of treaty ports. In terms of magnitude, an additional telegraph station is associated with an increase in modern Chinese banks by 0.448 per year (column 2). This is translated to a 37% increase in banks when evaluated by the mean (1.2)—a substantial marginal effect.[29]

To address the endogenous number of telegraph stations over time, we instrument it using the interaction terms between a prefecture's distance to HMTN and the province-specific trend in telegraph construction (columns 3 and 4, Table 4). The underlying assumption is that the effect of the distance to HMTN on subsequent telegraph expansion might depend on an overall trend in telegraph construction. When

[29] We also organized the data on a five-year basis to check the robustness of the annual panels. Specifically, we use the average number of telegraph stations in every five years to predict the average number of banks in the next five years, in that the effect of the telegraph on banks may not immediately appear in the next year (leaving aside the fact it may take time to establish a new bank). The results using the five-year interval remains consistent with that using the annual interval (not reported).

there was an overall increase in telegraph building, extra telegraph lines were more likely to connected to prefectures close to the HMTN. We distinguish the trends in telegraph construction by province. The reasoning is that, given the important administrative role of provinces in modern China, the progress in telegraph construction might vary across provinces.[30] Specifically, we use the total number of telegraph stations for all but one (n-1) of the prefectures located in the same province per year as the measure of the province-specific trend.

Table 4. The effect of the telegraph on modern Chinese banks: panel data results.
This table reports panel data results with prefectural and year fixed effects. The 21 military centers are excluded. The period of the analysis is 1897 to 1936. The dependent variable is the number of banks existing in each prefecture in each year. Telegraph denotes the number of telegraph stations at the prefectural level in the previous year. The controls include the number of population (log) and number of treaty ports in the previous year. Columns 3 and 4 report the 2SLS results. Telegraph is instrumented by the interaction terms between distance to HMTN and the annual number of telegraph stations at the provincial level between 1897 and 1936. Here the distance to HMTN is measured by a categorical variable that is scaled by ten intervals of 50 km. Accordingly, the first stage employs a difference-in-differences approach to examine the differential effect of the provincial trend in telegraph construction across prefectures varying by their distances to HMTN. Prefectures within the 50 km from HMTN is the reference group. Standard errors clustered at the prefectural level are reported in parentheses. *, **, and *** indicate significance at 10%, 5% and 1%, respectively.

	OLS		2SLS	
	1	2	3	4
Telegraph	0.502***	0.448***	1.587***	1.525***
	(0.142)	(0.115)	(0.390)	(0.358)
Controls		Yes		Yes
Year FE	Yes	Yes	Yes	Yes
Prefecture FE	Yes	Yes	Yes	Yes
Observations	10,640	10,640	10,640	10,640
Number of prefectures	266	266	266	266
R^2	0.483	0.514		
K. P. F-statistic			53.352	48.757

Given that both the distance to HMTN and the provincial trend in telegraph construction are continuous variables, their multiplication would inflate the estimates. To address this concern, we divided the distance to HMTN into ten ordered dummies by every 50-kilometer interval. Using a flexible difference-in-differences approach, we interact the distance dummies with the provincial trend to predict the prefectural telegraph expansion over time. We find that the overall growth of the telegraph in a

[30] Sustained telegraph construction relied on provincial governments' financial and administrative resources. Moreover, provincial governors' attitudes toward the telegraph also affected the progress of telegraph construction. For example, Ni Wenwei, the provincial governor of Henan, was aggressive in telegraph construction. In order to build a new line connecting Henan to Shandong, he transferred funds earmarked for water control on the Yellow River to telegraph use in 1887 (Xia, 2012).

province would bring more telegraph stations to prefectures located closer to the HMTN.[31] The instrumented results confirm the positive effect of telegraph expansion on banking development. An additional telegraph station is now found to increase the number of banks by 1.525 per year (column 4, Table 4).

4.4. Competing communications: the railways and the postal routes

Besides the telegraph, the railway was also introduced to China in the late 19th century. The defeat of the Qing dynasty in the First Sino-Japanese War in 1895 stimulated the government to develop a railway system. By 1937, over 11,000 km of railway had been laid in China, which covered 88 (30.7%) Chinese prefectures. As another form of modern communication, the railway may also bear upon the rise of modern banking in China (Chen, 1937). Meanwhile, because the railway connected economic or political centers, its distribution may be highly correlated with that of the telegraph. As shown in Fig. A.2 of Online Appendix A, the distribution of the railway stations in 1910 overlaid some of the telegraph stations in 1897 (especially in the North China Plain). The correlation between the distribution of the railway stations and that of the telegraph stations is also significantly positive (coefficient 0.29 and significant at 1% level). It is thus important to disentangle the effect of the telegraph on modern banks from that of the railway.

We used the number of railway stations to measure a prefecture's access to the railway. Based on Sun's (2003) *Zhongguo Tielu Zhanming Cidian* (Dictionary of Chinese Railway Stations), we manually identified the year of establishment and the location of each railway station. In the regression, we controlled for the number of railway stations in 1910 and compared it with the number of telegraph stations in terms of their effect on the number of banks.

Besides the railway, the imperial postal system was another means of information transmission during our sample period. The imperial postal system was built in 1896 based on the previous courier routes (*yilu*), which were mainly used to deliver official letters, silver remittance and goods.[32] The imperial postal routes were still a traditional infrastructure of information communication that worked by means of ships, horses, and later the railways in some regions. The difference was that they were open to the public, whereas the previous courier routes were for official use only. This unique setting allows us to compare the relative importance of the telegraph and the

[31] The reference group is prefectures whose distance to HMTN was within 50km. The results are consistent when we divide the categories based on distance percentiles.

[32] The imperial postal system started from the Customs Post Office in 1878, which was established by the commissioner of the imperial customs, Robert Hart. In 1896, the Customs Post Office became the Great Qing Post, the first modern postal system in Chinese history.

traditional postal system in banking development. If the telegraph did promote modern banks by improving communication efficiency, we should expect the impact of the telegraph on banks to have been greater than that of the imperial postal network.

We use the number of imperial post offices as the measure of a prefecture's access to the imperial postal network. We enumerated the number of postal offices by prefecture and year from the county gazetteers. The distribution of the postal offices also overlaid some of the telegraph stations (Fig. A.3 in Online Appendix A). The correlation coefficient between the two variables in 1896 is 0.34 (significant at the 1% level).

Table 5. Telegraph versus railways and imperial postal system.
All are 2SLS estimates at the prefectural level. Telegraph in 1896 is instrumented by the log distance to HMTN. Railway denotes the number of railway stations in 1910. Imperial post refers to the number of Qing postal offices in 1896. Controls include population in 1880 (log), number of treaty ports in 1896, distance to coast (log), and land size (log). Heteroskedasticity-robust standard errors in parentheses. *, **, and *** indicate significance at 10%, 5% and 1%, respectively.

	Number of banks in 1911	Number of banks in 1936	Average growth of banks, 1897–1936
	1	2	3
Telegraph in 1896	0.375*	4.836***	0.121***
	(0.195)	(1.805)	(0.045)
Railway in 1910	0.020	1.124*	0.028*
	(0.066)	(0.582)	(0.015)
Imperial post in 1896	-0.145	-0.812	-0.020
	(0.122)	(1.117)	(0.028)
Controls	Yes	Yes	Yes
K. P. F-statistic	24.649	24.649	24.649
Observations	266	266	266

We ran a 'horse race' test between the telegraph, on the one hand, and the railways and the imperial post, on the other (Table 5). All regressions are cross-sectional. The effect of the telegraph on the number and growth of banks remained significantly positive, suggesting that the observed effect of the telegraph on banks is not driven by the railway or the postal system. The effect of the telegraph remains robust when we use the panel data regressions at the prefecture-year level (not reported). The effect of railways on banks is significant in predicting the number of banks in 1936 and the growth in the number of banks between 1897 and 1936. This coincides with historical narratives that argue that the railway as modern transportation also facilitated financial development in China (Rawski, 1989). The number of imperial post offices had no effect on modern banks. This suggests that the rise of modern banks in China was mainly facilitated by modern information technology rather than the traditional information infrastructure.

5. The telegraph and the expansion of bank branch networks

It is reasonable to suppose that the main channel by which the telegraph promoted banking development was the expansion of bank branch networks. By providing almost instant, convenient communication and transfer services, the telegraph would have overcome the distance barriers that had hindered banking expansion. If this is the case, the telegraph would have enabled banks to open and manage branches on a much greater geographical scale.

To test this, we first regress the total number (and growth) of branches on the distribution of telegraph stations (1896) at the prefectural level. The telegraph is instrumented by the distance to HMTN. As reported in Table 6 (columns 1–3), the telegraph has a significantly positive effect on the number and growth of bank branches, suggesting that banks were more likely to open branches in prefecture with telegraph. For comparison, we also regress the total number (and growth) of bank headquarters on the telegraph (columns 4–6). The telegraph also has a positive impact on the headquarters, but the coefficient is not statistically significant. These results suggest that the effect of the telegraph on banking development mainly comes from the expansion of bank branches.

Table 6. The effect of the telegraph on banks branches and headquarters.
This table examines the effect of the telegraph on bank branches and headquarters, respectively. All are 2SLS estimations. Telegraph in 1896 is instrumented by the log distance to HMTN. Controls include population in 1880 (log), number of treaty ports in 1896, distance to coast (log), and land size (log). Heteroskedasticity-robust standard errors in parentheses. *, **, and *** indicate significance at 10%, 5% and 1%, respectively.

	Bank branches			Bank headquarters		
	Number in 1911	Number in 1936	Average growth 1897–1936	Number in 1911	Number in 1936	Average growth 1897–1936
	1	2	3	4	5	6
Telegraph in 1896	0.364**	5.445***	0.136***	0.030	0.232	0.006
	(0.162)	(1.706)	(0.043)	(0.078)	(0.300)	(0.007)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
K. P. F-statistic	24.239	24.239	24.239	24.239	24.239	24.239
Observations	266	266	266	266	266	266

5.1. The distance between the branch and the headquarters

Now we examine the specific mechanism of the 'expansion', i.e., whether the telegraph expanded the geographical scale of banks' branch networks. For this purpose, we examine whether the telegraph extended the distance between banks' headquarters

and their branches. We calculated the average (geographic) distances from each bank branch whose headquarters was located in a different prefecture to that headquarters. Specifically, for each bank branch in a prefecture, we calculated its great circle distance to the prefecture in which its headquarters was located.[33] Then we took the average of all the distances between the bank branches in this prefecture and their headquarters in other prefectures as our dependent variable and regressed it on this prefecture's number of telegraph stations in 1896. The average branch-headquarters distance varied strikingly, from the minimum of zero kilometers (without any cross-prefectural branches) to the maximum of 2,296 kilometers in 1936.

We find that the telegraph has a significantly positive impact on the branch-headquarters distance in both 1911 and 1936 (columns 1 and 2, Table 7). The instrumented coefficients of the telegraph are 1.541 in 1911 and 3.275 in 1936, respectively. Given the log measure of the branch-headquarters distance, the coefficients mean that, on average, an additional telegraph station in 1896 would increase the branch-headquarters distance by about 151.4 percentage points by 1911. This translates into a 173-kilometer increase in the distance when evaluated by the mean of distance (114.21). By 1936, this marginal effect had increased to 954 kilometers. This effect is substantial in the sense that 954 kilometers generally spanned about seven prefectures or a province in Qing China, which is equivalent to the distance between London and Zurich.

The above results remain robust to the estimations at the bank branch level (columns 3 and 4, Table 7). Specifically, we employ 1,938 bank branches that existed at any point between 1897 and 1936 as our observations.[34] We calculate the distance between each branch and its headquarters. Then we regress the distance on a dummy variable indicating whether the branch and the headquarters could be connected by telegraph. We assume that the branch and the headquarters could be connected if both were located in prefectures where a telegraph was present in 1896. Accordingly, we instrument the telegraph-connection dummy using the sum of the distance to HMTN from the headquarters and from the branch. We control for the branch's establishment-year fixed-effects to capture the common shocks over time. We also control for the population, treaty ports, land area, and distance to the coast of the prefecture in which the branch was located, or, alternatively, the branch's prefectural fixed-effects. The results show that if a branch and its headquarters could be connected by telegraph, the distance between them would be 90% (or 448 kilometers) greater

[33] To be accurate, we identified locations of the bank branches and their headquarters at the county level.

[34] We exclude the branches in the 21 military centers and those located in the same prefecture as their headquarters.

than the distance between those without telegraphic connection (column 3).

Table 7. Telegraph and bank branch-headquarters distance.
This table examines whether the telegraph facilitated the opening of distant branches by banks. We excluded banks in the 21 military centers and the banks that had no branches in other prefectures. Columns 1 and 2 report the 2SLS estimates at the prefectural level in 1911 and 1936, respectively. The dependent variable, branch-head distance, is the log average distance between all the bank branches in a given prefecture to their corresponding headquarters in another prefecture. Telegraph in 1896 is instrumented by the log distance to HMTN. Controls include population in 1880 (log), number of treaty ports in 1896, distance to coast (log), and land size (log). Heteroskedasticity-robust standard errors are in parentheses. Columns 3 and 4 report the 2SLS estimates at the bank branch level. The sample includes all the branches between 1897 and 1936. The dependent variable is the log distance between a branch and its headquarters. Telegraph connection is a dummy which equals one if both the branch and the headquarters were located in prefectures with a telegraph in 1896. It is instrumented by the sum of the branch's distance to HMTN and the headquarters' distance to HMTN (in log). The controls include population in 1880 (log), number of treaty ports in 1896, distance to coast (log) and land size (log) in the branch's prefecture. Standard errors are clustered at the prefecture-headquarters level. **, and *** indicate significance at 10%, 5% and 1%, respectively.

	Prefectural level		Branch level	
	Branch-HQ distance in 1911	Branch-HQ distance in 1936	Branch-HQ distance 1897-1936	Branch-HQ distance 1897-1936
	1	2	3	4
Telegraph in 1896	1.514**	3.275***		
	(0.622)	(0.989)		
Telegraph connection (Branch-HQ)			0.910**	2.836***
			(0.451)	(0.778)
Controls	Yes	Yes	Yes	
Branch's prefecture FE				Yes
Branch's establishment year FE			Yes	Yes
K. P. F-statistic	24.239	24.239	59.316	30.03
Observations	266	266	1938	1938

5.2. Distribution effect or growth effect

The above findings on the geographic expansion of the branch network raise the concern of whether the telegraph increased the overall presence (number) of bank branches or simply reshaped their geographic distribution within each bank's network. If the telegraph prompted the banks to open more branches, it suggests an overall growth effect of the telegraph on banking. However, if the telegraph just changed the banks' decision about where to open a branch, it simply suggests a redistribution effect on the part of the telegraph.

The redistribution effect coincides with the notion of firms' efficient reallocation of internal capital (e.g., Stein, 1997; Giroud and Mueller, 2015; 2019). Firms create value by reallocating resources among their plants; for example, capital would be

reallocated from some plants to others whose appeal in terms of investment suddenly increased. In our context, after a prefecture was connected to the telegraph, the value of opening branches in this prefecture increased. Banks would be more likely to move their branches from other prefectures to this one.

This subsection examines whether our results on the expansion of branches are driven by the growth effect or the redistribution effect of the telegraph. Given that the resource reallocation decision is made by the bank headquarters, we employ a network analysis at the bank-prefecture-year level. This method coincides with the firm network analysis of Giroud and Mueller (2019). In our setting, a bank's branch network covers the prefectures in which this bank established a branch at any point between 1897 and 1936.[35] The panel is unbalanced, i.e., a bank would not be included in the sample until it had established the first branch. We excluded those banks that never had a branch outside their home prefectures and excluded the prefectures that never had a branch. Finally, our sample has in total 205 banks with 2,123 branches, covering 234 prefectures between 1897 and 1937.

The dependent variable is the number of branches a bank opened in each prefecture each year. We use the average number of telegraph stations in the local prefecture in the previous year to capture the growth effect of the telegraph. To gauge the redistribution effect of the telegraph within a bank network, we use the average number of telegraph stations in the *other* prefectures in the previous year as the measure, and examine whether it would reduce the number of branches in the local prefecture. Here the other prefectures refer to the prefectures in the bank's branch network other than the local prefecture. We control for the bank- and year fixed-effects. The standard errors are clustered at the prefecture-bank level.

The results are reported in Table 8. In a bank's branch network, the number of branches is positively affected by the number of local telegraph stations but not by the number of telegraph stations in the other prefectures (column 1). This suggests that the telegraph did increase the overall presence of bank branches rather than merely redistributed their locations. The results remain robust when we control for the prefecture-year fixed effects (column 2). Doing so can capture the possible effect of the local prefectural characteristics on branch set-up over time, though the effect of the local telegraph is absorbed. The results show that the telegraph in the other prefectures still has no effect on local branches.

[35] In a bank's network, we assign zero for prefectures in which this bank had not yet opened a branch in a given year. For the other prefectures where the bank never opened a branch during the entire period from 1897 to 1936, we assume that these prefectures were not in the business scope of the bank and hence exclude them from analysis.

Table 8. Distribution effect versus growth effect.

This table examines whether the telegraph redistributed the branches within the bank network. The data are organized at the bank-prefecture-year level. A bank network covers the prefectures in which the bank established a branch at any point between 1897 and 1936. The dependent variable is the number of branches of a bank in each prefecture in each year. Telegraph is the number of telegraph stations in local prefecture in each year, which captures the growth effect of the telegraph on banks. Telegraph in other prefectures refers to the average number of telegraph stations in all the other prefectures inside the bank network, which captures the redistribution effect of the telegraph on bank branches. In addition to the simple average of the telegraph stations in the other prefectures (columns 1 and 2), we also use the weighted average. The weights include the mutual distances between the local prefecture and the other prefectures (columns 3 and 4), population of the other prefectures (columns 5 and 6), and population/mutual distance (columns 7 and 8). *, **, and *** indicate significance at 10%, 5% and 1%, respectively.

	Number of branches of a bank in each prefecture in each year							
	1	2	3	4	5	6	7	8
Telegraph	0.047***		0.044***		0.047***		0.045***	
	(0.011)		(0.011)		(0.011)		(0.011)	
Telegraph in other prefectures	0.013	-0.018	-0.013	-0.035	0.018	-0.015	-0.008	-0.032
	(0.026)	(0.035)	(0.026)	(0.035)	(0.026)	(0.035)	(0.025)	(0.035)
Year FE	Yes		Yes		Yes		Yes	
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Prefecture × year FE		Yes		Yes		Yes		Yes
Observations	25,628	23,698	25,628	23,698	25,628	23,698	25,628	23,698
Number of prefectures	234	234	234	234	234	234	234	234
Number of banks	205	205	205	205	205	205	205	205
R^2	0.189	0.244	0.189	0.244	0.189	0.244	0.189	0.244
Telegraph in other prefectures is measured by:	Simple average		Weighted by mutual distance		Weighted by population		Weighted by population/mutual distance	

The effect of the telegraph may vary across different other prefectures. For instance, the telegraph in a prefecture located farther from the headquarters may have a smaller redistribution effect (if any) on local branches relative to a telegraph in a nearby prefecture. To address this concern, we use the distance-weighted number of telegraph stations in the other prefectures. The distance-weight is the great circle distances between the other prefectures and the local prefecture (columns 3 and 4).[37] For robustness, we also use the population-weighted telegraph in the other prefecture as an alternative measure, reasoning that the presence of a telegraph in a populous (and thus likely prosperous) prefecture would make it more attractive as a place for a bank to open branches in (columns 5 and 6). Finally, we weighted the number of telegraph stations in the other prefectures using both the distance and the population (columns 7 and 8). These alternative measures of the other telegraph produce results consistent with that of the simple average measure.

6. The telegraph and information flow

The foregoing analyses are premised on the assumption that the telegraph substantially increased inter-regional information flow. This subsection examines whether this is the case. To gauge the information flow, we use the frequency of news reports about this prefecture in a national newspaper. The newspaper was the major form of mass media in the late 19th and early 20th centuries. Shen Bao (Shanghai News), which was started in 1872, was one of the largest national daily newspapers in China at the time. It was based in the financial center of Shanghai and applied the new technologies of the telegraph and printing press in reporting news from all over the country. We conducted textual analysis on Shen Bao, the full text of which was digitized by the Green Apple Data Center in 2010.

The 287 Chinese prefectures administrated more than 2,000 counties. To fully capture the news reports on a prefecture, we count the frequency of the county names reported by Shen Bao on an annual basis.[38] We have taken into consideration the fact that some county names changed over time due to changes in administrative divisions, based on the history of the administrative changes provided by Fu et al. (2013), Fu and Zheng (2007), and Guan (1955). Moreover, 510 counties were excluded because

[37] The weighted telegraph in the other prefectures is calculated by $\sum(Telegraph_{j,t,b}{*}w_{i,j,b})/\sum(w_{i,j,b})$, where i refers to the local prefectures and j refers to the other prefectures ($i \neq j$); t denotes the year index and b denotes the headquarters. The weight $w_{i,j,t}$ can be $1/\text{distance}_{i,j}$, $\text{population}_{j,t-1}$ or $\text{population}_{j,t-1}/\text{distance}_{i,j}$. We take the logarithm of distance and population.

[38] When doing the textual counting, we used the full name of counties in Chinese characters, i.e., including the postfix *xian* (county). This might omit some entries that did not use the full county names including *xian*.

they shared the same name as at least one other county and thus introduced ambiguity. We excluded Shanghai because it would be over-reported as the home of Shen Bao. Finally, a total of 1,691 counties were identified. After aggregating to the prefectural level on an annual basis, the frequency of news reports ranged from zero to 1,223, with an average of 18.25 news reports per prefecture-year. The prefectural distribution of the news frequency between 1897 and 1936 is depicted in Fig. A.3 in Appendix A. It shows that regions in which the telegraph network was dense were more likely to be reported on by outside newspapers.

Table 9. The telegraph and information flow: evidence from news reports.
This table examines the channel of information flow. News frequency is the frequency of news reports about each county that appeared in Shen Bao (Shanghai News), the most influential daily newspaper at the time. We aggregated the frequency of news reports to the prefectural level in the periods from 1897 to 1911 or from 1897 to 1936, respectively. Telegraph in 1896 is instrumented by the log distance to HMTN. Controls include population in 1880 (log), number of treaty ports in 1896, distance to coast (log), and land size (log). Heteroskedasticity-robust standard errors in parentheses. *, **, and *** indicate significance at 10%, 5% and 1%, respectively.

	News frequency, 1897–1911	News frequency, 1897–1936	Number of banks in 1911	Number of banks in 1936	Average growth of banks, 1897–1936
	1	2	3	4	5
Telegraph in 1896	2.100***	2.046***	0.357	2.092	0.052
	(0.552)	(0.560)	(0.241)	(1.810)	(0.045)
News frequency, 1897–1911			0.017		
			(0.039)		
News frequency, 1897–1936				1.752***	0.044***
				(0.324)	(0.008)
Controls	Yes	Yes	Yes	Yes	Yes
K. P. F-statistic	24.239	24.239	17.137	19.129	19.129
Observations	266	266	266	266	266

We regress the news frequency on the telegraph that is instrumented by distance to HMTN. The news frequency is aggregated between 1897 and 1911 (for the late Qing dynasty) and between 1897 and 1936 (the whole sample period), respectively. We take the logarithm of the news frequency to normalize the extreme values. The results show that the number of telegraph stations in 1896 has a significantly positive effect on the news frequency (Table 9, columns 1 and 2). The effect is robust to the inclusion of population size, treaty ports, and geographic factors. These results indicate a significant improvement in the informational environment caused by the telegraph.

To test whether the telegraph promoted banking development through increasing information flow, we simply regress the variables of banks on the telegraph and on the news frequency as well (Table 9, columns 3–5). News frequency has a significantly positive effect on the number of banks in 1936 and on bank growth between 1897 and

1936. A doubling of news reports would bring about 1.752 more banks in 1936 and a 0.044 increase in bank growth. Meanwhile, the effect of the telegraph on banks declines by 63% and becomes statistically insignificant.[39] The county level estimations produce similar results (Table A.7, Online Appendix A). This suggests that information flow is an important channel by which the telegraph promoted banking development.

7. Conclusion

In this paper, we explore the effect of the most advanced information technology at the time—the telegraph—on the development of a modern banking system in historical China. This episode provides a novel setting for testing the effect of information technology on banking development. The introduction of the telegraph to China dramatically accelerated the speed of information transfer, as the time cost was largely reduced as compared with that of the traditional method. Moreover, considering that the original purpose of building a telegraph network in Qing China was to transmit military information, and not to facilitate commercial activities, the exogenous nature of technology shock allows us to identify the causality between the development of information technology and banking development.

By constructing a rich dataset based on gazetteers, newspapers, and yearbooks, we were able to describe the diffusion of telegraph stations and modern banks from 1881 to 1936. We find that the telegraph significantly increased the number of banks. This effect mainly worked through the expansion of bank branch networks: by providing information rapidly, the telegraph enabled banks to expand their branches on a greater geographical scale. The information mechanism of the telegraph is reinforced by our textual analysis of historical newspapers. Finally, banks also benefited from the real economic development that was stimulated by the telegraph. Building on the above, we conclude that information technology played a crucial role in the early development of modern banking.

[39] Certainly, the results should be explained with caution in the sense that the endogenous news frequency would bias the estimates. For instance, the existence of a banking network might also increase news frequency, or both news frequency and presence of banks might be driven by other unobserved factors. If this were the case, the effect of news frequency on banks would be overestimated. Accordingly, the 63% drop in the effect of the telegraph on banks can be considered as the upper bound.

Appendix

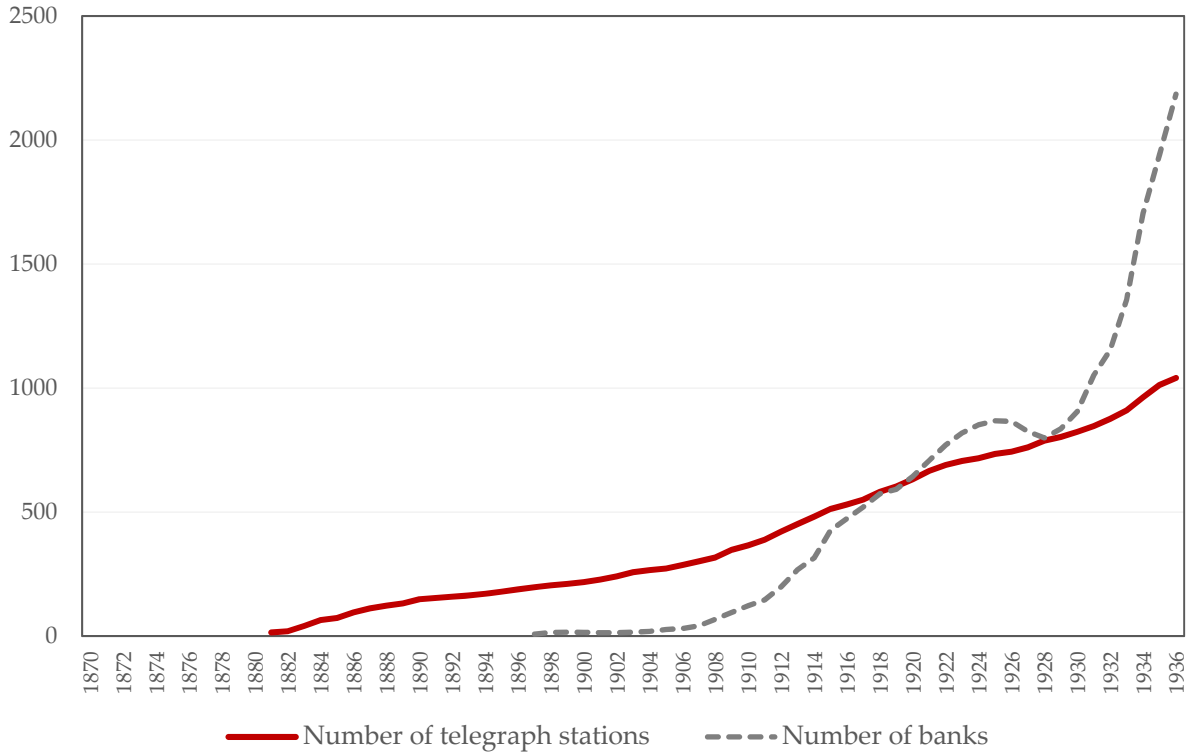

Fig. A.1. Number of telegraph stations and modern Chinese banks. This figure shows the number of existing telegraph stations and modern Chinese banks in China on an annual basis. The first telegraph station was built in 1881. The first modern Chinese bank, the Imperial Bank of China, was established in 1897.

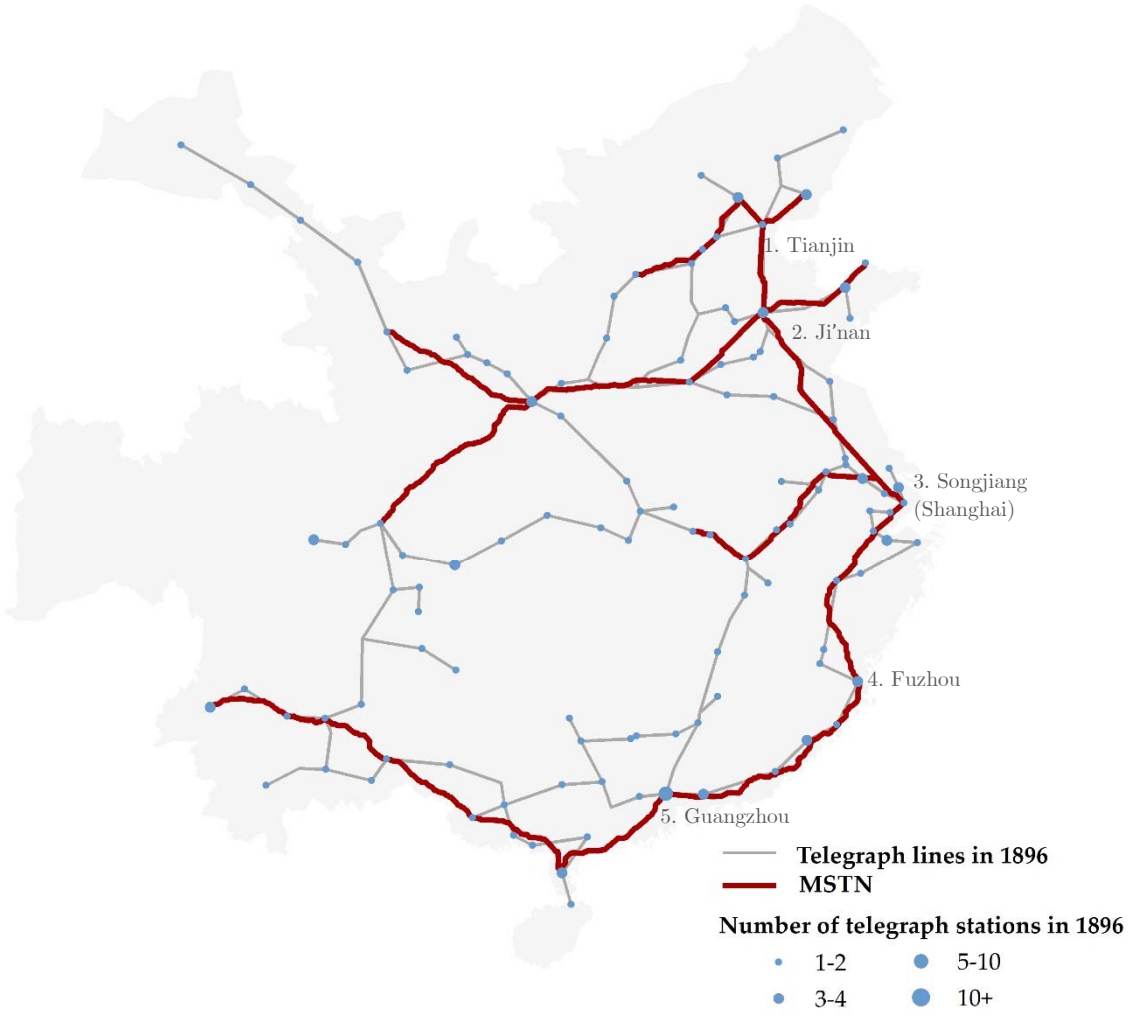

Fig. A.2. Alternative hypothetical telegraph trunk: minimum spanning tree network (MSTN). The MSTN is constructed based on the minimum construction cost of the whole telegraph trunk system. We first calculate the least cost bilateral path between each pair of military centers, and then calculate the Minimum Spanning Tree Network of the whole trunk based on the Greedy Algorithm method (Kruskal, 1956). The nodes (military centers) are the same as those in Figure 2.

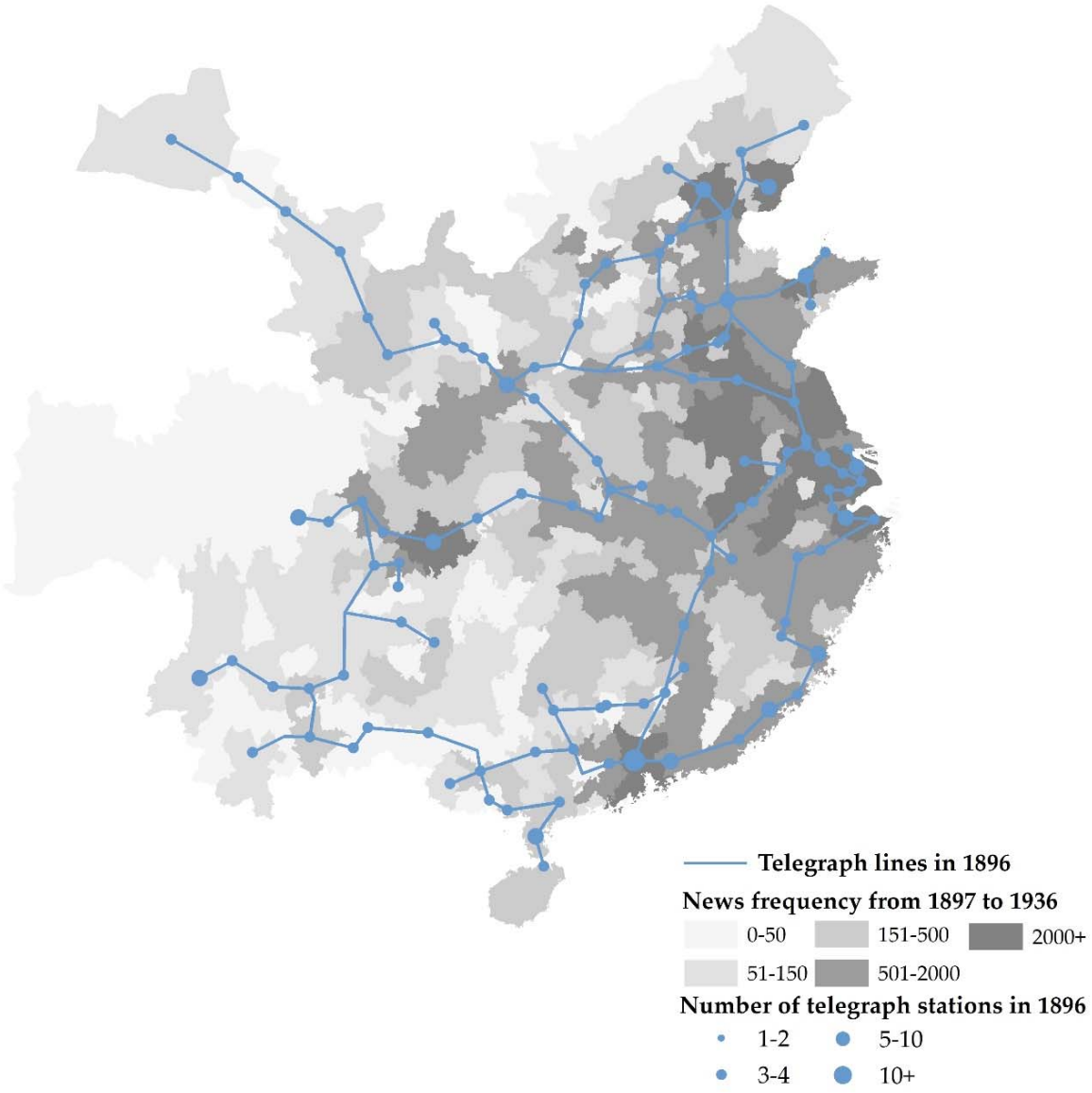

Fig. A.3. Distributions of the telegraph and of news frequency. This figure depicts the frequency of reports on a prefecture by the largest national newspaper, Shen Bao (Shanghai News), between 1897 and 1936, and compares the distribution of the news frequency with that of the telegraph. The news frequency is obtained by textual analysis on the full text of Shen Bao as digitized by the Green Apple Data Center in 2010.

Table A.1. Summary statistics.
Please refer to the text for variable definitions.

Variable	Obs.	Mean	S.D.	Min	Max	Mean excluding the 21 military centers
Number of banks in 1911	287	0.51	1.61	0	15	0.28
Number of banks in 1936	287	7.61	18.15	0	229	5.31
Average growth of banks, 1897–1936	287	0.19	0.45	0	5.73	0.13
Number of banks, 1897–1936	11,480	1.94	7.8	0	229	1.2
Telegraph in 1896	287	0.66	0.94	0	5	0.54
Telegraph, 1897–1936	11,480	1.91	1.93	0	12	1.75
Population in 1880 (log)	287	4.38	1.23	0.55	8.44	4.31
Treaty ports in 1896	287	0.08	0.29	0	2	0.06
Distance to coast (log)	287	5.66	1.44	-0.96	7.69	5.71
Land size (log)	287	2.48	0.75	0.23	4.88	2.45
Distance to HMTN (log)	287	3.15	1.82	0	6.69	3.40
Distance to MSTN (log)	287	3.71	1.88	0	6.69	4.00
Branch-headquarters distance (branch level, 1897–1936) (log)	2,695	5.90	0.94	2.90	7.75	5.79
Branch-headquarters distance in 1911 (prefectural level) (log)	287	1.18	2.53	0	7.65	0.88
Branch-headquarters distance in 1936 (prefectural level) (log)	287	4.11	2.76	0	7.74	3.99
News frequency, 1897–1911 (log)	287	4.09	1.94	0	8.25	3.95
News frequency, 1897–1936 (log)	287	5.01	2.17	0	9.47	4.86
Industrial establishments in 1934 (log)	287	1.46	1.82	0	7.12	1.27
Chambers of commerce in 1935 (membership numbers) (log)	287	3.14	3.08	0	9.35	3.01
Commercial tax revenue in 1931–1935 (in 1,000 taels) (log)	18	14.45	1.00	12.88	15.82	14.43
Principal component (of above three economic measures)	287	0	1.28	-1.91	3.44	-0.09

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