The Bedrock of Economic Geography

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Abstract

I study how deep locational fundamentals become part of persistent economic geography. The setting is Skåne, southern Sweden, a small region where economically meaningful bedrock contrasts occur within common modern institutions and can be linked to unusually rich parish-level records from Danish and Swedish state traditions. I link detailed geological maps to historical population records and land-tax data, farm-production data, geographically detailed modern public statistics, and restricted-access plant-level private-sector workplace records from Statistics Sweden. I focus on carbonate-rich bedrock–limestone, dolostone, marl, and related calcareous sedimentary formations–because these lime-rich parent materials are closely tied to cultivation conditions. This bedrock predicts where taxable agricultural capacity and population were concentrated throughout the historical record, both before and after Skåne was transferred from Danish to Swedish rule in 1658. Places with greater early fiscal capacity were also more densely populated, and the resulting density map strongly predicts where residents, private workplaces, employment, and value added are concentrated today. The modern relationship is explained less by a contemporaneous geological advantage than by the historical density map that bedrock helped create: agricultural advantage became economic centrality.

1 Introduction

Why do economic maps persist after the original productive advantage has faded? Even inside modern high-income countries with common formal institutions, people, workplaces, employment, and production are sharply concentrated. Contemporary concentration is sustained by market access, infrastructure, labor pooling, input-output linkages, and agglomeration economies. These forces do not rule out deep historical origins. They can be the

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channels through which an older economic map, formed when agriculture, surplus, and settlement depended more directly on the physical landscape, remains economically relevant after the initial advantage has weakened (Krugman, 1991; Ellison and Glaeser, 1999; Head and Mayer, 2004, 2006; Davis and Weinstein, 2002). I study one of the deepest such fundamentals: bedrock.

Bedrock shaped agricultural potential, drainage, and cultivation conditions. Those advantages affected where agricultural surplus could be produced and where villages, churches, roads, and market centers accumulated. Once that settlement system existed, it could remain economically relevant long after agriculture ceased to be the dominant sector. The relevant margin then changes: geological advantage first appears as agricultural and settlement density, and later as market access, infrastructure, and local labor pools.

The starting point is shared with a large non-economics literature in geology, geoarchaeology, landscape archaeology, landscape ecology, and historical geography. Geologists and landscape scholars study how parent material, glacial and other surface deposits, topography, hydrology, and agricultural potential shape land use, settlement, and monument landscapes (Jenny, 1941; Schaetzl and Anderson, 2005; Fanta et al., 2022; Demján et al., 2022). The contribution here is economic. I ask whether stable geological variation helped concentrate historical agricultural production and population, whether that historical density persisted, and whether it remains visible in the modern residential and private-sector production geography of a high-income region.

Skåne, the southernmost historical province of Sweden, is unusually informative for this question. It covers a small area and is institutionally integrated today, yet major bedrock categories vary over short distances. A broader country such as the United States offers more regional variation, but that scale also mixes geology with institutional history, colonization, migration, state capacity, market integration, and modern federal policy. Skåne offers the opposite advantage: local geological contrasts inside a historically coherent region with unusually rich historical and archaeological records. Its sovereignty history adds a second advantage. Skåne was Danish until 1658 and Swedish thereafter, so the same landscape is observed through early fiscal and population sources from two state traditions. This helps separate geological patterns from the quirks of any single fiscal source system.

The empirical analysis combines detailed bedrock maps from the Geological Survey of Sweden (SGU), registered archaeological-site records, historical settlement evidence, parish-level historical population records and land-tax data, geographically detailed modern public outcomes, and restricted-access plant-level private-sector workplace records from Statistics Sweden. For the link to modern outcomes, the key historical cross-section is the 1810 parish population map. The focal geological exposure is the share of each parish covered by carbonate-rich bedrock. I classify an area as carbonate-rich when the underlying geological classification indicates limestone, dolostone, marl, or related calcareous sedimentary formations. I focus on this category because these lime-rich parent materials are closely tied to soil chemistry and cultivation conditions, making them a natural candidate for a historical agricultural-surplus mechanism. This carbonate-rich bedrock share predicts land-tax density and population density across the historical record, both before and after Skåne's transfer from Denmark to Sweden in 1658. Places with higher early fiscal capacity were also more densely populated by 1810. Population density in 1810, in turn, strongly predicts where residents, employed residents, private workplaces, employment, and value added are concentrated today. For modern residential density, the direct relationship with carbonate-rich bedrock becomes weaker once the 1810 population map is included. The pattern is consistent with geology entering the modern economy through the settlement pattern it helped create.

The magnitudes are large enough to matter. Land-tax density is based on *mantal*, a historical assessment of agricultural taxable capacity, divided by parish area. Moving from the 25th to the 75th percentile of carbonate-rich bedrock predicts roughly 12 percent higher pre-1658 land-tax density. The modern density estimates are easiest to read proportionally: because the density variables are measured on the inverse hyperbolic sine scale, the coefficients are close to elasticities for positive values. The residential coefficients, 1.08 for modern population density and 1.06 for the density of employed residents, imply almost one-for-one persistence from the 1810 population map to the modern residential map. The restricted-access plant-level data show a similar pattern for production-side activity. A 10 percent higher 1810 population density is associated with roughly 10 percent higher private workplace density, 13 percent higher employment density, and 13 percent higher value-added density. These estimates make the persistence claim concrete: the historical map predicts both residence and production-side economic activity.

Additional evidence links the historical density map to agriculture and settlement. The Historical Database of Scanian Agriculture (HDSA) shows that carbonate-rich landscapes also have higher recorded grain-output density, although the HDSA parish sample is too small for precise production estimates. Settlement and archaeological measures then connect fiscal capacity, recorded settlement evidence, and earlier activity to the 1810 population map.

Boundary comparisons, in the spirit of a spatial regression-discontinuity design, compare nearby places on opposite sides of sharp bedrock changes. Around boundaries involving mafic and intermediate bedrock, where the underlying rock shifts between darker mineral-rich and chemically intermediate formations, burial and iron-related site records are more concentrated. These local comparisons show that geological discontinuities also line up with pre-modern archaeological activity. The carbonate-rich bedrock result is different in scale and interpretation: it concerns lime-rich agricultural landscapes, not a narrow boundary contrast, and is tied to historical settlement density and assessed agricultural capacity.

The first contribution is to the economics of locational fundamentals and agglomeration. Economic geography has long distinguished natural advantage from increasing returns: places can be large because they are intrinsically productive, or because early advantages trigger self-reinforcing concentrations of workers, firms, infrastructure, and market access (Krugman, 1991; Duranton and Puga, 2004; Rosenthal and Strange, 2004; Head and Mayer, 2004, 2006; Puga, 2010; Ellison et al., 2010; Redding and Rossi-Hansberg, 2017). I use bedrock to give that distinction a long historical test. Bedrock is a natural fundamental that predates settlement. Modern density is an equilibrium object shaped by centuries of human decisions. The empirical question is whether bedrock matters today mainly because it shaped earlier settlement, rather than because it is a direct contemporary amenity or productivity shifter.

The second contribution is to historical persistence. Existing work shows that economic activity can persist after large shocks and across long historical horizons: Japanese cities after wartime bombing, German cities after division, American portage sites after their original transport advantage vanished, Berlin neighborhoods after division and reunification, and subnational population centers across colonial and postcolonial histories (Davis and Weinstein, 2002; Redding and Sturm, 2008; Bleakley and Lin, 2012; Ahlfeldt et al., 2015; Maloney and Valencia Caicedo, 2016). I study persistence at a different margin. The shock is not war, division, or transport technology. The underlying variation is geological. The outcome is not only whether places remain populated, but whether the physical substrate helped organize a denser agricultural production base and settlement hierarchy, which then fed into the nineteenth-century density map and modern economic geography.

The third contribution is to work on the deep historical roots of economic development. Cross-country research has shown that geography, biogeography, population history, and early technology can predict modern development (Olsson and Hibbs, 2005; Nunn, 2009; Comin et al., 2010; Ashraf and Galor, 2011; Spolaore and Wacziarg, 2013; Henderson et al., 2018). The gain from Skåne is micro-geographic precision. I do not ask whether entire countries with different institutional trajectories have different levels of development. I ask whether, inside one modern region, small differences in the earth beneath villages and parishes helped build the historical settlement system that still anchors economic density.

The remainder of the paper proceeds as follows. Section 2 describes the setting and conceptual framework. Section 3 introduces the geological, historical, archaeological, settlement, and modern outcome data. Section 4 lays out the empirical design. Section 5 presents the historical and modern results. Section 6 studies mechanisms, and Section 7 reports robustness and scale checks. Section 8 concludes.

2 Setting and Conceptual Framework

2.1 Geological and Historical Setting

The setting is Skåne in southern Sweden. Figure 1 locates the region within Sweden and northern Europe. Skåne is attractive because it combines three features that are rarely available together: fine-scale geological variation, unusually rich historical records, and a modern institutional environment that is common across space. Several major bedrock environments occur within a small region, so carbonate-rich, sedimentary, mafic and intermediate, and crystalline landscapes can be compared inside the same regional economy. Historically, Skåne was part of Denmark until the mid-seventeenth century and was incorporated into Sweden after 1658. The empirical design uses variation within Skåne, comparing places that shared the same broad political transition but differed in geology, agricultural potential, and settlement conditions.

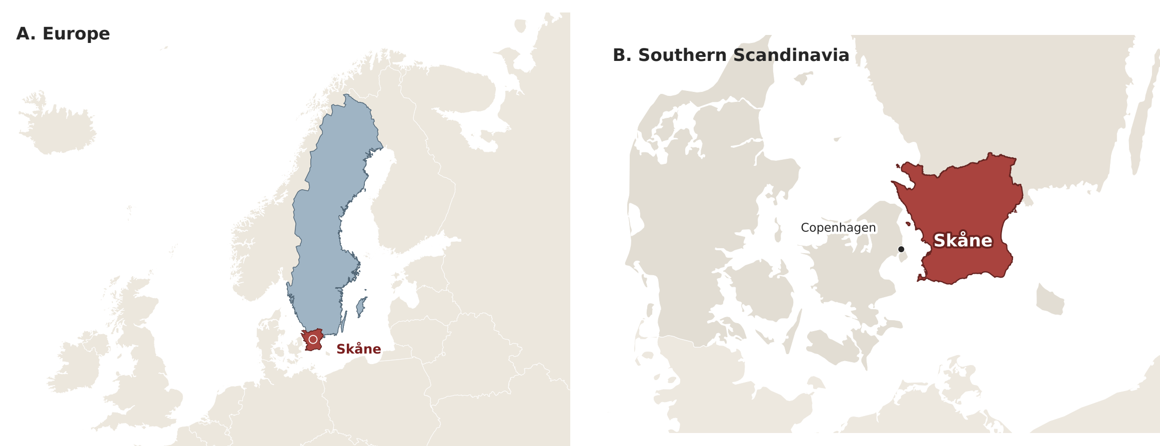

Figure 1: Skåne in northern Europe

Notes: The map locates Skåne using Natural Earth country boundaries and the GADM 4.1 first-level administrative boundary for Skåne.

The mechanism I emphasize runs from agricultural potential to settlement, rather than from the modern industrial use of rock. Bedrock affects the suitability of land for cultivation through the physical conditions under which farming takes place, including lime-rich parent material, drainage, terrain, and related agronomic conditions. These advantages can raise pre-industrial surplus, support denser settlement, increase local tax capacity, and make some places more likely to become durable centers in the regional settlement hierarchy. This links the paper to work on geography, biogeography, and the transition to agriculture, but moves the evidence from broad cross-country comparisons to fine spatial variation within one region (Olsson and Hibbs, 2005; Ashraf and Galor, 2011). Skåne's own historical record points in the same direction. Recent work describes a regional agrarian economy in which grain production, village organization, and specialization varied across local farming districts. In that setting, cultivation conditions shaped not only output, but also the organization of villages, common-field agriculture, and local institutions through which agricultural surplus was coordinated (Skoglund, 2022; Lagerås and Magnell, 2020).

Skåne's history makes this setting especially valuable. The region belonged to the Danish realm until the seventeenth century and became Swedish after the Treaty of Roskilde in 1658. That transfer matters for interpretation because the early fiscal and population records straddle a major sovereignty change. A carbonate-rich bedrock gradient that is visible both before and after 1658 is therefore not naturally read as an artifact of one Swedish administrative regime. At the same time, the transfer is not used as a treatment in the paper. The empirical variation comes from differences across parishes and city units within Skåne. The Danish-to-Swedish transition instead strengthens the historical setting: it shows that the same local economic geography can be followed through a major change in state authority.

2.2 Historical Density and Modern Location

The conceptual framework links locational fundamentals to historical density and modern centrality. Spatial models of persistence and path dependence distinguish geographic fundamentals, history, agglomeration, and the spatial distribution of activity (Davis and Weinstein, 2002; Bleakley and Lin, 2012; Ahlfeldt et al., 2015; Allen and Donaldson, 2020). I do not estimate a structural spatial equilibrium model. Doing so would require additional structure on migration, commuting, trade costs, land and housing markets, amenities, agglomeration elasticities, welfare, and counterfactuals. My aim is more direct: to ask whether a stable physical fundamental helped form a historical density system and whether that system remains visible in the modern location of activity.

Bedrock is the stable locational fundamental. Let g_i denote the geological characteristics of location i, with carbonate-rich bedrock as the focal lime-rich type. Historical agricultural potential A_i depends on bedrock and other predetermined local features:

$$A_i = A(g_i, Z_i, technology_t).$$

Here Z_i includes terrain, water access, location, and other physical conditions that shape cultivation. I do not try to decompose every physical pathway from bedrock to agricultural potential. I study whether geological variation predicts historically realized production, taxable-capacity density, population density, settlement, and modern economic geography.

In the pre-industrial economy, agricultural potential affects more than yield per hectare. It shapes where settlement is viable, where taxable agricultural capacity is dense, where churches and marketplaces are useful, and where roads and local public goods accumulate. I therefore treat population density, mantal density, villages, churches, towns, roads, and related fiscal, market, and administrative features as institutional expressions of a historical density system:

$$H_{it} = H(A_i, Z_i, technology_t, institutions_t).$$

Here H_{it} is the historical density system and Z_i denotes other predetermined local features such as terrain, water access, and inherited location. The notation is intentionally broad because the historical system is not a single variable. In the data it appears as taxable-capacity density, population density, settlement evidence, churches, towns, and market access. The mechanism is that favorable bedrock supported denser taxable agricultural capacity and a denser settlement system.

Once created, the historical density system can become modern centrality:

$$C_i = C(H_i),$$

where C_i captures inherited location advantages: roads, churches, market access, administrative functions, built environment, local labor pools, and expectations about where activity belongs. This is how the initial advantage can survive. Carbonate-rich bedrock need not be a contemporary input into each firm's location choice. Its modern relevance can instead operate through the settlement hierarchy and infrastructure that earlier agricultural advantages helped create. Modern economic geography is then the location of activity:

$$Y_i^M = Y(C_i, g_i, X_i),$$

where Y_i^M includes modern population density, the density of employed residents, and the density of private workplaces, employment, and value added. X_i denotes geographic controls such as location, terrain, water access, and market access. The framework allows for both an indirect effect through historical density and a residual direct association between bedrock landscapes and modern economic outcomes if the observed historical density measures do not fully capture older settlement advantages or if favorable bedrock landscapes remain bundled with modern locational advantages.

The framework leads to five empirical predictions. First, carbonate-rich bedrock should predict historical population density and taxable-capacity density. Second, the carbonate-rich gradient should be visible across historical years and should not depend entirely on one administrative regime; in Skåne, visibility before and after the 1658 sovereignty transition is informative. Third, historical density should predict modern population density and the density of employed residents. Fourth, if old settlement advantages organize the modern economic map, historical density should also predict where private workplaces, employment, and value added are concentrated. Fifth, the direct carbonate-rich bedrock coefficient in modern outcomes should attenuate when historical density is included if the historical density system is the main transmission channel, but it need not vanish. Historical density is one observed measure of a broader location system, not a complete sufficient statistic for every inherited advantage.

The relevant historical objects are therefore not only yields, but also graves, grave fields, villages, churches, towns, roads, and fiscal units. These are the institutions and settlement places through which land quality could become a durable economic geography. Skåne is unusually useful because archaeological and historical work documents both Iron Age central places and the later formation of medieval villages and parishes (Stjernquist, 1996; Carlie, 2008; Mogren, 2005; Thomasson, 2005). Sweden's unusually rich historical records on land, taxation, population, enclosures, and farm production also make it possible to follow this process over time (Myrdal and Morell, 2011; Gadd, 2011; Olsson and Svensson, 2017a). The setting therefore connects two bodies of evidence that are often separate: archaeological and agrarian history on the one hand, and modern spatial economics on the other.

The modern outcomes follow from this focus on the location of economic activity. In an integrated labor market, workers, firms, workplaces, and infrastructure sort across space, and historical advantages can appear in the location of people, employed residents, private workplaces, employment, production, and market access. I therefore focus on the spatial density of economic activity. From productivity to centrality is the organizing idea: a natural advantage that first mattered through agriculture can persist as the geography of residence, work, and production.

3 Data

I combine geological, historical, archaeological, and modern spatial data at unusually fine geographic detail. SGU maps describe the physical substrate beneath each location; historical parish sources track population, cultivated land, and fiscal capacity across early-modern and nineteenth-century Skåne; heritage-register data record archaeological traces of earlier activity; and modern spatial datasets measure the present-day distribution of people, private workplaces, employment, and production.

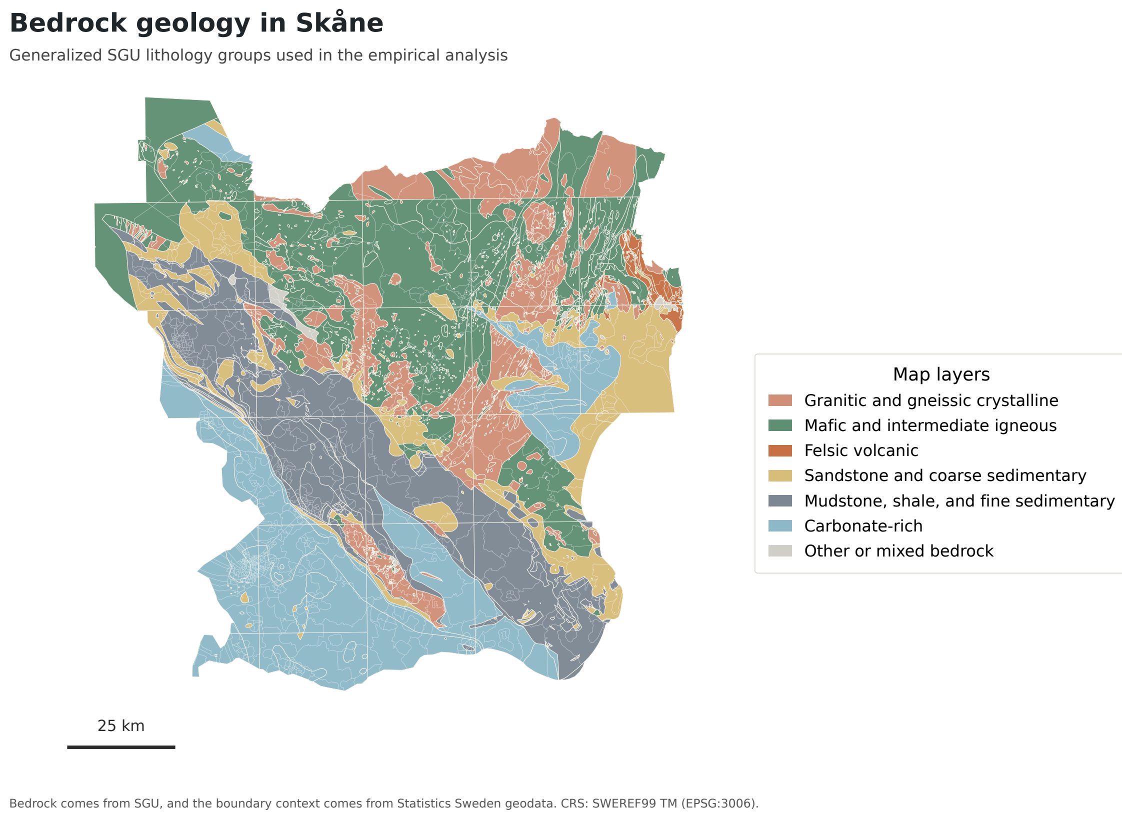

Figure 2: Setting map: bedrock geology in Skåne

Notes: The map shows Skåne's bedrock geology using generalized categories constructed from Geological Survey of Sweden (SGU) lithology labels. Colors denote the dominant bedrock category at each location, with the coastline and regional outline shown for orientation. The boundary context comes from Statistics Sweden geodata. Categories are aggregated to make the main geological contrasts legible; the underlying GIS data retain the finer SGU classifications used to construct parish-level bedrock shares.

3.1 Bedrock and Agricultural Potential

The geological variables come from Geological Survey of Sweden (SGU) bedrock data. Figure 2 shows the generalized bedrock categories used to introduce the setting. The main bedrock measure is the parish share of carbonate-rich bedrock. I classify an area as carbonate-rich if the underlying SGU lithology indicates limestone, dolostone, marl, or related calcareous sedimentary formations. I focus on this category because it has the clearest ex ante link to the agricultural mechanism. These are lime-rich parent materials. As they weather, they can supply calcium carbonate and base cations to the soil system, affecting soil reaction, acidity, base saturation, and the availability of plant nutrients. In agronomic terms, carbonate-rich bedrock is best read as an upstream geological measure for a pathway through which bedrock can shape agriculturally relevant soil conditions, rather than as a universal yield ranking of rock types (Jenny, 1941; Schaetzl and Anderson, 2005; Food and Agriculture Organization of the United Nations, 1973).

Figure 2 is the first empirical reason to study Skåne. The map shows that bedrock changes over short distances inside one small historical region. This matters for identification and interpretation. I am not comparing a mountainous country with a lowland country, or one institutional regime with another. I compare nearby parishes and city units whose underlying geology differs while their modern national institutions are common. The generalized categories in the map are deliberately broad enough to be legible: carbonate-rich, mafic and intermediate, mudstone/fine sedimentary, sandstone/coarse sedimentary, granite/gneiss, and smaller residual categories. These categories translate detailed SGU lithology into the main geological contrasts used throughout the paper. The parish-level bedrock shares are constructed from the same underlying layer, so the map and the regressions refer to the same physical variation.

I focus primarily on carbonate-rich bedrock because it is the most interpretable geological measure for the agricultural-surplus mechanism emphasized here. The appendix also reports results for the other main generalized categories. Skåne's historical geography was not shaped by a single rock type in isolation. Several bedrock categories capture broader landscape structure, while carbonate-rich bedrock is the category with the clearest link to a lime-rich agricultural landscape.

3.2 Historical Economy

The core historical outcomes are parish-year measures of population density, mantal density, and arable land density. The parish panel is built from the Swedish National Data Service (SND) Sweden 1570–1810 parish-level agricultural statistics, which combine population, agriculture, land ownership, and related historical source material for years around 1570, 1630, 1690, 1750, and 1810 (Swedish National Data Service, 2025). Together, these three measures capture people, assessed agricultural capacity, and cultivated land in the pre-industrial and early-modern economy. Population density is measured as residents per square kilometer in each historical parish or city unit. I use it in two ways. In the historical panel, population density is observed for 1570, 1630, 1690, 1750, and 1810. In the modern-outcome analysis, I use the 1810 observation as the historical baseline. That year is the latest population measure in the panel: late enough to summarize Skåne's inherited parish settlement system, but early enough to precede railways, large-scale industrialization, and the modern private-sector geography studied later.

The fiscal measure captures assessed agricultural capacity per unit of land. Fiscal capacity is measured as mantal per square kilometer. Mantal was a historical assessment of the taxable capacity of agricultural land. It was not a head count, not the number of people paying tax, and not simply the amount of tax collected in a particular year. It summarized the assessed fiscal strength of agricultural holdings and was therefore closely tied to land quality, productive capacity, farm organization, and the fiscal reach of the state. In this paper the relevant outcome is *taxable-capacity density*: mantal divided by land area and transformed using the inverse hyperbolic sine. This is an area-based measure. It asks where the landscape supported dense assessed taxable capacity, not whether each resident was individually richer. The distinction matters for the mechanism. Carbonate-rich areas can support a denser taxable settlement system even if taxable capacity per resident is not higher.

I use the SND parish panel, and the historical variables are taken from that harmonized source. I do not separately reconstruct population, mantal, or arable land from the underlying archival registers. I interpret arable land density more cautiously. It measures the extent of cultivated land in a given year, not output per hectare or land productivity. The main historical table uses parish-year observations with year fixed effects and clustered inference.

Appendix Table A1 lists the historical data sources and construction steps used in the analysis. It distinguishes variables taken directly from the historical parish panel from measures constructed from spatial layers. Population, mantal, and arable land come directly from the historical parish panel. The parish and city units in the historical data are linked to the corresponding spatial geometries used in the analysis sample; historical cities are kept visible because they are part of the settlement hierarchy that the paper studies.

I interpret the historical agricultural measures in light of evidence that Skåne was a major grain-producing region but not a uniform agrarian surface: plain, intermediate, and forest districts differed in crop mix, livestock intensity, cultivation conditions, and village organization (Skoglund, 2022). To connect the parish-level patterns to farm production, I use the Historical Database of Scanian Agriculture, which contains more than 85,000 farm-year observations from 1702 to 1881 based on historical tithe records, levies on agricultural output that can be used to infer production. The database also records farm characteristics, land-consolidation reforms, coded natural-condition fields, and distances to major market towns (Olsson and Svensson, 2017a,b). These records make it possible to construct parish-year grain-output density and relate the production data to the same bedrock geography used in the historical population and land-tax analysis. For population robustness, Tabellverket provides parish-level demographic statistics for 1749–1859, allowing the population-density pattern to be checked beyond the SND panel's 1810 endpoint (Demographic Data Base, CEDAR, Umeå University, 2025).

3.3 Historical Settlement Measures

I use several historical settlement measures, listed in Appendix Table A2. They start with churches and towns that can be dated before 1810, then add register evidence on historical settlements, settlement remains, and historically rooted names. The measures serve two purposes. First, they test whether visible historical places predict later population density. Second, they distinguish dated central places from the settlement landscape around them. This distinction matters because the village system in Skåne was both spatial and institutional: farmsteads, infields, commons, churches, and later enclosure reforms tied productive land to durable settlement locations (Mogren, 2005; Lagerås and Magnell, 2020).

The settlement measures are not meant to replace the direct historical population data. They add evidence on the geography of durable places. The church/town measure counts church-like records from Bebyggelseregistret with explicit dates or medieval period labels, together with conservatively coded historical towns observed before 1810. This measure captures early institutional and market centers whose timing can be placed before the 1810 population map. The register-based measure keeps those churches and towns and adds Swedish National Heritage Board/Fornsök records classified as historical settlements, medieval or historical remains, prehistoric settlement sites, and church-related heritage records not already included in the church/town measure. The settlement-landscape measure then adds Lantmäteriet Ortnamn records associated with historically rooted settlements and manors. It is a parish-level measure of durable settlement geography, rather than a list of precisely dated individual sites. Taken together, the measures show whether early churches and towns, register evidence, and old settlement names point to the same later density map.

3.4 Archaeology

Archaeological records provide a rich spatial record of known early activity. The Swedish National Heritage Board describes Fornsök as a national database of archaeological sites and monuments (Riksantikvarieämbetet, 2019). Appendix Table A3 summarizes the archaeological measures used in the paper. I use the register accordingly: it is especially valuable for broad spatial patterns of known archaeological presence, while narrower chronological interpretations are reserved for entries with reliable dating. The local boundary analysis compares archaeological presence on either side of boundaries involving mafic and intermediate bedrock–places where the rock changes between darker, mineral-rich formations and more chemically intermediate formations. The burial classification is anchored in archaeological work on Early Iron Age graves in Skåne and broader evidence on Iron Age central places, communication routes, and settlement landscapes (Björk, 2005; Stjernquist, 1996; Carlie, 2008; Larsson et al., 2020).

3.5 Modern Outcomes

The modern outcomes come from geographically detailed public data from Statistics Sweden (SCB). The geographic base is DeSO 2025, SCB's demographic statistical areas, which provide a fine official partition of Sweden for regional statistics.[1]

The public modern outcomes capture the residential side of contemporary economic geography. I construct population density from SCB's DeSO population statistics for 2025. I construct the density of employed residents from SCB's register-based labour-market statistics for residents aged 20–64 in 2024. This employment measure is tied to residence rather than workplace location; the restricted workplace data below add where private-sector activity is located.

The central persistence analysis uses modern outcomes linked to historical parish and city geometries.[2] Population density is residents in 2025 per square kilometer. The density of employed residents is employed residents aged 20–64 in 2024 per square kilometer. These public variables describe the residential side of modern economic geography.

For workplace outcomes, I use restricted-access plant-level records from Statistics Sweden (Statistics Sweden, 2026c). I refer to these units as private workplaces throughout the paper. The data cover private plants annually from 1997 to 2021 and report each workplace's coordinates in the Swedish national grid. I use those coordinates to assign plants to historical parish/city units and construct three preferred outcomes: private workplace density, employment density, and value-added density. Plant identifiers and years define private workplace counts and time windows, plant employment gives employment density, and value added gives the preferred monetary production measure.[3] The data also contain industry codes, labor costs, production value, and raw-material costs; the appendix reports results for the additional monetary outcomes.

These records matter because they separate the residential map from the production map. The open DeSO labour-market variable measures employed residents by where they

[1] The Skåne data contain 819 DeSO polygons. DeSO boundaries come from SCB's open geodata service, and outcome variables come from SCB's PxWeb statistical database (Statistics Sweden, 2026a,b, 2025).

[2] DeSO counts are allocated to historical units by the share of each DeSO polygon's area intersecting the parish or city polygon. Areas are measured in SWEREF 99 TM, Sweden's official projected coordinate system for national mapping.

[3] Value added is observed on the plant-year record in the restricted-access data.

live. The restricted-access plant-level data measure where private workplaces and private-sector production are located. All workplace outcomes are expressed per square kilometer of historical parish/city area. They allow me to ask whether the historical density system predicts the modern location of private economic activity itself, not only the residence location of workers.

Table 1: Summary statistics

Variable	Mean	SD	p25	Median	p75	N
Panel A. Historical parish-year panel, 1570–1810						
Carbonate-rich bedrock share	0.363	0.446	0.000	0.001	0.980	1,905
Mafic and intermediate bedrock share	0.140	0.279	0.000	0.000	0.094	1,905
Mudstone/fine sedimentary bedrock share	0.292	0.400	0.000	0.000	0.680	1,905
Sandstone/coarse sedimentary bedrock share	0.101	0.205	0.000	0.000	0.108	1,905
Granite/gneiss bedrock share	0.094	0.203	0.000	0.000	0.070	1,905
Historical population density	3.436	0.595	3.091	3.468	3.806	1,905
Mantal density	0.903	0.440	0.569	0.892	1.188	1,894
Arable capacity	6.953	0.839	6.463	6.982	7.504	1,905
Panel B. Parish cross-section matched to modern outcomes						
Carbonate-rich bedrock share	0.363	0.447	0.000	0.001	0.980	381
Pre-1810 church/town density	0.053	0.053	0.016	0.038	0.074	381
Register-based settlement density	1.326	0.531	0.900	1.280	1.708	381
Settlement-landscape density	1.501	0.463	1.148	1.473	1.803	381
1810 population density	3.973	0.461	3.698	4.026	4.248	381
2025 population density	4.450	1.338	3.455	4.296	5.349	381
2024 density of employed residents	3.650	1.329	2.674	3.533	4.566	381

Notes: Panel A uses parish-year observations from SND Sweden 1570–1810. Panel B uses one observation per historical parish or city unit after linking the 1810 historical data to modern DeSO-based outcomes from Statistics Sweden. Bedrock comes from SGU, archaeological records from the Swedish National Heritage Board/Fornsök, and parish/city geometries from Lantmäteriet. IHS denotes the inverse hyperbolic sine transformation.

Table 1 summarizes the scale of the empirical design. Panel A contains the repeated historical parish-year panel, with 1,905 population observations and 1,894 fiscal-capacity observations. The bedrock variables in this panel are time-invariant parish shares, while the outcomes vary by year. Panel B is the matched historical-modern cross-section with 381 parish or city units. This is the sample used when 1810 population density is linked to modern population density and the density of employed residents. The table shows why the carbonate-rich contrast is empirically powerful: the interquartile range is wide, with many units having almost no carbonate-rich bedrock and many units dominated by it.

4 Empirical Design

The empirical strategy follows the timing of the historical argument. I first ask whether bedrock predicts pre-industrial density and fiscal capacity:

$$Y_{it}^{hist} = \alpha + \beta Carbonate_i + X_i'\gamma + \lambda_t + \epsilon_{it}, \tag{1}$$

where Y_{it}^{hist} is historical panel population density, mantal density, or arable density for parish i in historical year t, $Carbonate_i$ is the parish share of carbonate-rich bedrock, X_i contains the standard geography controls, and λ_t are year fixed effects. The coefficient therefore compares carbonate-rich bedrock with all other bedrock. The main specifications do not add the full set of other bedrock shares, because doing so would turn the estimate into a within-bedrock-composition comparison and remove part of the broad carbonate-rich landscape contrast of interest. Appendix Table A4 reports the other generalized bedrock categories separately for transparency.

The design does not require Skåne to be geologically unique. It requires economically meaningful geological contrasts that can be observed within a common historical and institutional setting. The analysis therefore uses within-region variation in carbonate-rich exposure rather than broad comparisons across countries or institutional regimes.

In the main parish-level specifications, geography controls are exactly a full cubic polynomial in the historical unit's centered east-west and north-south coordinates, together with land area. Coordinates are measured in kilometers from the sample centroid, so the included terms are x_i, y_i, x_i^2, x_iy_i, y_i^2, x_i^3, $x_i^2y_i$, $x_iy_i^2$, and y_i^3, with area measured in square kilometers. Historical panel population density is measured as recorded residents per square kilometer in the SND parish-year observations for 1570, 1630, 1690, 1750, and 1810. Parish-years are the appropriate observation level because the SND historical panel is organized at the parish level, and parishes are also the natural geography for much of the population-statistical tradition (Swedish National Data Service, 2025; Demographic Data Base, CEDAR, Umeå University, 2025).

These location controls remove broad regional patterns that could otherwise be mistaken for a bedrock effect. They absorb east-west and north-south location gradients in Skåne, including proximity to the Öresund corridor, interior-coast differences, and gradual spatial curvature. They do not control for the full bedrock composition of each parish. The main coefficient therefore asks whether parishes with more carbonate-rich bedrock differ from otherwise similarly located parishes with less of it, not whether this category differs from every other rock type while holding all bedrock shares fixed.

The historical tables first report the overall relationship between carbonate-rich exposure and the outcome, before conditioning on location and broad regional gradients. They then add the coordinate controls and land area to separate the bedrock relationship from broad east-west gradients, north-south gradients, regional curvature, and differences in unit scale. The latter comparison is my preferred specification for the historical bedrock results.

I then use population density in 1810 as the historical measure linked to the later analysis. The settlement measures enter at this stage. They ask whether earlier churches, towns, and recorded settlement traces are part of the path from favorable bedrock and fiscal capacity to the early nineteenth-century population map:

$$PopDensity1810_i = \alpha + \beta Carbonate_i + \delta S_i + X_i'\gamma + \epsilon_i, \tag{2}$$

where S_i denotes the settlement measure used in the specification. I finally ask whether 1810 density predicts the modern location of activity:

$$Y_i^{modern} = \alpha + \beta Carbonate_i + \theta PopDensity1810_i + X_i'\gamma + \epsilon_i. \tag{3}$$

Here Y_i^{modern} denotes modern density outcomes: population density, the density of employed residents, and three private-sector production measures expressed per square kilometer: private workplaces, employment, and value added. Settlement measures are not included in the main modern-outcome equation because the main modern tables ask whether the 1810 population map itself predicts later activity. The three equations correspond to the historical panel, the 1810 cross-section, and the modern cross-section. Together, the specifications ask whether bedrock first predicts historical density and whether that density then predicts modern economic activity. If the coefficient on carbonate-rich bedrock declines once the 1810 population map is included, the evidence supports a persistence interpretation. If a residual coefficient remains for private-sector production outcomes, this suggests that 1810 density does not fully capture older settlement advantages or that favorable bedrock landscapes remain bundled with other locational advantages.

The 1810 cross-section links the historical and modern parts of the paper. It is late enough to be measured consistently in the historical parish data, but early enough to precede the full modern transformation of southern Sweden. I first estimate the geography-adjusted reduced-form relationship between carbonate-rich bedrock and modern density. I then add 1810 population density and ask whether the bedrock-modern relationship is absorbed by the historical population map.

4.1 Mechanisms, Boundaries, and Inference

The mechanism analysis asks why the 1810 population map took the shape it did. The HDSA farm data ask whether recorded grain-output density is higher in the same carbonate-rich landscapes. The settlement specifications ask whether churches, towns, and broader settlement evidence are concentrated in places that were already dense by 1810.

Local boundary comparisons provide a different type of evidence. They compare nearby places on opposite sides of sharp bedrock changes, in the spirit of a spatial regression-discontinuity design. I use boundaries involving mafic and intermediate bedrock for the local archaeology exercise because this bedrock category is more visible in burial and iron-related archaeological records than in the main population and fiscal-capacity results. It therefore provides a useful comparison: some geological variation appears in highly local archaeological traces, while the carbonate-rich bedrock result is interpreted as a broader agricultural and settlement-landscape relationship.

I also report checks for historical cities, Copenhagen access, stability across historical years, and spatially correlated errors. These checks ask whether the main relationships survive alternative ways of measuring centrality and allowing for geographic dependence.

The standard errors follow the structure of each dataset. Repeated parish-year panel specifications use standard errors clustered by historical parish. Collapsed parish/city cross-sections use robust standard errors. Because nearby parishes may share unobserved geography, I also report alternative standard errors that allow nearby places to have correlated regression errors.

5 Results

The results begin with the historical relationship between carbonate-rich bedrock, population density, and assessed agricultural capacity. I then use the 1810 population map to connect the historical economy to modern residence-based outcomes and restricted-access workplace outcomes.

5.1 Bedrock and the Historical Economy

Figure 3 provides the visual entry point into the historical analysis. Panel A colors each parish or city unit by its dominant generalized bedrock category. Panel B uses the same units but colors them by 1810 population density. Because the two panels are drawn on identical historical boundaries, each unit can be assigned both geological exposure and an early nineteenth-century population outcome. The empirical analysis builds on that unit-

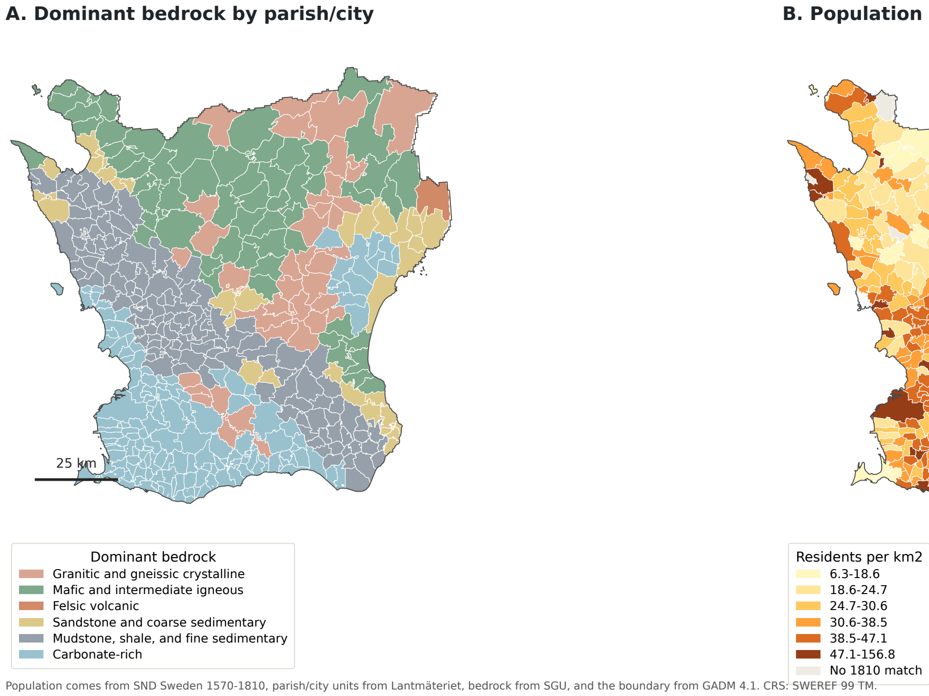

Figure 3: Core historical layer: dominant bedrock and 1810 population density

Notes: Both panels use the same historical parish/city units. Panel A colors each unit by its dominant generalized SGU bedrock category. Panel B colors the same units by 1810 population density, measured as residents per square kilometer. The parish/city units come from Lantmäteriet, bedrock from SGU, and 1810 population from SND Sweden 1570–1810.

level comparison. The figure also makes clear that the analysis is not driven by a single city alone. The 1810 density surface contains large towns, rural density differences, and broad regional settlement structure.

The historical regressions quantify this relationship. Carbonate-rich bedrock predicts the density of people and fiscal capacity in the repeated historical parish panel. The density and capacity variables are transformed using the inverse hyperbolic sine. Table 2 reports the baseline estimates of equation (1), comparing the carbonate-rich bedrock share with all other bedrock.

Panel A of Table 2 uses historical panel population density as the dependent variable. Column 1 reports the total carbonate-rich contrast with year fixed effects but without geography controls. The coefficient is 0.483, showing that carbonate-rich areas were substantially more densely populated in the historical panel. Column 2 adds the full cubic coordinate polynomial and land area. The coefficient falls to 0.179 but remains positive and precisely estimated. This is the main population-density historical specification: it compares parishes with different carbonate-rich shares after accounting for broad location gradients and unit size.

Panel B of Table 2 repeats the same structure for mantal density, an area-based measure of assessed agricultural production capacity. This adds information beyond population density: it asks whether carbonate-rich places contained denser assessed productive capacity, not only more residents. Column 1 gives a total carbonate-rich coefficient of 0.394. Column 2, the geography-adjusted specification, gives 0.141. Since mantal density is closer than population to land-based agricultural capacity, the positive coefficient links carbonate-rich landscapes to assessed productive capacity rather than only to settlement size. Carbonate-rich landscapes were places where assessed agricultural capacity was denser.

Table 3 reports the historical estimates separately by year. Panel A reports the carbonate-rich coefficient for fiscal capacity in 1570, 1630, 1690, 1750, and 1810. The coefficient is positive in every column, from 0.120 in 1570 to 0.167 in 1810, and is statistically significant in each year. This means that the fiscal-capacity relationship is not produced by pooling alone. It is visible before Skåne's transfer from Denmark to Sweden and remains visible after. Panel B repeats the exercise for population density. The coefficient again remains positive in every year, ranging from 0.161 to 0.199. The central empirical fact is therefore historical stability: carbonate-rich bedrock was associated with where people and taxable capacity accumulated before industrialization.

Population density and mantal density are the central historical outcomes because they measure settlement and assessed agricultural capacity, not only the extent of cultivation. Arable land records how much land was cultivated in a given year. It is not a direct yield or productivity measure. The main result is that the geology-relevant landscape was associated with where people and taxable surplus accumulated, not only with how land was classified.

Table 2: Total and geography-adjusted historical specifications

Specification	(1) Total	(2) Geography-adjusted
Panel A. Dependent variable: historical population density		
Carbonate-rich bedrock	0.483***	0.179***
	(0.045)	(0.060)
Panel B. Dependent variable: mantal density		
Carbonate-rich bedrock	0.394***	0.141***
	(0.034)	(0.043)
Geographic controls	No	Yes
Year fixed effects	Yes	Yes
Observations, population	1,905	1,905
Observations, mantal	1,894	1,894

Notes: The table pools the repeated historical parish-year observations for 1570, 1630, 1690, 1750, and 1810 and includes year fixed effects; Table 3 reports the corresponding year-by-year estimates. Standard errors are clustered by historical parish and reported in parentheses. Population density and mantal density are transformed using the inverse hyperbolic sine. Historical population and mantal come from SND Sweden 1570–1810, parish/city geometries from Lantmäteriet, and bedrock from SGU. Carbonate-rich bedrock is compared with all other bedrock. Geographic controls are a full cubic polynomial in centered east-west and north-south coordinates in kilometers and land area in square kilometers. Stars denote statistical significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

5.2 Fiscal Capacity and Later Density

Table 3 has already shown that the carbonate-rich gradient is visible in historical fiscal capacity and population density. Table 4 therefore asks a different question: how early fiscal capacity and early population density relate to the 1810 population map. Column 1 first reports the baseline carbonate-rich bedrock relationship with 1810 population density, using the same geography-adjusted specification as the 1810 column in Table 3. Column 2 adds pre-1658 fiscal capacity. Both coefficients are positive: carbonate-rich bedrock remains related to 1810 density, and early fiscal capacity is aligned with later density.

Column 3 adds pre-1658 population density. The coefficient on pre-1658 population density is large, as expected, because population density is persistent across historical periods. Once this earlier population density is included, the pre-1658 fiscal-capacity coefficient turns negative. This pattern shows that fiscal capacity and population density are tightly bundled components of the same historical density system. Column 4 changes the dependent variable to the change in population density between 1570 and 1810. The negative coefficient on

Table 3: Historical dynamics by year

	(1)	(2)	(3)	(4)	(5)
Year	1570	1630	1690	1750	1810
Panel A. Dependent variable: fiscal capacity					
Carbonate-rich bedrock	0.120*	0.134***	0.145**	0.139***	0.167***
	(0.068)	(0.051)	(0.060)	(0.048)	(0.042)
Panel B. Dependent variable: population density					
Carbonate-rich bedrock	0.196***	0.163**	0.172***	0.161***	0.199***
	(0.069)	(0.067)	(0.065)	(0.061)	(0.070)
Geographic controls	Yes	Yes	Yes	Yes	Yes
Observations, fiscal	381	376	381	381	375
Observations, population	381	381	381	381	381

Notes: The table uses collapsed parish/city cross-sections by year. Historical population and mantal come from SND Sweden 1570–1810, parish/city geometries from Lantmäteriet, and bedrock from SGU. Population density and fiscal capacity are transformed using the inverse hyperbolic sine. Standard errors are heteroskedasticity-robust HC1 standard errors. All specifications compare carbonate-rich bedrock with all other bedrock and include geographic controls: a full cubic polynomial in centered east-west and north-south coordinates in kilometers and land area in square kilometers. Stars denote statistical significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

pre-1658 fiscal capacity does not imply that fiscal capacity reduced later density; it shows that places with high early assessed capacity were already dense early in the period and did not grow faster from that high base. The table's main lesson is that early fiscal capacity and early population density jointly help explain the 1810 density map.

5.3 Settlement Evidence and the 1810 Map

Fiscal capacity and population density are the main quantitative historical measures, but settlement evidence adds a different kind of information. It asks whether the same geography appears in churches, towns, named settlements, and register-based settlement records. If carbonate-rich bedrock only predicted a fiscal accounting variable, these measures would add little. If it helped form a settlement hierarchy, the same geography should appear in visible historical places, and those places should predict the 1810 population map.

Table 5 reports that test. Panel A asks whether carbonate-rich bedrock predicts the settlement measures themselves. Each column is constructed in the same way: eligible point records are counted inside each parish or city unit, divided by the unit's area, and transformed with the inverse hyperbolic sine. The columns differ in the historical material they use. Column 1 uses early churches and historical towns per square kilometer, capturing institutional and market centers that can be dated before the 1810 population map. The

Table 4: Early fiscal capacity and later density

	(1)	(2)	(3)	(4)
Dependent variable	1810 pop. dens.	1810 pop. dens.	1810 pop. dens.	Pop. change
Carbonate-rich	0.199***	0.168**	0.086*	0.036
	(0.070)	(0.080)	(0.045)	(0.046)
Pre-1658 fiscal cap.		0.275*	-0.091	-0.283***
		(0.142)	(0.069)	(0.051)
Pre-1658 pop. density			0.699***	
			(0.056)	
Geographic controls	Yes	Yes	Yes	Yes
Observations	381	381	381	381

Notes: The table is a parish-level cross-section: each column uses one observation per historical parish/city unit after collapsing the repeated historical panel into pre-1658 fiscal capacity, pre-1658 population density, and 1810 population density. Historical population and mantal come from SND Sweden 1570–1810, parish/city geometries from Lantmäteriet, and bedrock from SGU. Non-negative density and capacity variables are transformed using the inverse hyperbolic sine. The dependent variable in column 4 is the change in transformed population density from 1570 to 1810. Standard errors are heteroskedasticity-robust HC1 standard errors. Pre-1658 fiscal capacity averages 1570 and 1630 mantal density. Carbonate-rich bedrock is compared with all other bedrock. Geographic controls are a full cubic polynomial in centered east-west and north-south coordinates in kilometers and land area in square kilometers. Standard errors are reported in parentheses. Stars denote statistical significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

coefficient is positive. Column 2 adds Swedish National Heritage Board records for historical settlements, medieval or historical remains, prehistoric settlement sites, and church-related heritage records that are not already part of the church/town measure. Column 3 adds Lantmäteriet Ortnamn records associated with historically rooted settlements and manors, giving a parish-level measure of the settlement landscape. Both register-based measures are positively related to carbonate-rich bedrock. Panel B then uses 1810 population density as the dependent variable. All three settlement measures predict the 1810 population map after controlling for carbonate-rich bedrock and geography. The pattern is informative because it is visible not only in a few well-known towns, but also across the settlement geography of the region.

Table 5: Settlement evidence and the 1810 population map

Settlement measure	(1) Church/town evidence	(2) Register evidence	(3) Settlement landscape
Panel A. Dependent variable: settlement-evidence density			
Carbonate-rich bedrock	0.089^{**}	1.383^{*}	1.537^{**}
	(0.038)	(0.720)	(0.748)
Observations	402	402	402
Panel B. Dependent variable: 1810 population density			
Settlement-evidence density	1.085^{**}	0.129^{***}	0.167^{***}
	(0.523)	(0.040)	(0.053)
Observations	381	381	381
Geographic controls	Yes	Yes	Yes

Notes: Settlement measures combine Bebyggelseregistret, historical towns, Swedish National Heritage Board/Fornsök records, and Lantmäteriet Ortnamn; 1810 population comes from SND Sweden 1570–1810, parish/city geometries from Lantmäteriet, and bedrock from SGU. In each column, eligible point records are counted inside each parish/city unit, divided by area, and transformed with the inverse hyperbolic sine. Column 1 uses early churches and historical towns observed before 1810. Column 2 adds Swedish National Heritage Board records for historical settlements, medieval or historical remains, prehistoric settlement sites, and church-related heritage records not already included in the church/town measure. Column 3 combines the same register evidence with Lantmäteriet Ortnamn records associated with historically rooted settlements and manors, giving a parish-level measure of the settlement landscape. Panel A reports the coefficient on carbonate-rich bedrock. Panel B reports the coefficient on the corresponding settlement-evidence density in specifications that also include carbonate-rich bedrock. All columns include geographic controls. Standard errors are reported in parentheses. Stars denote statistical significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

The settlement measures make the historical capacity result more concrete. Carbonate-rich areas were also places where durable settlement evidence accumulated, and those measures predict the later population map. The evidence shows how assessed agricultural capacity appeared in space: through churches, towns, named settlements, and the settlement landscape around them.

5.4 Persistence into the Modern Economy

I next turn to modern outcomes. Table 6 begins with public residence-based outcomes: modern population density and the density of employed residents. Panel A relates carbonate-rich bedrock directly to modern density after geographic controls. Panel B adds 1810 population density.

Table 6: Carbonate-rich bedrock and modern outcomes

	(1)	(2)
Dependent variable	Modern pop. density	Density of employed residents
Panel A. Without 1810 population density		
Carbonate-rich	0.461^{**}	0.470^{**}
	(0.222)	(0.218)
Panel B. With 1810 population density		
Carbonate-rich	0.245	0.258
	(0.208)	(0.203)
Pop. density, 1810	1.083^{***}	1.062^{***}
	(0.225)	(0.221)
Geographic controls	Yes	Yes
Year fixed effects	No	No
Observations	381	381

Notes: The table is a parish-level cross-section: each column uses one observation per historical parish/city unit in the matched historical-modern sample. Modern population and counts of employed residents come from Statistics Sweden public DeSO/RegSO data, 1810 population from SND Sweden 1570–1810, parish/city geometries from Lantmäteriet, and bedrock from SGU. Non-negative density outcomes are transformed using the inverse hyperbolic sine. Carbonate-rich bedrock is compared with all other bedrock, rather than conditioning on the full vector of other bedrock shares. Panel A reports the direct association between carbonate-rich bedrock and modern density after geographic controls. Panel B adds 1810 population density to test whether the modern relationship is absorbed by the historical density system. Standard errors are heteroskedasticity-robust HC1 standard errors. Geographic controls are a full cubic polynomial in centered east-west and north-south coordinates in kilometers and land area in square kilometers. Standard errors are reported in parentheses. Stars denote statistical significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Column 1 uses modern population density in 2025 as the dependent variable. In Panel A, the carbonate-rich bedrock coefficient is 0.461. In Panel B, adding 1810 population density reduces the coefficient to 0.245, while the 1810 coefficient is 1.083. Column 2 repeats the exercise for the density of employed residents in 2024. The carbonate-rich bedrock coefficient falls from 0.470 in Panel A to 0.258 in Panel B, while 1810 population density enters with a coefficient of 1.062. The result is not just that carbonate-rich bedrock has a reduced-form modern association. The stronger fact is that the historical population map is a powerful predictor of the modern residential map.

Table 7 turns to workplace-based economic activity using restricted-access plant-level records from Statistics Sweden. It reports the 1997–2021 average for three preferred outcomes: private workplace density, employment density, and value-added density. Appendix Table A6 reports additional production measures and the 2012–2021 and 2021 windows.

Carbonate-rich bedrock directly predicts all three workplace outcomes. The coefficient is 0.317 for private workplace density, 0.813 for private employment density, and 1.133 for private value-added density. When 1810 population density is added, the carbonate-rich bedrock coefficient for private workplace counts falls sharply, while the 1810 coefficient is 0.956. The early nineteenth-century density map therefore predicts where private workplaces are located today. The employment and value-added columns show the same historical-density relationship even more strongly. The 1810 coefficients are 1.271 for private employment density and 1.338 for private value-added density.

The private employment and value-added columns strengthen the interpretation. Even after 1810 population density is included, carbonate-rich bedrock remains positively related to the scale of private-sector activity. This is consistent with a broader historical settlement pattern: the 1810 population map captures a large part of that pattern, but not every element of market access, built environment, local labor pooling, and land-use organization that accumulated around favorable landscapes.

Table 7: Historical density and modern private economic activity, 1997–2021

Dependent variable	(1) Private workplaces	(2) Private employment	(3) Private value added
Panel A. Without 1810 population density			
Carbonate-rich	0.317**	0.813***	1.133**
	(0.160)	(0.232)	(0.469)
Panel B. With 1810 population density			
Carbonate-rich	0.126	0.560***	0.866*
	(0.141)	(0.209)	(0.469)
Pop. density, 1810	0.956***	1.271***	1.338***
	(0.171)	(0.269)	(0.275)
Geographic controls	Yes	Yes	Yes
Observations	381	381	381

Notes: Private economic-activity outcomes come from restricted-access plant-level private-sector workplace records at Statistics Sweden. Historical population comes from SND Sweden 1570–1810, parish/city geometries from Lantmäteriet, and bedrock from SGU. Each column is a parish-level regression with one observation per matched historical parish/city unit. Outcomes are inverse-hyperbolic-sine densities per square kilometer. Private workplaces are plant-year units in these restricted-access data. Private employment is the employment measure reported on the plant-year record and is distinct from the residence-based measure of employed residents used elsewhere in the paper. Private value added is the value-added variable reported on the plant-year record. Carbonate-rich bedrock is compared with all other bedrock. Geographic controls are a full cubic polynomial in centered east-west and north-south coordinates in kilometers and land area in square kilometers. Standard errors are heteroskedasticity robust and reported in parentheses. Stars denote statistical significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

6 Mechanisms

I interpret persistence using three kinds of historical evidence. Farm-production results connect carbonate-rich bedrock to the agrarian economy behind assessed agricultural capacity and historical population density. Settlement results ask whether that capacity took durable spatial form in churches, towns, named settlements, and settlement landscapes. Local archaeology then checks whether sharp geological changes also coincide with older traces of activity in the same landscape.

6.1 Farm Production in the Historical Database of Scanian Agriculture

The farm-production data provide a direct check on whether carbonate-rich landscapes were also places of higher measured agricultural output. I use the Historical Database of Scanian Agriculture to aggregate farm-level production to parish-year cells from 1702 to 1881. The database is built from historical tithe records–levies on agricultural output–and converts those records into comparable measures of grain production. I use total grain output per square kilometer, transformed with the inverse hyperbolic sine, as an output-density measure. This is not a crop yield per hectare. It asks whether the same lime-rich landscapes that predict population and land-tax density also carried more recorded grain production per unit of parish area.

Table 8 reports the corresponding regression. Column 1 includes year fixed effects only. The carbonate-rich bedrock coefficient is positive: parishes with more carbonate-rich bedrock have higher grain-output density in the HDSA panel. Column 2 adds the same geographic controls used in the historical tables–centroid coordinates and parish area–and the coefficient remains positive. The limitation is precision. HDSA contains many farm-year records, but the parish-level bedrock contrast is identified from a small set of Scanian parishes, and the parish-year coverage is uneven across time. The standard errors are therefore large enough that the table cannot establish a grain-output effect with certainty.

The result is nevertheless informative. The production coefficients point in the same direction as the stronger land-tax and population results, and they do so using a source that measures agricultural output rather than only people or assessed capacity. I therefore treat HDSA as supporting evidence on the agricultural mechanism, while the more precise historical estimates come from land-tax and population density.

Table 8: HDSA grain output density

	(1) Year FE only	(2) + geography
Carbonate-rich bedrock	0.248	0.174
	(0.313)	(0.331)
Observations	2105	2105
Year fixed effects	Yes	Yes
Geographic controls	No	Yes

Notes: The dependent variable is the inverse hyperbolic sine of total grain output per square kilometer in HDSA parish-year cells. Entries are coefficients on the parish share of carbonate-rich bedrock. Standard errors are clustered by HDSA parish and reported in parentheses. Geographic controls are parish centroid coordinates and parish area. Grain-output records come from the Historical Database of Scanian Agriculture, bedrock comes from SGU, and parish area and centroids are constructed from the historical parish/city geometries. Stars denote statistical significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

6.2 Fiscal Capacity and the Settlement System

I next ask whether assessed agricultural capacity was already spatially organized before the 1810 population map is observed. If earlier mantal density captures places where agricultural surplus could be produced and administered, it should also be connected to durable settlement structure: churches, towns, named settlements, and wider historical settlement traces. The preceding settlement results link carbonate-rich bedrock to those observable settlement measures. Table 9 adds the fiscal-capacity step using pre-1810 mantal density, measured as average mantal per square kilometer in 1570, 1630, 1690, and 1750 and transformed with the inverse hyperbolic sine. It asks whether earlier assessed capacity is related to the same settlement measures, and whether assessed capacity and settlement structure jointly predict the 1810 population map.

The table uses the same three settlement measures as Table 5. Column 1 gives the baseline relationship between pre-1810 mantal density and 1810 population density, without a settlement control. Columns 2–4 then add, respectively, the church/town measure, the register-based settlement measure, and the settlement-landscape measure. The first captures early churches and towns. The second adds historical settlement records, medieval or historical remains, prehistoric settlement sites, and church-related heritage records not already included in the church/town measure. The third further adds Lantmäteriet Ortnamn records associated with historically rooted settlements and manors. Panel A takes each settlement measure as the dependent variable and reports the coefficient on pre-1810 mantal density. Panel B takes 1810 population density as the dependent variable and reports the pre-1810 mantal-density and settlement-measure coefficients.

Table 9: Fiscal capacity and the settlement system

	(1) Baseline	(2) Church/town evidence	(3) Register evidence	(4) Settlement landscape
Panel A. Dependent variable: settlement-evidence density				
Pre-1810 mantal density		0.003	0.439***	0.567***
		(0.015)	(0.118)	(0.101)
Observations		381	381	381
Panel B. Dependent variable: 1810 population density				
Pre-1810 mantal density	0.341**	0.338**	0.294*	0.263
	(0.159)	(0.151)	(0.165)	(0.171)
Settlement-evidence density		1.267**	0.108***	0.138**
		(0.608)	(0.040)	(0.055)
Observations	381	381	381	381
Geographic controls	Yes	Yes	Yes	Yes
Settlement control in Panel B	No	Yes	Yes	Yes

Notes: Settlement measures combine Bebyggelseregistret, historical towns, Swedish National Heritage Board/Fornsök records, and Lantmäteriet Ortnamn; historical population and mantal come from SND Sweden 1570–1810, parish/city geometries from Lantmäteriet, and bedrock from SGU. Pre-1810 mantal density is the inverse hyperbolic sine of average mantal per square kilometer in 1570, 1630, 1690, and 1750; the measure excludes 1810. In each settlement column, eligible point records are counted inside each parish/city unit, divided by area, and transformed with the inverse hyperbolic sine. Column 1 reports the baseline relationship between pre-1810 mantal density and 1810 population density. Column 2 uses early churches and historical towns observed before 1810. Column 3 adds Swedish National Heritage Board records for historical settlements, medieval or historical remains, prehistoric settlement sites, and church-related heritage records not already included in the church/town measure. Column 4 combines the same register evidence with Lantmäteriet Ortnamn records associated with historically rooted settlements and manors, giving a parish-level measure of the settlement landscape. Panel A reports the coefficient on pre-1810 mantal density when settlement-evidence density is the dependent variable. Panel B reports the baseline mantal-density coefficient and then adds the corresponding settlement-evidence density to the 1810 population-density regression. All columns include geographic controls. Standard errors are reported in parentheses. Stars denote statistical significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Panel A shows that pre-1810 mantal density is most clearly related to the register-based and settlement-landscape measures. The coefficient is small and imprecise for churches and towns alone, but positive and precisely estimated when the evidence includes additional settlement records and old settlement names. This is the expected pattern if assessed agricultural capacity was organized across a settlement landscape rather than only around a small set of formally dated central places.

Panel B shows the baseline fiscal-capacity relationship and then adds the settlement measures. In column 1, pre-1810 mantal density predicts 1810 population density. Adding churches and towns leaves the mantal coefficient almost unchanged, and the church/town measure itself is positive. Adding the register-based measure or the settlement-landscape measure lowers the mantal coefficient, while the settlement-measure coefficients remain positive. This pattern shows that earlier assessed capacity and settlement evidence describe closely related parts of the same historical geography: fiscal capacity identifies where agricultural surplus could be assessed, while the settlement measures show where churches, towns, named settlements, and other durable settlement traces were located.

6.3 Local Archaeology Around Geological Boundaries

The final mechanism check separates the main carbonate-rich bedrock result from a more local archaeological pattern. In the broad parish regressions, carbonate-rich bedrock is positively related to historical population density, mantal density, the 1810 population map, and modern density. Mafic and intermediate bedrock has the opposite profile in Appendix Table A4. It is negatively related to those density outcomes. That makes mafic and intermediate bedrock a useful comparison case. If registered archaeological activity is higher around boundaries involving mafic and intermediate bedrock, the result points to a local archaeology relationship rather than to the agricultural-surplus mechanism behind the main persistence result.

Appendix Figure A1 compares archaeological point density near mafic and intermediate bedrock discontinuities and carbonate-rich bedrock discontinuities, with the corresponding side-by-side means reported in Appendix Table A7. The mafic and intermediate panel shows the clearer local archaeology pattern: burial records and iron-related records are higher on that side of the boundary. I interpret this as evidence on monument landscapes, movement corridors, preservation conditions, and registered iron-related traces near these local geological discontinuities. The carbonate-rich panel is flatter. This distinction is useful: carbonate-rich bedrock is the broader parish-scale agricultural and settlement landscape in the paper, while the mafic and intermediate result is a separate local archaeology result.

7 Robustness

Persistence in economic geography is likely to run through cities, market access, and spatial clustering. Earlier agricultural and settlement advantages could persist by becoming part of the central-place system that later organized roads, markets, employment, and population. I therefore use the robustness analysis to distinguish broad features of the Scanian landscape from relationships that operate mainly through historically central places.

7.1 City and Copenhagen Controls

Table 10 re-estimates the main carbonate-rich bedrock relationships while accounting for Copenhagen access, major historical city cores, town parishes, and the Copenhagen-adjacent part of southwestern Skåne. The logic is different for historical and modern outcomes. If bedrock helped form a settlement hierarchy, the historical fiscal-capacity and population-density relationships should remain visible outside the largest city cores. The modern reduced-form relationship, by contrast, should be more city-sensitive, because central places are one way the historical system survived.

Table 10 has five panels and five columns. The panels move down the main chain: fiscal capacity, historical population density, 1810 population density, modern population density, and the density of employed residents. Column 1 is the base geography-adjusted specification. Column 2 adds distance to Copenhagen. Column 3 excludes units within 10 kilometers of the major historical city cores, shown in Appendix Figure A2. Column 4 excludes pre-1810 town parishes. Column 5 excludes units within 30 kilometers of Copenhagen. This design asks whether the carbonate-rich bedrock relationship is only a Malmö, Lund, Helsingborg, Kristianstad, or Copenhagen story.

The pattern is revealing. Panel A shows the strongest result. The fiscal-capacity coefficient is 0.141 in the base specification, remains positive and statistically significant when distance to Copenhagen is added, is 0.125 when city-core buffers are removed, and is 0.155 or 0.160 when town parishes or Copenhagen-adjacent units are excluded. Panel B shows the same exercise for historical population density. The coefficient is positive throughout, though more sensitive to city and town restrictions. Panel C shows that the 1810 population-density relationship also remains positive across these specifications. Panels D and E show the modern reduced form. The coefficients for modern population and employed residents are positive in the base specification. They remain positive when only Copenhagen distance is added, and fall sharply when the specification removes the largest city-core neighborhoods. This does not weaken my argument. It shows that the historical bedrock-density relationship is broad, while the modern reduced form is partly carried by the central places through

Table 10: City and Copenhagen robustness: carbonate-rich bedrock coefficients

Specification	(1) Base	(2) Copenhagen	(3) Drop core	(4) Drop towns	(5) Drop Copenhagen
Panel A. Fiscal capacity (mantal density)					
Carbonate-rich	0.141^{***}	0.097^{**}	0.125^{**}	0.155^{***}	0.160^{***}
	(0.043)	(0.045)	(0.057)	(0.039)	(0.042)
Observations	1894	1894	1498	1855	1851
Panel B. Historical population density					
Carbonate-rich	0.179^{***}	0.151^{**}	0.159^{**}	0.115^{**}	0.173^{***}
	(0.060)	(0.065)	(0.065)	(0.048)	(0.062)
Observations	1905	1905	1505	1855	1860
Panel C. Population density, 1810					
Carbonate-rich	0.194^{***}	0.140^{**}	0.181^{**}	0.120^{**}	0.177^{***}
	(0.067)	(0.068)	(0.079)	(0.053)	(0.064)
Observations	381	381	301	371	372
Panel D. Modern population density					
Carbonate-rich	0.463^{**}	0.368	0.047	0.318	0.493^{**}
	(0.216)	(0.243)	(0.233)	(0.202)	(0.221)
Observations	381	381	301	371	372
Panel E. Employed-resident density					
Carbonate-rich	0.469^{**}	0.399^{*}	0.058	0.326^{*}	0.502^{**}
	(0.206)	(0.231)	(0.217)	(0.192)	(0.211)
Observations	381	381	301	371	372
Geographic controls	Yes	Yes	Yes	Yes	Yes
Copenhagen distance	No	Yes	No	No	No
Sample	None	None	City core	Town parishes	Copenhagen buffer

Notes: Entries are coefficients on carbonate-rich bedrock share; standard errors are reported in parentheses. Panels A and B use the repeated historical parish-year panel with year fixed effects and standard errors clustered by historical parish. Panels C–E use parish cross-sections with heteroskedasticity-robust standard errors. Carbonate-rich bedrock is compared with all other bedrock. Geographic controls are a full cubic polynomial in centered east-west and north-south coordinates in kilometers and land area in square kilometers. Column 2 adds log distance to Copenhagen. The sample restrictions exclude units within 10 km of major historical city cores, pre-1810 town parishes, or units within 30 km of Copenhagen. Stars denote statistical significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

which the historical density system persisted.

These specifications estimate a narrower relationship than the main analysis. In my interpretation, central places are not peripheral to the story; they are one way the historical density system survives. When the specification controls for Copenhagen access or removes major city cores, it asks what remains after taking out part of that mechanism. The attenuation in modern outcomes is part of the evidence: historical cities and city-adjacent geographies are among the ways settlement advantages persisted.

7.2 Spatial Inference

Spatial correlation matters here because geology, settlement, and population density are all spatially clustered. Nearby parishes may share unobserved landscape, administrative, and historical features, so the appendix reports inference checks that allow regression errors to be correlated over space. Appendix Table A9 focuses on the two headline historical outcomes. It reports the geography-adjusted carbonate-rich bedrock coefficients for historical population density and mantal density with parish-clustered standard errors, Conley-style standard errors at 25, 50, and 100 km, and a parish-level bedrock permutation exercise. In that permutation exercise, randomly reallocating the carbonate-rich share across parishes rarely produces historical-population or mantal-density coefficients as large as the observed ones.

Appendix Table A10 extends the same inference logic to the broader chain: carbonate-rich bedrock to historical density and fiscal capacity, settlement measures to the 1810 population map, and 1810 population density to modern population density and the density of employed residents. Appendix Figure A3 gives the corresponding visual summary. The pattern is the same as in the main tables: the strongest links are fiscal capacity, settlement persistence, and 1810-to-modern density persistence.

7.3 Historical Dynamics

The repeated historical panel makes it possible to ask whether the carbonate-rich gradient is visible before and after Skåne's transfer from Denmark to Sweden in 1658. The year-specific gradients reported in Table 3 show that the carbonate-rich bedrock relationship is visible in every historical year. Appendix Table A8 reports the corresponding broad pre- and post-1658 split. The important fact is that the gradient appears on both sides of the sovereignty transition, when administrative practice, source production, and state institutions changed. This makes the mechanism less likely to be an artifact of one country's institutions or record-keeping: the same bedrock-density relationship is visible under both Danish and Swedish rule.

8 Conclusion

I have asked whether the economic geography of a modern region can still reflect the earth beneath it. The evidence from Skåne suggests that it can. Carbonate-rich bedrock is associated with historical population density and assessed agricultural capacity, and the 1810 population map predicts where residents and private economic activity concentrate today.

The mechanisms help explain why the relationship could persist. The farm data support the agricultural interpretation: carbonate-rich parishes have higher recorded grain-output density, although the estimates are imprecise. The settlement evidence then shows how agricultural capacity could become a durable local advantage. Assessed capacity mattered for the long run when it was attached to places where surplus could be organized–through churches, towns, named settlements, and other durable features of the local economy–and those places help explain the 1810 population map. By contrast, the archaeology evidence is more local: older activity is concentrated around boundaries involving mafic and intermediate bedrock, while the main carbonate-rich result concerns a broader agricultural and settlement geography.

The robustness checks clarify what kind of persistence is being measured. I add controls for Copenhagen access and major historical cities, and I also re-estimate the main relationships after excluding parishes close to those cities. The modern reduced-form coefficients become smaller in these specifications, which is what the argument would lead one to expect if city locations and nearby urban geographies are part of the persistence mechanism. I also allow regression errors to be correlated across nearby parishes. Under this more demanding inference, the clearest evidence remains the historical land-tax relationship and the link from the 1810 population map to modern density. The carbonate-rich bedrock relationship is also present in the historical sources both before and after Skåne became Swedish in 1658. What changes is what that geography represents: in the historical data it is denser population and higher assessed agricultural capacity; in the modern data it is the location of residents and private-sector production.

The plant-level evidence is important because it shows that persistence reaches the production map, not only the residence map. Geographically detailed public data show where people live; restricted-access plant-level records show where private workplaces, employment, and value added are located. The modern claim is therefore about economic geography rather than only residential history.

The broader point is that geography can become history, and history can become modern economic geography. Bedrock did not mechanically determine modern outcomes. It helped organize an early density system whose economic relevance outlived the original agricultural setting. Part of the modern economic map has roots in the landscape that existed before the modern economy emerged.

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A Historical Data Appendix

The historical variables combine direct source variables, constructed densities, and additional settlement measures. Table A1 lists the data sources and construction steps used for the main historical analysis.

The first rows identify the direct historical outcomes: population density, mantal density, and arable capacity. The remaining rows list the geography, settlement-measure, church/town, archaeological, and name-record layers used in the mechanism and robustness analysis. Table A2 then defines the settlement measures used in the mechanism table, and Table A3 defines the archaeological measures used in the local boundary exercise.

Table A1: Historical data sources and constructed measures

Measure	Source and period	Construction in the analysis
Historical population: population counts, population per square kilometer, and inverse-hyperbolic-sine population density	Swedish National Data Service parish panel, 1570–1810	Population fields are matched to Lantmäteriet parish/city geometries, collapsed where several source rows map to one geometry, divided by area, and transformed with the inverse hyperbolic sine when used as density outcomes.
Fiscal capacity / mantal: mantal totals and mantal per square kilometer	Swedish National Data Service parish panel, 1570–1810	Mantal fields are scaled by parish/city area and transformed with the inverse hyperbolic sine when used as density outcomes.
Arable capacity: reported arable land and sown land	Swedish National Data Service parish panel, 1570–1810	Arable and sown-land fields are harmonized from year-specific source variables, scaled by area, and transformed with the inverse hyperbolic sine when used as density outcomes.
Parish and city geography: historical parish/city identifiers linked to spatial units	Lantmäteriet parish/city geometry; Swedish National Data Service source names	Historical source units are linked to parish/city polygons. City geometries are retained as separate units in the spatial analysis.

Measure	Source and period	Construction in the analysis
Historical settlement: settlement density and pre-1810 settlement density	Heritage-register, Bebyggelseregistret, historical towns, and selected Ortnamn name records	Historical settlement records and selected name records are combined, assigned to spatial units, scaled by area, and transformed with the inverse hyperbolic sine.
Medieval churches and pre-1810 towns: medieval church density, distance to church-like records, and access to historical towns	Bebyggelseregistret church chronology and historical-town layer	Church-like records and pre-1810 historical towns are converted to density, distance, and access measures.
Archaeological activity: grave indicators, iron-related indicators, and archaeological-site densities	Swedish National Heritage Board/Fornsök register records	Records are classified into grave, settlement, agrarian, communication, period-related, and reporting categories, then aggregated to grid and parish units.
Settlement names: densities of settlement-related names and historical settlement names	Lantmäteriet Ortnamn	Official settlement-name records are classified using feature types and settlement suffixes, then aggregated to spatial units.

Notes: Historical population, mantal, and arable-land variables come from the SND Sweden 1570–1810 parish panel. Parish/city geometries come from Lantmäteriet, bedrock from SGU, archaeological records from the Swedish National Heritage Board/Fornsök, building-register church records from Bebyggelseregistret, and official name records from Lantmäteriet Ortnamn.

Table A2: Historical settlement measures

Measure	Components	Use in the analysis
Church/town density	Church-like records from Bebyggelseregistret with explicit dates or medieval period labels, combined with conservatively coded pre-1810 historical towns.	Early institutional centers observed before 1810.
Register-based settlement density	Pre-1810 church/town records plus Swedish National Heritage Board/Fornsök records classified as historical settlements, medieval or historical remains, prehistoric settlement sites, and church-related heritage records not already included in the strict church/town layer.	Register-based settlement geography.
Settlement-landscape density	Register-based settlement evidence plus Lantmäteriet Ortnamn name records associated with historically rooted settlement and manor names.	Settlement geography including historically rooted names.

Notes: The measures combine church-like records from Bebyggelseregistret, historical towns, additional register-based settlement evidence, and official name records from Lantmäteriet Ortnamn. For each measure, eligible point records are counted inside the parish or city unit, divided by area, and transformed with the inverse hyperbolic sine. The measures are used to test whether durable settlement geography helps explain the 1810 population-density map.

Table A3: Archaeological measures

Measure	What it includes	Role
All archaeological records	Fornsök records from the Swedish National Heritage Board, assigned to the parish/city geography and measured per square kilometer.	Broad evidence on known archaeological activity.
Grave	Grave fields, mounds, stone settings, and related burial records.	Evidence on early activity in the local boundary comparisons.
Iron-related records	Records whose descriptions refer to burials, settlements, iron, or production.	Evidence on local archaeological activity near mafic and intermediate bedrock.
Dated iron records	Iron-related records that also contain period information in the heritage register.	A narrower measure used to check whether the broader iron-related result appears in dated records.

Notes: The archaeology variables are constructed from Swedish National Heritage Board/Fornsök records assigned to the analysis geography. They are used as spatial measures of known archaeological presence. Chronological interpretations are kept broad unless the underlying record contains reliable dating or period information.

B Additional Results Appendix

Table A4 reports separate geography-adjusted coefficients for all generalized bedrock categories, so the focus on carbonate-rich bedrock in the main text can be read against the full bedrock profile. Column 1 uses historical population density, column 2 fiscal capacity, column 3 pre-1658 fiscal capacity, column 4 1810 population density, and columns 5 and 6 modern population density and the density of employed residents. The table shows why carbonate-rich bedrock is the main agricultural-surplus category: it is positive across the central historical and modern density outcomes. It also shows why mafic and intermediate bedrock is interpreted differently: it is negatively related to historical and modern density in these broad regressions even though it is informative in the local archaeology boundary exercise.

Table A5 reports the modern density results in standard-deviation units. Panel A reports the reduced-form relationship between carbonate-rich bedrock and modern population density and the density of employed residents. Panel B adds 1810 population density. The standardized coefficients make the scale easier to compare across outcomes: the carbonate-rich reduced form is positive for density, while 1810 population density is the larger and more stable predictor once it is included.

Table A4: All generalized bedrock categories

Panel A. Historical outcomes				
	(1)	(2)	(3)	(4)
Dependent variable	Historical population density	Mantal density	Pre-1658 fiscal capacity	Population density, 1810
Carbonate-rich	0.179***	0.141***	0.115*	0.199***
	(0.060)	(0.043)	(0.061)	(0.070)
Mafic and intermediate	-0.231***	-0.191***	-0.196***	-0.202**
	(0.088)	(0.059)	(0.075)	(0.083)
Mud/fine sedimentary	0.004	0.014	0.066	-0.048
	(0.047)	(0.040)	(0.051)	(0.054)
Sand/coarse sedimentary	-0.037	-0.062	-0.108	-0.024
	(0.102)	(0.093)	(0.117)	(0.102)
Granite/gneiss	-0.133	-0.089	-0.128	-0.060
	(0.093)	(0.057)	(0.080)	(0.073)
Geographic controls	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	No	No
Observations	1905	1894	381	381

Panel B. Modern outcomes		
	(5)	(6)
Dependent variable	Modern population density	Density of employed residents
Carbonate-rich	0.461**	0.470**
	(0.222)	(0.218)
Mafic and intermediate	-0.791**	-0.859***
	(0.306)	(0.298)
Mud/fine sedimentary	-0.166	-0.152
	(0.181)	(0.177)
Sand/coarse sedimentary	0.456	0.487
	(0.368)	(0.364)
Granite/gneiss	-0.244	-0.264
	(0.294)	(0.282)
Geographic controls	Yes	Yes
Year fixed effects	No	No
Observations	381	381

Notes: Historical population and mantal come from SND Sweden 1570–1810, modern public outcomes from Statistics Sweden, parish/city geometries from Lantmäteriet, and bedrock from SGU. Each coefficient comes from a separate geography-adjusted regression for the bedrock category shown in the row. Density and capacity outcomes are transformed using the inverse hyperbolic sine. Historical population density and mantal density use the repeated parish-year panel with year fixed effects and standard errors clustered by historical parish. The remaining columns are parish/city cross-sections with robust standard errors. Geographic controls are a cubic polynomial in centered coordinates and land area. Standard errors are in parentheses. Stars denote significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A5: Standardized modern-outcome specifications

	(1)	(2)
Dependent variable	Modern pop. density	Employed-resident density
Panel A. Without 1810 population density		
Carbonate-rich	0.154**	0.158**
	(0.074)	(0.073)
Panel B. With 1810 population density		
Carbonate-rich	0.082	0.087
	(0.069)	(0.068)
Pop. density, 1810	0.373***	0.368***
	(0.077)	(0.077)
Geographic controls	Yes	Yes
Year fixed effects	No	No
Observations	381	381

Notes: Modern population and counts of employed residents come from Statistics Sweden public DeSO/RegSO data, 1810 population from SND Sweden 1570–1810, parish/city geometries from Lantmäteriet, and bedrock from SGU. The dependent variables, carbonate-rich bedrock share, and 1810 population density are standardized to mean zero and standard deviation one in the matched parish/city cross-section. Non-negative density outcomes are first transformed using the inverse hyperbolic sine. Coefficients are therefore in standard-deviation units for the focal standardized regressors. Carbonate-rich bedrock is compared with all other bedrock. Standard errors are heteroskedasticity-robust HC1 standard errors. Geographic controls are a full cubic polynomial in centered east-west and north-south coordinates in kilometers and land area in square kilometers. Standard errors are reported in parentheses. Stars denote statistical significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A6: Private economic activity in Statistics Sweden plant-level data: full outcome set

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable	Workplaces	Employment	Value added	Output	Labor costs	Materials
Panel A. 1997–2021						
Without 1810 population density						
Carbonate-rich	0.317**	0.813***	1.133**	0.687***	0.862***	0.798***
	(0.160)	(0.232)	(0.469)	(0.240)	(0.268)	(0.285)
With 1810 population density						
Carbonate-rich	0.126	0.560***	0.866*	0.403*	0.567**	0.497*
	(0.141)	(0.209)	(0.469)	(0.214)	(0.246)	(0.257)
Pop. density, 1810	0.956***	1.271***	1.338***	1.422***	1.483***	1.511***
	(0.171)	(0.269)	(0.275)	(0.267)	(0.295)	(0.311)
Panel B. 2012–2021						
Without 1810 population density						
Carbonate-rich	0.311*	0.842***	1.152**	0.673***	0.864***	0.750**
	(0.160)	(0.235)	(0.485)	(0.247)	(0.280)	(0.296)
With 1810 population density						
Carbonate-rich	0.124	0.583***	0.880*	0.382*	0.557**	0.438
	(0.142)	(0.212)	(0.486)	(0.222)	(0.259)	(0.269)
Pop. density, 1810	0.941***	1.297***	1.361***	1.458***	1.540***	1.564***
	(0.170)	(0.268)	(0.276)	(0.267)	(0.298)	(0.314)
Panel C. 2021						
Without 1810 population density						
Carbonate-rich	0.341**	0.949***	0.859***	0.803***	1.027***	0.844***
	(0.158)	(0.242)	(0.242)	(0.251)	(0.278)	(0.303)
With 1810 population density						

Carbonate-rich	0.155	0.690***	0.575***	0.516**	0.727***	0.538*
	(0.140)	(0.219)	(0.219)	(0.226)	(0.259)	(0.277)
Pop. density, 1810	0.929***	1.297***	1.420***	1.438***	1.504***	1.533***
	(0.169)	(0.269)	(0.271)	(0.269)	(0.298)	(0.317)
Geographic controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	381	381	381	381	381	381

Notes: Private economic-activity outcomes come from restricted-access plant-level private-sector workplace records at Statistics Sweden. Historical population comes from SND Sweden 1570–1810, parish/city geometries from Lantmäteriet, and bedrock from SGU. Each column is a parish-level regression with one observation per matched historical parish/city unit. Within each time-window panel, the first block omits 1810 population density and the second block includes it. Outcomes are inverse-hyperbolic-sine densities per square kilometer. Private workplaces are plant-year units in these restricted-access data. Private employment is the employment measure reported on the plant-year record and is distinct from the residence-based measure of employed residents used elsewhere in the paper. Private value added is the value-added variable reported on the plant-year record. Carbonate-rich bedrock is compared with all other bedrock. Geographic controls are a full cubic polynomial in centered east-west and north-south coordinates in kilometers and land area in square kilometers. Standard errors are heteroskedasticity robust and reported in parentheses. Stars denote statistical significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Archaeology Around Local Bedrock Boundaries

Appendix Figure A1 reports the local archaeology boundary figure discussed in the mechanism section. It compares archaeological point density near two types of local geological discontinuity: boundaries involving mafic and intermediate bedrock, and carbonate-rich bedrock boundaries. Signed distance is positive on the named bedrock side. The comparison distinguishes the broad carbonate-rich agricultural-density mechanism from a more local archaeological pattern around mafic and intermediate bedrock.

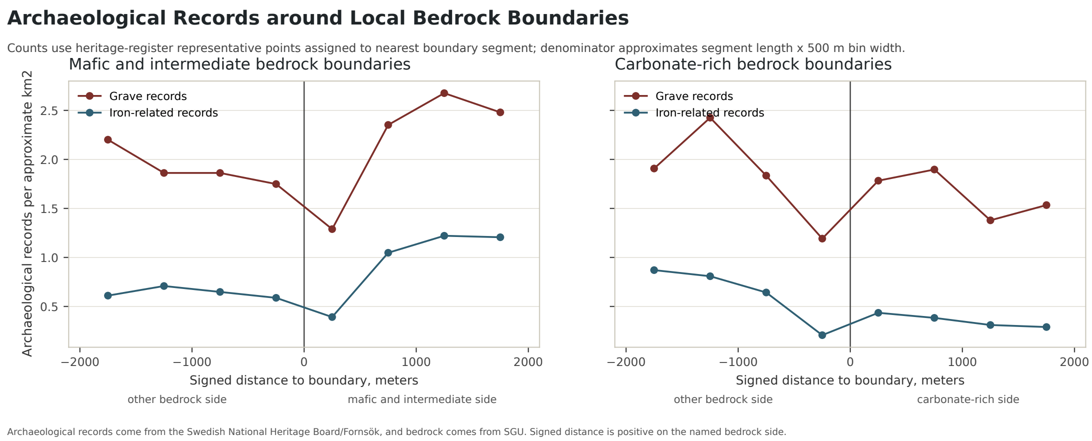

Figure A1: Archaeology around local bedrock boundaries

Notes: The figure compares archaeological point density near local mafic and intermediate bedrock discontinuities and carbonate-rich bedrock discontinuities. Archaeological records come from the Swedish National Heritage Board/Fornsök, and bedrock boundaries come from SGU. Signed distance is positive on the named bedrock side. The figure describes archaeological activity around local bedrock boundaries; it is not an estimate for one exact Viking- or Iron-Age period.

Table A7 reports the side-by-side means behind the mafic and intermediate panel. Grave records and iron-related records are higher on the mafic and intermediate side of the boundary, while the dated iron records are essentially flat. I therefore interpret the archaeology result as a local activity signal–burial records, monument landscapes, and iron- or production-related traces–rather than as evidence for one exact archaeological period. This is separate from the main carbonate-rich bedrock result, which operates at the parish scale through agricultural capacity, settlement density, and later population.

Table A7: Archaeological measures around mafic and intermediate bedrock boundaries

Outcome	Mafic and intermediate side	Other side	Difference	SE
Grave records	0.330	0.297	0.032	0.036
Iron-related records	0.175	0.122	0.054	0.030
Dated iron records	0.042	0.043	-0.001	0.018

Notes: Archaeological records come from the Swedish National Heritage Board/Fornsök, and bedrock boundaries come from SGU. Entries are unadjusted means in the 1 km sample around mafic and intermediate bedrock boundaries. Difference is the mean on the mafic and intermediate side minus the mean on the other side. Standard errors are computed from paired boundary-segment differences. The iron-related measure includes records whose descriptions refer to burials, settlements, iron, or production. The dated iron measure keeps only iron-related records that include a named historical period.

C Robustness Appendix

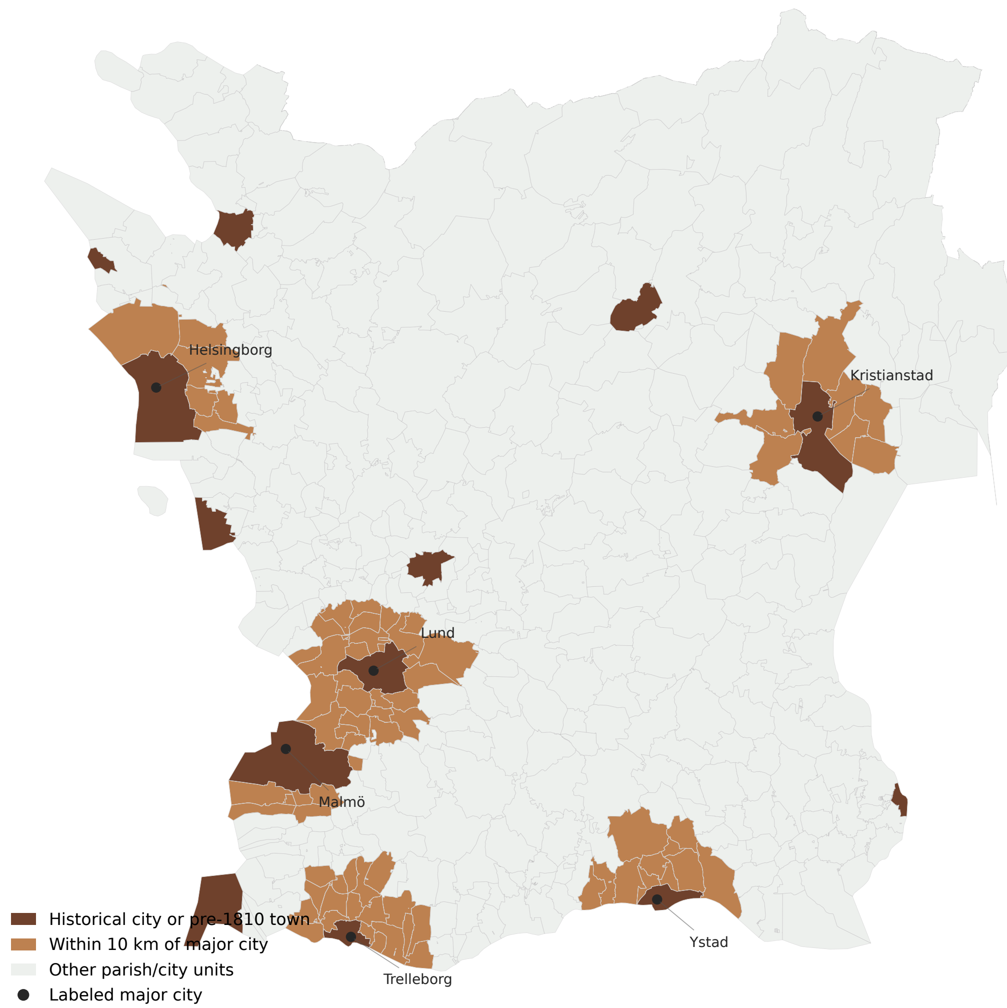

Figure A2: Historical central places and 10-kilometer city-core neighborhoods
Notes: The map classifies historical parish/city units by their relationship to the major historical city cores used in the city-robustness exercise. Dark units are historical cities or pre-1810 town parishes. Brown units are outside those cores but within 10 kilometers of a major city. Parish/city geometries come from Lantmäteriet, the historical town layer is constructed from the project settlement data, and city-distance measures are computed in SWEREF 99 TM.

Historical-Period Split

Table A8 reports the broad pre- and post-1658 split behind the historical-gradient discussion in the main text. Panel A uses population density and Panel B uses mantal density. In both panels, the carbonate-rich bedrock coefficient is positive and precisely estimated before and after 1658. The point is not a monotonic time pattern. The point is that the gradient is visible on both sides of Skåne's 1658 sovereignty transition, making it harder to interpret the pattern as an artifact of Swedish post-1658 administration.

Table A8: Carbonate-rich bedrock gradients around the 1658 sovereignty transition

Period	Pre-1658	Post-1658
Panel A. Dependent variable: population density		
Carbonate-rich bedrock	0.180^{***}	0.178^{***}
	(0.048)	(0.038)
Observations	762	1143
Panel B. Dependent variable: mantal density		
Carbonate-rich bedrock	0.127^{***}	0.150^{***}
	(0.045)	(0.029)
Observations	757	1137
Geographic controls	Yes	Yes
Year fixed effects	Yes	Yes

Notes: Entries are coefficients on carbonate-rich bedrock share. Pre-1658 combines 1570 and 1630; post-1658 combines 1690, 1750, and 1810. Specifications use inverse-hyperbolic-sine outcomes, compare carbonate-rich bedrock with all other bedrock, and include year fixed effects plus the same geography controls as Table 3: a full cubic polynomial in centered east-west and north-south coordinates and land area. Soil controls are not included. Standard errors are HC1 robust standard errors in parentheses. Stars denote statistical significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Spatial-Inference Checks

This appendix collects the inference checks that allow for stronger forms of geographic dependence than the baseline tables. Spatial correlation matters because geology, settlement systems, and population density are all geographically clustered: nearby parishes may share unobserved historical, environmental, or administrative features. These checks keep the estimates fixed and vary the inference: they ask how precision changes when standard errors are allowed to be spatially correlated and when the observed bedrock pattern is compared with placebo assignments.

Table A9 focuses on the two headline historical bedrock relationships. It reports the main clustered standard errors, Conley-style standard errors at 25, 50, and 100 km bandwidths, and a parish-level permutation check that randomly reallocates the carbonate-rich measure across parish units. Table A10 extends the same logic to the broader evidence chain, including settlement-to-1810 density and 1810-to-modern-density relationships. Figure A3 gives the visual version of these checks, making clear which links remain informative as the assumed radius of spatial correlation grows.

Table A9 should be read row by row. The first row uses historical population density with the geography-adjusted specification. The second row repeats the exercise for fiscal capacity. The Conley columns increase the allowed radius of spatial correlation from 25 to 100 kilometers, while the permutation column compares the observed coefficient to placebo assignments of carbonate-rich bedrock across parishes. The positive coefficients and low permutation p-values show that the headline historical relationships are not just arbitrary labels on the map.

Table A10 broadens the same exercise. The first two rows report the historical population and fiscal-capacity estimates with Conley-style standard errors using parish centroids. The modern persistence rows use the same coefficient definitions as the main modern table; the table changes the inference assumption, not the estimand. The next rows show that carbonate-rich bedrock predicts 1810 density, that 1810 density predicts modern population density and the density of employed residents, and that broad settlement measures predict the 1810 map. The same hierarchy appears as in the main text: fiscal capacity, settlement persistence, and 1810-to-modern density are the strongest links.

Table A9: Spatial-inference checks for headline historical outcomes

Outcome	Controls	Coef.	Parish SE	25 km SE	50 km SE	100 km SE	Perm. p	N
Population density	Geography	0.179	0.060	0.087	0.092	0.062	0.001	1905
Mantal density	Geography	0.141	0.043	0.052	0.054	0.035	0.001	1894

Notes: Historical population and mantal come from SND Sweden 1570–1810, parish/city geometries from Lantmäteriet, and bedrock from SGU. The coefficient is the coefficient on carbonate-rich bedrock share, comparing carbonate-rich bedrock with all other bedrock. Non-negative density and capacity outcomes are transformed using the inverse hyperbolic sine. All specifications include a full cubic polynomial in centered parish coordinates, parish area, and year fixed effects. Conley-style standard errors use parish centroids and Bartlett distance kernels. The permutation p-value shuffles carbonate-rich shares across parishes, preserving the repeated parish-year panel.

Table A10: Spatial-inference checks

Specification	Coef.	HC0 SE	Conley 25km	Conley 50km	Conley 100km	N
Carbonate to historical population	0.179	0.030	0.087	0.092	0.062	1905
Carbonate to mantal/tax density	0.141	0.026	0.052	0.054	0.035	1894
Carbonate to 1810 density	0.199	0.068	0.099	0.104	0.071	381
1810 density to modern population	1.083	0.221	0.231	0.222	0.200	381
1810 density to employed residents	1.062	0.217	0.224	0.215	0.192	381
Recorded settlement evidence to 1810 density	0.157	0.052	0.056	0.050	0.040	381
Broader settlement landscape to 1810 density	0.225	0.068	0.068	0.055	0.046	381

Notes: Historical population and mantal come from SND Sweden 1570–1810, settlement measures combine the historical settlement layers described in Appendix Table A2, modern public outcomes come from Statistics Sweden, parish/city geometries from Lantmäteriet, and bedrock from SGU. Conley-style standard errors use a Bartlett distance kernel based on parish centroids. Historical panel specifications include year dummies. All specifications include the carbonate-rich bedrock share and the cubic geography controls used in the main tables. These checks complement, rather than replace, the main Stata clustered and HC1 specifications.

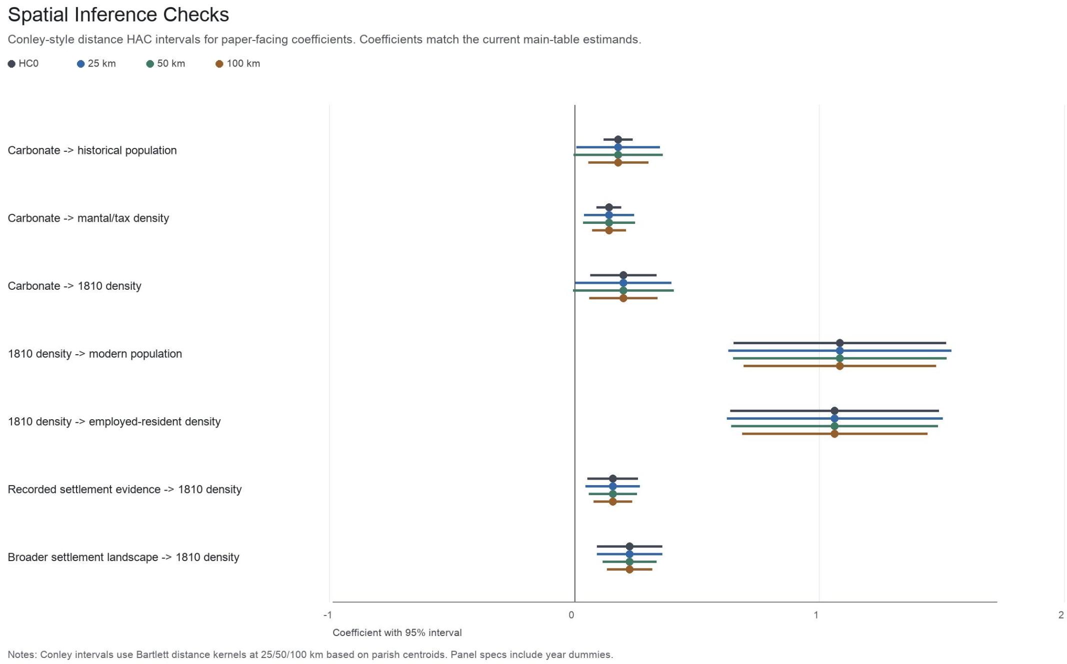

Figure A3: Robustness check: spatial-inference checks

Notes: Robustness figure. Conley-style standard errors are computed using parish centroids and Bartlett distance kernels. Historical population and mantal come from SND Sweden 1570–1810, parish/city geometries from Lantmäteriet, modern public outcomes from Statistics Sweden, and bedrock from SGU.