Transportation Cost in the Great Divergence: Yangtze China VS. England

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Abstract

The Great Divergence has arguably been one of the most important debates in the field of economic history over the past two decades. This article contributes to this ongoing discussion from a novel perspective, specifically focusing on transportation conditions. Utilizing travel route books published since 16th century China, I reconstructed the national trade transport network of China during the Ming and Qing dynasties (14th to 19th centuries) and estimated transport costs and speeds in the Yangtze region during the late 17th and 18th centuries. These estimates were then compared with those of England for the same period. The findings reveal that, in the late 17th century, transport costs and speeds in the Yangtze region of China were comparable to those in England. However, a divergence emerged after 1700. This timing of divergence in transportation between the Yangtze region and England supports the strand of literature proposing that The Great Divergence began around 1700.

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1 Introduction

Since the Pomeranz (2000) propose the concept the Great Divergence[1], discussions on this topic have remained among the most significant debates in the field of economic history. A key aspect of this debate revolves around the specific timing of the divergence. One strand of literature, by reconstructing and comparing economic development indicators such as GDP, wages, and living standards between Western Europe and Yangtze China, found that by 1800, there were already significant differences in development levels. This body of work further proposes that the Great Divergence occurred since 1700. (Broadberry and Gupta, 2006; Broadberry et al., 2018, 2021; Li and Van Zanden, 2012; Broadberry, 2013)

This article approaches the debate from a different perspective, focusing on the transportation condition. It is widely acknowledged that the progressive reduction in transport costs has been a crucial driver of long-term economic growth since the days of Adam Smith (Smith, 1776; North, 1958). Recent empirical studies further reveal the causal connections between the development of transport infrastructures and economic growth (Donaldson and Hornbeck, 2016).

Yet, very few studies have focused on the great divergence from the perspective of the availability of transportation. There are rich studies on transportation in 18th century England. These studies has shown that the turnpike trust revolution, beginning around 1700, significantly improved transportation infrastructure and contributed to subsequent economic expansion (Bogart, 2005; Bogart et al., 2023, 2022). However, there has been a lack of systematic studies exploring the transportation conditions in China during the same period. To address this gap, this study examines transport cost, speed and network in late 17th century China and compares them with those in England during the same timeframe.

Specifically, by following merchant travel route books published since the 16th century,

[1]The Great Divergence hypothesizing that until 1800, the development levels of Western Europe and the Yangtze China were comparable. Such hypothesis leads to two important issues: (1) Given China's vast territory, the comparison should focus on the most developed regions: Western Europe and Yangtze China. (2) The central concern of this hypothesis is why Western Europe achieved economic development while China experienced economic stagnation.

I reconstructed the national trade transport network of China during the Ming and Qing dynasties (14th to 19th centuries) and estimated transport costs and speeds in the Yangtze region during the late 17th and 18th centuries. My findings indicate that historically, China had a highly developed national transportation network capable of supporting a nationwide prosperous market[2]. By comparing the transportation costs and speeds in the Yangtze China with those of England, it is evident that up until 1700, the transportation costs and speeds were similar between the two regions. However, starting from 1700, England underwent a transportation revolution that significantly reduced transportation costs and increased speeds[3], leading to a clear divergence from the Yangtze Delta. Considering that transportation condition is a crucial determinant of an efficient market, it can be speculated that until around 1700, the market performances of the Yangtze Delta and England were comparable, but they began to diverge in the 18th century[4].

To gain these insights, I begin by examining several historical archives and popular travel route books used by merchants[5]. Using these sources, I reconstruct the commercial transport network and estimate the passenger and freight travel speeds and costs, both over land and via rivers, across various regions in late 17th century China. I then compare this new evidence with transportation situation in late 17th century England.

This study reveals that in Yangtze China, passengers and freight could travel as fast as 55 km per day through canals and minor rivers. On major rivers like the Yangtze, with tailwinds, ships could achieve speeds up to 65 km per day even while traveling upstream[6]. In

[2]This aligns with the findings of Shiue (2002), which, through the analysis of correlation in grain prices, identified the existence of a historical nationwide market in China that performed better than traditionally believed.

[3]see (Gerhold, 2014) and (Bogart, 2005)

[4]This corresponds with the findings of Shiue and Keller (2007), which discovered that by the mid-18th century, England's performance was noticeably superior to that of continental Europe, while the performance across continental Europe was on par with that of Yangtze China. This aligns with the historical fact that England was the first in Europe to undergo a transportation revolution.

[5]I have used several route books in this study. A majority of quotations I get for transport cost and speed are from *Shi Wo Zhou Xing* (*Traveling Everywhere on my own* 示我周行) (hereafter SWZX). This route book is first published in 1694, it can be expected the book reflects the transport situation in the 1680s. Brook (1981, 2002)

[6]Sources from SWZX do not provide a downstream travel speed along major rivers. However, considering the flow speed in the middle and lower part of the Yangtze River is very slow, it can be expected the speed

mountainous areas, small ships on creeks could travel downstream at speeds of up to 80 km per day, but upstream travel was much slower, around 28 km per day. For overland journeys, merchants using packhorses could cover 45 km per day in flat regions and approximately 30 km per day in hilly areas.

When these travel speeds are compared to those in late 17th century England, it becomes evident that the Yangtze Delta in China had transport speeds comparable to those of England during the same period. However, the situation in England changed dramatically with the turnpike revolution in the 18th century, which significantly increased both passenger travel and land freight speeds (Gerhold, 2014; Bogart, 2005). Unlike England, China did not undergo a similar transformative increase in transportation speeds.

This study estimates that the average cost of traveling through waterways was 0.021 silver taels[7] per 100 kilograms per 100 kilometers, while land shipments cost 0.213 silver taels per 100 kilograms per 100 kilometers. For passenger trips within the core Yangtze region, the average price was 0.022 silver taels per 100 kilometers. Traveling in periphery part of Yangtze Delta was considerably more expensive, costing nearly four times as much.

Compared to England, the transport costs in these two regions were similar in magnitude in the late 17th century when adjusted for unskilled wages. However, during the 18th century, England saw a 50% reduction in land transport costs and a three-fold increase in travel speed, while China's transport efficiency remained unchanged throughout the century.

1.1 Related Literature

This study contribute to several strands of literature. It first contribute to the debate in level of market integration in historical China. It is generally agreed that the progressive reduction in transport costs has been a crucial driver of long-term economic growth.(Smith, 1776; North, 1958) However, this perspective was challenged by Shiue (2002) and Shiue and Keller (2007). Utilizing a grain price correlation method, they demonstrated that Yangtze

between upstream and downstream would be close if there is a tailwind.

[7] Detail for measuring and currency unit see table 1

China had achieved an integrated market whose performance was comparable to that of continental Europe until the late 18th century, while England was achieving better market performance during the same period. They argue that these findings indicate that although strong market performance is necessary, it is not sufficient for sustained economic growth.

Their argument, however, has been questioned by economic historians, who point out that grain prices were heavily regulated by the government in historical China, leading to a "false market integration." (Li, 2000; Deng, 2011; Von Glahn, 2016; Ni and Uebele, 2019). Therefore, the level of market integration derived from government-controlled prices would be too optimistic. In this study, I explore the factors that constitute market performance from another perspective: the availability of transport. Specifically, I examine the transport condition in late 17th century China and compare it with that of England during the same period. Surprisingly, my findings largely align with those of Shiue (2002) and Shiue and Keller (2007), suggesting that Yangtze china do obtained comparable transportation infrastructure to support a efficient market that comparable to England until 1700.

This study also contributes to the literature on the Great Divergence. There has been an ongoing debate on the timing of the Great Divergence. While some world historians argue that the divergence occurred only after 1800 (Pomeranz, 2000; Parthasarathi, 1998, 2001; Frank, 1998), another strand of literature proposes that such divergence had already happened during the 18th century (Broadberry and Gupta, 2006; Broadberry et al., 2018, 2021; Li and Van Zanden, 2012; Broadberry, 2013). Utilizing Chinese historical route books, this study compares the transportation conditions between the Yangtze region in China and England during the 18th century. My findings support the hypothesis that the Great Divergence began since 1700.

Finally, this study contributes to the literature on Chinese historical geography, with a focus on transportation in historical China. Research on historical transportation routes in China is relatively scarce. Systematic studies are limited, with only a few such as the study on Tang Dynasty Transportation Network by Yan (1985). Unfortunately, Yan passed away before completing this work, leaving us without a comprehensive and reliable study of China's historical transportation network. Moreover, research on transportation costs and speeds in historical China is also extremely limited. Some preliminary explorations, such as those by Liu (2012); Kiyokoba (1991, 1996), have only addressed specific periods. This study, based on travel route books from the Ming and Qing dynasties and supplemented by various official archives, utilizes GIS technology to reconstruct the commercial transportation network and estimates transportation costs and speeds during historical China.

The rest of this article is organized as follows: Section two reconstructs the transportation network and estimates the transport costs and speeds in late 17th century China. Section three compares the transportation situation in England with that in the Yangtze region of China since the late 17th century. Finally, Section four concludes the article.

2 The Transport Revolution in 18th century England

Since Adam Smith's *The Wealth of Nations*, the improvement of transportation infrastructure has been recognized as a crucial driver of long-term economic growth. Recent studies have revealed that a significant transformation in England's transportation infrastructure occurred during the 18th century, laying the groundwork for the country's subsequent economic expansion.

Around 1700, the establishment of Turnpike Trusts marked the beginning of a concerted effort to improve the nation's roadways. These trusts, funded by tolls collected from road users, maintained and upgraded key routes as well as constructing new turnpike roads. By the mid-18th century, the network of turnpike roads had expanded significantly, covering several thousand miles. The impact of these improvements was profound: road conditions improved substantially, resulting in a marked decrease in land transportation costs and a significant increase in travel speeds(Alvarez-Palau et al., 2017a; Bogart, 2019). As shown in Table 7, the cost of transporting goods overland in 1830 was considerably lower than in

1680.

In addition to road improvements, the latter half of the 18th century saw a boom in canal construction. This expansion further transformed England's transportation landscape by enhancing connectivity between regions. While canal construction did not directly reduce the cost or speed of water transport, it significantly lowered overall trade costs by linking major industrial centers with cheaper water routes.

The cumulative effect of these infrastructure improvements on accessibility and economic activity was profound. By 1830, before the railway revolution, the accessibility of different regions in England had improved dramatically compared to 1680, facilitating greater economic integration and growth(Alvarez-Palau et al., 2017a). Such improvement in accessibility also facilitates economic growth from several perspectives. Recent studies suggest that the 18th-century transportation revolution was closely linked to the spread of steam engines(Bogart et al., 2017), the process of urbanization(Alvarez-Palau et al., 2020), and changes in occupational structures (Bogart et al., 2022).

However, as Needham (1974) famously questioned in his "Needham Puzzle," despite China's early technological advances, it did not undergo an industrial revolution like England. This puzzle extends to transportation as well. While England experienced substantial transportation reforms in the 18th century, China did not see a similar transformation until the late 19th century with the arrival of railroads and steamships.

To better understand why China did not follow the same path as England in transportation, a comparison between the two regions is crucial. Such an analysis could shed light on the broader Needham Puzzle and the differing roles of infrastructure in driving economic development.

3 *Status Quo Ante* of Transportation in 17th Century China

To enable the comparison between England and Yangtze China, the transport condition in historical China should be reconstructed. In this study, I reconstructed the national transportation network of Ming-Qing China and analyzed the transportation costs and speeds from the late 17th to the 18th century using historical sources. An overview of all the historical sources used in this study along with their abbreviations has been provided in table 2 and more detail in Appendix E. Detail information on units of distance, weight and currency used in this study are reported in table 1.

3.1 Transport Network

Routes in Ming-Qing China can be classified into two categories, official routes, and commercial routes. Official routes are the routes constructed and maintained by the government, which in most cases were part of the national official courier system. The courier system served to deliver official documents, public servants trips, transporting government supplies, military marches, and other government-related matters. Courier stations were set up on side of courier routes for a fixed range, providing services including accommodations and supplies[8]. Due to its official characteristics, the courier routes roads connected the national capital to the provincial capitals of each province, and from the provincial capitals to the important prefecture cities.

In addition to the official roads, well-developed commercial routes were also an important part of the transport networks in Ming-Qing China. The courier route system, designed for all-season accessibility, often did not offer the lowest transport costs or the shortest distances[9]. These commercial routes were often with shorter distances, lower costs, and

[8]According to the types of routes that stations were serving, they could be classified as land stations, waterway stations, and amphibious stations.

[9]A typical example is a path from Wuhan to Kaifeng. The courier routes detour upstream through the

relatively same or shorter travel time. However, their quality were not as good as official routes. In a sense, the official routes formed the backbone of the road network in Ming-Qing China, while the commercial routes served as crucial branches connecting various regions.

This study start with a GIS reconstruction on official routes or courier system in Ming-Qing China. In Ming Dynasty, there are more than 1000 courier stations, located already in Yang (2006). Using this information, I geo-located a total of 1,025 courier stations from the Ming Dynasty, with their spatial distribution illustrated in Figure B1. These courier stations were then connected using the routes described in *Comprehensive guide to worldwide routes* (*Huanyu Tongqu*, hereafter HYTQ[10]).

For commercial routes, this study incorporates data from two prevalent route books, *The comprehensive illustrated routebook]* (*Yitong Lucheng Tuji*, hereafter YTLC) and *Traveling everywhere on my own]* (*Shiwo Zhouxing*, hereafter SWZX), which together catalog over 300 routes, although some overlap. Notably, SWZX provides more granular details, including accommodations and logistical advice. One challenge is that many locations mentioned in the route books have either disappeared or changed names over the centuries. To address this, the locations of prefecture and county-level cities, as well as courier stations, were identified using the CHGIS database (CHGIS, 2024). The village-level locations cited in historical route books were then manually matched to contemporary names and similar pronunciations through Google Map. Ultimately, approximately 50% of the locations mentioned in the route books were identified and geo-located[11].

Han River to Xiangyang and then head to Kaifeng by Land. The commercial route, however, heads directly to the destination in a nearly straight line from the present-day Zhumadian. It would take roughly 940 km trips through courier routes, but only 460 km for commercial routes. One possible explanation for the courier route detour is that the commercial road is subject to flooding in the Huai River basin during the summer, which may cause the route to be disrupted. Since the official routes have high demands for on-road stability, the official routes prefer roads that were more stable for all-seasonality even with more distance. While commercial routes were more of a product of merchants' choice for transportation cost minimization.

[10]HYTQ is a official route book published in 1394, more detail see Appendix E

[11]Nearly five centuries have passed since these travel route books were published, and during this time, place names have undergone significant changes. Approximately 15% of the place names perfectly match the originals, but in many cases, the spelling of the place names has changed while their pronunciation remains similar. Therefore, if I relax the search criteria and looking for places with similar pronunciations, about 50% of the place names can be reasonably matched to corresponding locations.

Figure 1 shows the resultant transportation network, which encompasses 38,245 kilometers of land routes and 20,518 kilometers of waterway routes.

3.2 Travel Speed

The route book SWZX contains 22 observations[12] regarding travel times, primarily derived from comments about specific route segments or locations. These comments typically provide details about the trip's origin, destination, travel method, distance, required travel days, and sometimes costs. This information is invaluable for approximating travel speeds in late 17th-century China. One notable challenge in analyzing this data arises from the inaccuracies in the distances recorded, a consequence of the rudimentary cartography technology available in China at that time. As such, distances noted in SWZX tend to be overestimated. Recent studies by Jian et al. (2022) utilized GIS tools to recalibrate these measurements. They focused on a specific route from Fuzhou in Fujian province to Hangzhou in Zhejiang province. Their geoprocessing revealed that while 1 *li* during the Qing dynasty should correspond to 576 meters, the actual measurement for much of this route was slightly less than 500 meters.

To address inaccuracies in reported distances, I extracted data on trips with documented travel times from the Ming-Qing transport network GIS dataset constructed in this paper and converted to today's real equivalents. Employing this method, I identified an average discrepancy of approximately 20% between the recorded and actual distances. This discrepancy is often more pronounced in mountainous regions, affecting measurements for both land and waterway routes. The spatial distribution of these 22 observations, illustrated in Figure 2, provides a visual representation of the variances across different regions and route types, indicating a concentration of observations in the Yangtze Delta, Fujian, and Huguang. These data encompass a range of transportation methods tailored to diverse geographical conditions[13].

[12]Detail of these 22 observations is demonstrated in table A2

[13]It includes waterway trips on major rivers like yangtze River, trips on secondary rivers such as the grand cannal and trips on creeks in mountain regions. For land routes, it includes trips on flat and hill lands through pack horse, human labor and sedan.

In late 17th-century China, transportation methods were predominantly categorized by waterways or land routes. Waterways are subdivided into three classifications based on geographical features: major, secondary, and tertiary. Major waterways include significant rivers such as the Yangtze and its major tributaries. Secondary waterways consist of narrower rivers like the Great Canal, the Fuchun River, and secondary tributaries of large rivers. Tertiary waterways, the narrowest, typically include creeks in mountainous areas. Land routes are classified into flat and mountainous, reflecting the terrain they traverse.

The effect of traveling upstream versus downstream does not significantly alter travel speeds on major and secondary rivers. With a tailwind, ships on major rivers can maintain speeds up to 65 km per day, irrespective of the direction. Speed on secondary rivers is around 55 km per day. However, in mountainous regions, where streams are narrower and terrain influences water flow, the speed difference between upstream and downstream travel is substantial. In the cases of Fujian and Zhejiang, upstream travel speeds are approximately 28 km per day, while downstream can reach a speed of about 70 km per day. On land routes, travel speeds in flat regions are typically around 43 km per day, comparable to modern walking speeds, whereas in mountainous areas, speeds decrease to approximately 30 km per day. The detailed approximation of travel speed for 17th century China are presented in table 3 and their original cases in table A2. The reliability of these estimations is high, as data from both commercial travel routes books and official documents yield consistent speed estimations.

3.3 Freight and Travel Cost

Compared to the recorded information on transportation speed in SWZX, there is relatively little information on transportation costs, with only 11 entries. Given the limited data on transportation costs in SWZX, this study further compiles transportation cost data from 18th-century Qing Dynasty official historical documents. The DQHD records the transportation prices paid by provincial governments for grain transport across the country in the 18th century, totaling 92 entries.

By comparing the transportation costs recorded in SWZX, a commercial source, with those in DQHD, an official source from the Yangtze region of China, this study finds a high degree of consistency between the two data sources. This consistency indicates that the transportation cost information for the Yangtze region derived in this study is relatively reliable. The specific results are shown in Table 34. In the remainder of this section, I will detail the recorded transportation costs from SWZX and DQHD, as well as the process of reconstructing these costs. For raw data of SWZX, see table A3 and raw data fro DQHD see table A6.

3.3.1 Data from Travel Route Books

SWZX has reported 11 cases for transportation cost, with 5 of them passenger cost and 6 of them freight cost. All of these cases were from a broader definition of Yangtze China.

Passenger Fares in Travel Route Books

As mentioned in the previous section, passenger trips in the Lower Yangtze Delta mainly rely on stage ships. One route recorded in SWZX states that a trip of approximately 100 km from Hangzhou to Huzhou costs about 2 *fen* per person. For a journey of 34 km from Nanxun to Huzhou, it costs about 8 *li* if one boards the stage ship halfway. Another record shows that a 45 km trip from Huzhou to Meixi costs around 1 *yin* per person. By calculating the costs of these journeys, I find that the transportation cost of a stage ship in the late 17th century in the Yangtze Delta was about 0.02 silver taels per passenger per 100 km.

Interestingly, the YTLC also records information on passenger ship business in the Yangtze Delta. It notes that in Suzhou, a passenger can travel 20 *li* by boat for 2 wen. In Yangzhou, 3 *wen* allows a passenger to take a small boat for a trip to Guazhou, covering 18 km. In the Hangzhou area, an 80 km stage-ship ride from Xixing (now Xiaoshan, Zhejiang) to Dongguanyi (now Shangyu, Zhejiang) costs 2 *fen* per person. These records indicate that in the mid-16th century, when YTLC was written, the cost of stage-ship travel in the Yangtze Delta was around 0.02 silver taels per passenger per 100 km, which is very close to the late 17th-century prices.

For areas outside the Yangtze Delta, SWZX records a case stating that it costs 3 *qian* per person for a 250 km boat ride along the Fuchun River from the mountainous area of Zhejiang to the Yangtze Delta.With a 30% discount for using higher quality silver, the cost reduces to 2.1 *qian*. Assuming the journey costs 2.1 *qian*, the transportation cost is 0.084 silver taels per passenger per 100 km, which is about four times that of the Yangtze Delta.

SWZX also records the cost of passenger trips on land routes using a sedan chair. For a 39 km journey on flat land in Zhejiang, it cost 750 wen to hire a sedan chair. This equates to approximately 0.75 silver taels per passenger per 100 km.

Freight Cost in Travel Route Books

For freight cost, SWZX contains two records of the cost of shipping by waterway. The first is for the journey from Hangzhou to Yangzhou. For this 336 km trip along the Grand Canal, crossing the Yangtze River, it is noted that the cost of hiring a boat, though influenced by the type and size of the boat, was roughly 2 to 3 silver taels. This translates to a cost of 0.6 to 0.89 taels per 100 km. The second record is from the Jiangxi region, stating that for a journey from Tingzhou, Fujian, to Quzhou, Zhejiang, via Jiangxi, a traveler could hire a boat at Dengjiabu (now Yingtan, Jiangxi) for 1200 wen to travel upstream along the Xinjiang River to Yushan County, a distance of about 200 km. This sets the cost of hiring a boat in Jiangxi at 600 wen, or 0.6 silver taels, per 100 km.

Although these two locations are about 300 km apart, the cost of hiring a boat in both places is roughly the same. However, knowing the price of hiring a ship alone is insufficient for estimating waterway freight costs. I need to determine the loading capacity of the ships to assess the cost of waterborne freight in the lower Yangtze River region in the late 17th century. Two records in SWZX mention the type of ship but not its loading capacity. To address this, I referenced detailed descriptions of various ship types from Worcester (2020) and SGBL, a route book published in 1792. According to these descriptions, the capacity of the vessels in the two cases is approximately 40 to 60 piculs. Assuming a loading capacity of 40 piculs (1 picul is approximately 84 kg in Qing dynasty), I estimate that in the late 17th century, the transport cost on secondary rivers was about 0.021 silver taels per 100 kg per 100 km.

The route book has four records for land transport costs. The first two records are from a journey in the Jiangxi region, detailing transport costs using pack mules and wheeled vehicles. To complete this 56 km trip on flat land, it cost 100 wen to hire a mule and 220 wen for a wheeled vehicle. Assuming a mule can carry about 100 kg of freight on flat terrain, the freight cost for a pack mule is about 0.213 silver taels per 100 kg per 100 km. The route book does not specify the load capacity of a wheeled vehicle. Assuming the capacity of a wheeled vehicle in Jiangxi is similar to that in Beijing, which can carry 1000 *jin*, the freight cost for the wheeled vehicle is approximately 0.078 silver taels per 100 kg per 100 km. The last two records from the route in Zhejiang province detail the cost of hiring laborers to carry goods. Assuming one laborer can carry 0.4 *shi*, the cost is approximately 1.594 silver taels per 100 kg per 100 km.

A summary to transport cost accroding to SWZX is reported in table 4, and their original cases are reported in table A3.

3.3.2 Data from Historical Achieves

As a supplement to observations from SWZX, this article incorporates data on transportation costs from official archives. The DQHD provides 92 records of grain transport costs across various provinces, spanning the period from 1738 to 1776. The raw data is demonstrated in table A6. The price are spatially different, a spatial distribution on official downstream waterway freight cost is shown in figure B2. A statistic table of All records in Yangtze China has been shown in table 5.

Official records in Yangtze China mostly align with my estimations based on travel route books for transportation costs in the Yangtze Delta during 18th century. One exception is the transport cost for major rivers in 1776. Records from Jiangxi and Zhejiang provinces suggest a 50% reduction in major river transport costs. However, this reduction is questionable for there were no major technological changes in transportation in 18th-century China[14]. Given the lack of corroborating records from other sources, I treated these records as unreliable.

3.3.3 Transport Cost Conclusion

Combining these materials, this article estimates the transport costs in China proper, particularly for the middle and lower reaches of the Yangtze River, in the late 17th and 18th centuries. Detailed transport costs are reported in Table 6. In early and mid-Qing China, waterway freight costs were about one-tenth of mule-pack-based land transport costs, consistent with Kiyokoba's (1996) estimation for Song China. Passenger trips in the Yangtze Delta were reasonably cheap, at approximately 0.02 silver taels per passenger per 100 miles. Waterway freight costs in the Grand Canal and upstream of the Xinjiang River were slightly higher compared to downstream trips along the Yangtze River.

Given the similar travel speeds for upstream and downstream trips in the lower Yangtze River and its tributaries, it is likely that transport costs were not significantly affected by the direction of water flow due to the slow speed. Evidence from DQHD supports this suggestion, showing that the Qing government paid the same price for upstream and downstream trips in secondary rivers of the Yangtze Delta. Price differences between upstream and downstream transport were only observed in mountainous regions, with a ratio usually at 1:1.5.

[14]Given the fact that there were no transportation revolution in 18th century China and the fact that transport cost remained at same level when comparing transport cost in 1890s with 1690s, therefore it is likely that such drop is a political action but not able to reflect real market value.

4 Comparing Transportation Cost between Yangtze China and England in 18th century

4.1 Area and unit for comparison

By the 17th century, China had developed an extensive transportation system. But how did this system's performance compare with that of Western Europe, particularly England, which later became the birthplace of the Industrial Revolution in the 18th century? Alvarez-Palau et al. (2017b) summarize the speed and cost of both freight and passenger transportation in England and Wales in 1680 and 1830. Using this dataset and my estimates of transportation cost and speed in China at the end of the 17th century, this article compares the transportation situations in England and the Yangtze Delta region at that time.

The Yangtze Delta was chosen for comparison with England based on several considerations. As Pomeranz (2000) argues in *The Great Divergence*, even within China proper, there are huge cultural and economic differences, making it inappropriate to compare China as a whole with England. The Yangtze Delta has long been the most developed region in China and is comparable in geographical size to England, making it a more suitable basis for comparison.

One potential issue is the geographical distinction between the Yangtze Delta and England. While both areas have large plains, none of the rivers in England are comparable to the Yangtze River. The Thames, for instance, can only be classified as a secondary river by the standards used in this article. Major canal construction in England did not begin until the 1750s (Bogart, 2013), so waterway transport in late 17th-century England relied heavily on natural rivers. Therefore, the waterway transport in England is more comparable to transport on secondary rivers in the Yangtze Delta rather than primary rivers like Yangtze River.

As a result, this paper focuses on comparing transport costs on flat lands and secondary rivers in both regions.

4.2 Similar transport situation between Yangtze China and England in late 17th century

4.2.1 A comparison in transport speeds

As shown in Table 7, transport speeds for both waterways and land were similar between the Yangtze Delta and England in the late 17th century. After converting all units to miles per day, the transport speed via waterways in the Yangtze Delta was about 34.4 miles per day, and on flat land, it was about 26.9 miles per day. In England, waterway transport speed was about 38.4 miles per day, while land transport speed was 24 miles per day (Alvarez-Palau et al., 2017b; Bogart, 2019). The differences in travel speeds between the two regions are relatively small and fall within the margin of error.

The main difference appears in passenger travel speeds. In the Yangtze Delta, passengers typically traveled on stage-ships that operated day and night. Therefore, to compare passenger travel speeds, we should compare stage-ships in the Yangtze Delta with stagecoaches in England. It seems that in the late 17th century, passenger travel speed in England was about 40% faster than in the Yangtze Delta.

4.2.2 A comparison in transport cost

It is challenging to compare transportation costs between different countries historically. Although both late 17th century Yangtze China and England used silver as their primary currency[15], making direct comparison possible, the different purchasing power of their currencies makes such a comparison imprecise.

One approach is to use the Consumer Price Index (CPI) for comparison. Allen et al. (2011) constructed a bare-bones consumption basket to estimate the CPI in Western Europe and China from 1730 to 1925. For the CPI series before 1730 in China, I use the consumer

[15] Silver taels were used as the main currency during the Ming and Qing dynasties. One silver tael contained 37.3 grams of silver (Lin, 2006). Currencies in the late 17th century England were also made of precious metals. In the late 17th century, one penny contained 0.464 grams of silver (Allen, 2001; Feavearyear, 1932).

price index constructed by Peng (2006) as a supplement. However, a potential issue with using the Allen basket is that housing prices constitute a significant portion, which is unrelated to transportation costs, potentially diminishing the deflation effect.

A better approach is to use unskilled labor wages as the basis for deflation. This study uses Liu (2024) estimation of wages during the Ming and Qing dynasties, approximating that the nominal wage for unskilled labor was 0.06 silver taels per day at the end of the 17th century. For wage levels in England, this paper uses Allen (2001) estimate of the nominal unskilled labor wage in London.

The results, measured in silver, CPI, and unskilled labor wages, are presented in Table 8 and Figure 3.

Freight Cost Comparison

As shown in Table 8, both England and the Yangtze Delta maintained a ratio of approximately 1:10 between water and land transport costs at the end of the seventeenth century. When compared directly in terms of silver grams, the cost of water transport in the Yangtze Delta was approximately 0.125 grams of silver per ton-mile, and the cost of land transport was 1.254 grams of silver per ton-mile. In England, the cost of water transport was 0.464 grams of silver per ton-mile, and the cost of land transport was 4.965 grams of silver per ton-mile. Overall, the freight cost in the Yangtze Delta was about a quarter of the cost in England.

When deflated by the unskilled wage in the 1680s, the cost of shipping one ton of goods for a mile by water in the Yangtze Delta was 0.056 days of unskilled wage. In England, the cost was 0.05 days of unskilled wage, which is almost the same as in the Yangtze Delta. Land freight costs were also similar between England and the Yangtze Delta in the late 17th century, costing 0.56 days of unskilled labor wage in the Yangtze Delta and 0.535 days in England. This indicates that transport costs in the Yangtze Delta were comparable to those in England in the late 17th century when measured through unskilled labor wages.

When comparing based on CPI, Allen et al. (2011) estimated the CPI for both the Yangtze Delta and England from 1730 to 1925. Since this CPI does not cover the late 17th century, I adjusted their CPI estimates for the two regions using other consumption index estimates for England (Allen et al., 2011) and the Yangtze Delta (Peng, 2006), which provide longer coverage. The comparison shows that transport costs in the Yangtze Delta were around one-third of those in England in the late 17th century. As I have mentioned before, this discrepancy is likely because Allen's basket includes items such as housing prices, which are not directly related to transportation costs. This inclusion makes it less appropriate to use Allen's basket for deflating transport costs.

Passenger Fares Comparison

Passenger travel fares, however, show some different characteristics from freight costs. In the Yangtze Delta, people typically traveled on stage ships that operated both day and night. In contrast, travelers in England preferred stagecoaches due to the lack of a comprehensive river network comparable to that of the Yangtze Delta in the 17th century. However, if the origin and destination were connected by rivers, waterway travel was still an option in England. Thus, I included waterway travel in England for comparison.

In terms of silver grams, the cost of a stage ship in the Yangtze Delta was only 1% of the cost of a stagecoach in England and 7% of the cost of a waterway trip. In terms of unskilled labor wages, the cost of a stage ship in the Yangtze China was 6% of the cost of a stagecoach in England and one-third of the cost of waterway trips. Considering that passenger fares outside the core region of Yangtze China were four times higher than within the region, passenger transport costs via waterways were quite similar between England and periphery regions of Yangtze China.

Using the Consumer Price Index (CPI), the cost of a stage ship in the Yangtze China was 1.5% of the cost of a stagecoach in England and 8.5% of the cost of waterway trips. Overall, passenger travel fares were lower in the Yangtze China regardless of the comparison method.

4.2.3 Conclusion to the Comparison

The comparison reveals that, in terms of freight transport, both the speed and cost were quite similar between England and the Yangtze Delta in the late 17th century when evaluated through unskilled wages. However, the situation differed significantly for passenger transport. The speed of stagecoaches in England was about twice that of stage ships in the Yangtze Delta. Despite this speed advantage, the cost of passenger travel by stagecoach in England was 16 times higher than that of travel by stage ship in the Yangtze Delta.

4.3 The divergence since 1700

It is often assumed that the transport revolution in England occurred after the invention of railways around the 1840s. However, recent studies have found that England had already experienced a transport revolution centered on turnpike trusts before the advent of railways (Bogart, 2013). The most significant changes occurred in the 1750s and 1760s, during which over 300 turnpike trusts were established along 10,000 miles of road. By 1800, around 1,000 turnpike trusts managed over 20,000 miles of road (Bogart, 2005). This expansion was accompanied by significant improvements in the overall condition of England' s roads Bogart et al. (2023). Passenger travel speed increased fourfold, and long-distance services increased from 63 services per week in the first half of the 18th century to over 4,000 services per week in the 1830s (Gerhold, 2014). For freight, the construction of canals and turnpikes reduced overall transport costs in England by 40% and nearly doubled the speed of transport (Alvarez-Palau et al., 2017b).

In contrast, the transport situation in the Yangtze Delta showed little change over the same period. As shown in table 8, by comparing transport prices in the Yangtze Delta at various time periods, it can be observed that the cost of transport remained relatively constant from the end of the seventeenth century to the late eighteenth century. Transport costs in Zhili province in 1816 (Li, 2000) and the Yangtze Delta in 1890 (Fan, 1992; Kingsmill, 1898) were similar to those of the early eighteenth century. Given the lack of a transport technology revolution in China, it is likely that transport costs in the Yangtze Delta did not change significantly over nearly two centuries from the late seventeenth century to the first half of the nineteenth century. The nearly unchanged travel time for the same distance in Fujian over different eras suggests that the speed of transport in China remained constant throughout the Qing dynasty (Jian et al., 2022).

This indicates a divergence in transportation infrastructure developments between the Yangtze Delta and England starting around 1700. The timing of such divergence is interesting, as it coincident with the starting time of great divergence proposed by one strand of literature. Although there is much academic debate about the exact timing of the Great Divergence[16], recent wage data and GDP estimates for England and the Yangtze Delta suggest that the Great Divergence most likely occurred in the early eighteenth century, around 1700 (Broadberry and Gupta, 2006; Broadberry et al., 2018, 2021). Such coincidence in time raises the question of whether England's transport revolution is inextricably linked to the broader economic and technological divergence.

4.4 Level of market integration

On the other hand, the divergence in transportation infrastructure starting in 1700 likely led to a divergence in the level of market integration between the two regions. Using a grain price approach, Shiue (2002) and Shiue and Keller (2007) found that: (1) the level of market integration in ancient China was higher than previously thought; and (2) in 1750, the level of market integration in the Yangtze region of China was comparable to that of Europe but lower than that of England. However, this grain price-based approach has been criticized by historians, as they proposed that the grain market in Qing China was not a free trade market, and the government strongly intervened in grain prices. Therefore, a grain-based

[16]Pomeranz (2000) proposed the starting time point for great divergence in 1750

approach might overestimate the level of market integration in 18th century China (Li, 2000; Deng, 2011; Von Glahn, 2016; Ni and Uebele, 2019).

This study evaluates and compares one of the foundational elements of market performance, transport costs, in both regions. The findings reveal that while England started its transportation revolution in the 1700s, China saw hardly any significant changes in transport technology and networks. According to the law of one price, the price difference for the same commodities in two markets should be equal to or less than the transport cost between these two markets. If the price gap is higher than the transport cost, trade would occur and reduce the gap. This law provides the theoretical foundation for the potential connection between changes in market integration and the development of transport infrastructure. Thus, the comparison of transportation conditions between the two regions makes it reasonable to suspect that, by the late 17th century, the level of market integration in England and the Yangtze region of China was similar. However, the divergence in transportation developments starting from 1700 likely led to a divergence in market integration levels between the two regions.

This conclusion aligns with the findings of Shiue (2002) and Shiue and Keller (2007), further indicating that using the grain price approach to assess the level of market integration in historical China is, to some extent, reliable.

5 Conclusion

Through historical commercial route books and official archives, this paper reconstructs the transportation network of China during the Ming and Qing dynasties and evaluates the transport costs and speeds in the Yangtze region at the end of the 17th century. The paper then compares the transport costs and speeds in the Yangtze region from the late 17th to the 19th century with those of England during the same period. The comparison shows that in the late 17th century, the transport costs and speeds in both regions were very similar.

However, starting from 1700, England underwent a transport revolution, marked by the turnpike trust revolution and canal revolution, which significantly improved its transportation infrastructure, reduced transport costs, and increased speeds (Bogart, 2005, 2013, 2019). Meanwhile, China did not experience any significant transportation technology revolution during the same period. This indicates that starting from 1700, there was a divergence in transportation conditions between the Yangtze region of China and England. This timeline aligns with one strand of literature's estimate for the occurrence of the Great Divergence (Broadberry and Gupta, 2006; Broadberry et al., 2018, 2021), suggesting a potential link between the transport revolution and the Great Divergence.

Additionally, the comparison suggests that, by the late 17th century, the level of market integration in England and the Yangtze China was similar. However, the divergence in transportation developments since 1700 likely led to a divergence in market integration levels between the two regions. This inference aligns with the conclusions of Shiue (2002) and Shiue and Keller (2007), further indicating that using the grain price approach to assess market integration in historical China is, to some extent, reliable.

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Tables

Table 1: *Unit Conversion for Late 17th and 18th century China*

Measure and weights	
1 *li* 里 (Chinese miles)	500 meters
1 *jin* 斤 (catty)	600 grams
1 *shi* 石 (picul, weight)	84 kilograms
Currencies	
1 *tael* 两	approx. 37.31 grams of silver
1 *qian* 钱 (mace)	1/10 of a tael
1 *fen* 分 (candareen)	1/100 of a tael
1 *li* 厘	1/1000 of a tael
1 *wen* 文 (coppers)	assume 1/850 of a tael

Source: *Jin* and *shi* sourced from Peng (1965). *li* see text. Currency conversion ratio from Lin (2006) and Antony (2016).

Table 2: *Abbreviations to primary sources*

Name	Chinese	Abbreviations
Shiwo Zhouxing	示我周行	SWZX
Zhouxing Beilan	周行备览	ZXBL
Yitong Lucheng Tuji	一统路程图记	YTLC
Shanggu Bianlan	商贾便览	SGBL
Huanyu Tongqu	寰宇通渠	HYTQ
Qingding Daqing Huidian	钦定大清会典事例	DQHD

Notes: More detail in appendix E

Table 3: *An estimation to travel speed in late 17th century China*

Travel Method	Speed *km/day*
Primary River	65
Secondary River	55
Tertiary - Downstream	66.5
Tertiary - Upstream	28
Flat Land	43
Land-Hill	30

Source: Sourced from SWZX. Original cases see table A2.

Table 4: *Transport cost in late 17th century China from Commercial Route Books*

Travel Method	Cost
Freight Cost	*silver taels/100kg/100km*
Secondary River	0.021
Flat Land - mule/packhorse	0.213
Flat Land - wheeled vehicle	0.077
Flat Land - labor	1.594
Passenger Cost	*silver taels/pax/100km*
Waterway - stageship (core Yangtze)	0.022
Waterway - stageship (periphery Yangtze)	0.084
Flat Land - sedan	0.750

Source: Sourced from SWZX. Original cases see table A3.

Table 5: *Freight Cost in 18th century Yangtze China from Official archive*

Travel method	**Avg**	**Std**	**n**
	silver taels/100kg/100km		
Primary river	0.015	0.002	6
Secondary river	0.023	0.003	12
Tertiary river - upstream	0.043	0.006	4
Tertiary river - downstream	0.035	0.010	5
Flat Land	0.229	0.022	11
Hill Land	0.452	0.103	14

Source: Sourced from DQHD. Original cases see table A6.

Table 6: *An estimation to transport cost in late 17th century China*

Travel Method	Cost
Freight Cost	*silver taels/100kg/100km*
Primary River	0.016
Secondary River	0.021
Tertiary - upstream	0.043
Tertiary - downstream	0.035
Flat Land - mule/packhorse	0.213
Flat Land - wheeled vehicle	0.077
Flat Land - labor	1.594
Hill Land	0.452
Passenger Cost	*silver taels/pax/100km*
Waterway - stageship (core Yangtze)	0.022
Waterway - stageship (periphery Yangtze)	0.084
Flat Land - sedan	0.750

Source: Sourced from SWZX and DQHD.

Table 7: *Transport Speed in Yangtze China and England*

	Units	**Yangtze 1680s**	**England 1680**	**England 1830**
Passenger speed				
Waterway	mpd	34.4	38.4	30
Land	mpd	26.9	48	208.8
Freight speed				
Waterway	mpd	34.4	38.4	30
Land	mpd	26.9	24	48

Source: For Yangtze Delta see text. For England see Alvarez-Palau et al. (2017b)
Notes: mpd for miles per day

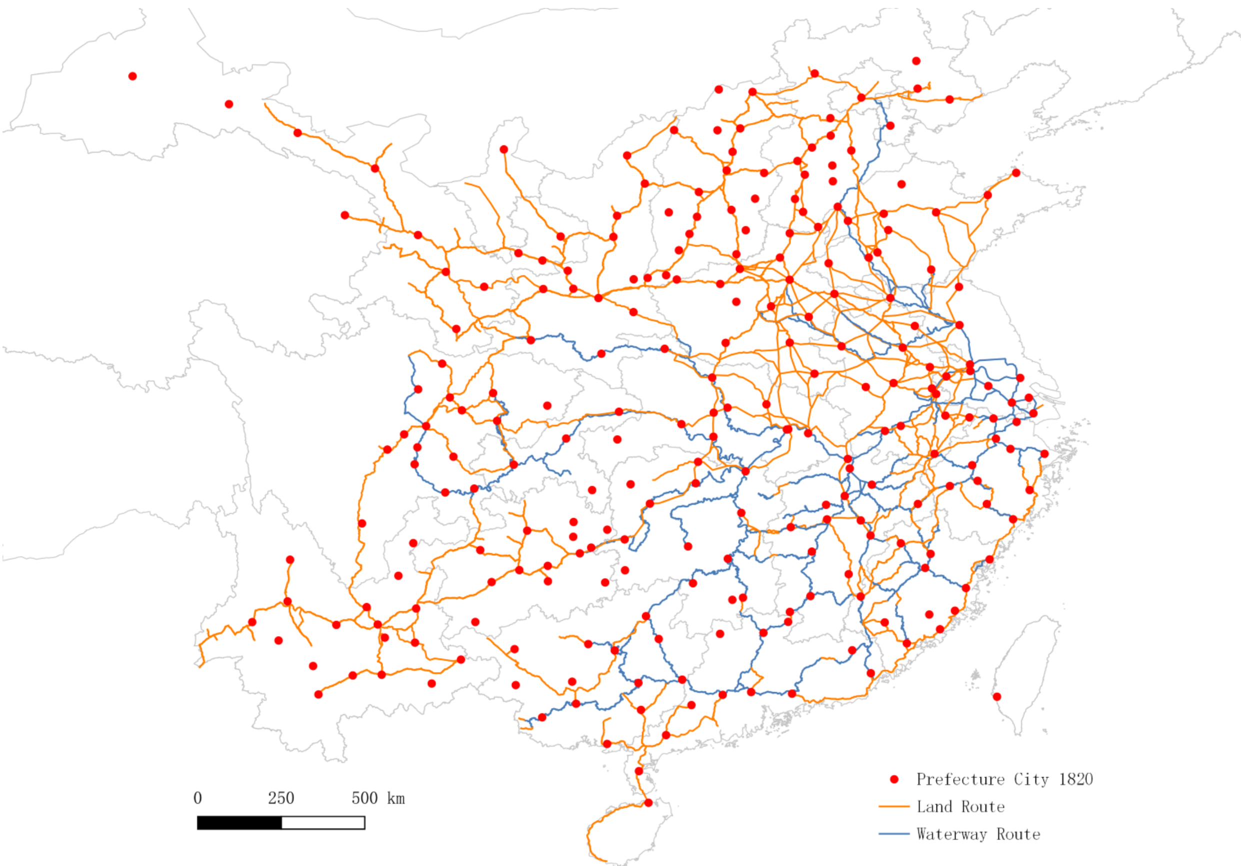
Table 8: *Transport Cost in Yangtze China and England*

Region	**Freight**		**Passenger**	
	Waterway	*Land*	*Waterway*	*Land*
Silver grams				
Yangtze –1680s	0.125	1.272	0.013	
England –1680	0.464	4.965	0.186	1.021
Zhili –1812	0.213	1.421		
England –1830	0.631	4.467	0.486	1.457
France –1830	0.742	3.191		
Jiangsu –1890	0.260	3.924		
Deflate by Wage (days)				
Yangtze - 1680s	0.056	0.568	0.006	
England - 1680	0.050	0.535	0.020	0.110
Zhili - 1812	0.071	0.476		
England - 1830	0.036	0.256	0.028	0.083
France - 1830	0.082	0.355		
Jiangsu - 1890	0.045	0.675		
Deflate by CPI (Allen Basket)				
Yangtze - 1680s	0.325	3.295	0.034	
England - 1680	0.825	8.827	0.330	1.815
Zhili - 1812	0.333	2.219		
England - 1830	0.676	4.785	0.520	1.560
France - 1830	0.873	3.753		
Jiangsu - 1890	0.157	2.374		

Notes: Unit in ton/pax mile. Transport cost for China see text, for England see Alvarez-Palau et al. (2017b), for France in 1830s see Ejrnaes and Persson (2000). Wage and CPI data from Liu (2024), Allen (2001), and Allen et al. (2011). CPI in China before 1730 is adjusted by CPI constructed in Peng (2006). Wage data is in days, therefore it stands for to what extend could 1 day wage transport (in ton/mile).

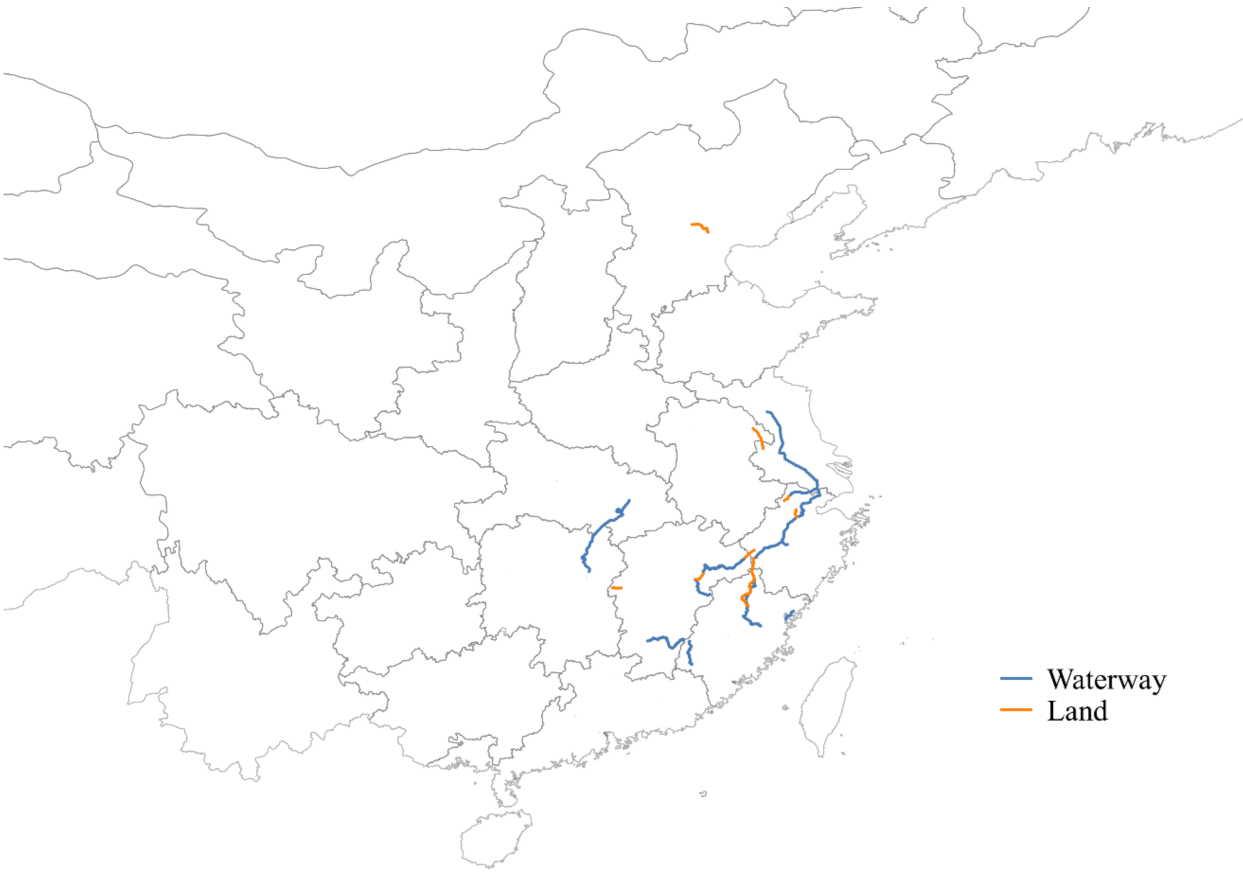
Figures

Figure 1: *Transportation Network in Ming-Qing China*



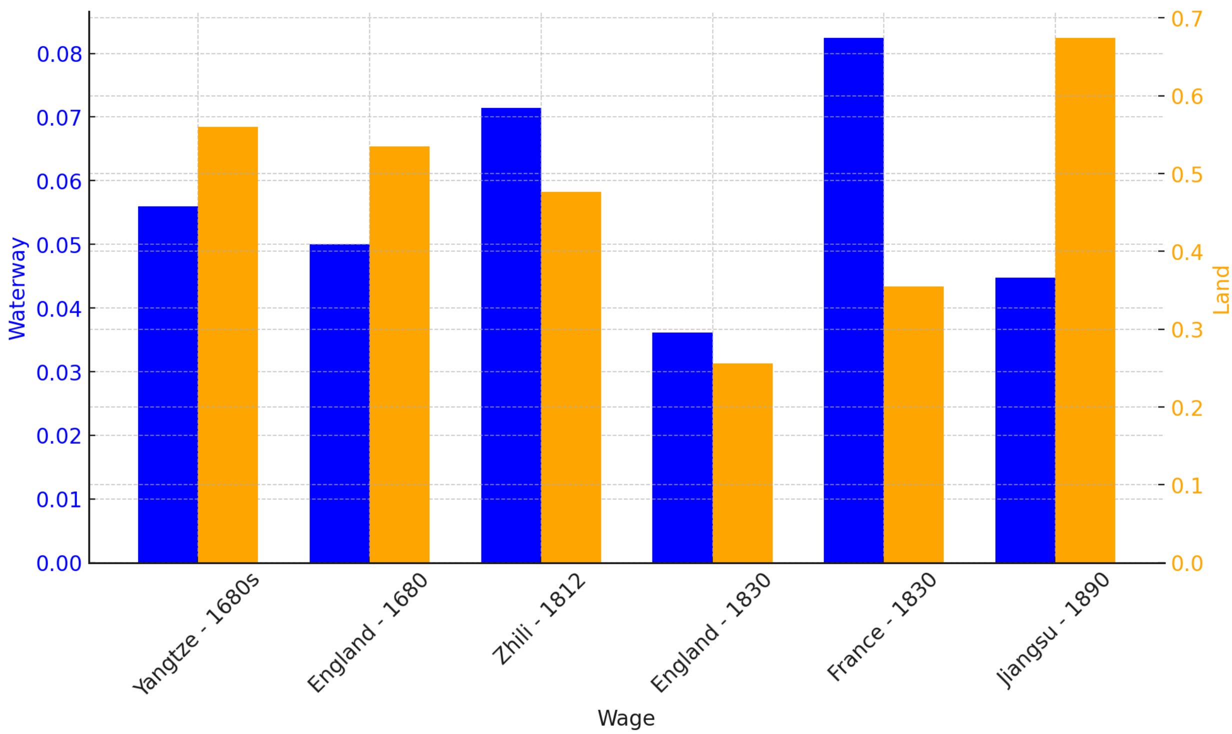
Note: GIS reconstruction of transportation network in ming-qing China. Using source from Yang (2006), SWZX and YTLC. Detail for construction see text. Prefecture seats location from CHGIS.

Figure 2: *Spatial distribution of quoted routes in SWZX*



Note: This graph shows all quoted routes used for transport cost and speed estimation from SWZW. A majority of sources are from Eastern China in Jiangsu, Zhejiang, Fujian, Jiangxi, and Huguang Province.

Figure 3: *Comparing Transport cost in England and Yangtze China*



Source: see table 8.

Appendix A. Additional Table

Table A1: *Transport cost in historical China*

Time	**Travel Method**	**Nominal Price**	**Silver Grams**	**Grain Liter**
		Copper Coin/100kg/100km		
Tang (738)	Land	498.00	-	149.40
	Waterway	165.84	-	49.75
Song (1202)	Land	336.02	3.84	8.41
	Waterway	33.60	0.38	0.84
Song	Land	-	10.13	18.39
(1100 price)	Waterway	-	1.01	1.84
		Zhongtong Chao/100kg/100km		
Yuan (1288)	Land	0.328	12.50	32.05
	Waterway	0.020	0.75	1.92
		Silver Taels/100kg/100km		
Qing (1694)	Land	0.213	7.95	24.66
	Waterway	0.016	0.60	1.85
Qing (1890)	Land	0.654	24.39	27.18
	Waterway	0.044	1.63	1.81

Source: All data here are for Yangtze China. Song (1100 price) is the transport cost from Song (1202) but deflating through grain and silver price in 1100. Tang and Song data are from Kiyokoba (1991), Kiyokoba (1996), and Liu (2012), Yuan data from *Da De Dian Zhang* (大德典章), Qing (1694) data see text, and Qing (1890) data from Fan (1992) and Kingsmill (1898) and. All grain price and silver price (excpet Yuang Dynasty) are sourced from Peng (1965) (grain price in 8th century from p218, Song price from pp313, Yuan price from pp403 and Qing price from pp560). Silver conversion ratio are from Peng (1965) as well (Song ratio from pp330, Yuan ratio from pp447 of 2020 edition). Qing Dynaty is then using Silver as its main currency.

Table A2: *Speed observations in route books*

Obs.	**Region**	**Travel Method**	**Route condition**	**Time Taken**	**Distance** ***km***	**Speed** ***km/day***
1	Fujian	waterway	Creek - upstream	16 days	400	25
2	Fujian	waterway	Creek - downstream	4 - 5 days	400	80
3	Fujian	land	Hill	3 days	105	35
4	Zhejiang	waterway	Rivers - upstream	6 days	330	55
5	Zhejiang	waterway	Rivers - downstream	6 days	330	55
6	Jiangsu	waterway	Canal	5 - 6 days	350	60
7	Jiangsu	waterway	Canal	3 days	170	55
8	Jiangsu	land	Flat	4 days	170	43
9	Zhili	land	Flat	2.5 days	117	45
10	Zhili	land	Flat	1 day	29	29
11	Huguang	waterway	Major Rivers - upstream	5 - 6 days	380	65
12	Huguang	land	Hill	1 day	31	31
13	Fujian	waterway	Creek - upstream	5 days	135	27
14	Fujian	waterway	Creek - downstream	2.5 days	135	67.5
15	Huguang	waterway	River - downstream	2 days	128	64
16	Fujian	land	Hill	4 days	170	42.5
17	Jiangxi	waterway	Secondary Rivers - downstream	6 days	270	45
18	Zhejiang	waterway	Creek - downstream	0.5 day	26	52
19	Zhejiang	stage ship	Rivers	1 night	34	34
20	Fujian	waterway	Coast	1 tide	43	43
21	Fujian	waterway	Creek - upstream	6 days	190	32
22	Jiangsu	land	Flat	2 days	83	41.5

Notes: All sourced from SWZX

Table A3: *Cost observations in route books*

Obs.	**Region**	**Travel Method**	**Route condition**	**Price**	**Distance**	**Capacity**	**Transport cost**
Freight Cost							*taels/100kg/100km*
1	Yangtze Delta	Waterway	Canal	2 - 3 taels	336 km	40 piculs	0.018 - 0.026
2	Jiangxi	Land-mule pack	Flat	100 wen	56 km	100 kg	0.212
3	Jiangxi	Land-wheeled vehicle	Flat	220 wen	56 km	1000 jin	0.078
4	Jiangxi	Waterway	River-upstream	1200 wen	200 km	40 piculs	0.021
5	Yangtze Delta	Land-labor	Flat	2 qian	55 km	25 kg	1.455
6	Yangtze Delta	Land-labor	Flat	1.3 qian	30 km	25 kg	1.733
Passenger Cost							*taels/pax/100km*
7	Yangtze Delta	Stageship	Canal	2 fen	100 km	1 pax	0.02
8	Yangtze Delta	Stageship	Canal	8 li	35 km	1 pax	0.023
9	Yangtze Delta	Stageship	Canal	1 fen	45 km	1 pax	0.022
10	Zhejiang	Waterway-pax	River-downstream	2.1 qian	250 km	1 pax	0.084
11	Jiangxi	Land-sedan chair	Flat	750 wen	39 km	1 pax	0.882

Notes: All sourced from SWZX

Table A4: *Cost observations in Kingsmill (1898)*

Region	Land	River	Land Silver	River Silver	Land Grain	River Grain
	Cash/catty/li		*Grams/100kg/100km*		*100L/100kg/100km*	
Shansi	0.0400	-	32.514	-	36.240	-
Shensi	0.0200	-	16.257	-	18.120	-
Kansu	0.0200	-	16.257	-	18.120	-
Ningshia	0.0300	-	24.386	-	27.180	-
Tsinghai to Kansu	0.0200	-	16.257	-	18.120	-
Shensi to Kansu	0.0200	-	16.257	-	18.120	-
Szechwan	0.0500	-	40.643	-	45.299	-
Yunnan	0.0300	-	24.386	-	27.180	-
Kwangsi	0.0400	-	32.514	-	36.240	-
Hupeh to Honan	0.0300	-	24.386	-	27.180	-
Kiangsu to Anhwei	-	0.0030	-	2.439	-	2.718
Kiangsu to Honan	-	0.0020	-	1.626	-	1.812
Kiangsu	0.0300	0.0008	24.386	0.650	27.180	0.725
Chekiang	0.0300	-	24.386	-	27.180	-
Honan to Shansi	0.0200	-	16.257	-	18.120	-
Honan	-	0.0040	-	3.251	-	3.624
Hopei	0.0300	0.0080	24.386	6.503	27.180	7.248
Shantung	0.0300	-	24.386	-	27.180	-
Manchuria	0.0400	-	32.514	-	36.240	-

Notes: Sourced from Kingsmill (1898). According to Fan (1992), this should be a survey on the transport price in China at 1890 conducted by Royal Asiatic Society. Grain Price is sourced from Peng (1965) (pp 676). Exchange ratio between copper coin and silver is derived from Lin (2006).

Table A5: *Cost observations in Yuan Dynasty*

Location	Method	Year	Nominal	Silver	Grain
			Zhongtong Chao /1000 jin/100 li	*taels /100kg/100km*	*liters /100kg/100km*
Origin Plan					
National	Land-hill	1288	12	0.39	38.5
	Land-flat		10	0.33	32.1
	Waterway-downstream		0.6	0.02	1.9
	Waterway-upstream	1292	1.2	0.04	3.8
New Plan					
Zhejiang	Land-hill	1300	15	0.49	48.1
	Land-flat		12	0.39	38.5
	Waterway-Yangtze-downstream		0.7	0.02	2.2
	Waterway-Yangtze-upstream		0.8	0.03	2.6
	Waterway-upstream		1	0.03	3.2
	Waterway-downstream		0.7	0.02	2.2
Jiangxi	Land-flat	1301	17	0.56	54.5
Henan	Land-hill	1301	15	0.49	48.1
	Land-flat		12	0.39	38.5
	Waterway-upstream		1	0.03	3.2
	Waterway-downstream		0.6	0.02	1.9

Source: Sourced from *Da De Dian Zhang* (大德典章), can be found in *Yong Le Da Dian Can Juan* (永乐大典残卷), volume 15950. Also can be found in *Yuan Dian Zhang* (元典章), volume 26. Grain price sourced from Peng (1965) (pp486-481). In Yuan Dynasty, 1 *jin* equals to 610 grams, 1 *jin* equals to 16 taels and 1 tael equals to 38.125 grams.(Yang, 2001)(pp401-402).

Table A6: *Cost observations in DQHD*

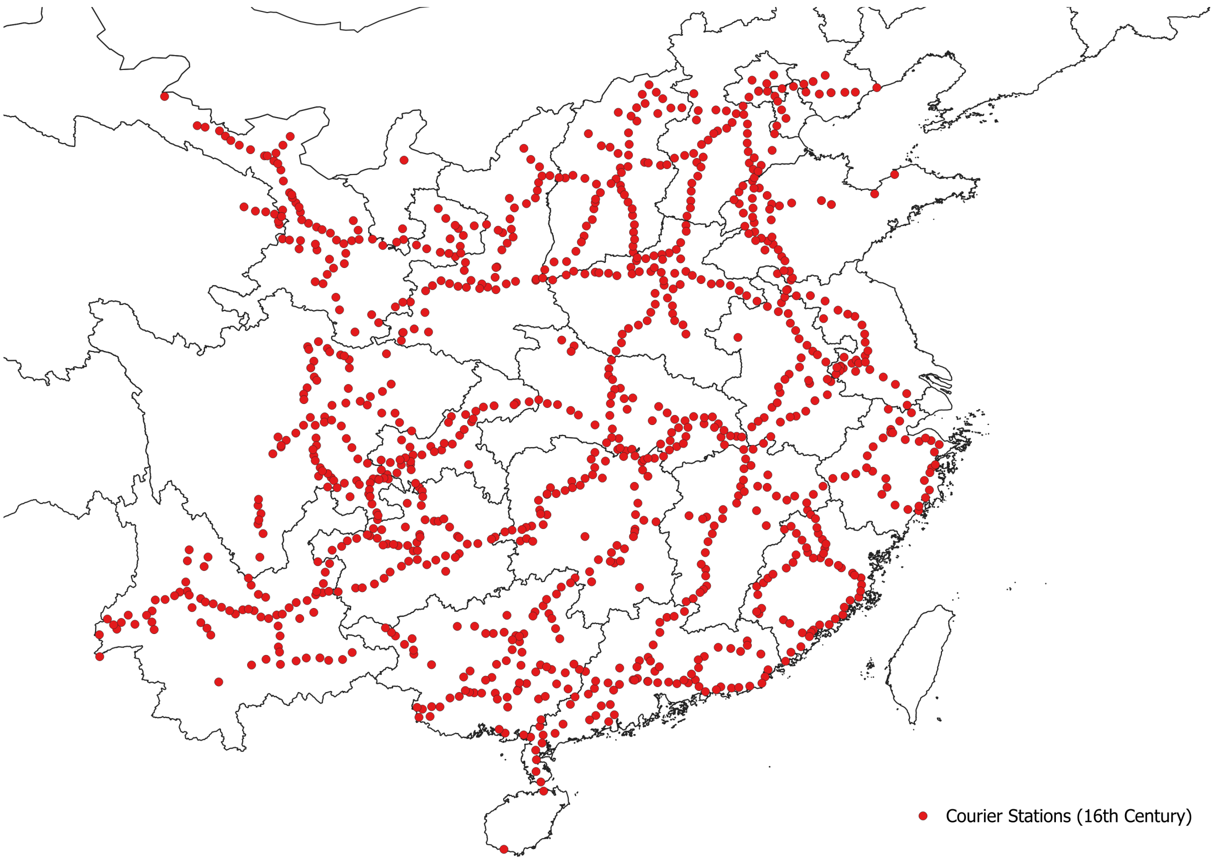
Obs.	Year	Region	Method	Sub-condition	Unit cost	Silver grams /100kg/100km	Silver grams /ton/mile
1	1738	Hunan	waterway	secondary	0.01 taels/shi/100 li	0.888	0.142
2	1738	Jiangsu	waterway	secondary	0.008 taels/shi/100 li	0.711	0.114
3	1738	Jiangsu	waterway	secondary	0.01 taels/shi/100 li	0.888	0.142
4	1738	Jiangsu	land	flat__labor	0.0015 taels/shi/li	13.325	2.132
5	1743	Guangxi	waterway	secondary	0.015 taels/shi/100 li	1.333	0.213
6	1743	Guangxi	waterway	tertiary	0.02 taels/shi/100 li	1.777	0.284
7	1743	Guangxi	land	flat	0.001 taels/shi/li	8.883	1.421
8	1743	Guangxi	land	hill	0.002 taels/shi/li	17.767	2.843
9	1743	Sichuan	waterway	primary-downstream-normal	0.007 taels/shi/100 li	0.622	0.099
10	1743	Sichuan	waterway	primary-upstream-normal	0.014 taels/shi/100 li	1.244	0.199
11	1743	Sichuan	waterway	primary-downstream-dry	0.009 taels/shi/100 li	0.800	0.128
12	1743	Sichuan	waterway	primary-upstream-dry	0.016 taels/shi/100 li	1.421	0.227
13	1743	Sichuan	waterway	tertiary-downstream	0.016 taels/shi/100 li	1.421	0.227
14	1743	Sichuan	waterway	tertiary-upstream	0.032 taels/shi/100 li	2.843	0.455
15	1743	Sichuan	land	flat	0.0015 taels/shi/ li	13.325	2.132
16	1743	Sichuan	land	slope	0.0022 taels/shi/ li	19.543	3.127
17	1743	Sichuan	land	hill	0.003 taels/shi/ li	26.650	4.264
18	1743	Zhili	waterway	secondary	0.00015 taels/shi/li	1.333	0.213
19	1743	Zhili	land	flat	0.001 taels/shi/li	8.883	1.421
20	1743	Shandong	waterway	secondary	0.02 taels/shi/100 li	1.777	0.284
21	1743	Shandong	land	flat	0.1 taels/shi/100 li	8.883	1.421
22	1743	Fengtian	land	flat	0.0012 taels/shi/li	10.660	1.706
23	1743	Zhejiang	land	flat	0.0007 taels/shi/li	6.218	0.995
24	1743	Zhejiang	land	hill	0.0015 taels/shi/li	13.325	2.132
25	1743	Zhejiang	waterway	secondary	0.001 taels/shi/10 li	0.888	0.142
26	1743	Zhejiang	waterway	tertiary	0.0015 taels/shi/10 li	1.333	0.213
27	1743	Shanxi	land	flat	0.1 taels/shi/100 li	8.883	1.421
28	1743	Jiangxi	waterway	secondary-downstream	0.01 taels/shi/100 li	0.888	0.142
29	1743	Jiangxi	waterway	secondary-upstream	0.012 taels/shi/100 li	1.066	0.171
30	1743	Jiangxi	waterway	primary-downstream	0.0058 taels/shi/100 li	0.515	0.082
31	1743	Jiangxi	waterway	primary-upstream	0.00696 taels/shi/100 li	0.618	0.099
32	1743	Henan	waterway	secondary	0.01 taels/shi/100 li	0.888	0.142
33	1743	Henan	land	flat	0.14 taels/shi/100 li	12.437	1.990
34	1743	Hubei	waterway	easy	0.007 taels/shi/100 li	0.622	0.099
35	1743	Hubei	waterway	hard	0.012 taels/shi/100 li	1.066	0.171
36	1743	Hubei	land	easy	0.001 taels/shi/li	8.883	1.421
37	1743	Hubei	land	hard	0.0015 taels/shi/li	13.325	2.132
38	1743	Hunan	waterway	primary-downstream	0.005 taels/shi/100 li	0.444	0.071
39	1743	Hunan	waterway	primary-upstream	0.007 taels/shi/100 li	0.622	0.099
40	1743	Hunan	waterway	tertiary-downstream	0.007 taels/shi/60 li	1.036	0.166
41	1743	Hunan	waterway	tertiary-upstream	0.01 taels/shi/60 li	1.481	0.237
42	1743	Hunan	waterway	tertiary-downstream-extream	0.01 taels/shi/60 li	1.481	0.237
43	1743	Hunan	waterway	tertiary-upstream-extream	0.012 taels/shi/60 li	1.777	0.284
44	1743	Hunan	land	flat__labor	0.05 taels/0.4shi/60 li	18.507	2.961
45	1743	Hunan	land	hill__labor	0.06 taels/0.4shi/60 li	22.208	3.553
46	1743	Hunan	land	hill-hard__labor	0.07 taels/0.4shi/60 li	25.910	4.146
47	1743	Anhui	waterway	primary	0.00651 taels/shi/100 li	0.578	0.093
48	1743	Anhui	waterway	secondary	0.01 taels/shi/100 li	0.888	0.142
49	1743	Anhui	waterway	tertiary-shallow	0.018 taels/shi/100 li	1.599	0.256

50	1743	Anhui	waterway	tertiary-extream	0.02 taels/shi/100 li	1.777	0.284
51	1743	Anhui	land	flat	0.001 taels/shi/li	8.883	1.421
52	1743	Anhui	land	slope	0.0015 taels/shi/li	13.325	2.132
53	1743	Anhui	land	hill	0.002 taels/shi/li	17.767	2.843
54	1743	Anhui	land	hill-hard	0.003 taels/shi/li	26.650	4.264
55	1744	Shaanxi	waterway		0.04 taels/shi/100 li	3.553	0.569
56	1744	Shaanxi	land	flat	0.1 taels/shi/100 li	8.883	1.421
57	1744	Shaanxi	land	hill	0.16 taels/shi/100 li	14.213	2.274
58	1744	Gansu	land		0.13 taels/shi/100 li	11.548	1.848
59	1744	Yunnan	land	flat	0.12 taels/shi/100 li	10.660	1.706
60	1744	Yunnan	land	hill	0.2 taels/shi/100 li	17.767	2.843
61	1744	Guizhou	land	flat	0.001 taels/shi/li	8.883	1.421
62	1744	Guizhou	land	hill	0.0018 taels/shi/li	15.990	2.558
63	1744	Guangdong	land	flat	0.003 taels/shi/li	26.650	4.264
64	1744	Guangdong	land	hill	0.004 taels/shi/li	35.533	5.685
65	1744	Guangdong	land	by vehicle	0.001 tales/shi/li	8.883	1.421
66	1744	Guangdong	waterway	downstream	0.007 taels/shi/100 li	0.622	0.099
67	1744	Guangdong	waterway	upstream	0.01 taels/shi/100 li	0.888	0.142
68	1744	Guangdong	seaship		0.07 taels/shi/100 li	6.218	0.995
69	1744	Fujian	waterway	tertiary-downstream	0.001 taels/shi/10 li	0.888	0.142
70	1744	Fujian	waterway	secondary-downstream	0.008 taels/shi/100 li	0.711	0.114
71	1744	Fujian	waterway	tertiary-upstream	0.0015 taels/shi/10 li	1.333	0.213
72	1744	Fujian	land	flat	0.001 taels/shi/li	8.883	1.421
73	1744	Fujian	land	hill	0.0015 taels/shi/li	13.325	2.132
74	1776	Fengtian	land		0.0012 taels/shi/li	10.660	1.706
75	1776	Fengtian	waterway		0.00014 taels/shi/li	1.244	0.199
76	1776	Fengtian	seaship		0.14 taels/shi/500km	1.244	0.199
77	1776	Zhili	waterway		0.00015 taels/shi/li	1.333	0.213
78	1776	Jiangxi	land	hill	0.001 taels/100 jin/li	12.437	1.990
79	1776	Jiangxi	waterway	primary	0.003 taels/shi/100 li	0.267	0.043
80	1776	Jiangxi	waterway	secondary-downstream	0.003 taels/shi/100 li	0.267	0.043
81	1776	Jiangxi	waterway	secondary-upstream	0.003 taels/shi/60 li	0.444	0.071
82	1776	Fujian	seaship		0.09 taels/shi/800km	0.500	0.080
83	1776	Fujian	seaship		0.0748 taels/shi/700km	0.475	0.076
84	1776	Zhejiang	land	flat	0.001 taels/shi/li	8.883	1.421
85	1776	Zhejiang	waterway	primary	0.00005 taels/shi/li	0.444	0.071
86	1776	Zhejiang	waterway	tertiary-hill	0.0002 taels/shi/li	1.777	0.284
87	1776	Yunnan	land	flat	0.135 taels/shi/100 li	11.993	1.919
88	1776	Yunnan	land	flat-horse	0.18 taels/shi/100 li	15.990	2.558
89	1776	Yunnan	land	hill	0.165 taels/shi/100 li	14.658	2.345
90	1776	Yunnan	land	hill-horse	0.2 taels/shi/100 li	17.767	2.843
91	1776	Yunnan	waterway	tertiary-wide	0.0004 taels/shi/li	3.553	0.569
92	1776	Yunnan	waterway	tertiary-narrow	0.0005 taels/shi/li	4.442	0.711

Notes: All sourced from DQHD

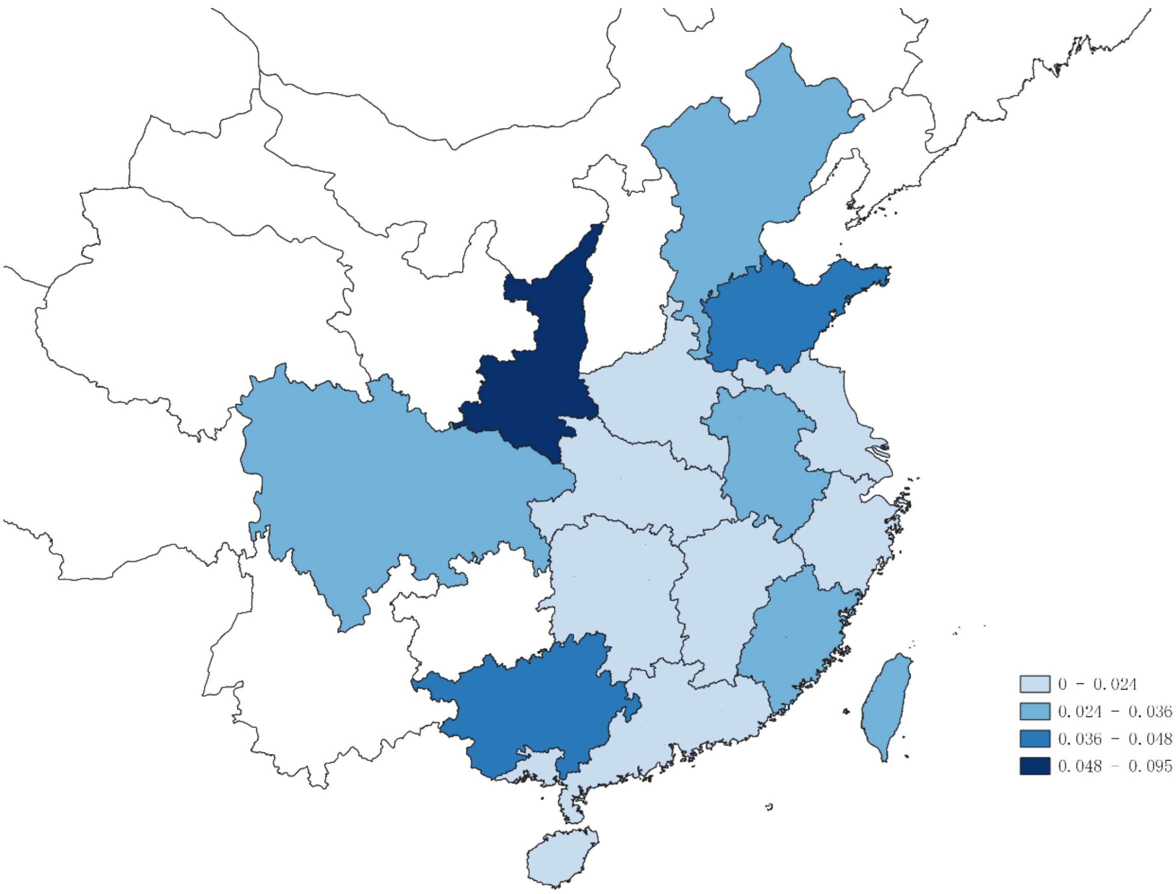
Appendix B. Additional Figure

Figure B1: *Courier Stations in Ming China*



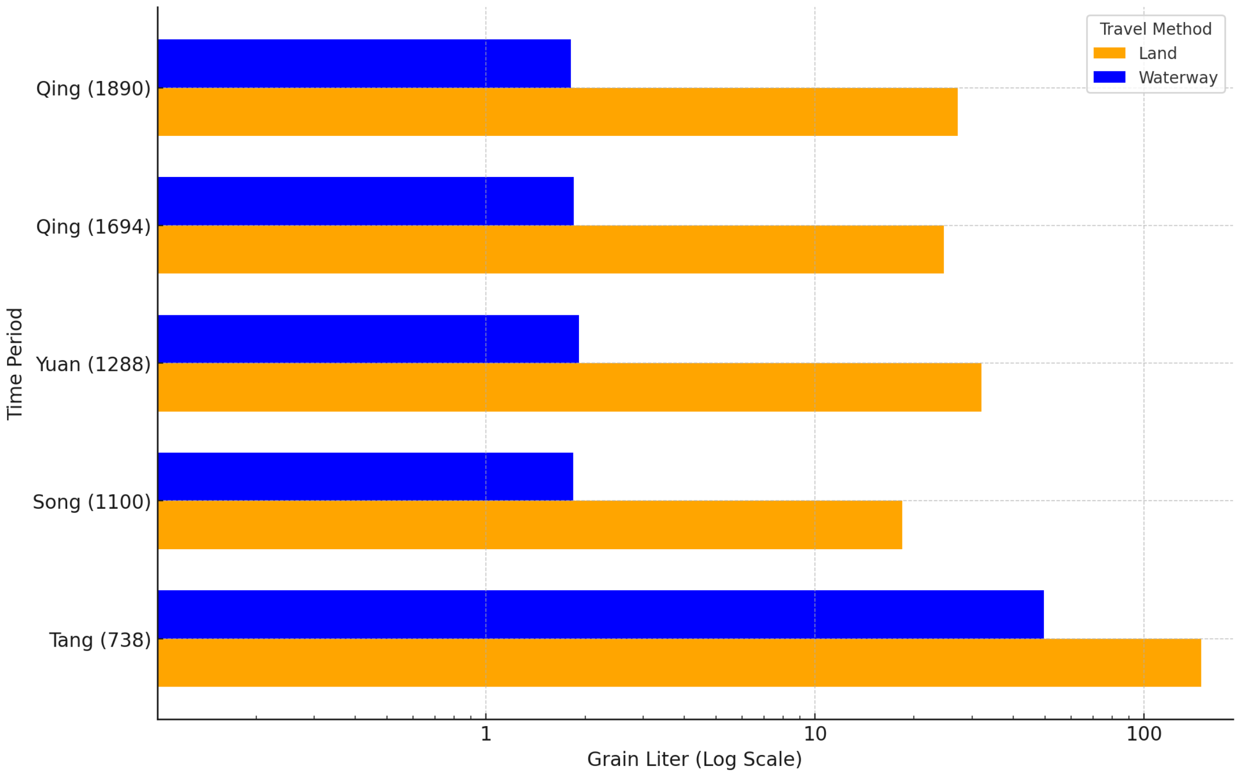
Note: Source from Yang (2006).

Figure B2: *Official downstream waterway transport costs in 1740s*



Note: Sourced from DQHD. Unit in silver taels/100kg/100km It can be observed waterway transport costs were diverse in 1740s China. In general, it cost higher in western and northern China. Regions that are plains or with comprehensive waterways obtained lower waterway transport costs in 1740s.

Figure B3: *Transport Costs over Different Dynasties in Historical China*



Source: see table A1

Appendix C. Travel in Ming-Qing China

Traveling in Ming-Qing China was considerably more complex than it is today. The first challenge appeared to be identifying the direction of the way. *Xu Hongzu* 徐弘祖, renowned as *Xu Xiake* 徐霞客, a prominent traveler and geographer, addressed this issue by carrying a copy of the *Ming Yitongzhi* (*Ming National Gazetteer* 明一统志), which consisted of a cumbersome ninety volumes (Brook, 1981). These extensive volumes were far from being portable or practical for the average traveler. To bridge this gap, a more accessible guide was published in the late 16th century, the *Yitong Lucheng Tuji* (*Comprehensive Illustrated Route Book* 一统路程图记) (hereafter as YTLC). This guide was specifically crafted for merchants and ordinary travelers. *Huang Bian* 黄汴, the author of YTLC and a merchant from Huizhou—present-day Anhui, China—recognized the challenges of traversing the vast Chinese Empire, particularly the absence of a practical, comprehensive route book for common use. In response, he authored YTLC to serve as a reference for future travelers. In the preface of the book, he notes:

> *My family resides in the mountainous region of Huizhou, an area known for its challenging transportation and limited educational opportunities. Despite the scarcity of flat land, it remains densely populated. These conditions have compelled many locals to pursue merchant trade as a means of survival. At the age of twenty, I began to travel with my father and brothers. Our journey took us from Hongdu to Changsha, and along the way, we explored the scenic landscapes of Dongting Lake. We then journeyed along the Yangtze River, stopping at Huaiyin and Yangzhou, before ultimately reaching our final destination, Beijing.*
>
> *I am anxious to return home as soon as possible during my trip from Yanzhou to Xuzhou, but the road ahead is murky indeed. I am troubled with asking the direction and realized that many travelers suffer the same difficulty of missing*

the direction of the way as I did.

Later, when I was living in Suzhou, I collected several route maps from merchants who traded in both capitals, all thirteen provinces, and the border regions. I examined them closely, compared their differences, then collated all the material. It took me twenty-seven years to work it into book form.

This book is formed into eight volumes and each volume has its specialized region. Once the reader read it, one can know the direction and distance of routes, the steepness of mountains and rivers, and the potential dangers of robbery. One can gain insights into various fields in various regions, just like the whole of China is displayed on one' s hand. I sincerely write this book and hope this book could provide references to officials' tours, merchants' trends, and ordinary people' s trips.

In the post of the book, it writes:

Should gentry obtain this book, it will help them carry out the emperor' s sagely commands, and should merchants obtain it, it will inform them about the characteristics and difficulties of local area[17]*.*

Indeed, Huang's YTLC achieved the impact he anticipated, gaining popularity towards the end of the Ming Dynasty. The book offers comprehensive details on 158 routes across China, alongside insights into the scenery, specialties, security, and cultural aspects of various regions. However, by the late 17th century, a new guide, *Shi Wo Zhou Xing* (*Traveling Everywhere on My Own* 示我周行) (here after SWZX), eclipsed Huang's YTLC in popularity. Unlike Huang' s guide, which typically summarizes regional situations in one or two sentences, SWZX provides extensive descriptions in full paragraphs. It includes meticulous

[17]Translation from (Brook, 1981)

details on practical matters such as hiring vehicles and pack mules, paying commercial taxes, finding lodgings, and offers specific information and precautions for different areas. Due to its thoroughness, SWZX was reprinted multiple times in the 18th century and continued to be a valued reference well into the late 19th century (Jian et al., 2022).

These route books provide a vivid depiction of Ming-Qing China as an empire with a well-developed transportation network, encompassing a variety of transport modes and extensive routes covering the majority of China proper. The books detail extensive waterway networks, where people traveled using different types of ships on canals, lakes, major rivers, and creeks. Depending on the waterway, ships varied greatly in capacity, ranging from a few piculs to hundreds of piculs.

For land routes, travelers commonly journeyed on foot, often with their belongings transported by pack horses or mules, especially for long-distance treks that could extend over thousands of kilometers. In flatter regions, different sizes of wheeled vehicles were available for shorter trips. Notably, near Beijing, one could hire vehicles for transporting goods from Tongzhou, the northern terminus of the Grand Canal, to the capital. A large vehicle could carry up to 2000 *jin* of goods but might face congestion in Beijing's city center, whereas a smaller vehicle, carrying up to 1000 *jin*, offered greater maneuverability.

In the Yangtze Delta, stage ships provided continuous day and night service, connecting cities and towns. These ships are meticulously detailed in the route books. In YTLC, the book has described the stage ships in Suzhou as follows:

> *For trips north of Suzhou cities, ships run only in days; For trips south to Suzhou city, ships run both day and night. One can take ships to Huzhou from both Meidu Bridge and Pingwang in Suzhou City, ships for this route run both day and night. Both day and night ships from Jiangxing to Pinghu should be boarded at Dongzhakou. Ships from Jianxing to Songjiang only run during the day but not at night.*

For Huzhou, it writes that one can take night ships to Suzhou from the east gate; night ships to Jian from the west gate; night ships to Hangzhou, Wukang county, and Deqing county from the south gate; and night ships to Yixing county from the north gate. At the end of the instruction, it concludes that:

> *All stage ships from Huzhou to other places run at the night only. Two exceptions are stage ships to Zhengze and Wuzhen, which there are also days ships available.*

While China has a long history of prosperous long-range naval trade with Southeast Asia and Japan (Brook, 2017; Wang, 2018; Ding, 1997). Surprisingly, route books in Ming-Qing China rarely mentioned traveling through sea routes. It seems that worries about the risk of naval journeys have hindered its role in travelers, especially merchants' trips. Huang's YTLC has negatively commented on a route traveling from Haizhou to Huaian Fu through seaway as follows:

> *It is uncertain whether there is wind available for a naval trip. A tailwind would make the journey easier but also riskier. If the wind is unavailable, it would be hard to know how long the journey would become. Under this circumstance, one should seek another route. ⋯Even though there is wind available for the naval journey, one also might lose their way at sea and end up with drifted further south to Taicang. Those travelers who take care of their safety should not choose this route.*

A meticulous examination of these route books reveals a distinct spatial concentration of commentary on routes and places, particularly in southern China, with significant focus on areas such as the Yangtze Delta, Huguang, and Fujian. In contrast, the routes in western and northern China receive comparatively less attention, featuring fewer comments and descriptions. This uneven distribution of detailed information in the route books suggests that southern China may have experienced higher levels of transportation and trade activities than northern China during the Ming and Qing periods.

Appendix D. A comparison on Transportation Cost in Chinese History (6th to 20th century)

In this section, I compare my estimation of transportation costs in 17th and 18th-century China with those of other periods in Chinese history. Through comparison, it could be found that there was a significant decrease in transport cost from the Tang Dynasty (7th century) to the Song Dynasty (12th century). However, from the Song Dynasty onward, until the late Qing Dynasty (19th century), transport coast remained relatively stable.

D.1 Tang and Song (7th to early 13th century)

Research on transportation costs in Chinese history is relatively scarce. One of the few studies on it is Kiyokoba (1991, 1996), which estimated transportation costs during the Tang and Song (8th and 12th century). Using official regulations quoted in *Da Tang Liu Dia* (*The Six Statutes of the Tang Dynasty* 大唐六典), Kiyokoba (1991) estimated transportation costs in 8th century China (Tang Dynasty). According to his estimation (see Table A1), land transportation by horse or mule pack ranged from 80 to 150 wen per 100 jin per 100 li. For waterway transportation, an upstream trip cost around 150 wen per 100 jin per 100 li, while a downstream trip cost only 50 wen per 100 jin per 100 li. This indicates that land transportation costs were similar to upstream waterway costs, and there was a 1:3 cost ratio between downstream and upstream waterway transportation in 8th century China (Tang Dynasty).

Using records from the official compendium of the Song dynasty, *Qingyuan Tiaofa Shilei* (*Laws and Regulations of the Qingyuan Period* 庆元条法事类), Kiyokoba (1996) estimated that land transportation cost 100 wen per 100 jin per 100 li. For waterways, the cost was 30 wen per 100 jin per 100 li upstream and 10 wen per 100 jin per 100 li downstream. As a supplement, Liu (2012) found an official price case from 1079 in historical archives[18],

[18]Sourced from *Xu zizhi tongjian changbian* (续资治通鉴长篇), *juan* 297.

which revealed that transportation costs at that time were consistent with those recorded in *Qingyuan Tiaofa Shilei*. This consistency indicates that these transportation costs represent the situation throughout the 11th, 12th, and early 13th centuries. A comparison of nominal transportation costs indicates an evolution from the Tang Dynasty to Song Dynasty in Chinese history. While land transportation costs remained relatively stable, nominal waterway transportation costs reduced by approximately 80% during the Tang-Song transition. Considering differences in measurement units and inflation over these five centuries, this reduction should be even higher (Liu, 2012).

D.2 Yuan (late 13th to early 14th century)

Currently, there is no estimations on the transportation costs during the Yuan Dynasty. In the *Da De Dian Zhang* (大德典章), I discovered records detailing the official transportation costs of that era. These records has been listed in Table A5. They document changes in transportation costs during Yuang Dynasty. In 1288, the central government of the Yuan Dynasty established a standardized transportation rate across the nation. However, due to severe inflation, these initial rates soon became inadequate. Consequently, various regions requested price increases, which the central government approved to a certain extent.

It is crucial to note that the rampant inflation throughout the Yuan Dynasty complicates direct price comparisons over time. To address this inflation, the Yuan government introduced a new currency, the *Zhiyuan Chao*, in 1287, replacing the previously used *Zhongtong Chao*. With the launch of the new currency, the government also established guidelines on the purchasing power of the *Zhiyuan Chao*[19], providing the cases in 1288 (the original plan) a reliable reference for comparing Yuan Dynasty transportation costs with those of other periods in Chinese history (Peng, 1965).

[19] 10 taels of *Zhongtong Chao* is equal to 2 guan of *Zhiyuan Chao* and equal to 1 taels of sterling silver (Peng, 2020)(pp447)

D.3 Late Qing (late 19th century)

In 1890, the Royal Asiatic Society conducted a systematic and comprehensive survey of the transportation situation in China. This survey provided detailed information on freight costs across various parts of China at that time (Fan, 1992; Kingsmill, 1898). A table listing all the cases is provided in Table A4. Here I use the waterway price for *Kiangsu to Honan* and the land price for *Kiangsu* as reference prices for comparing transportation costs in this study. I do this because: (1) it reflects the prices in the Yangtze China, and (2) the waterway trip from *Kiangsu* to *Honan* primarily relies on the Grand Canal, consisting with the criteria used for other periods' observations.

As discussed in Fan (1992), it is evident that freight rates by land are fairly consistent across different regions. For instance, the difference in transportation costs between Yunnan, a less developed and mountainous region, and the lower Yangtze, a well-developed and relatively flat area, is minimal. The highest land freight rate is only 2.5 times greater than the lowest. This indicates that commercial land transport faced similar challenges in both developed and underdeveloped areas and also, the presence of a competitive market. In contrast, land and river freight rates show significant disparities. When comparing the cost of transporting goods by junk from Kiangsu to Honan via the Grand Canal and Huai River with land freight costs, the ratios range from 1:10 to 1:25. In Kiangsu, the ratio can be as low as 1:37.5. This reflects the extensive local water routes in the lower Yangtze delta, where low water freight costs highlight the development of an efficient water transport network.

D.4 Deflate with grain price

By summarizing the transportation costs across various periods in Chinese history, I am able to estimate changes in historical transportation costs. However, a potential issue on comparing these data is that different currencies were used in different periods of Chinese history. Copper coins were mainly used in the Tang and Song Dynasties, paper money in the Yuan Dynasty, and silver in the Ming and Qing Dynasties. Additionally, the purchasing power of these currencies varied, making direct comparisons using nominal prices impossible. Therefore, to make transportation cost in different time period comparable, sort of deflating is needed. Here, I use grain prices for deflation. Grain is a basic necessity for human survival and a key component in constructing the Consumer Price Index (CPI) in various studies (Allen et al., 2011; Liu, 2024; Peng, 2006). Further, grain itself also has monetary attributes and has long been the most important trade commodity in historical China.[20]

Peng (1965) provides data on grain prices throughout Chinese history. In the first half of the 8th century during the Tang dynasty, the price of grain was about 330 wen per 100 liters (Peng, 1965)(pp218). In 1200, during the Southern Song dynasty, the grain price was 3039 wen per 100 liters (Peng, 1965)(pp313). An estimate for the Yuan dynasty puts the grain price at 39 grams of silver per 100 liters (Peng, 1965)(pp403)[21][22]. In 1680, during the early Qing dynasty, the grain price was 32.22 grams of silver per 100 liters, and by 1890, in the late Qing dynasty, it had risen to 89.37 grams of silver per 100 liters (Peng, 1965)(p560).

Considering the high grain prices during the Southern Song period after the Jingkang Incident[23], which may not accurately reflect the real purchasing power, and given Liu (2012)'s indication that nominal transportation costs remained roughly unchanged from the 11th to early 13th centuries, I have also provided deflated transportation cost estimates for the Northern Song period around 1100. These estimates are based on 1100 grain prices (1827 *wen* per 100 liters (Peng, 1965)(pp313)) and the 1202 transportation costs. o

I have also prepared silver price based deflation for comparisons. Peng (1965) does not provide the exchange rate between silver and copper coins during the Tang dynasty. Around 1104 in the Song dynasty, the exchange rate was 1250 *wen* of copper coins per tael of silver,

[20]While the wage of unskilled labor might be a better choice due to its lower volatility compared to grain prices, existing research on Chinese unskilled labor wages primarily focuses on the period after the 15th century. Historical records of unskilled labor wages before the 15th century are very limited, making it extremely difficult to use unskilled labor wages as a method for deflation.

[21]It is important to note that the 1965 edition listed this as 29 grams of silver per 100 liters, but the 2020 revised edition updated it to 39 grams of silver per 100 liters. Therefore, the 2020 edition data is used here. All other periods' data are consistent between the two editions.

[22]Due to severe inflation during the Yuan dynasty, only the transportation cost in 1288, when new currency was issued with a clear silver exchange rate, is used here.

[23]During which the Song empire is invaded by Jin and Song empire lost all of its territory in north China

and by 1200, the rate had changed to 3300 *wen* of copper coins per tael of silver (Peng, 1965)(pp329-330). During the Yuan dynasty, the newly issued *Zhiyuan Chao* in 1287 had an official exchange rate, with 2 *guan* of *Zhiyuan Chao* equivalent to 10 taels of *Zhongtong Chao* or 1 tael of silver (Peng, 1965)(pp447). In the Ming and Qing dynasties, silver taels were directly used as the circulating currency.

D.5 A comparison

Table A1 and Figure B3 display the transportation costs in the Yangtze China across different historical periods. Observations reveal a significant reduction in transportation costs between the Tang and Song dynasties. For waterway freight costs, the nominal price decreased by approximately 80%. When deflated by grain prices, the decrease exceeds 95%, surpassing the reduction in transportation costs brought by the 19th-century railway revolution in Britain (Bogart, 2013).

Furthermore, when comparing grain price-deflated freight costs across different eras, it is evident that from the Yuan dynasty to the late 19th century of the Qing dynasty, waterway freight costs remained relatively stable. Although land freight costs fluctuated, they were also relatively consistent. Comparing the grain price-deflated freight costs of the Yuan, Ming, and Qing dynasties with those of the Song dynasty (1202), it is evident that waterway freight costs during the Song dynasty were about half of those in the later dynasties.

Given that 1202 was during the Southern Song Dynasty after the Jingkang Incident, when grain prices were consistently high due to the loss of northern territories and frequent wars, this may potentially distort the effect of deflation. Given Liu (2012)'s argument that the nominal transportation costs during the Song dynasty remained relatively stable from the 11th century to the early 13th century, using grain prices from the relatively peaceful period of 1100 as the deflation basis suggests that waterway freight costs in Song Dynasty were roughly on par with those in the Yuan, Ming, and Qing dynasties, while land freight costs were about 60% of those during the Yuan, Ming, and Qing periods.

It is challenging to provide credible explanations for such a trend. One potential hypothesis is that the taxation structure among different dynasties played an essential role. The Song dynasty was unique in Chinese history. It was not only the only dynasty founded on indirect taxation but also the first sustainable tax state in global history (Liu 2015). In the Northern Song dynasty, around 40% of tax revenue came from commercial taxes. By the Southern Song dynasty, this ratio had increased to 84.7% (Gu 2003). In contrast, the Tang, Ming, and early Qing dynasties mainly relied on direct taxes such as land and poll taxes.

This difference in tax sources led the Song Empire have more incentive to maintain an efficient market, as more commercial activities meant higher tax revenues. This focus was demonstrated through massive investments in transport infrastructure, particularly canals. Many canals used in the Ming and Qing dynasties were initially constructed during the Song dynasty, and large-scale construction and maintenance projects were rare in the Ming and Qing periods. In fact, most construction projects during the Ming and Qing dynasties focused on maintaining existing canals rather than building new ones (Fan, 1992). As a result, commercial activities were more prosperous in regions once governed by the Southern Song dynasty during the Ming and Qing periods.

In general, the sources of state tax revenue determined policy focus and attitudes toward the construction of new transport infrastructure. These differences could potentially contribute to the trends in transport costs observed in Chinese history.

Appendix E. Primary Sources and their abbreviations used in this study

- *Shiwo Zhouxing* (SWZX) 示我周行 [Traveling everywhere on my own]
  - Author: anonymous
  - Type: Merchants' route book
  - Edition: 1694 (British Library), 1774 (Berlin State Library), 1784 (Library of Congress, Washington)

  - Note: 144 routes. The 1774 edition was the most widely circulated route book. (Brook, 1981)

- *Zhouxing Beilan* (ZXBL) 周行备览 [Ready reference for traveling everywhere]
  - Author: anonymous
  - Type: Merchants' route book
  - Edition: 1738 (Institute for Advanced Studies on Asia, The University of Tokyo)
  - Note: A 1738 reprint of SWZX, with a few difference on sequences of route.

- *Yitong Lucheng Tuji* (YTLC) 一统路程图记 [The comprehensive illustrated routebook]
  - Author: Huang Bian 黄汴
  - Type: Merchants' route book
  - Edition: 1570 (Naikaku Bunko (Cabinet Library), National Archives of Japan, Tokyo)
  - Modern reprint: Yang (2019c)
  - Note: 158 routes. The first national route book published by merchants.

- *Shanggu Bianlan* (SGBL) 商贾便览 [A convenient handbook to merchants]
  - Author: Wu Zhongfu 吴中孚
  - Type: Merchants' route book
  - Edition: 1792 (National Library of China, Beijing)
  - Modern reprint: Yang (2019b)
  - Note: 75 routes abridged from SWZX. One section provide a detail description on boats all over China.

- *Huanyu Tongqu* (HYTQ) 寰宇通渠 [Comprehensive guide to worldwide routes]
  - Author: Ming Government
  - Type: Official route book
  - Edition: 1394 (National Library of China, Beijing)
  - Modern reprint: Yang (2019a)
  - Note: A collection of all courier routes in early Ming Dynasty.

- *Qingding Daqing Huidian Shili* (DQHD) 钦定大清会典事例 [The official statutes and precedents of the Qing Empire]
  - Author: Qing Government
  - Type: Official achieves
  - Edition: 1812