State Simplification and Market Distortion: Evidence from China's Millennia-Long Salt Administration*

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Abstract

In historical settings and many developing economies today, states often adopt simplified administrative rules—what Scott (1998) terms "state simplification"—to make taxation and control tractable, at the cost of market distortion. We study this trade-off through China's salt administration, a state-enforced monopoly that lasted for over a millennium. To facilitate tax collection, the state partitioned the empire into rigid production and distribution districts and prohibited cross-district trade. Combining new county-level data on salt production from 960 to 1920 with boundary changes across five regimes, we show that shifts in *administrative* market access systematically shaped where salt was produced. To quantify welfare consequences, we estimate a spatial model in which a monopolist state chooses production sites subject to administrative trade barriers. Counterfactuals show that state simplification generated substantial efficiency losses, yet could remain fiscally attractive because it helped sustain revenue collection under limited state capacity. An extension in which the state chooses district granularity shows that the optimal degree of segmentation depends on state capacity.

Keywords: state capacity, market access, state simplification, inefficient institutions

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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 (see Besley and Persson (2009); Fukuyama (2011); Acemoglu and Robinson (2012) for seminal frameworks). 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 (e.g., Balán et al., 2022; for a review, see Jensen and Weigel (2025)).

In response, governments have frequently relied on monopolies over essential goods to secure revenue, often using geographic segmentation to implement monopoly. Salt administration stands out as one of the most prominent examples. Because salt was both indispensable and relatively price inelastic, it became a major source of fiscal revenue in many historical societies. States from China to France, Venice, the Habsburg Empire, and the Ottoman Empire developed institutional arrangements, commonly referred to as salt administrations, to regulate its production and distribution (Adshead, 2016).[1] Although these systems differed in their specific forms, they shared a common logic of state simplification (Scott, 1998): rather than attempting to tax a diffuse and difficult-to-monitor salt trade through ordinary market mechanisms, states adopted administratively tractable arrangements that facilitated monopoly enforcement and revenue extraction.

This paper studies the market consequences of state simplification through China's salt administration, a state-enforced monopoly that endured for over a millennium. As in many premodern societies, salt was a major source of fiscal revenue in historical China, at times accounting for nearly 50% of central government revenue (see Section 2). To secure these revenues, from the Song dynasty (960–1279) through the Republican era in the 1920s, the state organized the salt economy through a districting system: exclusive production and distribution zones with legally enforced boundaries that prohibited cross-district trade. These boundaries were periodically redrawn across regimes, reshaping the set of legally accessible markets for each production area and altering incentives for entry, expansion, and exit in salt production.

[1] India under the British Raj provides another important example. There, the salt monopoly and tax became both a major fiscal instrument and a focal point of political contestation, culminating in Gandhi's 1930 Salt March.

Leveraging the long history of Chinese salt administration and its systematic administrative records, we address two central questions in the study about the political economy of state capacity: What are the economic costs of state-simplifying institutions relative to a fiscally capable state that can raise revenue without distorting market boundaries? And why do such inefficient institutions persist for centuries despite their allocative costs?

To answer these questions, we first present an illustrative model that highlights a central fiscal-efficiency trade-off faced by the state: salt districting emerges as a state-simplifying strategy that reduces tax leakage at the cost of distorting market allocation. We then combine reduced-form evidence with a structural spatial framework to quantify these costs and to explain the persistence of such institutions.

Our reduced-form evidence on how administrative districting shaped the spatial distribution of salt production leverages changes in salt district boundaries across regimes. Using a novel county-level panel of salt production from 960 to 1920, we construct a market-access measure following the method developed by Donaldson and Hornbeck (2016). Unlike the standard measure, however, ours captures a county's access to consumer markets under the prevailing district constraints; we therefore refer to it as *administrative market access*. We find that this boundary-induced component plays a sizable role in explaining the relocation of salt production: doubling the administrative market access raises the probability that a county is selected as a salt production location by 1.5 percentage points, or 10% of the mean. This finding is robust to alternative measures of market access and various sample restrictions.

Although production location is not the only margin along which salt districting may generate distortions, the empirical finding provide a disciplined anchor for our spatial equilibrium analysis and a benchmark against which to validate the model.

Motivated by the reduced-form evidence, we develop a simple 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 also allow key parameters to vary across salt sources (i.e., sea salt vs. well salt) since those constitute the key comparative advantage across space. We then validate the model by simulating the reduced-form regression coefficients. Despite its parsimony, the model largely reproduces the empirical relationship between market access and site selection, suggesting it captures the core economic forces behind the reduced-form patterns.

Equipped with our spatial framework, we turn to our core research questions: the economic cost of state simplification, and the logic of replying on inefficient rules as a response to taxation challenges. We quantify the cost of salt districting by constructing a counterfactual high-capacity state—one no longer reliant on administratively convenient but economically distortive district boundaries, and able to preserve its salt monopoly even under integrated trade. Holding the monopoly structure fixed, we eliminate geographic segmentation, allow counties to source freely from all active sites, and let production-site selection be solely driven by efficiency rather than administratively defined markets. Removing district boundaries lowers the average salt price by 30%, raises consumption by about 50%, and increases both the number of operating sites (by 9) and average output per site (by 47%). Production also reallocates geographically: inland sites contract, while coastal production expands. Fiscal revenues rise by 12%, implying that simplification through salt districts imposed substantial efficiency losses and constrained revenue extraction—costs we interpret as a quantitative measure of limited fiscal capacity.

Our framework also allows us to clarify why such inefficient rules can persist. In a second counterfactual, we relax the monopoly assumption and introduce Bertrand competition among producers, which sharply compresses markups and profit margins. Prices fall by an additional 75%, and consumption rises roughly sixfold. However, fiscal revenues decline by 65%, underscoring a central fiscal-efficiency trade-off: geographic segmentation is inefficient, but it helps sustain monopoly rents and thus raises revenues when the state cannot otherwise enforce extraction. This logic helps explain why monopoly privileges, despite their distortionary costs, remain a durable

feature of revenue systems in many states.

Finally, we examine how such institutions evolve with state capacity. We extend the model to allow the state to choose the number—and thus the granularity—of districts. The results show that the optimal degree of segmentation is non-monotonic in capacity: as capacity rises, the optimal number of districts first increases and then declines, eventually reaching zero. This hump-shaped relationship rationalizes both historical and contemporary patterns. Stronger dynasties, such as the Song, maintained more finely partitioned systems, while weaker regimes consolidated districts. In modern settings, advances in administrative and enforcement capacity have largely eliminated the need for geographic restrictions altogether.

Our study contributes to the literature on state capacity and its economic consequences. While the importance of state capacity for development is well established in political economy and development economics (e.g. Besley and Persson, 2009; Acemoglu and Robinson, 2012), empirical efforts to quantify the costs of limited fiscal capacity—particularly in terms of market distortions—remain relatively limited. A related body of work in political sociology and historical institutionalism emphasizes how states simplify complex social and economic environments to make them more legible and governable (Scott, 1998). In this tradition, institutional arrangements such as monopolies, standardized categories, and territorial divisions are understood as tools that facilitate taxation and control. Recent research in economics similarly highlights the role of administrative capacity in shaping taxation systems (see Jensen and Weigel (2025) for a review).

Our paper brings these strands together by providing evidence on the economic consequences of such administrative simplification. We show how limited administrative capabilities, manifested through rigid institutions like salt districting, reshape production locations and distort market outcomes. By embedding state simplification into a spatial model of production and trade, we bridge qualitative institutional accounts with quantitative analysis and offer a framework for measuring the hidden efficiency costs of state legibility.

We also 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).[2] In contrast, we highlight a distinct but underex-

[2]See Redding and Rossi-Hansberg (2017) for reviews of recent developments in quantitative spatial models and

plored mechanism: state–imposed administrative boundaries as a determinant of market access.[3] In many historical and contemporary contexts, market access is not shaped solely by geography or infrastructure, but by politically motivated or administratively convenient constraints. Our analysis provides empirical evidence on how such administrative market access affects economic geography and efficiency.

Additionally, our analysis adds to the understanding of state monopolies as fiscal instruments. Historical research has documented the prevalence of state monopolies over salt (e.g., Adshead, 2016), tobacco (Goodman, 2005), alcohol (Nye, 2018), and other goods as key pillars of revenue systems across empires and early modern states. Yet the question of *how* such monopolies were implemented, whether through licensing, districting, or exclusive privileges, has received less systematic attention in economics. By examining China's salt administration, we show that districting was not merely an accident of geography or history but an institutional response to the challenges of sustaining monopoly rents. More broadly, our findings suggest that institutions designed to make revenue collection and oversight more tractable can also generate substantial allocative inefficiencies, a tension that remains central to the study of governance, development, and the design of economic institutions.

2 Background and Data

Historically, states have often relied on monopolies over essential goods to raise revenue. Salt, a necessity with relatively inelastic demand, is a canonical example, and its political and economic importance is hard to overstate. Even the word "salary" originates from the Latin word "salarium," where "sal" being the Latin word for salt.

Although abundant in the modern world, salt once shaped state capacity, military power, and even geopolitical boundaries. Across Eurasia, rulers quickly recognized its fiscal potential. The Venetian Republic used its salt tax to fund naval expansion and sustain public credit (Adshead, 2016). In France, control over salt-producing regions was so strategically valuable that it became an objective in the French Wars of Religion. The gabelle became one of the most extractive

empirical evidence on the role of market access on economic developments.

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

institutions of the ancien régime, accounting for roughly 25% of royal revenues in the 18th century (Giommoni et al., 2025).

It is thus unsurprising that wherever states could monopolize salt, they did. 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. In several dynasties such as the Tang and the Yuan, salt tax contributed nearly 50% of total state revenue. Even by the Qing dynasty (1644–1911), the last imperial dynasty, salt still accounted for about 17% of total tax revenue, making it second only to the land tax (Ni, 2017).[4]

This section explains the institutional design of salt districts and its underlying logic, after which we explain the main data employed in our analysis.

2.1 Salt Districting and Its Logic

How Salt Districts Functioned The salt-districting system emerged in the mid-Tang (mid-eighth century, c. 750s CE). It was refined and institutionalized from the Song dynasty onward and remained the backbone of salt administration into the Republican era until the 1930s, despite repeated political transitions.

Under this monopoly system, salt districts partitioned the empire into exclusive territorial units that defined where salt could be produced, shipped, and sold. Each district was linked to designated production sites and authorized destination markets: legally produced salt could circulate only within its assigned boundaries, while cross-district trade was strictly prohibited.

This spatial segmentation served two administrative purposes. First, it made production oversight more tractable by establishing district-specific quotas and reporting channels, enabling officials to audit output and detect irregularities at salt sites. Second, it reduced the burden of policing distribution by concentrating enforcement on a limited set of choke points such as district borders and designated routes, rather than requiring pervasive supervision of transport, wholesalers, and retailers throughout the empire.

Figure 1 plots salt districts across the Song, Yuan, Ming, Qing, and Republican periods. As

[4]Revenue from the salt monopoly was critical for financing military campaigns and sustaining the consumption of the imperial elite.

shown, district boundaries cross-cut provincial borders rather than aligning neatly with them. A typical salt district typically spanned multiple provinces.

When it came to collecting the salt tax, the state delegated district-level monopoly rights to merchant groups through licenses (*yan yin*). Issued by the government, these licenses granted exclusive rights to purchase and sell salt within a given district, specifying destination markets and official prices. In return, merchants were required to remit the tax upfront, converting a fiscal obligation into a profit opportunity. Licensed merchants then managed distribution to consumers through a three-tier structure: wholesalers (*gang shang*) sold to distributors (*shui ke*), who in turn supplied local retailers (*zi dian*). Retail prices were regulated by the state. By front-loading revenue collection and outsourcing distribution to incentivized intermediaries, this arrangement both stabilized fiscal receipts and reduced the state's monitoring burden.

Why Salt Districting? To understand the logic of salt districting, it is useful to compare it with the pre-districting arrangement. In the early Tang, the state attempted to directly manage production, distribution, and sales without relying on regional segmentation. This approach quickly encountered two constraints rooted in limited state capacity. First, the government lacked the ability to gather reliable information on output and costs at production sites, which weakened its control over production and enabled diversion. Second, it lacked the administrative capacity to monitor distribution from salt sites to geographically dispersed consumer markets. Direct state control often relied on unpaid compulsory labor and prisoners for salt production and transport, yet anecdotal evidence suggests that desertion was widespread, with escape rates in some cases exceeding half of those assigned. Together, these constraints led to pervasive leakage of salt into private trade, undermining monopoly enforcement and limiting the state's ability to extract stable fiscal revenue.

Salt districting emerged as an institutional response to these constraints during the mid-Tang reforms and was further refined in the Song dynasty. By partitioning the empire into exclusive territorial units and restricting legal trade to within district boundaries, the state transformed an empire-wide monitoring problem into a more tractable system of localized control. Districting improved information and enforcement by embedding production oversight within a regular administrative hierarchy. For example, each district was assigned a salt-site inspector, often referred to

as an "ambassador," who conducted on-site inspections and reported regularly to higher-level officials overseeing salt administration. Inspectors monitored compliance with output quotas, aiming to prevent both underproduction and unauthorized production. Districting also simplified the supervision of distribution by concentrating enforcement at key bottlenecks, such as transport routes and wholesale transfers, rather than requiring pervasive monitoring of transactions throughout the empire. By restricting cross-district trade, the state reduced opportunities for arbitrage and made official monopoly prices easier to enforce.

We formalize this logic in the illustrative model in Section 3. The model highlights a central fiscal-efficiency tradeoff: although salt districting distorts the spatial allocation of production and trade, it improves fiscal tractability by reducing leakage and facilitating revenue collection under limited state capacity.

Selection of Salt Sites Understanding how salt sites were chosen within the framework of salt districts is central to our analysis. We focus on two types of salt production that were under tight state regulation: sea salt and well salt.[5] Sea salt was mostly produced in coastal regions of eastern and southeastern China; 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. This interaction between endowments (productivity) and administration-driven market access motivates our analysis.

2.2 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

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

the Republic of China era in the 1920s to incorporate market price and production quantity data to estimate our model.[6]

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 Historical 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.[7] 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).[8] 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.

One can access comprehensive and reliable data on salt production, thanks to the fiscal importance and monopoly nature of this industry. 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. This limitation is less consequential for our purposes, however, since our focus is on understanding (legal) production under the salt-districting system.

Our main sample for the empirical analysis comprises 6,425 county–dynasty observations across four dynasties.[9] 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

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

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

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

[9] 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.

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.

Additional Data We extend our sample into the Republican era (1920s) to take advantage of unusually rich data on prices and quantities. This allows us to recover underlying productivity differences across localities, which we then incorporate into our structural estimation. We digitize these 1920s statistics from the *Salt Affairs Yearbook* (Salt Affairs Bureau (1929)), compiled by the National Government's Ministry of Finance—the central agency overseeing the state-controlled salt monopoly during the Republican period.[10] Our dataset includes county-level salt prices and site-level production measures. 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).[11] We also measure local land productivity using the average caloric suitability of each county, based on the crop suitability

[10] Qing records contain some price information, but data quality is uneven and county coverage is limited.

[11] 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.

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 placebo tests, we incorporate historical county-level data on the production of iron, copper, gold, and silver from Xia et al. (1980).

3 An Illustrative Model

To illustrate the core mechanism in the simplest possible way, consider a government (the salt monopoly) choosing whether to impose salt districts and which salt sites to operate in order to maximize net fiscal revenue. The key tradeoff is that districting can improve enforcement and increase the share of operating profits the government can collect, but it also restricts the legal markets each salt site can serve.

There are K markets indexed by $k \in \mathcal{K}$ and a set of potential salt sites indexed by $s \in \mathcal{S}$. Each market k has demand $q_k = N_k p_k^{-\sigma}$, where N_k is a market-size shifter and $\sigma > 1$ is the demand elasticity. Each salt site s produces salt with marginal cost $1/T_s$, where T_s denotes site productivity, and incurs a fixed operating cost f_s. Shipping salt from site s to market k involves iceberg trade cost $\tau_{sk} \geq 1$.

Let $r \in \{D, ND\}$ denote the regulatory regime, where D indicates that salt districts are imposed and ND indicates no districting. Under regime r, site s can legally serve markets in the set $D_s^r \subseteq \mathcal{K}$, with

$$D_s^D \subseteq D_s^{ND}, \tag{1}$$

so districting restricts the set of markets a site can legally serve. In this illustrative model, district boundaries are taken as part of the institutional environment rather than as an additional choice variable, so the markets each site can serve is exogenous.

Gross profits under a given regime We assume site-level gross profits are separable across salt sites: conditional on the regulatory regime, the gross profit of site s depends only on its own

productivity, trade costs, and the demand in the markets it can legally serve.[12]

Define the *administrative market access* of site s under regime r as

$$MA_s^r \equiv \sum_{k \in D_s^r} \frac{N_k}{\tau_{sk}^{\sigma-1}}, \tag{2}$$

which summarizes the effective demand that site s can legally access, with each market weighted by an inverse function of trade costs between the site and the market.

With CES demand and monopoly pricing, the gross profit of site s under regime r can be written as

$$\Pi_s^r = cT_s^{\sigma-1} MA_s^r, \tag{3}$$

where $c \equiv \frac{(\sigma-1)^{\sigma-1}}{\sigma^\sigma}$ is a constant. Because districting restricts the set of markets a site can legally serve, $D_s^D \subseteq D_s^{ND}$ implies $MA_s^D \leq MA_s^{ND}$, reducing site-level gross profits.

Leakage and fiscal revenue Because enforcement is imperfect, only a fraction $1 - \ell^r$ of gross profit is ultimately collected as fiscal revenue by the government, where $\ell^r \in [0, 1]$ captures leakage from smuggling, tax evasion, and other forms of loss. We assume that districting improves enforcement, so that $\ell^D < \ell^{ND}$. We interpret districting as an administrative technology that facilitates enforcement: by limiting legal cross-border salt flows, districting can make unauthorized diversion easier to detect.

The net fiscal revenue collected from operating site s is therefore

$$R_s^r = (1 - \ell^r) cT_s^{\sigma-1} MA_s^r - f_s. \tag{4}$$

Salt site operation Given regime r, the government operates site s if and only if its net fiscal revenue in Equation (4) is nonnegative, or equivalently,

$$MA_s^r \geq \frac{f_s}{(1 - \ell^r) cT_s^{\sigma-1}}. \tag{5}$$

[12]The illustrative model abstracts from within-district interactions across sites. The full model later allows for richer interactions and provides a microfoundation for this reduced-form separability under suitable parameter values.

This inequality shows that site operation depends on a comparison between administrative market access and an effective fixed-cost threshold. Districting affects site operation through two channels. On the one hand, it restricts legal market access, reducing MA_s^r and gross profit Π_s^r. On the other hand, it lowers leakage, increasing the share of gross profit the state can actually collect and thereby lowering the effective threshold for operation.

Government choice of districting: the fiscal-efficiency tradeoff Let $\mathcal{S}^r \subseteq \mathcal{S}$ denote the set of sites that satisfy the operation condition under regime r. The government chooses whether to impose salt districts by comparing total net fiscal revenue under the two regimes:

$$\max_{N} \sum_{s \in \mathcal{S}(N;\kappa)} [1 - \ell(N;\kappa)]\Pi_s(N) - f_s. \tag{6}$$

This problem highlights the central tradeoff of districting. Imposing salt districts improves enforcement and raises the share of gross profit the government can collect, but it also shrinks the legal markets each site can serve and reduces gross profits. Because districting also changes which sites satisfy the operation condition, it affects both the intensive margin of fiscal revenue among continuing sites and the extensive margin of site operation.

This illustrative model delivers a simple site-level selection condition, Equation (5), governing whether the government opens a salt site. We next test this prediction in the data using reduced-form evidence in Section 4. To capture other margins through which salt districts affect production—most notably, the allocation of production across sites—we then turn to a full model in Section 5 that generalizes the salt site selection problem by allowing for interactions across salt sites while assuming perfect enforcement within salt districts, so that the government fully appropriates gross profits under districting. This framework allows us to quantify the effects of salt districting. Finally, while the illustrative model treats district boundaries as exogenous, Section 7.3 enriches the analysis by allowing the number of districts to vary with state capacity.

4 Administrative Market Access and Salt Production Locations

4.1 Defining (Administrative) Market Access

To capture how salt districts shaped salt site selection, we use a market access approach, following Donaldson and Hornbeck (2016). Instead of transportation infrastructure, we exploit variations of administrative boundary changes across dynasties. Specifically, the administrative market access for county i in dynasty t is:

$$MA_{it} = \sum_{j \in S_{i(j)t}} \frac{N_{jt}}{d_{ij}^{\theta}}, \tag{7}$$

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.[13] County population in the Republic era come from Stauffer (1922).

Unlike with Donaldson and Hornbeck (2016), in which d_{ij} denotes the minimum-cost route distance through trasporation networks, we use the great-circle distance between county i and j. d_{ij} does not change over time; therefore, the variation mainly captures the administrative changes in $S_{i(j)t}$ induced by shifts in salt-district boundaries. Since d_{ij} cannot reflect topographical complexities, we additionally use the human mobility index minimum cost distance following Özak (2010, 2018) as a robustness check. 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

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

measures are highly correlated, while the relationship weakens with as distance increases.

4.2 Baseline Results

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:

$$Salt_{it} = \alpha \ln MA_{it} + \mathbf{X_{it}}\beta + \mu_i + \nu_t + \varepsilon_{it}, \tag{8}$$

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 (7). The parameter of interest is α, capturing the effect of market access on the choice of salt production. We include county fixed effect (μ_i) and dynasty fixed effect (ν_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 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 0.015, indicating that doubling 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 remains 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.

4.3 Decomposing Effects of Population vs. Salt Districts

Changes in market access arise from two sources: shifts in salt district boundaries and changes in population within markets. To disentangle these effects, we decompose changes in market access into two components: one driven by population changes while holding boundaries fixed, and the other driven by boundary changes while holding population fixed.

To address potential endogeneity in population change, arising from reverse causality (e.g., salt production attracting population) or omitted factors such as transportation improvements that affect both population and production, we exploit 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 technological progress primarily translates into population growth, changes in crop suitability serve as an exogenous predictor of population change. The change in CSI between the pre-1500 and post-1500 periods is calculated following Galor and Özak (2015, 2016), defining the Song and Yuan dynasties as the pre-1500 period and the Ming–Qing dynasties as the post-1500 period.

Replacing population with crop suitability, we decompose market access into two components: (1) boundary-driven market access, constructed using Song-period CSI and time-varying boundaries, and (2) CSI-driven market access, constructed using time-varying CSI and Song-period boundaries.

We present two main findings. First, both components significantly predict market access. Based on the following specification,

$$\ln MA_{it} = \gamma \ln MA_{it}^{\text{Song-CSI,t-BD}} + \mathbf{X_{it}}\eta + \mu_i + \nu_t + \varepsilon_{it}, \tag{9}$$

where $\ln MA_{it}^{\text{Song-CSI,t-BD}}$ is the boundary-driven market access, we find that boundary-driven measure signfiicantly increases market access (column (1)). When we replace $\ln MA_{it}^{\text{Song-CSI,t-BD}}$ in Equation (9) with $\ln MA_{it}^{\text{t-CSI,Song-BD}}$. We find that this CSI-driven market access also has a significant effect on production. When we include both components (column (3)), the results remain robust. Moreover, comparing columns (1) and (2) with (3) indicates that the coefficients of each component change only slightly after including the other, suggesting that the two components are only weakly correlated.

Second, both factors exert strong influences on salt production. Table 4, columns (1)–(3), estimate Equation 8 using the boundary- and CSI-driven market access measures. The within-grid standard deviation of boundary-driven market access is 0.50, while that of CSI-driven market access is 0.10, indicating that most temporal variation in market access is due to boundary changes. Column (3) shows that a one–standard-deviation increase in boundary-driven market access increases the probability of salt production by 0.7 percentage points (0.014×0.5)), whereas a one–standard-deviation increase in CSI-driven market access raises it by 0.8 percentage points (0.080×0.1). These results suggest that both factors have comparable influences on the spatial

distribution of salt production.[14]

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

The districting institutions reshaped the spatial allocation of production by changing the effective market access faced by each potential site. Locations that would otherwise be competitive may operate at a smaller scale or remain inactive if their legally accessible markets are limited, while other sites may continue producing despite higher costs because they are protected by district boundaries. Trade was likewise distorted, as markets were prevented from sourcing from the lowest-cost producers whenever those producers lay outside their assigned district.

To quantify the economic consequences of these restrictions and understand alternative institutional arrangements, we develop a model in which the government operates as a vertically integrated monopolist in the salt sector and determines the locations of salt production, subject to the constraint that salt can only be traded within designated salt districts.

There are K markets and N potential salt production sites. The government chooses which sites operate in order to maximize total monopoly profits, subject to demand in each market and the restriction that trade can occur only within administrative districts.

[14]The CSI-driven change in market access is driven by the Columbian Exchange, which is exogenous. This provides an opportunity to test whether boundary changes influence the location of salt production through channels other than market access. Specifically, we first use boundary-driven and CSI-driven market access to predict actual market access, and then regress the salt production dummy on the predicted market access while controlling for boundary-driven market access . The results show that boundary-driven market access has no direct effect on salt production. In other words, the boundary-driven component appears to affect salt production only through its impact on market access, rather than through alternative channels.

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:

$$\log \bar{q}_k = -\sigma \log p_k + \sigma \log b, \tag{10}$$

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

$$\log q_k \equiv \log(\bar{q}_k N_k) = -\sigma \log p_k + \sigma \log b + \log N_k \tag{11}$$

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.[15] For each shipment (ω), 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

[15] 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.

shipments, and follows Fréchet distribution with shape parameter θ 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 (ω) 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 τ_{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 (ω), the unit cost of producing salt in site s and ship it to market k is

$$c_{ks}(\omega) = \frac{\tau_{ks}}{z_s(\omega)}, \quad s \in S. \tag{12}$$

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 (ω), 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 ω 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[16]

$$c_k(S) \equiv \int_0^1 c_k(\omega; S) d\omega = \Gamma(1 + 1/\theta) \Phi_k(S)^{\frac{-1}{\theta}}, \tag{13}$$

where

$$\Phi_k(S) = \sum_{s \in S} T_s^{\theta} \tau_{sk}^{-\theta} \tag{14}$$

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.

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.

[16] $\int_0^1 c_k(\omega; S) d\omega = \int_0^{\infty} c dF(c)$, 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 $\Phi_k(S)^{\frac{-1}{\theta}} \int_0^{\infty} t^{\frac{1}{\theta}} e^{-t} dt = \Gamma(1 + 1/\theta) \Phi_k(S)^{\frac{-1}{\theta}}$.

Government chooses the quantity and price of salt for each market to maximizes its profits, subject to the demand given by Equation (11). 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

$$\pi_k(S) = \frac{\sigma^{-\sigma}}{(\sigma-1)^{1-\sigma}} b^\sigma N_k c_k(S)^{1-\sigma}. \tag{15}$$

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

$$\eta_{sk}(S) = \frac{T_s^\theta \tau_{sk}^{-\theta}}{\Phi_k(S)} = \frac{T_s^\theta \tau_{sk}^{-\theta}}{\sum_{s\in S} T_{s'}^\theta \tau_{s'k}^{-\theta}}. \tag{16}$$

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:

$$\max_{S\in\mathcal{P}(\{1,2,\cdots,N\})} \sum_{k=1}^{K} \pi_k(S) - \sum_{s\in S} f_s, \tag{17}$$

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 θ 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

$$\pi_k(S) = \sum_{s \in S} \kappa_k N_k T_s^{\theta} \tau_{sk}^{-\theta} \tag{18}$$

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

$$\max_{S \in \mathcal{P}(\{1,2,\cdots,N\})} \sum_{s \in S} \left(\sum_{k=1}^{K} \kappa_k N_k T_s^{\theta} \tau_{sk}^{-\theta} - f_s \right). \tag{19}$$

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:

$$\sum_{k=1}^{K} \kappa_k N_k T_s^{\theta} \tau_{sk}^{-\theta} - f_s > 0. \tag{20}$$

Reorganizing the terms, we can get that

$$\underbrace{\sum_{k=1}^{K} \kappa_k \frac{N_k}{\tau_{sk}^{\theta}}}_{MA_s} > \frac{f_s}{T_s^{\theta}}. \tag{21}$$

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 σ and θ, along with other model parameters, to account for these interactions. This flexibility is crucial when conducting counterfactual 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.[17] 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.[18]

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.[19] 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 σ) We allow the demand shifter b and demand elasticity σ 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 θ) 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 that these two types of regions display substantial differences in cost distributions, supporting this modeling choice.

The shape parameter of the Fréchet distribution (θ) is assumed to be the same across all

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

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

[19] 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.

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 θ'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 λ^f_{method}. If a site is active throughout the history, its fixed cost is set to zero.

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

$$\log \tau_{sk} = \beta^{\tau}_{method} \log \text{distance}_{sk}, \tag{22}$$

where β^{τ}_{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.[20]

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

$$f(\phi) = [m - \hat{m}(\phi)]' W [m - \hat{m}(\phi)], \tag{23}$$

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

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 λ^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 σ^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 μ^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 σ. 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 θ. A larger θ 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 β^τ. 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.[21]

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 σ 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 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.

[21] 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.

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 (8). 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 2 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:

$$SaltProbabilty_{it} = \alpha \ln MA_{it} + \mu_i + \nu_t + \varepsilon_{it}, \tag{24}$$

where μ_i and ν_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.

As a further robustness check, we allow salt production technology to vary across dynasties. While well salt production relied exclusively on boiling throughout the period, solar evaporation of sea salt was not practiced until the Yuan dynasty. We therefore impute the production method of each sea salt site—boiling, solar evaporation, or a combination—in each dynasty, and compute the average cost of sea salt production as a weighted average of method-specific costs observed in the Minguo data. We then recalibrate the mean of log productivity for sea salt sites, μ_{sea}^T, in each dynasty to match this imputed average cost, holding all other parameters at their Minguo baseline values. Table D.2 reports the recalibrated productivity parameters and the model's fit to the cost targets. We re-simulate the model under these dynasty-specific productivity levels and

re-estimate the market access regression. As shown in Table D.3, the estimated market access coefficients remain close to those in the data. This stability is intuitive: changes in average productivity shift average costs, but not by enough to alter the opening probabilities of most sites, leaving the estimated relationship between market access and site production largely unchanged.

Overall, these results provide further reassurance that the model captures the key determinants of salt production decisions.

7 Costs, Persistence, and Evolution of Salt Districting

Armed with our model and estimates, we conduct counterfactual exercises and additional analysis to clarify the role of state capacity in shaping both economic outcomes and institutional choices. Our analysis proceeds in three steps to shed light on the costs, persistence, and changes in salt districting as a state simplification strategy.

First, we quantify the aggregate costs of salt districting as a state simplification strategy. To do so, we consider a counterfactual high-capacity state that can enforce its monopoly and collect fiscal revenues without relying on geographically segmented markets. In this setting, salt districts are removed, and counties are free to source salt from all active sites, including those outside their original district.[22] This exercise isolates the allocative consequences of limited state capacity, holding the monopoly objective fixed.

Second, we turn to the persistence of such inefficient institutions. To this end, we consider a broader counterfactual that relaxes the monopoly assumption and introduces competition in an integrated market. This exercise does not represent a pure change in state capacity, but rather serves as a benchmark to highlight the fiscal role of monopoly power. While competition lowers prices and increases consumption, it also compresses markups and reduces fiscal revenues. Comparing this scenario with the monopoly benchmark reveals a central trade-off: under limited capacity, institutions such as districting help sustain monopoly rents and thus remain fiscally attractive despite their allocative costs.

[22] 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.

Finally, we extend the model by endogenizing the number of districts. This allows us to examine how state capacity shapes institutional design directly. In this extension, district granularity emerges as a function of capacity, reflecting the trade-off between enforcement gains and allocative distortions. The results illustrate that districting is not an arbitrary feature of the system, but an endogenous response to limited fiscal-administrative capacity.

7.1 Quantifying the Cost of Salt Districting: A Counterfactual

We begin with the first counterfactual and quantify how removing district boundaries affects trade, prices, consumption, aggregate productivity, and fiscal revenues.

Cross-district trade. Absent district boundaries, counties can source salt from all active sites and access lower-cost suppliers. The share of salt sourced from outside the original district for county k is given by

$$\text{Outside share}_k = \frac{\Phi_k^{out}(S)}{\Phi_k^{in}(S) + \Phi_k^{out}(S)}, \tag{25}$$

where the denominator represents the total production potential available to county k once district boundaries are removed. It includes production potential within the original district, $\Phi_k^{in}(S) = \sum_{s \in S_k} T_s^{\theta} \tau_{sk}^{-\theta}$, and outside the district, $\Phi_k^{out}(S) = \sum_{s \notin S_k} T_s^{\theta} \tau_{sk}^{-\theta}$. Under district restrictions, the second component is zero because cross-district trade is prohibited. The share of salt sourced from outside sites therefore reflects their contribution to the expanded production potential. Counties with relatively stronger outside potential consequently import a larger share of salt from external sites. Finally, the optimal set of active salt sites S may differ from the original set, as the government re-optimizes site choices in response to the removal of district boundaries.

Table 8 presents the trade share 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%).

Price and consumption. As production potential increases, unit costs fall and prices decline. As shown in Table 9, price reductions differ substantially across districts, reflecting heterogeneity in gains from trade. Particularly, districts with greater outside sourcing also experience larger price declines. This pattern is consistent with Arkolakis et al. (2012) that gains from trade are summarized by trade shares. 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. Overall, the county-level price falls by 30% on average, and aggregate consumption increases by 47%.

Reallocation of production and aggregate productivity. After removing salt district boundaries, salt production reallocates geographically from less productive inland districts—particularly those producing well salt—toward more productive coastal regions that produce sea salt. Column (3) of Table 9 shows that, on the extensive margin, the number of active salt sites declines in Lianghuai and Sichuan while increasing in other sea-salt districts, with Liangguang alone gaining 10 additional sites. Taken together, the expansion in demand leads to a net increase of about nine salt sites overall. On the intensive margin, average output per site follows a similar pattern.

Panel A of Figure 3 further illustrates the spatial distribution of these changes. Blue circles denote increases in output and red circles denote decreases, with darker shades indicating larger magnitudes. The map highlights a clear shift in production away from inland areas in Sichuan and toward coastal regions.

Production also reallocates toward more productive sites, as shown in Panel B. Sites in the top decile of the productivity distribution account for a larger share of total output once district boundaries are removed relative to the baseline model. Overall, this reallocation raises aggregate

productivity by about 109%.[23]

Fiscal profits. Column (6) of Table 9 shows the changes in fiscal profits. The profit changes vary substantially across districts, ranging from a 48% decline in Lianghuai to a 102% increase in Liangguang. These differences reflect two opposing forces: losses from reduced local sales as counties shift to cheaper out-of-district suppliers, and gains from expanded sales to other districts. Districts that lose market share to more productive coastal suppliers, such as Lianghuai, see net profit declines, while districts that gain new customers, such as Liangguang, see net profit increases.

In aggregate, total fiscal profits rise by 12% following the removal of district boundaries. This aggregate gain directly quantifies the fiscal cost of limited state capacity: a government able to enforce its monopoly without district boundaries would collect 12% more in fiscal revenues than under the district system. The forgone 12% represents the price the government pays for its inability to tax salt production without imposing geographic restrictions that distort trade and misallocate production.

Decomposing reallocation: existing sites versus entry and exit. We decompose the changes in price, consumption, aggregate productivity, and fiscal profits into contributions from reallocation among existing salt sites versus reallocation through entry and exit. To isolate these channels, we construct an intermediate counterfactual in which we remove district boundaries while holding the set of active salt sites fixed, then compare this to the full counterfactual that allows free entry and exit. Table 10 reports the results. Column (1) reprints the aggregate changes under the full removal of salt district boundaries. Column (2) shows the share attributable to reallocation among existing sites, and Column (3) shows the contribution from entry and exit.

Entry and exit play a limited role in price adjustment—accounting for only 5% of the price decline—but make a meaningful contribution to real outcomes: they explain 14% of the increase

[23] We define aggregate productivity as total salt output divided by total amount of brine used in production. Under the model, this yields

$$Z = \frac{\sum_k b^\sigma N_k \mu^{-\sigma} \Gamma(1-\frac{\sigma}{\theta})(\Phi_k(S))^{\frac{\sigma}{\theta}-1}\Omega_k(S)}{\sum_k b^\sigma N_k \, \mu^{-\sigma} \, \Gamma\Big(1+\frac{1-\sigma}{\theta}\Big) \, (\Phi_k(S))^{\frac{\sigma-1}{\theta}}},$$

where $\Omega_k(S) \equiv \sum_{s \in S_k} T_s^\theta \tau_{ks}^{-\theta+1}$.

in aggregate consumption, 9% of the productivity gain, and 7% of the rise in fiscal profits. While reallocation among existing sites remains the dominant force, entry and exit account for a non-trivial share of the aggregate effects.

This decomposition also highlights the value of the structural model. The reduced-form analysis identifies how boundary changes affect site entry and exit, which is observable across dynasties. The estimated model goes further by recovering the reallocation among continuing sites—a margin that is unobservable in the data due to the absence of production records across dynasties—and reveals that both margins contribute meaningfully to the aggregate effects.

Taken together, 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 by 12% and salt districts would not need to be imposed. It is precisely the lack of such capacity that gives rise to salt districts. Relative to this benchmark, imposing salt districts creates misallocation of production, raises prices, reduces consumption, and ultimately lowers the fiscal revenues the districts were designed to protect.

7.2 Why Inefficient Rules? A Counterfactual

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 by allowing for competition.

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

$$\tilde{p}_k(S) \equiv \left(\int_0^1 p_k(\omega; S)^{1-\sigma} d\omega \right)^{\frac{1}{1-\sigma}} = \frac{\gamma}{\Gamma(1+1/\theta)} c_k(S), \tag{26}$$

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 (13). 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 11 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.[24] 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 limited state capacity.

[24] Table D.4 shows the trade share across salt districts after removing salt district boundaries and introducing Bertrand competition across salt sites.

Imposing salt districts raises price and suppresses consumption, but it also increases fiscal profits, which explains why many states adopt such strategies despite their distortionary costs.

7.3 Extension: State Capacity and District Granularity

To further illustrate how state capacity shapes the choices of salt districts, we extend our model to illustrate how the *granularity* of the district system—the number of districts—can arise endogenously as a function of state capacity. Historically, periods of stronger state capacity (e.g., the Song dynasty) were associated with a more finely partitioned district system, while periods of weaker capacity (e.g., the Yuan dynasty) featured fewer districts. In modern settings, advances in monitoring and information technology allow governments to regulate salt production and distribution without relying on geographic districts.

We rationalize these patterns by endogenizing the choice of district granularity. The model predicts that the optimal number of districts first increases and then decreases with state capacity, consistent with the evolution of the salt administration in history and modern times.

Let D denote a partition of markets into salt districts. Conditional on a partition D, the government chooses the set of salt sites S, as in the baseline model, to maximize its monopoly profit net of the site fixed cost, $\Pi(D)$, given by equation (17). The full problem is to choose the partition D to maximize $\Pi(D)$. However, solving directly for the optimal geographic partition is computationally infeasible. To study district granularity, we therefore reduce the problem to the choice of the number of districts. Denote the number of salt districts by N and denote the maximum profit attainable under the best partition with N districts by

$$\Pi(N) \equiv \max_{D:|D|=N} \Pi(D). \tag{27}$$

This reduced-form object summarizes the effect of district fragmentation on monopoly profits after optimally adjusting both the partition and the set of active production sites. We assume $\Pi(N+1) < \Pi(N)$, meaning that a finer district system reduces monopoly profit because it restricts more cross-district trade, and limits the efficient allocation of production across sites.

Capacity and enforcement. Let $\kappa > 0$ denote state capacity, which is treated as the fundamental parameter. It interacts with the districting and jointly affects the state's net fiscal revenue through two channels: enforcement of the monopoly system and administrative cost.

(i) **Enforcement and Leakage.** A fraction $\ell(N;\kappa) \in [0,1]$ of monopoly rents is lost due to weak enforcement, such as smuggling and evasion. We assume that both more districts and stronger state capacity improve enforcement. For concreteness, consider the simple specification:

$$\ell(N;\kappa) = \exp(-a\kappa N), \qquad a > 0. \tag{28}$$

(ii) **Administrative cost.** Maintaining districts requires personnel, monitoring borders, and supervising local officials. We assume the administrative costs increase with the number of districts but decline with state capacity. In particular, we consider assume the following cost function:

$$C(N;\kappa) = c\frac{N}{\kappa}, \qquad c > 0. \tag{29}$$

Government problem. The government chooses the number of districts $N \in \{1, 2, \cdots\}$ to maximize its net fiscal revenue, given by

$$R(N;\kappa) = \big[1 - \ell(N;\kappa)\big]\Pi(N) - C(N;\kappa). \tag{30}$$

The marginal value of an additional district is then $\Delta R(N;\kappa) \equiv R(N+1;\kappa) - R(N;\kappa)$. Under the the parametric forms of $\ell(N;\kappa)$ and $C(N;\kappa)$ above, we have

$$\Delta R(N;\kappa) = \underbrace{\big(1 - e^{-a\kappa(N+1)}\big)\big[\Pi(N+1) - \Pi(N)\big]}_{\text{profit loss due to fragmentation}<0} + \underbrace{\big(e^{-a\kappa N} - e^{-a\kappa(N+1)}\big)\Pi(N)}_{\text{enforcement gain}>0} - \underbrace{\frac{c}{\kappa}}_{\text{admin cost}}. \tag{31}$$

This expression highlights the key trade-offs facing government. The first term represents the profit loss due to fragmentation from a finer districting. Because $\Pi(N+1) < \Pi(N)$, increasing the number of districts reduces the monopoly surplus that can be generated under perfect enforcement.

The second term captures the enforcement gain from an additional district: by tightening monitoring and restricting unauthorized trade, more districts allow the state to retain a larger share of monopoly profit. The third term reflects the administrative cost of operating additional districts, which declines with state capacity. The government will choose a finer partition with more districts as long as the enforcement gain outweigh the profit loss and additional administrative costs.

District granularity and state capacity. To examine how state capacity κ affects the marginal value of adding a district, differentiate equation (31) with respect to κ:

$$\frac{\partial \Delta R(N;\kappa)}{\partial \kappa} = \underbrace{a(N+1)e^{-a(N+1)\kappa}\big[\Pi(N+1)-\Pi(N)\big]}_{<0} + \underbrace{ae^{-aN\kappa}\Big[(N+1)e^{-a\kappa}-N\Big]\Pi(N)}_{>0 \text{ at low } \kappa;<0 \text{ at high } \kappa} + \underbrace{\frac{c}{\kappa^2}}_{>0}. \tag{32}$$

The first term is negative because finer districting reduces monopoly profits regardless of state capacity. The third term is positive because stronger states administer districts at lower cost.

The second term is central: it captures how state capacity affects the enforcement value of an additional district. It is positive when state capacity is sufficiently low,

$$\kappa < \frac{1}{a}\ln\left(\frac{N+1}{N}\right), \tag{33}$$

and negative when this condition is reversed. When state capacity is low, leakage is substantial, so the marginal value of adding a district may be higher for states with greater capacity. In this region, the number of districts and state capacity are complements, that is, $\frac{\partial \Delta R(N;\kappa)}{\partial \kappa} > 0$. When state capacity is high, however, leakage is already limited, and the incremental enforcement benefit of additional districts diminishes. In this region, the number of districts and state capacity become substitutes, $\frac{\partial \Delta R(N;\kappa)}{\partial \kappa} < 0$.[25]

Consequently, the optimal number of districts is hump-shaped in state capacity: weak states operate coarse district systems (e.g., the Yuan dynasty), intermediate states rely on finer dis-

[25] These results do not hinge on the specific functional forms assumed for leakage or administrative costs. The result holds more generally as long as $\frac{\partial \Delta R(N;\kappa)}{\partial \kappa} > 0$ for sufficiently low κ and $\frac{\partial \Delta R(N;\kappa)}{\partial \kappa} < 0$ for sufficiently high κ.

tricting to support enforcement (e.g., the Song dynasty), while strong states rely more on direct administrative control and require fewer and even no district boundaries (modern time).

8 Conclusion

How to tax has always been a fundamental challenge for states. In the absence of advanced technologies for monitoring, information gathering, and enforcement, governments have frequently turned to simplified administrative devices such as geographic monopolies and licensing regimes to secure fiscal revenues. While historians and social scientists have long emphasized the ubiquity of such strategies, their economic consequences remain less systematically understood.

In this study, we combine newly assembled historical data with a structural spatial equilibrium framework to quantify the economic costs of administrative simplification. Focusing on China's millennia-long salt monopoly, we show that rigid districting, designed to facilitate oversight and tax collection, systematically distorted production geography and reduced consumer welfare. Our counterfactual analysis demonstrates that removing these constraints would have significantly lowered prices, increased consumption, reallocated production toward more efficient coastal sites, and even enhanced fiscal revenues. Conversely, introducing competition highlights the fiscal logic of monopoly privileges: they secure state revenues at the cost of efficiency and integration.

Taken together, our findings highlight a broader lesson for the political economy of development: administrative technologies of taxation are not neutral instruments but active shapers of markets and economic geography. By prioritizing legibility and control, weak-capacity states often entrench inefficiencies that persist over the long run. This tension between fiscal capacity and market efficiency helps explain the resilience of monopolies in historical revenue systems and remains relevant in contemporary debates over state ownership, regulation of certain products, and the design of tax systems in developing economies.

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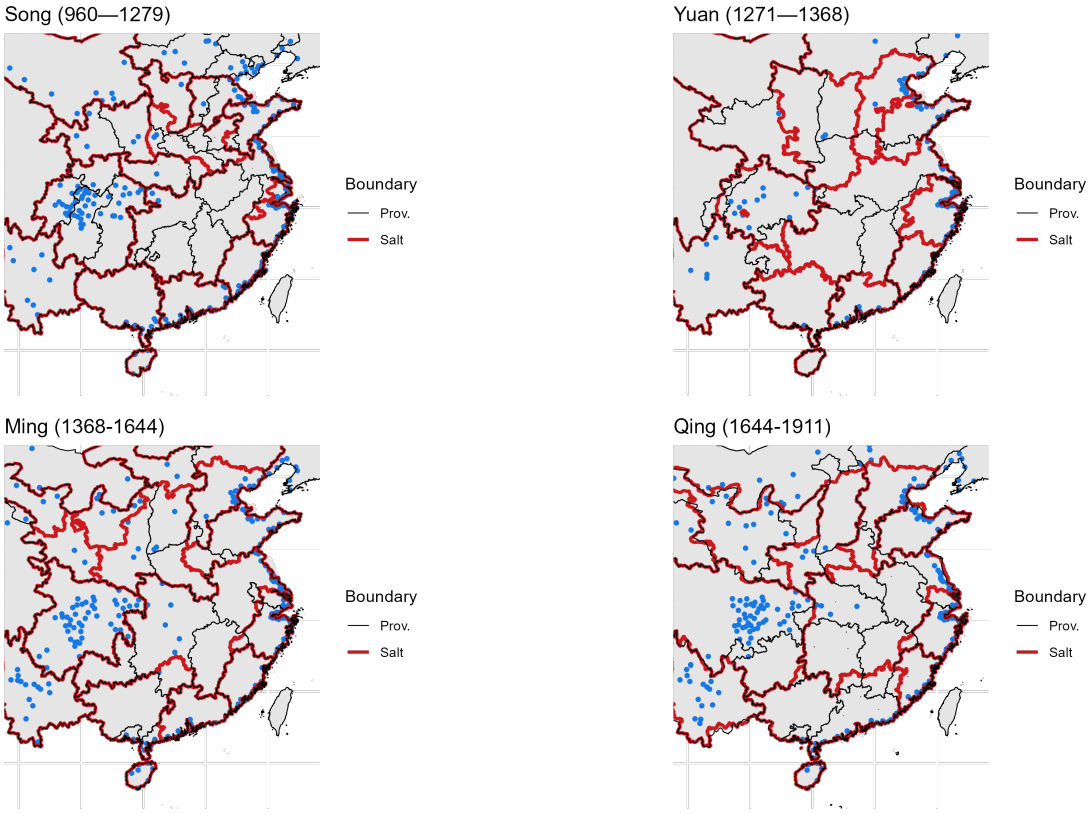
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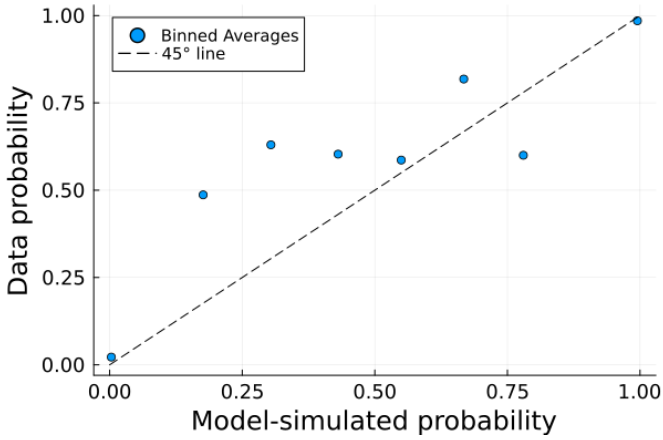
Figures

Figure 1: Salt Sites and Administrative Boundaries Across Four Dynasties



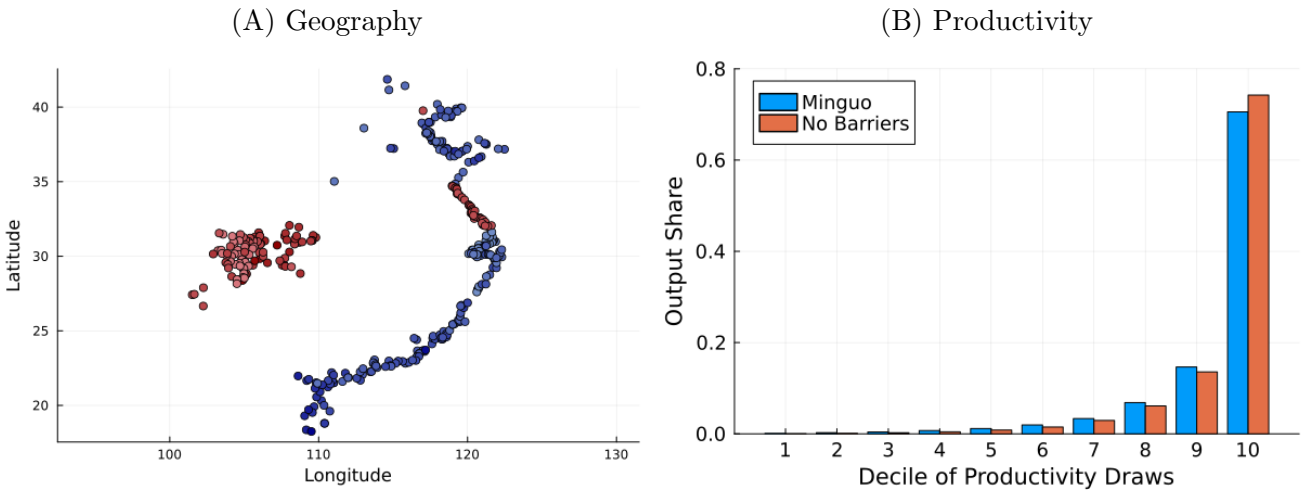
Note: This figure displays the location of salt sites (blue dots), salt district boundaries (red lines), and provincial boundaries (brown lines) across the Song, Yuan, Ming, and Qing dynasty.

Figure 2: 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 3: Removal of Salt District Boundaries: Changes in Salt Production



Notes: These figures show changes in salt site production after removing salt district boundaries. Panel (A) displays geographic changes in production quantity. 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 (B) shows the share of output 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 boundaries are removed.

Tables

Table 1: Opening and Closure of Salt Production

<table>
<tr><th>All</th><th>Song</th><th>Yuan</th><th>Ming</th><th>Qing</th></tr>
<tr><td rowspan="16">1650</td><td rowspan="8">204</td><td rowspan="4">70</td><td rowspan="2">67</td><td>60</td></tr>
<tr><td>7</td></tr>
<tr><td rowspan="2">3</td><td>1</td></tr>
<tr><td>2</td></tr>
<tr><td rowspan="4">134</td><td rowspan="2">52</td><td>35</td></tr>
<tr><td>17</td></tr>
<tr><td rowspan="2">82</td><td>18</td></tr>
<tr><td>64</td></tr>
<tr><td rowspan="8">1446</td><td rowspan="4">16</td><td rowspan="2">12</td><td>9</td></tr>
<tr><td>3</td></tr>
<tr><td rowspan="2">4</td><td>0</td></tr>
<tr><td>4</td></tr>
<tr><td rowspan="4">1430</td><td rowspan="2">61</td><td>22</td></tr>
<tr><td>39</td></tr>
<tr><td rowspan="2">1369</td><td>73</td></tr>
<tr><td>1296</td></tr>
<tr><td>Total Salt</td><td>204</td><td>86</td><td>192</td><td>218</td></tr>
</table>

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***	0.014***	0.013***	0.007**
	(0.004)	(0.004)	(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	Any
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. μ_i is county fixed effect, and ν_t is dynasty fixed effect. Geographic features include elevation, distance to coastline, and the number of rivers. See Section 4.2 for details. Standard errors are clustered at county level.

Table 3: Market Access Using Route Cost

	(1) Salt(0/1)	(2) Salt(0/1)	(3) Salt(0/1)	(4) Salt(0/1)	(5) Salt(0/1)	(6) Salt(0/1)
ln MA (Route Cost + Salt Districts)	0.0146***	0.0113***			0.0145***	0.0113***
	(0.003)	(0.003)			(0.003)	(0.003)
ln MA (Route Cost out of Salt Districts)			0.0127	0.0119	0.0070	0.0092
			(0.017)	(0.023)	(0.017)	(0.023)
County FE	*Y*	*Y*	*Y*	*Y*	*Y*	*Y*
Dynasty FE	*Y*	*Y*	*Y*	*Y*	*Y*	*Y*
Baseline Controls		*Y*		*Y*		*Y*
R-square	0.652	0.659	0.651	0.659	0.652	0.659
N	6,404	6,404	6,404	6,404	6,404	6,404

Note: Columns (1) and (2) report estimates using market access measured by route costs through the transport network constrained within salt districts. Columns (3) and (4) use market access measured by route costs through the transport network outside of salt districts. Columns (5) and (6) include both measures simultaneously. Even-numbered columns further control for baseline controls. Standard errors clustered at the county level are reported in parentheses.

Table 4: Decomposing Changes in Market Access

	(1) ln MA	(2) ln MA	(3) ln MA	(4) Salt(0/1)	(5) Salt(0/1)	(6) Salt(0/1)
ln MA (Pre-1500 CSI)	0.2709***		0.2818***	0.0138**		0.0138**
	(0.041)		(0.045)	(0.006)		(0.007)
ln MA (CSI, Song Boundary)		2.9892***	2.8580***		0.0864**	0.0800**
		(0.148)	(0.142)		(0.040)	(0.040)
County FE	*Y*	*Y*	*Y*	*Y*	*Y*	*Y*
Dynasty FE	*Y*	*Y*	*Y*	*Y*	*Y*	*Y*
Baseline Controls	*Y*	*Y*	*Y*	*Y*	*Y*	*Y*
R-square	0.839	0.845	0.851	0.659	0.656	0.656
N	6,404	6,212	6,212	6,404	6,212	6,212

Note: Columns (1)–(3) report the decomposition of market access into changes in salt district boundaries and market size, measured by the crop suitability index (CSI). Column (1) fixes the CSI at its pre-1500 values (mapped to the Song dynasty) but allows salt district boundaries to vary over time. Column (2) fixes the boundaries at the Song dynasty level but allows CSI to vary over time. Column (3) reports the coefficients on both terms. Columns (4)–(6) report the effects of the two components on salt production. Standard errors are clustered at the county level.

Table 5: Parameters

Parameter	Description	Sea Water	Well Water
b	Demand shifter	0.945 (0.180)	4.431 (1.416)
σ	Demand elasticity	1.264 (0.050)	5.236 (4.621)
θ	Shape parameter of Frechet	7.790 (6.262)	7.790 (6.262)
μ^T	Mean of log state of technology	-0.088 (0.561)	-2.354 (0.253)
σ^T	Dispersion of log state of technology	0.221 (0.139)	0.438 (0.151)
λ^f	Inverse of mean fixed costs	1.090e-05 (9.819e-06)	2.900e-05 (1.138e-04)
β^τ	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 (θ), 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. ν_t and μ_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: Sources of Reallocation After Removing Salt District Boundaries

		Reallocation from	
Relative Changes in	Strong State	Existing Sites	Entry & Exit
No. Sites	9	–	100%
Price	-0.3	95%	5%
Consumption	0.47	86%	14%
Sales	0.37	89%	11%
Agg. productivity	1.09	91%	9%
Profit	0.12	93%	7%

Note: This table decomposes the aggregate effects of removing salt district boundaries into contributions from reallocation among existing sites versus entry and exit. Column (1) reports relative changes expressed as a proportion of the baseline, except for the number of sites which reports the net level change. Column (2) isolates the contribution of existing-site reallocation by holding the set of active sites fixed. Column (3) reports the contribution from entry and exit.

Table 11: 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

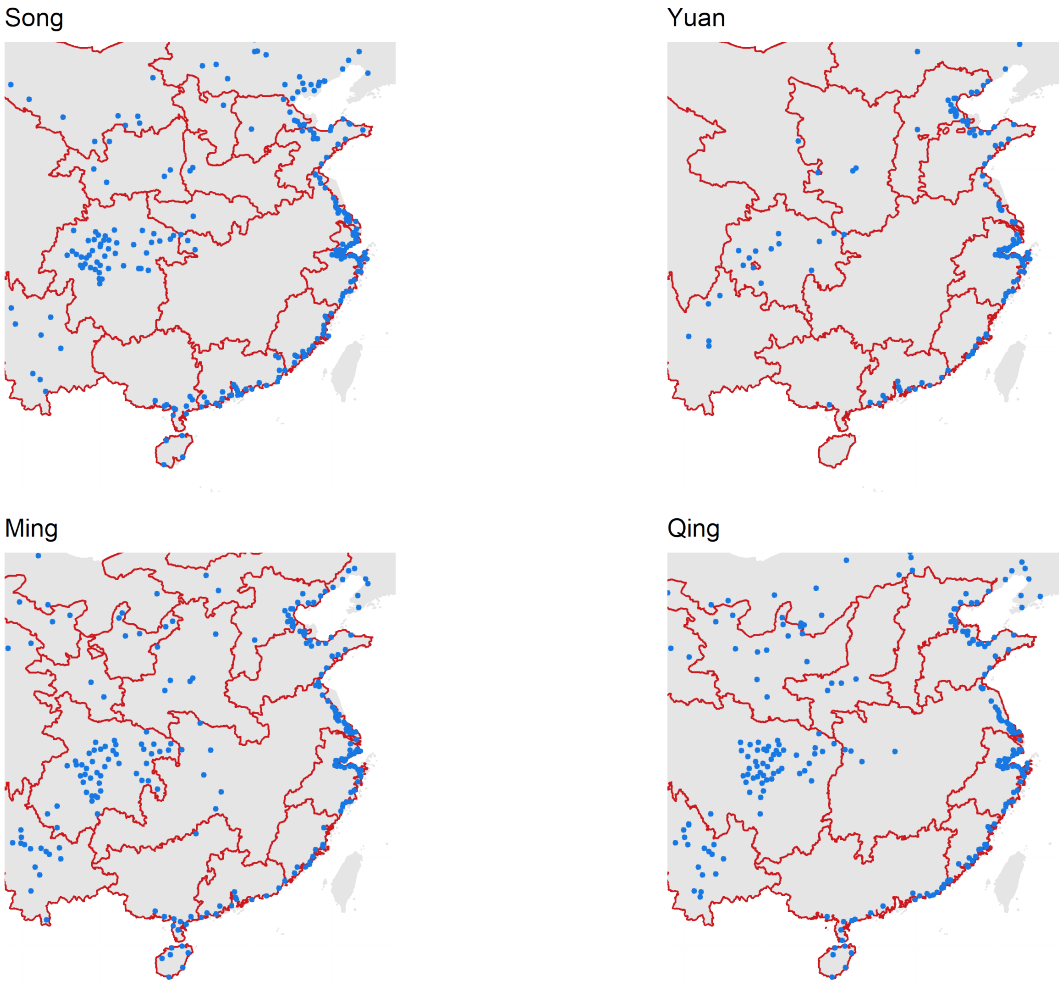


Figure A.1: Salt District Boundaries

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

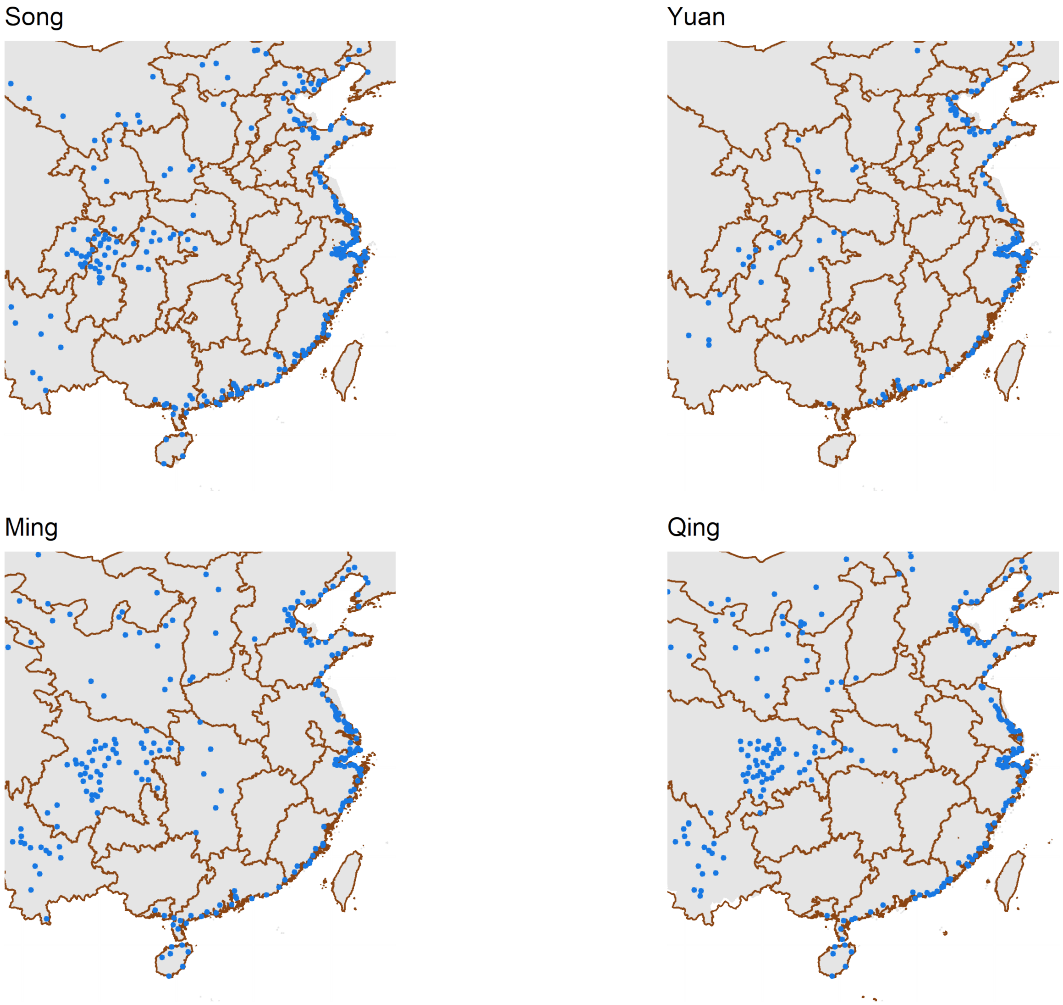


Figure A.2: Provincial Boundaries

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**

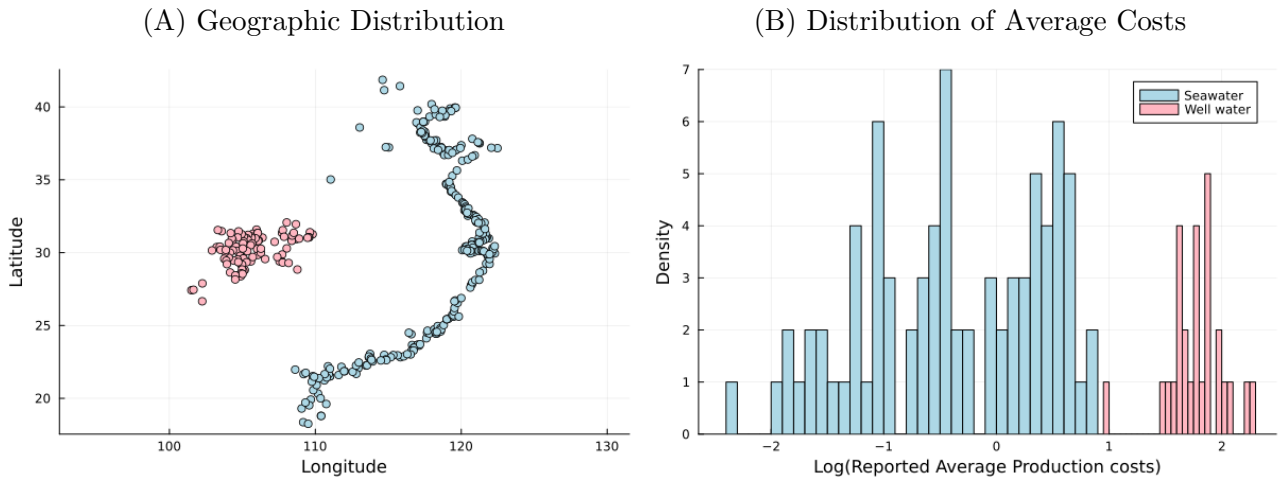
A.3 Salt Production Method

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)

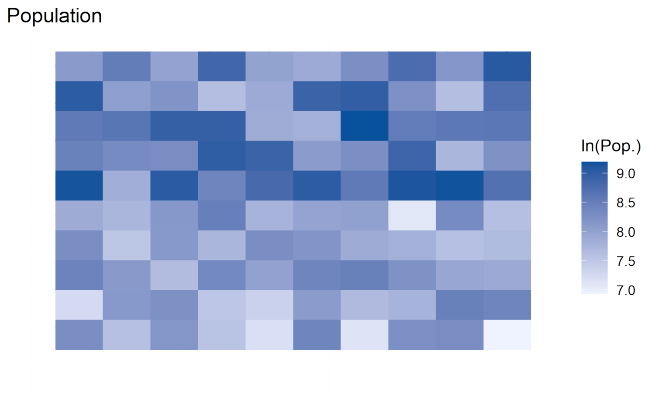
B Data Construction

B.1 Market Access

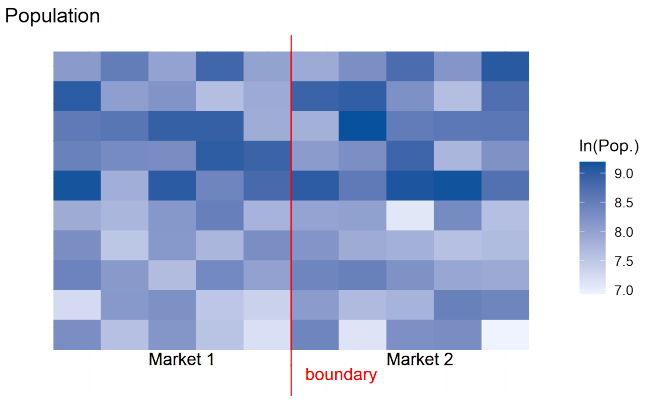
Figure B.1 serves as a simple illustration of constructing market access. Consider 100 square regions in space. Plot (a) displays random numbers representing population, with the northern part doubled for clarity. Assume a vertical line forms a boundary dividing regions into two markets where goods can 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

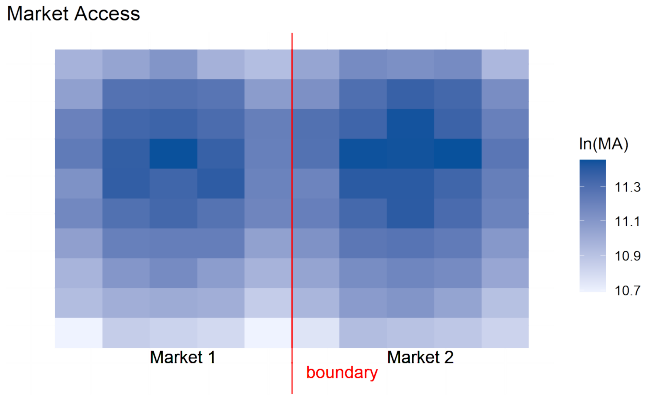
Figure B.2 is a simple case of local markets defined by salt district and provincial boundaries. The points in (a) represents counties which located in three provinces. The larger points are salt-producing counties. Based on salt production locations, the region is divided into two salt districts, as 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.



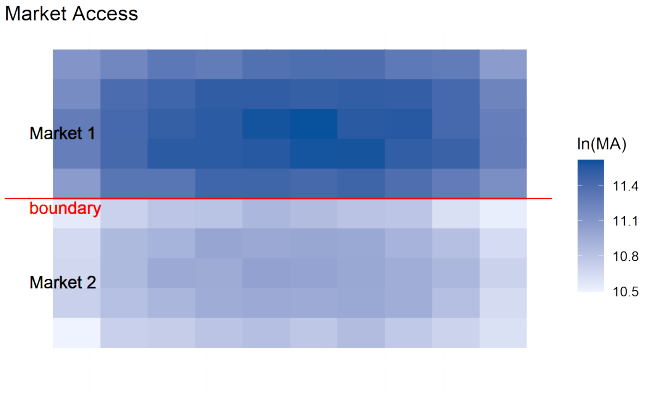
(A) Population



(B) Boundary and Markets

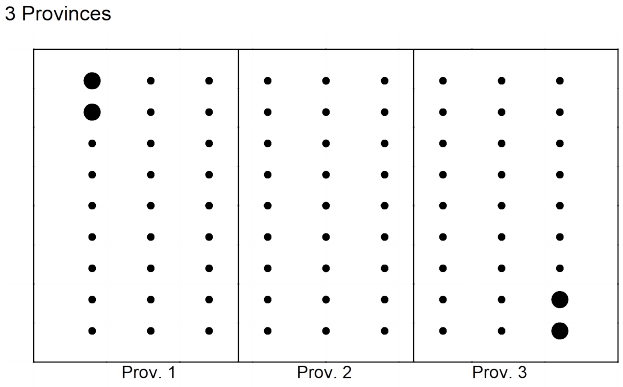


(C) Market Access (I)

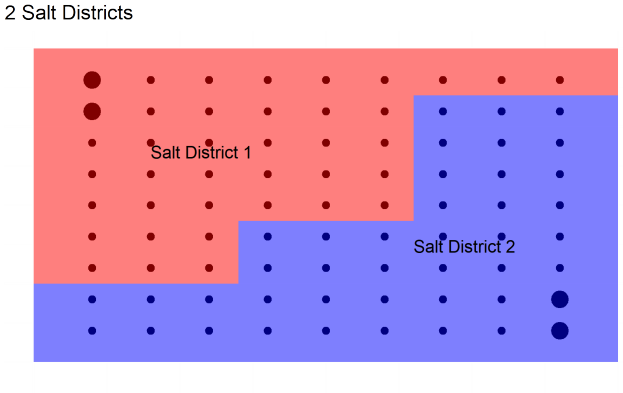


(D) Market Access (II)

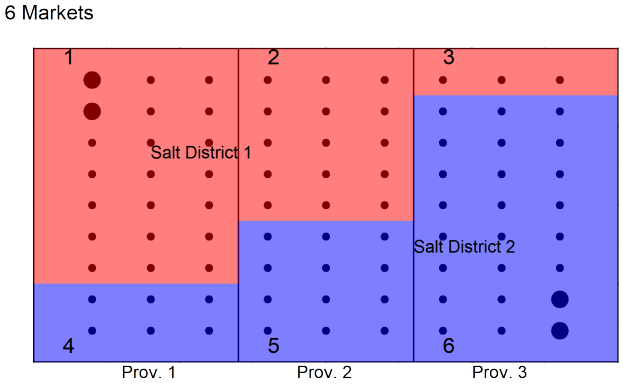
Figure B.1: Simulated Case of Market Access



(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

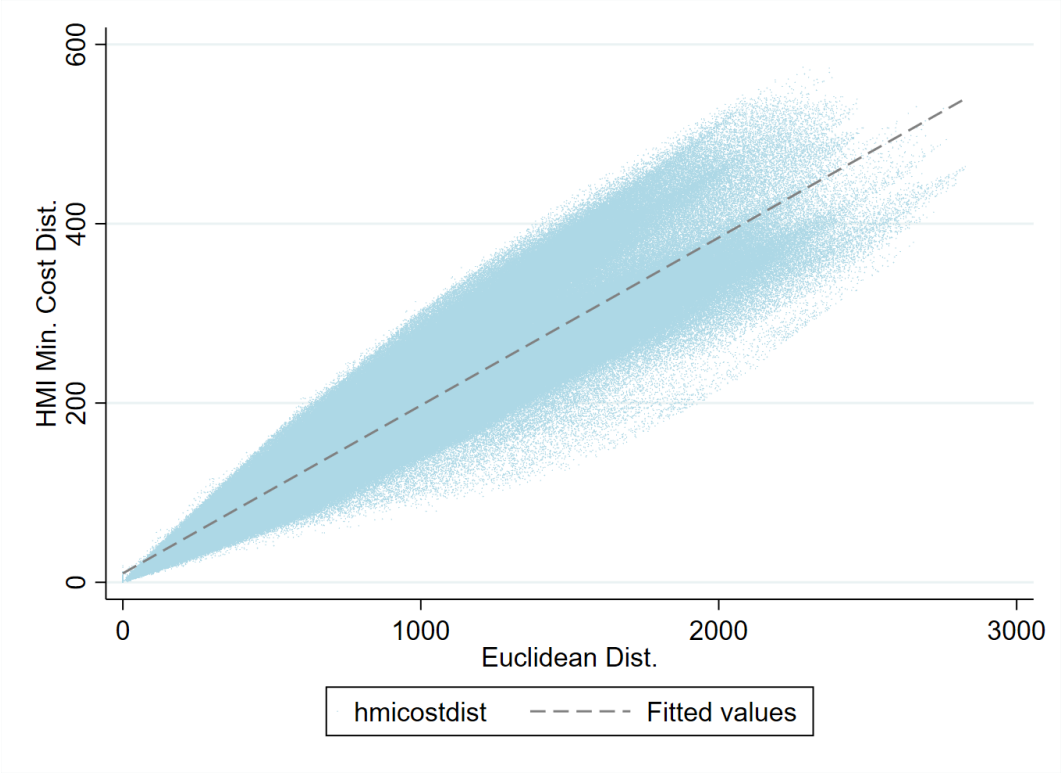


Figure C.1: Correlation: Great-circle Distance and Human Mobility Index Minimum Cost Distance

C.2 Crop Suitability and Population Density

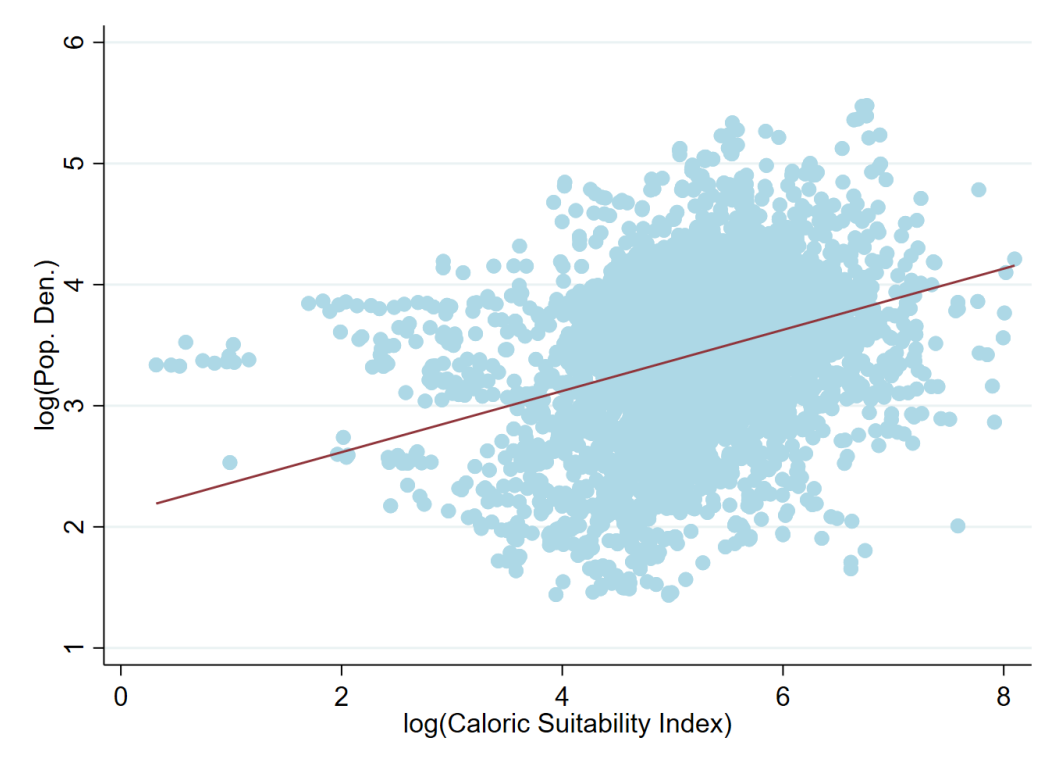
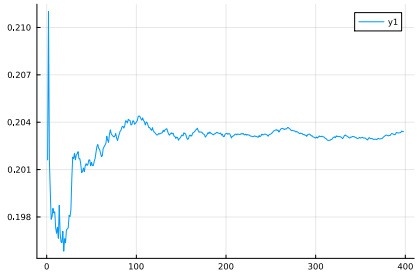


Figure C.2: Correlation: Crop Suitability Index and Population Density

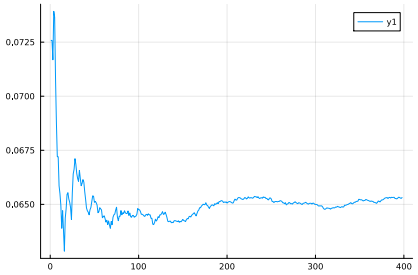
C.3 Convergence of Simulated Moments

Figure C.3: Convergence of Simulated Moments

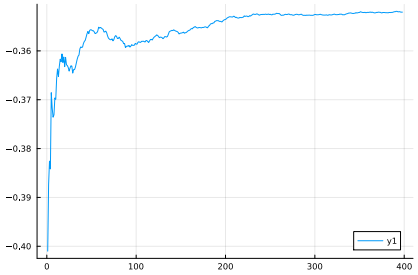
(A) #Active Salt Sites: Sea Salt



(B) #Active Salt Sites: Well Salt



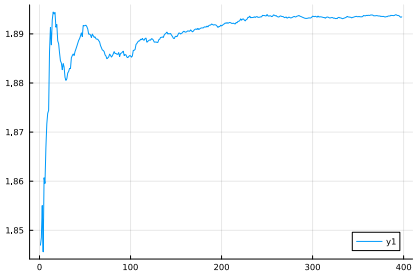
(C) Average Log Costs: Sea Salt



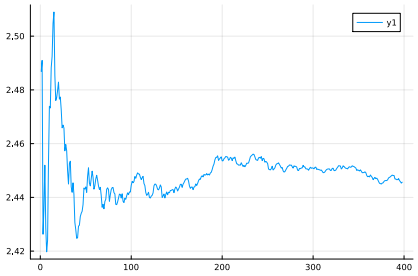
(D) Average Log Costs: Well Salt



(E) Average Log Price: Sea Salt

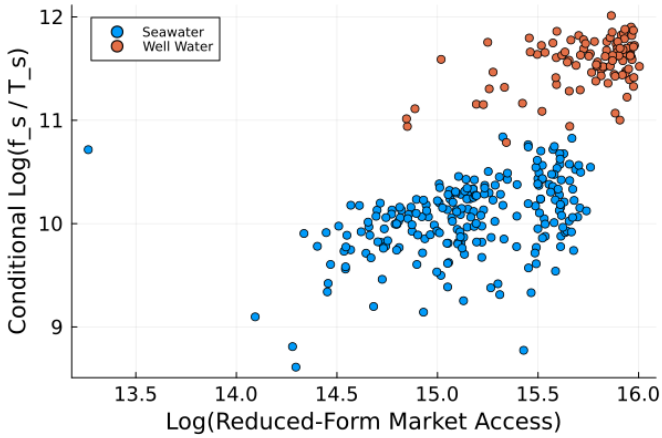


(F) Average Log Price: Well Salt



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.

Table D.2: Estimated Sea Salt Productivity Parameter and Average Sea Salt Cost by Dynasty

	Parameter	Avg Cost (Sea)	
Dynasty	μ_1^T	Data	Model
Song	-0.605	1.215	1.215
Yuan	-0.577	1.140	1.140
Ming	-0.278	0.829	0.829
Qing	-0.116	0.685	0.685
Minguo	-0.088	0.640	0.666

Notes: This table reports the calibrated average log productivity for sea salt districts, μ_{sea}^T, and the average production cost of sea salt across dynasties.

Table D.3: Regressions in Data and Model: Allowing for Technological Changes

	County		Salt Site	
	Data	Model	Data	Model
	(1)	(2)	(3)	(4)
Log Market Access	0.015	0.011	0.044	0.041
	(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. ν_t and μ_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. In the simulation, we recalibrate the average log productivity of sea salt, allowing for technological changes over dynasties. See Section 6.3 for details.

D.2 Additional Counterfactual Results

Table D.4: 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.5: 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.