A Study on the Rise of the Urban Class and Changes in Social Structure during Modern Urbanization

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ABSTRACT Accelerated modern urbanization reshaped class structures by weakening traditional agrarian identity boundaries and creating new mechanisms of occupational mobility. This study establishes a multidimensional analytical framework integrating historical bibliometrics, social network analysis, and comparative case analysis to examine the rise of urban classes and social structural change from 1850 to 1950. Population census data, occupational registration files, and social organization records from representative cities were collected and standardized, and the urban class was divided into commercial asset holders, professional and technical personnel, and industrial workers. Network analysis was used to identify class interaction nodes, mobility paths, and the changing strength of cross-class connections. The results show that the overall size of the urban class increased markedly, with professional and technical personnel exhibiting the most rapid expansion, closely associated with technical education and demand for engineers. The findings reveal the internal logic of urban structural reorganization and provide a data-driven spatial reference for urban governance, communication infrastructure planning, and propagation-aware urban service networks.

INDEX TERMS urbanization,social network analysis,urban spatial modelling,communication infrastructure,data-driven evaluation

I. INTRODUCTION

THE mass movement of population to urban areas caused by the Industrial Revolution disrupted the old hierarchical system grounded in land and the appearance of new groups of professionals was in fierce conflict with the old order of power. The initially agrarian population had already turned into an urban one, and yet the institutional machinery involved in identity change was falling hopelessly behind, causing the closure of the social ladders. Merchants, craftsmen, lawyers, engineers and other professional groups quickly accumulated in urban areas, but there were no distinct norms of belonging to a particular class and principles of interaction. This imbalance of structures caused identity crisis, aggravation of contradictions of interests, and problems with social integration, and It is high time that conduct systematic research to understand the inner process of urban classes formation. Knowledge of this historical process, not only assists in the explanation of the source of modern social stratification, but also a historical reflection of the issue of solidification of classes encountered by modern urbanization [1,2].

There are even some debates existing in academic circle about the formation path of urban class. The economic determinism holds that capital accumulation plays a key role in class differentiation. The cultural theorists stress the constraining effect of popularization of education and ideological change exerts. The institutional theorists hold that the legal system exerts constraining effect on social mobility. Most of the existing studies focus on one city or one period, which is not conducive to reflect the internal differentiation logic of urban class, formation and change of cross class interaction network, and the interaction logic of multiple constraints such as education, organization, space etc. and build an integrated analytical framework to explain the reorganization of social structure.

12 cities were chosen as samples, which exhibit large differences in the process of industrialization for long term (more than 100 years, from 1850 to 1950). The methods of historical bibliometrics, social network analysis and comparative case studies are used to explore the internal differentiation logic of the urban class, the process of evolution of cross-class interaction networks, and the interaction logic of multiple constraints such as education, organization, space, and an integrated analytical framework is constructed to explain the reorganization of social structure[3,4].

II. RELATED WORK

In the analysis of the urban class, a simple theory that can be applied is the theory of social stratification. The three-dimensional stratification model determines the position of

classes based on the economic resources, social prestige, and political power. Capital typology also differentiates the reciprocity of transformation of economic capital, cultural capital and social capital. These theories demonstrate the multidimensional characteristic of the boundaries of classes, although they do not give sufficient attention to the heterogeneity of the urban class in the era of industrialization, and the rapid differentiation of the new occupational groups is hard to explain. Urban sociology ecological models that examine the distribution patterns of class using patterns of spatial differentiation discover that a considerable relationship exists between residential segregation and occupational division of labor, but the inability to capture the dynamic process of class mobility by the use of static spatial analysis. Long-term historical studies focus on the accumulation effect of structural changes over time and show the class reproduction mechanism through the family lineages, inheritance of property, and marriage networks, but are hard to extrapolate to the macro level because of the weaknesses of micro-cases. Empirical research in the sociology of education supports the idea that the school education contributes to the intergenerational mobility, however, most empirical research is restricted to the analysis of education reform policies within a given country or within a particular country and lacks a cross city comparative approach [5,6]. A technological breakthrough in tracking the interactions in classes comes with the introduction of methods of social network analysis. It can determine the effects of informal social relationships on resource allocation by quantifying strength of relationships, determining central nodes of a network and determining paths of information dissemination. Intermediary bodies like industry associations and professional groups are seen to be instrumental in linking the various classes and spreading professional norms but the causal relationship between the organization process and the integration of classes have not been completely confirmed. The primary weakness of the current studies is the lack of links between macro-narratives and micro-mechanisms, the gap between quantitative analysis and qualitative explanation, and the fact that it is not possible to use single methods to measure multidimensional causal relationships.

III. METHODS

A. ACQUISITION AND CLEANING STRATEGIES FOR MULTI-SOURCE HETEROGENEOUS DATA

In this research, the original documents were obtained at the archives of 12 cities during the period 18501950, such as resident registers of city halls, business license stubs of tax offices, apprenticeship contracts of guilds, marriage certificates of churches and the obituaries of newspapers. These are of different forms such as hand written, printed and tabular and include a great number of variant characters and local dialect spelling [7,8]. A three-level verification system was created in the process of data input: archives were transcribed by the research assistants to electronic text, linguistic professionals standardized the representations of personal and place names, and historians cross-referenced the sources to determine the identity of the same person in various documents. A standardized dictionary of 437 occupational categories was created to resolve the ambiguity in occupational descriptions, combining 27 occupational terms, including cloth merchant, fabric seller , into a single category. Cross-period standardization of income data The barriers to comparability of income data due to monetary reforms and inflation were dealt with by standardization of income data to wheat purchasing power equivalents. Missing data were filled by the median of the same occupational group within the same city in the same year, and data with a missing rate of over 40% in key variables were removed, eventually creating a structured data set of simple personal attributes, family ties, and occupational mobility.

B. OPERATIONAL DEFINITION AND SEGMENTATION ALGORITHM FOR URBAN CLASS

In this research, the boundaries of urban social classes are defined by developing a three dimensional quantitative index system. Occupational stability is assessed by counting the number of job changes that one goes through in ten years. Individuals who have work experience in the industry over five years are given a 3 point, individuals with one job change are given a 2 point, and individuals who change jobs frequently are given a 1 point. The difference in income sources is calculated in terms of proportion of wage income, asset income and rent income. The total reliance on one source is rated 0 points and even distribution of the three types of incomes is rated 3 points. The level of education is split into four categories depending on level of literacy documented in the archives, years of schooling, and qualification certificate in a profession: illiterate is given 0 mark, primary education is given 1 mark, secondary technical school graduation is given 2 marks, and university degree is given 3 marks [9,10].

The 3D scores of 87,000 samples were fed into the K-means clustering algorithm. The value of k was varied between 2 and 10 and silhouette coefficient of every scheme was determined. The silhouette coefficient has a maximum of 0.67 at k = 3, which shows the best effect of classification. The algorithm converged in 58 steps, automatically grouping the samples into three evident clusters: commercial assets class (high income diversity and ownership of means of production); professional and technical personnel (high education level and remuneration depending on professional skills), and industrial worker (low education level, but stable urban jobs).

C. CONSTRUCTION AND MEASUREMENT INDICATORS OF SOCIAL NETWORK GRAPHS

This study builds social relationship networks with individuals as nodes and finds five types of interactive relationships from archives: the family relationship revealed in the register of marriage, the partnership displayed in the register of business, the organization affiliation presented in the register

of association, the program of cultivating teachers presented in the register of apprenticeship, and the condolence from friends recorded in the register of death. We assign different weights to the five types of relationships respectively. Marital relationship gets 5 points, while the relationship between two not very close individuals like those participating in the same activity once in a year gets 1 point, so we convert social relationship into numbers and assign weights to the edges.

The density of network is got by dividing the actual number of edges by the theoretical maximum number of edges. It represents the general level of interaction of network. Degree centrality counts the number of direct connections of each node and finds out the active individuals in society. Betweenness centrality counts the number of times that a node appears in the shortest path between other nodes. The larger the number, the more likely that the node appears in the middle of the shortest path between other nodes. It represents the degree to which the node plays a key role in the transmission of information and allocation of resources. Approach centrality measures the average distance between a node and any other node in the network. The shorter the distance, the more likely that the node can reach any other node in the network by walking a shortest path. The clustering coefficient measures the connection density between a node's neighbors. The larger the number, the more likely that the node is in a closely connected small group.

The layout algorithm is Force Atlas in the Gephi software, which is used to visualize it. The degree of connection defines edge thickness, the size of the node is in proportion to the degree of centrality, and the color represents the hierarchical category. The temporal variation properties of cross-hierarchical interaction strength are measured by computing the ratio between the number of nodes that are connected on different hierarchical levels.

D. LONGITUDINAL COMPARISON AND CAUSAL INFERENCE DESIGN

This paper splits 12 sample cities into an early-developing group and a late-developing group, according to the time of starting industrialization. By 1850, six cities had set up mechanized factories, such as Manchester and Lyon, and six more cities started to industrialize after 1870, such as Turin and Budapest. Two time periods, 1880 and 1920, were used to build up balanced panel data to difference-in-differences analysis. The experimental group, which was the early-developing group, realized the full effects of industrialization, whereas, the control group, which was the late-developing group, gives a counterfactual reference. Subtracting the differences in the increase in the population size of the urban population in the two groups, the effect of general tendencies of the time is removed and the net impact of industrialization is determined in a more precise way. Parallel trend tests indicate that there is a high level of consistency in the evolutionary patterns of urban classes structures in the years 1850 and 1870; thus, meeting the assumptions of the difference-in-differences technique. Annual data on education spending by the state, the number of schools and the percentage of professional and technical staff per city was gathered to determine the direction of causation of educational growth and class mobility, a three-variable vector autoregressive model was developed. Tests of Granger causality established that three years lag of educational investment significantly affected the size of the professional and technical class in a positive manner, yet the opposite causality test was not met and this validates that education is a precursor to the change of the class. Similar test was conducted on the number of industry associations, and the rate at which a mobility rate equals, the results showed a two-way causal relationship: the growth of associations encourages mobility, and the rate of mobility stimulates the creation of new associations, which leads to the formation of a self-reinforcing relationship.

IV. RESULTS AND DISCUSSION

A. THE TRAJECTORY OF THE QUANTITATIVE EXPANSION OF THE URBAN CLASS AND THE EVOLUTION OF ITS INTERNAL STRUCTURE

The census data of 12 cities at every ten years interval was analyzed in this study by dividing the population of each of the three subgroups of the urban class by the total urban population and finding out their percentages and dividing the growth rate of each period by the base year of 1880. The commercial asset class was determined using the records of paying business tax and employing three or more individuals in the tax register; professional and technical personnel were determined using their certificates of professional qualification and industrial workers were determined by cross checking with factory registers and residence registers. Table 1 shows the patterns of class distribution at four time points.

TABLE 1. Evolution of the size of the urban middle class from 1880 to 1920 (unit: percentage of total urban population)

Years	Total of the urban class	Commercial Bourgeoisie	Professional and technical personnel	Industrial workers
1880	23%	8%	5%	10%
1890	34%	11%	9%	14%
1900	46%	13%	16%	17%
1920	58%	15%	22%	21%

Table 1 shows that the total size of the urban class increased by 152% over forty years, while the proportion of professional and technical personnel jumped from 5% to 22%, an increase of 340%, far exceeding the 87.5%

of the commercial bourgeoisie and the 110% of industrial workers. The explosive growth of professional and technical personnel between 1890 and 1900, with their proportion doubling, closely coincides with the expansion of technical schools and the surge in demand for engineers during this

period. While the absolute number of industrial workers continued to increase, the growth rate slowed after 1900, with the average annual growth rate decreasing from 2.1% between 1890 and 1900 to 1.2% between 1900 and 1920, reflecting the transformation of the industrial structure from labor-intensive to technology-intensive.

B. THE LEVERAGE EFFECT OF EDUCATION SYSTEM EXPANSION ON SOCIAL MOBILITY

In this study, data on years of education of sample individuals were extracted based on their education record and a paired analysis on job levels was done in occupational registration. The four quartiles of occupational levels were determined on the basis of income. The propensity of various educational levels to each level of occupation was computed and variance in the rate of average annual growth of investment in public education and rate of cross-class mobility between urban areas in the period 1890-1920 were statistically tested. Table 2 presents the various effects of education on occupational mobility that are differentiated.

TABLE 2. Occupational level distribution and mobility probability of different education levels

Education level	Probability of entering the professional and technical level	Mean of occupational level	Increased liquidity within ten years	Sample size
Illiterate/primary education	6.3%	1.4	12%	38,420
Secondary technical school	35.8%	2.8	41%	15,670
University degree	68.2%	3.6	59%	4,130

Table 2 shows that graduates of secondary technical schools are 5.7 times more likely to enter the professional and technical class than those with primary education, and the probability is as high as 10.8 times for those with university degrees. The Pearson correlation coefficient between years of education and occupational level is 0.82 and passes the significance test, confirming the strong screening effect of education. City-level analysis reveals that in six cities where annual educational investment increased by more than 8% between 1890 and 1920, the average cross-class mobility rate reached 37%, while in cities where educational investment growth was less than 5%, the mobility rate was only 19%, a difference of 18 percentage points. Although the upward mobility rate of university graduates is high, their absolute number only accounts for 4.7% of the sample; the expansion of secondary technical education is the key lever driving large-scale class mobility.

C. THE PIVOTAL ROLE AND INTEGRATION MECHANISM OF INDUSTRY ASSOCIATION NETWORKS

The present study used the bylaws, membership lists, and records of activity to extract data on the time of the establishment of the industry associations, the composition of the membership, and the frequency of activities of the industry association in the different cities. It determined professional background of members and computed the percentage representation of members belonging to various social strata. The paper has also counted the common members of each association with other associations, formed an inter-association network and Gephi was used to determine the degree centrality index of each association. The table 3 shows network properties and assimilating functions of major associations.

TABLE 3. Network Location and Cross-Class Integration Effects of Major Industry Associations (1920 Data)

Association Type	Average number of members	Cross-class membership percentage	Degree centrality	Number of joint events held/year
Bar Association	247	42%	0.68	18
Chamber of Commerce	412	37%	0.71	23
Institution of Engineers	186	35%	0.59	14
Handicraft Guild	93	19%	0.31	7
Workers' Mutual Aid Association	328	12%	0.24	9

Table 3 shows that the centrality of three types of organizations—bar associations, chambers of commerce, and engineering societies—exceeds 0.59, making them pivotal nodes connecting different social classes. These associations have a cross-class membership rate of 35%-42%, far exceeding the 19% of handicraft guilds and the 12% of workers' mutual aid societies. Chamber of commerce members include both large factory owners and small merchants, establishing connections across economic status through annual trade fairs, credit rating mutual aid, and other activities. The frequency of cross-class interaction among association members is 29 percentage points higher than that of non-member groups. In 1850, the sample cities had an average of 12 industry associations; by 1920, this number had surged to 98, a 7.2-fold increase, and network density rose from 0.14 to 0.53. This significant leap in organization has facilitated institutionalized interaction among previously isolated social classes.

V. CONCLUSION

This paper, with the use of multi-source archival data and social network analysis, demonstrates that there is a dual logic of occupational differentiation and organizational integration in the emergence of the urban middle class due to industrialization. Technological advancements promote specialization and new occupational enclaves; the education system dismantles familial boundaries, and the ladder of upward mobility; and intermediate institutions like trade associations gather individuals with no connection into social groups with group consciousness. Nevertheless, as much as education brings about mobility, it also strengthens new

inequalities in the screening of diploma and the professional and technical group uses knowledge monopolies to constitute the intergenerational transmission of cultural capital. The historical experience indicates that the mere economic growth may not automatically reach the level of social integration; it is required to create platforms of various participation, enhance the system of vocational training, streamline the distribution of social services, encourage positive relationship between the various social layers, and prevent the danger of social disintegration. The work offers a historical lens of explaining the processes of social stratification in contemporary urban centers and has an implication on contemporary urban politics.

AUTHOR CONTRIBUTIONS

Yong Liu designed, collected and analyzed the data, and drafted the manuscript. Yong Liu conducted the study, critically revised the manuscript for important intellectual content, and gave final approval of the version to be published. Yong Liu participated fully in the work, take public responsibility for appropriate portions of the content, and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

CONFLICTS OF INTEREST

The author declares no conflict of interest.

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