Reform, Rails, and Rice: Political Railroads and Local Development in Thailand

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How do external threats to state sovereignty benefit local development? In this paper, we look at Thailand's railroad projects in the late-nineteenth and early-twentieth centuries as an example of a state's strategic response to colonial encroachment. By transporting government officials and establishing a permanent administrative presence, the railways served to ensure Thailand's sovereignty over peripheral regions and bring them under direct governance. These regions, long considered economically unviable and disconnected from Bangkok, gained rail access due to their strategic importance and, in turn, witnessed urbanization and increased agricultural production.

Studies on historical state-building and economic development have long emphasized sovereignty threats and fiscal constraints as important drivers of overall state capacity expansion, centralization, and subsequent economic growth (Tilly 1990; Besley and Persson 2011; Gennaioli and Voth 2015; Dincecco 2015; Bardhan 2016). While most of these studies focus on explaining the rise of modern states in Europe, they

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also provide general insight on how such challenges, that is, sovereignty threats and fiscal constraints, may benefit states-at-risk by catalyzing internal reforms and strengthening state capacity. The local benefits obtained from an increase in state capacity and subsequent development would likely vary depending on the level of perceived threat and the success of state-led initiatives under fiscal constraints.

In order to assess how increases in state capacity and development under these challenges are obtained and how they lead to diverging local development outcomes, we present an important case from a different geographic context and period: Siam in the nineteenth century, a crucial period in history during which many states faced colonial threats as Western powers rapidly expanded their imperialist pursuits across various parts of the world. In the Age of New Imperialism, French and British colonial ambitions prompted King Chulalongkorn of Siam and his government to pursue several strategies to maintain Siam's sovereignty and gain territorial control over the peripheral reaches of the kingdom. We first discuss how Siam's early railways became a key initiative taken by the government to facilitate the establishment of a modern territorial state and thwart British and French territorial ambitions in the late-nineteenth and early-twentieth centuries. We then investigate how these "political railroads" in Siam—deemed inefficient and costly relative to other development projects such as irrigation canals—contributed to local development in the peripheries of northern and northeastern Thailand, while serving the goal of establishing and maintaining the kingdom's sovereignty. Finally, we discuss both the strategic and distributive development effects of railway construction in the Siamese context and present empirical results to support our claim.

As the only Southeast Asian kingdom under Western colonial threat that maintained its independence, Siam provides an apt case study in which the introduction of new transportation infrastructure helped the kingdom establish and maintain sovereignty while also contributing to local development. In the 1880s, the British and French proposed to build railways connecting their respective holdings in Burma and Indochina to China. The proposed routes extended into Siamese territories in the east, northeast, and west that were under tenuous control by Bangkok. These British and French plans were summarily rejected by Siam, even if they made economic sense. Representatives from the Ministry of Foreign Affairs warned that allowing the British to construct the railway would result in British control of the northern tributary states and further loss of territory under Bangkok's influence (Kakizaki 2005, p. 82). The insistence of the British and French to build railways through areas under

Siamese control was a major factor that pushed Siam to plan and build its own railways. In order to achieve direct governance of strategic areas outside the immediate vicinity of Bangkok, the government decided to invest in a railway network to move people and information more efficiently across its territory (Kakizaki 2012, ch. 4).

While the strategic and political importance of Siam's early railways in the northern and northeastern regions are clear, the economic value of the railways has largely been in question by both contemporary commentators and economic historians alike. In terms of large-scale infrastructure investment, railroads were perceived as a suboptimal choice from an economic perspective, especially relative to the expansion of the irrigation canal network in the Central Plain (Van der Heide 1906; Feeny 1982; Ingram 1971).[1] Ultimately, however, the government decided to devote its limited resources to building the railway network rather than extending the canal network. These railways met political aims, such as facilitating the movement of civil servants from Bangkok taking up positions in the newly centralized administration in peripheral provinces (Potjanalawan 2016) and aiding the movement of defense forces and provisions to these areas under threat (Kakizaki 2012, p. 84).

In this paper, we show that Siam's "political railroads" led to urbanization and expansion of agricultural production in peripheral areas that had been previously overlooked by Bangkok and suffered from inferior transportation options. Subsequent economic development in Siam's north and northeast was largely a consequence of Siam's state consolidation efforts to maintain sovereignty rather than a concerted effort to develop economic viability in the peripheries.[2] At the same time, the government's budget limitations meant that strategic railways were built at the expense of other types of infrastructure, leading to localized benefits for areas in close proximity to rail lines.

The lessons from the Siam case contribute first and foremost to the literature on colonialism. While related works from the historical institutions literature tend to focus on different institutional legacies of direct colonialism and settlement, we present a state under external colonial threat that successfully maintains its independence (Acemoglu and

[1] Kakizaki (2005), on the other hand, argues that the opening of the Northern Line and Northeastern Line in particular resulted in more rice production and commodity flows. Contrary to earlier views that the railways were not important for transporting rice, official statistics do indicate that paddy and processed rice made up a large proportion of overall freight carried on the Northern Line and Northeastern Line up through WWII (see Online Appendix Figure 1A).

[2] Paik and Vechbanyongratana (2019) describe the long-term impact of Western colonial threat and Siam's centralization effort in more detail, showing that the regions that became centralized earlier continue to enjoy higher levels of development today.

Robinson 2013; Hariri 2012; Fourie and Obikili 2019; Michalopoulos and Papaioannou 2020). Siam centralized its administration and expanded its capacity against Western encroachment despite facing fiscal constraints. Its internal reforms and transformation into a modern state in the late nineteenth century can be considered similar in outcome to the rise of modern states in Europe, albeit in a different period and geographic context. In both cases, state centralization became a key determinant of economic development. In this regard, Siam offers what the broader literature on colonialism currently fails to consider: a counterfactual case of what might have happened if colonization had not taken place, that is, the case of states in Africa and Asia successfully maintaining independence during the Age of New Imperialism. The case of Thailand clearly suggests that the construction of railroads—and the beneficial effects for economic development related to them—are not limited to colonial countries.

The Siam case also contributes to works suggesting that large infrastructure projects, such as railways, roads, and canals, tend to have positive impacts on various local and national economic outcomes. In theory, the development of transportation networks increases market access and reduces the cost of transporting goods and people. In the case of the United States, counties that gained better market access due to the expansion of the rail network had increased agricultural land values (Donaldson and Hornbeck 2016). Atack and Margo (2011) further show that about one-quarter of the increase in farmland in the American Midwest can be attributed to the building of the railways in the nineteenth century. Tang (2014) shows that the development of the rail system in Japan led to industrial development and agglomeration economies along the newly built rail lines. Berger and Enflo (2017) show that in nineteenth-century Sweden, areas with railways built by the government due to military concerns saw more rapid population growth.[3]

Infrastructure development under the colonial context largely echoes similar findings. Donaldson (2018), for example, finds that in the case of colonial India, areas that gained direct access to railways during the colonial period saw decreased trade costs, which in turn led to increased interregional and international trade. Bogart and Chaudhary (2013)

[3] Some works, on the other hand, find that the railway impact on population increase and economic outcomes were not significant and suggest that the contribution of railways to development depends critically on context-specific factors such as geography, sectoral specialization, and the scale of economy. For example, Maravall (2019) initially finds limited indigenous population growth in areas with access to railways, and Herranz-Loncán (2011, 2014) finds that the railway in Uruguay had a marginal impact on the country's economy, especially relative to other Latin American economies before 1914.

also find that the colonial railways in India led to increased total factor productivity between 1874 and 1912, and this can be largely explained by the complementarity between railways and industrial development. Similarly, Jedwab, Kerby, and Moradi (2017) show that the colonial railways built by the British in Kenya for strategic purposes spurred the establishment of new cities that have persisted to this day despite the departure of European and Asian settlers and the decline of the railways.[4] Against the proponents of colonial involvement in infrastructure building, the case of Siam shows an alternative context in which an indigenous polity, not the colonizer, adopts Western technology to combat colonial encroachment. In doing so, the kingdom maintained its independence, centralized its administration, and grew its economy.

In the following, we evaluate the impact of railways on various development outcomes, particularly population and agricultural activity. Rather than looking at the entire rail system built in Thailand, however, our main interest lies specifically in the earliest railways built for strategic purposes in the northern and northeastern regions. Again, the nature of these railways differs from the usual context in that the combination of external colonial threats and limited government funds, not commercial interest, mainly determined the location and expansion of the railways.

With this in mind, we explore how variation in the intensity of the treatment (distance to railroad) may still explain the local development outcomes in the peripheries. We find that, like other railway cases, the benefits of the "political railways" were also positive, although they remained relatively localized and benefitted primarily peripheral areas within close proximity to the rail lines.

HISTORICAL BACKGROUND

Reform under Colonial Pressure

Up until the end of the nineteenth century, the "mandala" governance system was prevalent in much of Southeast Asia, including Siam. In a mandala system, the administrative center—in this case, Bangkok—had direct control over government administration in areas surrounding the capital. In areas further away, Bangkok had varying degrees of

[4] Jedwab and Moradi (2016) also discuss how rail reduced freight costs and boosted trade dramatically in northern Nigeria and South Africa in the early twentieth century. Jedwab and Storeygard (2019) present a dataset on the evolution of transportation infrastructure in Africa, including both colonial railways and post-colonial paved roads, to find a strong correlation between these transportation investments and economic development in Africa.

control over aspects of administration and taxation. In the peripheries of Bangkok's influence were the tributary states. Tributary states were independent kingdoms with their own hereditary leaders and administration. These smaller states paid tribute and provided manpower to Bangkok but were otherwise independent. The extent of a mandala state was determined by control over population and the ability to extract tribute, not a territorial border (Tambiah 1977). A decentralized mandala governance system made sense in the context of difficult transportation and communication between Bangkok and the peripheries.

In the second half of the nineteenth century, Siam maintained tributary relationships with several distant kingdoms and principalities that came under Bangkok's influence at the end of the eighteenth century, including: Luang Prabang in the northeast; Chiangmai, Lampang, Lamphun, Phrae, and Nan in the north; Cambodia in the east; and Pattani, Trengganu, Kelantan, and Kedah in the south (Bunnag 1977). The decentralized governance system meant that smaller kingdoms in the periphery of Siam's influence were at risk of appropriation by the colonial French and British administrations. In fact, the French and British progressively annexed land in Southeast Asia on the edges of Siam's influence, including areas in present-day Myanmar, Malaysia, Vietnam, Laos, and Cambodia.

French and British colonial ambitions and progressive colonization of peripheral territories under Siam's influence led King Chulalongkorn to pursue several strategies to thwart further annexations. He pursued diplomatic avenues to maintain its status as a buffer state between French and British holdings in Southeast Asia (Jeshurun 1970); established territorial borders consistent with Western concepts of sovereignty and the nation-state (Winichakul 1994); and adopted several Western institutions (e.g., the Torrens system of land administration based on cadastral survey) to gain legitimacy in the eyes of international actors (Larsson 2012). Possibly the most effective defense against colonial encroachment was the centralization of Siam's government and the integration of peripheral tributary polities into a centralized governance system.

Siam, however, faced many challenges in its bid to centralize the government. Along with resistance to centralization by hereditary leaders (Bunnag 1977; Walker 2014), transportation to and communication with the peripheries posed a large practical problem for directly governing outside Siam's Central Plain (Kakizaki 2012). Sending people and supplies to places that lacked canals or coastlines was exceedingly difficult, especially in the northern and northeastern reaches of the kingdom. While waterways (canals and rivers) were the main forms of transportation in

Siam throughout the nineteenth century, they were only navigable most of the year in the central region and not navigable at all during the dry season in the north and northeast. Regions with high mountainous terrain in particular had neither navigable waterways nor well-established roads allowing access to the rest of the country. Time-distances calculated by Kakizaki (2005) based on archival sources (reported in Online Appendix Figure B1) demonstrate the difficulties of travel from Bangkok to distant principalities (*mueang*) in the north and northeast at the end of the nineteenth century. Online Appendix Figure 2A indicates that travel to larger towns in the north took upwards of two months, much of it over land under man and animal power (Kakizaki 2005, pp. 156–7). The inability of the government to effectively and directly govern distant principalities, in addition to the need for better intelligence on French and British activities in the peripheries, led to the decision to establish a railway network in Siam.

Siam's "Political Railways"

The three earliest major routes that the government chose to pursue in the 1890s included routes to the northeast to Khorat, north to Chiangmai, and south to the border with British Malaya. The building of the northeastern and northern routes was particularly urgent at the end of the nineteenth century to facilitate the centralization of Siam's administration, quell unrest among peripheral populations, strengthen its control over the periphery, and maintain territorial integrity. The government did consider several proposed routes that would have made economic sense, connecting Siam's natural resources (such as teak and tin) and agricultural output (rice in particular) not only to Bangkok, but also to other centers of trade, such as Saigon, Singapore, and Moulmein (Whyte 2010; Kakizaki 2012). Both lines were seen as important for facilitating the governance of outer-lying areas that were under indirect or tenuous control by Bangkok. The line to the northeast through Khorat was seen as more urgent given the unrest in the area around Luang Prabang due to the arrival of the Ho, bandits from Southern China, between the 1870s and 1890s. Unrest attributed to the Ho in 1885 highlights the difficulties of transporting provisions and troops to the area and the need for the development of efficient transportation from Bangkok to the northeast for security purposes. According to the Ministry of Interior archival documents, Phraya Sisingthep, the government official in charge of transport during the unrest, expressed his concern about transport and urged the government to investigate new modes of transportation to facilitate future

security situations (Kakizaki 2005, p. 90). Although there is no archival material that directly addresses the choice of the Northeastern Line to Khorat as the first rail line to be constructed, the general consensus in the history community is that the route was chosen based on the area's vulnerability to interrelated unrest of populations in the peripheries and French territorial expansion (Kakizaki 2005, p. 90).

The lines not only terminated in strategically important places, but the routes were also carefully considered. King Chulalongkorn explained in an official communication that the northern route should bypass Tak—an important town for British trade and part of the route in the original British proposal—and the line should go through Phichai.[5] Phichai was of historical strategic importance as a staging area for mounting military campaigns against unrest in the north and northeast. Building the Northern Line became urgent in 1902 with the increasing frequency of rebellions in the north related to the unpopularity of Bangkok's centralization policies that took power out of the hands of local elites. While the Northern Line may have had economic benefits, the impetus for building the line was an urgent need for effective administration in areas that were under tenuous control by Bangkok. In fact, the early railways were referred to as "political railways" in the *Bangkok Times Weekly Mail* newspaper in 1903 due to the political purpose of rail construction rather than economic considerations (Kakizaki 2005, p. 7).

The importance of the early railways in facilitating the implementation of the centralized government administration was recognized early on. W. A. Graham, a former administrator and advisor to the Siamese government, notes that the economic returns to railway investments were still in question, but "[f]or purposes of administration the value of the railways cannot be overrated and, in fact, the present system of rural Government could hardly exist without them" (Graham 1924, pp. 152–3). In support of this point, a recent study by Potjanalawan (2016) found that a notable impact of opening the railway line in the northern town of Lampang was the facilitation of the movement of civil servants originating from Bangkok and other provinces to take up posts within the new centralized administration in Lampang and adjacent Phrae and Nan provinces. Furthermore, Graham (1924, p. 124) notes that areas that did not have rail infrastructure and remained difficult to reach "received nothing at all in the way of social, economic or administrative benefit from the State."

[5] Based on a communication between King Chulalongkorn and Phraya Suriyanuwat in 1903 on France's request to build a railway from Annam to the Khorat Plateau. Referenced in Kakizaki (2005, pp. 83–84).

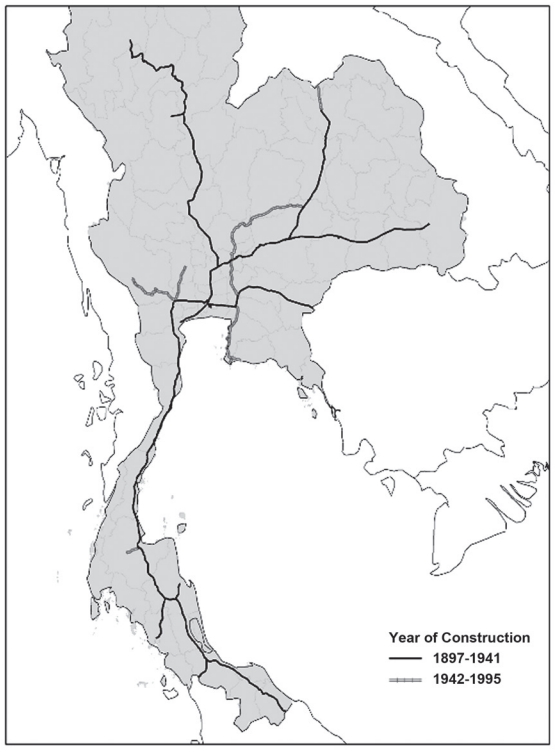

FIGURE 1
RAILWAY NETWORK EXPANSION, 1897–1995

Source: Compiled from Whyte (2010).

Transportation Infrastructure Investment Constraints

Figure 1 depicts the expansion of the railway network between 1897 and 1995, with 1941 marking a clear shift in railway planning from strategic to economic. We observe that the early railway plans originating between the 1880s and 1906 were drafted to facilitate Siam's centralization and guided network expansion up until 1941, when there was no longer a colonial threat and a new masterplan was introduced taking into consideration the economic viability of additional infrastructure development. However, after the initial phase of railway construction between 1897 and 1941, there was relatively little additional expansion of the system, even though large portions of the country remained effectively unconnected. Why did the expansion of the railroad network slow significantly after the three main lines to the northeast, north, and south were (nearly) completed? Railway investment was expensive and financing railway infrastructure in Siam was historically challenging.

Siam's capacity to raise revenues through taxation was constrained on two fronts. First, Siam's decentralized traditional governance system, still in existence in the 1890s, meant that the Bangkok government did not tax the peripheries directly. Hereditary leaders taxed their own populace and often did not forward the required share of taxes to Bangkok, although the process of centralization started in 1892 improved domestic tax collection in the peripheries (Bunnag 1977). Second, Bangkok could not raise significant funds from both internal and external trade because provisions in the 1855 Bowring Treaty with Britain limited import duties to 3 percent and exports could only be taxed once (in other words, inland tax, transit duty, or export duty) (Ingram 1971). The Bowring Treaty became a template for subsequent treaties with other external trade partners, effectively closing off trade as a lucrative source of government revenues. Siam set its own tariffs starting in the 1930s only after it achieved fiscal independence.

Despite challenges in collecting taxes from domestic sources and the restrictions placed on import and export duties, Siam largely avoided taking out foreign loans. Siam's policy to finance capital investment through domestic sources and maintain a balanced budget came out of a desire to remain free of Western interference (Ingram 1971, pp. 189–190, 299). Siam funded all transportation infrastructure investments with government revenues until 1905, including the Northeastern Line to Khorat and the Northern Line to Nakhon Sawan. Spending on railway construction comprised around 10 percent of government expenditures between 1897 and 1920 (Bureau of General Statistics 1933).

Political unrest in the north in 1902 highlighted the need for Siam's government to quickly complete the Northern Line for the purposes of administration. However, Siam could not divert additional resources for railway construction because of its limited fiscal space. With the urgency to complete the Northern Line, Siam's government made an exception to its balanced budget policy and took out two foreign loans for the specific purpose of railway construction in 1905 and 1907. These loans were obtained from British (Hong Kong and Shanghai Bank of London), French (Banque de l'Indo-Chine of Paris), and German (Deutsch-Asiatische Bank of Berlin) sources to maintain political balance (Department of General Statistics, Ministry of Finance 1922, pp. 73, 75). These two loans, other than a forced loan by the British in 1909 to construct the Southern Line that catered towards commercial interests, constitute the only foreign loans taken out by Siam for any purpose during the New Imperialist Era.

Constraints on government spending due to a balanced budget policy and binding treaties that limited fiscal space resulted in the slowing of rail infrastructure expansion after the 1920s, which meant that regions

excluded from the early railway plan would largely remain without basic transportation infrastructure through the 1950s. Only by the 1960s did the country see the beginning of large-scale investments in roads and highways, particularly in areas of the northeast where early railways did not extend. Investments in paved roads outside the central region picked up in the 1960s and accelerated significantly in the 1970s (Kakizaki 2012). The development of Thailand's highway system managed to fill in the gaps left by the incomplete railway network and connect these initially neglected areas with the rest of the country.

MAIN EMPIRICAL ANALYSIS

We estimate the impact of rail infrastructure built during the colonial period on various economic outcomes in 1947. Our analysis focuses on the Northern Line and Northeastern Line, which were constructed out of political urgency to areas that were relatively inaccessible by existing means of transportation.[6] The analysis is at the district (*amphoe*) level and includes districts in the northern and northeastern provinces, as well as the central provinces located north of Bangkok (Ayutthaya, Ang Thong, Lop Buri, Sing Buri, Chai Nat, and Saraburi). Western, eastern, and southern regions are excluded along with Central region provinces to the south of Bangkok since they are not "treated" with the construction of the strategic Northern Line or Northeastern Line. The benchmark year of 1947 is chosen because it comes shortly after the promulgation of a new master railway plan in 1941, which marked the end of railway expansion based on older plans that can be traced directly back to the colonial period. This is also the earliest year for which district-level census data with relevant population and agricultural variables are available for Thailand.[7]

[6] The Southern Line was also an important railway, both politically and economically. The building of the railway line south of Phetchaburi to the Malay Peninsula was initially postponed because of the political urgency of the Northern and Northeastern Lines. Prince Damrong, the Minister of Interior, argued to King Chulalongkorn in 1906 that a southern rail line was not important for administration because of the South's accessibility by sea, but was important for commerce and growing national security concerns at the southern border (Kakizaki 2005, p. 110). It was not until 1909 that construction commenced for both economic and strategic reasons. Although the Southern Line became strategically more important after the turn of the twentieth century, we exclude the Southern Line from our analysis for two technical reasons. First, the southern region was already relatively accessible by sea routes; thus, the railways did not greatly change transport accessibility compared to the north and northeast. Second, the land area in the south is very narrow, which means that there is little variation in access to rails across the southern districts.

[7] In the main analysis, the unit of observation is the district using 1947 administrative boundaries. The supplementary analysis uses 1966 data and administrative boundaries. The analysis from 1947 includes 221 districts, while the 1966 analysis has 312 districts. The disparity is due to many districts being split into two or more smaller districts between 1947 and 1966. All data and replication files can be found in Paik and Vechbanyongratana (2023).

The outcome variables used in the estimations include population density, proportion of land used for rice cultivation, and proportion of land used for garden crop cultivation at the district level. The first outcome variable, population density, is a proxy for urbanization. The next outcome, proportion of land cultivated as rice paddies, captures the impact of railways on integrating parts of the north and northeast into the international trade economy. Given that rice was Thailand's main export crop throughout the twentieth century, expansion of rice cultivation in areas in close proximity to the railways is consistent with the railways facilitating integration of the north and northeast into the world market. Finally, the proportion of land used for garden crops (in other words, perishable vegetable crops) were grown for local consumption and intra-regional trade. The expansion of cultivation of these locally consumed perishable crops would be consistent with the railways facilitating both population growth and intraregional trade.[8]

Siam's census returns constitute some of the only subnational data systematically collected in the first half of the twentieth century. The 1947 census used in this study was conducted according to international standards at the time, although it is believed that the censuses prior to 1960 systematically undercounted the population by 5 to 10 percent (Wilson 1983, p. 25). Das Gupta et al. (1965) note that there were sizeable undercounts in Chiangmai, Mae Hong Son, and Yala provinces in the 1947 census. Given that Chiangmai and Mae Hong Son are both in our dataset, the undercounts in these provinces raise a concern. We check the sensitivity of the main results by using projected population counts for the districts in the two problematic provinces based on the mean population growth rates for northern districts measured between the 1937 and 1947 censuses. The results of this test are reported in Online Appendix A and show that the main econometric results are not sensitive to the apparent undercounting in the two provinces. Thus, we are confident that the results using 1947 census figures are reliable and not biased due to non-random undercounting.

We run the following baseline OLS specification:

$$y = \beta_0 + \beta_1 Dist2Rail + X'\gamma + \delta + \varepsilon \tag{1}$$

The outcome variables, y, are: the natural log of district-level population density; the natural log of the proportion of district land cultivated in rice; and the natural log of the proportion of district land cultivated in

[8] In Online Appendix Table B1, we provide both the data sources and summary statistics.

garden crops in 1947. The variable *Dist2Rail* is the distance in kilometers from a district border to the nearest rail line.[9] Given the underdeveloped state of Thailand's transportation network and few existing connections with the railways in the first half of the twentieth century, we expect that the impact of the railways will attenuate with distance from rail access points. Since we hypothesize that railway access is positively correlated with economic outcomes, we expect the sign of the coefficient on the *Dist2Rail* variable to be negative for every outcome. We also include vector X, a set of district-level geographic controls (longitude, latitude, agricultural suitability, mean elevation, standard deviation of elevation, distance to nearest river, distance to Bangkok, and an indicator for the provincial administrative center), to capture the development potential of a district based on its exogenous geographic characteristics. Finally, δ is a set of provincial fixed effects.

Since 1947 is the first year that population and agricultural outcome data are available at the district (*amphoe*) level, we are unable to analyze trends before and after railway construction. Relying on relevant historical documents, we instead construct an instrument for the railways that helps us establish and test our causal argument. Specifically, we employ an approach similar to other works (Jedwab, Kerby, and Moradi 2017; Berger and Enflo 2017; Atack et al. 2010; Banerjee, Duflo, and Qian 2020) that use the distance to the nearest straight line connecting strategic centers as an instrument for access to railways.[10]

Siam sought to centralize and bring under direct control the northern region (left of Bangkok) and northeastern region (right of Bangkok). The northern region, containing the Kingdom of Chiang Mai, was under the threat of encroachment by the British, while the northeastern

[9] While the distance variable has been widely used in other works on railways, we also acknowledge that proximity to a railway may not necessarily reflect actual access to rails. We offer an alternative measure in the Online Appendix, in which we calculate the distance to the nearest railway station instead. We identify the location of each train station by looking at the endpoints of each recorded railway segment. All the railway stations are shown in Online Appendix Figure B2. Online Appendix Table B2 replicates Table 1 with this measure and we find that the results remain substantively the same.

[10] We argue that the line serves as a good instrument for the following reasons: First, the line closely approximates the actual railway. Railways were built based on many considerations, and one of these considerations would have been finding routes that connect strategic centers in the most efficient, cost-effective way possible. A straight line between two destinations is also the shortest distance between the two, and thus the route, controlling for other factors (such as terrains and rivers), would be the one that minimizes the cost of building. Second, the line satisfies the exclusion restriction requirement. By construction, each line is drawn to connect a pair of strategic centers with the shortest distance possible and gives no consideration to what types of obstacles or surroundings the line may cross between the two destinations. That is, the line is a function of only the relative positions of each destination pair, independent of the destination locations and their surroundings. It thus predicts the outcome variable only through the railways and is uncorrelated with other variables.

region, including Khorat (Nakhon Ratchasima), Nong Khai, and Ubon Ratchathani, was under French threat. In the northern region, Chiang Mai was the strategic center on the outermost periphery. As mentioned previously, King Chulalongkorn also made a strategic decision for the railway to pass through Phichai in Uttaradit province to (1) avoid encroachment by the British, who had a large presence in territories further west, and (2) capitalize on Phichai's historical strategic role as a staging area for military campaigns to the north and northeast. In the northeastern region, there are three strategic cities that are discussed in the historical record. Khorat in Nakhon Ratchasima province was of utmost strategic importance because (1) it was already under some degree of control by Bangkok, (2) it was a gateway to population centers on the Khorat Plateau, and (3) it provided quicker access to frontier areas under threat by the French. Officials also argued that rail access to Nong Khai was needed because, as an area distant from Bangkok and difficult to reach over land, Bangkok struggled to suppress rebellions and other unrest in the area (Kakizaki 2005, p. 89). Finally, although Ubon Ratchathani is a major terminus in the 1906 railway plan, Prince Damrong, the Minister of Interior, delayed its completion due to ongoing French threats just beyond the city. There was concern among government officials that the French would use the line to their own advantage and take over Bangkok (Kakizaki 2005, p. 84). The government only commenced construction of the Ubon Ratchathani line in 1920 when the Northern Line and Southern Line were nearing completion and the French threat of annexing the northeast had declined (Whyte 2010, p. 57).

The resulting straight lines connecting all the strategic centers to Bangkok are illustrated in Figure 2.[11] In mapping the centralization effort that Siam sought via railways, we exclude cross-regional lines. Our instrument is based solely on the lines that represent Siam's response to colonial threats and not commercial interests. Cross-regional lines connecting Phichai to Khorat, for example, would not serve the purpose of directly sending troops and administrative officials from Bangkok to the regions at risk of encroachment. Other cross-regional lines, such as those connecting Chiang Mai to Ubon Ratchathani, Chiang Mai to Nong Khai, or Phichai to Nong Khai, would not be considered viable since they

[11] In drawing these lines, we primarily consider the shortest total distance that connects all the points in each region. This means that, for example, we do not consider an alternative line connecting Nong Khai and Ubon Ratchathani in the northeastern region, since this line (355 km) is longer than the line between Nakhon Ratchasima and Nong Khai (325 km) or one between Nakhon Ratchasima and Ubon Ratchathani (296 km). Based on the shortest total distance approach, Nakhon Ratchasima becomes the center in the region that connects the other two strategic centers (Nong Khai and Ubon Ratchathani) to Bangkok.

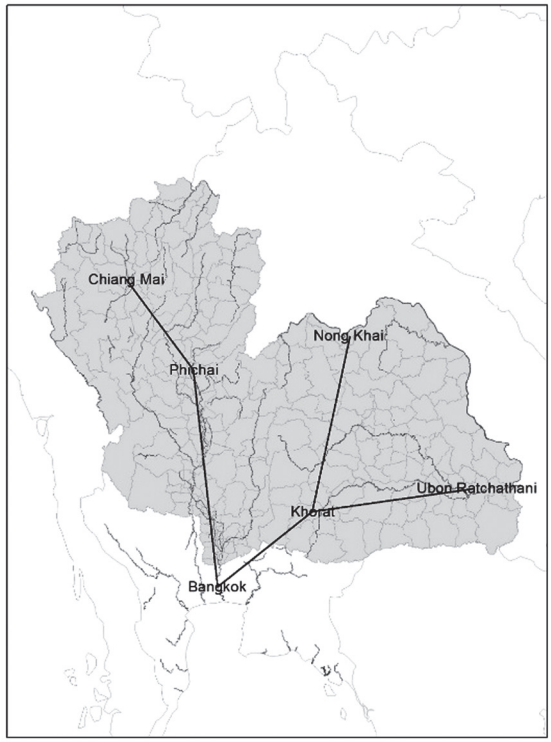

FIGURE 2
STRAIGHT LINES CONNECTING STRATEGIC CENTERS IN SIAM

Source: Background GIS files provided by the Information and Communication Technology Center, Office of the Permanent Secretary, Ministry of Transport (n.d.).

cross over Lao territory. Keeping the number of lines to a minimum also helps us to avoid the possibility of an "overfitting" problem, since more lines would generally mean that districts' proximity to the lines would become closer, such that those further away from a line would, at the same time, be closer to another, making a proximity comparison difficult (Banerjee, Duflo, and Qian 2020).

Our straight-line approach intentionally does not consider any economic or geographic features between strategic centers in order to satisfy the exclusion restriction requirement. Furthermore, the distance to the line can be considered an excludable instrument for the distance to the railroads because it is uncorrelated with other forms of pre-existing transportation infrastructure. Before the railways were built, rivers were the main transport routes in Siam. As seen in Figure 2 (rivers in dark gray), the straight lines tend to cut across the major rivers rather than follow along them. This is especially evident in the lines connecting

Phichai and Chiang Mai, and Khorat and Nong Khai.[12] Finally, one may be concerned that any observables that influence the location selection of the five strategic centers may, in turn, drive our results. We check that our IV results go through after dropping the five districts containing the strategic centers of Chiang Mai, Phichai, Khorat, Nong Khai, and Ubon Ratchathani.

Table 1 presents the OLS results for the 1947 district population density, rice cultivation, and garden crop cultivation outcomes with standard errors corrected for spatial autocorrelation.[13] First, Columns (1) to (4) in Table 1 report OLS estimates on the impact of rail access on the natural log of district population density. The coefficient estimates in both columns indicate that a 10-kilometer increase in distance from the nearest railway reduces population density by 7 percent under the fully controlled specification (Column (4)). Columns (5) to (8) repeat the same exercise for a different dependent variable, the natural log of the proportion of land planted with rice in each district. The results from this analysis are similar to the results for population density: an increase in a district's distance from a rail line by 10 kilometers is associated with around 9 percent lower proportion of land used for cultivating rice under the fully controlled specification (Column (8)). The results are consistent with Kakizaki's (2005) observation based on descriptive evidence that the opening of the railways resulted in increased rice cultivation and trade along the newly established railways.

The third outcome for 1947 is the proportion of land used for garden crop cultivation at the district level. Because of their perishable nature, vegetable crops were traded in domestic markets and not exported abroad. The advent of the railways potentially provided a means to quickly transport perishable goods to markets along the rail lines. The results in Table 1 Columns (9) to (12) show a strong relationship between railway access and vegetable cultivation, with districts further off the railways by 10 kilometers having on average a 13 percent reduction in the proportion of land used for garden crop cultivation under the fully controlled specification (Column (12)). Given that garden crops are generally consumed locally, it is possible that the increased garden crop cultivation near the railways is a function of larger populations that are also located near the

[12] We also include distance to the nearest river as a standard geographic control variable in our regressions.

[13] We use Colella et al.'s (2019) acreg function in STATA to gain standard errors corrected for spatial correlation. Colella et al. (2019) follow Conley (1999) in calculating these standard errors. We chose a distance cutoff of 100 kilometers when calculating the standard errors. Given the historical difficulties of travel, decentralized local control, and ethno-linguistic diversity across Thailand, a 100-km cutoff makes sense in this particular context.

TABLE 1
IMPACT OF RAILWAY ACCESS ON POPULATION, RICE CULTIVATION, AND VEGETABLE CULTIVATION, 1947

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	ln(Population Density)				ln(Proportion of District under Paddy Cultivation)				ln(Proportion of District under Garden Crop Cultivation)			
Distance to nearest rail	–0.010***	–0.009***	–0.008**	–0.007**	–0.013***	–0.011***	–0.009**	–0.009**	–0.019***	–0.017***	–0.014**	–0.014**
	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)	(0.004)	(0.004)	(0.006)	(0.005)	(0.007)	(0.007)
Amphoe muang district		0.439***	0.352***	0.359***		0.358**	0.250**	0.271**		0.767***	0.694***	0.711***
		(0.077)	(0.084)	(0.083)		(0.143)	(0.123)	(0.124)		(0.236)	(0.248)	(0.248)
Longitude			–0.184	–0.485*			–0.356*	–0.823***			–0.662**	–1.104**
			(0.165)	(0.251)			(0.187)	(0.269)			(0.292)	(0.433)
Latitude			0.528***	–0.189			0.613***	–0.487			0.729**	–0.317
			(0.174)	(0.290)			(0.217)	(0.374)			(0.316)	(0.444)
Agricultural suitability			0.022	0.251			–0.161	0.206			–1.775**	–1.432**
			(0.292)	(0.298)			(0.399)	(0.390)			(0.748)	(0.565)
Elevation mean (m)			–0.003***	–0.003***			–0.005***	–0.004***			–0.004**	–0.004**
			(0.001)	(0.001)			(0.001)	(0.001)			(0.002)	(0.002)
Elevation standard dev.			–0.002	–0.001			–0.002	–0.002			–0.005*	–0.005*
			(0.002)	(0.002)			(0.002)	(0.002)			(0.003)	(0.003)
Distance to river (kms)				–0.008**				–0.007***				–0.009
				(0.004)				(0.002)				(0.005)
Distance to Bangkok (kms)				0.008**				0.013***				0.012***
				(0.003)				(0.004)				(0.005)
Provincial fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	221	221	221	221	221	221	221	221	221	221	221	221

Notes: *** p<0.01 ** p<0.05 * p<0.1; standard errors corrected for spatial autocorrelation in parentheses.
Sources: Authors' calculations from dataset compiled from Registration Division, Ministry of Interior (1947), Kakizaki (2012), Whyte (2010), Information and Communication Technology Center, Office of the Permanent Secretary, Ministry of Transport (Thailand) (2002), and Ramankutty et al. (2002). The dataset is described in Online Appendix A.

TABLE 2
IMPACT OF RAILWAY ACCESS ON POPULATION, RICE CULTIVATION, AND VEGETABLE CULTIVATION, 1947 (IV REGRESSIONS)

	(1) ln(Population Density)	(2) ln(Proportion of District under Paddy Cultivation)	(3) ln(Proportion of District under Garden Crop Cultivation)	(4) Distance to Nearest Rail
Distance to nearest rail	–0.006*	–0.009*	–0.014*	
	(0.003)	(0.005)	(0.007)	
Distance to nearest IV (kms)				0.678***
				(0.080)
Provincial fixed effects	Yes	Yes	Yes	Yes
Geographic controls	Yes	Yes	Yes	Yes
N	221	221	221	221
Weak IV test				
Cragg-Donald Wald F-statistic				182.838

Notes: *** p<0.01 ** p<0.05 * p<0.1; standard errors corrected for spatial autocorrelation in parentheses.
Sources: Authors' calculations from dataset compiled from Registration Division, Ministry of Interior (1947), Kakizaki (2012), Whyte (2010), Information and Communication Technology Center, Office of the Permanent Secretary, Ministry of Transport (Thailand) (2002), and Ramankutty et al. (2002). The dataset is described in Online Appendix A.

railways. While this may provide part of the explanation for the positive correlation between railway access and perishable crop cultivation, statistics on railway freight from 1917 to 1934 suggest that garden produce was increasingly transported by train. Garden produce freight transported on the Northern Line and Northeastern Line increased from 2,590 tons in 1917 to 22,130 tons in 1934, with much of the produce originating at and destined for smaller stations rather than Bangkok and major junctions (Department of General Statistics, Ministry of Finance 1922; Division of the Central Service of Statistics 1937).[14] Thus, the rail impact on perishable produce cultivation is likely due in part to better access to regional markets through the rail lines.

Table 2 presents the corresponding set of IV results with all reported specifications, including a full set of geographic controls and provincial fixed effects. We find that the IV estimates for the main variable of interest (distance to the nearest rail) are similar in magnitude to the OLS results. Column (4) in Table 2 also reports the first-stage regression result, which confirms a strong and statistically significant correlation between our IV variable (distance to the nearest straight lines connecting major strategic centers) and the distance to the nearest rail line.

[14] See Online Appendix Figure B3 for rice and garden crop tonnage between 1897 and 1944.

The analysis includes all districts in the north and northeast. Although the routes of the rail lines were largely determined to meet political aims, they still passed through major regional populations and administrative centers (in other words, the *amphoe muang* districts). Since we are concerned that the central districts may drive the results, we exclude these districts from the analysis to see if the results still hold. Columns (1), (4), and (7) in Table 3 report results for a specification that excludes provincial administrative centers. Regardless of whether the *amphoe muang* districts are included or excluded, we find similar results where districts away from the rail lines have lower population density and less area under rice and vegetable cultivation.

Next, considering that the impact of distance from the rail line may be nonlinear, we additionally run the following specification with alternative measures of railway access:

$$y = \beta_0 + \beta_1 2Days + \beta_2 3Days + X'\gamma + \delta + \varepsilon \quad (2)$$

The variables 2*Days* and 3*Days* are indicator variables for districts located between 20 to 40 kilometers (one to two days' overland travel distance) and more than 40 kilometers (more than two days' overland travel distance) from railway access points, respectively. The excluded category is districts located within 20 kilometers from either the Northern Line or the Northeastern Line, or, in other words, located within one day of overland travel distance. These distance cutoffs are based on archival evidence collected by Kakizaki (2005) and indicate that a day's worth of travel in the absence of railways would have covered approximately 20 kilometers over land. Given the lack of road infrastructure, especially in the early period, it is expected that economic impacts of the railways will be most pronounced within a few kilometers of the stations.

The results for the non-linear specification are reported in Columns (2), (5), and (8) of Table 3. For the outcome variable district population density, the coefficient (Column (2)) on the indicator for one to two days' travel distance (20–40 kilometers) from the nearest rail line is –0.305. This means that these districts have, on average, a 26 percent lower population density than those within one day's travel distance (20 kilometers) from the railway. Districts located more than two days' travel distance (40 kilometers) from the rail line have a 41 percent lower population density. These results are consistent with the early railways attracting economic opportunities and urbanization, but at the same time indicate that the economic benefits of the railways were fairly localized. Similarly, the results in Columns (5) and (8) show that the amount of

TABLE 3
IMPACT OF RAILWAY ACCESS ON POPULATION, RICE CULTIVATION, AND VEGETABLE CULTIVATION, 1947
(ALTERNATIVE SPECIFICATIONS)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	ln(Population Density)			ln(Proportion of District under Paddy Cultivation)			ln(Proportion of District under Garden Crop Cultivation)		
Distance to nearest rail	–0.007**		–0.005*	–0.009**		–0.007*	–0.012*		–0.011*
	(0.003)		(0.003)	(0.004)		(0.004)	(0.007)		(0.007)
1 to 2 days' travel distance from rail		–0.305*			–0.307*			–0.539***	
		(0.159)			(0.177)			(0.206)	
More than 2 days' travel distance from rail		–0.536*			–0.639*			–1.562***	
		(0.306)			(0.328)			(0.601)	
Number of years district within 1 day of nearest rail			0.013***			0.011**			0.016**
			(0.004)			(0.005)			(0.008)
Provincial fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Geographic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	179	221	221	179	221	221	179	221	221

Notes: *** p<0.01 ** p<0.05 * p<0.1; standard errors corrected for spatial autocorrelation in parentheses.
Sources: Authors' calculations from dataset compiled from Registration Division, Ministry of Interior (1947), Kakizaki (2012), Whyte (2010), Information and Communication Technology Center, Office of the Permanent Secretary, Ministry of Transport (Thailand) (2002), and Ramankutty et al. (2002). The dataset is described in Online Appendix A.

land devoted to rice and garden crops drop by about 26 and 47 percent, respectively, for districts within one to two days' travel distance from the nearest rail line, compared to those within one day of travel from the rail line. Districts that are located more than two days' travel distance away also have the proportion of land cultivated for rice and garden crops drop by 42 and 79 percent, respectively.

In addition to railway access, one may be concerned that differences in the length of treatment (e.g., gaining railway access in 1897 versus 1941) might matter. In Columns (3), (6), and (9), we include an "exposure to railway" variable. This variable is defined as the number of years from 1897 up until 1942 that a given district had access to a railway within one day's travel distance from its border.[15] According to our estimates, early exposure to rail access by a decade is associated with increases in population density by 13 percent, as well as increases in the proportion of land cultivated for rice and garden crops by 11 and 16 percent, respectively. Accounting for how long a district was exposed to railway access, we also find that the coefficient estimates on the distance-to-rail variable remain consistent with our baseline regressions across different development indicators.

Next, although the historical narrative strongly suggests that the early rail lines were planned primarily for political and not economic purposes, we are still concerned that the routes may have been systematically chosen based on unobservable characteristics correlated to economic outcomes. To alleviate this concern, we run placebo tests based on planned but not completed rail lines, similar to Donaldson (2018). The Thai government proposed additional lines in 1941 to better connect the north and northeast to Bangkok, as well as to connect Siam with neighboring countries (Kakizaki 2012). However, due to budget constraints and the onset of WWII, the lines were never completed. The completed and planned lines as of 1941 are illustrated in Figure 3.[16] We run the regression specification given in Equation (1), but add controls for the distance to two of the government's proposed but never built lines from the 1941 plan. Non-significant coefficient estimates on the planned lines would suggest that there are no systematic unobservable factors driving the placement of railways that could also be driving our main results.

[15] This means that our exposure variable takes values between zero for districts that never gained railway access even by the end of 1941, and 45 (years) for those that gained railway access from the very beginning in 1897.

[16] Although there are four railway lines included in the 1941 plan that largely remained unbuilt, we use only the unbuilt Paklai and Chiang Saen lines for the placebo tests. This is because these two lines cut through areas without existing railways. The excluded lines were already "treated" for much of the planned routes as they were designed to connect existing rail lines.

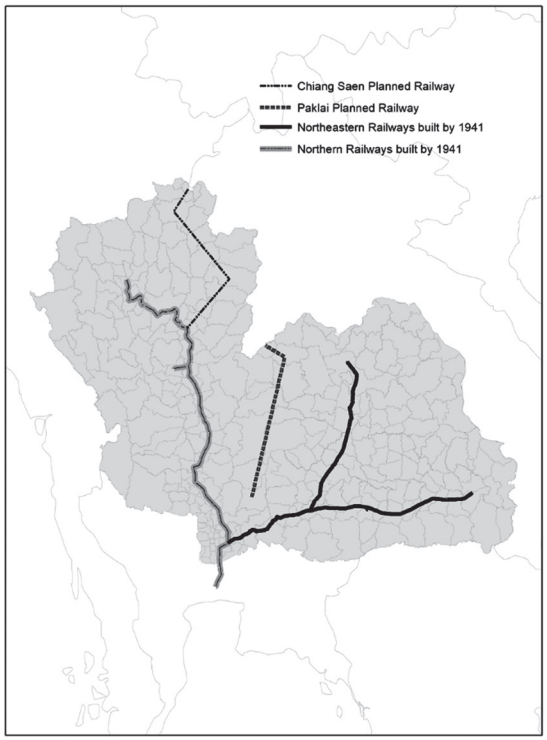

FIGURE 3
PLANNED AND COMPLETED RAILWAYS LINES IN 1941

Sources: Compiled from Whyte (2010) and Kakizaki (2012).

For all three outcomes reported in Columns (1), (3), and (5) in Table 4, the coefficients on the distance variable for the planned Chiang Saen route are not statistically significant or significant with the "wrong" sign. The coefficients on distance from the planned Paklai line reported in Columns (2), (4), and (6) are also not statistically significant. With these additional controls, the sign and magnitude of the railway access variable remains robust. Overall, the placebo tests support our claim that the positive development benefits accrued to districts located on the rail line are due to the presence of the railway and not some other unobservable factors.

Finally, we test whether this positive association between the railways and economic outcomes persists after 1947. In Online Appendix Table B3, we present results for 1966, nearly two decades after the end of railway construction for strategic purposes. While the 1966 Statistical Yearbooks only provide data on population and the area within a district that was harvested for rice, we specifically chose this year as a benchmark because it is during a period of alternative transportation development in the provinces

TABLE 4
PLACEBO TESTS, 1947

	(1)	(2)	(3)	(4)	(5)	(6)
	ln(Population Density)		ln(Proportion of District under Paddy Cultivation)		ln(Proportion of District under Garden Crop Cultivation)	
Distance to nearest rail	–0.008**	–0.007**	–0.010**	–0.009**	–0.016**	–0.012*
	(0.003)	(0.003)	(0.004)	(0.004)	(0.006)	(0.007)
Dist to proposed Chiang Saen Line (kms)	0.003		0.005		0.010*	
	(0.004)		(0.004)		(0.005)	
Dist to proposed Paklai Line (kms)		–0.003		0.000		–0.006
		(0.003)		(0.004)		(0.006)
Provincial fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Geographic controls	Yes	Yes	Yes	Yes	Yes	Yes
N	221	221	221	221	221	221

Notes: *** p<0.01 ** p<0.05 * p<0.1; standard errors corrected for spatial autocorrelation in parentheses.
Sources: Authors' calculations from dataset compiled from Registration Division, Ministry of Interior (1947), Kakizaki (2012), Whyte (2010), Information and Communication Technology Center, Office of the Permanent Secretary, Ministry of Transport (Thailand) (2002), and Ramankutty et al. (2002). The dataset is described in Online Appendix A.

(namely roads and highways), but before the government made systematic efforts to promote regional economic development and structural transformation of the economy in the 1970s and 1980s.[17] We run the same main regressions and placebo tests with the 1966 district population density and proportion of district land harvested for rice as the dependent variables. The results for population and rice harvest in 1966 reported in Online Appendix Table B3 show similar results to what was found in 1947, suggesting that urbanization and rice cultivation as outcomes of rail construction remain persistent. The placebo tests reported in Columns (5) to (8) in Table B3 also show that the coefficients on the distance to planned but unbuilt rail lines are not statistically significant or have the "wrong" sign. Again, these tests suggest that the negative impact of distance from the rail lines on both population and rice are likely not driven by unobservable characteristics driving both railway placement and economic outcomes.

Market Access Calculation and Counterfactuals

How does the economic outcome of the railways compare against the effect of counterfactual spending on other types of investment? Fiscal

[17] Garden crop cultivation statistics are not reported in the 1966 Statistical Yearbooks (National Statistical Office, Office of the Prime Minister, 1966).

constraints meant that King Chulalongkorn had to divert funds from other viable projects to build the railways. One way to assess the net benefit of railways against other investments is to calculate the impact of railways on market access. Following Donaldson and Hornbeck (2016) and Hornbeck and Rotemberg (2021), we create a complete GIS network database for Siam and obtain the least-cost route between each pair of districts.[18] This amounts to finding the routes that would be least costly given the various transportation route options for 166,056 (408 × 407) pairs, considering the cost of transportation via different waterways (rivers, canals, open water), overland (wagons and railways), as well as transshipment costs of changing the mode of transportation. The costs are then used to calculate each district's market access. Market access is defined as the following:

$$MA_S = \sum_d \tau_{sd}^{-\theta} N_d$$

where τ_{sd} is district s's trading cost with district d, θ is the trade elasticity, and N_d is the population in millions in district d. Normalized district-to-district transportation costs can be calculated as τ_{sd} (Hornbeck and Rotemberg 2021):

$$\tau_{sd} = 1 + t_{sd}/P$$

where t_{sd} is the district-to-district transportation cost calculated under the least-cost route between districts s and d, and P is the average price (baht) per ton of transported goods. In our case, P is 91.63 baht per ton, where P is the average paddy price determined by the Customs Department for duty purposes and announced quarterly in the *Royal Gazette* in 1941.[19]

Donaldson and Hornbeck (2016) note that the value of θ depends on the empirical context, and that in the literature it is generally between 3 and 13. When θ is equal to one, this is essentially the "market potential" as calculated by Harris (1954). Given that we do not have district-to-district trade and productivity data in this time period, we are unable to estimate the elasticity measure. We instead take $\theta = 1$ as the benchmark.[20] The market access coefficient estimate is positive and significant under both the population density and proportion of rice paddies as outcome variables, while positive and insignificant under the proportion of garden crops as the outcome under the benchmark case ($\theta = 1$). The coefficient

[18] See Online Appendix C for details on the network database created using GIS and the market access calculation.

[19] *Royal Gazette* Volume 58, pp. 52, 490, 800, and 1,294.

[20] We present results in Online Appendix Table C3 for different values of θ (3 to 13) and confirm that the general finding that more market access leads to more development remains similar.

TABLE 5
OLS COEFFICIENT ON THE MARKET ACCESS VARIABLE AT BENCHMARK TRADE ELASTICITY $\theta = 1$, 1947

	(1)	(2)	(3)
	ln(Population Density)	ln(Proportion of District under Paddy Cultivation)	ln(Proportion of District under Garden Crop Cultivation)
Market access with railways ($\theta = 1$)	0.256**	0.356**	0.209
	(0.125)	(0.180)	(0.270)
Provincial fixed effects	Yes	Yes	Yes
Geographic controls	Yes	Yes	Yes
N	221	221	221

Notes: *** p<0.01 ** p<0.05 * p<0.1; standard errors corrected for spatial autocorrelation in parentheses.
Sources: Authors' calculations from dataset described in Online Appendix A and market distance calculations described in Online Appendix C.

values on the market access variable are statistically significant across the population density and paddy cultivation outcome variables for all values of θ tested, and statistically significant for values of θ exceeding 9 for the garden crop outcome. Since garden crops are consumed locally and are rarely traded across districts, we expect the association between market access (which takes access to even peripheries as beneficial) and garden crops (perishable and thus unsuitable for long-distance trade) to be weaker than between market access and rice. Regardless of the specification, the coefficient values across all outcome variables all remain positive.

The market access coefficient estimates in Table 5 show what we expect: greater market access is associated with higher population density, and a larger percentage of the district under rice cultivation and garden produce cultivation. Next, knowing that more market access is associated with more development, we are interested in how much of the market access change can be attributed to building railways. For this exercise, we can calculate market access under two scenarios: scenario (i) includes the wagon routes and waterways only (MA_d^{NoRail}), and scenario (ii) includes wagon routes, waterways, and railways by 1941 (MA_d^{Rail}). Taking scenario (ii) as the observed benchmark, the difference in market access between the two scenarios ($MA_d^{NoRail} - MA_d^{Rail}$), gives an estimate of decreased market access attributable to the absence of railways for each district. Figure 4 shows the spread of the market access difference; here we find that the difference is the largest in districts that are peripheral and are the endpoints of the Northern Line and Northeastern Line (in other words, Chiang Mai in the north, Udon Thani in the upper northeast, and Ubon Ratchathani in the lower northeast).

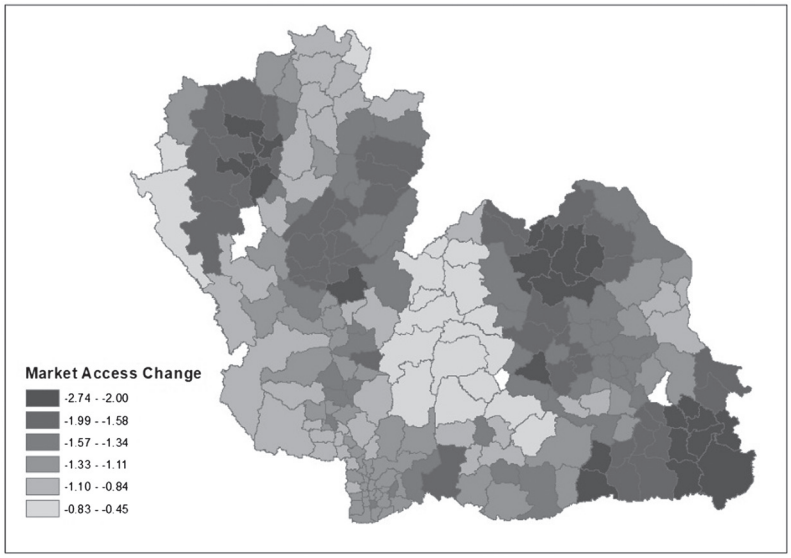

FIGURE 4
MARKET ACCESS DIFFERENCE IN THE ABSENCE OF RAILWAY

Source: Authors' market access calculations as described in Online Appendix C.

Based on the market access coefficient estimates in Table 5, we can also calculate the ratio of the outcome with rails to the outcome with no rails. We find that, on average, an absence of railways would have decreased population density, the proportion of districts planted in rice, and proportion of districts planted in garden products by 30, 39, and 25 percent, respectively.[21]

Next, we use our market access measure to assess the net effect of the positive economic consequences of the railway expansion compared against the counterfactual of expanding Thailand's canal network. As in the case of the United States (Donaldson and Hornbeck 2016), canals were an alternative consideration in Thailand. In 1903, a comprehensive water management plan was submitted to the government for funding

[21] The district-level market access difference is calculated as $(MA_d^{NoRail} - MA_d^{Rail})$. Taking the differences in the market access estimates, multiplying them by each of the coefficient estimates, $\hat{\beta}$, and exponentiating gives the ratio of the outcome with rails to the outcome with no rails:

$$ln\left(\frac{Y_d^{NoRail}}{Y_d^{Rail}}\right) = \hat{\beta}\left(MA_d^{NoRail} - MA_d^{Rail}\right)$$

$$\frac{Y_d^{NoRail}}{Y_d^{Rail}} = exp\left(\hat{\beta}\left(MA_d^{NoRail} - MA_d^{Rail}\right)\right)$$

We then calculate the mean ratio for each outcome across all districts.

consideration by the Ministry of Irrigation's J. H. Van der Heide. The original ambitious proposal had plans for new dams and canals to control water in the Central Plain, the main rice-growing area of the country. The plan expanded the canal network in the water control area with one major new proposed canal running from north to south, originating in Chai Nat and ending in the Gulf of Thailand.[22] The project was tremendously expensive, at a cost of 4 million baht per year, at a time when a total of 3.1 million baht was spent on capital expenditures per year. Given the country's balanced budget policy and reluctance to borrow from abroad, the government ultimately rejected Van der Heide's original plan and subsequent scaled-back plans presented in 1906 and 1908 (Ingram, 1971, pp. 197–198). The government also did not seek foreign financing for this proposal. It is clear that the government made a choice to continue funding railway construction instead of irrigation and canal development in the Central Plain. W. J. F. Williamson, a financial adviser to the Siamese government, wrote: "Before we can think of a great Irrigation scheme we must provide funds for the strategic Railways which are essential if the outlying Provinces are to be properly governed" (Ministry of Finance 1903, as cited in Ingram 1971, p. 197).

In order to estimate the net effect of railways in the northern and northeastern regions of Thailand, we again use the market access (MA_d^{Rail}) under scenario (ii) (wagon, waterway, and railway by 1941) as the observed benchmark and further calculate market access (MA_d^{Canal}) under scenario (iii) (wagon, waterway, and the proposed canal from the 1903 plan connecting Chai Nat to Samut Songkram), and take the difference between the two ($MA_d^{Canal} - MA_d^{Rail}$).

Based on the market access coefficient estimates in Table 5 and the difference in market access ($MA_d^{Canal} - MA_d^{Rail}$), we find that in the counterfactual case where the canal was built, the population density on average would have been 30 percent lower, proportion of land in rice paddies would have been 39 percent lower, and the proportion of land in garden crops would have been 25 percent lower than the observed benchmark scenario with railways. These figures are essentially the same as the previous counterfactual exercise. Although economic historians were previously critical of the relative economic impact of railway versus

[22] Online Appendix C, Table C1, Map 16 shows the main new proposed canal in Van der Heide's plan that did not coincide with existing waterways (Brummelhuis 2005). This canal would have potentially benefited the economy in two ways: an expansion of irrigated farmlands and an increase in market access. However, since the proposed canal was located west of Bangkok in the Central Plain, any benefit of connecting to the irrigation channels were localized to only nearby areas and did not reach the northern and northeastern regions. The only relevant comparison for the northern and northeastern districts in our data, therefore, would be on the changes in market access between building railways and the proposed canal.

water management investment, our analysis suggests that for the northern and northeastern districts in our sample, there would have been very little market access gain from the proposed water management canal that mainly connected areas in the Central Plain.

CONCLUSION

Historical state-building in Thailand and more broadly in Southeast Asia comprised polities that were highly decentralized in nature, with peripheries pledging allegiance and wartime support without the core seeking to directly govern those communities. This traditional Southeast Asian statecraft eventually evolved into modern states as we know them today with fixed geographic state borders under Western colonial threat in the nineteenth century. It illustrates how polities outside of Europe operated historically and became shaped by external threats, adding to the well-established state-building literature based largely on Europe.

The substantive results that we derive in this paper reinforce the scholarship that emphasizes the importance of threat-induced institutional reforms in pre-modern states. The paper shows that these reforms, when internally undertaken by indigenous polities, may not only help to maintain their independence but also result in positive economic benefits similar to cases of infrastructure development under direct colonization. In particular, Siam built its early "political railways" to the north and northeast as a means to achieve centralization and defend itself against progressive territorial encroachment by the French and British colonial administrations. While the earliest railways were built primarily for political purposes, this paper shows that investments in the early railways in the peripheral regions did result in greater economic activity (proxied by population density) and more rice and garden crop cultivation in 1947 due to newly gained railway access. At the same time, the results also suggest that the positive benefits of the railways were relatively localized, likely because of the lack of complementary transportation infrastructure connecting to the rail lines. The results for 1966 show that the earlier positive impacts of the railways on urbanization and rice cultivation remained persistent even with the introduction of the highway network in the 1950s and 1960s.

Our study provides a micro-level example of early centralization efforts in Siam, lending support to Paik and Vechbanyongratana's (2019) argument that colonial threats in the nineteenth century led to long-run uneven economic development across Thailand. The railway expansion was a key initiative that Thailand took to centralize and maintain its sovereignty. In its process, the strategically located regions of north

and northeastern Thailand witnessed urbanization and agricultural development that persisted via direct rail access, arguably at the expense of other regions. The railroad case thus provides additional insight into how external colonial threats and internal reform may have a long-term impact on local economies.

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