



Optimization of Urban Tourism Cooperation Network in Fujian Province Based on Baidu Migration Index

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Abstract. This study constructs a directed tourism flow network among nine Fujian cities using Baidu Migration big data from Spring Festival, May Day, and National Day Golden Weeks from 2023 to 2025, plus Spring Festival and May Day 2026. Social network analysis examines overall characteristics, nodal features, and temporal variations. Results reveal low network density (0.292) with a "strong core–weak periphery" structure, where Fuzhou, Xiamen, and Quanzhou form the core triangle. Betweenness centrality is highly concentrated in Fuzhou (66.07%). Node roles diverge: Fuzhou acts as a radiation hub, whereas Xiamen serves as an attraction pole. Temporally, Spring Festival shows "core agglomeration," while May Day and National Day exhibit "core diffusion." Recommendations include hierarchical guidance, directional capacity allocation, and strengthening mountain–sea tourism alliances to support Fujian's development as a world-renowned destination.

Keywords: Fujian Province, Baidu Migration Index, Tourism Cooperation Network, Social Network Analysis

1 Introduction

Mountain–sea collaboration is a key strategy for coordinated regional development in Fujian. As the province accelerates its vision of becoming a "world-renowned tourism destination," efficient inter-city tourism flows are essential. Golden Weeks concentrate population movements that reflect regional tourism cooperation patterns.

Tourism flow research has shifted from single destinations to multi-node interaction analysis^[1], with Baidu Migration widely used to reveal inter-city mobility patterns^[2,3]. Markov chains have characterized network transitions^[4], while multi-scale studies demonstrate core–periphery structures shaped by distance and resources^[5–6]. In Fujian, gravity models and SNA have identified Fuzhou, Xiamen, and Quanzhou as core nodes^[7–8]; self-drive networks show dispersed-concentrated patterns^[9].

However, existing studies largely rely on gravity models or annual statistics, rarely using Baidu Migration Index to dynamically quantify Golden Week networks. Grounded in "space of flows" theory, this study employs Spring Festival, May Day, and National Day Golden Weeks from 2023 to 2025, plus Spring Festival and May

Day 2026 to construct a directed network among Fujian's nine prefecture-level cities, analyzing overall features, nodal characteristics, and temporal differences to inform mountain–sea collaboration.

2 Research Design and Data Processing

2.1 Data Sources and Network Construction

Data were obtained from the Baidu Migration platform, covering Spring Festival, May Day, and National Day Golden Weeks from 2023 to 2025, plus Spring Festival and May Day 2026. Partial gaps exist (May 3, 2023; October 4–6, 2023). Given that peaks concentrate in the first 3–4 days and aggregated indicators are used, missing data minimally affect core structure.

Nine prefecture-level cities serve as nodes. Inter-city Baidu Migration Index sums represent tie strength, forming a 9×9 directed weighted matrix. Based on non-zero value distribution, a threshold of 20 was applied for binarization ($\geq 20 = 1$, $<20 = 0$), yielding a 9×9 adjacency matrix and an O-D network model (Figure 1).

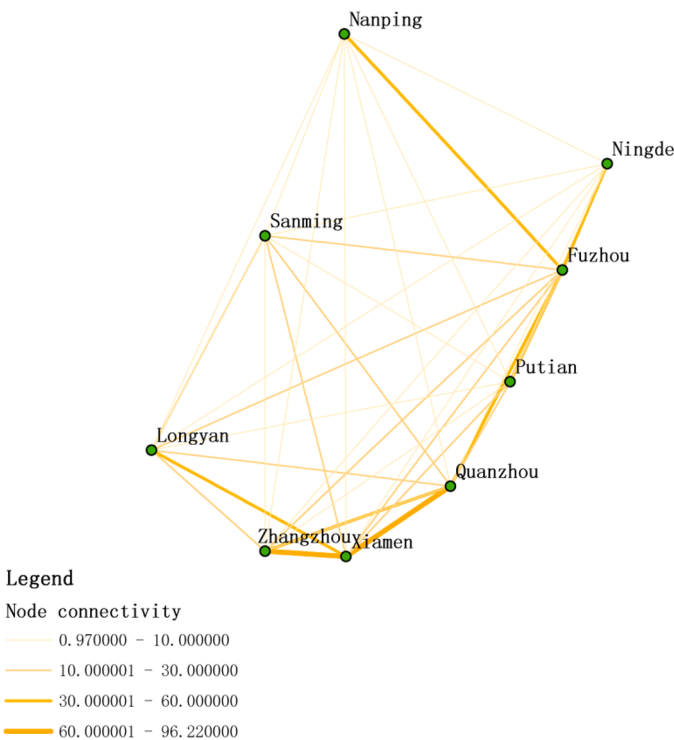


Fig. 1. Schematic of Holiday Tourism Flow Network Among Cities in Fujian.

2.2 Methods and Indicators

SNA measures the functions of actors in a network and their relationships with others. The following indicators are selected:

Network Density. Reflects the tightness of intercity tourism connections.

$$D = \frac{L}{n(n-1)} \quad (1)$$

Where D is network density, n is the number of nodes, and L is the number of actual connections in the directed network.

Network Centralization. Includes degree centralization, betweenness centralization and closeness centralization, measuring the overall centralization level of the network.

Core-Periphery Structure. A discrete core-periphery model is used to identify core and peripheral node groups.

Degree Centrality. Divided into out-degree and in-degree centrality, representing the radiation and attraction capacity of a node respectively.

$$C_{D,in}(n_i) = \sum_{j=1}^l r_{ij,in}, C_{D,out}(n_i) = \sum_{j=1}^l r_{ij,out} \quad (2)$$

Where $C_{D,in}$ and $C_{D,out}$ are in-degree and out-degree centrality, and $r_{ij,in}$ and $r_{ij,out}$ are the in-degree and out-degree of node i .

Closeness Centrality. The reciprocal of the shortest path from a node to all other nodes, reflecting information transmission efficiency.

$$C_c(n_i) = \frac{1}{\sum_{j=1}^i d(n_i, n_j)} \quad (3)$$

Where $d(n_i, n_j)$ is the shortest path between nodes i and j .

Betweenness Centrality. Measures a node's potential as an intermediary, with higher values indicating stronger transit capacity.

$$C_B(n_i) = \sum_{j=1}^l \sum_{k=1}^l \frac{g_{jk}(n_i)}{g_{jk}}, \quad j \neq k \neq i \quad (4)$$

Where g_{jk} is the number of shortest paths from node j to k , $g_{jk}(n_i)$ is the number of such paths passing through node i , and l is the total number of nodes.

3 Network Structural Characteristics

3.1 Overall Features

With 72 possible directed ties, 21 actual links yield a density of 0.292, indicating substantial room for strengthening connections.

Locally, Fuzhou, Xiamen, and Quanzhou are fully interconnected, forming a tight core triangle and the primary flow engine. Zhangzhou maintains bidirectional ties with Xiamen, Quanzhou, and Longyan, bridging the core and western Fujian. Longyan connects with Xiamen and Zhangzhou, showing Xiamen-mediated dependence. Sanming links bidirectionally with Fuzhou, Xiamen, and Quanzhou, connecting central and core areas. Nanping and Ningde maintain only unidirectional ties with Fuzhou; Putian connects bidirectionally with Fuzhou and Quanzhou. Except for Zhangzhou–Longyan, peripheral cities lack direct ties, exhibiting a typical core–periphery radial pattern.

Centralization reveals structural imbalance: out-degree (51.56%) exceeds in-degree (37.50%), indicating outward-radiation dominance by few cities. Out-closeness (66.13%) far exceeds in-closeness (46.04%), showing core cities' superior efficiency in dispatching tourists. Betweenness centralization (58.26%) indicates that a handful of nodes perform most transit functions.

Core–periphery analysis places Fuzhou, Xiamen, and Quanzhou in the core; the remaining six cities are peripheral. Intra-core density is 0.833, far exceeding overall density (0.292); core–periphery density is 0.444; intra-periphery density is 0.000. This structure necessitates strengthening core-to-periphery spillover and encouraging horizontal peripheral cooperation.

3.2 Nodal Features

Table 1 presents centrality results.

Table 1. Node Centrality of Fujian's Holiday Tourism Network.

Rank	City	Out-degree (%)	In-degree (%)	Out-closeness (%)	In-closeness (%)	Betweenness (%)
1	Fu zhou	75.0	62.5	87.5	79.17	66.07
2	Quan zhou	50.0	50.0	75.0	75.00	33.93
3	Xia men	37.5	50.0	62.5	75.00	28.57

4	Zhang zhou	25.0	25.0	56.25	56.25	0.00
5	Putian	25.0	25.0	60.42	60.42	0.00
6	San ming	12.5	12.5	52.08	48.96	0.00
7	Long yan	12.5	12.5	42.71	47.92	0.00
8	Ning de	12.5	12.5	52.08	48.96	0.00
9	Nan ping	12.5	12.5	52.08	48.96	0.00

Fuzhou leads in out-degree (75.0%) and in-degree (62.5%), with out-degree exceeding in-degree, indicating active radiation consistent with its capital and hub status. Quanzhou is balanced (50.0% each). Xiamen's out-degree (37.5%) is lower than its in-degree (50.0%), suggesting a destination orientation. Peripheral cities show limited connectivity: Zhangzhou and Putian at 25.0%; others at 12.5%.

In diffusion capacity, Fuzhou (87.5%) leads, followed by Quanzhou (75.0%), with Xiamen (62.5%) lowest among core cities. In agglomeration, Fuzhou (79.17%), Quanzhou (75.0%), and Xiamen (75.0%) top the list; Xiamen's agglomeration exceeds its diffusion, underscoring its destination role. Among peripheral cities, Putian (60.42%) diffuses best, while Longyan (42.71%) is weakest. Sanming, Ningde, and Nanping (48.96%) and Longyan (47.92%) show low agglomeration, indicating barriers to receiving core-city tourists.

Fuzhou's betweenness (66.07%) confirms its pivotal hub position. Quanzhou (33.93%) and Xiamen (28.57%) also transit, but gaps are substantial. Xiamen's lower betweenness and higher in-degree indicate an endpoint rather than transit role, whereas Quanzhou links more strongly. Other cities register zero betweenness, relying on core intermediaries.

4 Holiday Period Flow Comparisons

4.1 Total Flow and Net Direction

Average daily total flow is highest during May Day (22.09), followed by National Day (20.58), and lowest during Spring Festival (15.42) (Table 2). May Day generates strongest inter-city intentions; National Day sees some long-distance inter-provincial trips; Spring Festival is dominated by home-return visits.

Spring Festival shows "core agglomeration": Fuzhou (+0.53) and Xiamen (+1.15) are net receivers, while Quanzhou, Zhangzhou, and Longyan are net senders. During May Day and National Day, directions reverse: Fuzhou and Xiamen become net senders (May Day: −0.35, −0.56; National Day: −0.13, 0.00), while Zhangzhou, Sanming, and Longyan turn into net receivers. Zhangzhou records the largest peripheral

net inflows (May Day +0.57; National Day +0.27), benefiting from geographical proximity to Xiamen.

Table 2. Weighted Flows and Net Flows by City and Holiday.

City	Spring Festival			May Day			National Day		
	Out	In	Net	Out	In	Net	Out	In	Net
Fuzhou	2.22	2.75	0.53	3.93	3.58	-0.35	3.46	3.33	-0.13
Xiamen	2.47	3.62	1.15	5.58	5.02	-0.56	4.78	4.78	0.00
Quanzhou	2.78	2.46	-0.32	3.88	3.91	0.03	3.61	3.47	-0.14
Zhangzhou	1.99	1.85	-0.14	2.58	3.15	0.57	2.49	2.76	0.27
Nanping	1.05	0.84	-0.21	0.96	1.09	0.13	1.06	1.11	0.05
Sanming	1.34	1.05	-0.29	1.25	1.41	0.16	1.33	1.45	0.12
Longyan	1.34	1.02	-0.32	1.34	1.59	0.25	1.46	1.57	0.11
Ningde	1.11	0.86	-0.25	1.20	1.23	0.03	1.14	1.13	-0.01
Putian	1.12	0.97	-0.15	1.37	1.47	0.10	1.25	1.25	0.00
Total		15.42			22.09			20.58	

4.2 Temporal Evolution of Net Inflow

Daily net inflow variations (Figure 2) reveal temporal dynamics.

During Spring Festival, Fuzhou and Xiamen show net outflows in the first three days (approximately -2 to -1), turning to inflows from day 4, peaking on days 7-8 (Fuzhou approximately +3, Xiamen approximately +5.5). Quanzhou, Zhangzhou, and Longyan show early inflows (+0.3 to +0.9), turning to outflows mid-period, matching the home-return-return-trip pattern.

During May Day, Fuzhou and Xiamen record maximum outflows on day 1 (-3.4 and -6.6), narrowing and turning to inflows or balance by day 3, with further inflows on days 4-5 (Fuzhou +2.5, Xiamen +3.3). Peripheral cities show early-inflow, late-outflow: peaks on days 1-2 (Zhangzhou +2.4, Longyan +2.3), turning to outflows by days 4-5. This indicates core-to-periphery diffusion during May Day.

National Day follows a similar but amplified pattern. Fuzhou and Xiamen reach day-1 outflows of -4.6 and -8.7. Zhangzhou and Longyan record higher early inflow peaks (Zhangzhou +2.5, Longyan +3.5).

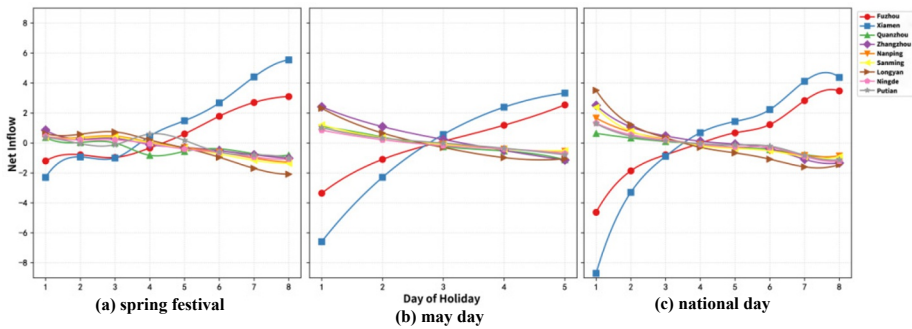


Fig. 2. Daily Variation of Population Inflow in Fujian Cities During Golden Week.

5 Optimization Strategies from a Mountain–Sea Perspective

5.1 Hierarchical Guidance of Urban Functions

Core cities should strengthen hub functions: Fuzhou should leverage its 66.07% betweenness to build a regional distribution center; Xiamen should maintain destination attractiveness; Quanzhou should bridge southern and central Fujian. Peripheral cities should highlight Wuyi Mountain, Tulou, and Danxia resources, actively receiving spillover, and build mountain–sea routes such as "Xiamen–Zhangzhou–Longyan" and "Fuzhou–Sanming–Nanping."

5.2 Directional Capacity Allocation

Spring Festival flows run periphery-to-core, while May Day and National Day show core-to-periphery diffusion. Transport authorities should dynamically adjust capacity: prioritize periphery-to-core routes before Spring Festival, and core-to-periphery routes before May Day and National Day. At Fuzhou hub, transit-stop products should convert pass-through flows into consumption.

5.3 Strengthening Route Alliances and Collaboration

To address zero intra-periphery density, peripheral cities should open direct routes (e.g., Longyan–Sanming–Nanping loop), reducing core dependence. A Golden Week early-warning platform using Baidu Migration data should monitor flows in real time. Cross-city joint ticketing and joint marketing should form an integrated coastal–mountain network.

6 Conclusion

This study reveals Fujian's Golden Week tourism network as a "strong core–weak periphery" structure with differentiated nodal roles, identifying Spring Festival "core agglomeration" versus May Day/National Day "core diffusion." Limitations include slight underestimation of return flows due to missing 2023 late-holiday data; future work may integrate multi-source data to explore evolution mechanisms.

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