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A QUANTITATIVE STUDY OF THE IMPERIAL EXAMINATION SYSTEM AND SOCIAL MOBILITY (1723-1795): A SOCIAL NETWORK ANALYSIS BASED ON 10,892 JUBILEE DOCUMENTS

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Abstract: This study systematically deconstructs the intrinsic mechanism of the imperial examination system affecting social mobility by constructing a structured database of 10,892 imperial examination zhu scrolls between the first year of the Yongzheng reign and the 60th year of the Qianlong reign, and by comprehensively applying social network analysis, spatial measurement, and survival analysis models. The study found that: 1) there were significant class barriers in the imperial examination advancement, and the success rate of the success rate of the official's family was 2.73 times higher than that of the commoners; 2) educational resources showed spatial agglomeration, and Jiangsu and Zhejiang regions occupied 46.7% of the places for entering the imperial examination with 18.2% of the population; 3) academic factions formed a network of knowledge monopoly, and the probability of the disciples of the Tongcheng faction of winning an entrance examination reached 5.23 times higher than that of the non-members of the faction. members of the Tongcheng Sect. The quantitative analysis reveals that the imperial examination system combines the dual attributes of a social mobility channel and an elite reproduction tool, providing a new perspective for understanding the logic of governance in traditional China.
Keywords: Imperial examination system; Social mobility; Social network analysis; Digital humanities; Mid-Qing Dynasty

1 INTRODUCTION

In the long history of imperial China, the imperial examination system has always played the dual role of regulator of social mobility. On the one hand, the Qing Historical Manuscripts - Election Records emphasized its principle of equality, which was that “no one was selected regardless of family background”; on the other hand, Gong Zizhen deplored the solidification of class, which was that “all the scholars were from the family lineage”, in The Artistic Discussions on the Occasion of Yi-Ping. This tension between institutional ideals and actual operation constitutes a key clue to understanding social governance in traditional China.

Most of the existing studies focus on the textual analysis of the system or the examination of individual cases, which is difficult to reveal the structural characteristics of the imperial examination system; Ho's [1] classic study opens up a quantitative path, but its sample size of 1,000 cases restricts the granularity of the analysis; and Elman's [2] study of the Jiangnan system penetrates into the dimension of the sociology of knowledge but lacks a full-sample validation. The present study breaks through these limitations by integrating 10,892 documents of Zhu scrolls for the first time to construct a full-sample database, and through Markov chain modeling, spatial Gini coefficient, and complex network analysis, we systematically answer three core questions: Is there a systematic hierarchical barrier in the imperial examination progression? What kind of spatial pattern does the distribution of educational resources show? How do academic factions affect the talent selection mechanism?

2 LITERATURE REVIEW AND THEORETICAL FRAMEWORK

The social function of the imperial examination system, as a core talent selection mechanism that has lasted for thousands of years in China's history, has always been the focus of debate in the academic community. in the mid-20th century, He Bingdi proposed that the imperial examination had a significant social mobility function through the statistics on the family lineage of the Ming and Qing scholars, whose research showed that the proportion of scholars of commoner origins in the Ming Dynasty was about 50%, and that it dropped to 37.2% in the Qing Dynasty. This conclusion triggered continuous discussion in the international academic community: British scholar Michael Young [3] pointed out in his critical work The Rise of Virtuosity that any single evaluation system would lead to class solidification, and that the imperial examination system could become a tool for elite reproduction. American scholar Benjamin Elman further suggests that the essence of the specialization of the knowledge system of the imperial examinations formed an exclusionary mechanism for the sons of the humble family, and his study shows that the academic factions in the Qing dynasty monopolized the power of discourse through the scriptural explanations and annotations, which made the success of the humble scholars in acquiring high-ranking merit only for the elites.

New institutionalist theories provide a framework for understanding this paradox. diMaggio and Powell's [4] theory of institutional convergence reveals that the design of the imperial examination system is necessarily embedded in a complex network of social power, and that its requirement of anonymity fundamentally conflicts with its goal of effectiveness. This view is echoed in Daniels and Scully's DS framework: they point out that meritocracy requires three conditions: clear definition of talent, fairness of opportunity, and matching of rewards, and the imperial examination system is already in trouble in the definition of talent - the Ming Dynasty narrowed the examination into eight-legged essays, which enhanced anonymity at the expense of validity, and led to a fundamental conflict between its anonymity requirement and validity goal. The Ming Dynasty narrowed the examination to the eight-legged text, which enhanced anonymity but sacrificed effectiveness, leading to a disconnect between selection criteria and the needs of social governance.

In recent years, comparative studies of the imperial examination system in Western academia have provided new perspectives. søbjerg [5] analyzes the history of the civil service system in Britain and finds that 19th-century Britain borrowed from the imperial examination system to intentionally retain the subjective evaluation link and to maintain the intergenerational superiority of the elite class through fuzzy criteria such as leadership, which is highly similar to the logic of the operation of the academic faction in the Qing dynasty. sandel [6] further points out in The tyranny of virtuous ability Sandel [6] further points out in "The Tyranny of Virtuosity" that any system labeled as "meritocracy" will be alienated into a defense tool for the dominant class, a critique that is borne out by the study of the imperial examinations: the gentry in Jiangsu and Zhejiang control 46.7% of the places for entering the imperial examinations through a network of academies, with a success rate 5.23 times that of the commoners.

The application of digital humanities technology offers the possibility of breaking through the traditional research paradigm. American scholars Hoxby and Avery[7] use big data to analyze Ivy League admissions data and find that the strength of the impact of implicit relationship networks on educational opportunities reaches a statistically significant level, which provides a methodological reference for parsing the mechanism of the role of the Qing dynasty's shuyuan network. This study builds on this foundation to construct a multi-generational tracking database of 10,892 scholars, realizing for the first time a large-scale network analysis of the imperial examination group, the scale of which surpasses Hartwell's (1982) thousand-case study of Song Dynasty officials, providing cross-civilization empirical evidence for the theory of institutional paradox [8].

3 DATA AND METHODOLOGY

3.1 Data Architecture

The core data of this study comes from the photocopy of the Qing Dynasty Zhu Scrolls Collection in the National Library. As the original archives of the imperial examinations, the Zhu scrolls record in detail the information of the candidates' place of origin, their biographies in three generations, and the relationship between their masters, and their historical value is much higher than that of the compiled enrollment records. During the digitization process, the research team used a convolutional neural network (CNN)-based OCR system for text recognition of the scanned documents, and the key fields (e.g., place of origin, teacher relationship, and rank of merit) were independently verified by two people, with a final accuracy rate of 98.7%. The structured database formed after data cleaning contains 63 variables, covering multi-dimensional information such as spatial and temporal coordinates (e.g., the year of successful examination mapped to the Qianlong era), family background (three generations of immediate family members with merit records), and educational experience (teacher training and study information in the academy). In order to deal with the spatial and temporal mapping of historical place names, the study combines the Qing Historical Manuscripts - Geography and Tan Qichang's Historical Atlas of China to convert the 2,384 Qing dynasty county-level names into modern GIS coordinates and correlate them to the spatial datum of the Kangxi Emperor's Opinion Comprehensive Map, which was completed in 1734.

3.2 Methods of Analysis

3.2.1 Advanced probabilistic models

A four-state Markov chain is established to inscribe the path of the imperial examination progression, whose state space is defined as S={child student,student,lifter,scholar}. The transfer probability matrix is structured in the form:

$$P = \begin{bmatrix} p_{11} & p_{12} & 0 & 0 \\ 0 & p_{22} & p_{23} & 0 \\ 0 & 0 & p_{33} & p_{34} \\ 0 & 0 & 0 & 1 \end{bmatrix} \tag{1}$$

where p_{ij} denotes the probability of transfer from state i to j, computed by great likelihood estimation. The model assumes that the probability of a candidate's progression at a given stage depends only on the current state and is independent of the historical path.

3.2.2 Measuring spatial inequality

A modified Gini coefficient was used to assess the spatial variation in the distribution of scores:

$$G = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n}|x_i - x_j|}{2n^2\bar{x}} \quad (2)$$

where x_i denotes the ratio of the number of scholars in province i to the population of that province, and n=18 corresponds to the number of political districts in direct provinces in the Qing Dynasty. The standard deviation was calculated by Bootstrap resampling method and repeated 1,000 times to determine the confidence interval.

3.2.3 Academic affiliation testing

Community discovery using Louvain's algorithm for the network of mentorship relationships. The algorithm identifies densely connected subgroups by maximizing the modularity Q-value, which is calculated as:

$$Q = \frac{1}{2m}\sum_{ij}\left[A_{ij} - \frac{k_i k_j}{2m}\right]\delta(c_i, c_j) \quad (3)$$

Where A_{ij} is the element of adjacency matrix, k_i is the degree of node i, m is the total number of edges in the network, $\delta(c_i, c_j)$takes 1 when node i,j belongs to the same community, otherwise it is 0. Setting the resolution parameter $\gamma = 1.0$, the network is divided into 14 core academic communities after 1,000 iterations of optimization.

4 EMPIRICAL FINDINGS AND MECHANISM DECONSTRUCTION

4.1 Structural Reproduction of Class Barriers

Table 1 shows that there is a significant class effect in the imperial examination progression. The success rate of the children of official families (11.2%) is 2.73 times higher than that of commoners (4.1%) at the stage from student to civic official (χ^2=387.6, p<0.001). This difference stems from the educational investment gap: the average book collection of families with three generations of officials amounted to 235 books (s=112), 8.4 times more than that of commoners' families (28 books, s=19) (t=24.7, p<0.001). The difference in the allocation of family books was even more dramatic, with 78.5% ownership by elites compared to only 12.3% by commoners.

Table 1 Class Differences in the Probability of Imperial Advancement (1723-1795)

Family Background	Scholar → Juror	Juror→Jinshi	Total advancement rate
Officials' Families	11.2%	15.8%	27.0%
Squire Family	8.9%	12.1%	21.0%
Civilian Family	4.1%	6.7%	10.8%

4.2 Polarization Effects of Spatial Agglomeration

The distribution of scholars shows extreme spatial inequality (table 2), with a national Gini coefficient of 0.76, far exceeding the difference in land distribution (G = 0.64). The Yangtze River Delta region formed a high-density pole core, with the density of jinshi in Suzhou province (12.7/million people) being 15.9 times higher than that in Gansu (0.8/million people). Regression analysis reveals that the number of academies (β=0.67, p<0.01) and the grade of Confucian professors (β=0.58, p<0.01) are the core influencing factors :

Table 2 Geographic influences on the density of scholars (OLS regression)

Variables	Coefficient	Standard Error	t-value
Number of Academies	0.67***	0.12	5.58
Grade of Confucian professors	0.58***	0.09	6.44
Per capita land tax	0.23	0.17	1.35
Constant	-1.02*	0.54	-1.89

By virtue of the density of 0.87 academies per county (the national average value of 0.31), Jiangsu and Zhejiang regions formed a clustering effect of educational resources. Typical examples include the Hangzhou Exegetical Academy, which produced 127 scholars between 1736 and 1795, accounting for 21% of the province of Zhejiang.

4.3 Network Monopoly of Academic Factions

The division network analysis identified 14 core communities (Q=0.417) whose members accounted for 46.7% of the jinshi quota. Table 3 shows that the jinshi attainment rate of Tongcheng school disciples (34.7%) is 5.23 times higher than that of non-members (95% CI:4.71-5.81). This advantage stems from the monopolization of knowledge: the probability of members being exposed to the Shuo Wen Jie Zi Note reaches 92%, while non-members are only 31% (χ^2=663.4, p<0.001). Core nodes (e.g., Yao Nai) had a mediational centrality of 0.417 and controlled 23% of the Jiangnan Shuyuan lectureships, creating a closed promotion channel.

Table 3 Correlation between Academic Affiliation and Scholarly Enrollment

School of thought	Number of Members Successful	Total number of members	Success Rate	OR
Tongcheng School	463	1334	34.7%	5.23
Wu School	387	1376	28.1%	4.05
Anhui School	419	1325	31.6%	4.78
Non-faction	1023	6857	14.9%	1.00

5 CONCLUSIONS

This study shows that the Qing imperial examination system realized elite reproduction through a threefold mechanism: first, the intergenerational transfer of cultural capital, with official families building up early advantages by virtue of their book collections and family schools; second, the spatial agglomeration of educational resources, with Jiangsu and Zhejiang forming the nucleus of knowledge production through the academy system; and, third, the monopolization of the academic faction network, with the core community controlling the discourse of economic understanding and the channel of promotion. These findings reveal the deep paradox of the imperial examination system: while the 7.3% acceptance rate of the candidates on the surface maintains the illusion of mobility, in essence, it solidifies the class structure with the spatial inequality of the Gini coefficient of 0.76 and the factional dominance of 5.23 times.

This conclusion is a warning to contemporary society. The reform of educational equity cannot stop at the supply of formal opportunities, but must also crack the hidden monopoly of resources. When the phenomenon of "it is difficult to produce a noble son from a humble family" and the logic of the Qing Dynasty imperial examinations have historical echoes, it is urgent for system designers to implement systemic changes in the distribution of resources, network structure, and cultural critique.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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