The Geography of State Communication: Horses, Fees, and Taxes in the Ottoman Relay System

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Abstract

This article reconstructs the Ottoman imperial courier relay network in 1756–67 using station-level postal records on traffic, costs, and local finance. It documents spatial variation in traffic and shows that travel time, rugged terrain, and distance to Istanbul and local courts predict courier flows. Stations were financed through a hybrid system of courier fees and local tax contributions, creating uneven fiscal burdens. Our estimates indicate that short-haul stations generated lower revenues per unit of traffic than long-haul relays, leaving them systematically under-resourced. These findings illuminate both the strengths and the limits of state capacity in a large premodern empire.

Keywords: state capacity, postal systems, Ottoman Empire, communications network, early modern.

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1. Introduction

Communication and transportation infrastructures are widely recognised as critical outputs of state capacity underpinning bureaucratic effectiveness, the provision of public goods, and information gathering (Mann 1984 and 2008, Lee and Zhang 2017, Soifer and vom Hau 2008). However, this recognition has tended to focus on the modern period, usually from the nineteenth century onwards, when data about post offices, mail volume, and frequency are more abundant, accessible, and often digitised. Historians, political scientists, economists, and other social scientists have studied how public postal services have contributed to economic growth (Rogowski et al. 2022; Aneja and Xu 2024); to global commerce before the First World War (Laborie 2015), to technological innovation (Acemoglu, Moscona, and Robinson 2016; Aneja and Xu, 2024); to the development of interstate organisations and cooperation (Laborie 2011); to the development of bureaucratic autonomy, defined as the ability to set the political agenda (Carpenter 2001); to a revolution in communications and the forging of a public sphere and of a shared political identity (John 1995; Behringer 2006; Gallagher 2016); and more broadly, to modern state-building (Maclachlan 2011; Harris 2012; Schwartz 2021; Tsai 2024).

Preindustrial communications infrastructure can also be used to study premodern state capacity and long-run economic growth, albeit with some important caveats. One crucial difference is that such communications infrastructures, since ancient times, were almost always exclusively government communications systems that were not intended to be a source of revenue or to be used by the public (i.e. by common subjects). In fact, common subjects were, for most of human history, strictly prohibited from accessing postal resources. (Headrick 2000, chap. 6; Radner 2014; Schobesberger et al. 2016;

Sasaki 2024, 2) Instead, these government communication systems were typically maintained by local populations as a form of in-kind tax obligation. Such postal system-related tax obligations are usually characterized as harsh and abusive in historical chronicles and even poetry; such narrative tropes can be found from the Mongol era until the early modern period. (Randolph 2017; Koh 2024)

Due to its exclusive mandate to only serve government communications, and to its complete integration into, and dependence on, the in-kind taxation agreements between the imperial state and its subjects, preindustrial relay communications systems are an excellent lens through which to study state capacity—especially for large, diverse, premodern empires like the Ottoman one. This paper reconstructs how the Ottoman imperial relay system channelled official communications and financed its operations. We first use station-level origin-destination data to map the geography of state communication and identify central nodes in the network. Degree and betweenness centrality measures reveal a dense cluster of well-connected relays around Aleppo and Antakya, and a corridor of bridging stations in central Anatolia linking Istanbul to the Syrian frontier. Regressions of courier traffic on route characteristics show that flows decline with travel time, rugged terrain, and distance from Istanbul, but rise with proximity to Islamic courts and the size of nearby urban centres, indicating that the relay system was shaped by administrative hierarchies and urban demand as much as by physical distance. We then relate these patterns of use to the tax and fee regime that financed post stations. Legacy in-kind tax quotas and horse fees tied to distance meant that busy short-haul stations systematically generated lower recorded revenues per unit of traffic than more peripheral long-haul relays. The article thus offers one of the first quantitative reconstructions of a premodern communications network and highlights the

fiscal and informational constraints that limited the Ottoman state's ability to adapt legacy institutions to changing demands.

Our findings contribute to debates on historical state capacity in three ways. First we document the scale and determinants of geographical variation in imperial communications. Second, we show how hybrid funding models could extend state control, and how much preindustrial state capacity relied on local extraction local expenditure of taxes and in-kind services (Ogilvie 2022). Third, we highlight the two-way relation between the power to extract information on local budgets and expenditure and the capacity to adjust policy on the basis of that information, as well as the role of quantification in enabling imperial commensuration (Porter 1995, 2020; Espeland and Stevens 1998; Emigh 2002; Chun and Sauder 2022). The Ottoman case illustrates how early modern empires could potentially have scaled infrastructure through local resources and intermediaries, yet it also highlights the constraints in responding to changing operational realities, such as courier traffic, in a timely manner in the context of a vast polity.

2. Historical Background: The Ottoman Postal System and its sources

The overland relay network was the most common type of large-scale communication infrastructure in preindustrial times, although seaborne, airborne, and smoke-signal systems did exist. (Ragheb 2002; Silverstein 2007; Gleick 2011) Among the relay networks that have existed, there was significant variation in how they were organised due to differences in terrain, climate, and fauna. For instance, the Tibetans, Swedish, and Incas used human runners, while the Mongols and the Ottomans used horse-mounted couriers. In some systems, different human couriers were used to deliver the same set of

letters, which was passed from courier to courier; in other systems, the same human courier delivered the same set of letters from origin to final destination, but he would change his horse (or mule, or yak) at designated relay stations. (Rowe 1946; Bayly 1996; Silverstein 2007; Linnarsson 2011; Vér 2016; Maurer 2019; C. Wang 2019; Koh 2024, 15–16; Midura 2025) Underpinning these variations was the common denominator of animal muscle, which constituted the core motor of long-distance communications for millennia until the invention of the steamship, the railway, and the telegraph. For this reason, the eminent Mongol historian, Thomas Allsen, remarked that information travelled at roughly the same speed in the 1840s as it had in 840 B.C.E. (Allsen 2011, 271)

The Ottoman postal system was one of these preindustrial relay communications systems that likewise served Ottoman official correspondence exclusively. At its most extensive, this overland relay system connected Belgrade to Baghdad, Crimea to Cairo and comprised over two hundred official post stations, and many more unofficial ones. The earliest written records of the Ottoman relay postal system date to the fourteenth century, when Ottoman princes and sultans granted immunity to whole villages from horse confiscations as an incentive to settle in newly conquered areas. At the time, individual couriers traversing the empire simply confiscated horses from passers-by they randomly encountered on the road. Such arbitrary confiscation worked as a mode of horse procurement in those early days, probably because the volume of government correspondence was not very high, relative to later centuries. (Koh 2024, chap. 1)

Sometime in the sixteenth century, Ottoman communications intensified, putting new pressure on the need for a more organised mode of horse procurement for postal purposes. Chronicles describe the inauguration of a new fixed post station system, where couriers would now exchange their tired horses for fresh, energetic ones at predesignated

locations. Post stations also provided local guides who would accompany couriers for part of their journey to assist with navigation as well as for security reasons. Villages were supposed to provision these post stations with horses, food, water and other resources. Sometimes, but not always, there was an official to coordinate and manage these post stations. (Koh 2024, chap. 1)

Although the earliest sources we have date to the fourteenth century, it is only in the seventeenth and eighteenth centuries when fiscal registers about post station operations began to be produced regularly. While the Ottoman Empire produced extensive aggregate annual figures of post station costs and revenues for over a century, the questions of how we can interpret these premodern sources and how premodern bureaucrats quantified the costs of provisioning such extensive relay systems that traversed multiple regions with distinct local dynamics of exchange, consumption, and production, remain open.

This difficulty of source interpretation may account for why much of the literature that has connected preindustrial postal systems with premodern state power has been qualitative, rather than quantitative. Generally, these qualitative studies have recognised that relay communications infrastructure has contributed to state building and power in the Roman and Byzantine empires, early modern Europe, late imperial China, colonial India, and the Ottoman lands (Brayshay 1991; Heywood 1980, 1996, 2001; Bayly 1996; Kolb 2001; Çetin 2013; Harris 2015a, 2015b; Randolph 2017; C. Z. Wang 2017; Fossella 2023; Koh 2024; Midura 2025), to commercial development in colonial Latin America and early modern Europe (Physioc 2022; Midura 2025), to the standardisation of monetary currencies across Mongol Eurasia (Kuroda 2020), to the fostering of an intellectual culture which can lead to innovation and growth (Mokyr 1990, 36, 195–96),

to the development of diplomacy and foreign relations across premodern Europe (Allen 1972).

In contrast, quantitative studies of preindustrial postal systems are relatively rare. A notable exception is Yu Sasaki's study of the French postal system from 1500-1850 and how its development influenced city-level growth. (Sasaki 2024) Like Sasaki (2024), this article is a quantitative study and the first for the Ottoman relay postal system, which operated at a scale much larger than the better-studied French and Italian systems. Considering that the distance from Lille to Marseille is 997 km, while the distance from Belgrade to Baghdad is 3,127 km; the friction of distance and the challenges that this friction posed for premodern state capacity are amplified in the case of the Ottoman Empire. Complementing the immense scale of the Ottoman relay system is the relatively uniform way in which each relay station operated across the empire. Thus, despite the vast scale of the postal relay system, the leanness of this institution and uniformity of its operations makes its archival documentation manageable for analysis.

This focus on coordination across vast space by local intermediaries, which a large relay communications system required, aligns with new research on the historical origins of state capacity. (Suryanarayan 2024) Scholars now generally accept that assessing premodern state capacity necessarily involves assessing local budgets and expenditure, since any premodern state desiring to collect taxes were either compelled by the tyranny of distance to delegate authority to local officials to help them do so, or they were compelled to grant local autonomy to these officials in order to retain the authority to tax (Stasavage 2010; Johnson and Koyama 2014; Ogilvie 2022; Costa, Henriques, and Palma 2024). Moreover, local administration of justice and delivery of public goods also depended on local agents and intermediaries. Recent scholarship of historical political

economy on state capacity has thus turned away from macro-historical accounts and instead refocused attention on endogenous processes involving the role of agents and intermediaries, of building and maintaining state capacity, and analysed these processes using subnational (or sub-imperial) units. (Suryanarayan 2024; Koh 2025; cf. Tilly 1992)

Besides scale, the nature of quantitative sources available for the Ottoman Empire differs significantly from its contemporary European counterparts. First, there exists no granular population estimates for the Ottoman Empire, and therefore no source comparable to Bairoch (1988) to test, for instance, the relationship between postal network development and population growth. (Sasaki, 2024) Second, unpublished Ottoman fiscal records of postal operations preserved in the Ottoman archives show inconsistency in bookkeeping practices over the eighteenth century. Therefore, for the purposes of this paper, we limit our focus to data drawn from only ten years' worth of registers. Finally, we also had to make interpretive decisions while cleaning, preparing, and transforming the raw data into an analysable spreadsheet form—what others have called "input as a phase of research". (Lemercier and Zalc 2019, 54)

One important change in the Ottoman fiscal sources on postal operations is that whereas local tax revenues earmarked for post station maintenance used to be recorded in kind, from the 1690s onwards, these same revenues began to be recorded in monetary units. For example, the record reproduced in Figure 1 shows the entry for Provadiya, a town located along the Black Sea coast in modern Bulgaria, which was obliged to contribute 4 post horses and 2000 *kile* of wheat in 1648. Previously, Provadiya was expected to provide 8 post horses, but imperial authorities had granted a petition submitted by Provadiya's common subjects to decrease that rate. The entry also notes that the town was exempted from Extraordinary Taxes (*'avārıż-ı divaniye*) and customary

taxes (*tekālif-i örfiye*) in return for provisioning the post station and maintaining the local fort. This in-kind tax rate of 4 post horses is what we refer to in this article as Provadiya's Legacy Horse Burden.

Figure 1. The entry for Provadiya which shows the Legacy Horse Burden, or "in-kind" tax rate, of 4 post horses. Source: MAD 4030, p. 44.

Many of the contemporary entries for other towns and villages in the Ottoman Empire resembled the entry for Provadiya, in that tax obligations were not recorded in monetary units. These obligations to maintain a certain number of horses were negotiated between local subjects, through their representatives, and the imperial administration. It is important to note, however, that the mutually agreed upon official tax rate could have been fictitious in some cases. For instance, the same fiscal register shows that Eskişehir had an official tax rate (or Legacy Horse Burden) of four post horses, but an explanatory

memo[1] attached to the entry reveals that in practice, Eskişehir provided up to forty post horses, and only managed to negotiate an official tax rate of ten post horses in 1670. This suggests that the official tax rates recorded in Ottoman fiscal registers already differed from actual courier traffic or capacity in the seventeenth century.

By the 1690s, tax obligations and the post station budget tended to be recorded in monetary units, not as taxes in kind. For instance, the Üsküdar post station, the first post station on the Anatolian side of Istanbul for couriers heading to the eastern border and to the Arab provinces, is recorded as having an annual budget of 240,000 akçe for the hijri year 1101 (1689-90 C.E.), with 152,000 akçe coming from local tax revenues and 88,000 akçe coming from the Imperial Treasury.

This shift towards expressing the Legacy Horse Burden in monetary units coincided with two other developments: first, the imposition of new fee of 10 akçe per horse per hourly usage in 1690s (Heywood 2001); second, the creation of new genres of fiscal documents to keep track of these fees.[2] This fee was levied only on officials who had authorization to use these post stations; at this point in time, common subjects were still not allowed, legally, to use these post stations even if they had money. (In practice, this almost certainly happened, but would have been considered illegal from an imperial

[1] The memo can be translated as follows: "Sometime in the year 1670, the common subjects of Eskişehir submitted a petition to the Imperial Council in Edirne, explaining that they had historically been responsible for rearing four post horses for the post station as part of their tax obligations. In reality, however, they had been compelled to keep as many as thirty or forty post horses. Faced with this hardship, the common subjects implored the authorities to consider their difficult situation. On October 19, 1670, their plea was granted. After verifying their claim with older documents stored in the Imperial Treasury, the sultan decreed that the villagers of Eskişehir would henceforth be required to maintain ten post horses for the post station instead of four." It does not seem that imperial authorities made an independent survey to check if the actual capacity of that town (in this case, Eskisehir) was only ten horses. Instead, this was a tax agreement, where the tax rate was pegged to units of horses, and not yet quantified into a monetary value. Source: MAD 4030, p 10.

[2] Akçe was the official monetary unit of the Ottoman Empire during this period containing 0.10-0.13 grams of silver from 1691 to 1772. To put this fee into context, in 1691 the daily wage of an unskilled labour in Istanbul was around 26.8 akçe. (Özmucur and Pamuk, 2002).

perspective.) Provincial postmasters began to compile detailed records of the names of every single official who visited their post station, the number of horses these officials and their entourages took, and their travel destination. Postmasters then submitted these records to the imperial capital, where bookkeepers translated this aggregated visitor data accordingly as annual reported revenue (in the form of fees collected). This annual reported revenue is what we refer to in this paper as actual revenue.

The regular submission of courier traffic data by postmasters to the imperial capital was part of a reimbursement process by the Imperial Treasury to individual postmasters. Although a 10 akçe hourly fee had been imposed for horses, many couriers were exempted from paying this fee upfront if they were on government business. These exempted couriers would have presented their "waivers" (*in'āmāt*) -- stamped papers with the sultan's monogram (*tuğra*) (Figure 2)— to the postmaster, who would have noted down that courier's name, rank, entourage, final destination, and the number of horses he took.

Figure 2. An example of a Courier Waiver, 1743. Source: BOA, Topkapı Sarayı Müzesi Arşivi Evrak (TS.MA.e) 891/31

In contrast, officials without such waivers would pay the 10 akçe fee in cash to postmasters. This distinction was a way to differentiate among the different couriers, such as those who were dispatched from the imperial capital, as opposed to those who were being dispatched by provincial governors. Over the eighteenth century, however, this simple binary distinction became more elaborate, and several horse-rationing lists were developed to assign specific horse quotas to specific ranks: this meant that officials were soon limited by their rank in the number of horses they could obtain at post stations, regardless of whether they had waivers, or not.

The criteria governing which kinds of courier would be exempted from cash payments at post stations kept changing over time. In addition, as mentioned, horse quotas began to be assigned to each official rank in the elaborate Ottoman hierarchy of officialdom; this meant that even those officials who enjoyed the privilege of not having to pay for horses in cash, who held special stamped papers, would have been constrained by rank-specific horse quotas. It is possible in these cases that officials might have persuaded postmasters to violate those quotas, either by offering cash or by threatening violence. (Koh 2022) As our data is drawn from the paperwork capturing the reimbursement process for postmasters, it would not have captured horses obtained through cash payments, especially in cases where officials violated their quotas.

Thus, bookkeepers in the imperial capital recorded the annual expenditure and annual revenue figures of all post stations across the empire spanning more than a century into a series of registers, called the Comprehensive Post Station Register. Our data is sourced from one such register. While this source has been previously used by

other Ottoman historians (i.e. Heywood 1976; Güneş 2008; Çetin 2013), we adopt a more systematic approach. Our analysis of this source shows that the Register actually contains three sets of information: courier traffic between source-target stations, budgeted annual costs and revenue of each post station based on the Legacy Horse Burden of neighbouring villages or towns, and actual annual costs and revenue based on recorded courier traffic. By using this information, in the next sections we assess quantitatively the scale and determinants of courier traffic, and the resource allocation (through fees and taxes) across stations.

3. Postal network and courier traffic

The Comprehensive Post Station Registers maintained by Ottoman bookkeepers in the imperial capital document the operational and logistical details of each post station and form the basis of our quantitative analysis. As far as we are aware, there are no similar kind of sources that exist for other premodern states in terms of degree of detail and characteristics. The particular register we draw our data from provides detailed, station-specific information on an annual or bi-annual basis, covering the years 1756 to 1767. We aggregate or average bi-annual records as needed resulting in an annual cross-sectional time series dataset suitable for analysis.

Figure 3 presents a stylised representation of Ottoman post stations as documented in the Comprehensive Post Station Registers. While these registers do not tell us the initial dispatch point of or the final destination of couriers, they record the last station visited by a courier, as well as the courier's next connecting station. For example, the total number of couriers visiting Post Station B would be recorded in the Register as

arriving from either “Post Station A” or “Post Station C,” with travel times between stations noted in hours.

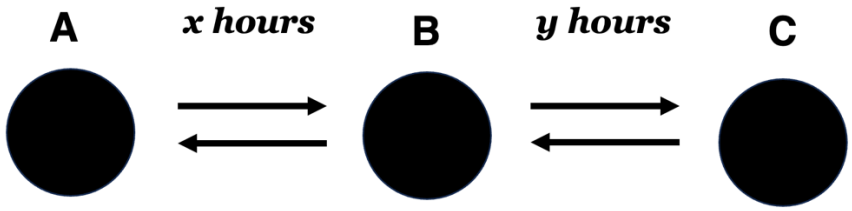

Figure 3. Stylised Image of Post Stations A, B, and C. Authors’ elaboration.

Figure 4 illustrates the geographical distribution and connectivity of 94 Ottoman post stations identified in the dataset for the years 1756 to 1767. Each post station is represented as a circle, with size proportional to the average volume of incoming and outgoing traffic over this period. Arrows indicate the direction and volume of traffic between stations, with thicker arrows denoting higher traffic volumes.

Figure 4. Postal traffic and network, 1756-67. Source: See Appendix. Made with FlowmapBlue.

Among these stations, 63 function as both sources and destinations within the network, serving a dual role. In contrast, 27 stations operate solely as destinations, receiving incoming couriers without dispatching any outbound traffic. Additionally, 3 stations are recorded as exclusive sources, sending couriers but not receiving them (Figures 5). This distinction is important because the registers contain Legacy Horse Burden data only for source stations (i.e. not for destination-only stations). Consequently, we structure our data from the perspective of the 66 stations that serve as sources.

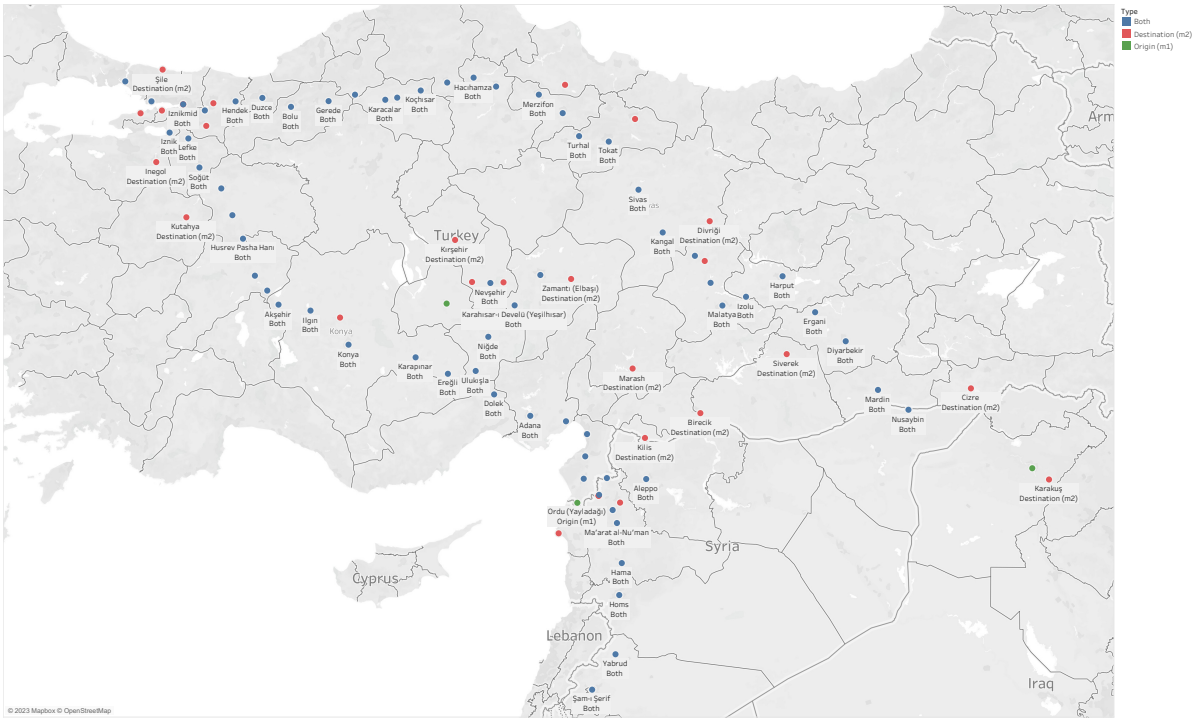

Figure 5. Origin and destination stations, 1756-67.

Appendix summarises the key characteristics of the Ottoman Empire's postal network during 1756-67. The columns on horses provided for couriers and guides, as well as incoming and outgoing traffic, indicate a strong linear relationship across stations, with about one-third of the total traffic attributed to guides and the remaining two-thirds to couriers.

The register also reports the average travel time between stations in hours. This number varies widely across the network, with an average of approximately 12 hours. Certain stations, such as Kayseri, Sivas, and Konya, had longer average travel times to adjacent stations, often exceeding 20 hours. In contrast, stations like Karacaviran and Ishaklı had average travel times as low as 6 hours.

It should be noted that Comprehensive Registers maintained by bookkeepers in the imperial capital, offer an idealised view of courier travel patterns. Narrative sources such as travelogues and chronicles reveal that couriers often deviated from fixed routes, adapting to factors like weather, banditry risks, or personal preferences, which could affect their travel times and chosen paths. As such, recorded travel times reflect a bureaucratic standard rather than actual overland conditions. Nonetheless, these times largely correlate with historical marching routes, allowing us to use them in our analysis as documented by Ottoman officials, even if not all underlying travel assumptions were made explicit.

The variation in traffic intensity across stations suggests a hierarchical structure, with certain nodes functioning as major hubs connecting multiple regions. For instance, high-traffic stations such as Üsküdar, Osmaneli (Lefke), and Iznik appear to serve as crucial regional centers. While many stations exhibit balanced flows of incoming and outgoing traffic, some stations, such as Aleppo, Niğde, and Diyarbakir record much higher

incoming than outgoing traffic, and others like Şam-ı Şerif, Hasançelebi, and Gekbüze show an opposite pattern, with higher outgoing traffic relative to incoming traffic.

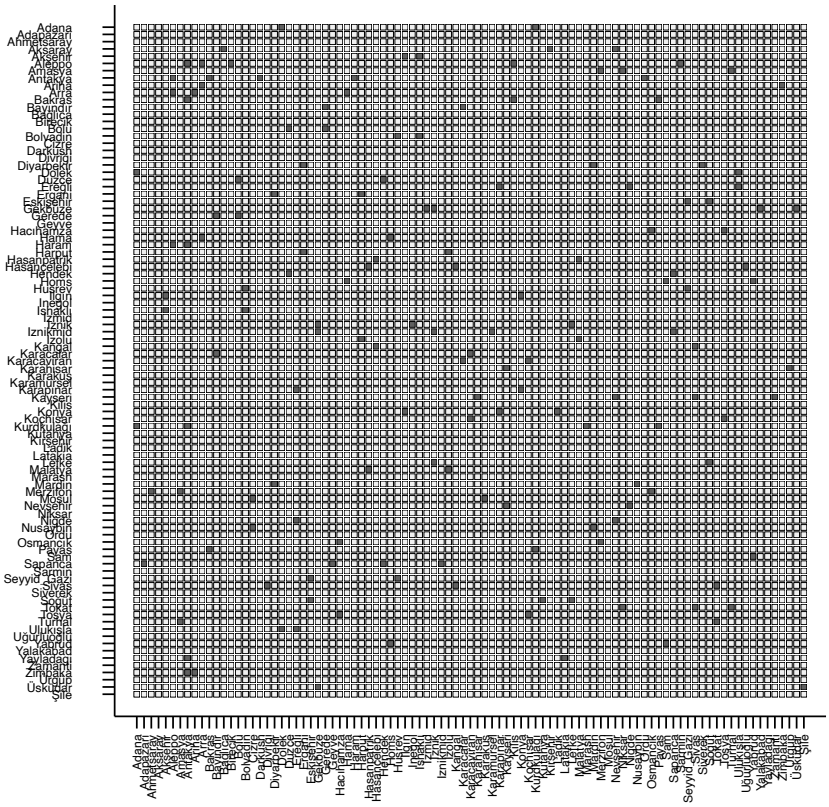

Figure 6. Network matrix: station connections

Using the directed network of origin-destination pairs for 1756-67, it is possible to compute several network centrality measures and compare them with observed flows of outgoing couriers. The centrality measures point to a clear hierarchy of stations. In terms of in-degree (the number of distinct origins that send couriers to a station), Antakya stands out with six incoming connections, ahead of Aleppo, Ereğli, Gekbüze, İznik, Maʿarrat al-Nuʿmān, Nevşehir, and Sivas, each with three. Out-degree centrality (the number of distinct destinations a station sends couriers to) is highest for Aleppo and

Antakya, followed by Gekbüze, İznikmid, Kayseri, Kurdkulağı, and Sapanca. Eigenvector centrality, which weights connections by the centrality of neighbours, again highlights Antakya and Aleppo as core nodes, together with Haram, Bakras, Kurdkulağı, and Kilis. These measures show that the south-eastern end of the network, centred on Aleppo and Antakya, forms a dense cluster of well-connected stations in both sending and receiving directions (Figure 6).

By contrast, measures of betweenness and closeness identify a different group of nodes. Stations such as Ereğli, Sivas, Konya, Karapınar, Ilgın, Ulukışla, Akşehir, Niğde, and Nevşehir score highest on betweenness and closeness centrality. These stations sit on many of the shortest paths between other stations and are, on average, closer to all other nodes in the network. In other words, central Anatolian relays act as bridges between the core coastal and frontier hubs. The main communication corridor that links Istanbul and north-western Anatolia to Aleppo and the Syrian interior passes through this belt of intermediate stations in central Anatolia (See Appendix).

Table 1. Correlation matrix of network centrality measures and courier traffic

	Courier outflow	Out degree centrality	In degree centrality	Eigenvector centrality	Closeness centrality
Courier outflow	1				
Out degree centrality	0.3601	1			
In degree centrality	0.3515	0.6146	1		
Eigenvector centrality	-0.0637	0.2734	0.3292	1	
Closeness centrality	0.0926	0.2283	0.2337	0.0197	1

Source: See Appendix.

The correlation matrix summarised in Table 1 suggests that courier outflows are positively related to simple degree measures: stations that send to or receive from more distinct neighbours tend to dispatch more couriers overall. The correlation of courier

outflows with out-degree and in-degree centrality is around 0.35. By contrast, eigenvector and closeness centrality have only weak correlations with traffic volumes. This suggests that the intensity of use of a station is driven more by its local branching (how many connections it has) than by its embeddedness in the wider network of "important" neighbours. High-traffic stations can be locally well connected but do not seem to be necessarily central in the global topology of the network.

While the network analysis is useful to provide an overall picture of connectedness of the postal system, it also has its limitations especially if the data does not reflect the entirety of the network, as in our case. Therefore, for the purposes of exploring the determinants of courier traffic, we rely on a basic OLS framework and a set of co-variates for which the data is available. Specifically, we estimate the following baseline regression model where c_{ij}^{t} is the number of horses used by couriers between stations i (source) and j (target):

$$c_{ij}^{t} = \beta_0 + \beta_1 . TRI_{(\frac{i}{j})t} + \beta_2 . h_{ij}^{t} + \beta_3 . Court_{Jt} + \beta_4 . Pop_{Jt} + \beta_5 . Ist_{it} + \delta_1 . year_{t} + \delta_2 . Station_{t} + \epsilon_{it} \quad (1)$$

In equation (1), h_{ij}^{t} refers to travel time in hours between stations i and j as reported in our sources, $TRI_{(\frac{i}{j})}$ captures the total ruggedness index of the source station but relative to the target station, Pop_{Jt} refers to the population of the nearest city in 1800 (Bosker et al 2013) expressed in thousands, $Court_{Jt}$ and Ist_{it} refer respectively to the distances to the nearest Islamic court and the imperial capital calculated as the geodesic distance between

these locations and target and source stations. The model includes source-station and year fixed effects and estimated with robust standard errors.

Table 2. OLS regression: courier traffic

VARIABLES	Courier traffic
Travel time (hours)	-18.99***
	(2.375)
Total ruggedness index (source/target)	-3,198***
	(852.0)
Distance to nearest court (target)	-0.649**
	(0.252)
Population of nearest city (target)	1.838***
	(0.303)
Distance to Istanbul (source)	-1.707***
	(0.346)
Constant	2,402***
	(255.0)
Observations	1,628
R-squared	0.745

OLS regression with year and source-station fixed effects. Robust standard errors in parentheses.

*** p<0.01, ** p<0.05, * p<0.1

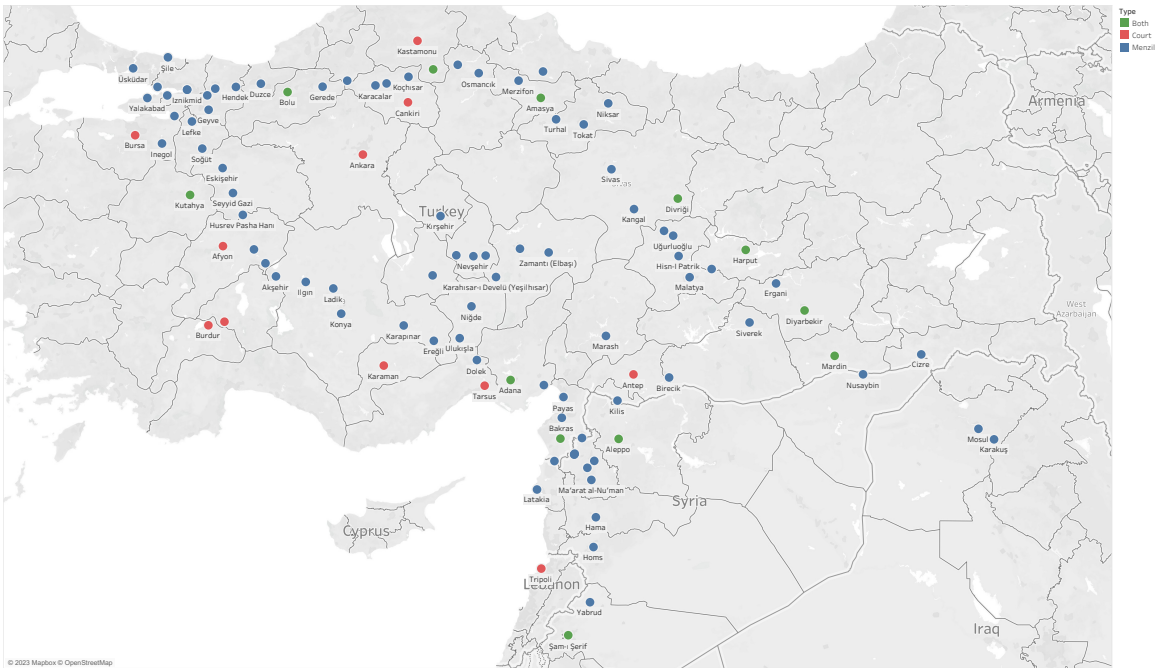

Figure 7. Islamic courts and post stations (1756-67)

The results summarised in Table 2 indicate strong frictions from distance, terrain, and institutional access. Longer travel times between source and target are associated with substantially lower courier volumes, even after controlling for station and year effects. Routes that cross more rugged terrain, proxied by total ruggedness index ratio between station pairs, also carry less traffic. Given that the Islamic courts were one of the major recipients of state communications, distance to the nearest Islamic court at the destination, as summarized in Figure 7, has a negative coefficient: relays that are closer to a court see higher courier flows. At the same time, the population of the nearest city at the destination is positively associated with traffic, which is consistent with higher demand for official communications in larger urban centres. Finally, greater distance to Istanbul is linked to lower traffic, confirming the capital-centred nature of the system. Together, these variables explain a large share of the variation in flows (R^2 around 0.75),

and show that the Ottoman state's communication network reflects a mix of administrative hierarchy, urban demand, and physical constraints such as travel time and ruggedness. The next section takes these patterns as a starting point and examines how they correspond to the allocation of resources and obligations within the relay system.

4. Resource allocation: taxes and fees

As highlighted in the previous section, Post station tax revenues that used to be recorded in kind (in units of heads of horse) gradually were expressed in monetary units. Each Ottoman town or village's Legacy Horse Burden continued to be recorded in number of horses in the eighteenth century, but accompanying this number was also its equivalent in the official Ottoman monetary unit of account (the currency, guruş) using a fixed multiplier (147.5).[3] Hence, for example, an in-kind tax rate of 40 horses would now also be recorded as 5900 guruş (40*147.5) alongside the original number of "40 horses".

This fixed multiplier and the formula governing post station accounts were based on a report dated 1698 by the grand vizier which declared that the annual cost of maintaining a horse was 147.5 guruş, on the basis of a 50 akçe per day cost over 354 days. This report also assumed that if each horse made one trip every four days, this would be ninety trips in 360 days, which would amount to 75 guruş (or 9000 akçe) of fees in a year, using a rate of 10 akçe per hour. The remaining 72.5 guruş was expected to be covered by local tax revenues. (Koh 2021)[4] These assumptions and fixed multipliers endured in fiscal

[3] Guruş or kuruş was an Ottoman monetary unit equivalent of 120 akçe. Pamuk (2000).
[4] This portion of a post station's revenue was presumed to have covered other costs including provisions for horses (e.g., straw, hay), horse-related equipment (e.g., halters, bridles), and salaries for station staff (such as cooks, grooms, and janitors). These expenses were itemised in a late seventeenth-century register, and in 1698 was used by the grand vizier as a standard multiplier (at 147.5 guruş per annum or 50 akçe per day).

records until the late eighteenth century and did not seem to have been revised or questioned.

To simplify and provide a framework, we can express this accounting logic in mathematical notation, as such the budgeted (or projected) total cost (PC_i^t) of operating a station based on the Legacy Horse Burden (a_i^t) of post station i at time t can be written as:

$$PC_i^t = a_i^t \times 147.5\ guruş \quad (2)$$

In principle, stations were expected to cover their costs through two budgeted revenue sources: courier fees and local tax revenues. Accounting guidelines stipulated a courier fee of 10 akçe per hour per horse, which would yield an annual revenue of 75 guruş per horse from courier fees[5], with the remaining 72.5 guruş derived from tax revenues:

$$PT_i^t = a_i^t \times 72.5\ guruş \quad (3)$$

$$PF_i^t = a_i^t \times 75\ guruş \quad (4)$$

Therefore, total budgeted revenue (PR_i^t) for each station was:

$$PR_i^t = PT_i^t + PF_i^t \quad (5)$$

The underlying component of budgeted revenue and expenditure was the Legacy Horse Burden is summarised in Appendix. The data reveal wide-ranging differences in

[5] Based on 360 days divided by 4. 10 akçe x 10 hours x 90 days.

each station's Legacy Horse Burden, from as few as 4 horses at peripheral stations like Harput to as many as 89 at Gekbüze and 40 at Üsküdar, and these numbers had perfect positive correlations with budgeted revenues from taxes and fees.

In the accounting framework presented in Equations (2) to (5) stations operated at a break-even level, with budgeted revenues matching budgeted costs. However, Comprehensive Post Station Registers contained another set of data derived from biannual and annual reports submitted by postmasters: actual courier traffic and actual taxes collected as summarised in Appendix.

By using the courier traffic reported by postmasters, it is possible to calculate actual fees collected by stations. Formally, if the number of horses used for couriers is (c_{ij}^t), fees claimed by postmasters for courier services between two stations are determined by the following formula:

$$AF_{ij}^t = h_{ij}^t \times c_{ij}^t \times 10\ akçe \tag{6}$$

Equation (6) represents the fees collected on a single itinerary. Since stations were typically connected with multiple others with differing travel times and courier traffic, total fees collected are the sum of fees from all connections (1,…n), as shown:

$$AF_i^t = \sum_{l=1}^{n} AF_{ij}^t \tag{7}$$

In certain Ottoman towns and villages, taxes were levied during the eighteenth century for the purposes of post station maintenance, which provided more resources to expand the station's capacity. Their imposition meant that the budgeted tax revenues

(Equation 3) could differ from the actual tax revenues allocated to post stations. Our sources do not tell us why some post stations received these additional tax revenues while others did not. Regardless, since they constituted a component of a post station's revenue, we add these tax amounts (AT_i^t), to the actual fee revenue (AF_i^t) to obtain the actual total revenue allocated to each postmaster locally:

$$\mathrm{AR}_i^t = AT_i^t + AF_i^t \tag{8}$$

A key question of interest is whether stations were allocated sufficient resources— in terms of revenues from taxes and fees— given their volume of traffic. To answer this question, we can estimate actual horse requirements based on real courier traffic and the assumed turnover rate of 90 couriers per horse per year. This number can be seen as the physical limit of the number of trips that a horse could do in a year. Typically, after a journey of 10-12 hours between two stations, a horse would require having a full day rest, and then it would be necessary to bring back the horse to its source station. While in practice it would be possible to push the limits of a horse to deliver more trips, we retain this estimate since it follows the formula stipulated by the Ottoman grand vizier in 1698. Based on a horse turnover ratio of 90, the actual number of horses kept in a station can, therefore, be estimated as:

$$\alpha_i^t = \frac{c_i^t}{90} \tag{9}$$

And the actual cost of running a station is:

$$AC_i^t = \alpha_i^t \times 147.5\ guruş \quad (10)$$

At the station level, the difference between the total revenue (AR_i^t) in equation (8) and the actual cost (AC_i^t) in equation (10) provides a measure of surplus or deficit in terms of resource allocation. To correct for scale, we express this surplus or deficit as a percentage of the actual cost:

$$r_i^t = \frac{AR_i^t - AC_i^t}{AC_i^t} \quad (11)$$

As shown in Appendix, across the postal network there was substantial variation between the Legacy Horse Burden and the actual horse burden (i.e. actual operational needs based on courier traffic and a standard turnover assumption of 90 trips per horse per year). For instance, stations such as Gekbüze show a legacy allocation far exceeding actual needs (89 vs. 47 horses), while others, like Akşehir, have significantly underestimated requirements (9 vs. 18 horses).

Similarly, average rate of surplus for the 61 stations (excluding Adana, Dolek, Kurdkulağı, Mardin, and Payas for which there is no tax revenue data) is 0.56 with a standard deviation of 1.2, indicating significant variation in resource allocation relative to costs. Nevsehir, for example, had the highest surplus rate at 525%, while Karacaviran registered the lowest at -55%.

Why were certain stations allocated more resources while others were underfunded given their running costs? To explore this question, in this section, we first

test whether the Legacy Horse Burden offers any insight into explaining post station surpluses or deficits. We then proceed to test whether the actual horse burden on the basis of the assumption that a horse made 90 trips per year (a figure provided by the grand vizier in 1698) correlate with average distance to connecting stations. This point is relevant because given the design of the fee system (10 akçe per courier-hour), stations handling shorter itineraries, despite high traffic, could generate lower revenue per courier. If that is the case, the resource allocation would not scale with actual station workloads, leading to persistent imbalances and structural underfunding at high-volume, short-distance stations.

To test these two hypotheses, we again rely on a basic OLS framework specified by the following baseline regression model:

$$r_{it} = \beta_0 + \beta_1 . a_{it} + \beta_2 . \alpha_{it} + \beta_3 . \alpha^2{}_{it} + \delta_t . year_t + \epsilon_{it} \quad (12)$$

where r_{it} is the surplus/deficit of resources for station in year t, as per equation (11). a_{it} and α_{it} represent the Legacy Horse Burden and actual horse burden of a station, respectively. The former is recorded in historical registers, while the latter is calculated using equation (9). Year fixed effects are included to control for any time-specific factors influencing surpluses and deficits across stations. The model employs robust standard errors clustered at the station level to account for within-station correlation over time. We do not include station-fixed effects due to limited within-station variation, as our primary objective is to explain variation between stations.[6]

[6] The between-effects model, while yielding broadly similar results, was not reported here as it primarily captures variation between stations rather than over time. We also tested for the random-effects model but given the potential correlation between station-specific unobserved factors and our predictors, we determined that a fixed-effects

The results summarized in Table 3 demonstrate that the Legacy Horse Burden (a_{it}) alone does not significantly explain variations in stations' fiscal surpluses. Conversely, the operational burden (actual number of horses required, α_{it}) consistently and significantly correlates negatively with fiscal surplus.[7] Furthermore, introducing the squared term significantly strengthens the model, highlighting a clear non-linear relationship. The negative fiscal impact of increased operational burden becomes disproportionately greater at higher traffic levels. First three models exclude Gekbüze, an extreme outlier. In Model (4), when this station is included, our core findings remain substantively unchanged, though statistical significance and model fit improve markedly when it is excluded.

Table 3. Station surplus/deficit, 1756-67.

VARIABLES	(1)	(2)	(3)	(4)
Legacy horse burden (a_{it})	-0.0357			
	(0.0229)			
Actual horse burden (α_{it})		-0.0946***	-0.351***	-0.180***
		(0.0213)	(0.0748)	(0.0401)
(α_{it})2			0.0102***	0.00334***
			(0.00242)	(0.000808)
Constant	0.767***	1.474***	2.610***	1.890***
	(0.285)	(0.283)	(0.448)	(0.347)
Observations	671	671	671	683

approach with year effects and clustered errors more robustly addresses within-station variation while accounting for autocorrelation and station-specific heterogeneity.

[7] Due to the possible correlation between legacy and actual horse burdens, we test these variables separately.

R-squared	0.041	0.324	0.482	0.381

Notes: OLS regression with year fixed effects. Robust standard errors adjusted for 61 stations are in parentheses. Models 1-3 exclude the outlier station Gekbuze.

*** p<0.01, ** p<0.05, * p<0.1

These correlations potentially indicate that the Ottoman postal system was structurally inadequate in compensating stations based on actual operational demands. This inadequacy likely stemmed from the design of the fee system, specifically the interaction between courier traffic volume and itinerary distances. Stations with higher courier volumes typically served shorter routes, reducing their revenue per courier due to fees being charged per courier-hour. This structural imbalance exacerbated their financial deficits.

While the negative relationship between operational burden and fiscal surplus is partly mechanical—since courier traffic is a component of both revenue and cost calculations—this correlation reveals that the Ottoman administration's accounting framework was insufficiently responsive to actual variations in courier traffic, structurally disadvantaging stations with higher volumes. The fixed-cost and fixed-turnover assumptions underpinning the resource allocation system did not scale adequately with real operational demands, as further evidenced by the insignificant impact of Legacy Horse Burdens.

To illustrate this point further, we repeat the same exercise in equation (12) but change the dependent variable to average distance, measured as the outgoing courier traffic weighted average travel time in hours. The regression results summarised in Table 4 show a clear negative correlation between the actual number of horses required and the

average distance. Specifically, each additional horse required due to increased courier traffic is associated with approximately a 0.2-hour decrease in the average itinerary distance. Including a squared term for horses required slightly alters the coefficient, though this term itself is not statistically significant.

Table 4. Average distance to outgoing stations, 1756-67.

VARIABLES	(1)	(2)	(3)
Legacy horse burden (a_{it})	0.0194		
	(0.0840)		
Actual horse burden (α_{it})		-0.205***	-0.362**
		(0.0474)	(0.145)
(α_{it})2			0.00627
			(0.00483)
Constant	11.43***	13.93***	14.63***
	(0.964)	(0.714)	(0.932)
Observations	671	671	671
R-squared	0.002	0.188	0.196

Notes: OLS regression with year fixed effects. Robust standard errors adjusted for 61 stations are in parentheses. Models exclude the outlier station Gekbuze.

*** p<0.01, ** p<0.05, * p<0.1

This relationship reiterates our earlier finding in Table 2, and indicates that stations with higher courier traffic tended to serve disproportionately shorter routes. The shorter distances inherently reduced revenue per courier, given the Ottoman fee structure, which charged fees per courier-hour. Consequently, stations with high courier

traffic faced structural disadvantages and rising fiscal deficits. While the reverse causality could be a possibility—that shorter itineraries could enable higher courier dispatch frequencies—the fiscal implications remain unchanged. Regardless of the causal direction, high-traffic stations generated lower fees per courier, leading to systematic underfunding. Therefore, the Ottoman resource allocation system, based on courier fee structure, Legacy Horse Burdens, and local taxes, inadequately compensated stations that handled frequent, short-distance journeys.

5. Conclusion

This study brings together a unique dataset on the premodern Ottoman postal network, documenting both budgeted costs and revenues based on a centrally designed plan and actual costs and revenues based on post stations' recorded operations. We use these sources to reconstruct, first, how official communications flowed across the relay network, and second, how far the fiscal regime that financed the system tracked those operational patterns.

The analysis of courier traffic shows that the relay system was highly structured. Network centrality measures point to a dense cluster of well-connected stations around Aleppo and Antakya, and to a corridor of bridging relays in central Anatolia that linked Istanbul and north-western Anatolia to the Syrian frontier. Regression results confirm that geography and administrative hierarchy shaped these flows: courier volumes decline with travel time, terrain ruggedness, and distance from Istanbul, but rise with proximity to Islamic courts and with the size of nearby urban centres. In other words, the relay

system's geography of communication reflected both the physical frictions of moving across space and the institutional pull of courts, cities, and the imperial capital.

We then relate this geography of communication to the allocation of resources across stations. Our first set of results directly measures how the surplus or deficit rate- capturing both taxes and fees- responds to stations' actual operational burdens. We find a significant non-linear negative relationship: stations handling heavier traffic tended to be systematically under-resourced. A second set of results clarifies the mechanism behind this imbalance. High-traffic stations typically served shorter routes, and because horse fees were tied to distance travelled (courier-hours), these short-haul, high-frequency relays generated lower fee income per courier than more peripheral long-haul stations. Legacy Horse Burdens, inherited from seventeenth-century in-kind tax quotas, also show little systematic relationship with measured operational burden. Together, these findings indicate that the combined revenue tools of the system (distance-based fees, Legacy Horse Burdens, and local taxes) did not scale in line with actual demand at the busiest nodes.

More broadly, the Ottoman relay system illustrates both the strengths and limits of premodern state capacity. On the one hand, the imperial bureaucracy was capable of extracting detailed information from hundreds of postmasters about courier movements, compiling standardised accounts of costs and revenues, and designing a hybrid revenue regime to cover those costs. On the other hand, there is little sign that policymakers systematically synthesised these data to adjust tax quotas or fee rules in response to the observed geography of communication and the resulting pattern of deficits. The relay system's fiscal design thus struggled to adapt inherited institutions to changing operational realities –at least in this ten-year period for which our dataset covers.

Several caveats qualify these conclusions. Seventeenth-century sources, as well as comparisons between Legacy Horse Burdens and estimated actual horse burdens, suggest that registers may understate the number of horses maintained at certain stations, which may bias our measures towards under-allocation. Cash transactions at post stations, which our sources do not record, may also have provided additional income streams, whether through fees paid by officials exceeding their horse quotas or through services to private users. These unobserved revenues could have mitigated the deficits we document in the fiscal accounts. Nevertheless, even under generous assumptions about such hidden resources, the Ottoman relay network channelled communications along a clear hierarchy of routes and hubs, but the fiscal regime that funded it was only imperfectly aligned with that geography of use.

Data availability. The data underlying this article will be shared on reasonable request to the corresponding author.

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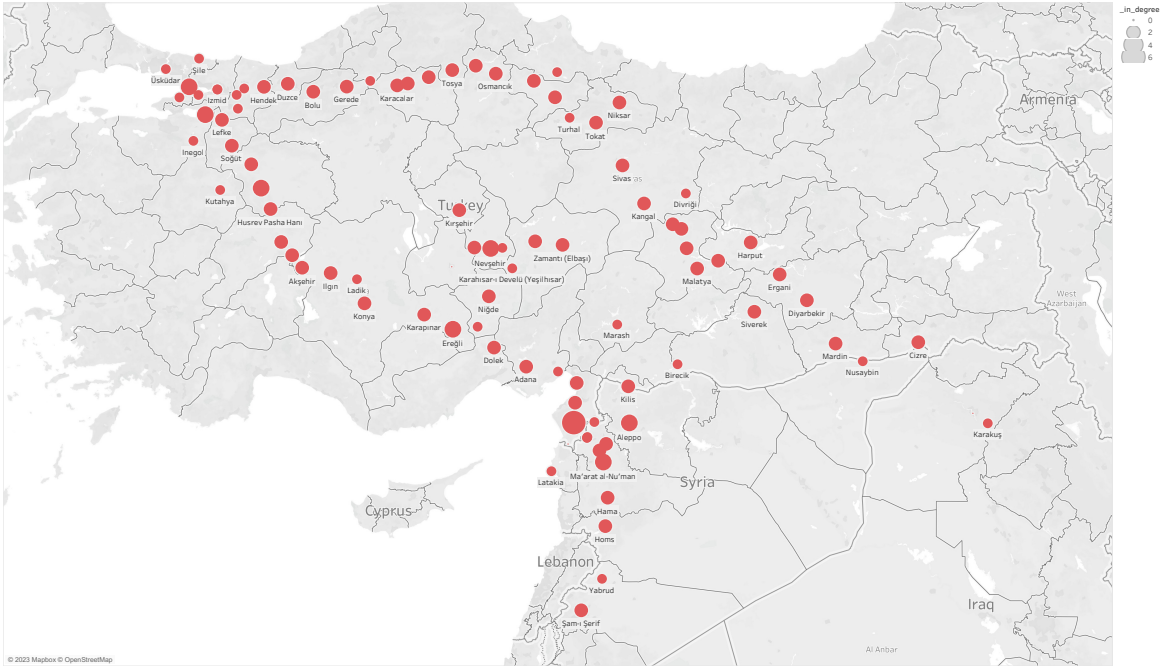
Station	Legacy horse burden (a)	Budgeted Taxes (guruş) (PT)	Budgeted Fees (guruş) (PF)	Actual horse burden (α)	Actual Taxes (guruş) (AT)	Actual Fees (guruş) (AF)	Deficit surplus rate (r)	Outgoing horses to couriers	Outgoing guides to couriers	Incoming couriers	Incoming guides	Outgoing connections	Incoming connections	Travel time (hours)
Adana	11	797.5	825	14		1360		643	288	683	313	2	2	15
Aksaray	4	290	300	1	290	46	3.72	21	9	0	0	3	0	14
Akşehir	9	652.5	675	18	1259	874	-0.2	830	364	793	344	2	2	7
Aleppo	13	942.5	975	4	551	390	0.93	107	52	171	105	3	1	19
Amasya	8	580	600	13	903	895	0.06	514	217	522	227	2	2	12
Antakya	10	725	750	13	1844	954	0.47	295	125	371	165	4	4	12
Ariha	5	362.5	375	6	729	288	0.32	253	113	221	92	2	2	8
Bakras	6	435	450	14	827	718	-0.23	582	247	565	242	2	2	9
Bayındır	14	1015	1050	19	1221	1102	-0.06	834	354	850	363	2	2	9
Bolu	14	1015	1050	20	1310	1493	0	878	375	875	363	2	2	12
Bolvadin	9	652.5	675	19	448	1010	-0.47	834	365	883	384	2	2	9
Diyarbekir	10	725	750	5	725	403	0.8	142	57	219	89	3	2	16
Dolek	13	942.5	975	15		1487		655	298	635	287	2	2	16
Duzce	14	1015	1050	20	1015	1496	-0.12	889	378	898	389	2	2	12
Ereğli	10	725	750	16	2001	1191	0.4	515	232	672	299	3	3	12
Ergani	9	652.5	675	5	653	497	0.6	228	97	236	98	2	2	15
Eskişehir	13	942.5	975	19	2566	1104	0.36	770	457	807	343	2	2	9
Gekbüze	89	6452.5	6675	47	11983	3307	1.29	1052	469	904	407	4	3	11
Gerede	14	1015	1050	19	624	1286	-0.32	871	376	853	366	2	2	11
Hacıhamza	10	725	750	17	725	943	-0.31	757	333	742	330	2	2	9
Hama	8	580	600	4	1383	337	1.97	180	90	163	61	2	2	12
Haram	8	580	600	4	580	292	0.65	143	114	225	90	2	1	11
Harput	4	290	300	6	290	589	0.1	250	117	238	104	2	2	17
Hasançelebi	8	580	600	7	580	909	0.52	420	167	292	112	2	2	11
Hendek	14	1015	1050	20	1015	1492	-0.12	891	379	904	394	2	2	12
Hisn-I Patrik	7	507.5	525	6	508	401	0.03	283	109	285	112	2	2	10

Homs	6	435	450	6	370	509	0.07	238	94	276	135	2	1	15
Husrev Pasha Hanı	11	797.5	825	19	798	1209	-0.27	846	368	795	350	2	2	10
Ilgın	11	797.5	825	18	1591	1674	0.22	829	364	867	383	2	2	14
Ishaklı	6	435	450	19	683	641	-0.51	835	370	794	345	2	2	6
Iznik	26	1885	1950	22	652	1480	-0.32	942	423	1020	458	2	2	11
Iznikmid	15	1087.5	1125	21	1088	1091	-0.27	837	359	943	408	2	1	8
Izolu	10	725	750	6	725	453	0.52	251	96	252	140	2	2	13
Kangal	15	1087.5	1125	7	1088	699	0.83	310	124	311	127	2	2	16
Karacalar	6	435	450	18	673	746	-0.43	788	341	815	342	2	2	7
Karacaviran	6	435	450	17	490	660	-0.54	779	340	777	333	2	2	6
Karahısar-ı Develü (Yeşilhısar)	4	290	300	1	290	31	2.15	35	14	28	12	2	1	10
Karapınar	15	1087.5	1125	16	1072	1827	0.25	709	314	727	330	2	2	18
Kayseri	6	435	450	1	435	122	3.7	40	18	32	14	2	2	25
Konya	18	1305	1350	18	3682	2571	1.4	571	258	866	383	2	2	21
Koçhısar	10	725	750	17	800	963	-0.27	756	325	760	330	3	2	9
Kurdkulağı	11	797.5	825	14		887		452	196	652	289	3	2	12
Lefke (Osmaneli)	12	870	900	21	1940	1320	0.05	959	432	1043	466	2	2	9
Ma'arat al-Nu'man	5	362.5	375	5	363	312	-0.11	206	86	28	13	2	2	10
Malatya	7	507.5	525	6	508	376	0.04	273	107	275	107	2	2	10
Mardin	10	725	750	4	0	302		158	61	141	53	2	2	14
Merzifon	12	870	900	17	1695	1223	0.24	557	240	563	239	3	2	10
Mosul	10	725	750	3	725	258	1.87	117	45	0	0	2	0	16
Nevşehir	6	435	450	1	435	72	5.25	32	17	32	16	2	1	14
Niğde	4	290	300	1	290	103	3.2	36	17	63	24	2	2	15
Nusaybin	10	725	750	3	725	254	1.42	140	53	162	63	2	1	13
Ordu (Yayladağı)	7	507.5	525	3	508	262	0.7	144	64	0	0	2	0	13
Osmancık	10	725	750	16	625	1175	-0.23	729	324	745	331	2	2	12
Payas	6	435	450	13		683		602	257	602	253	2	2	8

Sapanca	13	942.5	975	21	943	1168	-0.29	652	281	907	394	1	2	9
Seyyid Gazi	11	797.5	825	19	485	954	-0.48	846	365	797	475	3	2	8
Sivas	8	580	600	8	561	982	0.32	260	110	321	126	2	2	21
Soğüt	13	942.5	975	21	2107	1573	0.21	629	276	743	439	3	2	14
Tokat	6	435	450	12	435	935	-0.16	426	180	402	172	3	2	13
Tosya	10	725	750	17	1478	1048	0.06	747	328	768	336	3	2	10
Turhal	8	580	600	12	465	793	-0.23	543	225	544	229	2	2	10
Ulukışla	12	870	900	15	749	1098	-0.14	658	293	627	283	2	2	12
Yabrud	7	507.5	525	5	1200	509	1.26	318	143	266	105	2	2	15
Zimbaka	5	362.5	375	6	708	353	0.33	253	108	236	113	1	1	10
Üsküdar	40	2900	3000	24	2249	1517	0.11	2018	829	2071	916	2	1	9
Şam-ı Şerif	7	507.5	525	2	1500	194	3.82	351	153	262	113	2	1	12
Average	11	797.5	825	12	1115	877	0.56	526	230	538	238	2	2	12
Min	4	290	300	1	0	31	-0.54	21	9	0	0	1	0	6
Max	89	6452.5	6675	47	11983	3307	5.25	2018	829	2071	916	4	4	25
Median	10	725	750	14	725	891	0.11	550	236	583	247	2	2	12

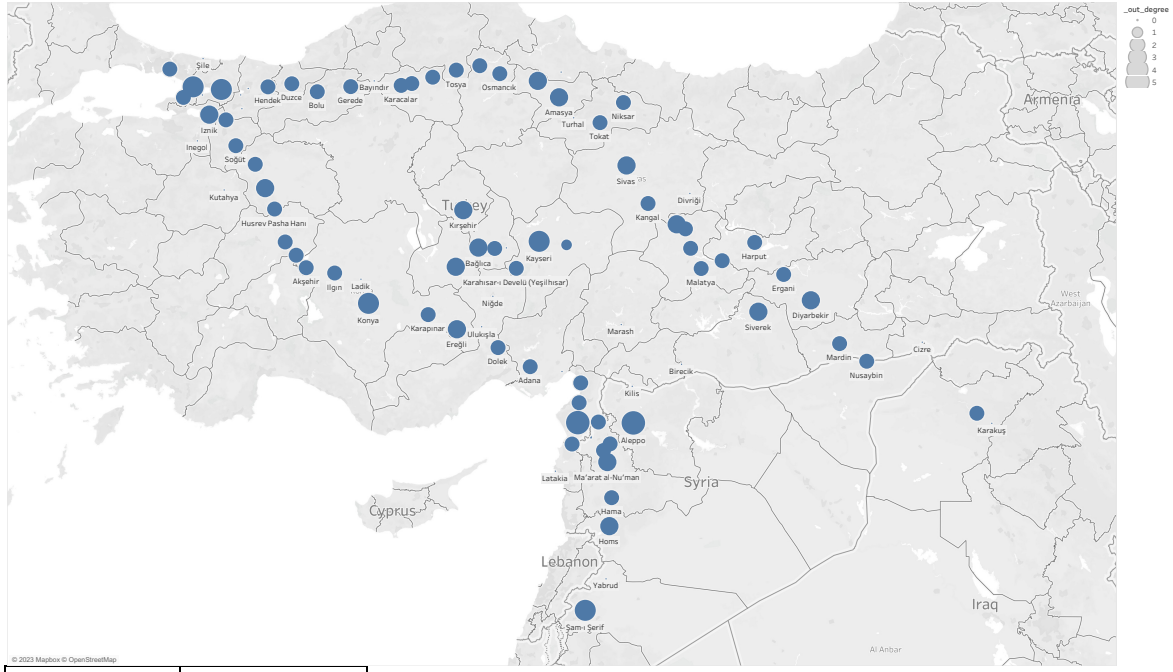
Appendix Table. Figures are averages for the period 1756-67. Horses to couriers and to guides are additively two components of outflow traffic, while incoming couriers and guides represent inflow traffic. Travel time is the average of connecting stations measured in hours. 27 (only target) stations with no outbound traffic data are not included in this summary table.

In-degree centrality: directed unweighted



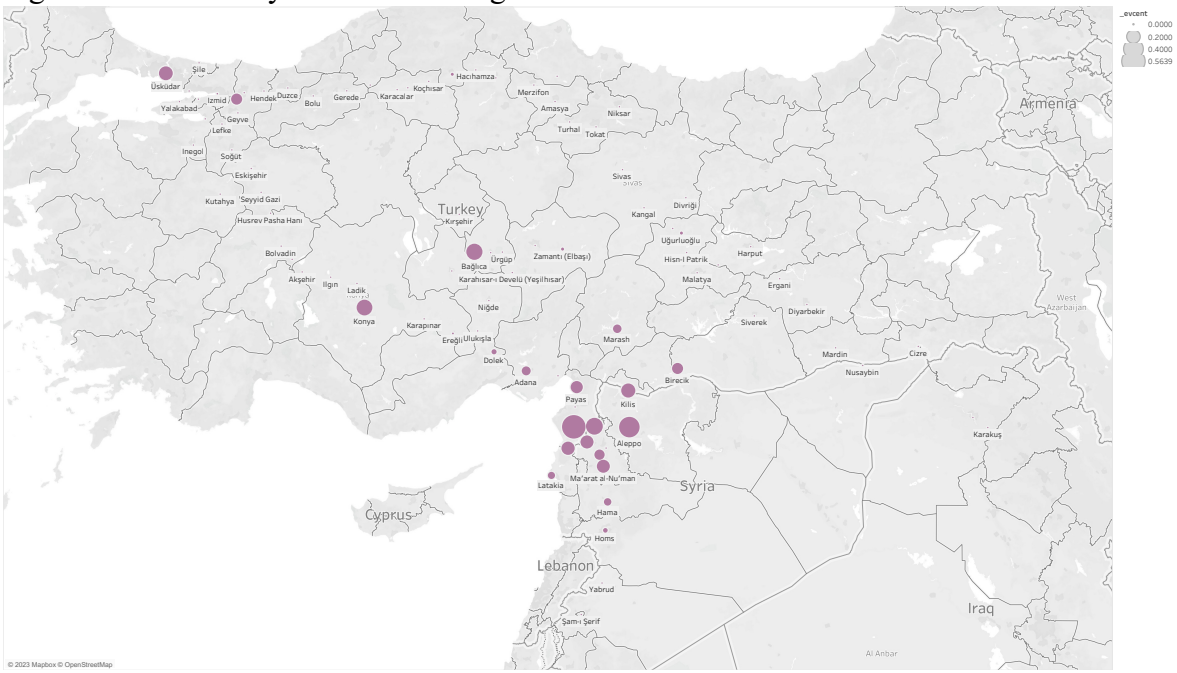
_nodelab	_in_degree
Antakya	6
Aleppo	3
Ereğli	3
Gekbüze	3
Iznik	3
Ma'arat al Nu'man	3
Nevşehir	3
Sivas	3

Out-degree centrality: directed unweighted



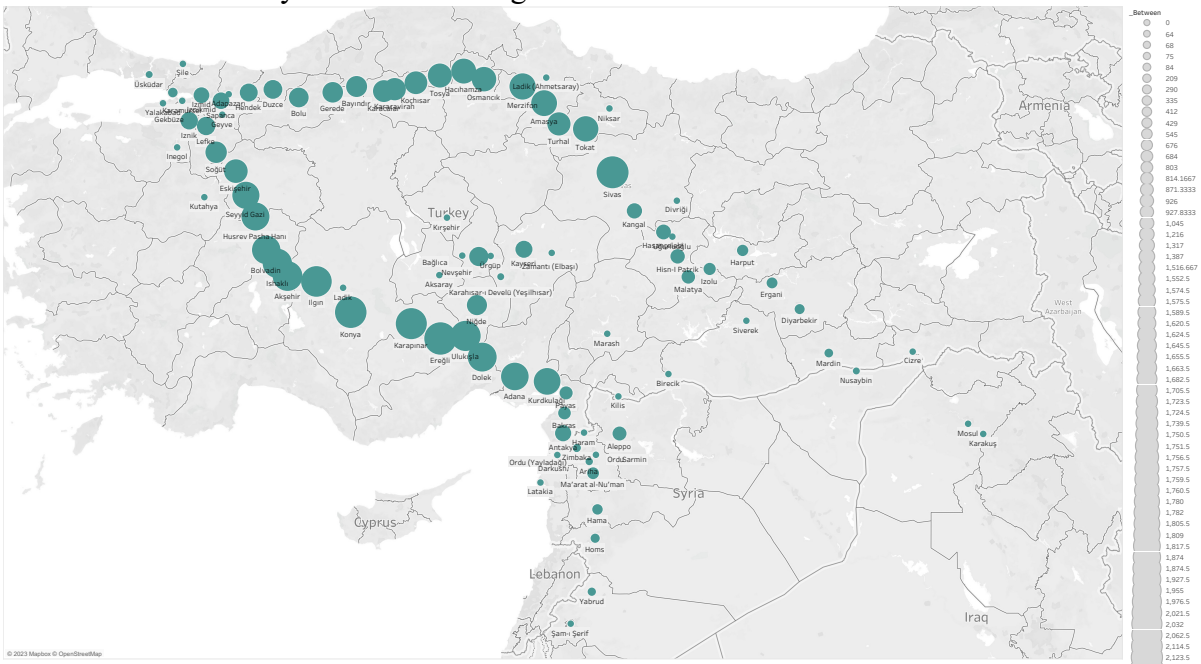
_nodelab	_out_degree
Aleppo	5
Antakya	5
Gekbüze	4
Iznikmid	4
Kayseri	4
Kurdkulağı	4
Sapanca	4

Eigenvector centrality: directed unweighted



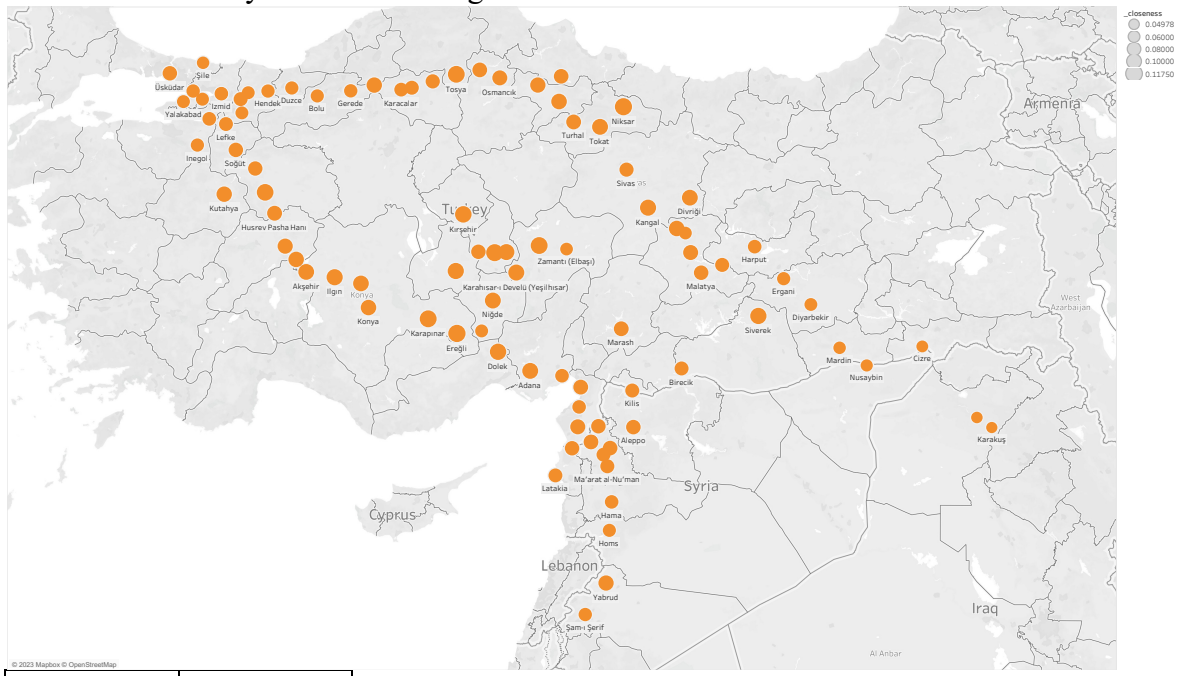
_nodelab	_evcent
Antakya	0.5639364
Aleppo	0.4294353
Haram	0.2888024
Bakras	0.266703
Kurdkulağı	0.252797
Kilis	0.2023879

Betweenness centrality : directed unweighted



_nodelab	_between
Ereğli	2982.5
Sivas	2290
Konya	2123.5
Karapınar	2114.5
Ilgın	2062.5
Ulukışla	2032
Akşehir	2021.5

Closeness centrality: directed unweighted



_nodelab	_closeness
Ereğli	0.1174968
Niğde	0.115869
Nevşehir	0.1142857
Karapınar	0.1121951
Kayseri	0.1119221
Ulukışla	0.1111111