Cliometrica
https://doi.org/10.1007/s11698-026-00352-y

ORIGINAL PAPER

The political economy of noble rank proliferation in imperial China

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Received: 30 December 2025 / Accepted: 21 October 2026
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Abstract

Imperial Chinese dynasties varied dramatically in elite population outcomes: under the Ming's eight-rank system, the registered clan grew to over 157,000 members by 1595, imposing catastrophic fiscal costs, while under the Qing's fourteen-rank system, the registry recorded 16,454 living male clansmen at the end of a comparable period. Conventional wisdom attributes such divergence to rank count; we show that rank count alone does not explain it. Using cross-dynasty comparative analysis of seventeen dynasties and 87,318 individual records from the Qing Yudie (Genealogical Registry), we provide convergent evidence linking demographic control to institutional complementarity—specifically, mandatory demotion combined with examination-based exit—rather than to the number of rank tiers alone. Clansmen recorded with rank or office averaged 2.95 recorded sons versus 0.83 for those without (regression-adjusted: 1.784 sons), a differential closely associated with marriage-market access: 91% of clansmen with recorded rank or office married versus 41% of those without, with controls for marriage structure attenuating the gradient by approximately 84% (a descriptive combined attenuation that includes a small sample restriction; a same-sample two-equation decomposition associates 85.5% of the gradient with the marriage component). The Ming combined rank tiering with no exit mechanism; the Qing combined mandatory demotion with examination-based exit. Institutions work as a package, not as individual policy parameters.

Keywords Noble ranks · Imperial China · Institutional design · Elite management · Fertility · Genealogical records

JEL Classification N45 · D72 · H11 · P48 · J13

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Published online: 10 November 2026

1 Introduction

By 1562, the Ming imperial clan's stipend entitlements had reached 37 percent of the dynasty's total grain revenue. The clan had grown from fifty founding males in 1368 to over 157,000 registered members by 1595—and was still expanding. Princes could not farm, trade, or hold office; they could only draw stipends, take wives, and produce sons who would do the same. The state was legally obligated to feed every one of them, forever. This was not an accident of demography. It was closely tied to a founding institutional choice: the founding emperor's guarantee that every male descendant would receive a stipend, in perpetuity, with no exit. Imperial Chinese dynasties varied enormously in how they structured noble rank systems, but the Ming stood alone in combining central treasury financing, stipend eligibility extending to every male descendant, and the complete absence of any exit-producing mechanism. The result, by the mid-sixteenth century, was a ruling house whose stipend entitlements claimed more than a third of the empire's grain revenue—and were still growing.

This paper asks a single unifying question: how do institutional complementarities—specifically mandatory demotion rules and examination-based exit mechanisms—determine the demographic and fiscal sustainability of hereditary elite systems? Our central contribution is to show that rank count alone does not determine population outcomes; what matters is whether ranks are embedded in a complementary institutional architecture combining mandatory demotion and examination-based exit—where "exit" denotes exit from the titled, stipend-bearing hierarchy, not from the clan registry: unsuccessful examinees remained registered clan members in the Yudie with minimal allowances. We support this with two complementary strands of evidence: a cross-dynasty comparative analysis of seventeen dynasties spanning two millennia and individual-level microdata from 87,318 records in the Qing Yudie genealogical registry in thepreceding paragraph, since Table 1 describes that sample. The Ming–Qing contrast serves as the motivating puzzle: two dynasties whose noble hierarchies comprised, respectively, eight substantive title grades (Ming) and fourteen formally codified categories, two of which were heir designations (Qing), produced radically divergent outcomes, one collapsing under the fiscal weight of an exploding clan and the other sustaining controlled growth across nearly three centuries.

The puzzle deepens when we examine outcomes. The Yuan and Ming dynasties both employed eight-rank systems, yet produced vastly different results. Yuan princes governed themselves from territorial appanages, keeping the clan small and dispersed across the empire. Ming princes, by contrast, received stipends from the central treasury—every male descendant, regardless of generational distance from the founding emperor, was entitled to at least two hundred shi of grain annually. The result was the geometric population growth described above, which showed no sign of abating before the dynasty's collapse in 1644.

The Qing founders, many of whom had observed the Ming's collapse, designed their system differently. Their system developed into fourteen principal ranks—from Prince of the Blood (heshuo qinwang, rank 1) down to Grace-Bearing

Table 1 Sample construction

Sample	Criterion	N
Raw Yudie records	Full genealogical registry	87,318
Birth restriction	Born 1650–1900	70,592
Estimation sample (Table 3, Cols. 1, 3, 4)	Non-missing paternal-line information	70,589
Father-ID-restricted sample (Table 3, Col. 5; Table 6)	Non-missing father identification	69,993

General (feng'en jiangjun, rank 14), below which descendants fell to untitled "idle clansman" status. It instituted mandatory generational demotion for non-exempt lines, under heir-, maternal-status-, and period-specific rules detailed in Appendix A.3, and it required examinations for title inheritance. Under this combination, the Qing registry recorded 419 male clansmen in 1660 and 16,454 in 1915 (Rawski 1998, p. 93)—roughly an order of magnitude below the Ming's 1595 registered total, although the two counts are not compiled on the same basis (see the note to Fig. 2).

The Qing's rank system architecture is closely tied to this outcome: mandatory demotion and examination filtering meant that, across the dynasty as a whole, 92 percent of recorded descendants are ultimately recorded without rank or office, in the category of "idle clansman" (xiansanzongshi) status (80,181 of the 87,318 registry records carry no rank or office; Table 2), receiving only minimal stipends insufficient to support marriage or reproduction at scale. The rank structure thus functioned less as a static system of hereditary privilege than as a managed funnel that systematically withdrew titles and the fertility advantages they conferred across generations. Full details of the rank system, population composition, and fiscal data are provided in Sect. 5.

Our analysis yields a central finding that challenges intuitive expectations: rank count alone does not determine population outcomes. The critical institutional margins are the complementary institutions that govern how individuals move through the rank structure and who qualifies for stipends. The Ming's difficulty was not that eight ranks were too few: universal stipend eligibility combined with the absence of exit-producing demotion created unbounded growth incentives. Under the Qing's fourteen ranks, mandatory demotion and examination filtering meant that only a small minority of clan members were recorded with a rank or office: 9.1 percent of records in the birth-restricted registry data.

Unlike prior work documenting family-level fertility strategies among Qing nobles (Wang et al. 1995), this paper asks how state-level institutional design shaped the demographic environment within which those family decisions were made—and why the Qing's configuration succeeded where the Ming's failed. This paper makes three contributions. First, we provide the first quantitative cross-dynasty framework explaining variation in noble rank structures as endogenous institutional choices responding to fiscal centralization, demotion requirements, and population management objectives—extending prior comparative work (Wang and Xu 2021a, 2021b; Jiang 1986) by combining systematic institutional coding across seventeen dynasties

Table 2 Descriptive statistics by rank

Rank	N	Mean sons	Mean wives	% Married	% Childless
Emperor	19	7.05	10.32	84.2	21.1
Prince 1st Rank	162	4.85	4.40	89.5	13.6
Prince 2nd Rank	96	3.80	3.34	79.2	25.0
Beile	62	4.18	3.00	79.0	24.2
Beizi	57	3.78	3.07	93.0	12.3
Duke	256	3.18	2.48	84.4	21.9
General	1377	2.84	2.05	91.9	18.2
Commandant	619	3.47	1.83	91.6	15.5
Other Officials	4489	2.76	1.73	91.3	16.8
Idle Clansmen	80,181	0.83	0.54	41.2	65.2

Table 2 reports descriptive statistics for the full Yudie dataset of 87,318 records. The three mutually exclusive categories are: birth-window rank-or-office holders (N = 6438; born 1650–1900 with any recorded rank or office), rank or office holders born outside the 1650–1900 birth window (N = 699), and idle clansmen (N = 80,181); these sum to 87,318. The "Other Officials" row (N = 4489) comprises 3790 birth-window rank-or-office records assigned to this display row plus 699 rank or office holders born outside the birth window; the Emperor through Commandant rows show the remaining 2648 birth-window records by highest noble rank. All displayed rows are mutually exclusive and sum to 87,318. The regression analyses do not use these display categories directly: they restrict the sample to births in 1650–1900 and use the rank indicators defined in Sect. 5.4.2, with column-specific samples reported in Table 3 notes; the regression estimates are therefore unaffected by this descriptive regrouping. Table 3, Column 5, and Table 6 use the 69,993-individual father-ID-restricted sample; other columns use the samples stated in Table 3 notes. That sample is restricted to individuals born 1650–1900 with non-missing father identification; see Table 1 for sample construction details

with individual-level microdata. Second, we compile a comprehensive database of rank structures across seventeen dynasties, supplemented by detailed population time series for the Song, Ming, and Qing. Third, using 87,318 individual records from the Qing Yudie genealogical registry, we provide the first individual-level quantitative evidence documenting the mechanisms through which institutional design was associated with recorded sons. A descriptive decomposition links the large majority of the rank–fertility differential to differential marriage-market access—rank predicts marriage access, and controlling for marriage structure is associated with an 84 percent combined reduction in the rank–sons gradient (Table 3 notes; see also Tables 4 and 5 on the demotion mechanism). To probe the institutional channel over time, we examine the Yongzheng Emperor's 1730 examination reforms: the rank–fertility premium is 60.1 percent smaller under the post-1730 birth cohort coding (Column 1 ofTable 6); because birth year is only a cohort marker and final rank or office is itself institution-affected, we read this interaction as descriptive rather than as identifying the effect of the reform. A separate sensitivity specification adds a Rank × linear time trend, allowing the rank gap to follow a linear secular path; it is reported as a descriptive check and is not used to establish a discrete post-1730 causal effect. This timing pattern is consistent with the proposed institutional mechanism, while not cleanly distinguishing it from persistent cultural or selection-based differences; we acknowledge the comparative nature of the exercise and present these findings as suggestive rather than definitive, and not as proof of causation. Taken together, the

Table 3 Correlates of recorded sons in the Yudie

	(1)	(2)	(3)	(4)	(5)	(6)
Has Rank	1.784*** (0.041)	1.823*** (0.041)	1.842*** (0.048)	1.841*** (0.049)	0.293*** (0.036)	0.893*** (0.114)
Father's Sons		−0.009*** (0.002)		−0.009*** (0.002)	−0.009*** (0.002)	
Wives					1.209*** (0.031)	
Gen FE	Yes	Yes	Yes	Yes	Yes	Yes
Cohort FE	Yes	Yes	Yes	Yes	Yes	Yes
Lineage FE	No	No	Yes	Yes	Yes	No
R^2	0.120	0.120	0.120	0.120	0.511	0.459
N	70,589	70,592	70,589	70,589	69,993	40,825

* $p<0.05$, ** $p<0.01$, *** $p<0.001$. Standard errors clustered at the lineage level in parentheses. Lineage FE controls for 112 princely lineages. Sample sizes are reported by column: N = 70,589 in Columns (1), (3), and (4); N = 70,592 in Column (2); N = 69,993 in Column (5); and N = 40,825 in Column (6). Column (2) is estimated on the full birth-restricted sample, which additionally includes the three adoptive-succession entries described in Sect. 5.4.1. Because Columns (4) and (5) are estimated on different samples, the 84% coefficient reduction is a descriptive combined attenuation reflecting both the wives control and the sample restriction, rather than a same-sample causal mediation estimate; a same-sample counterpart that does not involve this restriction is reported in Sect. 5.4.4: the two-equation decomposition, computed on the Column (1) sample, associates 85.5 percent of the gradient with the marriage component. In Column (6), the coefficient on father's age at death is 1.160 (SE = 0.033; standardized to mean zero and unit variance, so the coefficient is per one standard deviation of paternal lifespan, approximately 25 years), not displayed. The standardized rank coefficient is approximately 1.0 standard deviation of the sons distribution (coefficient 1.784 / SD 1.78, where 1.78 is the standard deviation of the sons variable in the Column (1) estimation sample (N = 70,589); the full-sample SD of 1.73 cited in Sect. 5.4.3 is computed on all 87,318 records and used for the full-sample standardized magnitude reported in Sect. 5.4.3), indicating that holding a recorded rank or office is associated with a one-standard-deviation increase in recorded sons relative to idle clansmen

Table 4 Iron-cap mechanism-illustration comparison

	Iron-cap	Non-iron-cap	Difference
Mean sons	4.58	2.83	+1.75
With generation FE			+1.71***
N	55	6383	

*** $p<0.001$. The raw mean difference (+1.75) is descriptive; the generation-FE estimate (+1.71) carries the significance test. Sample: Ranked individuals only. This comparison is descriptive and should not be interpreted as a causal estimate; iron-cap status was not randomly assigned (see Sect. 5.4.5)

Table 5 Titled status and fertility in four iron-cap lineages

	(1)	(2)	(3)	(4)	(5)
Titled (=1)	1.139*** (0.021)	1.015*** (0.023)	1.016*** (0.023)	0.438*** (0.027)	0.391*** (0.027)
Wives/concubines	–	–	–	0.313*** (0.005)	0.307*** (0.005)
Generation FE	No	Yes	Yes	Yes	No
Lineage FE	No	No	Yes	Yes	Yes
Birth decade FE	No	No	No	No	Yes
Wives control	No	No	No	Yes	Yes
N	9596	9596	9596	9596	9596
Pseudo R^2	0.064	0.100	0.102	0.212	0.229

Notes to Table 5: Poisson regression. Dependent variable: number of sons recorded in Yudie. Sample: four iron-cap lineages (Li/Prince Li, Su/Prince Su, Yu/Prince Yu, Rui/Prince Rui), males born 1609–1912, N = 9596. *** $p < 0.001$. Standard errors in parentheses (lineage-level clustering is not applied given the four-lineage sample; reported SEs are heteroskedasticity-robust). Descriptive decomposition: adding wives control reduces titled coefficient by 56.8 percent, consistent with marriage-market access as the leading proximate channel linking rank to recorded sons. Within-lineage temporal comparison: titled members born before 1750 averaged 2.94 more sons than untitled members of the same lineages; after 1750 this differential fell to 1.22 sons—a decline of 58 percent, directionally consistent with Qianlong-era institutional changes. Seven-lineage robustness (adding Zhuang/Shuo Se, Zheng/Jirgalang, Keqin/Yoto; N = 12,828): titled coefficient 1.052 (SE = 0.020) with lineage fixed effects, 0.441 (SE = 0.024) with wives control; attenuation share 58.1 percent, compared to 56.8 percent in the four-lineage sample (Table 5)

evidence supports a general principle: the fiscal sustainability of hereditary elite systems depends not on the number of ranks, but on whether those ranks are embedded in a complementary institutional architecture that severs the link between elite status and unbounded reproduction.

The two strands of evidence introduced above play distinct roles. The macro strand uses variation in fiscal model, demotion rules, scattered titles, and examination requirements across the seventeen dynasties to test three propositions about rank structure and positions the Ming–Qing comparison as a structured comparative case study. The micro strand uses the Yudie records to document the reproductive success gradient across ranks, the marriage-market access channel, and the demographic consequences of mandatory demotion. The two strands address different threats

Table 6 Descriptive pre/post birth cohort interaction around 1730

	(1) Baseline	SE	(2) + Trend	SE
Rank main effect	3.439***	(0.045)	3.617***	(0.058)
Post-1730	0.157***	(0.031)	0.314***	(0.040)
Rank × Post-1730	−2.068***	(0.051)	−1.353***	(0.097)
Rank × Time Trend	–	–	−0.005***	(0.001)
Implied reduction	60%		–	

OLS with generation and lineage fixed effects. Dependent variable: Sons (count). Sample: N = 69,993 (born 1650–1900, non-missing father identification). Rank is the broad Has Rank indicator used in Table 3 and equals one when any noble rank or official position is recorded in the individual's Yudie entry. The implied-reduction figure in Column (1) is mechanically the ratio of the two reported coefficients (2.068/3.439 = 60.1 percent); it is arithmetic on the printed values, not an estimated policy effect. No corresponding ratio is reported for Column (2): in the presence of the Rank × Time Trend term, the printed Rank main effect is defined relative to the trend specification, so a ratio of the two coefficients has no comparable interpretation. Standard errors clustered at the lineage level in parentheses. *** $p < 0.001$. Column (1): baseline pre/post specification without secular trend control. Column (2): adds a Rank × linear time trend as a descriptive sensitivity specification. The Rank main effect equals the pre−1730 rank gap in Column (1), where no trend is included; in Column (2) it is the Rank effect evaluated at the origin of the time trend and is not the pre−1730 gap. The Rank × Post-1730 interaction is invariant to the origin and scale of the time variable and is the only Column (2) coefficient we interpret substantively; the Column (2) Rank main effect and the Rank × Time Trend coefficient depend on that normalization and are reported without substantive interpretation. No ratio of the two Rank coefficients is reported for Column (2). "Implied reduction" row reports |Rank × Post-1730| / Rank main effect for Column (1) only; it is a derived quantity describing the change in the conditional rank–recorded-sons gap, not an estimated coefficient, and it carries no standard error

to inference: the macro strand addresses the concern that the Ming–Qing divergence reflects factors unrelated to institutional design; the micro strand addresses the concern that aggregate population differences are artifacts of measurement or composition rather than individual behavioral responses to institutional incentives. We distinguish three layers of inference explicitly, each carrying its own evidentiary standard. This tiered framework makes explicit that our claims rest on different types of evidence with different levels of confidence; we discuss the evidentiary basis for each tier below and return to it explicitly at key junctures throughout the paper. First, design facts (high confidence): how rank inheritance, demotion floors, side-titles, and examination requirements differ across dynasties, and how these rules mechanically change the mapping from births to titled population—these claims rest on primary institutional sources. Second, within-Qing behavioral gradients (moderate-to-high confidence): the rank–marriage–sons gradient in the Yudie micro-data, together with the descriptive shifts of this gradient around institutional reference years, which we treat as suggestive rather than confirmatory, supported

by a large individual-level dataset from a record system widely regarded as unusually systematic. Third, cross-dynasty counterfactual attribution (suggestive): the claim that institutional differences contributed materially to the Ming–Qing population divergence—here, unmodeled differences in political organization, military institutions, geography, and mortality regimes constitute threats to inference, and we present the evidence as suggestive rather than definitive, and not as proof of causation. Together, these strands allow us to marshal convergent evidence consistent with causal mechanisms connecting institutional design to demographic and fiscal outcomes over the long run.

The remainder of the paper proceeds as follows: Sect. 2 reviews the relevant literature on political economy and Chinese nobility institutions. Section 3 develops our theoretical framework, identifying four key institutional variables and deriving propositions about their effects. Section 4 presents a formal model of population dynamics under different institutional configurations. Section 5 describes our data sources, presents cross-dynasty rank structures alongside population and fiscal evidence, and provides the full micro-level empirical analysis using the Qing Yudie records—including the fertility gradient, the marriage-market mechanism, the iron-cap comparison, and the descriptive cohort comparison around 1730. Section 6 tests our propositions against the historical record, with particular attention to the Ming–Qing comparison and alternative explanations. Section 7 discusses broader implications and limitations. Section 8 concludes.

2 Literature review

The study of noble rank systems sits at the intersection of political economy theories of elite management and Chinese institutional history.

2.1 Political economy of elite management

North et al. (2009) distinguish "limited access orders," where elites restrict participation to maintain rents, from "open access orders" characterized by impersonal rules. In limited access orders, formal institutions—including noble rank systems—help make elite bargains observable and enforceable. A duke's privileges are publicly known; violations are easily detected.

Svolik (2012) analyzes the "problem of authoritarian power-sharing": how dictators share power with ruling coalitions while preventing coups. Noble rank systems partially address this commitment problem by creating observable entitlements backed by tradition and precedent.

A related strand examines the fiscal implications of elite entitlements. Brewer (1989) shows that early modern European states' fiscal capacity depended critically on the institutional ability to tax and limit aristocratic privileges—the same tension at the heart of Ming fiscal collapse. Besley and Persson (2011) formalize this logic, demonstrating that fiscal capacity and legal institutions are complementary investments; states that fail to constrain elite rent extraction lose both revenue and

institutional legitimacy. Harrison (2002) provides a complementary game-theoretic model of dictator–elite relations, showing that coercive compliance in the Soviet command economy ultimately collapsed when the dictator could no longer credibly commit to elite rewards—a dynamic directly analogous to the Ming's fiscal insolvency driven by unconstrained clan entitlements. Our paper contributes to this fiscal state literature by showing how institutional design within the hereditary elite—not just taxation of commoners—was central to long-run state fiscal capacity.

2.2 Chinese nobility institutions

Chinese historians have produced extensive documentation of noble rank systems. Chaffee (1999) provides the most comprehensive English-language study of the Song (960–1279) imperial clan. Zhang Dexin (1988) documents Ming (1368–1644) clan institutions, calculating that by 1562, clan stipend entitlements reached 8.53 million shi—thirty-seven percent of national grain tax revenue. Jiang (1986) provides an early quantitative analysis of Qing imperial clan demography based on the Yudie.

Recent work examines institutional complementarities. Zhou (2018) demonstrates that centralized bureaucracy and civil service examinations were mutually reinforcing. Jia et al. (2024) compare power structures in Imperial China and Premodern Europe. Our analysis extends their framework to the imperial clan—where hereditary status was unavoidable, but fiscal consequences could be shaped through institutional design.

2.3 Gap in the literature

Despite extensive scholarship on individual dynasties, no study has explained cross-dynasty variation in noble rank structures as endogenous institutional choices using a unified quantitative framework that combines systematic institutional coding with individual-level microdata. The implicit conventional wisdom in this literature is that rank count—the number of hereditary title grades—is the primary institutional determinant of noble population outcomes. Zhang Dexin (1988) attributes the Ming's demographic explosion primarily to its eight-rank structure, treating rank proliferation itself as the key variable. Chaffee (1999) similarly frames the Song's relatively controlled clan size as a product of its restricted title grades. Jiang (1986), while providing quantitative documentation of the clan's demographic trajectory, does not formally test whether rank count or complementary institutions drive the cross-dynasty variation. We show that this conventional wisdom does not hold: the same rank count was followed by catastrophically different outcomes in the Yuan and Ming, and it is the package of complementary institutions—not rank count per se—that distinguishes sustainable from unsustainable trajectories. Prior comparative work—most notably Wang and Xu (2021a, 2021b) on Ming–Qing demotion architectures and Jiang (1986) on Qing imperial clan demography—provides essential building blocks, but stops short of formalizing the institutional trade-offs across seventeen dynasties or identifying the micro-level mechanisms through which rank

design shaped individual reproductive success outcomes. This paper fills that gap. Our approach follows the tradition of cliometric research that combines institutional analysis with quantitative historical data, as exemplified by recent work examining demographic transitions through the lens of institutional constraints (Perrin 2022).

Our micro-level findings also connect to the historical demography literature. A central mechanism in our paper is that stipend income is associated with reproductive success through marriage-market access—a relationship directly predicted by Malthusian models in which income relaxes the preventive check on marriage and fertility. Clark (2007) documents this income–fertility gradient among pre-industrial English families, showing that wealthier households consistently left more surviving descendants. Lee and Wang (2001) provide the closest parallel in the Chinese context, documenting that reproduction among the Qing nobility was regulated through both marriage and deliberate control of fertility within marriage, with both margins responsive to economic resources. More broadly, our findings parallel the literature on inheritance institutions and population dynamics: just as impartible inheritance (primogeniture) constrained household proliferation among European peasants, while partible inheritance accelerated it (Goody 1976; Hajnal 1982), the Qing's mandatory demotion functioned as an institutional analog to impartible inheritance for the imperial clan—limiting the perpetuation of high-status, high-fertility households across generations. The Ming's universal stipend system, by contrast, resembles partible inheritance in its demographic consequences: every male descendant retained entitlements, incentivizing early marriage and large families regardless of generational distance from the founding emperor.

The closest precursor to our micro-level analysis is Wang et al. (1995), who demonstrate that Qing nobles exercised deliberate fertility control as a form of Malthusian preventive check—focusing on family-level strategic behavior as the proximate mechanism. Our paper asks a fundamentally different question: how did state-level institutional design shape the demographic environment within which these family decisions were made? Where Wang, Lee, and Campbell treat the institutional setting as background, we treat it as the object of analysis—asking why registered growth remained controlled under the Qing's institutional configuration but not under the Ming's, and identifying the institutional features that distinguish them. We further probe the institutional interpretation through the 1730 Yongzheng reform (a descriptive cohort comparison) and the within-lineage iron-cap comparison, and extend the analysis to a cross-dynasty comparative framework spanning seventeen dynasties—neither of which appears in prior work. Our findings are in fact complementary to theirs: the deliberate fertility control they document at the family level is consistent with the behavioral response to the institutional incentives we identify at the state level.

3 Theoretical framework

Definition: Throughout this paper, 'rank count' refers to income-bearing hereditary noble titles applicable to imperial clan members, excluding bureaucratic grades and purely honorific scattered titles unless otherwise stated.

The emperor faces a fundamental problem in managing his imperial clan. On one hand, a large and distinguished clan provides legitimacy benefits: it signals dynastic strength, provides insurance against succession crises, and creates networks of loyal supporters. On the other hand, supporting clan members imposes fiscal costs that grow with population, and too many high-ranking relatives create political risks by multiplying potential succession claimants.

We identify four institutional variables that vary across dynasties and interact to determine population outcomes.

3.1 Fiscal model

The first variable is the fiscal model: whether clan members are supported from the central treasury or from decentralized sources. Under centralized fiscal support, as practiced by the Song (960–1279), Ming (1368–1644), and Qing (1644–1912), all stipends come from the imperial government. Under decentralized or appanage support, as under the Western Han (206 BCE–9 CE) kingdoms or Yuan (1271–1368) princely domains, clan members maintain themselves from assigned territories.

Fiscal centralization has important implications for rank design. When the treasury pays all costs, the emperor needs policy instruments to ration limited resources among competing claimants. Fine gradations in rank provide such instruments. When princes finance themselves from their own territories, the emperor needs only broad categories.

3.2 Demotion rules

The second variable is the demotion rule. Mandatory demotion, as practiced by the Tang (618–907) and Qing (1644–1912), creates systematic downward pressure on titles across generations; the precise step depended on heir designation, maternal status, examination outcome, and period, and our formal model represents it with a stylized single-step ladder as a reduced-form approximation (Sect. 4). We distinguish two components of this variable: intergenerational rank tiering (present in both Ming and Qing rules) and effective exit from the titled, higher-stipend hierarchy into minimal-allowance idle status (present only under Qing kaofeng (examination for title inheritance) and tingfeng (suspension of enfeoffment) mechanisms). Under the Ming, collateral descendants experienced rank tiering within the eight-level ladder—a Zhen'guo Jiangjun's (Defender-General's) son inherited as Fuguo Jiangjun (Supporting General), and so on—but the ladder terminated at Feng'guo Zhongwei (State-Serving Commandant), below which all male descendants remained permanently entitled to stipends regardless of generational distance from the founding emperor. Under the Qing, exam-based filtering (kaofeng, examination requirement for title inheritance) and enforcement of tingfeng (suspension of enfeoffment) created a credible exit point: descendants who failed the examination received no title and no title-associated stipend, while retaining only the statutory minimal allowance. It is this exit mechanism, rather than rank tiering per se, that distinguishes the

Qing institutional configuration and accounts for the population-control pattern in our framework.

Exit rules represent an extreme form of demotion. The Tang's "five mourning grades exit" (wufu zhi wai) rule meant that clan members beyond the fifth degree of relationship lost noble status entirely. Once a clansman fell outside this fifth degree of consanguinity from the reigning emperor, he was released from the noble register and reclassified as a commoner. This automatically limited titled population but potentially undermined legitimacy.

3.3 Scattered titles

The third variable is the presence or absence of scattered titles (san jue). Northern Wei (386–534) and Northern Qi (550–577) created parallel versions of each rank: "founding state" titles (jian guo jue) with income and "scattered" titles (san jue) without. A scattered duke held the same ceremonial precedence as a founding-state duke but received no income. This effectively doubled status gradations without doubling fiscal commitments. The innovation was to decouple the two functions of noble rank—conferring honor and conferring income—that most systems bundled together. A ruler could satisfy a clansman's demand for prestige by granting a scattered title while withholding the fiscal burden of a stipend-bearing title. This instrument was particularly valuable when the number of claimants outpaced the treasury's capacity to reward them all materially.

3.4 Examination for inheritance

The fourth variable is whether examination requirements filter title inheritance. The Qing's examination system required clan members to demonstrate basic competence before inheriting titles. Depending on the rule in force and the candidate's circumstances, those who did not qualify could have the award suspended pending further study and re-examination, or enter untitled "idle clansman" status with only minimal support.

3.5 Propositions

From this framework, we derive three qualitative propositions.

Proposition 1: Conditional on the presence of demotion mechanisms, the fiscally sustainable rank count increases with fiscal centralization. When princes self-finance, the emperor needs only broad categories. When all stipends come from central treasury and demotion rules create flows through the hierarchy, finer gradations allow gradual descent and better resource allocation. Without demotion, additional ranks serve no population-control purpose regardless of fiscal model.

Proposition 2: Scattered titles substitute for rank proliferation. Northern Wei achieved twenty-two effective gradations by creating income and non-income versions of eleven basic ranks.

Proposition 3: Rank count alone does not determine population outcomes. The Ming paradox demonstrates this clearly: eight ranks with no effective exit mechanism (universal stipend eligibility down to the lowest rank) and universal stipends produce geometric expansion regardless of rank structure. Figure 1 illustrates these contrasting institutional designs for the Ming and Qing cases.



Fig. 1 Institutional Design Comparison: Ming vs. Qing Noble Rank Systems (Schematic). Left panel: Ming (1368–1644), perpetual ranks with no exit mechanism. Right panel: Qing (1644–1912), mandatory generational demotion with examination-based exit into idle clansman status; the twelve iron-cap title lines exempt from demotion are discussed in Sect. 5.4.5

4 A formal model

To formalize these intuitions, consider a dynasty with n noble ranks indexed from 1 (highest) to n (lowest). Let b_i denote the benefit associated with rank i, with benefits strictly decreasing. Denote by d the demotion rate and e the examination difficulty. Let f(b) be the fertility function, increasing in benefits. This assumption—that fertility responds positively to income and status—receives empirical support from Li and Guo's (1994) demographic study of the Qing imperial clan, which documents that higher-ranking nobles with access to greater resources exhibited higher completed fertility than their lower-ranking counterparts. The resource gradient was substantial: annual stipends ranged from 10,000 taels for Princes of the First Rank to 110 taels for Grace-Bearing Generals (Feng'en Jiangjun, rank 14), with idle clansmen receiving only approximately 36 taels annually—a 278:1 differential between the highest-ranked and the untitled categories (Li and Guo 1994; Table 2; Lai 1997, p. 277). The Demotion Target column of Table 13 shows the simplified rank-to-rank correspondence for a designated heir under the standard demotion rule; it abstracts from non-heir sons, whose initial awards were graded by maternal status and examination outcome, from the twelve iron-cap exemptions, and from the hereditary floors introduced for grace-enfeoffed lines in 1774, and it should not be used to compute a uniform number of generations to exit. In the lowest titled rank, one qualified son could still succeed by examination, with other sons entering idle status; the final row therefore describes non-inheriting sons rather than the automatic fate of the line. Note that the 91:1 ratio cited in Sect. 5.4.4 compares the highest titled rank to the lowest titled rank (110 taels for Grace-Bearing Generals); the 278:1 figure extends the comparison to include untitled idle clansmen. We present here the two core cases that motivate the propositions; full derivations of the steady-state conditions, comparative statics, and parameter values are provided in Appendix F.

4.1 Population dynamics without demotion

Consider the case of no demotion and no examination filter: d = 0 and e = 0. This corresponds to the Ming institutional configuration, in which rank tiering existed but terminated at a minimum rank below which all descendants remained stipend-eligible indefinitely—effectively d = 0 for the purpose of population dynamics. Each rank-i individual has f(b_i) surviving sons who inherit rank i unchanged. The population at rank i in generation t+1 equals the fertility rate times the population in generation t:

$$P_i(t+1) = f\left(b_i\right) \cdot P_i(t) \tag{1}$$

If fertility exceeds replacement at any rank—if f(b_i) > 1 for any i with b_i > 0—then population at that rank grows geometrically:

$$P_i(t) = f\left(b_i\right)^t \cdot P_i(0) \tag{2}$$

This diverges as t approaches infinity regardless of the number of ranks n. The system is unsustainable. This is the Ming scenario.

4.2 Population dynamics with demotion

Now consider mandatory demotion with examination filtering: d = 1 and e > 0. Each rank-i individual has f(b_i) sons, but these sons are assigned to rank i+1 rather than inheriting their father's rank; this uniform single-step ladder is a stylized reduced-form representation of rules that in practice varied by heir designation, maternal status, examination outcome, and period (Appendix A.3). Moreover, only a fraction (1-e) pass the examination. The transition equation becomes:

$$P_i(t+1) = (1-e) \cdot f\left(b_{i-1}\right) \cdot P_{i-1}(t), \ for \ \ i > 1 \tag{3}$$

At the bottom rank n, descendants exit the titled system entirely. Population flows down the hierarchy like water through cascading pools. With a fixed number of ranks and an exogenous top-rank inflow, the titled population converges to a finite steady state (Appendix F); the product (1-e) · f(b_i) governs the attenuation down the hierarchy—where it falls below one, each successive rank holds fewer members. This is the Qing scenario.

4.3 Model implications

The central insight of this paper is that noble rank proliferation is an institutional design margin whose demographic consequences depend critically on complementary rules—demotion, examination screening, and stipend eligibility—not on rank count alone. The model formalizes this intuition. It clarifies why rank count alone is insufficient for population control. Adding ranks to the Ming system would simply create more positions for geometric growth. What the Ming lacked was not gradations but mechanisms to limit eligibility and induce status degradation. Two institutional levers reduce the steady-state titled population: stricter examination (reducing the fraction entering each lower rank) and steeper benefit reductions at lower ranks (directly reducing fertility incentives). Additional ranks do not reduce the population by themselves—as the comparative statics in Appendix F show, adding a rank with positive benefits mechanically adds to the steady-state total—but a finer gradation allows benefits to be stepped down more steeply along the demotion path. The Qing deployed both levers, embedded in a fine-grained gradation. The Ming lacked examination-based exclusion and a minimal-allowance exit from the titled hierarchy: statutory stipends declined steeply across its ranks and collateral lines descended through the hierarchy, but the hereditary floor remained positive (Table 12). Appendix F provides the full steady-state derivation and comparative statics formalizing these claims. We note explicitly that the model takes the institutional parameters as given and does not model the ruler's choice problem. The historical record, discussed in Sect. 6.2, shows that institutional design was in practice shaped by political feasibility constraints, founding-coalition bargaining, and path dependence. The model should therefore be understood as characterizing the long-run equilibrium

properties of institutional configurations—which configurations are fiscally sustainable in the long run—rather than as a description of period-by-period decision-making by any actual ruler. This tension between the formal model and the path-dependence narrative is not a weakness but a feature: the model identifies what the fiscally more sustainable configuration looks like, while the historical record explains when such designs become politically feasible. The Ming–Qing divergence illustrates precisely this gap—the Ming founders chose a fiscally inferior design not from ignorance but because their political constraints (prioritizing kinship loyalty over fiscal efficiency in the aftermath of Mongol rule) precluded the fiscally more sustainable alternative. The model thus serves as a diagnostic benchmark against which to measure historical institutional choices, rather than a positive theory of how those choices were made.

5 Data

Our analysis draws on institutional records, demographic records, fiscal records, and secondary scholarship.

5.1 Cross-dynasty rank structures

Appendix D provides detailed rank structures across seventeen dynasties; Appendix A presents the full specifications for three dynasties examined in depth (Qin, Ming, and Qing). Rank counts range from eight to over twenty-two, with no clear temporal trend. The early imperial period maintained approximately twenty ranks for military merit. The Period of Disunion saw both simplification and elaboration. The reunified Tang operated with eleven ranks. The conquest dynasties showed no consistent pattern. Ming preserved minimal structure; Qing elaborated to fourteen levels.

(See Appendix A for detailed rank structures by dynasty.)

5.2 Case studies

We summarize key institutional features across major dynasties.

5.2.1 Qin: the military merit revolution

The Qin's twenty-rank system made noble status contingent on military merit. Crucially, imperial relatives were excluded from automatic noble status: members of the royal clan without recognized military merit could not be entered in the clan register (Shiji, juan 68). This meritocratic design avoided the accumulation problems of later dynasties.

5.2.2 Han: the Tui'en solution

The Han reintroduced hereditary nobility through feudal kingdoms. The "Grace Decree" of 127 BCE required kingdoms to be subdivided among all sons, fragmenting substantial kingdoms into impotent territories within generations.

5.2.3 Northern Wei: scattered titles

The Northern Wei created over twenty-two ranks through "scattered titles"—for each rank, two versions existed: "founding state" titles with income and "scattered" titles without. This doubled status gradations without doubling fiscal commitments.

5.2.4 Tang: demotion and stipend reduction

The Tang developed systematic mechanisms: rank demotion each generation, the "five mourning grades" exit rule terminating noble status after five generations, and progressive stipend reduction. Emperor Xuanzong's 734 edict established the "eighty percent rule"—heirs received only eighty percent of predecessors' allocations. After the An Lushan Rebellion, this increased to fifty percent reduction.

5.2.5 Song: non-hereditary restrictions

The Song imposed radical restrictions in response to explosive growth. In 1044, Emperor Renzong limited hereditary succession to descendants of the "Ten Kings." In 1070, Emperor Shenzong fixed succession lines permanently at ten. The 1069–1070 reforms also terminated stipends for kin beyond five degrees of mourning while allowing them to sit for civil examinations—prefiguring the Qing's kaofeng system.

5.2.6 Yuan: appanage self-financing

The Yuan maintained only eight ranks because princes governed territorial appanages, financing themselves rather than drawing from central treasury. This obviated the need for elaborate stipend gradations.

5.2.7 Ming: universal stipends and geometric explosion

The Ming combined only eight ranks with universal stipend eligibility and no effective exit mechanism. While Ming rules did include intergenerational rank tiering within collateral branches, the ladder terminated at the lowest rank (Fengguo Zhongwei) with no mechanism to remove descendants from stipend eligibility thereafter. From roughly 50 males in 1368, the clan reached over 157,000 by 1595; by 1562, nominal clan stipend obligations reached 8.53 million

shi—thirty-seven percent of national grain revenue. The full institutional logic behind this trajectory, and a systematic comparison with the Qing case, is presented in Sect. 6.

5.2.8 Qing: demotion, examination, and controlled growth

The Qing adopted a sharply different institutional configuration. Fourteen principal ranks combined with mandatory demotion and examination filtering (kaofeng). The registry recorded 419 male clansmen in 1660 and 16,454 in 1915 (Rawski 1998, p. 93)—roughly an order of magnitude below the Ming's 1595 registered total over a comparable duration, on bases that are not directly comparable (see the note to Fig. 2). Full comparative analysis of the Ming–Qing contrast, including alternative explanations, is presented in Sect. 6.

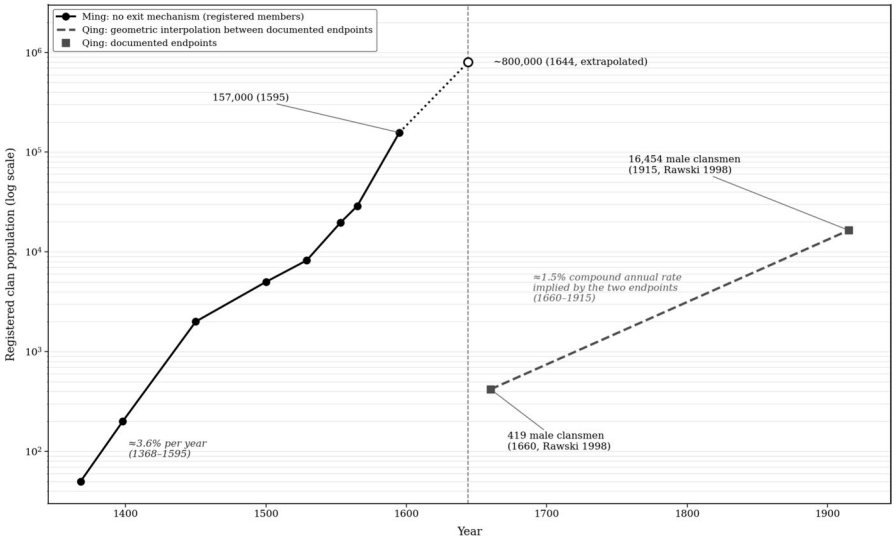


Fig. 2 Imperial Clan Population Growth: Ming vs. Qing. The figure plots the Ming series reported in Appendix B (Table 18); the Qing series is geometrically interpolated at the constant compound growth rate implied by its two documented endpoints, 419 registered males in 1660 and 16,454 in 1915, and intermediate values are interpolations rather than historical counts (Table 19); the Qing system had fourteen principal ranks (detailed in Appendix A.3). Despite comparable duration (~270 years), the Ming reached over 157,000 registered members by 1595, while the Qing registry recorded 16,454 living male clansmen in 1915 (Rawski 1998, p. 93)—a difference of roughly an order of magnitude, consistent with a central role for institutional design. The two endpoints are not compiled on the same basis: the Ming figure is a registered-member count whose coverage of female clan members cannot be verified from the sources available to us, while the Qing figure counts living male clansmen only. The comparison should therefore be read as an order-of-magnitude contrast rather than as a like-for-like ratio. The 1644 Ming data point (~800,000) is an extrapolation from the 1595 registered count of 157,000 at observed late-Ming growth rates and should be treated as illustrative rather than a verified historical figure. Population figures represent estimated registered clan members at each point in time; the last reliable Ming count is 157,000 in 1595. Ming entered fiscal crisis zone (stipends > 50% of tax revenue) by late dynasty. Qing's institutional design—mandatory demotion plus examination filter—was associated with low registered population growth: 16,454 living male clansmen in 1915 (Rawski 1998, p. 93)

5.3 Population and fiscal comparison

Figure 2 illustrates the demographic divergence between the Ming and Qing dynasties; the underlying data are reported in Appendix B. Two features deserve emphasis beyond what was noted in the Introduction. First, the Ming trajectory follows a near-exponential path across the full dynasty—consistent with geometric growth driven by universal stipend eligibility and no exit mechanism—while the Qing series is drawn as a geometric path between its two documented endpoints, at a compound annual rate of roughly 1.5 percent against the Ming's roughly 3.6 percent, the latter computed from an approximate founding figure; the shape of Qing growth between 1660 and 1915 is not documented by the sources available to us, so the contrast we draw is between average growth rates and endpoints, not between curve shapes. Second, the Ming observations of the early 1560s bracket Zhang Dexin's (1988) documented fiscal crisis point (1562), when nominal clan stipend obligations reached 8.53 million shi or thirty-seven percent of national grain revenue, well before the 1595 population peak—confirming that fiscal strain preceded the dynasty's military collapse by decades.

Fiscal data are consistent with the divergence. By 1562, nominal Ming clan stipend entitlements equaled approximately 37 percent of national grain tax revenue. Comparable dynasty-wide expenditure shares are unavailable for the Qing.

5.4 Micro-level evidence from the Qing genealogical records

The preceding cross-dynasty analysis documents that the Qing maintained controlled population growth where the Ming did not—consistent with the view that rank count alone does not determine outcomes and that complementary demotion and examination rules are the operative margin in the comparative record. We now turn to micro-level evidence from the Qing's own genealogical records to examine the mechanisms through which demotion and examination filtering operated at the individual level.

5.4.1 Data

Our dataset comprises 87,318 individual records extracted from the Yudie, the comprehensive genealogical registry maintained by the Imperial Clan Court throughout the dynasty. The Yudie records each clan member by name under his father's entry, with birth date, death date where applicable, maternal status (whether born of a primary consort, secondary consort, or concubine), rank or official position, and spouse information. The Yudie was compiled continuously from 1651 (Shunzhi 8) through 1921, in 28 editions (Harrell et al. 1985, p. 38) recording all male-line descendants of Taksi, father of the dynastic founder Nurhaci; Ju (1994) provides the authoritative description of the registry's compilation history, structure, and coverage. Lu and Cheng (1993) document that the Yudie followed the convention of recording living members in vermilion ink and deceased members in black, with each edition updating prior entries by converting living members to deceased upon their deaths.

For each individual, we therefore observe: generation number, birth year, death year (where recorded), number of sons, number of wives and concubines, and noble rank or official position.

Our outcome variable, Sons_i, is the number of sons recorded under each father's entry in the Yudie. Births were entered on the basis of periodic reports to the Imperial Clan Court; sons who were registered and subsequently died remain listed, recorded in black rather than vermilion ink (Lu and Cheng 1993). The count includes registered sons who later died, and it does not condition on whether a son outlived his father. In our dataset, this correspondence is exact: summing recorded sons across the fathers of each generation reproduces the number of individual records in the next generation. We refer to this variable as recorded sons throughout, rather than as fertility, to reflect that Sons_i conflates biological fertility with early-life survival and registration completeness. Where we use "fertility" as shorthand in compound expressions (e.g., "rank–fertility gradient"), it refers to recorded sons in this sense, a count that reflects surviving registered offspring as they would have affected household resources and stipend inheritance rather than total births.

We note that death year recording is incomplete, particularly in the early Qing period: the father's own death year is missing for approximately 45 percent of the birth-restricted sample. The registry's recorded age-at-death field is distinct from the calendar death-year field, so the two missingness rates need not be complements. Because the outcome does not depend on the father's death year, these individuals remain in the estimation sample. We examine in Appendix Table 15 the relationship between missing death year and rank conditional on birth cohort and generation fixed effects. Titled nobles have systematically lower rates of missing death year (approximately 20 percentage points lower), consistent with more complete recording of prominent lineage members. Sons are entered under the father's record at registration, so the completeness of the father's own death-year record does not mechanically determine whether his sons are enumerated. We cannot, however, rule out that death-year completeness proxies for overall recording quality correlated with reproductive outcomes; the age-at-death analysis in Sect. 5.4.3 partially probes this concern by re-estimating the main specification on the subsample with recorded age at death. Because the count does not condition on the timing of the father's death, sons entered under the father's record are counted irrespective of whether they were born before or shortly after his death; posthumous sons recorded in the Yudie are therefore included.

We acknowledge that this definition conflates total births with infant and child survival to registration: higher-ranking nobles likely provided better nutrition and care, which may have raised child survival rates independently of the number of births. Our rank–sons gradient therefore captures the combined association of rank with fertility and with child survival and may overstate the purely biological fertility component. We cannot fully disentangle the two channels with available data; however, since our proposed mechanism operates through marriage access (which affects the number of births), the inflation from differential child survival is a limitation rather than a threat to the directional interpretation. Since the measure tracks the male line, it reflects paternal recording conventions standard in Chinese genealogical sources; daughters are not counted. We restrict our analysis sample to births

after 1650, by which point registration was systematic, and our birth cohort fixed effects absorb common period-specific variation in recording completeness. To our knowledge, this constitutes the largest individual-level analysis of any pre-modern genealogical dataset.

We restrict our analysis to individuals born between 1650 and 1900, yielding 70,592 records; of these, 69,993 also have non-missing father identification and constitute the father-ID-restricted sample used in Table 3, Column 5, and Table 6; Columns (1), (3), and (4) of Table 3 use the 70,589 estimation sample of birth-restricted records with non-missing paternal-line information (the three excluded records are adoptive-succession entries with a blank paternal-line field in the registry extract; all carry a rank or office, hence 6,435 rank-or-office holders in the estimation sample versus 6438 in the birth-restricted sample). Because Yudie compilation ended in 1921, members of the youngest cohorts are observed for shorter periods, and the outcome should be read as sons recorded by the registry's final compilation; Table 3 specifications include birth cohort fixed effects, and Table 7 reports the gradient separately by birth cohort. Of the 70,592 birth-restricted records, 6438 (9.1 percent) are recorded with a noble rank or official position; the remaining 64,154 were classified as "idle clansmen"—clan members with no rank or office recorded in their Yudie entry, who received only minimal monthly allowances, as opposed to the stipend-bearing titled nobility.

Concretely, an "idle clansman" refers to a male recorded in the Yudie with no rank or office entry. This encompasses both those born into collateral branches too

Table 7 Rank premium by birth cohort

Cohort	Premium	SE	N
1650–1700	3.89	(0.09)	5256
1701–1750	2.41	(0.05)	10,284
1751–1800	1.41	(0.04)	13,944
1801–1850	1.20	(0.04)	17,905
1851–1900	1.04	(0.04)	23,203

The five cohort windows are mutually exclusive and jointly exhaustive of the birth-restricted sample: 1650–1700, 1701–1750, 1751–1800, 1801–1850, and 1851–1900 (inclusive boundaries as listed). Cohort N values sum to 70,592, the full birth-restricted sample of individuals born 1650–1900; they therefore differ from those in Table 8, which reports the full Yudie dataset restricted only by birth year, and from the N = 69,993 father-ID-restricted sample used in Table 3, Column 5, and Table 6, which additionally requires non-missing father identification. Standard errors clustered at the lineage level. *** $p<0.001$. Because the Yudie ends in 1921, members of the 1851–1900 cohort—especially those born late in the interval—are observed for shorter reproductive periods; cohort windows do not eliminate this differential right-censoring, so the final-cohort estimate and the implied 73 percent decline should be read as descriptive recorded-by-1921 patterns rather than as clean evidence of institutional tightening alone. Table 9 "Exclude post-1850" specification shows that the gradient among earlier cohorts (coefficient 1.98) remains large

distant from the main line to receive initial rank and those whose line had descended through successive generations of mandatory demotion to idle status. A small number of idle clansmen may also include individuals who held rank at an earlier point but were stripped of it through punitive demotion ("removal of noble title") for criminal offenses—a legally distinct but observationally indistinguishable category in the Yudie records, since the registry records only the final status at time of compilation rather than the route by which that status was reached. We treat these cases as part of the idle clansman category. Punitive removal was relatively rare compared to institutional generational demotion, the modal route into idle status, but we cannot quantify its frequency in the extracted data, and the direction of any resulting misclassification bias cannot be signed ex ante.

One further timing caveat applies to the office component of the rank measure: whereas noble titles were typically conferred or confirmed early in adult life, official positions could be attained later, so for office holders the recorded status may postdate part of the reproductive career. The Appendix Table 16 estimates based on the strict noble-title definition, which is not subject to this concern, indicate that the marriage-access gradient is robust to it. The core sons gradient is likewise robust to the definition: re-estimating the baseline with the strict twelve-title indicator (1811 title holders) yields a coefficient of 1.885 (heteroskedasticity-robust SE = 0.075; generation and birth-decade fixed effects; N = 70,589), close to the broad-definition baseline of 1.784. Throughout the paper, rank is accordingly measured as the status recorded in the individual's Yudie entry—final recorded status at compilation—rather than as a lifetime treatment history or as status at a particular point in the reproductive life cycle. Because titles were typically inherited or awarded in early adulthood and generational demotion operated across rather than within lifetimes, recorded status will generally coincide with status during the marriage and childbearing years. The main exception is punitive removal late in life, which, as noted above, was relatively rare; such cases place formerly titled men in the idle category; the direction of any resulting bias cannot be signed ex ante.

Our father-ID-restricted sample comprises 69,993 individuals after excluding those with missing father identification. The descriptive statistics in Table 2 use the full 87,318 records; the reproductive success specifications use the column-specific samples reported in Tables 1 and 3 notes. Table 1 summarizes these construction steps.

Table 2 reports descriptive statistics for three mutually exclusive categories: birth-window rank-or-office holders (N = 6438; clansmen born 1650–1900 with any recorded rank or office), rank or office holders born outside the 1650–1900 birth window (N = 699), and idle clansmen (N = 80,181), summing to 87,318. The "Other Officials" row (N = 4489) comprises 3790 birth-window rank-or-office records assigned to this display row plus the 699 rank or office holders born outside the 1650–1900 birth window. The Emperor through Commandant rows show the remaining 2648 birth-window records classified by their highest noble rank. All displayed rows are mutually exclusive and sum to 87,318. The regression analyses do not use these display categories directly: they restrict the sample to births in 1650–1900 and use the rank indicators defined in Sect. 5.4.2, with column-specific

samples reported in Table 3 notes; the regression estimates are therefore unaffected by this descriptive regrouping.

Ranked individuals averaged 2.95 sons compared to 0.83 for the unranked—a raw difference of 2.12 sons, or 257 percent of the untitled mean (Cohen's d = 1.23 relative to the full-sample standard deviation of 1.73 sons). The differential in marriage access was equally stark: ranked nobles averaged 1.95 wives, while unranked clansmen averaged 0.54—a difference of 262 percent of the untitled mean (Cohen's d = 1.45). These are large effects by any standard. Ranked individuals were also born earlier on average (1779 vs. 1811, birth-restricted sample), reflecting the dynasty's progressive filtering of the titled population.

5.4.2 Empirical strategy

Our empirical strategy exploits two sources of variation. The first source is a documented institutional change in 1730: the Qing state compendium Huangchao Wenxian Tongkao (Comprehensive Examination of Documents and Institutions of the Imperial Dynasty) records that in Yongzheng 8 (1730) the court formalized the "exam-award rule for eligible legitimate sons of princes, dukes, and lower-ranked titled fathers" (dingwanggong yixia dizi kaoshou li)—an explicit rule-set mapping examination performance in mounted archery, foot archery, and translation (Manchu-Chinese translation, reflecting the Qing court's effort to maintain Manchu linguistic identity among the imperial clan) directly onto rank outcomes for title inheritance. We treat 1730 as the point of concentrated administrative tightening of title inheritance rules rather than the date of a single discrete reform edict: examination requirements had existed since Kangxi 27 (1688) (Du Jiaji 1991). What changed in 1730 was the award schedule for non-heir legitimate sons: the Yongzheng reform formalized a lower, rank-specific schedule of examination awards graded by the father's rank, so that the same examination outcome now yielded a substantially lower title than before 1730 (Du Jiaji 1991). We therefore treat 1730 as a documented change in the payoff schedule of an existing institution, rather than its codification or creation. This distinction matters for interpretation: the reform operates through a discrete shift in the mapping from examination performance to rank outcomes, not through the introduction of a new eligibility hurdle.

The Yongzheng reign (1723–1735) was characterized by systematic institutional consolidation and retrenchment, driven in part by the mounting fiscal burden of supporting the banner population (Elliott 2001, chap. 8). Ye Gaoshu's study of the Yongzheng emperor's rectification of banner affairs documents that a Manchu-language proficiency requirement governing the promotion of banner personnel, promulgated in the early Yongzheng years but repeatedly postponed, was finally put into effect in Yongzheng 8 (1730) (Ye 2004, p. 97), one of several banner administration requirements whose enforcement was tightened in that year—suggesting 1730 functioned as a point of concentrated administrative tightening across multiple domains of banner administration. Although the examination-based system had been established under the Kangxi-era regulations of 1688, the Yongzheng reforms transformed its practical consequences by lowering the baseline rank associated with examination outcomes, one of several documented adjustments to the

examination-award schedule during the eighteenth century. Documentary sources associate the tightening with fiscal and administrative pressures and with the uniform standardization of rules across princely lineages. These facts are consistent with a system-wide administrative reform, but they do not establish exogeneity with respect to lineage-specific fertility trends or eliminate the composition concern discussed below.

We implement this as a descriptive pre/post cohort comparison: comparing the fertility premium of ranked over unranked clansmen before and after 1730, within the same lineages. A causal difference-in-differences reading would require that, absent the reform, the rank–fertility gap would have followed a parallel trend for cohorts born before and after 1730. Given the secular pre-period decline in the rank premium—driven partly by the compositional effects of the founding era—and the fact that the reform itself changed who obtained titles, we do not claim this condition holds, and we read the estimates as a descriptive interrupted pattern rather than as causally identified. As a robustness check, Sect. 5.4.6 also reports specifications that explicitly control for a Rank × linear time trend, under which the post-1730 interaction remains large.

The second source of variation is cross-rank: within the same generation and birth cohort, individuals holding rank or office faced different stipend levels and marriage-market access than untitled idle clansmen. We use this variation in the baseline OLS specification below, controlling for generation and birth cohort fixed effects; richer specifications add lineage fixed effects to absorb persistent differences across families. We estimate the recorded-sons differential between ranked and unranked clansmen using the following specification:

$$Sons_i = \beta \cdot Rank_i + \gamma_g + \delta_c + \varepsilon_i$$

where Sons_i is the number of sons recorded under individual i's entry (as defined in Sect. 5.4.1), Rank_i is an indicator equal to 1 if any noble rank or official position is recorded in the individual's Yudie entry (the Has Rank variable of Table 3; for the marriage outcome, Appendix Table 16, Column 1, reports a specification restricted to the twelve noble titles listed in Table 15, Panel B), γ_g are generation fixed effects, and δ_c are birth cohort fixed effects. Generation fixed effects absorb time-invariant differences across generations (such as baseline mortality), while cohort fixed effects absorb period-specific shocks (such as wars or famines). Our coefficient of interest, β, captures the recorded-sons differential between ranked and unranked individuals within the same generation and birth cohort.

5.4.3 Main results

Table 3 presents the main regression results. Column (1) reports the baseline with generation and cohort fixed effects: ranked individuals had 1.784 more sons than unranked individuals (SE = 0.041, $p < 0.001$). To convey economic magnitude, this coefficient represents 163 percent of the estimation-sample mean of 1.10 sons (N = 70,589) and a standardized magnitude of 1.03 full-sample standard deviations (full-sample SD = 1.73 sons)—a large effect by conventional benchmarks. Column (2)

adds father's number of sons; the coefficient is negative (−0.009), consistent with resource dilution and weighing against a simple positive intergenerational correlation. Column (3) adds lineage fixed effects for 112 princely houses; the coefficient increases to 1.842, which weighs against positive selection across princely houses. Column (4) combines both controls. Column (5) adds wives: the coefficient drops to 0.293—an 84 percent combined attenuation relative to Column (4), reflecting the wives control together with the Column 5 sample restriction—consistent with marriage access as the leading proximate channel linking rank to recorded sons. Note that Column (5) also restricts the sample to the 69,993 individuals with non-missing father identification, compared to N = 70,589 in Column (4); the attenuation figure therefore reflects both the addition of the wives control and this sample restriction, though the two effects are comparable within the restricted sample.

As a further robustness check addressing the concern that our dependent variable depends on the length of the father's reproductive life and on recording completeness (Table 3, Column 6), we restrict the sample to individuals with recorded age at death (N = 40,825, 57.8% of the birth-restricted sample) and add father's age at death as a control variable. The rank coefficient estimated on this subsample without the age control is 2.081; adding father's age at death as a control, it attenuates to 0.893—a reduction of 57%—while remaining large and highly significant (SE = 0.114, $p <$ 0.001). The age-at-death coefficient is itself large (1.160, SE = 0.033; father's age at death enters standardized to mean zero and unit variance, with a sample standard deviation of approximately 25 years, so the coefficient denotes the change in recorded sons per one-standard-deviation increase in paternal lifespan—roughly 0.047 sons per year of life), indicating that paternal lifespan is associated with recorded sons. Two interpretations are consistent with this pattern. First, part of the rank premium reflects the income–longevity gradient: higher-stipend nobles lived longer and therefore had more time to sire sons. Second, the remaining 43% of the rank premium that survives the age control may reflect an association of rank with marriage-market access that is independent of lifespan, though other lifespan-independent advantages correlated with rank may also contribute. Either way, the pattern remains consistent with the proposed institutional channel—rank linked to stipends, stipends to marriage access, and marriage access to reproductive outcomes. We retain the full sample as our primary specification because the subsample with recorded age at death may be systematically selected toward individuals with more complete Yudie records, but we interpret the magnitude of the rank premium conservatively in light of this robustness check.

As a further bound on the mortality effect, we restrict the sample to fathers who survived to at least age 40—an age by which most reproduction would have been completed under historical conditions. Among this subsample (N = 15,454, of which 3988 are titled), the raw rank premium in recorded sons is 1.157 sons, compared to 2.190 in the full age-at-death subsample. Crucially, the premium is stable across all cutoffs above age 40: it is 1.157 for fathers dying at 40 +, 1.224 for fathers dying at 50 +, and shows no systematic decline with age. This pattern weighs against the possibility that the rank premium is driven entirely by differential survival: if longer-lived titled nobles were mechanically accumulating more sons simply by living longer, we would expect the premium to shrink as we

condition on increasingly long-lived fathers. Instead, the premium stabilizes once we restrict to adult fathers: the association is not eliminated when the sample is restricted to fathers observed to survive to at least age 40.

As a complement to the binary specification in Table 3, we additionally estimate a rank-category specification that replaces the binary rank indicator with dummy variables for each rank category. Figure 3 displays these marginal effects graphically (OLS with generation and birth-decade fixed effects, without lineage FE; N = 70,589); Appendix Table 14 reports the corresponding estimates with lineage fixed effects added (N = 69,993), which are somewhat larger due to the within-lineage identification absorbing negative selection across princely houses. The two specifications tell a consistent qualitative story. In Fig. 3 specification, princes of the first rank (wang) averaged 3.72 additional sons relative to idle clansmen, followed by beizi (Prince of the Fourth Rank, +2.88), princes of the second rank (junwang, +2.64), beile (Prince of the Third Rank, +2.58), dukes (+2.37), commandants (+1.93), generals (+1.78), and other officials (+1.64). The ordering is broadly but not strictly monotonic: beizi (2.88) exceeds junwang (2.64) and beile (2.58), which we attribute to the small beizi sample (N = 38 in the estimation sample), and commandants (+1.93) slightly exceed generals (+1.78); the latter inversion does not appear in the lineage-fixed-effects estimates of Appendix Table 14. The overall pattern confirms a rank–fertility gradient consistent with the Qing hierarchy, with meaningful differences in reproductive outcomes across all levels, not merely at the ranked/unranked threshold. In terms of magnitude, the standardized rank coefficient is approximately 1.0 standard deviation of the sons distribution—large in substantive terms, representing more than

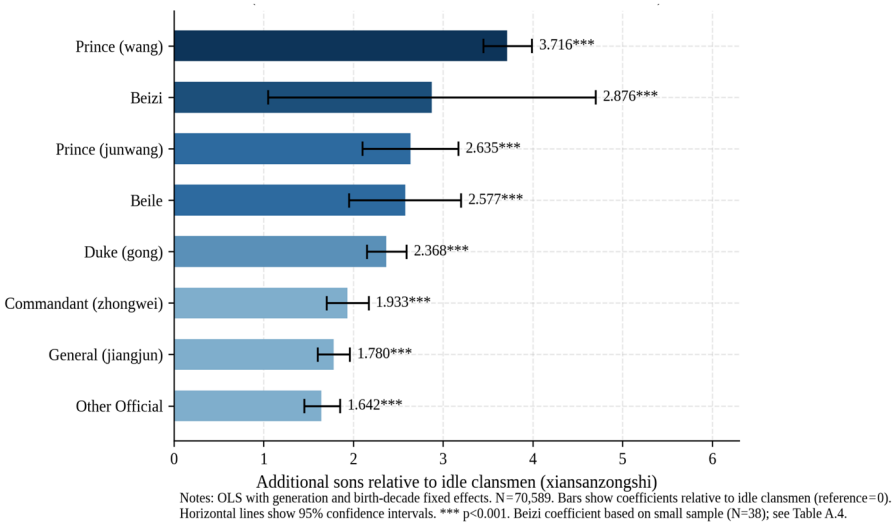


Fig. 3 Estimated Rank Coefficients for Recorded Sons (OLS with Generation and Birth-Decade Fixed Effects). Reference category: Idle Clansmen. Bars indicate 95% confidence intervals

twice the mean fertility of untitled clansmen (0.83 sons), and substantial relative to other institutional determinants of pre-modern demographic outcomes.

5.4.4 The marriage market mechanism

We hypothesize that rank affects fertility primarily through access to the marriage market. The stipend gradient was steep: Princes of the First Rank received 10,000 taels of silver annually, while Grace-Bearing Generals (Feng'en Jiangjun) at the bottom of the titled hierarchy received only 110 taels—a 91:1 ratio (Li and Guo 1994, Table 2, p. 121). These figures are drawn from Li and Guo's systematic compilation of stipend schedules recorded in the Zongrenfu Zeli (Imperial Clan Court Regulations) and related administrative compilations; they represent officially mandated entitlements rather than actual disbursements, which may have fallen short during periods of fiscal stress. To be explicit: stipend levels in our analysis are inferred from these administrative records rather than directly observed for each individual in the Yudie. Our analysis therefore measures the stipend entitlement gradient rather than realized income, though the two are likely highly correlated given that the Qing maintained relatively strict fiscal administration of clan stipends through the Imperial Clan Court. Idle clansmen who had fallen below the titled threshold received only 3 taels monthly (approximately 36 taels annually; Lai 1997, p. 277; see also Jiang 1986, p. 52), roughly one-third of the lowest titled rank and wholly insufficient to support polygynous marriage. This steep income gradient was closely tied to marriage-market access. This pattern is consistent with the findings of Wang et al. (1995)—an independent study using a different edition and sample of the Yudie from our own dataset—who document that the mid-eighteenth-century decline in imperial lineage stipends coincided with a pronounced fall in polygynous marriage rates—the mean number of wives per polygynous male dropped from approximately 3.7 in the 1700s to 2.4 by the 1840s—with correspondingly lower completed fertility among the nobility. Their findings are consistent with the income channel operating primarily through marriage-market access rather than through biological fecundity per se.

To probe this mechanism, Column (5) adds number of wives as a control variable. The rank coefficient drops from 1.841 (Column 4) to 0.293 (Column 5)—a combined attenuation of 84 percent from the wives control together with the Column 5 sample restriction (the two-equation decomposition below, computed on the same 70,589-observation sample as Column (1), provides a same-sample counterpart: 85.5 percent). The coefficient on wives is 1.209 (SE = 0.031), indicating that each additional wife was associated with approximately 1.2 additional sons. We interpret this as a descriptive decomposition rather than a formal causal mediation: (i) rank strongly predicts marriage access; (ii) conditional on marriage structure, the residual rank–sons gradient shrinks substantially. This is consistent with marriage structure being an important proximate correlate of the gradient, while leaving open the possibility that other correlated channels also contribute.

As a complementary decomposition, we apply the two-equation framework of Imai et al. (2010), estimating a mediator model (wives ~ rank + covariates) and an outcome model (sons ~ rank + wives + covariates) separately and recovering the

mediated and residual components analytically. We stress that a causal reading of this exercise would require the sequential ignorability assumption—that marriage outcomes are as good as randomly assigned conditional on rank and covariates—which is not defensible in this observational historical setting: the number of wives is likely related to wealth, lineage position, political prestige, health, and longevity, all of which may also affect the number and survival of sons, and estimating separate mediator and outcome equations does not by itself resolve this "bad control" problem. We therefore present the exercise as an alternative descriptive decomposition, not as causal mediation. Results: total association = 1.784 sons; component associated with marriage = 1.527 sons (95% CI: [1.471, 1.581]), or 85.5 percent of the total; residual component = 0.257 sons (14.5 percent). Standard errors for the mediated component are obtained by bootstrap (1,000 replications). The two-equation results closely mirror the single-equation decomposition in Column (5) of Table 3: under both approaches, the descriptive decompositions associate marriage structure with the large majority of the observed gradient. The figure (85.5 percent; computed from unrounded coefficients) is slightly higher than the 84 percent attenuation in Column (5) of Table 3, reflecting the different construction: the OLS figure compares coefficients with and without the wives control in a single regression, while the two-equation approach recovers the mediated share from separate mediator and outcome models following Imai et al. (2010).

The marriage margin is directly observable in the data. The raw marriage rate differential is 50 percentage points (91% vs. 41%). Appendix Table 16 reports regression-adjusted estimates: controlling for generation fixed effects, the probit average marginal effect of holding a noble title on marriage probability is 54.5 percentage points, and a linear probability model using the broader Has Rank indicator yields 48.4 percentage points. These estimates complement Wang et al. (1995), who document deliberate control of fertility within marriage in this population, responsive to economic resources; in our decomposition, the rank gradient in recorded sons is associated primarily with the number of recorded wives.

Alternative fertility channels. The marriage-market channel is associated with the large majority of the rank–fertility gradient (an 84 percent combined attenuation; Table 3 notes), but three alternative channels deserve consideration.

First, income effects independent of marriage. Rank-associated stipends could raise fertility directly—through better maternal nutrition, lower infant mortality, or larger household resources—rather than solely through the number of wives. If this were the primary channel, the rank–fertility premium should track real stipend levels closely over time. Real stipend values declined substantially as the clan expanded faster than the stipend budget: Li and Guo (1994) document that nominal stipends were frozen, while the titled population roughly doubled between 1750 and 1850. The cohort profile in Sect. 5.4.6 shows a post-1730 decline, but the present pattern cannot distinguish institutional change from changes in income, composition, selection, cultural norms, or occupational opportunities. We acknowledge that declining real stipends likely contributed to the long-run compression of the fertility premium documented in Table 7.

Second, inheritance expectations. Titled status conferred not only current income but also the prospect of transmitting rank to at least one son. Clansmen anticipating

title inheritance might have maintained higher fertility independently of current stipend levels. This channel is consistent with our findings but difficult to test directly. Crucially, however, an expectations account would predict that uncertain inheritance under stricter examinations raises precautionary fertility rather than lowering it; the cohort data cannot establish which prediction holds here. The data pattern is consistent with the income-and-marriage channel; a pure inheritance expectations story remains possible and is not excluded here.

Third, marriage-market stigma independent of stipends. Idle clansmen may have faced social stigma that depressed their marriage prospects independently of their minimal stipend receipts—potential fathers-in-law treating idle status as a permanent disqualification regardless of absolute income. This channel would reinforce the income mechanism rather than replace it and is consistent with the large observed marriage rate differential (91 percent versus 41 percent). We cannot separately identify the stigma component from the income component with available data and acknowledge this as a limitation. The combined effect is captured in our marriage rate differential, which likely represents an upper bound on the pure income channel.

In sum, the evidence most strongly supports a combined income-and-marriage-access channel as the leading proximate channel. The post-1730 shift is consistent with the institutional explanation, and we do not use its timing to weigh against the stipend-decline explanation, while inheritance expectations and marriage-market stigma remain plausible auxiliary channels that we cannot rule out. A fourth possible channel is deliberate fertility limitation among lower-ranking clansmen: Li and Guo (1994) document evidence of marital fertility control among low-status imperial clan members, suggesting that the fertility gap may reflect not only constrained marriage access but also voluntary restraint among those with limited resources and inheritance prospects. We cannot separately identify this channel with available data, but note that it would reinforce rather than contradict our central finding that rank-associated resources shaped reproductive outcomes.

Nonlinearities and threshold effects. A natural question is whether the rank–fertility gradient reflects a simple threshold effect—concentrated at the ranked/unranked boundary—rather than a continuous gradient across ranks. The rank-category estimates reported in Sect. 5.4.3 (Fig. 3; Appendix Table 14) address this question directly. The graded, broadly monotonic pattern documented there—higher rank categories generally displaying larger coefficients, from generals (+1.78) up to princes of the first rank (+3.72)—is inconsistent with a pure threshold model in which only the crossing of the ranked/unranked boundary matters. Instead, the data reveal a continuous income-and-marriage-access gradient in which higher rank categories generally confer additional reproductive advantage. We therefore find no evidence that a threshold specification would better capture the underlying mechanism, though we acknowledge that the discrete nature of rank categories precludes a fully continuous nonlinearity test.

5.4.5 Within-Qing variation: iron-cap princes

A potential concern is that the rank–fertility correlation reflects selection rather than causation. We address this partly using the Qing's twelve "iron-cap" (tiě màozi)

princely lineages (eight founding lineages plus four later imperial grants), whose titles were exempt from mandatory demotion. These lineages retained princely rank in perpetuity. We use this comparison as a mechanism-illustration design: it shows what happens when the demotion constraint is relaxed within the same broad institutional ecosystem, testing whether the demotion mechanism is directionally consistent with observed fertility differences. We do not claim this identifies the causal effect of demotion under random assignment, since iron-cap status was assigned on the basis of political prominence and military merit rather than at random. Indeed, iron-cap lineages likely possessed persistent advantages—in wealth, marriage networks, and political prestige—that are independent of the demotion exemption itself. This endogeneity means the iron-cap comparison may overstate the demotion effect and should be read as directional corroboration rather than causal identification.

Table 4 reports the results. Among ranked individuals only (N = 6438), holders of iron-cap princely titles (N = 55) averaged 1.75 more sons in raw terms; with generation fixed effects the difference is 1.71 (SE = 0.344, $p < 0.001$). This coefficient is substantial—approximately equal to the ranked/unranked differential in the full sample. The iron-cap comparison is directionally consistent with the demotion mechanism: relaxing the demotion constraint within the same institutional ecosystem is associated with substantially higher fertility, as the theoretical framework predicts.

We acknowledge, however, a potential endogeneity concern: iron-cap status was assigned to lineages distinguished by exceptional military merit and political prominence, meaning these families may have possessed persistent advantages in wealth, marriage networks, or social prestige independent of demotion rules. Recent historical scholarship confirms that iron-cap status reflected lineage identity more than military achievement per se: Du Jiaji (2019) demonstrates that several founding iron-cap princes—including Dodo, who was designated banner lord at age nine, and Dorgon, who had never fought in battle before his enfeoffment—received their status primarily on the basis of legitimate birth (di) rather than military merit. This reinforces the endogeneity concern. Critically, however, Du also establishes that even within iron-cap lineages, only the single designated heir retained the princely title intact; all other sons followed standard demotion trajectories. This within-lineage variation limits the scope of the selection problem: the observed fertility difference among iron-cap members is consistent with the operation of the perpetual-inheritance rule for the heir and is less readily explained by a uniform advantage enjoyed by all members of a privileged founding family alone, although individual-level selection cannot be excluded. The cohort comparison of Sect. 5.4.6 faces its own selection and composition concerns and therefore does not resolve this issue. A more direct test would compare fertility within iron-cap lineages before and after periods of institutional tightening—exploiting within-lineage variation over time to reduce confounding from the persistent advantages of founding status.

We examine this pattern using genealogical records for four of the eight founding iron-cap lineages. The selection criterion is data availability and dynasty representativeness: we include all four founding lineages with complete multi-generational Yudie coverage spanning the full dynasty (1609–1912)—the Li Princely House (Daishan lineage, N = 4359), the Su Princely House (Haoge lineage, N = 1970), the

Yu Princely House (Dodo lineage, N = 2988), and the Rui Princely House (Dorgon lineage, N = 279), covering 9596 males born between 1609 and 1912. The remaining three founding lineages (Zhuang/Shuo Se, Zheng/Jirgalang, and Keqin/Yoto) have shorter or more fragmentary coverage and are incorporated as a robustness check in Sect. 5.4.8; results are stable across all specifications. The eighth founding lineage, Commandery Prince Shuncheng (Lekdehun), is excluded from both samples due to incomplete Yudie coverage for that branch. Within these lineages, the iron-cap title was hereditary for the designated heir only; all collateral branches followed standard demotion trajectories, generating within-lineage variation in rank status across individuals and over time.

Table 5 reports Poisson regression estimates of sons on titled status, with progressively richer sets of fixed effects. Column (1) shows the baseline: titled nobles had 212 percent more sons than untitled clansmen (SE = 0.021, $p < 0.001$). Columns (2) and (3) add generation and lineage fixed effects respectively; the titled coefficient is stable at 1.015–1.016 (SE = 0.023), changing little once cohort trends and persistent cross-lineage differences are absorbed. Column (4) adds number of wives as a control. The titled coefficient falls to 0.438 (SE = 0.027), a reduction of 56.8 percent, while the wife coefficient is 0.313 (SE = 0.005, $p < 0.001$). Note that this 56.8 percent figure is not directly comparable to the 84 percent attenuation reported in the full-sample OLS (Table 3, Column 5): the two estimates differ in sample (iron-cap lineages only vs. full Yudie), model (Poisson vs. OLS), and control set. Both show substantial descriptive attenuation of the rank–fertility gradient after controlling for marriage structure, but the magnitude difference reflects these specification differences rather than a substantive inconsistency. This attenuation pattern is consistent across all four lineages: titled nobles averaged 2.13–3.11 sons compared to 0.59–0.89 for untitled clansmen, with the gap consistent with differential access to polygynous marriage as the leading proximate channel. Column (5) replaces generation fixed effects with birth-decade fixed effects; results are unchanged. Figure 4 illustrates the fertility trends. Panel A shows that all four lineages exhibit a common downward trajectory after c.1750, consistent with the tightening of examination requirements and real stipend decline during the Qianlong reign. Panel B shows that the titled–untitled fertility gap, while shrinking over time, persists throughout the Qing period. A split-sample robustness check confirms the titled coefficient remains large and significant in both the pre−1750 subsample (coef = 1.382, SE = 0.039, N = 1650) and the post-1750 subsample (coef = 0.962, SE = 0.029, N = 7946), with the modest decline in the later period consistent with the broader temporal decline described in Sect. 5.4.6.

5.4.6 Descriptive cohort comparison around 1730

The 1730 Yongzheng reforms are the central institutional reference point in our data. The reforms lowered the title awards associated with Kaofeng examination outcomes. Documentary sources associate this change with fiscal and administrative pressures, but do not establish that it was unrelated to lineage-specific demographic trends. We therefore compare the rank–recorded-sons gap among cohorts born after 1730 with that among cohorts born before, within the same lineages and controlling

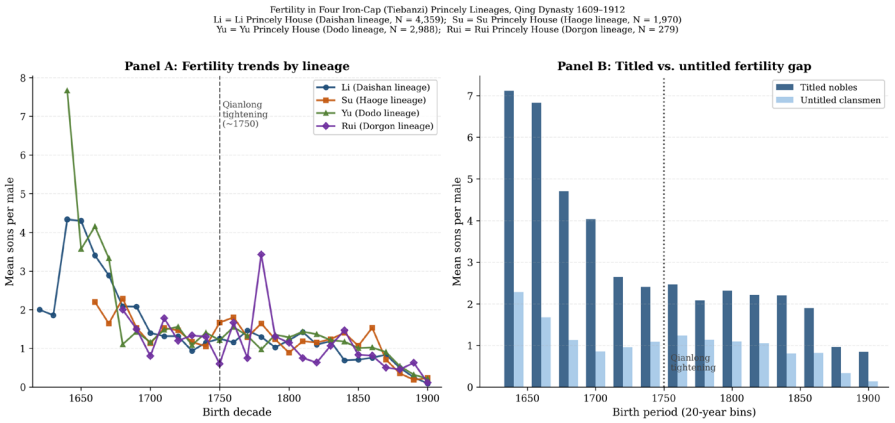


Fig. 4 Fertility in Four Iron-Cap Lineages, Qing Dynasty 1609–1912. Panel A plots mean sons per male by birth decade for each lineage. Panel B plots mean sons per male for titled nobles versus untitled clansmen by 20-year birth cohort. The dashed vertical line at c.1750 provides a mid-dynasty reference point within the Qianlong-era institutional and fiscal changes discussed in Sects. 5.4.8 and 7.6. Li = Li Princely House (Daishan lineage, N = 4359); Su = Su Princely House (Haoge lineage, N = 1970); Yu = Yu Princely House (Dodo lineage, N = 2988); Rui = Rui Princely House (Dorgon lineage, N = 279)

for dynasty-wide demographic trends. Critically, the institutional account implies compression of the premium through lower title awards attached to examination outcomes rather than through untitled clansmen's fertility, though the cohort data cannot adjudicate between this and other accounts. The 1730 cutoff is a historically motivated birth cohort reference point, not an individual treatment-assignment date. Title eligibility was normally assessed later in life, and final recorded rank or office may itself be affected by the institutional rules. The interaction therefore describes a change in the conditional rank–recorded-sons association across cohorts; it does not identify the causal effect of the 1730 reform or isolate it from later Qianlong-era changes, selection, composition, and secular change. We summarize this as a descriptive comparison of pre- and post-1730 birth cohorts across ranked and unranked individuals, with lineage fixed effects absorbing persistent cross-lineage differences in wealth, prestige, and recording completeness. Table 6 uses the broad rank-or-office indicator defined in Sect. 5.4.2 and is therefore not a title-specific test of the kaofeng reform.

Table 6 presents the estimates. The pre-1730 rank premium was 3.44 additional sons. After 1730, this fell to 1.37 sons—a reduction of 60 percent (interaction coefficient = −2.07, SE = 0.051, $p < 0.001$). The positive Post-1730 main effect (+0.157) indicates a modest rise in average fertility among untitled clansmen after 1730, likely reflecting compositional change as more descendants were pushed into idle status and the surviving untitled group became younger and more fecund on average; this compositional shift is itself one of the reasons the comparison is presented as descriptive rather than causal. Figure 5 displays decade-specific rank coefficients. The pre-period shows a secular decline in the rank premium, driven in part by the compositional effects of the founding era (the earliest cohorts contain

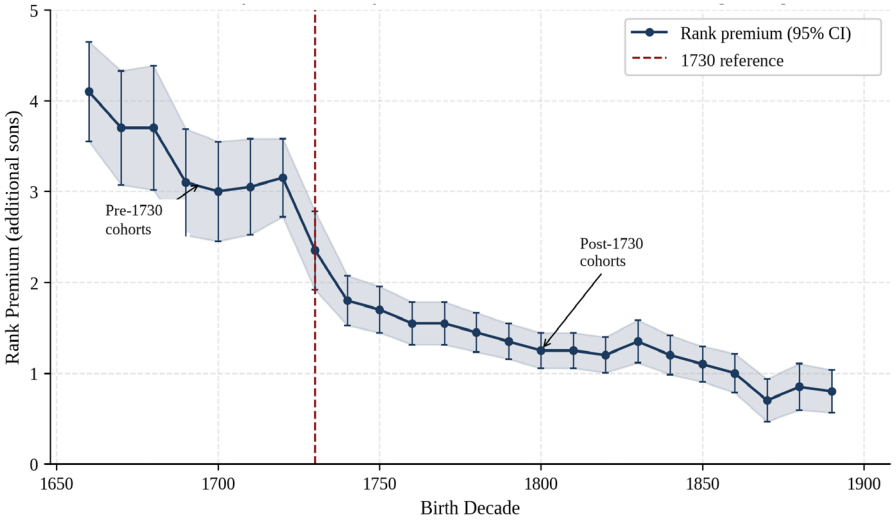


Fig. 5 Conditional Rank–Recorded-Sons Association by Birth Decade. Notes: Each point = rank coefficient with generation FE. Bars = 95% CI

a disproportionate share of high-ranking founding nobles). Controlling explicitly for a Rank × linear time trend yields a post-1730 interaction coefficient of −1.35 (SE = 0.097, $p < 0.001$); the interaction remains sizeable, and we retain the rank-specific trend only as a descriptive sensitivity specification, not as evidence that the post-1730 pattern departs from the pre-existing trajectory. The present design cannot distinguish institutional change from changes in income, composition, selection, cultural norms, or occupational opportunities.

Figure 5 displays the cohort profile graphically, showing decade-specific rank coefficients with 95% CI. The premium declined from 4.1 sons (1660s) to below 1.0 (1880s), with acceleration during 1720–1750.

Two caveats qualify a causal reading of this design, and we present the results accordingly. First, exposure is assigned by birth cohort, while examination and title-allocation decisions occurred later in life: individuals born shortly before 1730 partially encountered the new rules, and those born after 1730 encountered them only upon reaching inheritance age. This fuzziness makes the mapping from birth year to institutional exposure approximate; its effect on the estimated interaction cannot be definitively signed ex ante. We would prefer to assign exposure by the date at which title eligibility was actually determined, but individual examination, title-conferral, and title-removal dates are not available in our extracted records, which give final recorded status only; birth cohort is therefore the only exposure marker our data support, and we use it as a descriptive temporal marker. Second, titled status is itself an outcome of the rules that changed in 1730: if the reform altered who received or retained titles, the composition of the ranked and unranked groups differs across the 1730 boundary, and part of the post-1730 interaction may reflect selection into rank status rather than a change in the fertility consequences of rank. For these reasons, together with the secular pre-period decline documented in Fig. 5, we present

the 1730 analysis as an interrupted descriptive pattern consistent with the proposed institutional mechanism, rather than as a causally identified treatment effect. Throughout, we treat it as a supporting descriptive temporal regularity that does not by itself distinguish institutional change from evolving composition, selection, cultural factors, or occupational opportunities.

5.4.7 Heterogeneity over time

Table 7 examines whether the rank–fertility differential varied over the dynasty. In the early Qing (births 1650–1700), ranked individuals had 3.89 more sons than unranked individuals. By 1701–1750, this differential had fallen to 2.41; by 1751–1800, to 1.41; and by 1851–1900, to 1.04. The rank premium declined by 73 percent over two centuries.

This temporal pattern is descriptively compatible with institutional, compositional, and secular channels that the present design cannot distinguish. As the clan expanded, stipend values declined in real terms, examination requirements became more stringent, and the proportion recorded with rank or office fell from 18 percent in 1650–1699 to under 5 percent by 1850–1899 (Table 8).

Table 8 Proportion of ranked clansmen by birth cohort

Birth Cohort	% Ranked	N
1650–1699	18.3	5100
1700–1749	12.4	10,192
1750–1799	11.1	13,866
1800–1849	9.1	17,826
1850–1899	4.6	23,088
1900–1912	1.0	5456

Table 8 reports the proportion of ranked clansmen among all males born in each cohort window within the full Yudie dataset (N = 87,318 total records; cohort N values sum to 75,528; the 11,790 excluded records comprise 2594 with no usable birth year, 1,195 with valid birth years before 1650, and 8001 born after 1912). The 1900–1912 cohort is heavily right-censored: with Yudie compilation ending in 1921, its members are observed only to ages 9–21, before most title acquisition and childbearing would normally occur, so its low ranked share partly reflects incomplete observation rather than institutional filtering alone. Ranked status is defined as a non-null rank or office entry in the Yudie; individuals with no rank or office entry are classified as "idle clansmen" (xiansanzongshi)—males with no rank or office recorded in their Yudie entry, either because they were born into a collateral branch too distant from the main line to receive initial rank, or because their rank had been demoted to zero through the mandatory reduction rules, or, in a small number of cases, because a previously held rank was removed through punitive demotion. This differs from the father-ID-restricted sample of Table 3, Column 5, and Table 6 (N = 69,993), which is further restricted to individuals born 1650–1900 with non-missing father identification. See Table 1 for full-sample construction details

5.4.8 Robustness

Table 9 presents robustness checks. The rank coefficient is stable when we exclude the early Qing period before 1700 (1.53), restrict to the period before 1850 (1.98), or limit the sample to generations 10–15 who experienced the full demotion system (2.14). In each case, the coefficient remains large, positive, and highly significant, indicating that the main result is not driven by the choice of sample period or generational coverage.

As a further robustness check, we expand the within-lineage sample from the four founding iron-cap lineages used in Sect. 5.4.5 to seven, adding the Zhuang Princely House (Shuo Se lineage, N = 328), the Zheng Princely House (Jirgalang lineage, N = 1715), and the Keqin Princely House (Yoto lineage, N = 1189). The expanded sample covers 12,828 males born 1609–1912—a 34 percent increase over the original 9596. The baseline Poisson coefficient on titled status is 1.039 (SE = 0.020), compared to 1.139 in the four-lineage sample; adding lineage fixed effects yields 1.052 (SE = 0.020). Adding wives as a control reduces the coefficient to 0.441 (SE = 0.024)—a reduction of 58.1 percent, virtually identical to the 56.8 percent attenuation observed in the original sample. The stability of the titled coefficient and the attenuation share across samples of varying composition weighs against lineage selection as the source of the rank–fertility gradient and its marriage-market channel.

A final descriptive exercise addresses the concern, raised in Sect. 7.6, that Qianlong-era institutional reforms (the 1743 maternal-status award matrix, the 1748 codification of the fourteen categories and examination-award table, and the 1774 hereditary floor edicts) may complicate the interpretation of the 1730 Yongzheng comparison. For descriptive purposes, we subdivide the post-1730 period into two sub-windows, 1730–1769 and 1770–1800, and estimate separate rank–cohort interactions for each sub-window relative to the pre-1730 baseline, restricting the sample to individuals born 1650–1800 (N = 29,482). The results are as follows. The rank premium in the pre-1730 period is 3.36 sons. In the 1730-1769 window, it falls to 1.69 sons—a reduction of 49.6 percent relative to the pre-1730 baseline. In the 1770–1800 window, it falls further to 1.35 sons—a cumulative reduction of 60.0 percent. The additional decline between the two post-1730 sub-windows is 0.35 sons (computed from unrounded coefficients). We

Table 9 Robustness checks

Specification	Coef	SE
Baseline	1.784***	(0.041)
Exclude pre−1700	1.53***	(0.038)
Exclude post-1850	1.98***	(0.051)
Gen 10–15 only	2.14***	(0.049)

Dependent variable: Sons (count). All specifications are OLS with generation and birth-decade fixed effects, estimated on subsamples of the main estimation sample (born 1650–1900 with non-missing paternal-entry information; baseline N = 70,589, matching Table 3, Column 1). Standard errors clustered at the lineage level in parentheses. *** $p<0.001$

do not attach a formal test to this incremental change. These windows contain heterogeneous and partly opposing institutional changes—including the 1743 and 1748 measures in the first window and the 1774 hereditary floors in the second—so they cannot isolate the effect of any individual reform, and no formal breakpoint test is claimed. This reading is consistent with the decade-by-decade pattern in Fig. 5: the rank premium declines from roughly 3.0–3.2 sons in the 1700s–1720s to approximately 2.4 in the 1730s—a sharp decline—and then continues smoothly through approximately 1.8 in the 1740s and 1.4–1.7 across the 1750s–1770s, with no visible acceleration around 1770. Because the sub-windows bundle heterogeneous reforms, we draw no inference about any individual Qianlong measure from this pattern; a cumulative Qianlong-era contribution cannot be excluded, and the post-1730 coefficient should not be attributed to the Yongzheng reform alone (see Sect. 7.6). The staged Qianlong-era measures fall within the post-1730 period; we do not rank the sub-period changes against one another.

6 Analysis

Our analysis exploits the Ming–Qing comparison as a structured comparative case study. As established in Sects. 5.2 and 5.3, the two dynasties are matched on duration and fiscal model, yet sharply different inheritance rules—perpetual inheritance without exit versus mandatory demotion with examination filtering—were associated with a difference of roughly an order of magnitude in registered clan population. We treat this as a comparative case study rather than a clean causal experiment, and estimates should be interpreted as descriptive associations informed by institutional logic rather than causally identified treatment effects. Three structural differences between the dynasties could in principle confound the comparison and deserve explicit acknowledgment. First, ethnic composition and the Manchu Banner system: the Qing imperial clan was embedded within the Eight Banner military-administrative structure, which affected residential concentration, marriage-market access, and state surveillance capacity independently of the rank system. We address this directly in Sect. 6.2, noting that the cohort series cannot separate the Eight Banner channel from the institutional account. Second, military organization and geographic dispersion: Banner garrisons concentrated Qing nobles in ways that Ming princely estate confinement did not, potentially affecting occupational alternatives and fertility incentives through channels unrelated to demotion. Third, macro-demographic context: the Qing inherited a post-war recovering population in the mid-seventeenth century, while Ming clan growth occurred against a backdrop of expanding agricultural colonization. These differences mean the Ming–Qing comparison is best understood as providing suggestive rather than definitive evidence for an institutional explanation. We organize the evidence below according to the three-layer inference framework introduced in Sect. 1 and address alternative explanations in Sect. 6.2.

6.1 Testing the propositions

The three propositions derived in Sect. 3.5 generate testable predictions about how institutional variables should correlate with population outcomes across dynasties. Given the absence of parallel trends and comparable administrative units across dynasties, we adopt a structured comparative case approach rather than formal panel estimation at the dynasty level. Table 10 summarizes the key institutional variables and population outcomes across the major dynasties analyzed in this study. The Ming–Qing comparison, highlighted in bold, represents our core comparative case study.

Proposition 1—that the fiscally sustainable rank count increases with fiscal centralization conditional on demotion mechanisms—receives support broadly consistent with the available evidence when properly specified. The clearest contrasts come from comparing dynasties that share fiscal model but differ in demotion architecture. Yuan with appanage self-financing maintained only eight ranks: because princes drew on territorial revenues rather than central treasury, the emperor had no fiscal incentive to create fine-grained stipend gradations. Qing with central treasury support and mandatory demotion maintained fourteen: the central fiscal model created demand for gradations to calibrate graduated descent, and demotion rules made those gradations functionally meaningful

Table 10 Institutional design and population outcomes across key dynasties

Dynasty	Ranks	Fiscal central	Demotion	Scattered titles	Exam filter	Population outcome
Qin	20	Low	N/A	No	No	Stable (meritocratic, no hereditary)
Han	20	Partial	Partial	No	No	Moderate growth
N. Wei	22	Partial	No	Yes (11 income)	No	Controlled
Tang	9–11	High	Yes	No	No	Controlled
Song	12	High	No	No	No	Controlled (~20 k peak)
Yuan	8	Low	N/A	No	No	Limited (appanage system)
Ming	**8**	**High**	**No**	**No**	**No**	**Explosion (157 k registered by 1595)**
Qing	**14**	**High**	**Yes**	**No**	**Yes**	**Controlled (16,454 males, 1915)**

Ming and Qing rows (bold) represent the core comparative case: comparable duration and fiscal model, but sharply different institutional designs associated with a difference of roughly an order of magnitude in population outcomes. The comparison is structured to maximize comparability, though we acknowledge remaining structural differences discussed in Sect. 6.2. The Demotion column codes mandatory generational demotion that terminates in exit from the titled, higher-stipend hierarchy; Ming collateral-line rank tiering, which descended to the lowest rank but entailed no exit from eligibility (Sect. 5.2.7), is accordingly coded No. Rank counts are reported on each dynasty's own formal basis: the Ming count comprises substantive title grades, while the Qing count comprises formally codified categories including two heir designations (Shizi and Changzi), so the eight-versus-fourteen contrast is not a same-basis comparison (see Appendix A). See Table 21 in Appendix D for complete cross-dynasty comparison. The last reliable registered count is 157,000 members in 1595 (Wanli 23; Zhi 1990); the 1644 figure in Table 18 is extrapolated and unreliable. The Han row aggregates the Western and Eastern Han; Appendix Table 21 reports them separately (20 and 15 ranks, respectively)

as population-control instruments. The Han case provides additional corroboration: it employed twenty ranks under a mixed fiscal model (kingdoms partly self-financing, commanderies centrally administered), producing moderate rank differentiation consistent with an intermediate position on the fiscal centralization dimension. The Ming case, which also used central support but maintained only eight ranks, is not a counterexample but is consistent with the conditional nature of the proposition: without an exit-producing demotion rule, additional ranks would have served no population-control purpose regardless of fiscal model: collateral descendants would still flow downward but accumulate permanently at the positive-stipend floor. The Qin case is a limiting case in which hereditary rank was absent entirely: because noble status was contingent on military merit rather than descent, the fiscal model dimension did not apply, and rank structure reflected military incentives rather than clan management.

Proposition 2—that scattered titles substitute for rank proliferation—receives support broadly consistent with the available evidence. Northern Wei's twenty-two-plus nominal levels correspond to only eleven income-bearing categories, with the remaining levels carrying purely honorific status. This decoupling of ceremonial rank from fiscal entitlement allowed the Northern Wei to satisfy demand for status differentiation without proportionally expanding stipend commitments—exactly the substitution the proposition predicts. The Tang system shows a partial parallel: its nine to eleven ranks were accompanied by progressive stipend reductions across generations, achieving fiscal compression through the benefit structure rather than through formal scattered titles. The Song, with twelve ranks and no scattered titles, achieved controlled growth through non-hereditary restrictions that effectively functioned as an exit mechanism—consistent with the broader principle that population control requires some instrument severing the link between rank and unlimited reproduction, whether through scattered titles, demotion, or eligibility restrictions.

Proposition 3—that rank count alone does not determine population outcomes—receives the strongest and most direct support in the cross-dynasty evidence. The clearest test is the Ming–Yuan comparison: both employed exactly eight ranks, yet produced radically different demographic outcomes. The Yuan clan remained small under a system in which princes self-financed from territorial appanages and had no incentive to expand central stipend claims; the Ming clan exploded under universal central treasury support combined with no exit mechanism, which converted every rank into a permanent entitlement. Rank count was identical; the contrast is consistent with a central role for the complementary institutions—fiscal model, demotion rules, exit mechanisms—which differed fundamentally. A second test is the Song–Tang comparison: the Song employed twelve ranks and the Tang nine to eleven, yet both achieved controlled clan populations through different exit mechanisms (non-hereditary restrictions in the Song; the five-mourning-grades rule in the Tang). The Han provides a third data point: twenty ranks with a partial demotion mechanism (the Tui'en "subdivision" decree) produced moderate growth rather than explosion, consistent with partial complementarity yielding intermediate outcomes. Taken together, these cases are consistent with rank count having little independent predictive power for population outcomes once the presence or absence of complementary institutions is accounted for.

6.2 Alternative explanations

6.2.1 Ethnic and cultural differences

One might argue that Manchu cultural traditions—a martial ethos emphasizing discipline, frugality, or lower baseline fertility—explain the Qing's demographic success independently of institutional design. This hypothesis deserves serious engagement, and the evidence below does not settle it; we report four observations bearing on it. First, the broader Manchu Banner population (including non-imperial Manchus with no demotion rules or examination requirements) grew slowly in registered terms: recorded Manchu Banner adult males increased from 55,330 in 1648 to 229,011 in 1887, an annualized rate of about 0.6 percent (Liu 2021). These administrative totals reflect enrollment, removal, migration, and mortality as well as fertility, so they do not identify fertility restraint; they nonetheless show that slow registered growth was not unique to the institutionally constrained imperial line. Second, the elaborate apparatus of mandatory demotion, examination filtering, and stipend eligibility rules suggests the Qing founders themselves did not trust culture alone to solve the population problem: they built formal coercive mechanisms whose fiscal logic is transparent in the primary sources. Third, the cohort pattern in Sect. 5.4.6 does not adjudicate between institutional and cultural interpretations, and we do not use it to weigh against a cultural account. Finally, the Ming founder Zhu Yuanzhang was himself a social outsider from a peasant background whose deliberate policy choices set the institutional conditions under which the explosion occurred; cultural predispositions do not readily explain why a Han Chinese founder chose universally generous stipends, while Manchu founders chose graduated demotion. The divergence is at least as readily described in terms of institutional choices under different political constraints as in terms of inherited cultural dispositions, and cultural differences cannot be excluded.

6.2.2 Measurement differences

Perhaps population differences reflect measurement rather than reality. This explanation is difficult to sustain because Qing maintained more systematic records than Ming, Ming figures likely undercount rather than overcount, and fiscal data independently corroborate the population differences.

6.2.3 Economic conditions

Perhaps Ming experienced exceptionally favorable conditions. But general population growth rates were similar across both dynasties; the divergence was specific to imperial clan members—the pattern one would expect if clan-specific institutional design mattered.

6.2.4 Geographic concentration

Ming princes were confined to estates with little to do except produce children. This may have amplified growth but does not by itself account for the fundamental divergence, which appeared from the dynasty's beginning.

6.2.5 Eight banner system and occupational opportunities

A more serious alternative explanation concerns the Eight Banner system. Ming imperial clansmen were systematically prohibited from participating in political, military, or commercial affairs—confined to estates where reproduction was virtually their only occupation. Qing imperial clansmen, by contrast, were embedded within the Eight Banner military-administrative structure, holding military ranks, serving as garrison commanders, and occupying frontier posts. Qing rulers employed imperial kinsmen and Banner nobles in selected strategic posts (Rawski 1998, p. 95). This occupational difference might itself have suppressed Qing fertility independent of the demotion mechanism.

We acknowledge occupational opportunities as a contributing factor but argue that it appears insufficient as a complete explanation. Four considerations bear on this. First, on timing, we note only what the series shows and draw no inference against the Banner explanation from it. The present cohort pattern cannot distinguish institutional change from changes in income, composition, selection, cultural norms, or occupational opportunities.

Second, by mid-Qing the supply of imperial clansmen vastly exceeded available positions. Although the court created posts for clansmen in the guards, the Imperial Clan Court, the Six Boards, the Lifanyuan, and the Censorate, the Jiaqing emperor acknowledged in 1813 that the state could not employ all imperial clansmen (Rawski 1998, pp. 116–17); most therefore faced limited official employment regardless of institutional constraints.

Third, the more direct fertility-relevant variable is income rather than occupation. Idle clansmen received minimal stipends (3 taels monthly) that sharply constrained marriage access, while ranked nobles received substantial allowances enabling polygyny—regardless of whether they held official positions.

Fourth, registered growth in the broader Eight Banner system was also slow (about 0.6 percent annually for recorded Manchu Banner adult males, 1648–1887; Liu 2021). These administrative totals are subject to the registration caveats noted under Ethnic and Cultural Differences above and do not identify fertility restraint; they show only that slow registered growth was not unique to the imperial line.

6.2.6 Political constraints on reform

Perhaps Ming emperors wanted demotion but could not implement it. This explanation has merit but is incomplete. The Ming founder Zhu Yuanzhang explicitly chose perpetual inheritance to ensure clan solidarity, famously insisting that members of the imperial clan should never be reduced to commoner status. This was not a failure of institutional imagination but a deliberate political choice: the early Ming state,

emerging from peasant rebellion against Mongol rule, prioritized kinship loyalty over fiscal efficiency. By the mid-Ming, when the fiscal burden became apparent, path dependence had set in—the numerous princes wielded enough collective influence to block reform attempts. The Jiajing Emperor's efforts to restrict stipends in the 1520 s met fierce resistance from the princely estates. Thus the Ming's institutional outcome reflects both initial choices (prioritizing loyalty) and subsequent lock-in (vested interests preventing reform), illustrating how suboptimal institutions can persist even when their costs are recognized. This historical narrative creates a productive tension with the formal model in Sect. 4, which takes institutional parameters as given and abstracts from the political frictions documented here. We acknowledge this tension directly: our model characterizes a long-run equilibrium under which demotion rules are self-sustaining once adopted, not a frictionless optimization by any single ruler. The Qing case may be distinctive in that the Manchu founders embedded demotion as a founding constitutional principle before vested interests could consolidate—a window of institutional plasticity that the Ming had already foreclosed by the time its costs became visible. The model therefore captures the logic of successful institutional design under low political constraints, while the Ming comparison illustrates what happens when those constraints bind. Future work incorporating political economy frictions into the formal framework could enrich this analysis.

6.3 "Horizontal" versus "vertical" demotion arrangements

Recent scholarship by Wang and Xu (2021a, 2021b) provides independent historical corroboration for our central theoretical distinction, supplying high-confidence design-fact evidence (first layer of inference) that directly supports the horizontal–vertical demotion contrast we identify as the key institutional parameter. Their systematic comparative analysis identifies a crucial structural distinction: the Ming system employed what they term "horizontal arrangement," while the Qing system used "vertical arrangement." This conceptual framework, derived from primary institutional sources rather than from demographic inference, provides an independent route to the same conclusion as our population data: superficially similar rank counts were associated with divergent outcomes under fundamentally different architectures governing intergenerational descent.

Table 23 in Appendix E summarizes the key institutional differences between Ming and Qing systems.

In the Ming's horizontal arrangement, primogeniture inheritance and demotion operated as parallel tracks. Imperial princes (*qinwang*) and commandery princes (*junwang*) passed their titles intact to eldest sons through perpetual inheritance (*shixi wangti*), while younger sons received demoted ranks. These two tracks ran in parallel—the main line never descended, while collateral lines descended but never exited. In contrast, the Qing's vertical arrangement applied demotion to the main line itself, with succession graded by the father's rank, the heir's designation and maternal status, examination outcome, and period, and with line-specific hereditary

floors from 1774 onward (Appendix A.3)—except for the twelve "iron-cap" princely lines granted perpetual hereditary status.

The most consequential difference concerns the treatment of descendants beyond the lowest rank. In the Ming system, all male descendants—regardless of generational distance from the founding emperor—retained noble status and stipend entitlement at the *fengguozhongwei (State-Serving Commandant)* floor level. As Wang-Shizhen (1590) recorded in the *Yanshantang Bieji*: "From this point, though all may be collateral branches, they may still be called *zhongwei* and are not reduced to commoners." This constitutional guarantee created what economists would recognize as a "ratchet effect"—clan membership could never be lost, only accumulated.

The Qing system, by contrast, allowed descendants to fall into "idle clansman" status, receiving minimal allowances of approximately three taels monthly—insufficient to support a comfortable life or incentivize high fertility. By the Qianlong era, the share of idle clansmen was rising rapidly: our Yudie-based estimates indicate that approximately 89 percent of males born between 1721 and 1760 had no rank or office recorded, a share that continued to grow in later cohorts. Across the full cumulative registry, 80,181 of 87,318 records (91.8 percent) carry no rank or office, and the cumulative registry share is consistent with the 91 percent untitled share among Qianlong generation males documented in Jiang 1986 (p. 53). This exit mechanism placed the great majority of clansmen in an incentive environment that had no Ming counterpart.

Wang Haomiao and Xu Ziyou's analysis also reveals important differences in the treatment of younger sons. In the Ming system, apart from the eldest son, legitimate and illegitimate sons followed the same developmental trajectory, with younger sons enjoying equal rank treatment. The Qing system, by contrast, differentiated sharply by maternal status: sons of primary consorts, secondary consorts, and concubines followed distinct demotion trajectories, with concubines' sons often descending directly to idle status within a few generations.

6.3.1 The Jingjiang principality as comparative case

Wang and Xu's second article (2021b) provides within-Ming variation through the Jingjiang principality (accelerated demotion: sons descended two ranks rather than one). Despite this stricter rule, the absence of any exit mechanism meant that descendants continued to accumulate at the lowest titled floor indefinitely. By c.1570 this produced a ratio of 1 prince to 712 commandants—illustrating that demotion alone, without an exit mechanism, could not prevent population explosion.

6.3.2 Theoretical implications

Their comparative analysis supports three refinements to our theoretical framework. First, rank count is endogenous to exit rules. The Ming's eight-rank system sufficed because all descendants remained at the floor; additional ranks would serve no population-control purpose. The Qing's fourteen formally codified categories (twelve substantive titles plus two heir designations) were necessary to create meaningful

differentiation before exit, allowing gradual status decline that softened the shock of losing noble status entirely.

Second, the scope of hereditary perpetuity is the critical parameter. Demotion of younger sons alone cannot control the titled population if collateral branches remain eligible for hereditary stipends indefinitely. Under the Ming, princely main lines retained the qinwang or junwang title intact, while collateral lines descended through the ladder but became permanently hereditary upon reaching the fengguo zhongwei floor; each generation also created new collateral branches, so the number of perpetual stipend-bearing lines compounded over time. The Qing confined undiminished princely succession to the twelve iron-cap lines, each preserving a single title per generation, while most other lines descended toward exit.

Third, floor design affects fertility incentives. The Ming's generous floor (two hundred *shi* annually) subsidized reproduction even among the most distant relatives. The Qing's minimal allowance for idle clansmen created negative incentives at the margin, as additional children would divide an already inadequate inheritance.

Taken together, these three features created a two-dimensional compression that the Ming system lacked entirely. The first dimension is horizontal: the majority of sons exited the titled hierarchy rapidly through differential demotion by maternal status, with concubines' sons often descending to idle status within a few generations rather than descending slowly alongside all other sons as in the Ming. The second dimension is vertical: even those who remained in the hierarchy descended through the ranks under mandatory generational demotion; after 1774, favored heir lines stopped at hereditary floors above idle status, while most other descendants continued to exit. The Ming's failure lay not only in the absence of an exit floor, but in allowing too many sons to enter and remain in the system at all—each descending too slowly, and too many descending simultaneously, to prevent geometric accumulation. The Qing's institutional innovation was to compress both the number entering the titled hierarchy in each generation and the number of generations for which a lineage branch remained within it.

7 Discussion

7.1 Multiple functions of rank proliferation

Our analysis reveals that rank proliferation serves multiple functions beyond status differentiation.

Ranks serve as rationing devices when fiscal resources are centrally allocated. The emperor benefits from having many gradations to calibrate rewards.

Ranks provide infrastructure for demotion. With many ranks, descent is gradual; status distinctions persist across many generations. The Qing's fourteen ranks created a long demotion corridor: status declined gradually across generations rather than abruptly, softening the political cost of status loss.

The Northern Wei example shows that ranks can serve purely symbolic functions when combined with scattered titles.

7.2 Institutional complementarity

Rank systems achieve their intended effects only when combined with appropriate inheritance rules and eligibility criteria. The Ming could not have solved its problem by adding ranks; without exit-producing demotion, more ranks would have created more positions for growth.

This complementarity has implications for reform. Partial reforms that modify one dimension while preserving others may fail entirely. The Ming attempted various partial reforms without ever addressing universal eligibility. None succeeded. As discussed in Sect. 6.2, our formal model characterizes long-run equilibrium properties of institutional configurations rather than period-by-period optimization; the Ming comparison illustrates what happens when political constraints prevent adoption of the fiscally more sustainable configuration. The Qing case is consistent with an outcome driven not by deliberate global design but by founding-era incentives that happened to align with long-run fiscal sustainability: demotion was acceptable to the Manchu military aristocracy because iron-cap exemptions preserved the founding coalition's status, while imposing discipline on all others. The Ming–Qing divergence thus illustrates two complementary lessons. The first is institutional: demotion combined with examination-based exit is, within the formal model, the design that delivers demographic control. The second is political: more fiscally sustainable institutional configurations are adoptable only during windows of low political constraint—before vested interests consolidate around the status quo. The Qing case is consistent with the possibility that founders succeeded not merely by knowing the better design, but by implementing it before any constituency existed to resist it. This reframes the tension between the formal model and the path-dependence narrative: the model characterizes which configurations are fiscally sustainable; the historical record explains when such configurations become politically feasible.

7.3 Path dependence

Founding-era choices create constituencies that resist subsequent change, as Sect. 6.2 documents in detail.

The Qing case is consistent with the possibility that this trap was avoided because demotion was a founding principle rather than a later reform, leaving no constituency of non-demoted members to block it.

7.4 Implications for state capacity

The Qing's elaborate system demonstrates remarkable institutional sophistication, challenging narratives of Chinese institutional stagnation. The Ming's crisis demonstrates that state capacity encompasses expenditure control, not merely revenue extraction.

7.5 Cross-cultural parallels

The mechanisms we identify find parallels in other imperial contexts, suggesting candidate mechanisms of elite management that may not be China-specific. European dynasties addressed similar challenges through primogeniture—restricting inheritance to eldest sons—which limited noble proliferation but created different political tensions as disinherited younger sons sought alternative paths to status through the church, military, or colonial ventures. The Ottoman Empire employed more extreme measures: the kafes system confined potential heirs in palace quarters, while the notorious practice of fratricide eliminated succession rivals entirely. Russia's Table of Ranks (1722) created a merit-based hierarchy that absorbed ambitious elites through bureaucratic promotion while limiting hereditary claims. These varied institutional responses illustrate a common underlying problem: how to maintain elite loyalty while preventing the fiscal burden of an ever-expanding privileged class. China's demotion systems represent one solution within this broader institutional repertoire, notable for achieving population control through graduated status reduction rather than outright exclusion or violence. The comparative perspective suggests our theoretical framework—emphasizing the trade-off between loyalty and fiscal sustainability—may illuminate elite management strategies in other historical contexts. We stress, however, that the Qing case is highly specific: it combines patrilineal imperial descent, institutionalized polygyny, a centralized stipend system, and a conquest-dynasty context with distinctive legitimacy pressures. The cross-dynasty comparison in this paper is a structured comparative case study, not a clean causal experiment; many structural differences across dynasties remain uncontrolled. Claims about generalizability to other settings should therefore be treated as suggestive hypotheses for future research rather than established findings.

7.6 Limitations

Four categories of limitation deserve explicit acknowledgment. First, data quality is uneven across dynasties. For pre-Song dynasties, our rank structure data derive from reconstructed administrative codes and dynastic histories rather than systematic administrative records; stipend schedules, population counts, and clan membership figures are often fragmentary or absent. The cross-dynasty comparisons in Table 10 should therefore be understood as indicative rather than precise, and propositions tested against pre-Tang evidence rest on sparser foundations than the Ming–Qing comparison. We note also that while Song imperial clan genealogical records exist—most prominently the clan registers documented by Chaffee (1999)—they do not contain the individual-level fertility and marriage information present in the Qing Yudie, and sex ratios in the Song records are subject to well-documented under-registration of female births. We therefore restrict the micro-level empirical analysis to the Qing case, where data completeness and systematic record-keeping are most reliable; extending the individual-level analysis to the Song remains an important direction for future work.

Second, identification is inherently constrained in cross-dynasty analysis. Dynasties differ along many dimensions simultaneously—ethnic composition, military organization, geographic scope, broader demographic environment—and we cannot randomly assign institutional configurations. Our comparative case approach maximizes internal comparability on observable dimensions, but the possibility of confounding by unobserved factors cannot be fully excluded. The micro-level evidence from the Yudie addresses some of this concern by documenting the individual-level mechanisms, but it is necessarily restricted to the Qing case and cannot establish that the same mechanisms operated identically in earlier dynasties.

Third, external validity is limited. The Qing case combines patrilineal imperial descent, institutionalized polygyny, centralized stipend administration, and a conquest-dynasty context with distinctive legitimacy pressures. Claims about generalizability—to other Chinese dynasties, to non-Chinese imperial systems, or to modern elite management contexts—should be treated as hypotheses requiring independent validation rather than inferences from our evidence.

A fourth limitation concerns the temporal scope of the 1730 evidence. The 1730 Yongzheng reform provides our central descriptive reference point, but the Qing peerage system continued to evolve under the Qianlong emperor: the Qianlong court capped the number of officially recognized secondary consorts by rank in 1742, specified a father-rank-by-maternal-status award matrix in 1743, and codified the fourteen formal title categories together with a comprehensive examination-award table in 1748; the edicts of Qianlong 39 (1774) subsequently introduced hereditary floors for grace-enfeoffed lines and should therefore not be characterized simply as further tightening (Huangchao Wenxian Tongkao 1787, juan 246; Qinding Da Qing Huidian Zeli 1764, juan 1; Huangchao Tongdian 1787, juan 32). The post-1730 indicator in our pre/post cohort comparison begins with the Yongzheng reform but likely also absorbs some of the later Qianlong-era institutional changes; the estimated post-1730 change should therefore not be read as isolating the effect of the Yongzheng reform alone. This does not undermine 1730 as the reference point for the descriptive comparison—the interaction remains sizeable when a Rank × linear time trend is included—but it means our coefficient should be interpreted as reflecting the combined pattern associated with institutional and non-institutional changes across the eighteenth century, rather than the isolated effect of the Yongzheng baseline compression.

8 Conclusion

This paper set out to explain why imperial Chinese dynasties exhibited such striking variation in noble rank structures, and why the same rank count could produce such divergent demographic outcomes. The explanation our evidence supports is institutional complementarity. Rank proliferation is neither inherently stabilizing nor destabilizing: it is a neutral infrastructure whose effects depend critically on the demotion rules, examination requirements, and stipend eligibility criteria with which it is paired. The Ming case illustrates what can happen when this infrastructure lacks an effective exit mechanism—ranks became reservoirs for geometric

growth rather than channels for controlled descent. The Qing case illustrates the full institutional configuration—fourteen ranks combined with mandatory demotion and examination filtering—under which only 6,438 individuals are recorded with a rank or office (approximately nine percent of the 70,592 individuals born 1650–1900), with the remaining approximately 91 percent recorded without rank or office and with markedly fewer recorded sons than the rank-or-office group. The micro-level evidence from 87,318 Yudie records is consistent with the proposed mechanism: the descriptive decomposition shows an 84 percent combined attenuation of the rank–fertility gradient once marriage structure is controlled (Table 3 notes), consistent with marriage-market access as the leading proximate correlate of the rank premium; and the rank premium fell by 60 percent across the 1730 boundary in the baseline descriptive comparison (Column 1 of Table 6), with the interaction remaining sizeable when a rank-specific linear trend is included—a descriptive pattern we report without attaching a magnitude to any institutional cause.

These findings address broader questions about how autocratic regimes manage their elites. The emperor's problem—balancing legitimacy benefits against fiscal and political costs of a large clan—has analogs wherever ruling groups must reproduce themselves across generations. Our analysis suggests that effective solutions require attention to system-wide institutional configurations, not just individual policy parameters.

These findings raise suggestive parallels for broader questions of institutional design, though we caution that the Qing case is highly contextually specific and direct generalization to modern settings should be treated as hypothesis rather than inference. With that caveat, the institutional complementarity principle we identify suggests that reforms targeting single parameters (compensation levels, promotion criteria, or retirement rules) may underperform without attention to how these elements interact. The Ming's experience illustrates that even well-intentioned generosity can produce catastrophic outcomes when institutional safeguards are absent; the Qing's experience suggests that sustainable elite management benefits from coordinated design across multiple institutional dimensions. For scholars of institutional economics, our findings underscore that historical cases offer not merely cautionary tales but systematic evidence on how institutional configurations are associated with divergent demographic outcomes.

Future research might extend this micro-demographic approach to other hereditary elites. The European aristocracy offers a natural comparison: the Almanach de Gotha documents genealogical records for hundreds of noble houses across several centuries, enabling analogous tests of whether primogeniture and entail—Europe's institutional equivalents of mandatory demotion—produced similar demographic compression. The Ottoman Kafes system, which confined potential dynastic rivals in palace isolation rather than granting them titles and stipends, represents a third institutional solution to the same ruler's dilemma—one that severely curtailed the political and social opportunities of confined princes; while confined princes could have concubines, their offspring were typically killed to prevent succession challenges, producing a distinct demographic logic from either the Qing or European models. Comparing these three configurations—Qing demotion-and-exit, European

entail-and-primogeniture, and Ottoman confinement—would allow a systematic test of whether institutional complementarity is a general principle of hereditary elite management or a feature specific to the Qing's conquest-dynasty context. Closer to the present, the logic of our findings raises a suggestive hypothesis—not a prescription—for settings where states must balance the legitimacy benefits of privileged groups against their long-run fiscal costs: reforms targeting single parameters while leaving complementary institutions unchanged may systematically underperform. Whether this hypothesis holds beyond the highly specific Qing context—patrilineal descent, institutionalized polygyny, centralized stipend administration, conquest-dynasty legitimacy pressures—remains an open question that requires independent validation in each new setting rather than direct extrapolation from our evidence.

This study demonstrates how cliometric methods—combining formal theory with micro-level historical data—can illuminate long-run institutional dynamics. By integrating a simple formal framework with a novel dataset of nearly 90,000 individual records, we marshal convergent evidence consistent with institutional design shaping demographic and fiscal outcomes. The findings contribute to ongoing debates about state capacity, elite management, and the institutional foundations of fiscal sustainability. More broadly, our analysis illustrates how pre-modern states managed the tension between political loyalty and the fiscal costs of an expanding privileged class—a problem with analogs across many historical settings, though the specific mechanisms we identify are deeply embedded in the Qing's patrilineal descent system, institutionalized polygyny, and conquest-dynasty context and should not be extrapolated to other settings without careful attention to structural differences.

Appendix A: Detailed rank structures by dynasty

A.1 Qin twenty-rank system

The Qin system established during the Warring States period and maintained after unification comprised the following ranks, each associated with specific military achievements and privileges:

See Table11.

The system's largely meritocratic character limited hereditary accumulation: ranks were earned primarily through demonstrated military achievement rather than inherited ancestral status. Advancement criteria varied with the soldier's starting status and command responsibility rather than following a uniform per-rank schedule of enemy-head counts (Shangjun shu, "Jingnei"; Han Feizi, "Dingfa"; Shuihudi Qin bamboo slips, "Junjue lü").

Table 11 Qin twenty-rank system

Rank	Title	Required merit
1	Gongshi (Common Serviceman)	Entry level
2	Shangzao (Superior Artisan)	Military merit
3	Zanniao (Hairpin Ornament)	Military merit
4	Bugeng (Exempt from Service)	Military merit
5	Dafu (Grand Master)	Military merit
6	Guandafu (Official Grand Master)	Military merit
7	Gongdafu (Ducal Grand Master)	Military merit
8	Gongcheng (Ducal Rider)	Military merit
9	Wudafu (Fifth-Rank Grand Master)	Military merit
10–14	Various Commanders	Increasing merit
15–18	Senior Commanders	Distinguished service
19	Guanneihou (Marquis Within the Passes)	Exceptional merit
20	Chehou (Full Marquis)	Highest distinction

A.2 Ming eight-rank system with stipend specifications

The hierarchy developed during the early Ming; the mature stipend schedule shown below was fixed in 1395:

See Table12.

The critical feature was universal eligibility at the bottom rank. Every male descendant, regardless of how many generations removed from the founding emperor, received the minimum 200 shi annually. This guaranteed stipend created strong fertility incentives; geometric population growth followed.

Table 12 Ming eight-rank system

Rank	Title	Annual Stipend (shi)	Eligibility
1	Qinwang (Imperial Prince)	10,000	Emperor's sons
2	Junwang (Commandery Prince)	2000	Non-heir sons of an imperial prince (the heir succeeded as qinwang)
3	Zhenguo Jiangjun (Defender-General)	1000	Non-heir sons of a commandery prince (the heir succeeded as junwang)
4	Fuguo Jiangjun (Supporting General)	800	Defender-generals' sons
5	Fengguo Jiangjun (State-Serving General)	600	Supporting generals' sons
6	Zhenguo Zhongwei (Defender-Commandant)	400	State-serving generals' sons
7	Fuguo Zhongwei (Supporting Commandant)	300	Defender-commandants' sons
8	Fengguo Zhongwei (State-Serving Commandant)	200	All subsequent male descendants

A.3 Qing noble rank system: stipend schedule and demotion trajectories

The Qing system established gradually between 1636 and 1748:

See Table13.

Below the lowest rank in this table (Rank 12, Feng'en Jiangjun, equivalent to Rank 14 in the full institutional system), non-inheriting sons, and sons who did not obtain succession under the applicable rules, could enter "idle clansman" status, receiving only minimal allowances of approximately 3 taels monthly (approximately 36 taels annually)—insufficient to support a comfortable life or incentivize high fertility (Lai 1997, p. 277). Note on coverage: this table covers 12 of the 14 institutional ranks, omitting the two Buru Bafen Gong ranks (dukes without the Eight Privileges; bafen denotes eight ceremonial privileges, not the Eight Banners) for which stipend data are unavailable in Li and Guo (1994), Table 2. Ranks are numbered sequentially within this table; the correspondence to the full 14-rank institutional system is: Junwang = Rank 3 (institutional); Beile = Rank 5; and the four general ranks (Ranks 9–12 here) correspond to institutional Ranks 11–14. Stipend figures represent the lowest sub-grade for ranks with multiple grades (e.g., ranks 11–13 each have three sub-grades); full sub-grade schedules are reported in Li and Guo (1994), Table 2. The stipend series follows Li and Guo (1994), Table 2, and is strictly decreasing across all ranks reported here. The two duke ranks without the Eight Privileges (buru bafen zhenguo gong and buru bafen fuguo gong) are omitted as their stipends are not recorded in Li and Guo (1994), Table 2.

The twelve "iron-cap" princely lineages were exempted from demotion, their titles passing intact in perpetuity:

1. (Prince Li)—Daishan lineage.
2. (Prince Rui)—Dorgon lineage.
3. (Prince Yu)—Dodo lineage.
4. (Prince Su)—Haoge lineage.
5. (Prince Zhuang)—Shuo Se lineage.
6. (Prince Zheng)—Jirgalang lineage.
7. (Commandery Prince Shuncheng)—Lekdehun lineage.
8. (Commandery Prince Keqin)—Yoto lineage.

These eight founding-era lineages, together with four titles granted hereditary status later, comprised the twelve "iron-cap" princely lines:

9. (Prince Yi)—Yinxiang lineage (added in the Yongzheng era).
10. (Prince Gong)—Yixin lineage (granted hereditary status in the Tongzhi reign, in recognition of his political role after the Xinyou Coup and during the Tongzhi Restoration).
11. (Prince Chun)—Yixuan lineage (elevated to Prince Chun in the Tongzhi reign; hereditary status granted after the accession of his son, the Guangxu Emperor).
12. (Prince Qing)—Yikuang lineage (added in 1908, at the end of the dynasty).

They represented the Qing equivalent of an "old nobility": a small set of princely lines exempt from ordinary demotion.

Critically, even these "iron-cap" exemptions applied only to single-line inheritance: the designated heir inherited the princely title intact, but younger sons of

Table 13 Qing noble rank stipend schedule (simplified; 12 of 14 ranks)

Rank	Title	Stipend (taels)	Demotion target (heir line, simplified)
1	Heshuo Qinwang (Prince of First Degree)	10,000	Rank 3
2	Shizi (Heir Apparent)	6000	Rank 3
3	Duoluo Junwang (Prince of Second Degree)	5000	Rank 5
4	Changzi (Eldest Son)	3000	Rank 5
5	Duoluo Beile (Prince of Third Degree)	2500	Rank 6
6	Gushan Beizi (Prince of Fourth Degree)	1300	Rank 7
7	Feng'en Zhenguo Gong (Duke of First Rank)	700	Rank 9
8	Feng'en Fuguo Gong (Duke of Second Rank)	500	Rank 10
9	Zhenguo Jiangjun (First-Class General)	360	Rank 10
10	Fuguo Jiangjun (Second-Class General)	260	Rank 11
11	Fengguo Jiangjun (Third-Class General)	160	Rank 12
12	Feng'en Jiangjun (Fourth-Class General)	110	One eligible son may continue at the floor by examination; other sons may enter idle clansman status; rules varied by period

iron-cap princes followed standard demotion trajectories like all other imperial clansmen. This mechanism explains why iron-cap lineages did not experience population explosions despite perpetual princely status—the exemption preserved one title per generation, not unlimited high-status positions. The distinction between main-line perpetuity (which the iron-caps enjoyed) and universal perpetuity (which the Ming granted) appears central to the difference in population outcomes.

See Tables14,15 and16.

Table 14 Rank-category fertility regression (OLS, with Lineage FE)

Rank Category	Coef. vs. Idle Clansmen	SE
Prince (wang)	5.032***	(0.413)
Prince (junwang)	3.405***	(0.445)
Beile	2.898***	(0.505)
Beizi	3.506***	(0.665)
Duke (gong)	2.631***	(0.218)
General (jiangjun)	2.315***	(0.083)
Commandant (zhongwei)	2.292***	(0.162)
Other Official	2.060***	(0.037)
Idle Clansmen (reference)	–	–
Generation FE	Yes	Yes
Birth Cohort FE	Yes	Yes
Lineage FE	Yes	Yes
N	69,993	

*** $p<0.001$, ** $p<0.01$, * $p<0.05$. Robust (HC) standard errors in parentheses. Dependent variable is number of sons. Reference category is idle clansmen (xiansanzongshi). Sample: births 1650–1900 with non-missing father record (N = 69,993). Specification absorbs generation FE, birth-decade FE, and lineage FE (father-name clusters). The gradient is broadly monotonic across noble ranks (wang through commandant). The minor exception—beizi (3.506) exceeding beile (2.898) and junwang (3.405)—reflects the small beizi sample (N = 38 in the estimation sample) and does not affect the overall pattern, which is inconsistent with a pure threshold model in which only the ranked/unranked boundary matters

Table 15 Balance test—probability of missing death year by rank

	(1)	(2)
Panel A: Titled noble indicator		
Titled noble (= 1 if any noble rank)	−0.208***	
	(0.007)	
Panel B: Individual rank indicators		
Note: Bracketed rank numbers in Panel B are ordinal positions within the twelve substantive noble titles (excluding Shizi and Changzi) and therefore differ from the fourteen-rank numbering used in Table 13 *and the main text*		
Qinwang / Prince (Rank 1)		−0.217*** (0.025)
Junwang / Commandery Prince (Rank 2)		−0.192*** (0.032)
Beile (Rank 3)		−0.135*** (0.047)
Beizi (Rank 4)		−0.218*** (0.039)
Feng'en Zhenguo Gong (Rank 5)		−0.235*** (0.049)
Feng'en Fuguo Gong (Rank 6)		−0.200*** (0.029)
Buru Bafen Zhenguo Gong (Rank 7)		−0.337*** (0.083)
Buru Bafen Fuguo Gong (Rank 8)		−0.205*** (0.065)
Zhenguo Jiangjun (Rank 9)		−0.230*** (0.027)
Fuguo Jiangjun (Rank 10)		−0.243*** (0.019)
Fengguo Jiangjun (Rank 11)		−0.190*** (0.016)
Feng'en Jiangjun (Rank 12)		−0.199*** (0.011)
N	84,724	84,724
R-squared	0.407	0.407
Birth decade FE	Yes	Yes
Generation FE	Yes	Yes
Mean dep. var	0.522	0.522
Joint F-test (all rank = 0)		78.075
Joint F *p*-value		< 0.001

OLS regression of an indicator for missing death year on rank indicators (Panel B) or a titled noble indicator (Panel A), birth cohort decade fixed effects, and generation fixed effects. Standard errors clustered at the line-age level in parentheses. Sample: N = 84,724 (individuals with non-missing birth year and generation). Mean of dependent variable = 0.522. This mean refers to the broader Table 15 sample; within the birth-restricted sample used in the main text (born 1650–1900), the missingness rate is approximately 45 percent, as reported in Sect. 5.4.1. Titled nobles have significantly lower rates of missing death year (approximately 20 percentage points lower), consistent with more complete recording of prominent lineage members in the Yudie. Sons are entered under the father's record at registration, so the completeness of paternal death-year recording does not mechanically determine whether the father's sons are enumerated, though it may proxy for overall recording quality; the age-at-death analysis in Sect. 5.4.3 partially probes this concern. The rank coefficients in Panel B are negative and of similar magnitude across all twelve rank categories (range: −0.135 to −0.337), with no clear monotonic ordering across ranks. This contrasts with the fertility premium, which follows a near-monotonic rank gradient (Fig. 3 and Appendix Table 14); recording-quality differences nevertheless cannot be excluded. *** $p<0.001$, ** $p<0.01$, * $p<0.05$

Table 16 Noble rank and marriage probability

	(1)	(2)
Noble title (twelve ranks)	0.545*** (0.015)	
Has Rank (any rank or office)		0.484*** (0.004)
Estimator	Probit (AME)	OLS
Generation FE	Yes	Yes
Mean dep. var	0.468	0.468
N	70,589	70,589

The dependent variable is an indicator equal to 1 if at least one wife is recorded in the individual's Yudie entry (mean = 0.468). Column (1) reports the average marginal effect of a noble-title indicator from a probit model; the indicator equals 1 for holders of the twelve noble ranks listed in Table 15, Panel B (N = 1811 in the estimation sample). Column (2) reports the coefficient from a linear probability model using the broader Has Rank indicator employed in Table 3 (=1 if any rank or office is recorded; N = 6435 in the estimation sample). Both specifications include generation fixed effects and are estimated on the sample of individuals born 1650–1900 with non-missing paternal-line information (N = 70,589). Heteroskedasticity-robust standard errors in parentheses. Adding birth-decade fixed effects to the two specifications yields 0.530 and 0.475, respectively. *** $p<0.001$

Appendix B: Population time series data

B.1 Song dynasty clan population estimates

See Table17.

The Jingkang catastrophe killed or captured approximately 95% of the clan, demonstrating the vulnerability of concentrated populations to external shock.

Table 17 Song dynasty clan population estimates

Year	Period	Population	Source	Notes
960	Founding	~20	Inference	Brothers and sons
1022		~1200	Court records	Living males only
1064	Zhiping 1	~2000	Official count	Males aged 5+
1085	Yuanfeng 8	~5000	Court records	Rapid growth period
1100	Yuanfu 3	~8000	Estimate	
1125	Xuanhe 7	~20,000	Chaffee	Pre-Jingkang peak
1127	Jingkang 2	~500	Court records	Post-catastrophe
1181	Chunxi 8	21,666	Cumulative	Including deceased
1233	Shaoding 6	1427	Quanzhou records	Branch only
1276	End	~3000	Estimate	Much reduced

B.2 Ming dynasty clan population estimates

See Table18.

Growth rates varied by period, accelerating during the mid-dynasty fiscal crisis as provincial administrations lost ability to verify claims.

Table 18 Ming dynasty clan population estimates

Year	Reign	Registered	Growth rate	Multiple
1368	Hongwu 1	~50	–	1×
1398	Hongwu 31	~200	4.7%/year	4×
1450	Jingtai 1	~2000	4.5%/year	40×
1500	Hongzhi 13	~5000	1.8%/year	100×
1529	Jiajing 8	8214	1.7%/year	164×
1553	Jiajing 32	19,611	3.6%/year	392×
1565	Jiajing 44	28,840	3.2%/year	577×
1595	Wanli 23	157,000+	5.9%/year	3140×
1620	Wanli 48	~300,000	2.5%/year	6000×
1644	Chongzhen 17	~800,000 (extrapolated, unreliable)	4.1%/year	16,000×

B.3 Qing clan population: documented anchor points

See Table19.

Only two points in the Qing series are documented, both reported by Rawski (1998, p. 93): 419 registered male clansmen in 1660 and 16,454 in 1915. The two endpoints imply a compound annual growth rate of approximately 1.5 percent, the rate used for the geometrically interpolated Qing series in Fig. 2; intermediate values on that path are interpolations and are not offered as historical counts. For the share of clansmen without rank or office we rely on countable quantities rather than reconstructed stocks: 91.8 percent of the 87,318 records in our dataset carry no rank or office (a cumulative registry share, not a point-in-time stock), and Jiang (1986, p. 53, Table 5) documents a 91 percent untitled share among males of the Qianlong generation (2277 of 2498), based on full Yudie counts. Jiang's unit is the patrilineal generation rather than a birth cohort or a point-in-time stock, and his tabulation excludes clansmen expelled from the registry for criminal offenses; the two figures are nonetheless consistent in direction and magnitude.

Table 19 Documented anchor points, Qing clan population

Year	Reign	Recorded population
1660	Shunzhi 17	419 male clansmen
1915	Post-abdication count	16,454 male clansmen

Appendix C: Fiscal impact data

C.1 Ming clan stipend expenditure

See Table20.

By the early seventeenth century, nominal clan stipend obligations exceeded total national grain tax revenue (108 percent by 1614; 143 percent by 1624). These figures are Zhang Dexin's entitlement-basis calculations, which assume full statutory payment to the registered clan population; actual disbursements fell substantially short, with stipends increasingly discounted, commuted, or simply unpaid (Zhang Dexin 1988, p. 80). Ratios are reproduced as printed in the source; we note that Zhang's printed ratio for 1624 (143.3 percent) is inconsistent with his own numerator and denominator as printed (39,672,144 and 25,793,645 shi, which imply 153.8 percent), an inconsistency internal to the source.

Regional variation was extreme. Shanxi province, home to multiple princely establishments, faced clan stipend obligations of 3.12 million shi against retained local grain revenue of 1.52 million shi—more than double the province's retained revenue (Zhang Dexin 1988, p. 80).

Table 20 Ming clan stipend expenditure

Year	Stipends (million shi)	Tax Revenue (million shi)	Share
1562	8.53	22.85	37.3%
1565	8.60	22.85	37.7%
1569	8.48	26.82	31.6%
1571	8.62	26.82	32.1%
1594	18.48	28.37	65.1%
1604	23.84	28.37	84.0%
1614	30.75	28.37	108.4%
1624	39.67	25.79	143.3%

C.2 Qing clan expenditure

Systematic fiscal data for aggregate Qing clan expenditure are not readily available: surviving records document stipend schedules, individual-level disbursements, and Imperial Clan Court treasury flows rather than dynasty-level totals as a share of state revenue (Lai 1997).

Surviving records do not document a Ming-style fiscal crisis arising from Qing clan obligations, but they do not permit a like-for-like comparison of aggregate fiscal shares.

Appendix D: Comparative institutional analysis

D.1 Cross-dynasty institutional comparison matrix

A systematic comparison of institutional features across all seventeen dynasties reveals the complex interactions between rank structure, demotion rules, and fiscal models.

See Table21.

Several patterns emerge from this comparison:

First, dynasties that achieved controlled clan populations either avoided central fiscal responsibility (Yuan's appanage system), implemented demotion mechanisms (Tang, Qing), used non-hereditary status (Song), or created scattered titles (Northern Wei, Northern Qi). Among the cases with documented population

Table 21 Cross-dynasty institutional comparison matrix

Dynasty	Ranks	Demotion	Exit rule	Scattered	Central fiscal	Exam filter	Outcome
Qin	20	No	Merit-based	No	No	No	Controlled
W. Han	20	Tui'en	No	No	Partial	No	Subdivided
E. Han	15	Partial	No	No	Partial	No	Moderate
Cao Wei	17	No	No	No	Yes	No	Unknown
W. Jin	18	No	No	No	Partial	No	Unknown
Chen	12	No	No	No	Yes	No	Unknown
N. Wei	22+	No	Partial	Yes	Partial	No	Controlled
N. Qi	18	No	No	Yes	Yes	No	Controlled
N. Zhou	11	No	No	No	Yes	No	Unknown
Sui	12	No	No	No	Yes	No	Unknown
Tang	9–11	Yes	Yes (5 gen)	No	Yes	No	Controlled
Song	12	No	Non-hereditary	No	Yes	No	Controlled
Liao	15	No	No	No	Partial	No	Unknown
Jin	15	No	No	No	Yes	No	Unknown
Yuan	8	No	No	No	No (appanage)	No	Dispersed
Ming	8	No	No	No	Yes	No	Explosion
Qing	14	Yes	Via exam (to idle status)	No	Yes (titled)	Yes	Controlled

outcomes, no dynasty relying on central fiscal support without some control mechanism avoided population problems in the long run.

Second, the Ming stands alone in combining central fiscal responsibility with universal eligibility and no exit-producing demotion mechanism. This combination proved uniquely disastrous.

Third, examination filtering appears only in the Qing, though merit-based selection existed under Qin in a different form. The Qing innovation was applying examination requirements to inheritance rather than initial appointment.

D.2 Institutional innovation trajectories

Chinese noble rank institutions evolved through several distinct phases:

Phase 1: Merit Revolution (Qin, 221–206 BCE) The Qin fundamentally transformed Chinese nobility by making status contingent on demonstrated military achievement. This revolution established the principle that noble status required justification beyond birth—a principle that, while often honored in the breach, shaped all subsequent Chinese institutions.

Phase 2: Feudal Compromise (Han, 206 BCE–220 CE) The Han restored hereditary nobility for imperial relatives and meritorious generals while maintaining merit ranks for broader advancement. The tension between hereditary and meritocratic principles generated institutional innovations like the Tui'en decree that sought to preserve legitimacy benefits while preventing dangerous accumulation.

Phase 3: Scattered Title Innovation (Northern Dynasties, 386–589 CE) The conquest dynasties of the Period of Disunion developed scattered titles as a mechanism for maintaining status hierarchies without proportional fiscal commitment. This innovation addressed the fundamental trade-off between legitimacy (requiring generous recognition) and fiscal sustainability (requiring limited expenditure).

Phase 4: Demotion and Exit (Tang, 618–907) The Tang systematized demotion as a central feature of clan management. Combined with the five-generation exit rule, this created automatic population control through institutional design rather than ad hoc adjustments. However, the exit rule may have created legitimacy costs by formally severing clan connections.

Phase 5: Non-Hereditary Status (Song, 960–1279) The Song approach—treating clan members as a specialized category of officials with lifetime appointments—represented an alternative to both hereditary nobility and automatic demotion. This preserved imperial prerogative over status allocation while avoiding the accumulation problems inherent in hereditary systems.

Phase 6: Minimal State (Yuan, 1271–1368) The Yuan's appanage system delegated clan management to territorial self-financing, minimizing central involvement. While effective at limiting fiscal exposure, this approach required accepting territorial fragmentation and reduced central control.

Phase 7: Catastrophic Centralization (Ming, 1368–1644) The Ming combined the worst features of previous systems: central fiscal responsibility without exit-producing demotion, universal eligibility without filtering, and hereditary status without

exit. The result was predictable in retrospect but apparently not anticipated by the founding generation.

Phase 8: Learning and Synthesis (Qing, 1644–1912) The Qing synthesized lessons from earlier dynasties, combining central fiscal control (unlike Yuan) with demotion (like Tang) and examination filtering (innovation). The registered population remained controlled over nearly three centuries.

D.3 Why might the Qing have avoided the Ming pattern?

The question naturally arises: why did Qing founders avoid Ming mistakes when Ming founders had equally available historical examples to draw upon?

Several factors may explain the difference:

Proximity of Example The Qing founders directly observed Ming decline, including the fiscal strain imposed by clan obligations. This recent, vivid example may have been more influential than ancient precedents available to the Ming founder.

Outsider Status Both Ming and Qing founders were outsiders to the systems they replaced—Zhu Yuanzhang a peasant rebel, the Aisin Gioro a Manchurian clan. However, the Qing inherited a functioning Ming administrative apparatus including officials who understood Ming problems. The Ming founder had no such institutional inheritance.

Coalition Requirements The Qing needed to reward Manchu military aristocracy whose support had been essential for conquest. The eight founding-era iron-cap princely lines represented this founding coalition; four additional lines received hereditary status later. The demotion system may have been more acceptable to this coalition because it preserved their own perpetual status while limiting other claims.

Institutional Capacity The Qing inherited centuries of Chinese administrative development. The examination system, bureaucratic registration, and fiscal apparatus were more sophisticated than those available to the Ming founder. This capacity made elaborate schemes like demotion-with-examination feasible.

Ideological Resources Qing legitimacy rested on conquest and effective governance rather than on generous treatment of imperial relatives. The Ming founder, by contrast, may have felt stronger ideological pressure to care visibly for his kinsmen as demonstration of dynastic virtue.

These factors combined to produce different institutional choices despite superficially similar circumstances. The result was a difference of roughly an order of magnitude in clan population and corresponding divergence in fiscal sustainability.

Appendix E: Bureaucratic grades and scattered ranks

E.1 The three-type framework

Building on Yan Buke's (2023) distinction between "personnel rank classification" and "position classification", we identify three analytically distinct rank systems operating in parallel across Chinese dynasties:

1. Bureaucratic Grades: Classification of official positions.

2. Scattered Ranks: Personal status titles independent of office.
3. Noble Titles: Hereditary honors for imperial kin and meritorious subjects.

Table 22 Evolution of bureaucratic grades

Period	System	Levels	Classification type	Key characteristic
Qin	Military merit	20	Hybrid	Rank-office fusion
Han	Salary grades	17–18	Position-based	"Office without rank"
Cao Wei	Nine grades	9	Transitional	Nine-rank system begins
N. Wei	Subdivided grades	30	Personnel-based	Maximum subdivision (post-reform)
Sui-Tang	9 grades, 18 levels	18	Personnel-based	"Rank-office separation"
Ming–Qing	9 grades, 18 levels	18	Mixed	Simplified scattered ranks

E.2 Evolution of bureaucratic grades

See Table22.

E.3 Tang scattered ranks: peak complexity

The Tang dynasty developed the most elaborate scattered rank system in Chinese history:
Civil Scattered Ranks: 29 levels.

— Grand Preceptor class: Ranks 1–2
— Grand Master class: 11 titles including kaifu yitong sansi, tejin, guanglu dafu, etc.
— Gentleman class: 16 titles from chaosan dafu down to jiangshi lang

Military Scattered Ranks: 29 levels.

— From Grand General (piaoji dajiangjun) at the top
— Through various general and commandant titles
— Down to Deputy Lieutenant (ling) at the bottom

Total Tang Rank Complexity: Approximately 100 distinct levels.

— Functional offices: 18 levels
— Civil scattered ranks: 29 levels
— Military scattered ranks: 29 levels
— Imperial clan titles: 11 levels
— Meritorious nobility: 9 levels

E.4 The historical trajectory

The evolution of rank systems followed a clear pattern reflecting changing relationships between status and function:

1. Zhou Dynasty: Noble ranks as primary status markers, tied to feudal landholding and military obligation.

2. Qin Dynasty: Revolutionary military merit system—rank advanced with enemy heads taken in battle, each grade carrying corresponding privileges (Appendix A.1).

3. Han Dynasty: Ranks devalue through mass grants and sales; salary grades become dominant.

4. Wei-Jin Period: Aristocratic revival through Nine-Rank Zhongzheng System; personnel classification resurges.

Tian Yuqing's (2012) seminal study of Eastern Jin "gate-valve politics" clarifies this transition. He argues that true aristocratic shared governance existed only during the Eastern Jin century (317–420), representing an aberration from imperial autocracy. Before (Sun Wu) and after (Southern Dynasties), apparent aristocratic dominance masked underlying imperial supremacy. The maintenance of balance among powerful families paradoxically stabilized the Jin court for over a century, while the Southern Dynasties' return to unchecked imperial power produced frequent succession crises. This insight illuminates elite management: systems constraining the emperor may actually strengthen dynastic stability.

5. Northern Dynasties: Scattered titles proliferate; distinction between shishi (income-bearing) and sanshi (honorary) titles.

6. Sui-Tang: Peak of personnel classification; elaborate parallel hierarchies.

7. Song-Yuan: Gradual simplification; scattered ranks lose practical significance.

8. Ming–Qing: Hybrid systems maintained; scattered ranks simplified while other control mechanisms develop.

E.5 Implications for noble rank analysis

This broader context illuminates why different dynasties chose different rank structures:

Personnel-based eras (Wei-Jin, Tang) saw rank proliferation across all three types—bureaucratic, scattered, and noble. Status hierarchies became elaborate because status itself was the primary currency of politics.

Position-based eras (Han, late Qing) saw simpler rank structures. When function mattered more than status, elaborate gradations became unnecessary.

Table 23 Ming vs. Qing Demotion Systems (Wang and Xu 2021a, 2021b)

Dimension	Ming (Horizontal)	Qing (Vertical)
Demotion pattern	Parallel tracks: main line perpetual, collateral lines demote	Graded demotion by heir status, maternal status, examination outcome, and period; twelve iron-cap lines exempt; hereditary floors for some grace-enfeoffed lines from 1774
Number of ranks	8 (qinwang to fengguozhongwei)	12–14 (heshuo qinwang to feng'en jiangjun)
Main line inheritance	Perpetual (shixi wangti) for all princes	Graded demotion; perpetual for the twelve iron-cap lines, with hereditary floors halting descent for some grace-enfeoffed lines after 1774
Floor mechanism	Fengguozhongwei: 200 shi/year, permanent	Xiansanzongshi: 3 taels/month, minimal
Exit mechanism	None: "not reduced to commoners"	Yes: descent to idle status (~89% by the Qianlong era; ~92% cumulative)
Examination filter	None	Required for title inheritance (kaofeng)
Younger sons' treatment	Equal treatment regardless of maternal status	Differentiated by maternal status (di/ce/shu)
Population outcome	157,000+ (1595, last reliable count)	16,454 male clansmen (1915)

The Ming–Qing contrast fits this pattern: Ming's eight-rank system for imperial clan was position-based in spirit (everyone at the bottom rank got the same stipend), while Qing's fourteen-rank system was personnel-based (elaborate distinctions in privilege and status). The critical difference was that Qing combined personnel-based complexity with mandatory demotion, achieving both symbolic richness and fiscal sustainability.

See Table23.

Appendix F: Derivation of the steady-state condition

This appendix derives formally the conditions under which the modeled titled population reaches a finite steady state versus grows without bound, corresponding to the Qing and Ming institutional scenarios respectively described in Sect. 4.

F.1 Model setup

Consider a dynasty with n noble ranks indexed $i = 1$ (highest) to n (lowest). Let b_i denote the benefit associated with rank i, with benefits strictly decreasing: $b_1 > b_2 > \cdots > b_n > 0$. Let f(b) be the fertility function, strictly increasing in b, with $f(b) > 0$ for all $b > 0$. The assumption that f is increasing in b is supported by the micro-level evidence in Sect. 5.4: empirically, the benefit gradient is associated primarily with marriage-market access rather than with biological fecundity per se, since rank determined stipend entitlements that in turn governed the ability to contract polygynous marriages. The function f(b) should therefore be interpreted as capturing this reduced-form relationship between rank-associated benefits and completed male fertility, aggregating across the marriage-access and direct-income channels documented in Sect. 5.4.4. Let $I > 0$ denote the exogenous flow of new appointments to rank 1 per generation (imperial favor, examination success at the top). Crucially, I represents a per-generation flow of new creations—not the stock of rank-1 holders. In the Qing context, this corresponds to the rate at which the emperor created new Princes of the First Rank (Qinwang) through fresh enfeoffment; we do not assign a numerical value to I, since the annual rate of fresh enfeoffment is not documented in the sources available to us. The assumption $P_1(t) = I$ (rank-1 population fixed at the inflow) is a simplifying approximation that treats the rate of new imperial appointments as roughly constant—reasonable for a steady-state characterization of the Qing system at equilibrium, though the actual stock of rank-1 nobles grew modestly over the dynasty as multiple successive lines of iron-cap princes accumulated. For the purposes of deriving steady-state comparative statics, this approximation does not affect the qualitative results. Let $P_i(t)$ denote the population at rank i in generation t. Two institutional parameters govern descent: $d \in \{0,1\}$ (demotion, $d = 1$ means sons inherit rank i+1) and $e \in [0,1)$ (examination filter, fraction e of candidates fail and exit the titled system).

F.2 Case 1: No demotion, no examination (Ming Scenario, d = 0, e = 0)

Without demotion, each rank-i noble has $f(b_i)$ sons who inherit rank i unchanged. The transition equation for each rank is:

$$P_i(t+1) = f(b_i) \cdot P_i(t) \tag{F.1}$$

Solving by iteration:

$$P_i(t) = f(b_i)^t \cdot P_i(0) \tag{F.2}$$

Since benefits are positive at every rank, $f(b_i) > 1$ whenever resources are sufficient to support above-replacement fertility. Under the Ming system, where every male descendant received at minimum 200 shi annually, this condition held across all ranks. Therefore $P_i(t) \to \infty$ as $t \to \infty$ for every rank i. Total clan population $N(t) = \Sigma P_i(t)$ grows without bound—the explosion result.

F.3 Case 2: Full demotion with examination filter (Qing Scenario, d = 1, e > 0)

This case is a simplified exit benchmark rather than a description of the full Qing rules: it abstracts from succession by one qualified son at the lowest titled rank, from the hereditary floors introduced for grace-enfeoffed lines in 1774, and from the grading of awards by heir designation and maternal status (Appendix A.3). With mandatory demotion, sons of a rank-i noble are assigned to rank i+1. Of these, only a fraction $(1 - e)$ pass the examination requirement and enter the titled system. Descendants falling below rank n exit the titled hierarchy entirely. Rank 1 is replenished each generation by exogenous appointments I. The transition equations are:

$$P_1(t) = I(exogenous, fixed) \tag{F.3}$$

$$P_i(t+1) = (1-e) \cdot f(b_{i-1}) \cdot P_{i-1}(t), \quad for\, i = 2, 3, \ldots, n \tag{F.4}$$

Define the effective reproduction factor at rank i:

$$\lambda_i \equiv (1-e) \cdot f(b_i), \quad for\, i = 1, 2, \ldots, n-1 \tag{F.5}$$

The transition equation (F.4) can be written as $P_i(t+1) = \lambda_{i-1} \cdot P_{i-1}(t)$.

F.4 Derivation of the steady-state population

At steady state, $P_i(t+1) = P_i(t) = P_i^*$ for all i. Applying this to equation (F.4):

$$P_i * = \lambda_{i-1} \cdot P_{i-1} *, \quad for\, i = 2, \ldots, n \tag{F.6}$$

Solving recursively from $P_1^* = I$:

$$P_2 * = \lambda_1 \cdot I \tag{F.7}$$

$$P_3 *= \lambda_2 \cdot P_2 *= \lambda_1 \lambda_2 \cdot I \tag{F.8}$$

$$P_i *= I \cdot \prod_{k=1}^{i-1} \lambda_k, where \prod_{k=1}^{0} \lambda_k \equiv 1 (empty\, product) \tag{F.9}$$

The total steady-state titled population is therefore:

$$N *= \Sigma_{i=1}^{n} P_i *= I \cdot \Sigma_{j=0}^{n-1} \prod_{k=1}^{j} \lambda_k \tag{F.10}$$

Expanding the outer sum explicitly: the j = 0 term contributes I (rank 1 alone), the j = 1 term contributes $I\lambda_1$, the j = 2 term contributes $I\lambda_1\lambda_2$, and so on. Since n is finite and all λ_i are finite, N* is always finite and well-defined. This is the fundamental contrast with the Ming case: the exit at rank n converts geometric explosion into a bounded, finite equilibrium.

F.5 The stability condition

Equation (F.10) shows that N* is finite for any finite n. The economically relevant question is whether N* is small enough to remain fiscally sustainable—that is, whether modeled titled-system expenditure remains below a fiscal ceiling Φ. Define per-capita titled-system cost c_i at rank i (stipend plus administrative costs). Total fiscal cost at steady state is:

$$C *= \Sigma_{i=1}^{n} c_i \cdot P_i *= I \cdot \Sigma_{i=1}^{n} c_i \cdot \prod_{k=1}^{i-1} \lambda_k \tag{F.11}$$

Fiscal sustainability requires $C^* \leq \Phi$. This places a joint constraint on the institutional parameters (n, e) and the benefit structure (b_i). In particular, the steady state is fiscally sustainable if and only if:

$$I \cdot \Sigma_{i=1}^{n} c_i \cdot (1-e)^{i-1} \cdot \prod_{k=1}^{i-1} f(b_k) \leq \Phi \tag{F.12}$$

Two institutional levers reduce C*: (1) increasing examination stringency e, which multiplies each λ_i by (1−e) and shrinks the population at every rank below rank 1; and (2) reducing benefits b_i at lower ranks, which lowers $f(b_i)$ and hence λ_i. As with N*, adding a rank with positive benefits and positive cost mechanically adds a positive term to C*; the fiscal role of a finer gradation is instead to permit benefits to be stepped down more steeply along the demotion path. The Qing system combined both levers within a fourteen-rank gradation—mandatory examination and a steep stipend gradient (91:1 across the titled ranks, extending to 278:1 when the idle clansman stipend of approximately 36 taels is included)—while the Ming employed neither examination-based exclusion nor an exit from

the stipended hierarchy: its stipend schedule also declined across ranks (50:1 from prince to the lowest commandant) but terminated in a positive hereditary floor.

F.6 Comparative statics

To see how N* responds to changes in institutional parameters, differentiate equation (F.10) with respect to e. Since $\lambda_i = (1-e)\cdot f(b_i)$, we have $\partial\lambda_i/\partial e = -f(b_i) < 0$. It follows immediately that $\partial N^*/\partial e < 0$: stricter examination reduces the modeled titled population. Similarly, $\partial N^*/\partial b_i > 0$ for all $i < n$: raising benefits at any rank above the exit tier increases fertility there and expands downstream titled populations (the bottom rank benefit b_n affects only the exiting cohort and does not enter N*). And adding an additional rank n+1 before the exit point adds term $I\cdot\prod_{k=1}^{n}\lambda_k > 0$ to N*, so N* is strictly increasing in n—more ranks with positive benefits increase the total population at steady state.

These comparative statics formalize the population-cost side of Propositions 1 through 3 in Sect. 3.5 (the governance-benefit side of Proposition 1 is qualitative and lies outside the model): additional ranks with positive stipends raise the steady-state total; examination stringency provides a direct lever on N* independently of rank structure; and benefit reductions at lower ranks are amplified through the cascade, reducing downstream populations multiplicatively rather than additively.

F.7 Parameter values and model scope

This subsection records the scope of the model when relating it to the Qing case; we do not attempt a quantitative calibration. We leave n generic because the historically branching Qing succession system cannot be mapped cleanly onto a single linear rank chain. We report the comparative statics symbolically rather than fixing numerical values for the examination parameter e or the inflow I, for which we have no documented source. We caution that the model characterizes the stock of titled clansmen only: the registered population totals reported in Appendix B combine titled nobles with the far larger idle clansman population, whose fertility the model does not represent, and are therefore not directly comparable to the model's steady-state object. A quantitative calibration matching the full registered series would require modeling the idle clansman state explicitly, which we leave to future work.

Funding No specific funding was received for this study.

Data availability The Yudie data underlying this study are available from the corresponding author upon reasonable request.

Declarations

Conflict of interest The author has no competing interests to declare that are relevant to the content of this article.

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