# Market Distortion under Weak State: Evidence from China's Millennia-Long Salt Administration *

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**Abstract**

This paper examines the market consequences of weak state capacity through the lens of China's salt administration system—a state-enforced monopoly that endured for over a thousand years. To facilitate tax collection, the state established rigid production and distribution districts that prohibited cross-district trade. We show that this administrative simplification, while strengthening state control, resulted in persistent spatial misallocation and welfare losses. Drawing on novel county-level data on salt production from 960 to 1920 and exploiting temporal variation in salt district boundaries across five dynasties, we find that administrative market access significantly increased the likelihood of local salt production. We then estimate a structural model of a state monopoly choosing production sites under administrative constraints. Counterfactual simulations indicate that removing district restrictions would lower salt prices, boost consumption, and raise fiscal revenue. Production would shift from inland to coastal areas, improving overall efficiency.

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# 1 Introduction

A central question in the political economy of development concerns the origins and consequences of state capacity—the ability of a state to extract revenue, enforce rules, and provide public goods (Besley and Persson, 2011; Fukuyama, 2011; Acemoglu and Robinson, 2012). Among its core dimensions, the capacity to raise revenue through taxation is particularly fundamental. Yet across much of human history—especially in historical societies and contemporary developing contexts—states often face steep constraints: limited information, rudimentary technology, and high monitoring and enforcement costs. In response, many governments, especially those with weak state capacity, have relied on monopolies over essential goods to raise revenues, often through geographic segmentation to establish monopoly power (e.g., France's *pays de grande gabelle* and colonial India's opium belts). While designed to facilitate oversight and tax extraction, these strategies frequently ignored geographic comparative advantage and distorted production incentives. Understanding these economic consequences is crucial for designing effective fiscal policies when state capacity is limited.

This paper examines the market consequences under weak state capacity through the lens of China's salt administration system, a state-enforced monopoly that endured for over a millennium. The empire was divided into exclusive salt production and distribution zones with rigid boundaries that precluded market competition and cross-district trade. These districts were periodically redrawn across dynasties, shaping the spatial organization of salt production for centuries. By using reduced-form evidence and a spatial equilibrium framework, we show that geographic segmentation distorted the spatial distribution of production, lowered consumer welfare, and shaped state revenues. In doing so, we aim to illuminate a broader pattern: while states under weak capacity are limited by their institutional constraints, they actively shape markets through the administrative technologies they deploy.

We begin by providing reduced-form evidence on how administrative salt districting shaped the spatial distribution of salt production. Using a novel panel dataset of county-level salt production from 960 to 1920, we construct a measure of market access, following Donaldson and Hornbeck (2016), which captures a county's potential to reach consumer markets under prevailing salt district constraints. Exploiting temporal changes in salt district boundaries across four major dynastic

regimes, we show that increases in market access significantly raise the likelihood of local salt production. Specifically, a 100% percent increase in market access raises the probability of being selected as a salt site by 15%.

Motivated by this empirical pattern, we develop a spatial equilibrium model in which a state monopolist chooses salt production sites to maximize fiscal profits under administrative constraints. The state government weighed the higher profits from operating salt sites closer to consumers—reducing costly shipping—against the additional fixed costs of establishing those sites. The model allows for substitutability or complementarity between salt sites (e.g. Arkolakis et al., 2023). In the presence of salt districts, shipping across boundaries is prohibited—effectively infinite in cost—mirroring the logic of rigid territorial governance. This setup allows us to examine how boundary changes alter the production potential of each site through its access to markets. In a special case with independent site choices, the model yields a closed-form expression linking site selection directly to market access, which validates our reduced-form strategy.

We estimate the model via simulated method of moments, targeting moments that describe price variation, cost heterogeneity, production quantities, and spatial price gradients. We allow key parameters to vary across salt sources (i.e., sea salt vs. well salt) and validate the model by simulating our reduced-form regression coefficients. The model successfully reproduces the empirical relationship between market access and site selection, confirming its ability to capture the core economic forces at play.

Equipped with the structural model, we perform two counterfactual exercises designed to probe the fundamental institutional features of the system. The first simulates a strong-capacity state, one unconstrained by the need for administratively simple but economically distortive districting, and capable of preserving its monopoly over salt. We retain the monopoly structure but remove geographic segmentation, allowing counties to engage in free trade and letting production site selection be driven purely by efficiency. Eliminating district boundaries reduces the average salt price by 30%, increases consumption by around 50%, and expands both the number (by 9 sites) and average size (by 47%) of production sites. Importantly, we find that salt production reallocates geographically absent salt district boundaries: inland sites decline, while coastal regions expand their output. Fiscal revenues rise by 12%, suggesting that institutional simplification via salt districts imposed a substantial efficiency cost and limited revenue extraction, either because

it lacks the capacity to collect it or because it fails to sustain its monopoly.

In the second counterfactual, we relax the monopoly assumption by introducing Bertrand competition among producers, which further drives down markups and profit margins. As expected, salt prices further fall by 75%, and consumption rises sixfold. However, fiscal revenues decline by 65%, highlighting the trade-off under weak state capacity: geographic segmentation distorts efficiency but secures higher fiscal revenues. The results help explain why monopoly privileges—despite their distortionary effects—were a persistent feature of revenue systems in weak-capacity states.

This paper contributes to literatures on state capacity, spatial misallocation, and state-market relations by offering rare empirical and theoretical insights into how weak institutional environments mediate the geography of economic activity. More broadly, it suggests that the weak-state governance may shape market formation and resource allocation, even in the absence of overt repression or expropriation.

Our study contributes to several lines of research. First, it offers a new approach to quantifying the economic costs of weak state capacity. While the importance of state capacity for development is well established in political economy and development economics (e.g. Besley and Persson, 2010; Acemoglu et al., 2005), empirical efforts to measure its consequences—particularly in terms of spatial misallocation and market distortion—remain limited. We provide systematic evidence of how limited administrative capabilities, manifested through rigid institutions like salt districting, distort production decisions and reduce consumer welfare.

Second, we contribute to the growing literature on market access and economic development, which typically emphasizes geographic and technological determinants of trade costs and connectivity (e.g. Redding and Sturm, 2008; Ahlfeldt et al., 2015; Donaldson and Hornbeck, 2016; Juhász, 2018; Donaldson, 2018; Boehm and Chaney, 2024).[1] In contrast, we highlight a distinct but underexplored mechanism: state–imposed administrative boundaries as a determinant of market access.[2] In many historical and contemporary contexts, particularly under weak or extractive states, market access is not shaped solely by geography or infrastructure, but by politically mo-

[1] See Redding and Rossi-Hansberg (2017) for reviews of recent developments in quantitative spatial models and empirical evidence on the role of market access on economic developments.

[2] Fajgelbaum et al. (2019) show that U.S. state taxes distort individual and firm location choices, leading to spatial misallocation.

tivated or administratively convenient constraints. Our analysis provides empirical evidence on how such administrative market access affects economic geography and efficiency.

Third, our work contributes to the literature on state simplification and institutional legibility, building on the insights of James C. Scott and others in political sociology and historical institutionalism. While this tradition has richly documented how states simplify complex societies to enhance extractive capacity, its economic consequences—especially in terms of distortion and loss—have not been formally modeled or quantified. By embedding simplification into a structural spatial model of production, we bridge qualitative institutional accounts with rigorous economic analysis, offering a framework for assessing the hidden trade-offs of state legibility.

Together, these contributions suggest that the institutions built to make weak states more governable may also make their economies more inefficient—a tension with broad relevance for the study of governance, development, and the design of economic institutions.

# 2 Historical Background

Historically, states have often relied on monopolies over essential goods to raise revenue. Salt, a necessity with relatively inelastic demand, is a canonical example. In China, state control over salt dates back to the 7th century BCE, when rulers asserted authority over the "goods of the mountains and seas," which included salt. Over the centuries, the salt tax became a major fiscal pillar. During the Qing dynasty (1644–1911), for example, it contributed around 17% of total tax revenue, making it the second largest source after the land tax (Ni, 2017).[3]

This section provides a brief history of China's salt monopoly, focusing on its institutional design. In particular, we examine how the state implemented the monopoly through market segmentation—via salt districts—its licensing system, and the selection of production sites.

## 2.1 Salt Monopoly via Spatial Segmentation

China's imperial salt monopoly lasted for over a millennium, from the Tang dynasty (618 CE) to the early 20th century. In the early Tang, the state attempted to directly manage production,

[3]Revenue from the salt monopoly was critical for funding military expenditures and sustaining the extravagant lifestyles of the imperial elite.

distribution, and sales without regional salt districts. This approach quickly ran into two major obstacles. First, the government lacked the capacity to gather reliable information on output and costs at production sites, limiting its control over production. Second, it lacked the manpower to oversee distribution from salt sites to markets.[4] Together, these weaknesses led to pervasive leakage of salt into private trade, preventing the state from establishing an effective monopoly to extract substantial fiscal revenue.

The formal establishment of a systematic salt monopoly came with Liu Yan's reform in the mid-Tang dynasty and later refined during the Song dynasty. At the core of this system were *salt districts*, which divided the empire into exclusive territorial units, each with tightly regulated rights of production and distribution. Salt could be traded only within district boundaries, and cross-district trade was strictly prohibited. The establishment of salt districts addressed the challenge of information gathering. For example, in the early Qing period, each district was assigned a salt-site inspector (often referred to as an "ambassador"), who conducted on-site visits and reported monthly to the transportation commissioner—the official overseeing salt production. Inspectors monitored compliance with state-imposed output quotas, seeking to prevent both underproduction and illegal salt production.

The second challenge—monitoring transport and sales—was addressed through the licensing system, developed alongside the salt districts. The state delegated monopoly rights to merchant groups in each salt district via licenses (*yan yin*). These licenses issued by the state granted exclusive rights to purchase and sell salt within its district, with specified destination markets and official prices. In exchange, merchants were required to remit taxes upfront, transforming a fiscal burden into a commercial opportunity. Merchants then oversaw distribution to consumers, operating through a three-tiered system: wholesalers (*gang shang*) sold to distributors (*shui ke*), who in turn supplied local retailers (*zi dian*). Prices at the retail level were fixed by the government. This arrangement enabled the state to secure revenue in advance and reduce monitoring costs.

The effectiveness of the licensing system in sustaining the monopoly crucially depended on the existence of salt districts. Without spatial segmentation, the state lacked the capacity to

[4]Direct state control often relied on unpaid compulsory labor and prisoners for salt production and transport. However, anecdotal evidence suggests desertion was widespread, with escape rates in some cases exceeding half of those assigned.

assign quotas and prices consistent with merchant incentives, and to curb illegal trade.[5] In such conditions, merchants had strong incentives to deviate, making salt leakage into private markets inevitable and driving the system toward competition. By confining trade within districts, however, the state could better align quotas and prices with merchant interests, while concentrating enforcement at district borders, thereby reducing personnel needs to limit illicit flows.

### 2.2 Selection of Salt Sites

Understanding how salt sites were chosen within the framework of salt districts is central to our analysis. We focus on three types of salt production that were under tight state regulation: sea salt, well salt, and lake salt.[6] Sea salt was mostly produced in coastal regions of eastern and southeastern China; lake salt production was concentrated in northwest China; and well salt was primarily produced in southwestern inland regions, especially Sichuan province.

The selection process is highly regulated by the state. Local governments first identified potential sites and submitted their proposals to the state government, who approved the final list. The choices of salt sites was shaped not only by natural endowments—such as coastlines or underground brine—but also by the institutional geography of salt districts, which determined the market size each site could serve. Anecdotal evidence suggests that district boundaries significantly influenced the opening and closure of sites. Our empirical results further demonstrate that markets structured by salt districts played a key role in shaping these decisions.

## 3 Data

We construct a novel county-level panel dataset of salt production across a millennium, from 960 to the 1920s. Our main empirical analysis uses data across four Chinese dynasties from Song (960–1270), Yuan (1271–1368), Ming (1368–1644), and Qing (1644–1911). We extend coverage to the Republic of China era in the 1920s to incorporate market price and production quantity data

[5]Most illegal salt originated from official production sites, where producers secretly exceeded the licensed quota and diverted the surplus to markets offering higher prices relative to production costs. The transport and sale of such salt were strictly prohibited, and those caught faced severe penalties, often including execution.

[6]Other types of salt include earth salt and rock salt, but these had very small production scales and were under loose state control.

to estimate our structural model.[7]

## 3.1 Salt Production

We digitize the list of salt production sites across four dynasties from Ji (2013), *The Distribution and Evolution of Salt Production Sites in Ancient China*, which compiles information from historical government records, local gazetteers, and traditional geographical works. The dataset documents approximately 1128 salt sites operating from Song to Qing dynasty.[8] To locate these sites, we manually match historical place names to modern online maps to identify their geographic coordinates, and then then assign them to counties using the China Historical Geographic Information System (CHGIS, 2016).[9] This procedure allows us to construct a county-level indicator that records whether a county engaged in salt production in a given dynasty, defined as the presence of at least one documented site.

We consider this dataset to be both comprehensive and reliable. Salt production was a state monopoly subject to strict government regulation. Each site required government approval and was assigned a unique registration number with ongoing oversight, ensuring systematic official record-keeping. One caveat is that our dataset excludes private salt production that escaped official documentation. However, historical evidence suggests such operations were negligible relative to total output, minimizing any bias to our analysis.

Our main sample for the empirical analysis comprises 6,425 county–dynasty observations across four dynasties.[10] Among them, 354 counties (about 20 percent) engaged in salt production at some point. The number of operating sites varied substantially over time, ranging from 86 in the Yuan dynasty to 218 in the Qing, reflecting broader economic and political conditions such as wartime disruptions. Production was highly dynamic: many counties experienced entries and exits. Table 1 documents these dynamics. Of the 204 counties producing salt in the Song dynasty, more than 134 ceased during the Yuan, leaving only 60 that operated continuously across all four dynasties. By contrast, 73 counties entered during the Qing despite no prior record of production. Figure 1

[7] Appendix Table A.4 provides a detailed description of data sources.

[8] We exclude salt production outside the China proper region, as the salt district and provincial institutions were not enforced in those regions.

[9] To ensure compatibility across years, we fix county boundaries to those in 1911 when borders varied over time.

[10] The empire expanded over time, so the number of counties in our sample increased: 1,556 in the Song, 1,595 in the Yuan, and 1,637 in both the Ming and Qing dynasties.

(blue dots) display the spatial distribution of the salt sites in each dynasty.

## 3.2 Salt Districts

Salt districts were a central component of the monopoly system, defining the counties to which each production site could sell. These boundaries were redrawn in every dynasty. To reconstruct them, we compile district maps from multiple historical sources: Guo (1990) for the Song, Zhang (2009) for the Yuan, Liu (1996) for the Ming, and Zhang (1920) for the Qing. The number and names of districts varied: the Song maintained 14, the Yuan 11, the Ming 12, and the Qing 10. For consistency, we harmonize the salt districts across dynasties and align their boundaries with county borders as of 1911. District size differed markedly both across and within dynasties. In the Qing, for example, Fujian encompassed 53 counties with a population of about 12.65 million, whereas Lianghuai covered 301 counties and roughly 114 million people. Table A.1 lists the districts and their covered counties in each dynasty.

We also incorporate provincial boundaries from Hartwell (2015), which jointly shaped the salt market. The literature documents substantial barriers to interprovincial trade, often rooted in political disputes. Figure 1 illustrates the salt district boundaries (red lines) and provincial boundaries (brown lines) across the four dynasties.

## 3.3 Market Access

To capture the role of salt districts in determining salt site selection, we construct a market access measure based on the set of counties each site could serve. Following Donaldson and Hornbeck (2016), the market access for county $i$ in dynasty $t$ is

$$MA_{it} = \sum_{j \in S_{i(j)t}} \frac{N_{jt}}{d_{ij}^{\theta}}, \tag{1}$$

where $N_{jt}$ is the population of county $j$, $d_{ij}$ is the bilateral trade cost, and $S_{i(j)t}$ denotes the salt district containing counties $i$ and $j$. Importantly, two counties must locate in the same district, as cross-district trade was prohibited. To reflect costs associated with interprovincial trade, we further restrict the two counties to be in the same province.

County-level population is constructed using prefecture-level estimates from Ge (2000), assuming uniform population distribution within each prefecture. While Ge (2000) provides population data for multiple years from 980 to 1910, we select four benchmark years—1078, 1290, 1580, and 1820—based on data quality and approximately even temporal spacing.[11] County population in the Republic era come from Stauffer (1922). In addition, we construct county-level crop suitability as an instrument for population using the index from Galor and Özak (2015, 2016). These indices provide calories at $5'$ by $5'$ grid resolution for Pre-1500CE and Post-1500CE periods, which we apply to Song-Yuan and Ming-Qing dynasties, respectively.

To measure bilateral trade costs, we use two measures. First, we calculate bilateral great-circle distance, which is computationally straightforward but may not reflect topographical complexities. Second, we use the human mobility index minimum cost distance following Özak (2010, 2018). This index provides 1 $km \times$ 1 $km$ grid-level estimates of potential minimum travel time, accounting for human biological constraints and geographical and technological factors that affected pre-industrial travel times. Figure C.2 shows that these two measures are highly correlated, while the relationship weakens with as distance increases.

## 3.4 Additional Data

We extend our sample to the Republic era in the 1920s to leverage rich data of price and quantity to estimate our structural model. Unlike earlier periods (Song through Qing dynasties), where price and quantity data are largely unavailable, we digitize these data in the 1920s from *Salt Affairs Yearbook* (Salt Affairs Bureau (1929)), a statistical publication compiled by the National Government Ministry of Finance, a key body in state-controlled salt monopoly during the Republic era.[12] Our data includes county-level salt prices and site-level production data. For each salt site, we observe total output in *Dan* (approximately 50 kilograms) and average production costs in *yin yuan* (silver coins).

To control for regional characteristics and ensure comparability across counties, we include fixed effects for macro-regions as defined in Skinner et al. (2013).[13] We also measure local land

[11] A prefecture is an administrative region encompassing multiple counties.

[12] Qing dynasty records contain some price data but suffer from quality concerns and limited county coverage.

[13] Skinner et al. (2013) divides the core of China into nine macro–regions: Northeast China, North China, Northwest China, Upper Yangzi, Middle Yangzi, Lower Yangzi, Southeast Coast, Lingnan, and Yungui.

productivity using the average caloric suitability of each county, based on the crop suitability index described above. In addition, we construct county-level geographical characteristics from the CHGIS maps, including distance to the coastline, elevation, and river counts. Finally, as a robustness check, we incorporate data on historical mine production from Xia et al. (1980).

# 4 Reduced-Form Effects of Salt Districts

To investigate the impacts of imposing salt districts on salt production, we use a market access approach, following Donaldson and Hornbeck (2016), which exploit variations in county population and, importantly, boundary changes across dynasties.

## 4.1 Empirical Specification

We relate changes in the markets a county could serve—driven by shifts in salt district boundaries and summarized by the market access term—to whether the county engage in salt production. We begin by estimating the following regression:

$$Salt_{it} = \alpha \ln MA_{it} + \mathbf{X_{it}}\beta + \mu_i + \nu_t + \varepsilon_{it}, \tag{2}$$

where $i$ indexes county and $t$ indexes dynasty. The outcome variable $Salt_{it}$ is a dummy variable that is set to one if county $i$ has at least one salt site in operation in dynasty $t$. The main explanatory variable is the logarithm of market access, where the market access $MA_{it}$ is given by Equation (1). The parameter of interest is $\alpha$, capturing the effect of market access on the choice of salt production. We include county fixed effect ($\mu_i$) and dynasty fixed effect ($\nu_t$) to control for permanent heterogeneities across counties such as natural salt resources and aggregate economic conditions which may affect the site operation. We also include a vector of control variables, including macroregion–dynasty trend defined by Skinner et al. (2013), local agricultural productivity times dynasty dummies, and other geographical features including elevation, distance to the coastline and number of rivers times dynasty dummies. Standard errors are clustered at the county level.

The key identification assumption is that, after adding fixed effects and control variables, the

market access is uncorrelated with unobserved county-dynasty-specific shocks. In the next section, we use an instrumental variable approach to address potential endogeneity issues.

The first four columns in Panel A of Table 2 shows that larger market access is associated with a larger probability of a county engaging in salt production. After controlling for a rich set of fixed effects and control variables, column (4) reports an estimated coefficient on log market access at 0.0149, indicating that a 100 percent increase in market access leads to a 1.5 percentage point increase in the likelihood of salt production. Given an average probability of a county has salt production around 15 percent, this estimate can be translated into a 10% increase.

**Robustness checks.** We consider two sets of robustness checks. First, Panel B shows that our results are robust to alternative constructions of market access. Column (1) uses the minimum cost distance constructed from human mobility index of Özak (2010, 2018), which accounts for terrain conditions as well as distance in measuring trade costs. Column (2) implements a leave-out measure that excludes county $i$ itself. We also explore different values of the trade cost elasticity in $d_{ij} = \text{distance}_{ij}^{\theta}$, which we set to 1 in our baseline. Specifically, column (3) uses $\theta = 1.9$ following Barjamovic et al. (2019) that study trade and city locations in Bronze Age Assyria, and column (4) uses $\theta = 3.8$ following Donaldson (2018) for British India. The estimated effect of market access remain robust across all these alternative measures of market access.

Second, Panel C confirms that our results robust to the set of counties in our sample. Column (1) restricts the sample to counties within 200 kilometers of salt-producing counties, while Column (2) limits it to provinces that ever produced salt. Column (3) focuses on coastal provinces where sea salt was produced. Column (4) uses a balanced panel. We obtain similar estimates across these samples.

**Placebo tests.** We conduct placebo tests using production of other mines. One concern is that market access might be correlated with factors such as transportation improvements that simultaneously increase population and salt production. To address this, we test whether our salt-based market access measure predicts the production of other mines, which were also under strict state control. In Panel D, we replace the dependent variable with dummies for iron, copper, gold or silver, and any of these productions in columns (1)–(4). In all cases, the coefficients on

salt-based market access are close to zero and statistically insignificant, confirming that our results are not driven by common shocks affecting mining more broadly.

## 4.2 Instrumental Variable Approach

A potential concern is reverse causality; namely, salt production may itself attract population. In addition, unobserved factors such as improvements in transportation might simultaneously affect both population growth and salt production.

To address these concerns, we implement an instrumental variable (IV) strategy using exogenous variation in the crop suitability index (CSI) following the Columbian Exchange. The Columbian Exchange introduced New World crops to Eurasia, boosting agricultural productivity. In a Malthusian context—where advancements in agricultural technology mainly translate into larger populations—we use the resulting changes in crop suitability as an exogenous predictor of population growth. The change in crop suitability indices between the pre-1500 and post-1500 periods is calculated following the methodology of Galor and Özak (2015, 2016). We define the Song and Yuan dynasties as the pre-1500 period and the Ming-Qing dynasties as the post-1500 period.

Our instrument replaces population with CSI in the construction of market access, which is then used to predict market access in the first stage. The IV regression takes the same form as Equation (2):

$$Salt_{it} = \alpha \widehat{\ln MA_{it}} + \mathbf{X_{it}}\beta + \mu_i + \nu_t + \varepsilon_{it}, \tag{3}$$

where $\widehat{\ln MA_{it}}$ is the predicted value obtained from the first-stage regression:

$$\ln MA_{it} = \gamma \ln MA_{it}^{CSI} + \mathbf{X_{it}}\eta + \mu_i + \nu_t + \varepsilon_{it}. \tag{4}$$

Table 3 reports the IV results. Column (1) reproduces the baseline estimates. Column (2) presents the first-stage estimates from Equation (4), showing that CSI is strongly correlated with population, with an F-statistic of 43.2. The IV estimate in column (3) is 0.0827, indicating that a 100% increase in market access is associated with a 8.3 percentage point higher probability

of salt production. Finally, column (4) reports the reduced-form regression of the salt dummy directly on CSI-based market access, yielding a coefficient of 0.029. These results confirm that our baseline findings are not driven by confounding factors affecting both population growth and salt production.

### 4.3 Decomposing Effects of Population vs. Salt Districts

Changes in market access arise from two sources: shifts in district boundaries and changes in population within destination markets. To isolate these two effects, we decompose market access into (1) market access based on Song CSI and time-variant boundary, and (2) market access based on time-variant CSI and Song boundary. The former captures the boundary change, and the latter captures the CSI change. The within-grid standard deviation of boundary-driven market access is 0.50, while that of CSI-driven market access is 0.10, which suggests that the over-time variation of market access is mainly driven by the boundary change.

Table 4 reports the decomposition results. As shown in columns (1)–(3), we find that changes in both salt district boundaries and crop suitability have a strong influence on salt production. A one-standard-deviation increase in boundary-driven market access leads to a $0.7 = 0.014 \times 0.5$ percentage points increase in the probability of salt production, and a one-standard-deviation increase in CSI-driven market access leads to a $0.8 = 0.08 \times 0.1$ percentage points increase in the probability of salt production.

Taken together, the reduced-form evidence shows that, under limited state capacity, the administrative system of salt districts so as to achieve monopoly strongly shaped whether a county produced salt. By prohibiting trade across districts, these boundaries, however, may have distorted production decisions and reduced efficiency. In the next section, we develop a quantitative model to assess the equilibrium costs of these distortions.

## 5 Model

To quantify the costs of imposing salt district boundaries arising from limited state capacity, we develop a model in which the government selects the locations for salt production, subject to the restriction that salt can only be traded within designated salt districts.

We model the government as a vertically integrated monopolist in the salt sector. Accordingly, we abstract from merchants and treat distribution as internal to the state monopoly. There are $K$ markets and $N$ potential salt sites. The government selects a set of sites to maximize total profits subject to the demand from each market.

## 5.1 Demand

In each market $k \in \{1, 2, \cdots, K\}$, there exists a continuous mass $N_k$ of identical consumers. Individual demand for salt follows a log-linear inverse demand function:

$$\log \bar{q_k} = -\sigma \log p_k + \sigma \log b, \tag{5}$$

where $p_k$ and $\bar{q_k}$ denote the price and quantity of salt, respectively; $\sigma > 1$ is the absolute value of demand elasticity; and $b > 0$ is a demand shifter capturing factors other than price, such as consumer preferences. Aggregating across consumers, total market demand in $k$ is given by

$$\log q_k \equiv \log(\bar{q_k} N_k) = -\sigma \log p_k + \sigma \log b + \log N_k \tag{6}$$

While we assume that the demand elasticity and shifter are constant across markets within a salt district, we allow these parameters to vary across different types of salt.

## 5.2 Production of Salt

State government chooses a set of salt sites $S \subseteq \{1, 2, \cdots, N\}$ to produce salt and ship it to all destination markets.We solve the government's problem backwards. We first describe the government production decision given its salt site choices, and we then go back and solve the optimal site choice problem.

**Production technology.** Salt is produced using a constant-return-to-scale production technology with brine as the sole input. We abstract away from labor, due to lack of data on labor and wages. Any cross-location wage differences will be absorbed by local productivity, which determines the local production cost.

The government supplies salt to market $k$ with a continuum of shipments that together sum to $q_k$.[14] For each shipment $(\omega)$, the government draws a vector of productivities from each salt site it chooses to open, $\mathbf{z}(\omega; S) = \{z_s(\omega)\}_{s\in S}$. We assume that $z_s(\omega)$ is i.i.d. across salt sites and shipments, and follows Fréchet distribution with shape parameter $\theta$ and scale parameter $T_s$ which depends on local condition: $P(z_s(\omega) \leq z) = e^{-(z/T_s)^{-\theta}}$.

The supply of brine is perfectly elastic, with price normalized to one and same across salt sites. The unit cost of production for shipment $(\omega)$ at salt site $s$ is then given by $1/z_s(\omega)$. Shipping from salt sites to destination markets incurs an iceberg type of shipping costs. Let $\tau_{ks}$ denote the amount needed to be produced for one unit of salt to reach market $k$ from salt site $s$. Therefore, for each shipment $(\omega)$, the unit cost of producing salt in site $s$ and ship it to market $k$ is

$$c_{ks}(\omega) = \frac{\tau_{ks}}{z_s(\omega)}, \quad s \in S. \tag{7}$$

**Government's problem given a set of salt sites.** Suppose the government had chosen a set of salt sites $S \subseteq \{1, 2, \cdots, N\}$. For each destination market $(k)$ and shipment $(\omega)$, the government chooses the site among its many salt sites that has the lowest cost to serve that market. Therefore, the actual cost of serving market $k$ for shipment $\omega$ is $c_k(\omega; S) = \min_{s\in S} c_{ks}(\omega) = \min_{s\in S} \frac{\tau_{ks}}{z_s(\omega)}$. Given i.i.d. Fréchet draws for $z_s(\omega)$ across salt sites, we can integrate $c_k(\omega; S)$ over $\omega \in [0, 1]$, yielding the unit cost of *all shipments* given by[15]

$$c_k(S) \equiv \int_0^1 c_k(\omega; S)d\omega = \Gamma(1 + 1/\theta)\Phi_k(S)^{\frac{-1}{\theta}}, \tag{8}$$

where

$$\Phi_k(S) = \sum_{s\in S} T_s^\theta \tau_{sk}^{-\theta} \tag{9}$$

is the production potential of salt to market $(k)$, summarizing the technology of the salt sites the government chooses to operate, and shipping costs from those sites to the market.

[14] Without loss of generality, we can assume the shipment $\omega \in [0, 1]$ such that $q_k = \int_0^1 Q_k(\omega)dj$. The quantity of shipment is pre-determined and not responding to productivity shocks.

[15] $\int_0^1 c_k(\omega; S)d\omega = \int_0^\infty cdF(c)$, where $F(c) = 1 - e^{-c^\theta \Phi_k(S)}$. Denote $t \equiv c^\theta \Phi_k(S)$, and then we can write the integral as $\Phi_k(S)^{\frac{-1}{\theta}} \int_0^\infty t^{\frac{1}{\theta}} e^{-t} dt = \Gamma(1 + 1/\theta)\Phi_k(S)^{\frac{-1}{\theta}}$.

With cross-district trade prohibited, shipping costs across districts are effectively infinite. A county's production potential therefore depends solely on salt sites within its district. Imposing salt districts limit the salt sites available to the market, reducing its production potential, and increasing the unit cost of salt.

Government chooses the quantity and price of salt for each market to maximizes its profits, subject to the demand given by Equation (6). With a constant demand elasticity, the markup is constant and is equal to $\frac{\sigma}{\sigma-1}$. The gross profit from market $k$ is given by

$$\pi_k(S) = \frac{\sigma^{-\sigma}}{(\sigma-1)^{1-\sigma}} b^\sigma N_k c_k(S)^{1-\sigma}. \tag{10}$$

The share of shipments, sales, and profit of market $k$ produced at salt site $s$ are equal to its contribution to the production potential, given by

$$\eta_{sk}(S) = \frac{T_s^\theta \tau_{sk}^{-\theta}}{\Phi_k(S)} = \frac{T_s^\theta \tau_{sk}^{-\theta}}{\sum_{s\in S} T_{s'}^\theta \tau_{s'k}^{-\theta}}. \tag{11}$$

**Choice of salt sites.** Operating a salt site incurs a fixed cost of operation ($f_s$). We assume that this fixed cost is measured by the amount of brine, the price of which is normalized to one. The government chooses a set of salt sites to maximize its total profits from all markets, net of the fixed costs:

$$\max_{S\in\mathcal{P}(\{1,2,\cdots,N\})} \sum_{k=1}^{K} \pi_k(S) - \sum_{s\in S} f_s, \tag{12}$$

where $\mathcal{P}(\{1,2,\cdots,N\})$ is the power set of all sites. With salt districts, the government can determine site choices independently for each district, which reduces the dimensionality of the problem.

## 5.3 Equilibrium

An equilibrium is a vector of salt prices, $\mathbf{p} = \{p_1,\cdots,p_K\}$; a vector of salt quantity, $\mathbf{q} = (\{q_1,\cdots,q_K\}$; and a set of salt sites the government chooses, $S$, such that

(i) $\mathbf{p}$, $\mathbf{q}$ and $S$ solve the government profit maximization problem;

(ii) The salt market clears for each market $k$.

## 5.4 Special case: $\sigma = \theta + 1$

We consider the special case where the demand elasticity satisfies $\sigma = \theta + 1$, with $\theta$ denoting the shape parameter of the Fréchet distribution. In this case, the demand expansion from lower prices exactly offsets the cannibalization effect of an additional salt site. Consequently, the decision to operate a site is independent across sites. The gross profit from market $k$ can then be written as

$$\pi_k(S) = \sum_{s \in S} \kappa_k N_k T_s^{\theta} \tau_{sk}^{-\theta} \tag{13}$$

where $\kappa_k \equiv \frac{\sigma^{-\sigma}}{(\sigma-1)^{1-\sigma}} b^{\sigma} \Gamma(1 + 1/\theta)^{1-\sigma}$ is a constant. The government's location choice becomes

$$\max_{S \in \mathcal{P}(\{1,2,\cdots,N\})} \sum_{s \in S} \left( \sum_{k=1}^{K} \kappa_k N_k T_s^{\theta} \tau_{sk}^{-\theta} - f_s \right). \tag{14}$$

Notably, the location decision for each salt site is separable. The government operates site $s$ whenever its total gross profit exceeds the fixed setup cost:

$$\sum_{k=1}^{K} \kappa_k N_k T_s^{\theta} \tau_{sk}^{-\theta} - f_s > 0. \tag{15}$$

Reorganizing the terms, we can get that

$$\underbrace{\sum_{k=1}^{K} \kappa_k \frac{N_k}{\tau_{sk}^{\theta}}}_{MA_s} > \frac{f_s}{T_s^{\theta}}. \tag{16}$$

The left-hand-side term corresponds to the market access term ($MA_s$) defined in the reduced-form analysis. The reduced-form regression directly tests this inequality—specifically, whether an increase in market access raises the probability of operating a salt site.

Our structural model extends beyond this special case by allowing for either complementarity or substitutability among salt sites. In particular, we estimate the $\sigma$ and $\theta$, along with other model parameters, to account for these interactions. This flexibility is crucial when conducting counter-

factual exercises that quantifies the economic cost of imposing trade boundaries by simulating an economy in which all all boundaries are removed and free trade across salt districts are permitted.

# 6 Estimation

We estimate the model using rich data from the Republic era in the 1920s. The dataset covers eight salt districts with information on population, salt prices, and salt sites' production quantities and costs.[16] There are 1301 counties (i.e., markets); 372 potential salt sites, 105 of them are active in the 1920s, and 28 of them are always active throughout the history.[17]

We allow most model parameters to vary by the type of salt produced and consumed in a district: one is sea salt, either through solar evaporation or boiling, and the other is well salt.[18] Among the eight salt districts, seven produces sea salt, while the Sichuan district produces well salt. Appendix A.3 provides further details on the distribution of production methods across districts.

## 6.1 Parametrization

**Demand parameters ($b$ and $\sigma$)** We allow the demand shifter $b$ and demand elasticity $\sigma$ to differ between sea salt districts versus well salt districts. This distinction is motivated by underlying differences in consumer preferences across regions. In particular, well salt districts, such as Sichuan, are characterized by humid climates, which historically shaped local tastes for saltier and spicier foods. In contrast, coastal regions relying on sea salt generally experienced milder climates and developed different culinary traditions and salt consumption patterns.

**Local productivity of salt production ($T_s$ and $\theta$)** We assume that the average productivity of each salt site—captured by the scale parameter of the Fréchet distribution ($T_s$)— is drawn iid from a log-normal distribution, $\log N(\mu^T_{method}, \sigma^T_{method})$. Both the mean and dispersion parameters are allowed to differ between sea salt and well salt districts. Appendix Figure A.3 Panel (B) shows

[16] Specifically, we include the Changlu, Shandong, Lianghuai, Liangzhe, Fujian, and Sichuan salt districts.

[17] The potential salt sites are those that were active at any point from Song dynasty through the Minguo period in the 1920s.

[18] Among the three major types of salt production—sea salt, lake salt, and well salt—we pool sea and lake salt, which share similar evaporative technologies and geographic settings, and treat well salt separately.

that these two types of regions display substantial differences in cost distributions, supporting this modeling choice.

The shape parameter of the Fréchet distribution ($\theta$) is assumed to be the same across all districts. This assumption allows us to simulate the model when trade barriers are removed between salt districts, as it ensures a closed-form solution for the minimum cost serving each market. Nevertheless, we estimate the model for seawater and well-water separately and find that the estimated $\theta$'s are similar for the two types of regions.

**Fixed costs of operating salt sites ($f_s$)** We assume that these fixed costs are drawn i.i.d. from an exponential distribution with inverse mean of $\lambda^f_{method}$. If a site is active throughout the history, its fixed cost is set to zero.

**Trade costs ($\tau_{sk}$)** We assume that trade costs are log-linear in the distance between the salt site and the destination county; that is

$$\log \tau_{sk} = \beta^{\tau}_{method} \log \text{distance}_{sk}, \tag{17}$$

where $\beta^{\tau}_{method}$ represents the elasticity of trade costs with respect to distance and is allowed to vary by salt type. In particular, the Sichuan district, which relies on well salt production, features a rugged, mountainous terrain that poses greater obstacles to transportation compared to the flatter coastal regions where sea salt is produced. These geographic differences likely resulted in higher and more rapidly increasing trade costs with distance in Sichuan, justifying a separate elasticity parameter.[19]

## 6.2 Method of Simulated Moments

Table 5 summarizes the 13 parameters for estimation. We estimate these parameters using the method of simulated moments. Denote the vector of parameters by $\phi = (\boldsymbol{b}, \boldsymbol{\sigma}, \theta, \boldsymbol{\beta^{\tau}}, \boldsymbol{\mu^{T}}, \boldsymbol{\sigma^{T}}, \boldsymbol{\lambda^{f}})$, where $\boldsymbol{x} = [x_{sea}, x_{well}]$. Denote the data moments by $m$, and the model simulated moments by

[19] We normalize the distance by the average distance from a salt site and its home county, approximately 18.2 kilometers.

$\hat{m}(\phi)$. The estimate $\hat{\phi}$ minimizes the following criterion function:

$$f(\phi) = [m - \hat{m}(\phi)]' W [m - \hat{m}(\phi)], \tag{18}$$

where we use the identity matrix as the weighting matrix.

**Moments** We use the following five sets of moments by salt type for estimation.

(i) The share of active salt sites. These extensive margins help us identify the mean of fixed cost of operating a salt site $\lambda^f$.

(ii) The average and dispersion of log quantity produced at each salt site. The average quantity is pinned down by local demand shifter $b$. The larger the magnitude of $b$, the larger the quantity. Additionally, the dispersion in site-specific quantities can reflect the dispersion in local productivities $\sigma^T$. The larger the dispersion in local productivities, The larger the dispersion in quantity. Here, the identification idea is similar to the conventional approach of estimating $T_s$ in the international trade literature by using the share of imports to estimate local productivities.

(iii) The average of log cost at each salt site. We assume that the observed cost reflects the variable cost, which helps pin down the average local productivity $\mu^T$.

(iv) The average and dispersion of log price across markets. Given the average productivity that pins down the marginal cost, the average price identifies the markup, which is in turn determined by the demand elasticity $\sigma$. In particular, the price is equal to a constant markup $(\frac{\sigma}{\sigma-1})$ over the marginal cost. The dispersion in price, together with other moments, further pins down the shape parameter of the Fréchet distribution $\theta$. A larger $\theta$ implies a smaller dispersion in the productivity draws, and thus sites become closer substitutes. Therefore, the dispersion in price and quantity is greater.

(v) The regression coefficient of log market price on log inverse of distance $(\log(\sum_{s \in S} \text{distance}_{sk}^{-1}))$. This moment identifies the trade elasticity $\beta^\tau$. The larger the magnitude of the coefficient, the larger the trade elasticity.

**Simulation** For each salt site, we draw two random shocks from a uniform distribution. One shock is transformed into a log-normally distributed fixed cost ($f_s$), and the other into a log-normal distributed average productivity ($T_s$). The realized fixed cost and productivity depend on the type of salt produced at the site. To ensure that our simulated moments are not sensitive to any particular set of random draws, we simulate 200 independent economies using different random seeds and compute the moments as averages across these simulations.[20]

**Estimation results** Table 5 reports the estimates for the two types of salt districts, respectively. The estimated demand shifter ($b$) is larger in Sichuan district, indicating a strong taste towards salt consumption. This estimate stems from the fact that the salt consumption per capita in Sichuan is comparable to that in other districts despite the price is much larger. The estimate of demand elasticity $\sigma$ is 1.264 for districts consuming sea salt, which can be translated into a markup of $479\% = 1.264/(1.264-1) \times 100\%$. The high markup stems from the large difference between the average cost and price: the average log cost in sea salt districts is approximately $-0.4$ and the average log price there is 1.84. On the other hand, the demand elasticity is estimated at 5.236 for Sichuan district. This estimate can be translated into a markup of $124\% = 5.236/(5.236-1) \times 100\%$. This relatively smaller markup reflects the smaller difference in price and cost in Sichuan.

The dispersion in local Fréchet draws is estimated to be 7.790, which is greater than $\sigma - 1$ for both types of districts. This implies that salt sites are substitutes rather than complements. The opening of an additional salt site will lead to reduction in sales of existing sites. This result is consistent with the nature of salt as a largely homogeneous good, where production in one location does not necessarily lower the cost of production in another location.

The trade elasticity with respect to distance in Sichuan district is almost twice as big as that in other districts. These estimates are consistent with the premise that transportation costs in mountains are larger than those in plains.

The estimate of the average log local productivity in sea salt districts is higher than that in the Sichuan district. The large difference in local productivity stems from the fact that the average cost is much lower in sea salt districts. It is also consistent with the fact that the variable cost

[20] Appendix Figure C.3 plots the simulated moments against the number of economies used to compute the averages. The x-axis indicates the number of simulated economies, each based on an independent random seed, while the y-axis reports the corresponding average moment. The figure shows that the simulated moments converge to stable values as the number of economies approaches 200.

of producing salt using seawater, especially through evaporation, is lower than that by extracting and boiling well water. Despite the high average log productivity, those districts have a smaller dispersion in the productivity compared to the Sichuan district.

The estimates for the inverse mean of fixed costs are larger in Sichuan district than those in other districts, implying a smaller average fixed cost there. These estimates stem from the fact that, despite the high variable cost, 27 out of 103 potential well salt sites (26%) are still operating. In comparison, 78 out of 269 potential sea salt sites are operating (29%). The fixed costs paid to operate salt sites are approximately 1.68% of the gross profits (before subtracting the fixed costs). This share is around 0.31% for sea salt regions and 5.26% for well salt regions.

**Targeted and untargeted moments** Table 6 compares the model-simulated and data moments. Overall, the model does a good job in matching the number of active salt sites at the extensive margin, as well as the distribution of prices, quantities, and costs.

Additionally, Table D.1 breaks down the number of active salt sites by salt district. In estimation, we do not target those numbers by district but only the total number of active salt sites in sea salt districts and well salt district. Therefore, the number of active sites by district are untargeted. However, the model predicts well the the openings in each district, which reassures that the distributions in sea salt districts do not differ substantially and that our model is a good approximation of those districts.

## 6.3 Model Validation

With the estimates in hand, we validate the model by simulating changes in salt district boundaries across dynasties and replicating the reduced-form regression specified in Equation (2). Specifically, we feed in the model two key changes: (i) the salt district affiliation of each salt site, imposing an infinite trade cost for shipments across district boundaries, and (ii) the population associated with each market. For each dynasty $t$, we solve the government's location choice problem to determine whether a given salt site is in operation. Since we construct moments by averaging over 200 simulations, the salt site opening measure reflects a probability—specifically, the share of simulations in which a site is predicted to be active. To mirror the reduced-form analysis, we map the salt site operation to the county level and define $\text{SaltProbability}_{it}$ as the probability that

county $i$ has at least one active salt site in dynasty $t$. Using the full set of simulated site openings across all periods, Figure 3 presents a binscatter that groups counties by their model-simulated probability of opening (x-axis) and plots the corresponding share of those sites that are open in the data (y-axis). The model-simulated probabilities are highly correlated with the data, with a correlation of 0.78, indicating that the model predicts salt site openings well despite not targeting them in estimation.

We also compute the reduced-form market access measure for each county $i$ in dynasty $t$, defined as $MA_{it} = \sum_{j \in S_t} \frac{N_{jt}}{d_{ij}}$, where $S_t$ is the salt district to which county $i$ belongs, $N_{jt}$ denotes the population of county $j$, and $d_{ij}$ is the distance between counties $i$ and $j$. This construction mirrors that of the reduced form; the only difference is that in the model, we normalize the smallest distance to one.

We then estimate the following reduced-form regression:

$$SaltProbabilty_{it} = \alpha \ln MA_{it} + \mu_i + \nu_t + \varepsilon_{it}, \tag{19}$$

where $\mu_i$ and $\nu_i$ are county and dynasty fixed effects, respectively.

Table 7 column (1)–(2) compares the regression coefficients generated by model simulations with the corresponding reduced-form estimates. The model implies that a 100% increase in market access raises the probability of a county to have salt production by 0.011 percentage points. Given the average simulated probability of site opening is 0.063, this estimate can be translated into a 17.5% increase, comparable to the 15% increase from the reduced form.

Columns (3)–(4) use the salt-site-level probability of operation as the dependent variable and regress it on salt-site-specific market access. The model-simulated coefficients closely match their reduced-form counterparts. These results provide reassurance that the model captures the key determinants of salt production decisions.

# 7 Quantifying Costs of Weak State Capacity

Limited state capacity to enforce tax collection and curb illegal salt consumption led to the creation of salt districts, prohibiting cross-boundary trade. We use our model to quantify the economic

costs of such governance choice. To this end, we first compute a counterfactual economy with strong state capacity, where government can effectively collect taxes and preserve its monopoly even without salt districts. In this setting, counties are free to source salt from all active sites, including those outside their original district.[21]

**Cross-district trade.** Absent of salt district boundaries, the share of county $k$'s salt sourced from other districts is

$$\eta_{k\leftarrow\text{other}} = \frac{\sum_{s\in S^{\text{other}}}(T_s/\tau_{sk})^\theta}{\sum_{s\in S^{\text{own}}}(T_s/\tau_{sk})^\theta + \sum_{s\in S^{\text{other}}}(T_s/\tau_{sk})^\theta}, \tag{20}$$

where $S^{\text{own}}$ denotes salt sites within $k$'s district and $S^{\text{other}}$ those outside. The denominator reflects the new production potential, which previously excluded the second term since cross-district trade was prohibited. Notably, $S^{\text{own}}$ may differ from the original set of sites, as the government re-optimizes site choices under free trade. The import share is given by the contribution of salt sites in other districts to this new production potential.

Table 8 presents the trade flow patterns across districts after boundary removal, with columns representing destination districts and rows representing origin districts. For instance, the first column shows that approximately 55% of salt consumed in Changlu is sourced locally, 21% from Shandong, 10% from Lianghuai, and so forth. The reduction in local sourcing varies dramatically across districts, ranging from 11 percentage points in Liangguang (from 100% to 89%) to 78 percentage points in Sichuan (from 100% to 22%). These differences in local sourcing reduction are driven by the average productivity of local salt sites. Districts with low productivity sites experience larger increases in sourcing from other districts.

Which districts have lower-productivity sites on average? Our analysis reveals that districts with larger populations tend to have sites with lower productivity and higher fixed costs. To understand this pattern, consider the special case where $\sigma = \theta + 1$ and a salt site operates if $MA_s \geq f_s/T_s^\theta$. Districts with larger populations generate higher market access for salt sites, enabling them to support sites with relatively higher $f_s/T_s^\theta$ ratios—that is, sites with higher

[21] Since we estimate trade elasticities separately for sea salt and well salt districts, we need to make an assumption on the shipping costs between the well-water district and sea salt districts. In our baseline, we apply the well-water estimate to these shipments, implying relatively high trade costs. As a result, the gains from removing boundaries (or the costs of imposing them) should be viewed as a lower bound.

fixed costs and lower average productivity. Figure C.3 confirms this positive relationship between conditional log fixed costs (scaled by local productivity) and log reduced-form market access.

**Price and consumption.** Table 9 shows substantial variation in price reductions across districts, reflecting differences in the gains in trade. Particularly, districts with low productivity sites benefit most. Among all districts, the Sichuan district (i.e., the well-water district) experiences the largest gains following the removal of district boundaries: the average county-level price in Sichuan falls by 60%, and total salt consumption increases by 236%. These large effects are driven by Sichuan's unique production method—well water extraction—which entails much higher production costs compared to sea salt districts. In the baseline with district boundaries, the average price in Sichuan is approximately 0.64 log points higher than in other districts ($= 2.49 - 1.85$). Once cross-district salt trade is permitted, counties in Sichuan gain access to cheaper salt from sea salt districts, leading to substantial price reductions and increased consumption. The average county-level price falls by 30%, while aggregate consumption increases by 47%.

**Reallocation of production.** Salt production reallocates geographically from less productive districts, especially inland areas, toward more productive ones in coastal regions. Column (3) in Table 9 shows that, on the extensive margin, the number of salt sites declines in Lianghuai and Sichuan while increasing in other sea salt districts, with Liangguang alone seeing an increase of 10 sites. On the intensive margin, average output per site likewise falls in Lianghuai and Sichuan while increasing elsewhere. Overall, higher demand leads to a net increase in total sites.

Column (5) shows that sales follows a similar pattern. local sales within the district falls and sales to other districts increase. the net change in sales depends on the relative magnitude of these two forces. overall sales increases while it shifts from less productive to more productive districts.

**Fiscal profits.** As shown in column (6), profit changes exhibit substantial variation across districts, ranging from a 48% decline in Lianghuai to a 102% increase in Fujian. these profit changes reflect the interplay between reduced local sales and increased sales to other districts. Moreover, although sales to Sichuan generate sales increase, the profits may fall because it has a higher demand elasticity which leads to a lower profit ratio over sales. For instance, Lianghuai experiences a large drop in local sales, leading to substantial profit reduction. Although sales to

other districts, particularly to Sichuan, this increase does not generate proportional profit gains. On net, Lianghuai sees a 48% profit reduction. In other districts, on the other hand, see profit increases. For instance, Liangguang experience 102% profit increase due to mild local sales drop and strong sales growth to other districts. Total profits, which form the effective tax base for state government, increase by 12% when salt district boundaries are removed.

In sum, these results highlight the economic costs of limited state capacity. In the counterfactual, where the state can effectively collect taxes and maintain its monopoly, fiscal profits rise and salt districts would not be imposed. It is precisely the lack of capacity that gives rise to salt districts. Relative to this counterfactual, imposing salt districts creates misallocation of salt production, raises prices, reduces consumption, and lowers fiscal profits.

## 7.1 Role of State Capacity

The government's decision to forgo free trade, despite its potential to raise fiscal profits, indicates that the associated losses must be even larger due to limited state capacity. To shed light on the trade-offs government faces, we compute another counterfactual under weak state capacity.

We assume the government retains the authority to designate salt production sites but, due to lack of capacity to fully control the distribution, no longer holds monopoly power to set prices. Instead, following Bernard et al. (2003), we assume that salt sites compete à la Bertrand. Counties continue to source from the lowest-cost site with the same probability as before. The pricing rule, however, changes: the lowest-cost site sets its price equal to the cost of the second-lowest site, thereby charging a smaller markup. The salt price index for county $k$ is thus given by

$$\tilde{p}_k(S) \equiv \left( \int_0^1 p_k(\omega; S)^{1-\sigma} d\omega \right)^{\frac{1}{1-\sigma}} = \frac{\gamma}{\Gamma(1+1/\theta)} c_k(S), \tag{21}$$

where $\gamma = \left[ \frac{1+\theta-\sigma+(\sigma-1)(\sigma/(\sigma-1))^{-\theta}}{1+\theta-\sigma} \Gamma\left(\frac{1+2\theta-\sigma}{\theta}\right) \right]^{1/(1-\sigma)}$ and $c_k(S)$ is the unit cost of all shipments defined in Equation (8). Our calibrated model shows that markups under competition, $\frac{\gamma}{\Gamma(1+1/\theta)}$, are substantially lower than the monopoly ones, $\frac{\sigma}{\sigma-1}$. The decline is especially pronounced in sea salt districts, where markups fall from 4.79 to 1.21, while in well-water districts they drop from 1.24 to 1.04. Consequently, the profit share of revenue falls from $\frac{1}{\sigma}$ under monopoly to $\frac{1}{\theta+1}$ under

competition. This creates offsetting effects on total profits: lower prices stimulate demand and sales, but reduced markups compress profit margins, leaving the net effect theoretically ambiguous.

Table 10 reports the relative changes when salt district boundaries are removed under weak state capacity. Compared with the strong–state scenario, three salient differences arise. First, columns (1)–(2) show that competition further drives down prices, with an average decline of 75%, and increases consumption nearly sixfold. Although the overall trade patterns resemble those in the strong–state case, the distribution of price reductions differs.[22] Previously, price declines were proportional to the share of salt sourced from other districts, implying that less productive regions such as Sichuan benefited the most. Under competition, however, Sichuan experiences the smallest price decline. This arises because the reduction in markups is substantially larger in sea salt districts than in well-water districts.

Second, the surge in demand is met almost entirely along the intensive margin as shown in columns (3)–(4): output per site rises sharply, while the extensive margin contracts slightly, with the total number of operating sites falling by two. Some sites exit because competition compresses profit margins to the point where continued operation is unprofitable. Thus, only the most productive sites survive. Nonetheless, the pattern of geographic reallocation—shifting production from inland to coastal areas and from less to more productive districts—remains broadly similar to the strong–state scenario.

Third, profits reflect the interplay between expanded sales and diminished profit margins. The calibrated model indicates that profits fall across all districts, with an aggregate decline of 65%. Sichuan experiences the smallest loss, supported by sales growth and only a modest reduction in markups. In contrast, several sea salt districts, such as Lianghuai, incur the largest profit declines, as sharp reductions in markups coincide with small or negative sales growth.

The loss in profits underscores the trade-off government faces under weak state capacity. Imposing salt districts raises price and suppresses consumption, but it also increases fiscal profits, which explains why weak states adopt such strategies despite their distortionary costs. The implications for consumer welfare are ambiguous: while higher prices reduce consumer welfare, the additional fiscal revenues may be deployed toward the provision of public goods that benefit households.

[22]Table D.2 shows the trade share across salt districts after removing salt district boundaries and introducing Bertrand competition across salt sites.

# 8 Conclusion

This paper highlights how state efforts to strengthen control through administrative simplification can generate persistent economic distortions. Using China's historical salt monopoly as a case study, we show that rigid administrative boundaries—designed to enhance tax collection—limited market integration and led to significant spatial misallocation. Our structural analysis reveals that these constraints have reduced overall efficiency and led to welfare losses. These findings underscore the trade-off between state control and market efficiency, particularly in contexts of weak state capacity.

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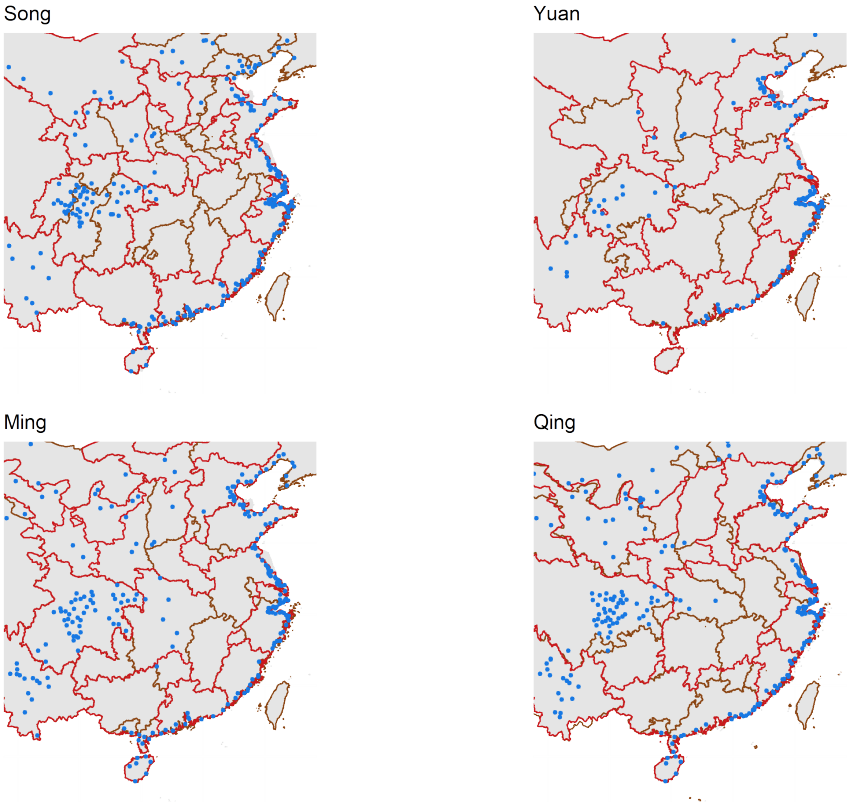
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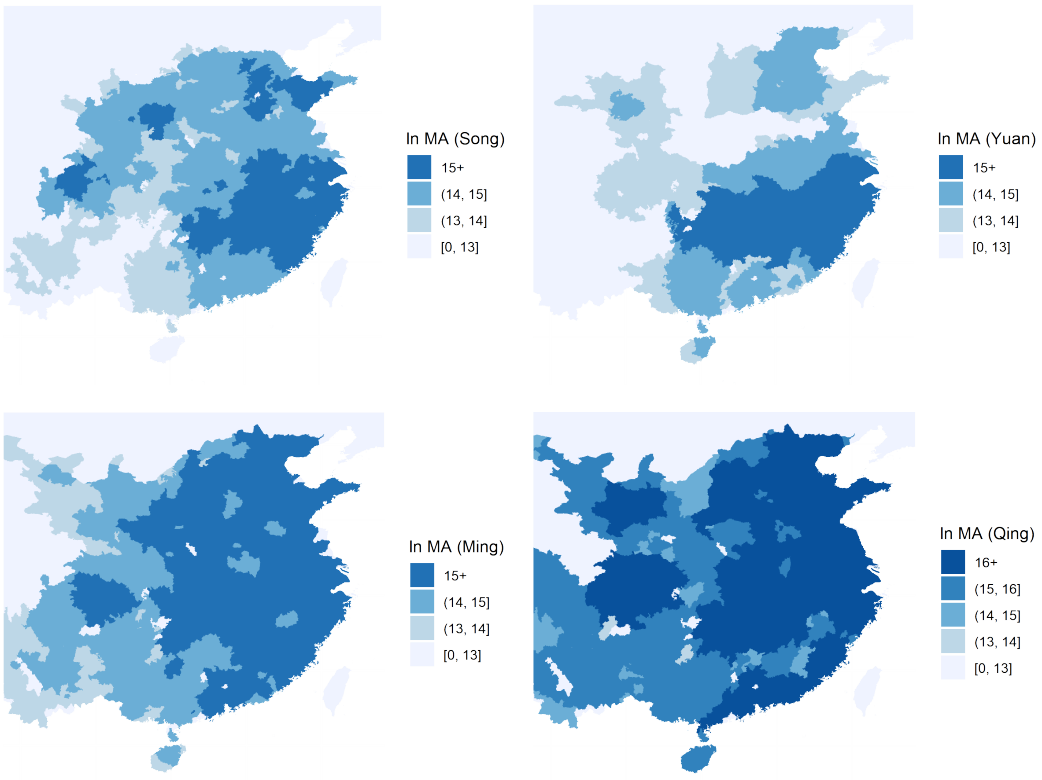
# Figures

Figure 1: Salt Sites and Administrative Boundaries Across Four Dynasties



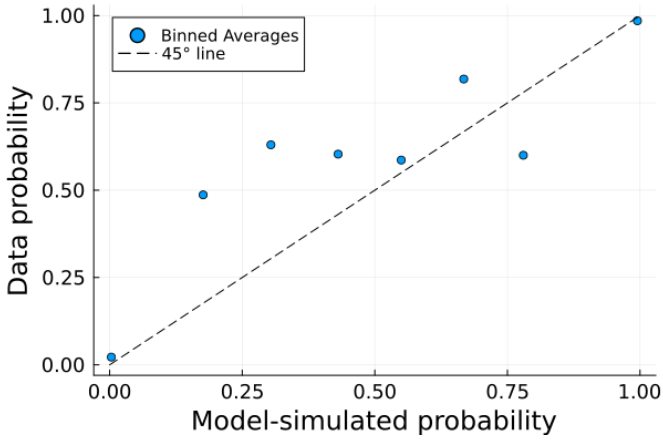

Note: This figure displays the location of salt sites (blue dots), salt district boundaries (red lines), and provincial boundaries (brown lines) across the Song, Yuan, Ming, and Qing dynasty.

Figure 2: Market Access Across Four Dynasties




Note: This figure displays the geographic distribution of market access across the Song, Yuan, Ming, and Qing dynasty. We calculate the market access using county population and great-circle distance between county pairs.

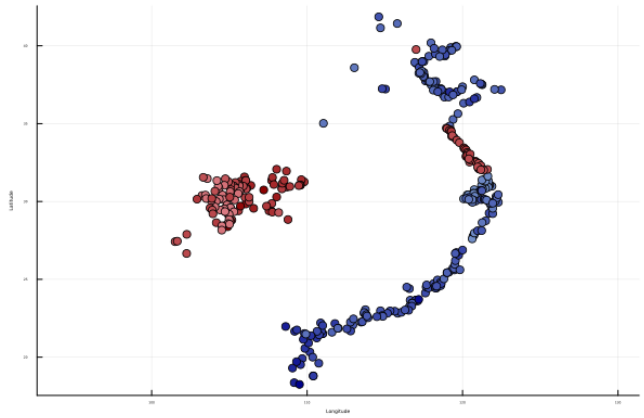
Figure 3: Binscatter Plot of the Site Opening Probability in Data and Model



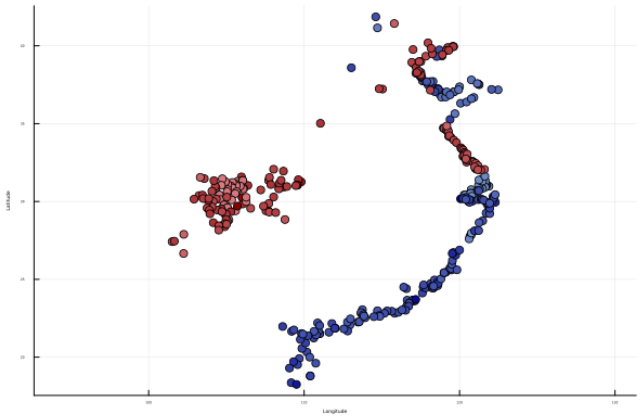

Notes: This figure displays a binscatter using the full set of simulated site openings across all periods. Counties are grouped by their model-simulated probabilities of opening on the x-axis, with the corresponding share of open sites in the data plotted on the y-axis.

Figure 4: Removal of Salt District Boundaries: Changes in Salt Production and Profits

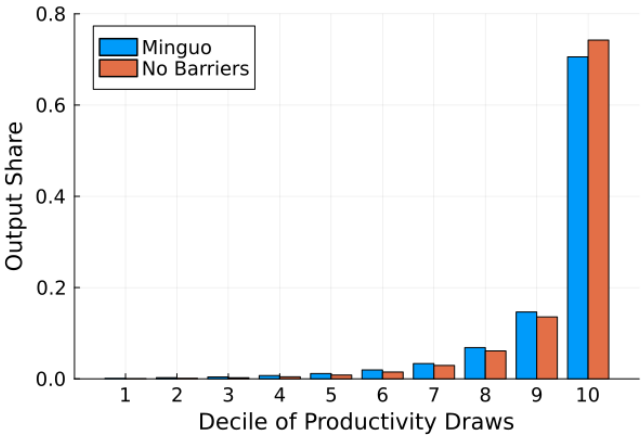
(A) Changes in Production Quantity: Location



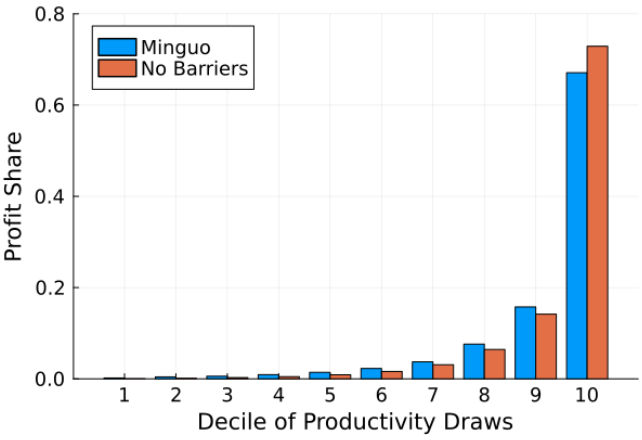
(B) Changes in Profits: Location



(C) Changes in Production Quantity: Productivity




(D) Changes in Profits: Productivity




Notes: These figures show changes in salt sites after removing salt district boundaries. Panel (A) and (B) depict geographic changes in production quantity and profit, respectively. Blue indicates increases, and red indicates decreases, with darker shades representing larger magnitudes—darker blue for larger increases, and darker red for larger decreases. Panel (C) and (D) shows the share of output and profits accounted for by salt sites in each decile of productivity distribution. Blue bars correspond to the 1920s, and orange bars correspond to the counterfactual in which salt boundiers are removed.

# Tables

Table 1: Opening and Closure of Salt Production

| All | Song | Yuan | Ming | Qing |
|---|---|---|---|---|
| 1650 | 204 | 70 | 67 | 60 |
| | | | | 7 |
| | | | 3 | 1 |
| | | | | 2 |
| | | 134 | 52 | 35 |
| | | | | 17 |
| | | | 82 | 18 |
| | | | | 64 |
| | 1446 | 16 | 12 | 9 |
| | | | | 3 |
| | | | 4 | 0 |
| | | | | 4 |
| | | 1430 | 61 | 22 |
| | | | | 39 |
| | | | 1369 | 73 |
| | | | | 1296 |
| Total Salt | 204 | 86 | 192 | 218 |

Note: This table displays the opening and closure of salt production from Song to Qing dynasty. The numbers in blue correspond to the count of salt-producing counties, while the numbers in black correspond to the count of counties without salt production.

Table 2: Market Access and Salt Production

**A. Baseline results.**

Dependent Variable: Salt dummy

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| ln MA | 0.016*** | 0.015*** | 0.015*** | 0.015*** |
| | (0.004) | (0.004) | (0.004) | (0.004) |
| County FE | $Y$ | $Y$ | $Y$ | $Y$ |
| Dynasty FE | $Y$ | $Y$ | $Y$ | $Y$ |
| Macroregion×Dynasty Trend | | $Y$ | $Y$ | $Y$ |
| Crop Suitability×Dynasty FE | | | $Y$ | $Y$ |
| Geo. Features×Dynasty FE | | | | $Y$ |
| R-square | 0.652 | 0.658 | 0.658 | 0.659 |
| N | 6,404 | 6,404 | 6,404 | 6,404 |

**B. Robustness: alternative market access**

| | HMI Dist | Leave-out MA | $\theta = 1.9$ | $\theta = 3.8$ |
|---|---|---|---|---|
| ln MA | 0.014*** | 0.006*** | 0.013*** | 0.007** |
| | (0.004) | (0.002) | (0.004) | (0.003) |
| County FE | $Y$ | $Y$ | $Y$ | $Y$ |
| Dynasty FE | $Y$ | $Y$ | $Y$ | $Y$ |
| Baseline Controls | $Y$ | $Y$ | $Y$ | $Y$ |
| R-square | 0.659 | 0.659 | 0.659 | 0.659 |
| N | 6,404 | 6,404 | 6,404 | 6,404 |

**C. Robustness: different samples**

| | 200km | Salt Prov. | Coastal Prov. | Bal Panel |
|---|---|---|---|---|
| ln MA | 0.011** | 0.011* | 0.009** | 0.014*** |
| | (0.004) | (0.006) | (0.004) | (0.004) |
| County FE | $Y$ | $Y$ | $Y$ | $Y$ |
| Dynasty FE | $Y$ | $Y$ | $Y$ | $Y$ |
| Baseline Controls | $Y$ | $Y$ | $Y$ | $Y$ |
| R-square | 0.654 | 0.657 | 0.553 | 0.658 |
| N | 5,556 | 4,660 | 4,290 | 6,186 |

**D. Placebo tests using other types of mines**.

Dependent variable: production dummy

| | Iron | Copper | Gold/silver | Mine |
|---|---|---|---|---|
| ln MA | 0.004 | 0.001 | 0.005 | 0.005 |
| | (0.005) | (0.003) | (0.005) | (0.007) |
| County FE | $Y$ | $Y$ | $Y$ | $Y$ |
| Dynasty FE | $Y$ | $Y$ | $Y$ | $Y$ |
| Baseline Controls | $Y$ | $Y$ | $Y$ | $Y$ |
| R-square | 0.372 | 0.330 | 0.361 | 0.442 |
| N | 6,404 | 6,404 | 6,404 | 6,404 |

Note: This table estimates regressions of the form: $Y_{it} = \alpha \ln MA_{it} + X_{it}\beta + \mu_i + \nu_t + \varepsilon_{it}$, where $Y_{it}$ is a dummy set to one if county $i$ engaged in salt production in dynasty $t$ for Panel A–C, and is a dummy for other types of mine production for Panel D. $\mu_i$ is county fixed effect, and $\nu_t$ is dynasty fixed effect. Geographic features include elevation, distance to coastline, and the number of rivers. See Section 4.1 for details. Standard errors are clustered at county level.

Table 3: IV Estimates of Effects of Market Access on Salt Production

| | (1) Baseline | (2) 1st stage | (3) IV | (4) Reduced form |
|---|---|---|---|---|
| ln MA | 0.0149*** | | 0.0827*** | |
| | (0.004) | | (0.018) | |
| ln MA, with CSI | | 0.3508*** | | 0.0290*** |
| | | (0.022) | | (0.006) |
| County FE | *Y* | *Y* | *Y* | *Y* |
| Dynasty FE | *Y* | *Y* | *Y* | *Y* |
| Baseline controls | *Y* | *Y* | *Y* | *Y* |
| N | 6,404 | 6,404 | 6,404 | 6,404 |

Note: This table reports the estimates of the effects of market access on salt production, replacing population in the baseline market access with the crop suitability index (CSI) and using it as an instrument for market access. Column (1) reprints the baseline result. Column (2) shows the first-stage regression result. Column (3) shows the IV estimate. Column (3) shows the reduced-form estimate that regresses the salt dummy on the CSI-based market access. Standard errors are clustered at county level.

Table 4: Decomposing Changes in Market Access

| | Baseline (1) | Boundary (2) | CSI (3) | Both (4) |
|---|---|---|---|---|
| ln MA | 0.0149*** | | | |
| | (0.004) | | | |
| ln MA (Pre-1500 CSI, varying boundary) | | 0.0138** | | 0.0138** |
| | | (0.006) | | (0.007) |
| ln MA (varying CSI, Song Boundary) | | | 0.0859** | 0.0800** |
| | | | (0.040) | (0.040) |
| County FE | *Y* | *Y* | *Y* | *Y* |
| Dynasty FE | *Y* | *Y* | *Y* | *Y* |
| Baseline Controls | *Y* | | | |
| R-square | 0.659 | 0.659 | 0.655 | 0.656 |
| N | 6,404 | 6,404 | 6,224 | 6,212 |

Note: This table reports the decomposition of market access into changes in market size, measured by crop suitability index, and changes in salt district boundaries. Column (1) reprints the baseline result. Column (2) uses the market access that fixes the crop suitability index to the pre-1500 values (mapped to Song dynasty) but allow salt district boundaries to vary over time. Column (3) uses the market access that fixes the boundary in Song dynasty, but allow crop suitability index to vary over time. Column (4) reports the coefficients on both terms. Standard errors are clustered at county level.

Table 5: Parameters

| Parameter | Description | Sea Water | Well Water |
|---|---|---|---|
| $b$ | Demand shifter | 0.945 (0.180) | 4.431 (1.416) |
| $\sigma$ | Demand elasticity | 1.264 (0.050) | 5.236 (4.621) |
| $\theta$ | Shape parameter of Frechet | 7.790 (6.262) | 7.790 (6.262) |
| $\mu^T$ | Mean of log state of technology | -0.088 (0.561) | -2.354 (0.253) |
| $\sigma^T$ | Dispersion of log state of technology | 0.221 (0.139) | 0.438 (0.151) |
| $\lambda^f$ | Inverse of mean fixed costs | 1.090e-05 (9.819e-06) | 2.900e-05 (1.138e-04) |
| $\beta^\tau$ | Elasticity of trade costs wrt distance | 0.308 (0.031) | 0.582 (0.073) |

Notes: This table reports the estimated parameters. We allow the parameters to differ between sea salt and well salt districts, except for the Frechet shape parameter ($\theta$), which is held the same. Standard errors are in parentheses.

Table 6: Moments

| | Seawater | | Well water | |
|---|---|---|---|---|
| Moment | Data | Model | Data | Model |
| Share of active salt sites | 0.210 | 0.203 | 0.073 | 0.067 |
| Average log price | 1.843 | 1.854 | 2.366 | 2.617 |
| Average log quantity | 11.651 | 12.027 | 10.945 | 10.506 |
| Average log cost | -0.401 | -0.418 | 1.777 | 1.727 |
| Dispersion of log price | 0.258 | 0.284 | 0.455 | 0.432 |
| Dispersion of log quantity | 1.648 | 1.614 | 2.142 | 2.092 |
| Regression coefficient of log price on inverse distance | -0.362 | -0.345 | -0.842 | -0.816 |

Notes: This table reports the targeted moments from the data and their simulated counterparts from the model.

Table 7: Regressions in Data and Model

| | County | | Salt Site | |
|---|---|---|---|---|
| | Data | Model | Data | Model |
| | (1) | (2) | (3) | (4) |
| Log Market Access | 0.015 | 0.011 | 0.044 | 0.042 |
| | (0.004) | (0.001) | (0.020) | (0.003) |

Notes: This table reports the coefficient from a regression of the form:

$$y_{it} = \alpha \ln MA_{it} + \mu_i + \nu_t + \varepsilon_{it},$$

where $y_{it}$ for columns (1) is a dummy variable indicating whether county $i$ has salt production in period $t$ from the data, and for column (2), the model-simulated probability of salt production. $\nu_t$ and $\mu_i$ are dynasty and county fixed effects. Columns (3)–(4) replicate the analysis at the salt site level, using the openings and market access of salt sites. Standard errors are in parentheses.

Table 8: Trade Shares Across Salt Districts With No Barriers

| District | Changlu | Shandong | Lianghuai | Liangzhe | Fujian | Liangguang | Hedong | Sichuan |
|---|---|---|---|---|---|---|---|---|
| Changlu | 0.55 | 0.17 | 0.04 | 0.00 | 0.00 | 0.00 | 0.18 | 0.05 |
| Shandong | 0.21 | 0.60 | 0.09 | 0.01 | 0.01 | 0.01 | 0.18 | 0.06 |
| Lianghuai | 0.10 | 0.15 | 0.35 | 0.13 | 0.02 | 0.01 | 0.15 | 0.07 |
| Liangzhe | 0.07 | 0.06 | 0.24 | 0.81 | 0.09 | 0.03 | 0.15 | 0.10 |
| Fujian | 0.01 | 0.01 | 0.09 | 0.03 | 0.77 | 0.06 | 0.04 | 0.05 |
| Liangguang | 0.02 | 0.01 | 0.17 | 0.01 | 0.11 | 0.89 | 0.09 | 0.38 |
| Hedong | 0.04 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.22 | 0.07 |
| Sichuan | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.22 |

Notes: This table shows the trade shares across salt districts after removing salt district boundaries observed in the 1920s. Rows (origin district) indicate where salt is produced, while columns (destination district) indicate where salt is consumed. Each entry $s_{ij}$ shows the share of salt consumed in $j$ that originates from district $i$. Entries are normalized such that each column sums to 1.

Table 9: Removing Salt District Boundaries

| District | Relative Changes in Price (1) | Consumption (2) | Sites (3) | Output/Site (4) | Sales (5) | Profit (6) |
|---|---|---|---|---|---|---|
| Changlu | -0.12 | 0.14 | 1 | 0.16 | 0.05 | -0.10 |
| Shandong | -0.12 | 0.14 | 2 | 0.59 | 0.57 | 0.36 |
| Lianghuai | -0.21 | 0.25 | -1 | -0.21 | -0.40 | -0.48 |
| Liangzhe | -0.07 | 0.08 | 4 | 0.95 | 1.27 | 0.96 |
| Fujian | -0.11 | 0.10 | 2 | 1.19 | 1.45 | 1.02 |
| Liangguang | -0.08 | 0.08 | 10 | 1.46 | 1.64 | 0.69 |
| Hedong | -0.26 | 0.43 | 0 | 1.20 | 0.44 | -0.28 |
| Sichuan | -0.60 | 2.36 | -9 | -0.16 | -0.29 | -0.28 |
| Nation | -0.30 | 0.47 | 9 | 0.47 | 0.37 | 0.12 |

Notes: This table shows the relative changes after removing all salt district boundaries observed in the 1920s. For columns (1)–(2) and (4)–(6), relative changes are calculated as $\frac{x_{\text{no barriers}} - x_{\text{baseline}}}{x_{\text{baseline}}}$. For column (3), the number of salt sites, changes are reported in levels, $x_{\text{no barriers}} - x_{\text{baseline}}$.

Table 10: Removing Salt District Boundaries Under Weak State Capacity

| District | Relative Changes in Price (1) | Consumption (2) | Sites (3) | Output/Site (4) | Sales (5) | Profit (6) |
|---|---|---|---|---|---|---|
| Changlu | -0.79 | 6.03 | -1 | 5.32 | 0.60 | -0.78 |
| Shandong | -0.79 | 5.97 | -0 | 7.74 | 1.42 | -0.66 |
| Lianghuai | -0.81 | 6.71 | -3 | 3.29 | -0.09 | -0.87 |
| Liangzhe | -0.78 | 5.62 | 2 | 9.94 | 2.54 | -0.50 |
| Fujian | -0.79 | 5.76 | 1 | 10.54 | 2.79 | -0.47 |
| Liangguang | -0.78 | 5.75 | 9 | 10.45 | 3.66 | -0.36 |
| Hedong | -0.83 | 7.89 | -0 | 7.30 | 1.75 | -0.61 |
| Sichuan | -0.66 | 7.08 | -8 | 1.07 | 0.49 | -0.09 |
| Nation | -0.75 | 6.27 | -2 | 6.27 | 1.26 | -0.65 |

Notes: This table shows the relative changes after removing all salt district boundaries observed in the 1920s and introducing Bertrand competition across salt sites. For columns (1)–(2) and (4)–(6), relative changes are calculated as $\frac{x_{\text{no barriers}} - x_{\text{baseline}}}{x_{\text{baseline}}}$. For column (3), the number of salt sites, changes are reported in levels, $x_{\text{no barriers}} - x_{\text{baseline}}$.

# Online Appendix

## A Supplementary Data Descriptions

### A.1 Salt Districts

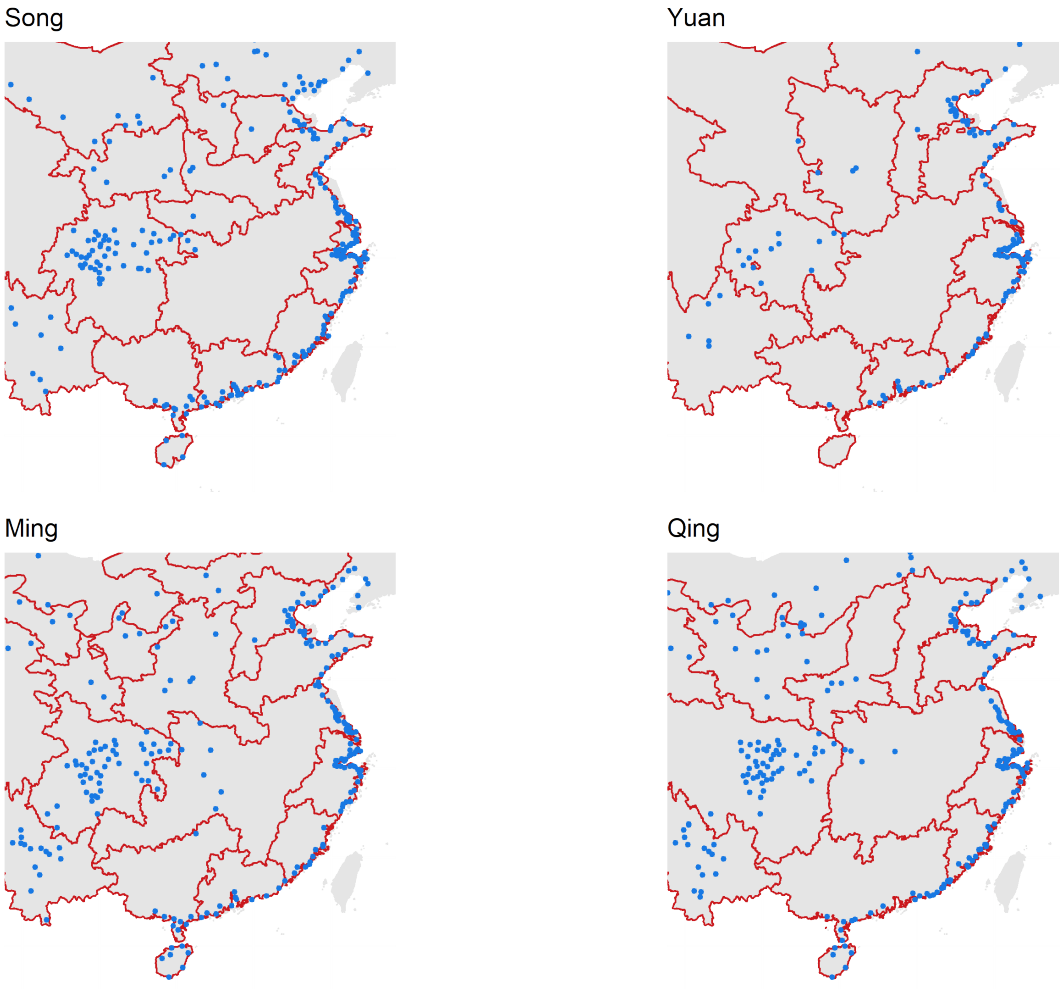



Figure A.1: Salt District Boundaries

Table A.1: List of Salt Districts

| Dynasty | Salt District Name | Freq. | Percent |
|---|---|---|---|
| **Song** | Northeast Sea Salt: Hebei | 126 | 8.09 |
| | Northeast Sea Salt: Jingdong | 60 | 3.85 |
| | Southeast Sea Salt: Huai | 308 | 19.78 |

| | | | |
|---|---|---|---|
| | Southeast Sea Salt: Zhe | 89 | 5.72 |
| | Fujian Sea Salt | 61 | 3.92 |
| | Guangnan Donglu Sea Salt | 67 | 4.3 |
| | Guangnan Xilu Sea Salt | 146 | 9.38 |
| | East Xie Zhou Lake Salt | 147 | 9.44 |
| | West Xie Zhou Lake Salt | 101 | 6.49 |
| | South Xie Zhou Lake Salt | 45 | 2.89 |
| | Earth Salt | 54 | 3.47 |
| | Sichuan Well Salt | 222 | 14.26 |
| | Dali | 103 | 6.62 |
| | Xixia | 28 | 1.8 |
| | **Total** | **1,557** | **100** |
| **Yuan** | Hejian Sea Salt | 198 | 12.41 |
| | Shandong Sea Salt | 105 | 6.58 |
| | Lianghuai Sea Salt | 298 | 18.68 |
| | Liangzhe Sea Salt | 133 | 8.34 |
| | Fujian Sea Salt | 61 | 3.82 |
| | Guandong Sea Salt | 63 | 3.95 |
| | Guangxi Sea Salt | 143 | 8.97 |
| | Xie Salt | 198 | 12.41 |
| | Weihong Salt | 91 | 5.71 |
| | Sichuan Well Salt | 161 | 10.09 |
| | Yunnan Well Salt | 144 | 9.03 |
| | **Total** | **1,595** | **100** |
| **Ming** | Changlu | 154 | 9.41 |
| | Shandong | 150 | 9.16 |
| | Lianghuai | 331 | 20.22 |
| | Liangzhe | 122 | 7.45 |
| | Fujian | 61 | 3.73 |
| | Guangdong | 63 | 3.85 |
| | Haibei | 172 | 10.51 |
| | Hedong | 224 | 13.68 |
| | Shaanxi Lingzhou | 27 | 1.65 |
| | Sichuan | 164 | 10.02 |
| | Yunnan | 99 | 6.05 |
| | Kaizhong | 70 | 4.28 |
| | **Total** | **1,637** | **100** |

| | | | |
|---|---|---|---|
| **Qing** | Changlu | 193 | 11.78 |
| | Shandong | 116 | 7.08 |
| | Lianghuai | 301 | 18.36 |
| | Liangzhe | 122 | 7.44 |
| | Fujian | 53 | 3.23 |
| | Liangguang | 246 | 15.01 |
| | Hedong | 177 | 10.8 |
| | Shaangan | 102 | 6.22 |
| | Sichuan | 229 | 13.97 |
| | Yunnan | 100 | 6.1 |
| | **Total** | **1,639** | **100** |

## A.2 Provinces

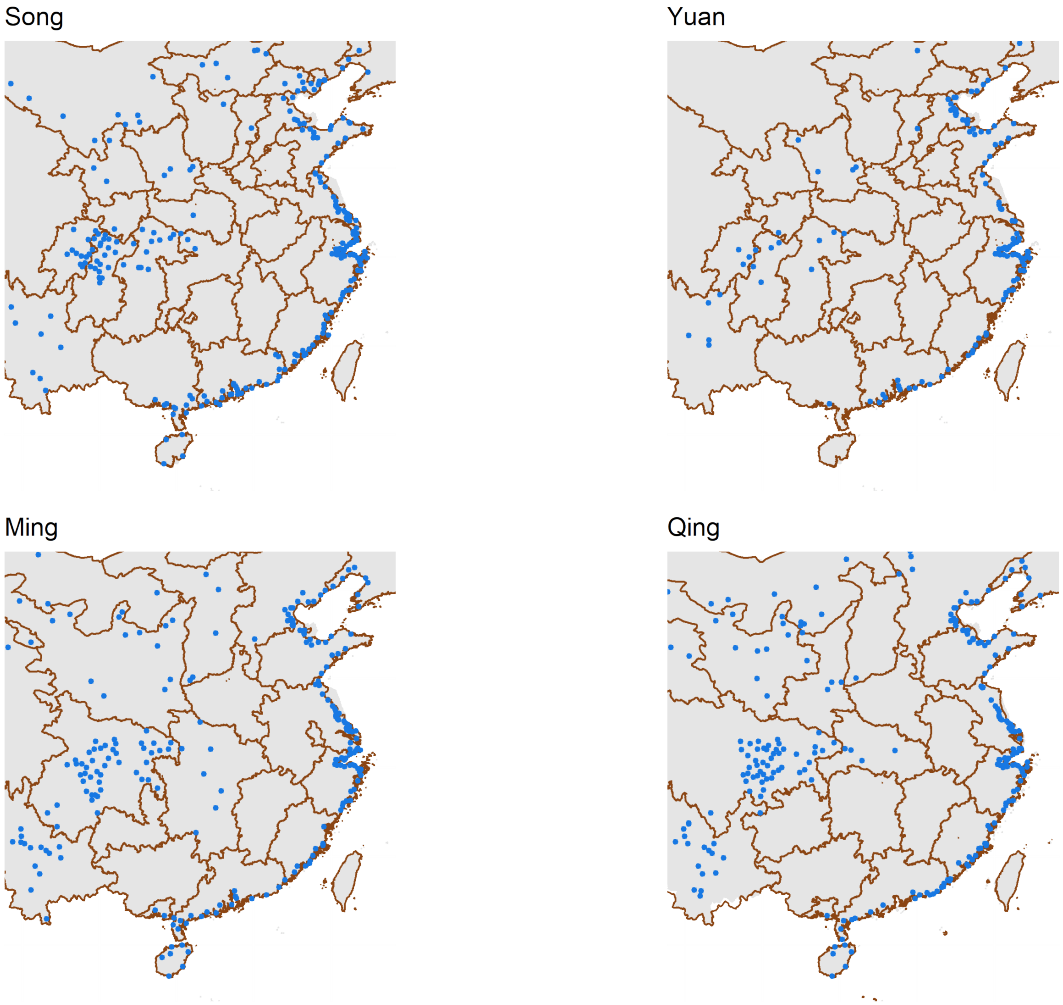



Figure A.2: Provincial Boundaries

Table A.2: List of Provinces

| Dynasty | Province Name | Freq. | Percent |
|---|---|---|---|
| **Song** | Aboriginal Tribal Lands | 5 | 0.32 |
| | Chengdufu Lu | 52 | 3.34 |
| | Dali | 103 | 6.62 |
| | Fujian Lu | 61 | 3.92 |
| | Guangnan Dong Lu | 67 | 4.3 |
| | Guangnan Xi Lu | 146 | 9.38 |
| | Hebei Dong Lu | 65 | 4.17 |
| | Hebei Xi Lu | 69 | 4.43 |

| | | | |
|---|---|---|---|
| | Hedong Lu | 77 | 4.95 |
| | Huainan Dong Lu | 34 | 2.18 |
| | Huainan Xi Lu | 35 | 2.25 |
| | Jiangnan Dong Lu | 52 | 3.34 |
| | Jiangnan Xi Lu | 60 | 3.85 |
| | Jingdong Dong Lu | 55 | 3.53 |
| | Jingdong Xi Lu | 38 | 2.44 |
| | Jinghu Bei Lu | 63 | 4.05 |
| | Jinghu Nan Lu | 43 | 2.76 |
| | Jingji Lu | 21 | 1.35 |
| | Jingxi Bei Lu | 48 | 3.08 |
| | Jingxi Nan Lu | 35 | 2.25 |
| | Kuizhou Lu | 84 | 5.39 |
| | Liangzhe | 112 | 7.19 |
| | Lizhou Lu | 24 | 1.54 |
| | Qinfeng Lu | 42 | 2.7 |
| | XiXia | 28 | 1.8 |
| | Yongxing Lu | 76 | 4.88 |
| | Zizhou Lu | 62 | 3.98 |
| | **Total** | **1,557** | **100** |
| **Yuan** | Gansu | 20 | 1.25 |
| | He'nan | 194 | 12.16 |
| | Huguang | 286 | 17.93 |
| | Jiangxi | 129 | 8.09 |
| | Jiangzhe | 216 | 13.54 |
| | Shaanxi | 147 | 9.22 |
| | Sichuan | 137 | 8.59 |
| | Yunnan | 121 | 7.59 |
| | Zhongshu | 345 | 21.63 |
| | **Total** | **1,595** | **100** |
| **Ming** | Fujian | 61 | 3.73 |
| | Guangdong | 88 | 5.38 |
| | Guangxi | 122 | 7.45 |
| | Guizhou | 56 | 3.42 |
| | He'nan | 104 | 6.35 |
| | Huguang | 139 | 8.49 |
| | Jiangxi | 80 | 4.89 |

| | | | |
|---|---|---|---|
| | Jingshi | 153 | 9.35 |
| | Nanjing | 8 | 0.49 |
| | Shaanxi | 156 | 9.53 |
| | Shandong | 104 | 6.35 |
| | Shanxi | 103 | 6.29 |
| | Sichuan | 164 | 10.02 |
| | Yunnan | 99 | 6.05 |
| | Zhejiang | 77 | 4.7 |
| | Zhongdu | 123 | 7.51 |
| | **Total** | **1,637** | **100** |
| **Qing** | Anhui | 68 | 4.15 |
| | Fujian | 61 | 3.72 |
| | Gansu | 66 | 4.03 |
| | Guangdong | 89 | 5.43 |
| | Guangxi | 119 | 7.26 |
| | Guizhou | 71 | 4.33 |
| | Henan | 106 | 6.47 |
| | Hubei | 68 | 4.15 |
| | Hunan | 71 | 4.33 |
| | Jiangsu | 64 | 3.9 |
| | Jiangxi | 80 | 4.88 |
| | Nemenggu | 1 | 0.06 |
| | Shaanxi | 27 | 1.65 |
| | Shandong | 107 | 6.53 |
| | Shanxi | 166 | 10.13 |
| | Sichuan | 151 | 9.21 |
| | Yunnan | 105 | 6.41 |
| | Zhejiang | 78 | 4.76 |
| | Zhili | 141 | 8.6 |
| | **Total** | **1,639** | **100** |

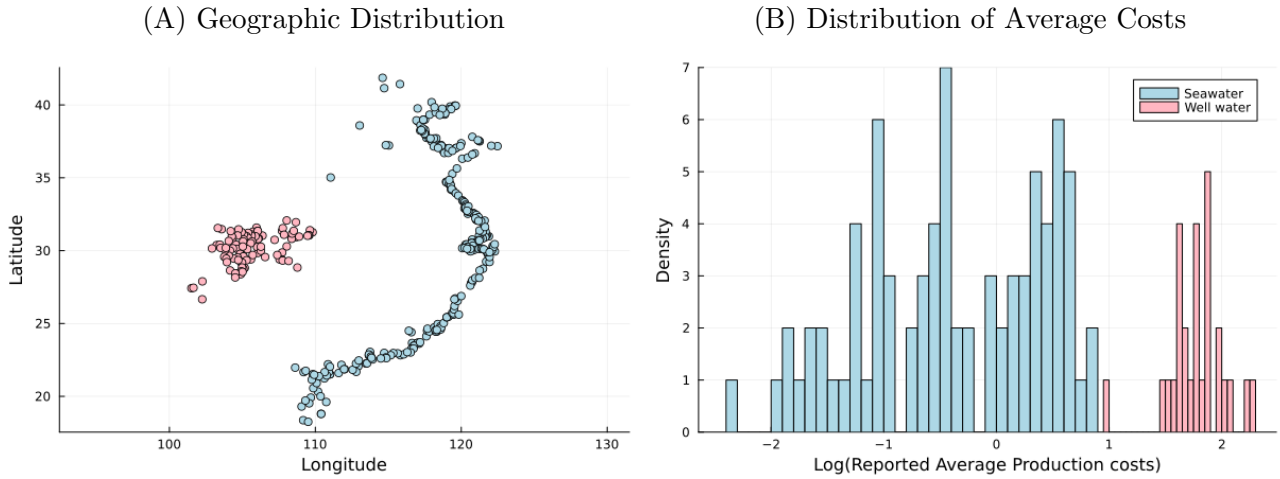
## A.3 Salt Production Method

Salt production methods are a key determinant of production costs. There are two primary methods, depending on the salt source: seawater or well water. Salt from seawater is produced

either by evaporation or by boiling, while salt from well water is produced exclusively through boiling. The choice of production method is shaped by geographic conditions. Panel (A) of Figure A.3 displays the production method at each salt site, and Table A.3 summarizes the methods used across districts. Most districts rely on a single method. Among the eight districts in the estimation sample, seven use seawater—through either evaporation or boiling—while Sichuan, the only inland district, relies on well water.

Panel (B) of Figure A.3 presents the distribution of log average production costs by salt source. Production costs for well water are consistently higher: even the lowest-cost well-water site exceeds the highest-cost seawater site. On average, the production cost for well water is 2.2 log points higher than that for seawater.

Figure A.3: Distribution of Production Method




Notes: These figures show the distribution of production methods—sea salt versus well salt. Panel (A) displays the geographic distribution, and Panel (B) presents the histogram of log average production costs. Blue represents sea salt, and red represents well salt.

## A.4 Data: Summary Statistics

Table A.3: Production Method by District

| Salt District | Production Method |
|---|---|
| Shandong | Seawater: solar evaporation |
| Hedong | Seawater: solar evaporation |
| Fujian | Seawater: solar evaporation |
| Changlu | Seawater: solar evaporation |
| Liangzhe | Seawater: solar evaporation, boiling, or a combination of the two |
| Lianghuai | Seawater: solar evaporation, boiling, or a combination of the two |
| Liangguang | Seawater: solar evaporation or the two |
| Sichuan | Well water boiling |

Notes: This table reports the production method for each district.

Table A.4: Summary Statistics

| Variables | Data source | Obs. | Mean | SD | Min | Max |
|---|---|---|---|---|---|---|
| Salt | A | 6,425 | 0.109 | 0.312 | 0 | 1 |
| *Market Access: Baseline* | | | | | | |
| ln Market Access (Great-circle Distance) | B, C, D, G | 6,425 | 14.973 | 1.316 | 9.827 | 17.412 |
| ln Market Access (HMI Distance) | B, C, D, F, G | 6,425 | 12.263 | 1.410 | 0 | 15.518 |
| *Market Access: Robustness Check* | | | | | | |
| ln MA (Excluding the Origin County) | B, C, D, G | 6,425 | 14.862 | 1.322 | 8.391 | 17.279 |
| ln MA (CSI, Great-circle Distance) | B, C, E, G | 6,425 | 9.497 | 0.794 | 4.508 | 11.650 |
| ln MA (CSI, HMI Distance) | B, C, E, F, G | 6,425 | 6.787 | 0.818 | 0 | 9.976 |
| ln MA (Same Salt District, Diff. Prov.) | B, C, D, G | 4,910 | 14.397 | 1.754 | 9.789 | 17.505 |
| ln MA (Diff. Salt District, Same Prov.) | B, C, D, G | 3,534 | 13.621 | 1.576 | 8.361 | 16.904 |
| ln MA (Diff. Salt District, Diff. Prov.) | B, C, D, G | 6,425 | 16.456 | 0.728 | 14.313 | 17.991 |
| ln MA ($\theta = 1.9$) | B, C, D, G | 6,425 | 15.247 | 1.525 | 9.567 | 18.731 |
| ln MA ($\theta = 3.8$) | B, C, D, G | 6,425 | 17.627 | 2.132 | 6.636 | 26.200 |
| ln MA ($\theta = 8.28$) | B, C, D, G | 6,425 | 25.347 | 3.834 | 1.084 | 46.829 |
| *Market Access: Instruments* | | | | | | |
| ln MA (t-CSI, Song Boundary) | B, C, E, G | 6,212 | 11.236 | 0.520 | 7.521 | 12.276 |
| ln MA (Song-CSI, t-boundary) | B, C, E, G | 6,425 | 11.293 | 0.794 | 0 | 12.242 |
| Mine (N) | H | 6,425 | 0.204 | 0.712 | 0 | 12 |
| Mine (=1) | H | 6,425 | 0.122 | 0.327 | 0 | 1 |
| Iron (=1) | H | 6,425 | 0.060 | 0.238 | 0 | 1 |
| Copper (=1) | H | 6,425 | 0.024 | 0.153 | 0 | 1 |
| Gold/silver (=1) | H | 6,425 | 0.051 | 0.219 | 0 | 1 |
| ln Crop Suitability | E | 6,425 | 11 | 1.184 | 0 | 13.087 |
| ln Elevation | B | 6,425 | 5.519 | 1.589 | 0.382 | 8.414 |
| ln Dist. to Coastline | B | 6,425 | 12.524 | 1.262 | 6.030 | 14.436 |
| Rivers (N) | B | 6,425 | 3.031 | 2.027 | 0 | 17 |

Source: A: Ji (2013); B: CHGIS (2016); C: Provincial boundaries, Hartwell (2015); D: Population data, Ge (2000); E: Caloric Suitability Index, Galor and Özak (2015, 2016); F: Human Mobility Index, Özak (2010, 2018)
G: Salt district boundary, Guo (1990), Zhang (2009), Liu (1996), Zhang (1920); H: Xia et. al., (1980)

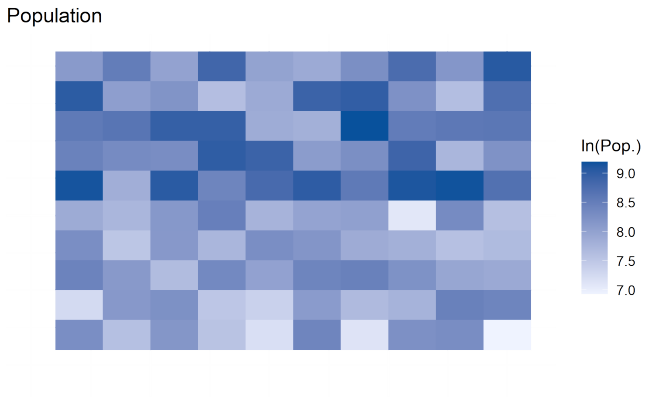
# B Data Construction

## B.1 Market Access

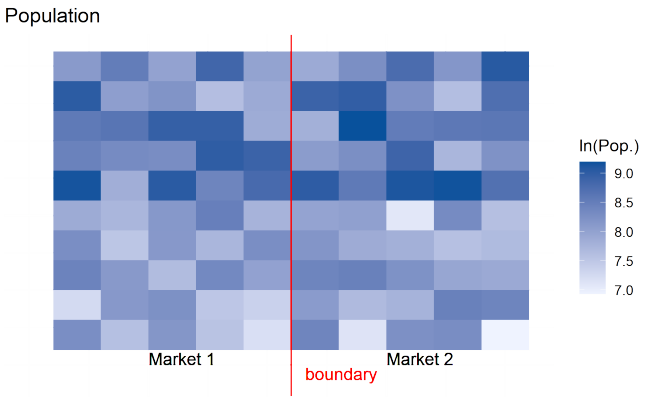
Figure B.1 serves as a simple illustration of constructing market access. Consider 100 square regions in space. Plot (a) displays random numbers representing population, with the northern part doubled for clarity. Assume a vertical line forms a boundary dividing regions into two markets where goods can only be traded within each market. Using the equation $\sum_{j \in S} \frac{N_j}{d_{ij}}$, market access for each region is calculated in (c). Results indicate higher market access in the middle and north parts of both markets, reflecting densely populated areas and favorable transportation locations. Adjusting the boundary and redefining markets alters market access, as shown in (d). The north regions have significantly higher market access values due to a larger market size, but still, market access remains greater in the middle regions.

## B.2 Local Markets Defined by Salt Districts & Provinces

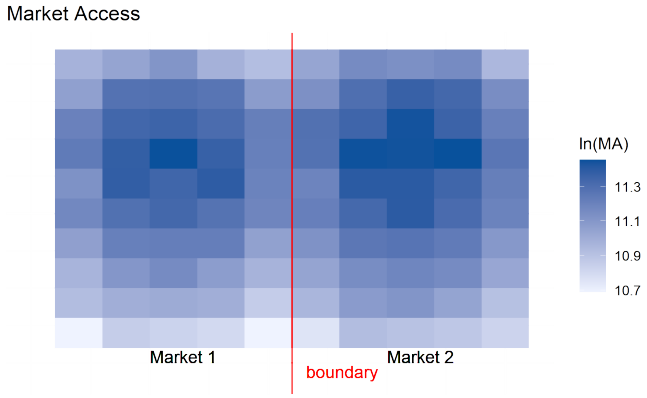
Figure B.2 is a simple case of local markets defined by salt district and provincial boundaries. The points in (a) represents counties which located in three provinces. The larger points are salt-producing counties. Based on salt production locations, the region is divided into two salt districts, as shown in (b). Combining the provinces in (a) and salt districts in (b) in one figure, (c) shows the 6 local markets defined by two layers. One local market contains the counties with the same salt district and the same province.



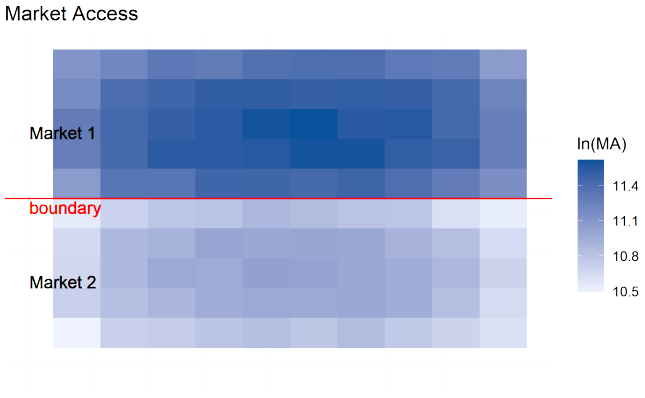

(A) Population




(B) Boundary and Markets

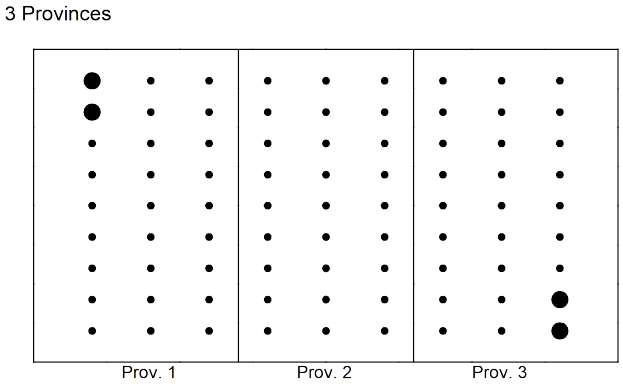



(C) Market Access (I)

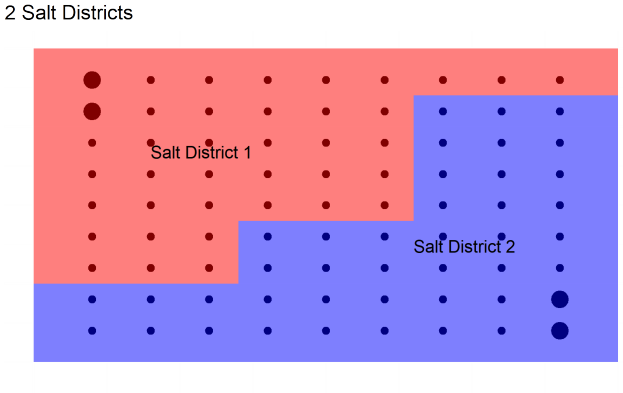



(D) Market Access (II)

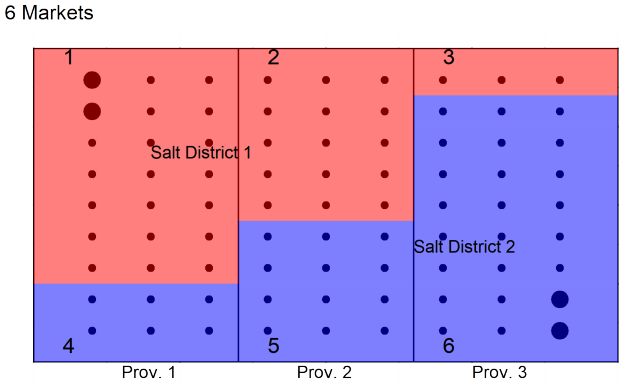
Figure B.1: Simulated Case of Market Access




(A) Provinces




(B) Salt Districts




(C) Local Markets

Figure B.2: Simple Illustration of the Local Market Definition

# C Supplementary Figures

## C.1 Great-circle Distance and HMI Minimum Cost Distance

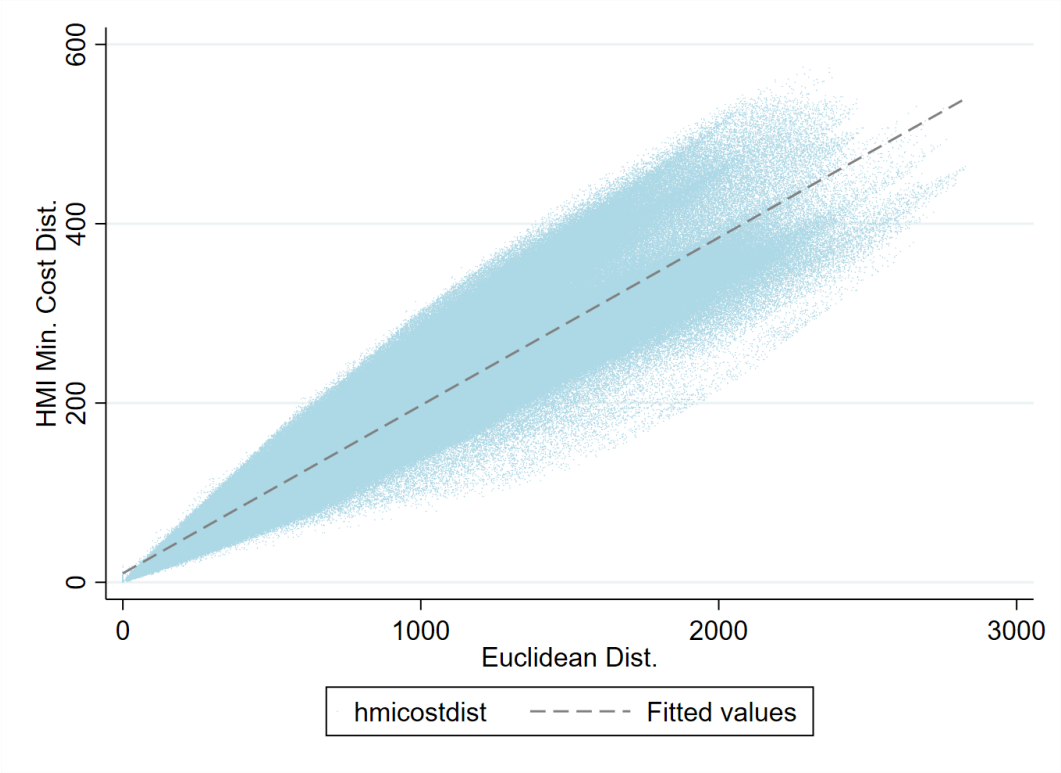



Figure C.1: Correlation: Great-circle Distance and Human Mobility Index Minimum Cost Distance

## C.2 Crop Suitability and Population Density

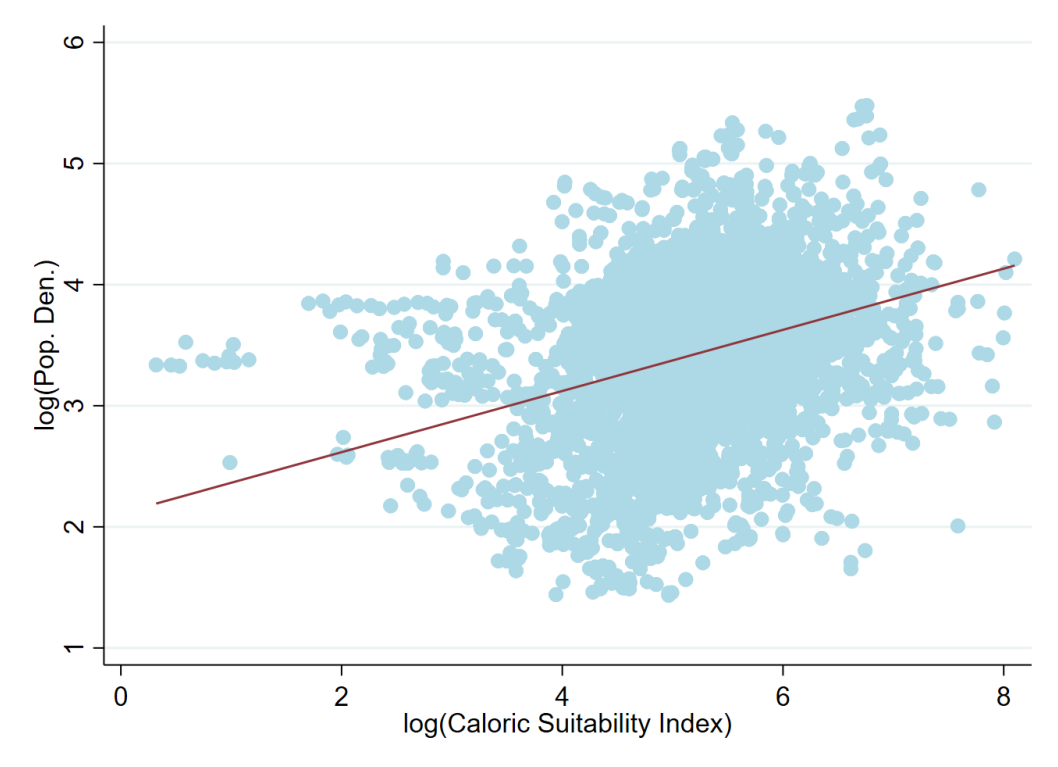
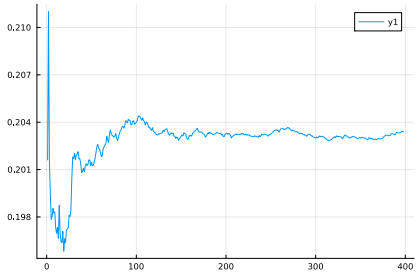



Figure C.2: Correlation: Crop Suitability Index and Population Density

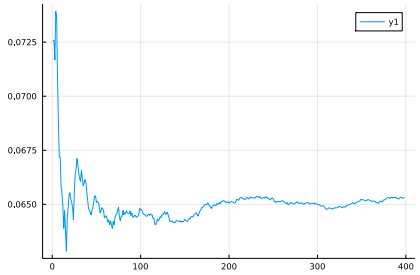
## C.3 Convergence of Simulated Moments

Figure C.3: Convergence of Simulated Moments

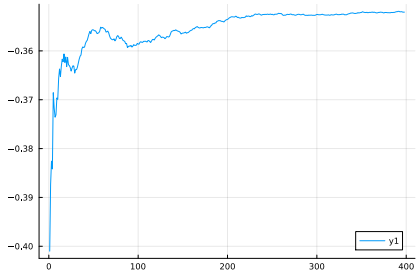
(A) #Active Salt Sites: Sea Salt




(B) #Active Salt Sites: Well Salt



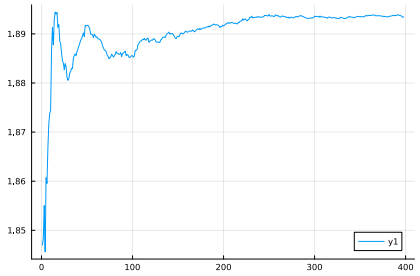

(C) Average Log Costs: Sea Salt



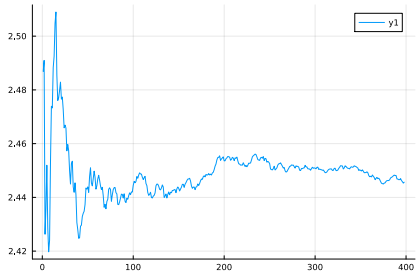

(D) Average Log Costs: Well Salt




(E) Average Log Price: Sea Salt

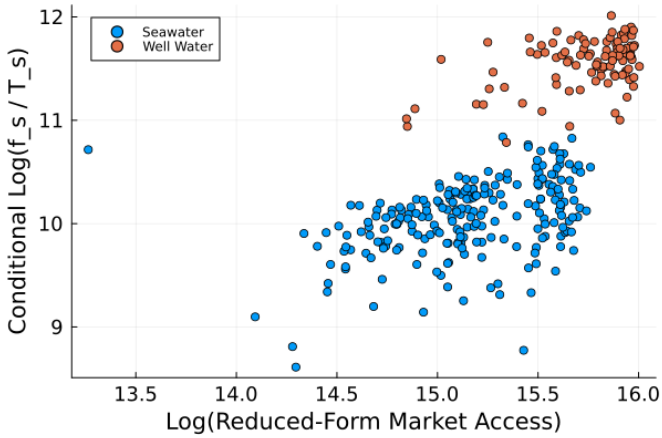



(F) Average Log Price: Well Salt




Notes: These graphs show the convergence of average moments computed from multiple simulates as the number of simulation increases.

Figure C.3: Selection of Salt Sites




Notes: This graph plots the fixed cost of each site, scaled by the site's average productivity—measured as the scale parameter of the Fréchet distribution—against the log reduced-form market access of the site, defined as $MA_s = \sum_{k \in \mathrm{D}(s)} \mathrm{population}_k / \mathrm{distance}_{sk}$.

# D Supplementary Tables

## D.1 Additional Estimation Results

Table D.1: Untargeted Moments

| Salt District | Data | Model |
|---|---|---|
| Changlu | 2 | 8.440 |
| Shandong | 6 | 8.215 |
| Lianghuai | 15 | 11.790 |
| Liangzhe | 30 | 24.205 |
| Fujian | 7 | 6.140 |
| Liangguang | 17 | 15.355 |
| Hedong | 1 | 1.310 |
| Sichuan* | 27 | 24.855 |

Notes: This table reports the number of active salt sites in each district. Except for Sichuan, these numbers are not targeted in the estimation.

## D.2 Additional Counterfactual Results

Table D.2: Trade Shares Across Salt Districts With No Barriers Under Weak State Capacity

| District | Changlu | Shandong | Lianghuai | Liangzhe | Fujian | Liangguang | Hedong | Sichuan |
|---|---|---|---|---|---|---|---|---|
| Changlu | 0.49 | 0.19 | 0.05 | 0.00 | 0.00 | 0.00 | 0.17 | 0.05 |
| Shandong | 0.23 | 0.54 | 0.09 | 0.01 | 0.01 | 0.01 | 0.17 | 0.06 |
| Lianghuai | 0.11 | 0.16 | 0.29 | 0.14 | 0.02 | 0.01 | 0.14 | 0.07 |
| Liangzhe | 0.08 | 0.07 | 0.26 | 0.79 | 0.12 | 0.03 | 0.15 | 0.10 |
| Fujian | 0.02 | 0.01 | 0.09 | 0.04 | 0.72 | 0.07 | 0.04 | 0.06 |
| Liangguang | 0.03 | 0.01 | 0.20 | 0.02 | 0.13 | 0.87 | 0.09 | 0.40 |
| Hedong | 0.04 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.22 | 0.07 |
| Sichuan | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.19 |

Notes: This table shows the trade shares across salt districts after removing salt district boundaries observed in the 1920s and introducing Bertrand competition across salt sites. Rows (origin district) indicate where salt is produced, while columns (destination district) indicate where salt is consumed. Each entry $s_{ij}$ shows the share of salt consumed in $j$ that originates from district $i$. Entries are normalized such that each column sums to 1.

Table D.2: Removal of Salt District Boundaries: Fixed Locations

| District | Log Pop | Log Average Price | | | Log Total Consumption | | | #Sites | | | Log Quantity/Site | | | Log Total Profit | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Basline | Cf. | %Chg | Basline | Cf. | %Chg | Basline | Cf. | %Chg | Basline | Cf. | %Chg | Basline | Cf. | %Chg |
| Nation | 19.79 | 2.09 | 1.76 | -28 | 17.44 | 17.77 | 40 | 100.31 | 100.31 | 0.00 | 11.52 | 11.86 | 40 | 18.82 | 18.93 | 11 |
| Changlu | 17.66 | 1.85 | 1.73 | -11 | 15.32 | 15.44 | 13 | 8.44 | 8.44 | 0.00 | 11.80 | 11.96 | 18 | 16.86 | 16.79 | -7 |
| Shandong | 17.37 | 1.75 | 1.64 | -11 | 15.15 | 15.26 | 12 | 8.22 | 8.22 | 0.00 | 11.57 | 11.99 | 52 | 16.59 | 16.87 | 33 |
| Lianghuai | 18.58 | 2.05 | 1.83 | -20 | 16.07 | 16.28 | 23 | 11.79 | 11.79 | 0.00 | 12.49 | 12.34 | -14 | 17.75 | 17.19 | -43 |
| Liangzhe | 17.45 | 1.58 | 1.54 | -5 | 15.49 | 15.54 | 5 | 24.20 | 24.20 | 0.00 | 11.32 | 11.91 | 80 | 16.73 | 17.36 | 87 |
| Fujian | 16.57 | 1.69 | 1.60 | -8 | 14.52 | 14.57 | 6 | 6.14 | 6.14 | 0.00 | 11.18 | 11.87 | 100 | 15.82 | 16.48 | 92 |
| Liangguang | 17.76 | 1.80 | 1.76 | -4 | 15.61 | 15.64 | 3 | 15.35 | 15.35 | 0.00 | 11.39 | 12.15 | 113 | 17.00 | 17.47 | 60 |
| Hedong | 16.50 | 2.19 | 1.89 | -26 | 13.69 | 14.03 | 41 | 1.31 | 1.31 | 0.00 | 13.00 | 13.80 | 123 | 15.61 | 15.31 | -26 |
| Sichuan | 18.12 | 2.71 | 1.83 | -59 | 15.47 | 16.60 | 208 | 24.86 | 24.86 | 0.00 | 10.84 | 10.71 | -12 | 15.38 | 15.07 | -26 |

Notes: This table shows the changes after removing all salt district boundaries observed in the 1920s, with location held fixed at those in the 1920s. Percentage changes are calculated as the difference in log values before and after the removal of district boundaries.