Network Analysis of Ottoman Pottery Across the Balkans and the Aegean

Tsveta Kodzhabasheva

Dodwell, E. (1821). Bazar in Athens [Painting]. Benaki Museum – Athens, Greece. https://www.benaki.org/index.php?option=com_collectionitems&view=collectionitem&id=108895&Itemid=540&lang=en

Network Analysis of Ottoman Pottery Across the Balkans and the Aegean

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Research Master Thesis Archaeology Year 2 (1086VTRSY)

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Leiden, 15.12.2024, Final Version

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Chapter 1: Introduction

This thesis aims to expand our understanding of the Ottoman period by addressing the challenges posed by the limited archaeological data available from that era. It evaluates how network theory can contribute to reconstructing trade relations during the Ottoman period. To achieve this, network models of both domestic and international Ottoman trade are developed, using pottery evidence from five sites across the Balkans (Belgrade, Sofia, and Varna) and the Aegean (Mytilini and Izmir), from the 15th to the 20th centuries. The reconstructed trade networks are analysed and compared with historical sources to identify differences between the archaeological and historical narratives. This comparison aims to uncover the reasons behind these discrepancies and assess whether archaeological data, even when limited, can provide insights which the historical sources cannot.

Figure 1: Borders of the Ottoman Empire between 1300 and 1512 (İnalcık, 1994, p. 1).

The Ottoman Empire is one of the longest lasting imperial systems in the Mediterranean. Established in the late 13th century in northwestern Anatolia, it quickly spread its control to most of Western Asia, Northern Africa and Southeast Europe, encompassing the current territory of about 20 modern states (Figure 1). The Ottomans reached the peak of their Empire after the conquest of Constantinople in 1453 and remained a major military and political power up until mid-18th century. After that, the state fell into a period of economic decline and territorial losses. In 1923, after the

expulsion of the last sultan - Mehmed VI, the modern state of Turkey was created (Özoğlu, 2011, p. 7).

The Ottomans controlled a vast territory populated with different ethnic and religious groups for about seven centuries. This left a huge mark on the economy and demography in the region which is still noticeable today. However, this long historical period is barely visible in the archaeological research (Baram and Carroll, 2000b, p. 3).

There are multiple reasons for the lack of interest in the Ottoman past by most researchers. Ottoman heritage is considered problematic and it is often unwanted by the modern states which emerged on the territory of the Empire after its disintegration. Sites from the Ottoman period are rarely excavated and the material from this archaeological layer is often neglected and disregarded (Baram and Carroll, 2000b, p. 5).

To this day, modern Balkan nations commonly perceive Ottoman rule as a period of colonial exploitation, which led to a period of backwardness and economic decay in the region. (İnalcık, 1996, p. 18; Todorova, 1996, p. 62). This perspective can be traced back to a long history of negative Western views of the Ottoman Empire (Baram and Carroll, 2000b, p. 5). During the 15th–16th century, the Ottomans were at their political and economic peak and they were seen as the perfect state, a model for the rest of Europe to follow (İnalcık, 1996, p. 20). In the beginning of the 19th century, the Western European industrial progress rapidly changed the economic and political situation on the continent, stripping the Ottoman Empire from the political power it held before. During this period, the concept of nationalism and the nation-state also started to gain popularity in the West (İnalcık 1996, p. 33). This ideology started to spread among the Ottoman Empire's indigenous communities and it eventually became an important factor in their campaign for independence (Brown 1996b, p. 5; Todorova 1996, p. 48). Following the Empire's collapse, the new nation-states in the Balkans aimed to distance themselves from their shared Ottoman background and construct their distinct national identities to set themselves apart from the 'foreign' Ottoman rule (Baram & Carroll, 2000b, p. 7).

The origins of Ottoman archaeology date back to the late 18th century, when Western travellers and antiquarians began exploring Ottoman territories (Vroom, 2017, p. 901). Early Ottoman archaeology was largely influenced by classical archaeology, with scholars emphasising on monumental structures such as mosques, marketplaces, and public baths. It is only in the recent decades that the focus has expanded to include smaller towns and rural settlements, as well as everyday items like ceramics and household objects (see Vroom, 2017; 2019). However, Ottoman archaeology remains relatively underdeveloped (Guinova, 2005a, p. 268), and there is still much research to be done in order to broaden our understanding of the period.

Notably, the book by Baram & Carroll: *A Historical Archaeology of the Ottoman Empire* (2000a) is the first full book dedicated to Ottoman archaeology (Vroom, 2017, p. 902). This marks the start of Ottoman archaeology as a distinct field and highlights the opportunities for future research. Books on Ottoman archaeology remain relatively few to this day, with recent works including Bikić (2003), Georgopoulou & Thanasakis (2019), and Pletnyov (2004a).

1.1 Research Aims

Figure 2: A map of the five analysed sites and the Ottoman capital, Istanbul (Kodzhabasheva, 2024; map source: Stadia Maps, Stamen Design: https://stadiamaps.com/).

The goal of this research is to explore the application of network theory in reconstructing trade relations during the Ottoman period. Pottery is considered one of the best-researched materials from this period (Guinova, 2005a, p. 270). Nevertheless, Ottoman ceramics are still underrepresented in archaeological publications and research. This further presents an opportunity to evaluate the potential of network methods in working with limited archaeological data.

This research aims to reconstruct Ottoman trade routes by using imported pottery from the 15th to the 20th century. The ceramics are collected from three sites in the Balkans (Belgrade, Sofia, and Varna) and two sites in the Aegean (Mytilini and Izmir). These sites were strategically chosen because the Balkans and the Aegean were central to Ottoman political and economic influence (Figure 2). As such, they are most likely to reflect Ottoman economic strategies and any shifts in these strategies over time. Additionally, these sites are among the few that provide ceramic data from the Ottoman period.

Network models for each century are developed using imported ceramics. These models are then analysed and compared to historical accounts of Ottoman economic trends. The goal is to identify differences between the archaeological and historical scenarios, exploring the reasons behind these discrepancies. The research further explores whether the archaeological evidence reveals insights not found in historical records and whether there is historical information that the archaeological data does not reveal.

1.2 Research Questions

The main research question of this thesis is:

- How can network theory contribute to the reconstruction of trade relations in the Ottoman period in the Balkans and the Aegean?

To answer this question, and narrow its focus, I will first address the following sub-questions:

1) What trends can be observed in the economy and trade of the Ottomans in the Balkans and the Aegean from the 15th to the 20th century, based on network models of ceramic data from Belgrade, Sofia, Varna, Mytilini, and Izmir?
2) How does this archaeological scenario differ from the information on trade and economy presented in the historical accounts and why?
    - Is there historical information that is not visible in the archaeological scenario?
    - What insights can the archaeological scenario provide that are not apparent in the historical accounts?

1.3 Methodology

The main approach used in this thesis is *network analysis*, where *network methods* are applied to reconstruct trade connections based on Ottoman pottery data from the Balkans and the Aegean.

This thesis adopts the definition of a *network*, taken from Brughmans & Peeples (2023), which is a description of a system of relations as well as a formal representation of the abstraction of such a system of relations between a group of entities or actors. Graphs are commonly used to visualize networks, wherein the entities are represented as a collection of *nodes* or *vertices*. The *edges*, which indicate indicate the relationships between the entities, are depicted with lines. All techniques used in creating a network model, graph and further employed into researching a system's network are referred to as *network methods*.

Formal analyses of network structures, simply referred to as *network analyses*, typically include both visual inspection of the network and the compilation of a broad range of statistics aimed to quantify various aspects of network structure. These properties represent how connected the actors are to one another, whether they form a subgroup in any other way, or whether they are all interconnected in a dense network of relationships (Brughmans & Peeples, 2023, p. 6; Peeples, 2019, p. 454). When the qualities of the network structures are formally described and quantified, they typically reveal aspects and traits that would remain hidden when focusing solely on the individual actors within these structures. (Brughmans & Peeples, 2023, p. 1).

The core of formal network approaches is *relational perspective*. This perspective emphasises that the structure of a network – the arrangement of nodes and edges, and the varying positions of these elements, are just as crucial for understanding the behaviour of actors within the network as the individual attributes of those actors themselves (Brughmans & Peeples, 2019, p. 7).

Network methods are a valuable tool in archaeological research. These models serve as simplified abstractions of real-world networks (Brughmans, 2012, p. 645; Orton, 1980, p. 45), which allows researchers to focus on specific patterns or dynamics that would otherwise be too complex to analyse. Network methods are used when they are most effective for answering specific research questions, ensuring the approach aligns with the objectives of the study (Figure 3).

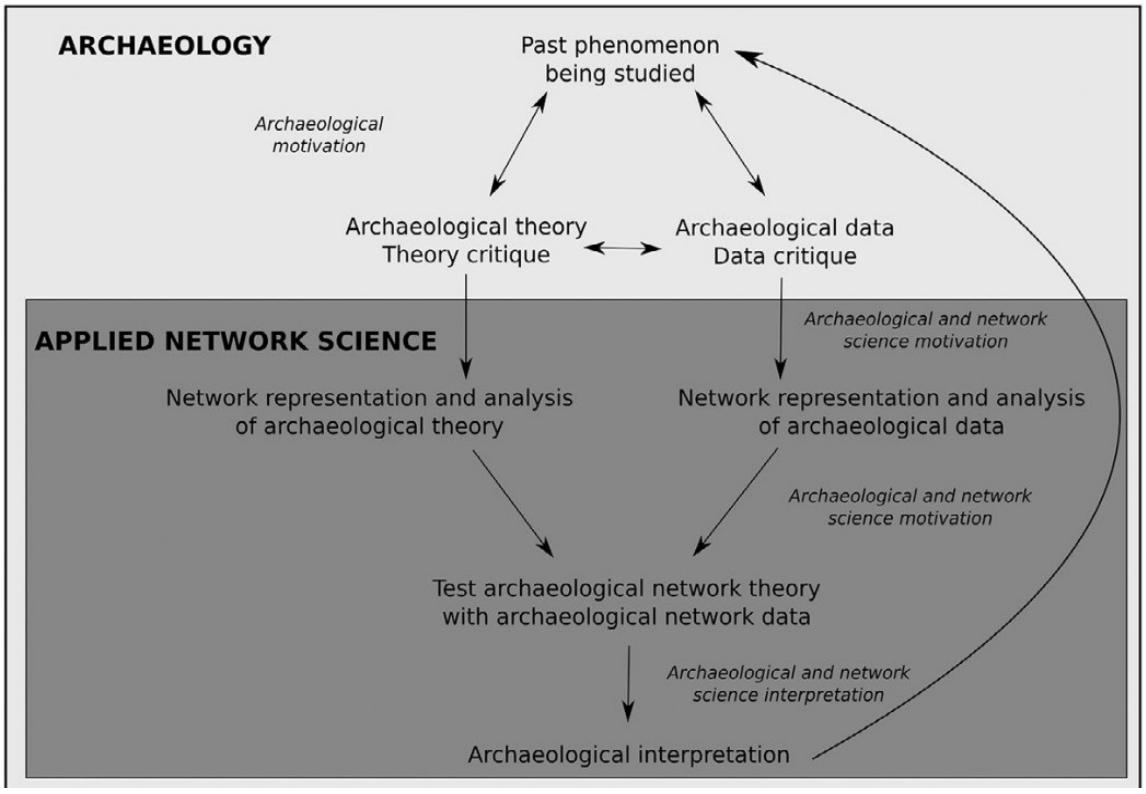

Figure 3: Generalising abstraction of a typical archaeological network research (Brughmans & Peeples, 2023, p. 11).

Network methods are particularly useful to use in this thesis due to the nature of the research questions, which focus on trade relations and connections. Network models enable an analysis of each site's position within the broader network and its relationships with other sites. This approach offers deeper insights into the dynamics of trade that cannot be achieved through the study of ceramics alone.

The ceramic data for Sofia, Belgrade, Varna, and Izmir is gathered from published materials, while data for Mytilini comes from a dataset of excavated material. The presence of imported pottery at a site is assumed to indicate a connection with its production centre. While the connection may not be direct, it still provides evidence of trade occurring between the two locations, a key factor in constructing a network.

The main characteristics of ceramics commonly found at the sites are introduced in advance to ensure their presence within the network can be accurately interpreted. Historical data provides social implications of these ceramics, while details regarding their materials and decorative elements are drawn from archaeological sources.

Network models are constructed using the NetworkX library in Python 3. This library is selected for its flexibility, especially in integrating maps for visualisation, as well as for its extensive analytical tools. Separate network models are created for each century, accompanied by an independent archaeological interpretation. This archaeological interpretation is then compared with available historical data on Ottoman trade and economy.

1.4 Thesis Outline

The thesis will be structured in the following way: After *Chapter 1: Introduction*, follows *Chapter 2:Background*, which includes several subchapters. First, a short historical overview of the Ottoman Empire is presented, in order to contextualise the network model. The geographical focus is Southeastern Europe and specifically the Balkans and the Aegean. Next, the main economic trends and changes in the Ottoman empire throughout the centuries are presented. These include imperial mechanisms, policies and demographic changes that affect the commercial practices of the Ottoman merchants. After this, a more detailed historical background is given on each of the five sites researched in this thesis. This includes a short background to their history, economics and demographics. Next, a short description is given for the most common pottery imports found at the sites. This includes both historical information about the pottery, as well as more archaeological information about the materials used, decoration and production. This is essential for understanding the significance of these imports. As a final part of this chapter, the main concepts of network theory are discussed. This includes a synthesised literature overview, recent developments in the field and its relevance to the methodology employed in this thesis.

Chapter 3: Data and Methods includes two main subchapters – *Data* and *Methodology*. The first one describes the process of data collection for each of the five sites. This includes the publications which were used, the area from which the material was collected and what is included and excluded from the final database and the reasons behind it. After this, issues with the quantitative data which were encountered during the data collection are discussed. In the *Methodology* subchapter, the process of data preparation is explained, which concerns the cleaning, refining and organising of the data into a database. The procedure for creating the network model is further summarised - the main concepts employed in network making, the software used, and the visualisation techniques. Finally, the algorithms used in the network analysis are explained.

In Chapter 4: Results, the network models for each century are presented and described, as well as the results from the network analyses. These results are further used for creating an archaeological scenario for each century in *Chapter 5: Discussion.* The archaeological scenario is then compared with the historical information presented in the *Chapter 2: Background*.

Finally, the research questions are addressed in *Chapter 6: Conclusion*, along with the main findings of this thesis and potential future implications.

Chapter 2: Background

In this chapter, relevant background information on the Ottoman period is presented. The historical scenario is based on the historical details presented in this chapter. This scenario is crucial for evaluating the results from the archaeological network models. The chapter is divided into several sections. It starts with a brief historical overview of the Ottoman Empire and the definitions of certain terms often used in Ottoman studies. This is important for properly contextualising our research. The organisation of the Empire's international commerce, trade routes, networks and merchants is then outlined chronologically, using information from historical accounts and documents. Next, the five sites of interest - Belgrade, Sofia, Varna, Mytilini, and Izmir, are looked into more detail, highlighting their historical and demographic characteristics. After this, the main types of ceramics encountered in our dataset are presented. These pottery details are crucial for interpreting the archaeological network models. Finally, the main concepts of network methods are presented, together with a short historical overview of the development in the field and its relevance to this research.

2.1 Historical Overview

The Ottoman Empire was founded around 1299 by Osman I in northwestern Anatolia and quickly developed into a powerful state. It operated under a centralized government led by the Sultan, who held both political and religious authority as the head of the state and military. The Empire expanded rapidly, filling the power-vacuum left by the decline of the Byzantine and Seljuk Empires. Under Sultan Orhan and Sultan Murad I, the Ottomans successfully campaigned into the Balkans and the Aegean, aided by rivalries among Byzantine royal families. For instance, Turkish mercenaries were employed by John V Palaeologus and John Cantacuzenus, who were both competing for the Byzantine throne (Charanis, 1942-1943, p. 287). Later on, the Ottomans supported John Cantacuzenus in his wars against the Serbs and Bulgarians, gaining valuable experience and intelligence about the Balkan region (Çelik, 2010, p. 12).

The capture of Constantinople in 1453 by Sultan Mehmed II was a major turning point for the Empire, establishing it as a dominant Mediterranean power. Constantinople (Istanbul) became the Empire’s capital and a hub of trade and culture. The Ottoman Empire's strategic location at the crossroads of Europe, Asia, and Africa strengthened its role as an intermediary in international trade.

The Ottoman military system was a powerful and multifaceted force. The *Janissaries*, who are an elite infantry force originally recruited through the *devshirme* system in 15th-16th century (a

tax on Christian populations), were key to ensuring loyalty to the Sultan (Brown, 1996, p. 14). The *Sipahi* cavalry were another important military force which consisted of feudal warriors who were granted land in exchange for military service.

The Empire was administratively divided into provinces called *vilayets*, which were further subdivided into *sanjaks* (districts) and then into *timars*, lands allocated to military officials or *Sipahi* cavalry (Figure 4 & Figure 5). Local rulers, such as *beys* and *pashas*, were responsible for the administration, justice, and military affairs. A key aspect of Ottoman governance was the inclusion of local elites into the imperial administration, which helped manage the vast and diverse territories of the Empire. This combination of military strength and effective administration was vital for the Empire's stability and longevity (Çelik, 2010, p. 12).

Map. 1. Asian Ottoman Empire. 1883

Figure 4: Ottoman provinces in Asia in the 19th century (Karpat, 1985, xiv).

The so-called *millet* system gave the Empire's non-Muslim ethnic groups a certain amount of autonomy. This administrative framework allowed religious and ethnic communities to govern themselves according to their own laws and customs. Each millet, such as the Rum Millet (Ortho-

dox Christians), Armenian Millet, and Jewish Millet, had its own leaders who were often religious authorities and who oversaw internal matters. They oversaw internal matters. In return *millet* communities paid taxes and recognized Ottoman sovereignty. This system made it easier to govern a multicultural society (Baram & Carroll, 2000b, p. 6).

Figure 5: Ottoman Provinces in Europe in the 19th century (Karpat, 1985, xvi).

2.2 Economy and Society

2.2.1 The Classical Age (15th–16th century)

During the 15th and 16th centuries, the Ottoman Empire's economy thrived thanks to its strategic location at the intersection of Europe, Asia and Africa. This geographic advantage allowed the Empire to control and benefit from several major, well-established trade routes connecting Europe, Asia, and Africa. This helped the Ottomans create a dynamic commercial network which supported both local and long-distance trade across the Empire's vast territories.

Due to the interest of the Ottomans to expand their territories in Europe, the Ottoman capital was moved to Edirne in 1369 and remained the capital until 1453, after which the newly conquered Constantinople became the capital of the Ottoman Empire. The Ottomans started considering the Balkans as their main domain, focusing most of their resources in the area. The Empire had the so-called colonisation policy, which was mostly implemented in frontier regions such as the Balkans. Settlers from Asia Minor were brought to populate towns along the main highways and the surrounding mountain regions. The Ottoman government used deportations along with voluntary emigration in order to keep possibly dissident groups in Asia Minor, Anatolia, and the Balkans under control. They were less of a threat against the Sultan when they were away from home. In addition to founding new towns, the Ottomans rebuilt and repopulated a large number of Balkan towns that suffered a population decline as a result of the extensive wars with and prior the Ottomans. Approximately one-fourth of the Balkan population was Muslim by the early 16th century. Muslims resided mostly in urban areas, while the local Christian community gradually retreated to the mountainous areas. This trend continued for three centuries later. In the census of Eastern Rumelia in 1881, one-third of the population was Muslim (Eminov, 1997, p. 27-32).

The urbanisation policy of the Ottoman state supported the emergence of a new Balkan merchant class. A larger population and expanding urban centres boosted trade by creating greater consumer demand. The Balkans experienced notable economic growth in the 16th century, aided by a policy of establishing *hans* (caravansaries) along main trade routes to ensure the protection of caravan traders (Masters, 1988, p. 115). This period saw two distinct groups of merchants arise. In the western Ottoman Balkan provinces, merchants expanded in response to the Ottoman Empire's ambition to dominate Mediterranean commerce. Meanwhile, a merchant class in the central and eastern Balkan provinces developed to secure Istanbul's supplies (Stoianovich, 1960, p. 238). Although Ottoman merchants, especially those involved in provisioning Istanbul, were viewed as subordinate to the state due to stringent state controls, some likely managed to profit from trade (Faroqhi, 1994, p. 474).

Istanbul, both in Byzantine and Ottoman times, depended heavily on resources from the Black Sea region. By the mid-16th century, regions along the Black Sea coast in Bulgaria, the Dunabian principalities, Thrace, Macedonia, Thessaly, the Morea, and parts of Asia Minor, including Izmir, were required to reserve much of their surplus in grains, livestock, butter, and more for the Ottoman capital. By the late 16th century, a substantial portion of trade in the eastern Balkan peninsula was controlled by Greek merchants who managed the flow of goods to Istanbul (Stoianovich, 1960, p. 242). Grain from the Mediterranean parts of the Empire was set aside for imperial use and stored in granaries due to its durability, while Black Sea grain, with a maximum storage lifespan of

one year, was directed to meet Istanbul's daily needs and distributed to bakeries (Çelik, 2010, p. 21). In return, Istanbul merchants supplied the Black Sea and northern areas with ready-to-wear clothing, silk, and wool textiles (İnalcık, 1994, p. 179).

During the Byzantine period, Black Sea maritime trade was nearly monopolized by the Latins. By the late 14th century, trade connections were established between the Kingdoms of Bulgaria and the Italian states, primarily Venice and Genoa, who had access to the Black and Azov Seas (Ishirkov, 1912, p. 47). The Ottomans, however, wanted full control over the region, achieving this in the mid-15th century by closing the Black Sea to foreign ships (Çelik, 2010, p. 19). The Veneto-Ottoman treaties of 1454, 1479, 1482, and 1513 granted the Venetians navigation rights in the Black Sea, a provision absent from the 1540 treaty. Only Ragusian ships are known to have sailed to Varna for wool and leather exports to Italy until at least 1590. From 1592 to the Küçük Kaynarca Treaty in 1774, the Black Sea remained entirely off-limits to foreign ships (Çelik, 2010, p. 22; Stoianovich, 1960, p. 240).

International trade in the Ottoman Empire maintained earlier traditions. The Empire encouraged its merchants to transport goods from the Near and Middle East to Italy and Central Europe via the Adriatic Sea, and later through the Danube and Balkan overland routes. Muslim, Greek, and Slavic traders extended their commerce to Austria and Lyon (Stoianovich, 1960, p. 238). Despite papal prohibitions against trading with Muslim states, Venice and Genoa established peaceful trade relations with the Ottomans. Religious differences were largely overlooked in commerce, serving mainly to justify war during conflicts. Italian states often followed this approach, as trade was vital to their economies. It's unsurprising that Venice was the first Christian state to secure trade privileges from a Muslim state - the Ayyubids, at the end of the 12th century (Çelik, 2010, p. 2).

Dubrovnik's merchants expanded their trade and maritime ventures in the 16th century, aided by their status as an Ottoman vassal state (İnalcık, 1994, p. 189). Dubrovnik served as a critical transit hub for Balkan trade with Italy from 1400 to 1600. Before Ottoman rule, it exported silver from Bosnian and Serbian mines to Italy. However, once Dubrovnik came under Ottoman protection in the 15th century, the Ottomans restricted silver exports to within the Empire (İnalcık, 1994, p. 256). Dubrovnik merchants avoided Venice, focusing instead on Ancona and Florence, though Venetian woollen cloth was still imported. The more expensive varieties went to Istanbul, Edirne, and Rhodes, while cheaper cloth was distributed across the Balkans. Acting as an intermediary between the Ottomans and Europe, Dubrovnik enjoyed reduced customs duties compared to other foreign merchants (İnalcık, 1994, p. 262).

Foreign merchants within the Empire were regarded as a distinct autonomous group, or *millet*, organised under a deputy or consul who represented them. Besides Istanbul, the largest foreign

merchant presence was in Izmir (İnalcık, 1994, p. 190). The Ottomans granted capitulations to Christian nations, providing foreign traders with legal and economic privileges, including exemptions from local prosecution, taxes, and military service. These privileges were extended to merchants from Italy, England, the Netherlands, and France as early as the 16th century. These traders operated mainly in Levantine and Mediterranean ports (İnalcık, 1994, p. 364). They often relied on brokers from local minority communities, such as Armenians, Greeks, and Jews, to sell their goods (Panzac, 1992, p. 193). Among the most commonly traded goods passing through these ports were spices from South Asia, which were then distributed to Europe (İnalcık, 1994, p. 343).

Most large cities in the second half of the 16th century were inland. This pattern began to shift in the 17th and 18th centuries, as exports to Europe increased and Mediterranean ports expanded (Faroqhi, 1984, p. 75).

2.2.2 Crisis and Transformation (17th century)

In the late 16th century, the Ottoman Empire's fiscally-driven economic system began to unravel. A series of factors contributed to this, including continued wars with the Habsburg and Safavid Empires. The Ottomans introduced several military and fiscal measures, one of which was a rapid, unsustainable expansion of the state's military organisations. However, the fiscal and logistical demands of this expansion strained resources, resulting in cycles of dispossession and unemployment among soldiers and other military personnel. Many of these displaced and now-armed men formed independent bands, disrupting local order and weakening central control. In response, the Ottoman state increasingly relied on local governors, landholders, and power brokers to manage provincial security and stability. These local leaders, gaining greater authority and resources to maintain order, established relatively independent power bases, thus shifting influence from the imperial centre to the provinces. This decentralisation marked a significant shift in the balance of power within the Ottoman Empire (Goffman, 1999, p. 87).

Beginning in the 17th century, the Ottoman political and economic relationship with Europe also evolved. Until then, the Empire dictated trade terms, intimidating other European states. However, after 1600, Western Europe began to be seen as an economic and political equal. Dutch and English ships began trading in silks and spices, areas previously dominated by the Ottomans. These global shifts impacted traditional trade routes. By 1700, Dutch and English maritime traders managed to redirect goods from the 'Orient' directly to Europe, bypassing the Ottoman Empire (Eldem et al., 1999, p. 89).

This shift in global commerce affected the Ottoman Empire's demographic structure as well. The Jewish population had grown rapidly since the 15th century, but in the 17th century, tolerance to-

wards the Jewish community in the Empire declined, while at the same time it increased in Western Europe. England and the Netherlands became new refuges for Jewish merchants. Between 1660 and 1800, the Jewish population in Balkan towns diminished, with many Jews from Salonika and Morea migrating to Izmir, which had now become a centre of Eastern Mediterranean trade. Over time, Balkan towns became less Jewish, Armenian, and sometimes Turkish, while becoming increasingly Greek, Slavic, and Albanian (Stoianovich, 1960, p. 248).

The rise of Greek merchants became particularly notable after the 1650s. They played a prominent role in gathering grain from the Balkan coast and the Black Sea to supply Istanbul (Faroqhi, 1994, p. 518). Greeks maintained a hegemonic influence over the Orthodox Christian millet, which led other Balkan ethnicities, except the Serbs, to become largely 'Hellenised' over time (Stoianovich 1960, p. 310). Greek became the language of both culture and commerce, with Slavic, Vlach, and Albanian merchants often identifying as Greek to attain a higher social status. This trend was especially common in the 17th and 18th centuries (Stoianovich 1960, p. 281).

During this period, Balkan trade routes continued to connect to Central European cities such as Brashov, Sibiu, Timişoara, Vienna, and Pest (Spasov et al., 2016, p. 73), with trade primarily conducted overland. The Danube River became a significant conduit to the Black Sea, although navigation was hindered by the Iron Gates gorge, which made passage difficult for anything larger than a boat. The Ottomans viewed the Danube as primarily important for transporting grain downstream from the Iron Gates (Faroqhi, 1994, p. 483). Other key trade routes included the main highway from Istanbul to Buda via Belgrade, Nis, Sofia, Filibe, and Edirne, as well as routes linking Istanbul to Aleppo and Damascus (Faroqhi, 1994, p. 485). Dubrovnik merchants remained active in Balkan trade, importing textiles from Italy. However, as Venice's influence on the global market declined and Ottoman expansion into Europe ceased, Dubrovnik's neutrality lost its former commercial advantage. By 1700, the city's importance as a trade centre had declined (Faroqhi, 1994, p. 512).

International trade in the Mediterranean flourished during the 17th century. Large numbers of foreign merchants settled in Izmir, which evolved from a port of local significance to a major commercial hub frequently visited by European traders between 1570 and 1650. The transit trade in spices, previously the most dominant commerce in the region, gave way to English traders importing coffee into the Empire in exchange for raw materials. By the early 17th century, Izmir began to rival the former Genoese colony of Chios and eventually surpassed it as a centre of commerce (Faroqhi, 1994, p. 505). Chios merchants also benefited from Izmir's rise, with silk production thriving on the island. Izmir saw increasing numbers of Greek and Jewish merchants, alongside

French, Dutch, and English traders who dominated commerce in Izmir and the Levant (Faroqhi, 1994, p. 522).

The late 17th century is generally perceived as a period of economic decay for the Ottoman Empire. The Habsburg conquest during the 1683-1699 war reclaimed nearly all territories the Ottomans had acquired since 1526. This concluded with the economic decline (Pletnyov, 2004, p. 213; Stoianovich, 1960, p. 263). However, this decline is more accurately described as a shift in the world's commercial centre and as changes in the Ottoman government's economic and administrative structure, which continued well into the following century.

2.2.3 Reforms and Decentralisation (18th century)

Modern historians regard the 18th century as a period of diminished central authority over the Ottoman provinces, marked by the rising power of provincial elites, or *ayans*. The bandit unrest for half a century after 1769 devastated much of the Balkan and Morea countryside. These armed groups, often composed of displaced or unemployed soldiers, roamed both rural and urban areas, severely disrupting social and economic life (Stoianovich, 1960, p. 253). This phenomenon has traditionally been seen as a symptom and accelerator of the Ottoman Empire's so-called 'decline'. However, recent scholarship has identified it as characteristic of a broader era of decentralisation (Anastasopoulos, 2006, p. 11).

In the 18th century, the Ottoman Empire moved away from protectionist and urbanisation policies, reflecting a decline in its capacity to safeguard local industries and foster economic self-sufficiency. This shift was partially due to the Empire's failure to engage in the broader European demographic expansion of the time. The absence of industrial protectionism in the Ottoman Empire, combined with Western Europe's industrial and population boom, forced the Ottoman provinces to serve as raw material suppliers for Europe. The primary exports of the Ottomans were wool, angora from goats and camels, silk and cotton, as well as olive oil, tobacco and dried fruits. The new textile factories in Austria, Saxony, Prussia, and Switzerland depended on Macedonia and Thessaly's cotton and wool, leading to a thriving Balkan cotton production between 1720 and 1800. Balkan cotton and wool were exported to Austria and Germany overland, while imports arrived on European ships via Aegean and Adriatic ports. These imports mainly consisted of manufactured goods like woollen fabrics, gold brocade, metal, and mechanical goods. Additionally, textile dyes, sugar, and coffee were imported from European colonies in the Americas (Panzac, 1992, p. 191).

During the 18th century, trade involving German, English, Austrian, and Russian merchants in the Balkans expanded significantly. By the end of the century, Austrian vessels were permitted to navigate the Danube, while Russian ships obtained rights to sail and trade in both the Black Sea and

the Mediterranean. However, this expansion did not equate to an increase in overall trade value. After 1760, market revenues declined in major Balkan ports such as Istanbul, Kavala, Varna, and various Danubian ports (McGowan, 1994, p. 730). Yet, despite this decline, Balkan merchants began to experience remarkable prosperity, with Bulgarian traders starting to play a prominent role in Ottoman commerce from 1750 onward (Stoianovich, 1960, p. 288).

The Greeks of Constantinople, Izmir, Chios, and Janina benefited significantly from the new political and economic landscape of the early 18th century, expanding their commerce and increasing their wealth (Stoianovich, 1960, p. 273). Izmir continued to grow throughout the century, though silk exports to France and England declined, likely due to competition from Italian silk. Nonetheless, domestic demand for silk remained strong, since its price has increased during that period. Cotton production in Izmir also expanded during the 18th century, with most exports directed to Marseilles. The increased import of American dyes into the region reflects a thriving textile industry. By the late 18th century, European trade with the Ottomans grew substantially, with France becoming their leading trading partner, followed by English and Dutch merchants. While most Ottoman ports exported more than they imported, Istanbul was an exception, importing three to four times the volume it exported (Panzac, 1992, p. 192). By the end of the century, European merchants held the largest share of trade at key Ottoman ports such as Alexandria, Smyrna, and Salonika, controlling the main trade routes and the most valuable cargoes (Panzac, 1992, p. 196).

Izmir emerged as the Ottoman port that benefited most from the changing global order. Although trade within the Ottoman Levant remained relatively stable in terms of value, the value of global trade as a whole continued to rise. By the end of the 18th century, Levantine trade represented a much smaller fraction of world trade than it had two centuries earlier, accounting for less than one percent (McGowan, 1994, p. 725). Despite the flourishing trade within the Levant, a broader global trading network was expanding in which the Ottomans played barely any role.

2.2.4 Modernisation and Decline (19th–20th century)

The 19th century was, overall, a turbulent era for the Ottoman Empire, characterised by numerous political and economic reforms, alongside rebellions and territorial losses in the Balkans. This period also witnessed an intensification of Western European political and economic influence over the Ottomans and an increase in industrialisation. Political and economic reforms in Istanbul shifted towards re-centralisation, particularly in western Anatolia, where the High Porte effectively standardised and centralised revenue collection. This renewed central authority weakened local powers and was especially advantageous for Greek Orthodox merchants in Izmir (Goffman, 1999, p. 125). By the late 18th century, international merchants dominated most international trade. How-

ever, in the early 19th century, non-Muslim Ottoman merchants began to take control of European trade from foreign merchants (Quataert, 1994, p. 839).

In the late 18th and early 19th centuries, import and export trade in the Balkans declined due to the disruption caused by bandit groups. Following the military reforms of 1826 and the establishment of a regular army, stability increased, creating conditions facilitating the increase of trade activity (Spasov et al., 2016, p. 75). Between 1838 and 1846, Black Sea ports such as Varna, Nesebar, Sozopol, and Bourgas strengthened connections with Western Europe, boosting both imports and exports. Ruse became one of the most crucial ports on the Danube, engaging extensively in trade with Austro-Hungary. Overland trade routes also thrived, with merchants from southwest Bulgarian territories trading with Austria and Bohemia by transporting goods through Sofia to nearby Danubian ports. During this period, the number of Bulgarian trade agencies in Austria also saw significant growth (Spasov et al., p. 73).

At the start of the 19th century, the Macedonian region primarily exported cotton, along with tobacco, leather, timber, rose oil, and silk to Europe. Ohrid had become a depot for Austrian and German manufactured goods. Trade with England primarily occurred through three main distribution centres: Istanbul, Romania (including Bucharest, Galați, Braila, Ploieşti, and Giurgiu), and Manchester (Spasov et al., 2016, p. 86).

Commerce in the Romelian and Anatolian regions expanded more rapidly during the 19th century. The volume of Ottoman exports and imports rose significantly, with the European provinces leading in international trade, followed by Anatolia and the Arab provinces. Trade relations with Egypt, Iran, and India were largely neglected. After 1850, the Crimean War and the loss of the Romanian Principalities resulted in the Ottomans losing most of their trade in the European territories (Quataert, 1994, p. 830).

The Ottomans had primarily been purchasing finished and colonial goods while selling mostly raw materials since the previous century, a trend that continued into the 19th century. British exports to the Empire doubled in value during the late 1820s and doubled again before 1837. Following the Anglo-Ottoman treaty in 1838, monopolies were prohibited, and older commercial restrictions were lifted, facilitating the rise of free trade within the Ottoman Empire. The conventions of 1861 and 1862 aimed to improve the marketability of Ottoman products by lowering export taxes, particularly benefiting Western and Central Europe (Quataert, 1994, p. 825). Until around 1820, trade with Russia held greater significance than that with Western and Central Europe. However, by the end of the century, this relationship had reversed. Nevertheless, the quantity and value of domestic trade consistently surpassed those of international Ottoman commerce during the period from 1800 to 1914 (Quataert, 1994, p. 828-834).

It was during the 19th century that the notion of nationalism began to spread throughout the Ottoman Empire, further intensifying the existing ethnic and religious divisions (Goffman, 1999, p. 127). Several independent states emerged from Ottoman control, including the Danubian principalities, the Greek Republic, the Principality of Serbia and the Principality of Bulgaria. In the newly established state of Bulgaria, trade continued to thrive through the Danube, the Black Sea ports, and various rail routes in the late 19th and early 20th centuries. The Ottoman Empire remained Bulgaria's largest exporter, while Austro-Hungary was the primary source of industrial goods (Spasov et al., 2016, p. 111). All newly formed states experienced an increase in their export trade compared to the period before their independence (Quataert, 1994, p. 831). Meanwhile, within the Ottoman Empire, the significance of Muslim merchants grew in various parts of Anatolia towards the end of the 19th and the beginning of the 20th centuries. This shift was facilitated by Greek independence and the demographic changes occurring within the Empire (Quataert, 1994, p. 841).

2.3 The Sites

In this section, a short overview is given for each one of the five sites discussed in this research for the period 15th–20th century. This includes the geographical location of the sites, as well as their political and economic situation during the Ottoman period. The information is collected from historical and ethnographical sources and it is crucial for understanding the role of each site in the Ottoman trade network.

2.3.1 Belgrade

Situated at the meeting point of the Sava and Danube rivers, Belgrade (Figure 6) has always held strategic value. The city has undergone multiple destructions and reconstructions over its long history, because of its role as a frontier garrison. Belgrade was frequently the site of conflicts and clashing states that tried to erase the existence of one another.

Figure 6: A view of the Belgrade Fortress (source: https://tvrdjavesrbije.rs).

Throughout its Medieval and Early Modern history, Belgrade has changed hands multiple times - it was under Byzantine rule, Serbian, Bulgarian, Ottoman and Austro-Hungarian. At the begging of the fifteenth century, the city was designated as the capital of the Serbian monarchy and it was strengthened to serve as a barrier against the Ottoman invasion (Popović & Bikić, 2004, p. 239). In August 1521, the Ottoman forces led by the sultan Suleiman the Magnificent managed to conquer the fortress of Belgrade and soon afterwards, the city became the centre of the *Smederevo*

sanjak. Belgrade continued to be a military stronghold during the Ottoman era. Its primary purpose was to act as the starting point for military operations against the Habsburg Monarchy, in addition to being the main military winter quarters and store for arms and supplies (Bikić, 2003, p. 175). That meant that the army stationed at the fortress would spend more time at the location, which caused for a change in its main function - from predominantly militarily to more economically orientated. The role of tradesmen and craftsmen in the city became more important and thus Belgrade was transformed to a major market place within the Ottoman Empire (Bikić, 2003, p. 176).

The Habsburg Empire finally succeeded in capturing Belgrade in 1688. The Ottoman army managed to retake it again in 1690. In the eighteen century, the Habsburg Empire was able to seize Belgrade twice more in 1717-1739 and 1789-1791 (Bikić, 2003, p. 10). Belgrade was finally able to become independent of the Ottoman Empire in 1830 following two uprisings by Serbians against Ottoman control in the 19th century.(Cox 2002, p. 42).

The ongoing conflict between the Ottoman Empire and the Habsburg Monarchy caused an abrupt decrease in the population of the western Balkans, and specifically Belgrade. In 1683, when the Austro-Ottoman war broke out and lasted until 1690, Belgrade was home to over 50,000 people. However, there were only 25,000 people living in Belgrade at the start of the 19th century (Stoianovich, 1960, p. 249).

2.3.2 Sofia

The capital of modern-day Bulgaria is situated at the foot of the Vitosha mountain, in the Sofia field (Figure 7). Shortly before the Second Bulgarian Empire collapsed in 1396, the Ottoman Empire captured the city. Sofia is located in the middle of the European part of the Ottoman Empire and thus its position was favourable for making it the capital for the *Rumelia vilayet* from 1530 up until 1836. After, council of the *beylerbeys* (provincial governors) was moved to Bitola, in present-day North Macedonia (Ishirkov, 1912, p. 2).

Bulgarians made up the majority of Sofia's population until the 16th century. However, because of the city's advantageous location on major trade routes and the urbanisation policy of the Ottoman state, many Turks migrated to Sofia and eventually the Turkish community grew to dominate. In the same period, Sofia received a large influx of Jewish immigrants from the Iberian peninsula (Ishirkov, 1912, p. 45). With no records of Jewish residents in 1520, towards the middle of the 17th century, Sofia had recorded about 2 000 Jews (Stoianovich, 1960, p. 245). The population of many major cities in the West Balkans, including Sofia, increased by 68% between 1525 and 1575. This population increase also promoted the growth of trade (Stoianovich, 1960, p. 242). In general, Sofia's population was quite diverse, with Turks making up the largest portion, followed by Bulgarians and Jews. Many other ethnic groups, including Greeks, Albanians, Armenians, Alemanians,

Ragusians, Persians, and Romani, also resided in Sofia, making the population about 40 to 50 000 citizens in the 17th century (Ishirkov, 1912, p. 37-38).

Figure 7: A view of Sofia with Vitosha mountain in the background (source: https://www.flickr.com/photos/deensel/37591925970).

In the Ottoman Balkans, Sofia functioned as an intersection for inland trade, supplying a variety of goods to Serbia, Macedonia, and even further north, beyond the Danube river. Sofia became even more of a centre for international trade and its ties to Central Europe increased when the Black Sea was closed to non-Ottoman foreign ships in the sixteenth century (Ishirkov ,1912, p. 55). The migration of multiple Dubrovnik commercial families to Sofia throughout the 16th century enhanced trade relations between the two cities. These traders frequently imported products from Italy, particularly Ancona and Florence (Ishirkov, 1912, p. 46).

Sofia's population suffered from the wars with Russia and the Habsburg Empire in the 17th century, in the same way as Belgrade did. This was one of the main reasons as to why the Turkish population in the city seriously declined in the 17th century. This encouraged the rural population around Sofia who were mostly Slavs and Albanians, to settle in the big city (Stoianovich, 1960, p. 250). In 1699, the sultan Mehmed IV issued a *firman* (an official order issued by the Ottoman sultan) which allowed Bulgarians to settle in the Turkish neighbourhood of Sofia (Ishirkov, 1912, p. 42). Eventually, Sofia became less Turkish and after the migration of Jewish people to Europe, Bulgarians started to dominate the city (Stoianovich, 1960, p. 244).

2.3.3 Varna

Varna has been a major trade hub on the Black Sea coast ever since 6th century BC when it was established as a Greek colony by the name of *Odessos* (Figure 8). The city was part of the Roman/Byzantine Empire and later on, it was incorporated into the Bulgarian state. Varna became part of the Ottoman Empire in 1399, during the Balkan conquest of the Ottomans.

Figure 8: The port of Varna (source: https://chernomorie-bg.com).

Varna has had close trade connections with the Mediterranean ever since its establishment. During the 16th century, Venetian and Ragusian ships travelled freely through the Black Sea and engaged in commerce with the locals. In the period between 1592 and 1783, the Black Sea was often referred to as the 'Ottoman lake', since it was completely blocked off for European ships, which included Italian merchants (Stoianovich 1960, p. 240). The Black Sea region served mostly as a supplier of wheat to the huge consumer market in the Ottoman capital. An Ottoman document from 1782 gives us a list of ships that brought cereals to Istanbul. Out of these ships, 80% of wheat came from the ports of present-day Bulgaria and about 20% from present-day Romania (Panzac, 1992, p. 195). The treaty of Küçük Kaynarca changed the economic role of the Black Sea. Russian ships were allowed to pass through the basin and from 1783 onwards, Russian merchants could sell their goods to any Ottoman buyer (Stoianovich, 1960, p. 240).

One of the main exports of Varna was grain, which came from the Dobrudzha plateau, north of Varna. It was transported to Istanbul and it was distributed for the daily needs of its inhabitants (Çelik, 2010, p. 21; İnalcık, 1994, p. 185). In return, Varna imported manufactured goods (Faroqhi, 1984, p. 77) and Turkish ceramics from Istanbul, as reported in documents from the reign of Suley-

man I (Pletnyov, 2002-2003, p. 429). Tax documents show that the majority of imported pottery in Varna during Ottoman times came by ships (Pletnyov, 1999, p. 113).

The first document describing the demography of Varna during the Ottoman era is a *firman* dated to 1527, which makes it evident that the city was the *hass* (an administrative-military classification of land) of Sultan Selim I. This meant that the revenue of Varna would go directly to the central state treasury (İnalcık, 1997, p. 141; Pletnyov 2005b, p. 2). During that period, Varna's population remained predominantly Christian, with one Muslim neighbourhood and ten Christian ones (Pletnyov 2005b, p. 2). These Christians were most likely Greek traders, as historical accounts suggest that Greeks dominated trade throughout the Black Sea coast and the eastern Balkan Peninsula. (Stoianovich 1960, p. 241). After this, the city's Muslim population grew dramatically, most likely as a result of the wave of immigrants from Anatolia who settled in the region (Pletnyov 2004, p.12).

2.3.4 Mytilini

The site of Mytilini is situated on an islet on the southwest coast of the island of Lesvos (Figure 9). This islet was divided from the mainland by a narrow sea passage which created the perfect natural defence for the city (Acheilara, 1999, p. 6). Lesvos had been ruled by the Romans/ Byzantines for over a millennium before the Ottomans. Italian fleets raided the Aegean islands during the events of the Fourth Crusade. The Gatteluis, a Genoese/Byzantine dynasty who dominated most of northern Aegean, ruled Lesvos from 1355 up until 1462 when the island was conquered by the Ottomans (Williams, 2009, p. 107).

Figure 9: View of Mytilini, Lesvos (source: https://www.lesvos.com).

Lesvos' history is strongly connected to that of the Eastern Mediterranean. The island has long held a strategic position because of its proximity to the West Anatolian shore and there was regular trade and migration between Lesvos and the western coast of Anatolia.

Additionally, Lesvos' location on the maritime routes to Istanbul and the Black sea during the Ottoman era benefited merchants on the island who wished to engage in maritime trade activity. (Anagnostou 2007, p. 132). The harbour of Mytilini was closely tied to the commercial activities of Chios, who suffered an economic decline in mid 16th century (Faroqhi, 1984, p. 115). During the 17th century, however, the economies of many West Aegean ports greatly prospered due to the emergence of Izmir as an international trade centre (Faroqhi, 1994, p. 522).

After the Ottoman conquest, the majority of Lesvos' population remained Greek Orthodox. Along with the Ottoman occupation, the island saw the emergence of a Muslim minority which constituted both from immigrants from Anatolia and from converted locals. Muslims accounted for about 7% of the island's overall population in the 15th century and this number rose to about 19% in early 19th century (Kiel, 2018, p. 167).

The First Balkan War (1912–1913) led to the annexation of Lesvos by the Greek state which led to a restriction of trade with Western Anatolia for the first time in centuries. Rather, trade increased with Greece and the Aegean (Giannopoulou and Demesticha, 1998).

2.3.5 Izmir

Izmir is located on a well-protected gulf on the west coast of Anatolia (Figure 10). It is currently one of the biggest cities on the Aegean and the third most populous city in Turkey. West of the gulf are located the Greek islands of Lesvos and Chios.

After the events of the Fourth Crusade and the capturing of Constantinople by the Latins in 1204, Izmir flourished as the commercial hub of the Byzantines (Goffman, 1999, p. 85). In 1390 the city was conquered by the Ottomans and it was part of the Empire up until its demolition in 1924. (Baykara, 1974, p. 53). Izmir became part of the *Aydın sanjak* together with all Anatolian land in the Ottoman Empire. After some years, it became the provincial centre of the *sanjak* (Kanberoğlu 2023, p. 607).

Izmir held a position of an important culturally diverse port throughout the Ottoman period, party because of its strategic geographic location which made it an important node in East Mediterranean trade network. Additionally, the region around Izmir is rich in produce such as cotton, madder, thuja, olive oil, thyme oil, tobacco, wine, fruits, animal products, coal and more (Kanberoğlu, 2023, p. 608).

Izmir's economic role rose in the late 16th – early 17th century. Ottoman central government did not participate in the creation of 17th century Izmir. The Ottomans did not have a specific plan for Western Anatolia and viewed the region only as a suppler for Istanbul. The city's inclusion on the global trade map was in fact brought by local officials. The changes in the Ottoman economic system and the reorganisation of the commerce in the Empire launched Izmir's economic boom (Goffman, 1999, p. 83-89). The commercial decline of Chios during that period also gave rise to Izmir's economic boom (Goffman, 1999, p. 120).

Figure 10: A panoramic view of Izmir (source: https://turkeytravelguide.com).

The arrival of merchants from Europe - Dutch, English, French and Venetian, who joined the already existing traders in Izmir - Arabs, Armenians, Greeks, Jews and Turks led to a shift in Izmir's export strategy. Izmir significantly reduced its trade with the cities in the north and north-east, including Istanbul, and became the centre of trade with the regions to the south, as well as Europe (Goffman, 1999, p. 89; Kanberoğlu, 2023, p. 609). During that period, Izmir took over the silk trade from Iran. Up until that time, Aleppo was the major trade centre for Iranian silk, because of its proximity to the region. The routes to Izmir were, however, much safer and this attracted European merchants as well (Masters, 1988, p. 28).

The city prospered and in the 19th century, when it was integrated in the world's economic system. Western Europe's industrialisation brought new inventions and increased European dominance over the Ottoman Empire. In West Anatolia, the English steam-powered ships easily outperformed competitors in trade, and were able to sell their products in Izmir and its surrounding area.

To support their industries and the growing urban population back home, they gathered cottons, grains and other materials from the area. In the 19th century, Izmir was the main Ottoman city that benefited from the new economic system (Goffman, 1999, p. 126-128).

The great fire of Izmir in 1922 destroyed a big part of the city together with the court records and other administrative documents, which are the main source of local urban history. For this reason, many aspects connected with the urbanisation and demographics of Izmir cannot be studied properly (Goffman, 1999, p. 133).

2.4 Pottery Types

In this section, the main types of imported pottery which are most commonly encountered in the network model are presented. It is important to discuss the background of these pottery types so that the character of the commercial connection between the sites and the pottery production centres is better understood. First, ceramics made in Ottoman domestic centres will be introduced. These are divided into those produced in imperial centralised workshops and those from other centres with less state influence. Finally, ceramic production centres outside of Europe are presented. These centres are often encounter in the dataset of this thesis.

2.4.1 Ottoman Domestic Ceramics

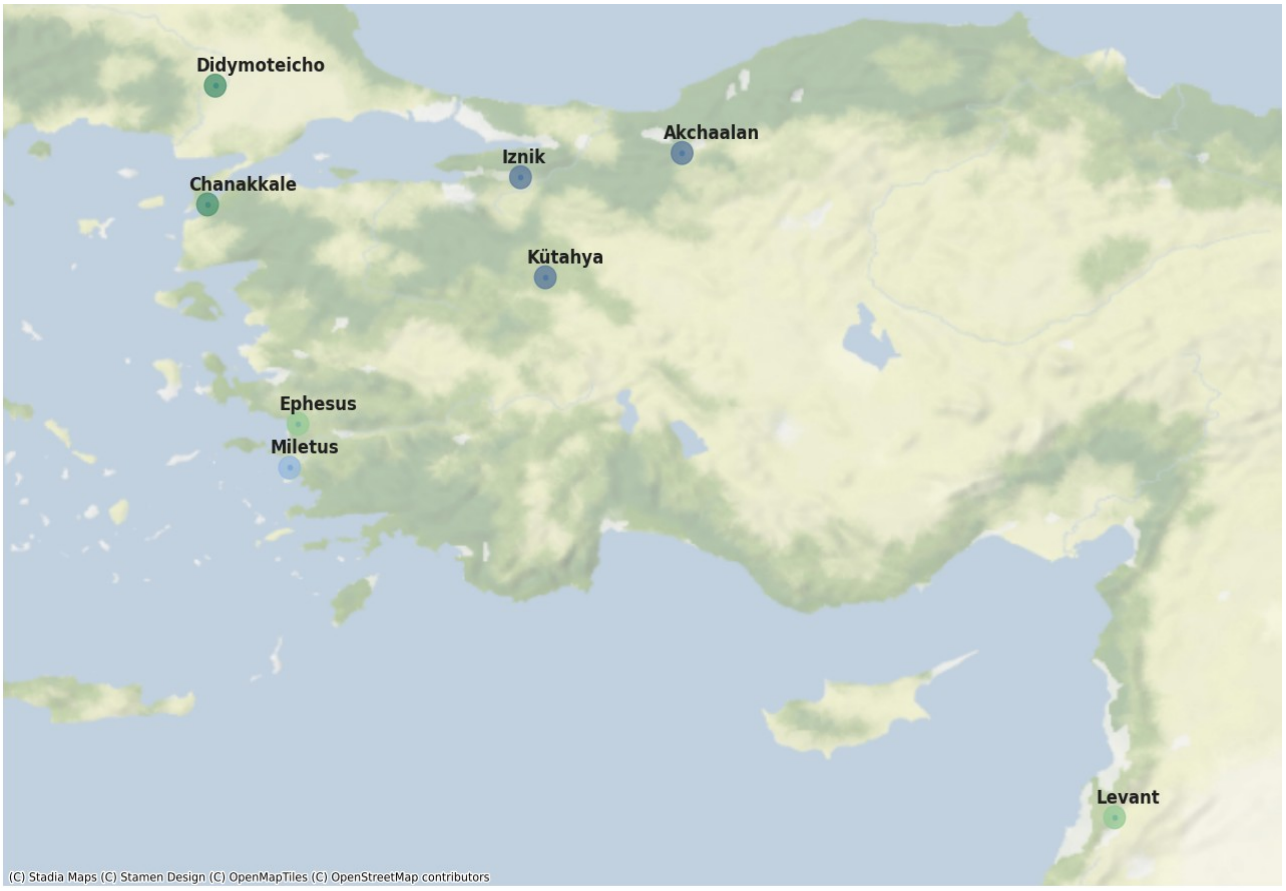

Figure 11: Location of the domestic pottery production sites present in the dataset of this thesis. Sites in: blue: centralised production; green: non-centralised production (by Kodzhabasheva, 2024; map source: Stadia Maps, Stamen Design: https://stadiamaps.com/).

Centralised Production

Miletus

Miletus ware is considered to be the first mass-produced ceramic type developed by the Ottoman potters in Anatolia. The name 'Miletus' originates from the name of the site where this type of pottery was first excavated in huge quantities (Figure 11, site in light-blue). Recently, it has been

established that Miletus ware was likely not produced extensively in Miletus itself but mainly in Iznik, with smaller amounts made in Kutahya and Akchaalan (Figure 11, sites in darker blue) (Atasoy & Raby 1989, p. 83; Vroom, 2005, p. 157). For this reason, in this thesis, it is considered to originate from the region of Northwest Anatolia.

Miletus pottery can be categorised as reddish earthenware, covered in white slip on both the exterior and the interior. The main motifs of the painted decoration on the interior are flower rosettes and sunburst in dark-blue, turquoise, purple and black. This decoration is then covered with transparent glaze. The exterior is sometimes covered with monochrome green paint (Burlot et al., 2020, p. 2). The most common ceramic shapes found are open forms such as plates and deep bowls (Figure 12).

The exact start of this ceramic production is not known but it is commonly acknowledged that by the second half of the 14th century Miletus ware was already widely spread across Ottoman Anatolia, the Aegean and the Balkans. In the archaeological context, these ceramics can be dated up to the 16th century.

Figure 12: Examples of Miletus ceramics (after Burlot et al., 2020, p. 2).

Iznik

The production of Iznik ware (Figure 13) began in the late 14th, early 15th century in the small town of Iznik, where up until that period Miletus ware had been produced. Other production centres, such as Kütahya, have also been mentioned (Vroom, 2005, p. 159). This type of pottery flourished in the late 15th century to the late 17th century and was widespread all over the Ottoman Empire, Europe and the Near East (Vroom, 2005, p. 161).

In addition to ceramic vessels designed for the tables of upper and middle classes, Iznik potters also produced wall tiles which are one of the most important decorative feature of the Ottoman buildings. The white-bodied Iznik ceramics with their typical blue on white decoration is a unique development in the pottery production in that geographical area. This development could be connected to the migration of master potters to Iznik, who had advanced ceramic making techniques (Atasoy & Raby, 1989, p. 14). In addition, the establishment of the *Nakkashane* - a palace atelier which also functioned as an academy, by Fatih Sultan Mehmed in the Topkapı Palace in the 15th century, could have had an impact on the artistic style of Iznik ware. In this workshop, court artist developed a specific art style for book binding and illumination. This style further spread throughout the Ottoman Empire and influenced various different crafts. According to Atasoy & Raby (1989, p. 14), a connection between the Iznik pottery decoration and this new design trend can definitely be observed.

Figure 13: Iznik dish from the 16th century (Atasoy & Raby, 1989, p. 140).

Iznik was considered a high-quality ware and it was one of the Empire's most exported ceramic types. Both Iznik and Kütahya became the most traded types of glazed ceramics within and outside the Ottoman Empire from the 16th to the end of 18th century. The trading of these wares was fully state controlled. This was conducted through granting concessions to merchants. These concessions were practically licenses sold to merchants, so that they can engage with the trading of

Iznik and Kütahya wares. The sales of concessions to merchants provided the state with revenues. Restrictions, bans, and sanctions were used to control the Empire's commodity flow (Vroom 2017, p. 907). Although Iznik was enjoyed by the Ottoman elite, it was definitely overshadowed by Chinese porcelain which was held in the highest regard. Very commonly, the motifs and decorations on Iznik ceramics were imitating the ones on Chinese porcelain.

Kütahya

Ceramics at Kütahya have been produced as early as the 15th-16th century. However, it is difficult to tell the difference between the earliest Kütahya ware manufacturers and those from Iznik before the beginning of the 18th century, when Iznik faience production started to decline. Kütahya became the new production centre for Ottoman export ceramics and continued manufacturing pottery vessels well into the 19th century. Yet, it was during the 18th century when these vessels were massively exported (Vroom, 2005, p. 169). The vessels produced were mostly small thinly-potted utensils such as small ewers, dishes, plates and coffee cups - *fildžan* (Pletnyov, 2005a, p. 4).

The decoration on these vessels most often consists of white slip layer with painted geometrical, floral and faunal decorations in blue, green, red, yellow and purple. Sometimes Christian motifs are depicted, as well as men and women wearing contemporary 18th century Ottoman clothes (Figure 13). It is generally considered that the Kütahya potters are either Greek or Armenian, since lots of the inscriptions on the vessels are written in these two languages (Vroom, 2005a, p. 169).

The Kütahya coffee cups were one of the most popular Ottoman ceramic exports during the 18th century. They very often imitated the decorations of Chinese and European porcelain, although their quality was not that high (Pltenyov, 2005a, p. 4). Kütahya ware was spread all over the Empire and the Mediterranean basin and the Black Sea coast (Vroom, 2005, p. 171).

Figure 14: A fildžan (left) and a plate with a decoration of a woman (right) from Kütahya, found in Varna from the 18th century (after Pletnyov 2002, p. 19-21).

Other Production Centres

Chanakkale

The Chanakkale (or Çanakkale) ware is named after its production centre on the Dardanelles (Figure 11). This pottery was especially popular from the second half of the 18th century up until the first half of the 19th century. It was exported in huge quantities to many locations in the Aegean, North Africa and the Balkans (Vroom, 2005, p. 183).

The ceramics from Chanakkale are mostly large shallow dishes made from red clay, covered in white or light grey slip with cream-coloured glaze on the interior and transparent glaze on the exterior (Figure 15) (Pletnyov, 2002, p. 4). The decoration of the rim mostly consists of freehand vegetal patterns in black-purple to dark-reddish-brown colour. The central motif of the dish can be an abstract rosette flowers, ships, kiosks, mosques, birds or any other animal. After the 19th century, Chanakkale potters start making different types of vessels such as bowls, jugs, vases and decorative figures of animals (Vroom, 2005, p. 181).

Figure 15: A Chanakkale dish found in Varna from the 19th century (Pletnyov, 2002, p. 22).

Didymoteicho

Didymoteicho is an inland town located in Central Trace (Figure 11), which became a popular ceramic production centre in the 17th century. Pottery was produced there up until the 20th century (Liaros, 2018, p. 203). The potters of Didymoteicho produced various production of tableware,

decorated with combinations of drips of coloured slip and glaze as well as central medallion decorations (Figure 16). The glaze colours were most commonly green and yellow. This ware was spread all over the Mediterranean basin and Anatolia (Vroom, 2005, p. 187).

Figure 16: Dishes (left) and a jug (right) from Didymoteicho from the 18th-19th century (after Liaros, 2018, p. 208-209).

Additional Ottoman domestic pottery discussed in this thesis includes ceramics from the ***Levant*** and ***Ephesus*** (Figure 11, sites in light green). However, the pottery from Ephesus appears only within a single century and in limited quantities, so this background does not go into detail about it. Similarly, the ceramics exported from the Levant consist of several types but are less popular than those mentioned here, which is why they are not further elaborated upon.

2.4.2 Chinese porcelain

Porcelain is one of the three main types of ceramics, in addition to earthenware and stoneware. The difference between them is the clay used and the temperature at which the ceramics are fired. Porcelain has the highest density of them all. Although the definition is flexible, porcelain most commonly refers to ceramics made from refined petuntse kaolin clay fired at a temperature of 1200 to 1400 degrees Celsius, which makes the white fabric hard and translucent (Scheurleer, 1974, p. 29). The decorations on these wares vary. They could be painted by hand, printed, stamped, incised or carved. These motifs, which usually include landscapes, birds, animals or mythical scenes, are most commonly painted in underglaze blue colour on a white background (Vroom, 2005, p. 163).

The earliest evidence of porcelain production is from the 6th and 7th century AD in the provinces of Hebei and Henan in north China. Porcelain was not manufactured in Europe until the 18th century (Vainer, 1991, p. 218). The name ‘porcelain’ derives from the Italian word *porcellana* which means to have a finish like a cowrie shell (Madsen & White, 2011, p. 31).

Most of the export porcelain in the 17th-18th century was produced in Jingdezhen - a city in southeast China, located in the province of Kiangsi. Stonewares were produced at this centre as early as the middle of the Shang period (16th-11th century BC) and porcelains by about 600 AD. The production of big quantities of porcelain continues up to 1858, when the export trade significantly declined, threatened by the newly produced European porcelains. During the 11th-12th century, Jingdezhen potters introduced a new method for refining their ceramics, by combining kaolin clay with a granitic mineral rock - petuntse, which is sometimes referred to as 'China stone'. The location of Jingdezhen on the Chang River was perfect for the production of porcelain. The riverbed contained kaolin and the hills around the city contained petuntse, which was used for making both the fabric and the glaze. Jingdezhen was very well connected to Canton, which was the closest port from which the porcelain was shipped abroad (Madsen & White, 2011, p. 32).

Chinese porcelain has influenced the ceramic production of every region it has been exported to. This ceramic technique first spread to potters in Korea, Vietnam and Japan (Vainer, 1991, p. 134). After Chinese porcelain started to be exported to the Middle East and Europe, potters there tried to mimic these wares using their local available resources.

Figure 17: Lonquan celadon dish from the 14th-15th century (Vanier, 1991, p. 137).

The large-sized Longquan celadon dishes (Figure 17) were imported in the Middle East up until the 15th century and showed off at the imperial banquets of the sultans. (Vainer, 1991, p. 136). The so-called *fritware,* which was widely spread throughout the Middle East, aimed to resemble the results of porcelain. The case is the same with the later ceramics produced at Iznik and Kütahya

(Vainer, 1991, p. 139). Chinese porcelain was seen as very luxurious and expensive and it was valued more than Iznik ware. The Chinese producers were making large quantities of blue-and-white porcelain targeted for the Islamic market. They included various islamic motifs and shapes and even Arabic calligraphy on their ceramics (Vainer, 1991, p. 142).

The import of Chinese porcelain into the Ottoman Empire began in the first half of the 16th century. Sultan Selim I acquired some porcelain pieces as a military conquest in Egypt. Porcelain has been extremely valued and collected in the palace treasury. Only after the second half of the 17th century, this ware starts to enter the Empire via trade roads (Pletnyov, 2005a, p. 2).

The first porcelain pieces probably entered Europe during the 14th century (Figure 18) as gifts exchanged among the nobility (Vainer, 1991, p. 143). In the continent, porcelain was barely known until the 17th century. Although attempts to imitate these wares were made early on, it was not until the 18th century that the English and the German managed to create fabric similar to the original. This marked the beginning of the first large-scale porcelain production outside Jingdezhen (Vainer, 1991, p. 134).

Figure 18: Porcelain dish from the 14th century (Vanier, 1991, p. 139).

Japanese porcelain

In addition to Chinese and European porcelain, Japanese porcelain can also be found in the Ottoman pottery assemblages (Figure 19). The production of porcelain in Japan started relatively later than the Chinese one - the beginning of the 17th century (Godden, 1979, p. 301). When the Ming dynasty's collapse disturbed the supply of Chinese porcelain to Europe in the middle of the 17th century, the Dutch East India Company purchased a substantial amount of Japanese porcelain. Early-production Japanese porcelain has a coarser paste and an impure purplish-grey tone due to the incorporation of cobalt. A large portion of Japanese porcelain made in the Imari style, which began production at the start of the 17th century, was shipped to Europe (Faÿ-Hallé et al., 1983, p. 233).

Figure 19: A Japanese porcelain vase in the 'Imari' style from the 18th century (Godden, 1979, p. 303).

2.4.3 Italian Maiolica

Maiolica is tin-glazed earthenware from Italy, with a peak of production between 1420 and 1565, also known as the classical period of Italian maiolica. The term ‘maiolica’ was first used to describe Spanish lustre (metallic sheen) ware imported into Italy. During the 16th century, the term began to be applied to describe all Italian tin-glazed ceramics (Scott-Taggart, 1972, p. 27). Maiolica was widely exported all over Northwestern Europe, the Italian and the Adriatic peninsula, as well as

the Balkans, the Aegean and Western Anatolia, mostly during the 15th-16th centuries (Vroom, 2005, p. 147).

Figure 20: Production centres of Italian maiolica present in the dataset of this thesis (in red) and the location of Venice (in blue) (by Kodzhabasheva, 2024; map source: Stadia Maps, Stamen Design: https://stadiamaps.com).

There are around 30 known centres in the Italian peninsula where Maiolica was produced. (Scott-Taggart, 1972, p. 22). About fourteen of them were especially important during the classical period of Maiolica. These include Orvieto, which was one of the earliest maiolica centres with most ceramic pieces dating from the 15th century, Florence and Montelupo (Scott-Taggart, 1972, p. 24). Venice developed the production of maiolica relatively late compared to other Italian centres, with a peak between 1550 and 1570 (Scott-Taggart, 1972, p. 32). The dataset of this thesis also includes Maiolica ceramics originating from Faenza, Genoa (Liguria), and Abisola (Figure 20).

After firing, the ceramics are coated with a thin white layer of a mixture containing tin oxide. The base colours of the decorations are blue, ochre, yellow, copper-green, manganese (purplish-brown), white and black (Scott-Taggart, 1972, p. 6) (Figure 21). After the middle of the 16th century, wares with white background and little decoration became more popular (Scott-Taggart, 1972, p. 33). This could have been influenced by the introduction of Chinese porcelain and the spread of porcelain art style in Europe. European potters managed to imitate only the surface decor-

ations, because they lacked the technology to make the porcelain paste. Some researchers label this type of pottery as ‘soft-paste porcelain’ (Faÿ-Hallé et al., 1983, p. 12).

Figure 21: Maiolica dish from Faenza, 15th century (Solon, 1907, p. 58).

2.4.4 European porcelain

Since the introduction of Chinese porcelain in Europe, there have been lots of attempts by European potters to imitate these ceramics. The earliest successful attempts of making ‘soft-paste porcelain’ are by the tin-glaze potters in Italy who made *maiolica* and the Dutch potters who produced *delftware*. However, they only managed to imitate the decorations of porcelain. The technology of firing and the material has always fascinated European scientists and potters but the ‘secret’ of hard-paste porcelain was not discovered until the end of the 17th - beginning of the 18th century (Faÿ-Hallé et al., 1983, p. 12).

In Germany and in the Austro-Hungarian Empire, there were about 250 factories producing porcelain at the end of the 18th century. Porcelain factories were also operating in England and France. Most of the factories established in the 18th century were located in capitals or large towns. Some of the most famous ones are at St. Petersburg, Copenhagen, Sèvres (vicinity of Paris), Meis-

sen - near Dresden, Vienna, Berlin, Munich, Thuringia and they all depended on the sponsorship of royal or princely courts (Charleston & Ayers, 1971, p. 7) (Figure 22).

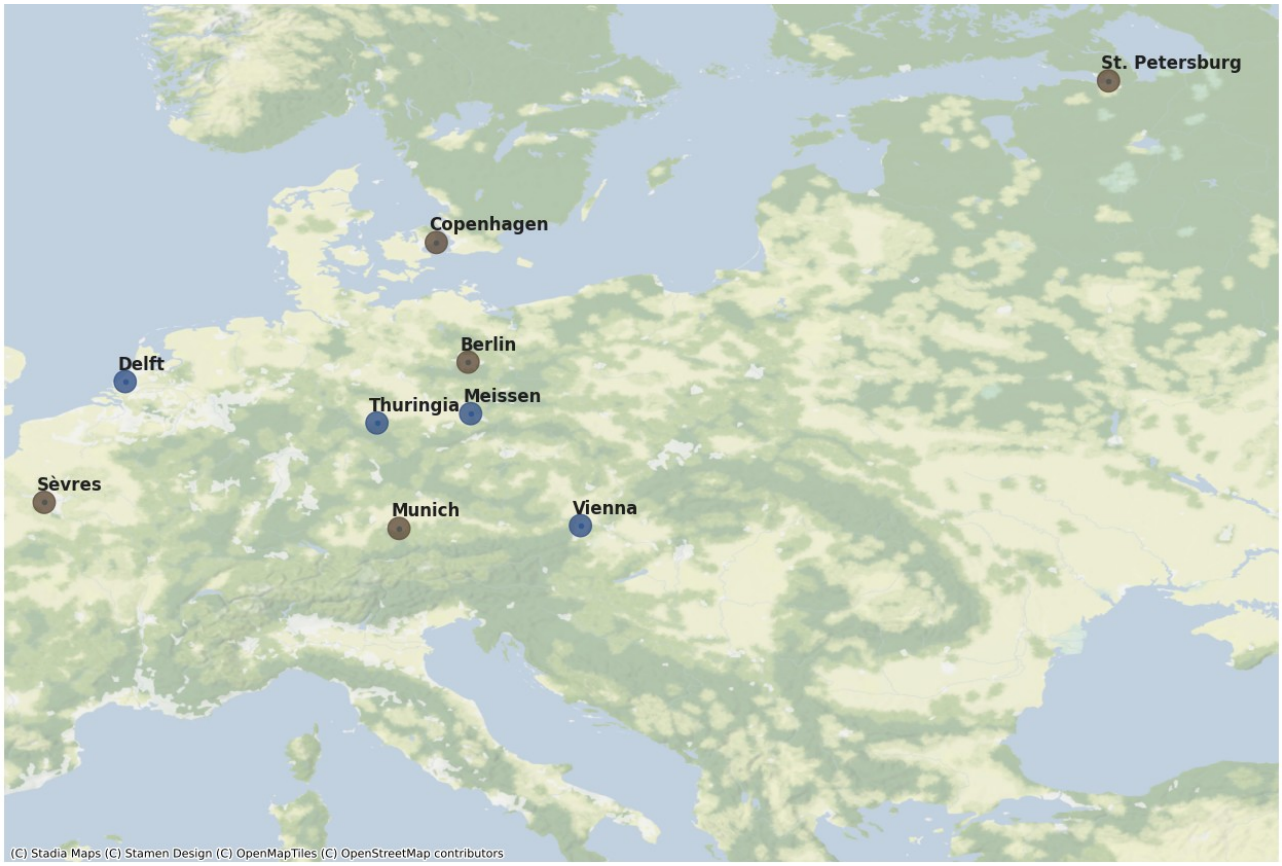

Figure 22: Popular European porcelian production centres; in blue: centres present in the dataset of this thesis; in brown: centres not present in the dataset (by Kodzhabasheva, 2024; map source: Stadia Maps, Stamen Design: https://stadiamaps.com).

The Meissen porcelain factory near Dresden, Saxony has one of the longest production histories in Europe, which continues to this day (Figure 23). It was established in 1710 and for a big part of the 18th century, Meissen porcelain was the most exported European porcelain. (Faÿ-Hallé et al., 1983, p. 12). In the late 18th century, Austria and Prussia completely banned the import of Saxon porcelain. During the same periods Russia, France and England placed a taxation on Saxon porcelain ranging from 40% to 60%. This caused severe economic problems for the Meissen factory. Still, Russia and the Ottoman Empire continued to be profitable markets (Charleston & Ayers, 1971, p. 72).

At the end of the 18th century, porcelain factories all over Europe started to mass-produce ceramics and to significantly lower their quality, making porcelain available for a much wider consumption and the lower classes (Faÿ-Hallé et al., 1983, p. 12).

Figure 23: A cup and a plate from the Meissen factory, 18th century (The Metropolitan Museum of Art, object numbers: cup: 54.147.75 and plate: 54.147.76, https://www.metmuseum.org/art/collection/search/201777).

2.5 Network Theory

At its core, *network theory* focuses on understanding the structure of relationships between a set of actors, which are formally represented through network models. This formal description of networks helps with analysing patterns in the connection between these actors. In archaeology, these actors are most commonly objects, sites or locations. Instead of focusing on the individual actors, network methods focus on the relationship between the different entities and the patterns that emerge from them in order to better understand their behaviour in the network (Brughmans 2012, p. 625). The most common way to depict a network is by a network graph, in which the actors are depicted as nodes and the relationship between them as lines referred to as edges (Figure 24). The network also includes additional attribute data to both nodes and edges (Brughmans, 2010, p. 277; de Nooy et al. 2005, p. 7; Peeples, 2019, p. 453; Wasserman and Faust 1994, p. 93).

Network methods have been used by archaeologists at least since the 1970s, but they have become more popular in the past decade (e.g., Bentley & Maschner, 2003; Brughmans, 2014; Brughmans et al., 2015; Brughmans & Peeples et al., 2023; Carrignon et al., 2020; Isaksen, 2013; Knappett, 2011; Knappett, 2013; Levy et al., 2021; Peeples et al. 2014; Peeples, 2019; Roberts et al., 2012). In archaeology, network methods draw on concepts and techniques from various disciplines related to network theory, including Graph Theory, Social Network Analysis (SNA), and Complexity Science (Peeples, 2019, p. 451), which are discussed in the following paragraphs.

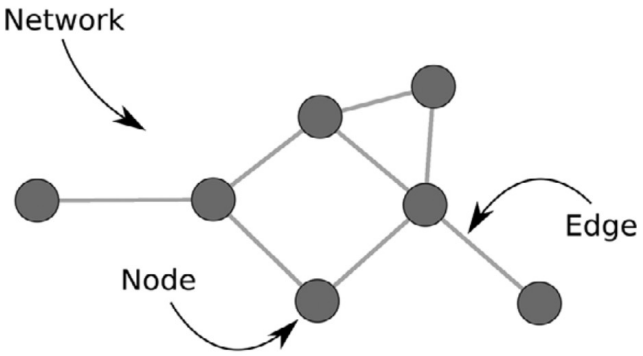

Figure 24: Example network with nodes and edges (Brughmans & Peeples, 2023, p. 5).

Graph Theory

Graph theory is the branch of mathematics focused on the study of graphs. These are mathematical tools used to characterize the structure of relationships among entities. It serves as one of the primary foundations of Social Network Analysis (SNA). Graph theory and networks are usually used in combination, since graph theory provides network analysts with a means to visualize networks through lines and vertices, along with descriptive and mathematical systems (Brughmans, 2012, p. 628).

Graph theoretical approaches have been utilized in archaeological research since at least the 1960s (e.g., Clarke 1968). However, it wasn't until the mid-1970s that graph-based methods began to be employed to investigate patterns of interaction among social entities (Peeples, 2019, p. 455). These methods have facilitated the development of various quantitative approaches to archaeological data. According to Brughmans (2012, p. 629), geographers Forrest Pitts (1965, 1979) and Peregrine (1991) were pioneers in applying the mathematical aspects of graph theory, in addition to its visual components.

Social Network Analysis

Social network analysis (SNA) began to emerge as a distinct field of network theory in the early 20th century. SNA involves the study of the structure of relationships between social entities. Unlike other network-based approaches, SNA focuses on social units in particular and looks at social ties as pathways for the exchange of resources between people. Some of the earliest works concerning social networks are by Both (1957), Barnes and Harary (1983), and Harary et al. (1965).

SNA studies are diverse, concentrating on the social processes that influence network structures. Advances in SNA and social physics have notably impacted archaeological research (Brughmans, 2012, p. 624). However, archaeologists have not typically collaborated with graph theorists to create mathematical techniques tailored to their specific needs. Many archaeological network analyses have been heavily influenced by SNA methodologies (Peeples, 2019, p. 457). SNA has developed into a significant research perspective within the social and behavioural sciences. The introduction of the sociogram by Jacob Moreno in the early 1930s was fundamental for SNA (Moreno, 1934). Similar to graphs, the sociogram represents the interpersonal structure of groups as points and lines in a two-dimensional space. (Brughmans 2012, p. 632).

While SNA methods have a long history, Brughmans (2012, p. 633) notes that archaeologists only began to show interest in these methods after the 2000s. An exception is Cynthia Irwin-Williams' (1977) publication on analyzing prehistoric trade through a network model, which introduced several new analytical approaches that have since become foundational techniques for archaeological network analysis. It is notable that her work did not have a wider influence on the archaeological community, possibly due to the lack of affordable computing power in the 1970s.

Relevant research themes from SNA theory that apply to archaeological network theory include the following: *Network Centrality Measures* - one of the most widely used tools in archaeology derived from SNA, which enables the identification of nodes with better access to information and greater potential for disseminating information due to their central position in the network. *Affiliation Network*s - two-mode networks that illustrate the layered and diverse nature of social re-

lationships. *Ego Networks* - which examine the social context surrounding a specific individual (Brughmans, 2012, pp. 635-638).

Complex Networks and Social Physics

Complexity Science Approaches, often referred to as network science or complex networks, consist of network models primarily developed in fields such as physics, mathematics, and computer science. These models are used to investigate how complex systems behave and develop. The main goal of these approaches is to identify and study the key processes and rules that determine how the structure of a network affects its behavior and how it changes over time (Brughmans, 2012, p. 642; Strogatz, 2001). Two types of complex networks, small-world and scale-free (Figure 25), are the most commonly applied in archaeology.

Small-world networks*:* Stanley Milgram first explored the "small-world problem" in his experiments on how letters travel between two strangers (1967, 1992) (Korte & Milgram, 1970). Milgram's findings led to the concept of "six degrees of separation," showing that any two individuals on the planet are connected by an average of six interpersonal steps. Watts and Strogatz later discovered that "real-world networks are neither entirely ordered nor completely random but possess characteristics of both" (Watts, 2004, p. 244; Watts & Strogatz, 1998) (Brughmans, 2012, p. 643).

Scale-Free Networks and Power Laws: In their fundamental 1999 paper, Albert-László Barabási and his student Réka Albert revealed that real-world networks don't follow a normal degree distribution but rather exhibit a power-law distribution, where highly connected nodes, or 'hubs' emerge, resulting in the 'rich get richer' effect. Many real-world networks have been shown to follow this scale-free structure (Albert & Barabási, 1999; 2002).

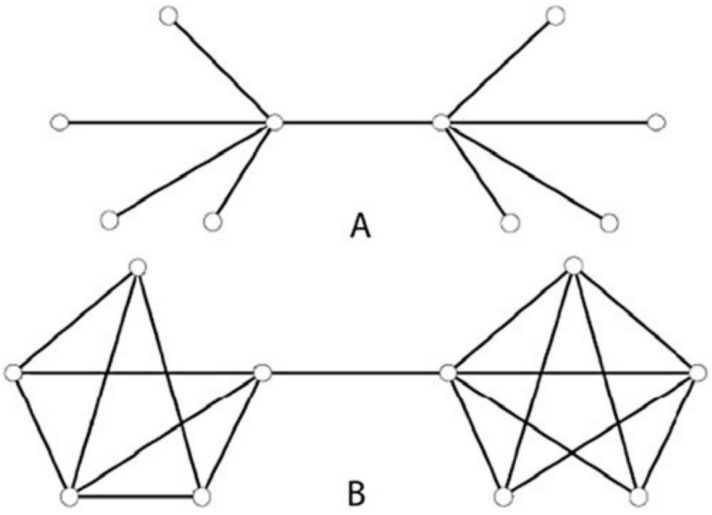

Figure 25: Schematic example of a scale-free network (A) and a small-world network (B) (Brughmans, 2010, p. 280).

Other Types of Networks

Networks are broadly applicable to a lot of archaeological situations. Recent trends in archaeological network analysis focus on combining and comparing networks derived from different types of evidence, such as material culture, linguistic, genetic, and geographic data (Peeples, 2019, p. 478). The field of archaeological network analysis has advanced significantly in recent years, continuously evolving and integrating insights from other disciplines. One example is the growing use of *agent-based models*, which help test ideas about the nature and impact of interactions. These simulations allow researchers to test ideas about the nature and scale of network interactions. A notable example is the study by Brughmans & Poblome (2016), which combines network analysis with agent-based modelling to examine the level of integration among the commercial centres of the Roman world.

Another area of network theory currently being researched, but still with much to be explored, is *network dynamics*. Many studies so far have focused primarily on analysing static 'snapshots' of networks from different periods (Peeples, 2019, p. 483). Archaeology can play an important role in this area, as many archaeological networks focus on changes over time. Recent studies addressing this issue include Roberts et al. (2012). They developed a series of techniques to divide artifact assemblages into manageable historical intervals using cross-dating. Another notable study is by Levy et al. (2021), who introduced the concept of *chronological networks*. They also created ChronoLog, a software tool that allows users to construct chronological networks interactively. This field is likely to see considerable development in the future

2.6 Summary

This Background chapter provided an overview of the Ottoman period, giving details on the economic landscape and trade routes in the Balkans and the Aegean from the 15th to the 20th century. The historical scenario used to compare the archaeological results is constructed based on this historical and economic context. From this overview, it is evident that the Ottoman economy reached its peak in the 15th and 16th centuries, characterised by a highly centralised economic system. During this period, the Ottomans maintained international trade relationships, particularly with the Italian states. Many European merchants also resided in the Eastern Mediterranean, participating in the South Asian spice trade that passed through the Ottoman lands. In the 17th century, however, this tightly controlled fiscal system began to unravel, leading to the emergence of Izmir as a global commercial centre. Trade in the Balkans also expanded, particularly with Europe. In the 18th century, decentralisation occurred, with the rise of local provincial leaders. The nature of trade with Europe also shifted, as many central and western European economies prospered due to industrialisation. In the 19th and early 20th centuries, the Ottoman Empire entered a period of decline, culminating in its dissolution. During this time, Western Europe became politically and economically dominant in global trade. The individual historical scenarios for each of the five sites (Belgrade, Sofia, Varna, Mytilini, and Izmir) align with these broader global trends, offering additional insights into the trade strategies of each city.

The most popular and well researched pottery types during the Ottoman period were also introduced in this chapter. The actual collection process of the pottery data is explained in the following chapter, together with the methodology of creating the network model which will be used to construct the archaeological scenario. In order to answer the researched questions posed in Chapter 1, various network approaches have been employed, drawn especially from Graph Theory and SNA. The mathematical tools for network visualisation- representing the nodes as vertices and the connection between them as lines, are taken from Graph Theory. For the analysis of the relationship between the nodes and their influence in the network, one of the most popular tool derived from SNA is used - *Network Centrality Measures.* Further information on the creation of the network model and its analysis is also presented in the next chapter.

Chapter 3: Data and Methods

In order to transform archaeological data into network modelling data, certain simplifications and assumptions must be made. Building a network model requires a collection of actors (nodes), as well as a way to measure the relationship between them (edges). This means that the network phenomenon should be defined and conceptualised using a quantifiable proxy. Therefore, it is crucial to clearly describe the data and carefully examine the assumptions underlying the model's creation. Only then can the network be properly understood and analysed (Brughmans & Peeples, 2023, p. 154; Peeples, 2019, p. 466).

The creation of the network involves several key steps, as described by Peeples (2019, p. 468). First, the boundaries of the network need to be defined, which in archaeology is usually a geographic region. In this case, the boundaries are the Balkans and the Aegean coast.

Next, the nodes must be selected. In this thesis, the nodes are divided into two categories: the researched sites - Belgrade, Sofia, Varna, Mytilini and Izmir, and the pottery production centres. These sites act as a proxy for individual traders in these cities. This is an example of a *two-mode network*. In addition, the network is *bipartite*, which means that the edges only connect the two categories of nodes, and no nodes within the same category have an edge between them (Figure 26). As Knappett (2011) argues, this approach works particularly well for networks based on material culture data.

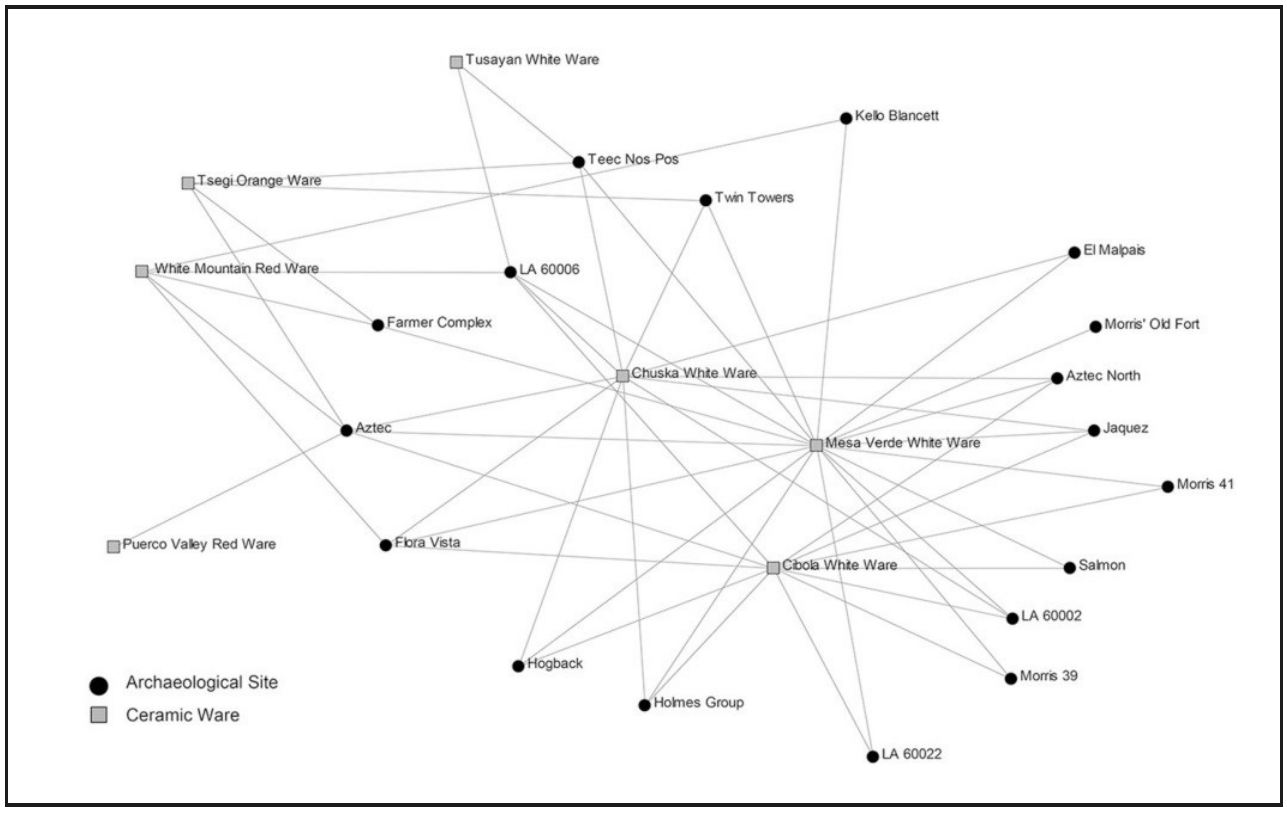

Figure 26: An example of a two-mode bipartite archaeological network (Peeples, 2019, p.469).

The final step is defining the relationships between the nodes: the edges. The connections between the entities, can come from different sources. The most common types of data used for network building fall into four main categories: geographical, documentary, material culture, and simulations. These approaches are often combined (Peeples, 2019, p. 471) but material culture remains widely used (Brughmans, 2012, p. 627), as in this network, where the edges are based on the quantity of imported pottery found at each of the five sites.

The aim of this chapter is to trace the data's collecting process in detail and to describe all modifications made to it and the reasoning behind them. First, the way the data is collected is going to be explained for each individual site. This includes the choices of what pottery information to use in the final database and what information to disregard. Following, some issues that were encountered during the data collection stage are presented and discussed, together with the limitations they can potentially cause to the network model. After this, the data is prepared for the model, which includes organising it into datasheets, refining and normalising. The final step in the methodology is the actual creation of the network model, where the main principles behind the process are explained.

3.1 Data

3.1.1 Data Collection

For all sites, except for Mytilini, data was collected based on published materials which contain quantitative information on Ottoman pottery, such as articles, books, reports and etc. The data for three of the cities - Belgrade, Sofia and Varna, had already been collected for my BA thesis (Kodzhabasheva, 2020), but it was double-checked and refined before included in this thesis. The dataset for Izmir is also based on published work and it was also compiled by me specifically for this thesis. The data for Mytilini was obtained from pottery analysis on the yet unpublished excavated material from the site. The data collected for each site comes from locations varying in size and function. It is important to mention these locations to accurately evaluate how well the pottery data represents the overall pottery situation at the site.

What is recorded in the database is the origin and the amount of imported vessels found at one of the five sites during the Ottoman period. It is important that their dating and quantity are clear, since these are essential criteria for the creation of the network model. The exact quantity is needed for determining the edge *weight* - the strength of the connections between the sites and the pottery production centres. Dating is essential for assigning the imports to the correct century. However, this dating can be broad, spanning several centuries.

The method of counting pottery vessels varies per site. It is based on the available information in the published materials, as most publications present data differently. In publications that specify the exact number of imported vessels, this number was recorded in the dataset. In other publications where only sherds are discussed, the minimum number of individual vessels was estimated. If there is a possibility that several sherds come from the same pottery vessel, then these sherds were counted as one vessel. Otherwise, each sherd was treated as a separate vessel. When the exact number of sherds was not provided in the text, the number of vessels was determined based on the vessels and sherds illustrated in the figures.

The types of ceramics included in the dataset are tableware, kitchenware and various household ceramic objects such as candlesticks, basins, lamps, etc. Uncategorised pottery vessels and pottery vessels without a clear origin are disregarded. Tobacco pipes are also excluded from the datasets because of their great number and diversity which will complicate the analysis of the network (publications discussing tobacco pipes – Belgrade: Bikić, 2012; Varna: Stancheva, 1972; Sofia: Stancheva and Nikolova, 1989; Mytilini: Humphrey, 2009).

The focus of this research is imported pottery, however, in the process some information on locally produced wares was also gathered. This information is available in Appendix C, however, it

is not used for the network analysis in this thesis. The first variation of the dataset is presented in Appendix B. This dataset is further simplified and some pottery production centres are grouped together. This is further explained in *3.2.1 Data Preparation* and available in Appendix A.

Belgrade

Several publications were used for making the dataset with imported pottery found in Belgrade (Bikić, 2012a; 2012b; Popović & Bikić, 2004; Gajić-Kvaščev et al., 2018; Živković et al., 2017). The data for the local/regional pottery is all taken from the publication by Bikić (2003). All these publications concern pottery finds from the excavations at the Belgrade fortress – the former walled area of the established medieval town. Since the Ottoman layer at the site is from the 16th to the 17th century, the majority of imported wares that are included in the dataset are from that period as well. There is a major overlap of imported pottery discussed in these publications, which is taken into account when the number of vessels is noted down.

There are four types of imported ware found in Belgrade from the period 16th-18th century. The first one is Iznik, which is referred to as 'Iznik ware' in the publication by Živković et al. (2017) and simply as 'Luxurious Turkish ware' in the catalogue by Popović & Bikić (2004).

The second type of ceramics found in Belgrade is 'Haban ware' (Bikić, 2012a; Popović & Bikić, 2004, p. 184; Gajić-Kvaščev et al., 2018), which origin is a bit unclear, but it is located in the region of the Czech Republic, Slovakia and Hungary (Bikić, 2012a, p. 207). For this reason, its origin (source node) is simply referred to as 'Central Europe' in the dataset.

The third type is Italian Majolica (Popović & Bikić, 2004, p. 185). This is a very broad term but since there is no further information given about this ware in none of the used publications, its source node is just 'Italian States'.

Lastly, the source node for the Chinese porcelain found at the site is simply 'China' (Popović & Bikić, 2004, p. 185), since no more details about the type of porcelain are given.

Izmir

The data for this site is collected from the publication of François & Ersoy (2011), which analysed the material found at one 18th century house in the Sifa district of Izmir. This site has the largest number of published pottery, in comparison to all other sites that are included in this thesis.

The domestic imports include vessels from the domestic centres of Didymoteicho, Chanakkale and Kütahya. In order to simplify the final database and to make sure that every node with the same origin has one name, the origin of the five grey wares, referred to as *Provinces arabes* in the publication, is changed to *Levant* in the final database.

Several production centres of Italian imports are mentioned in the publication. The most popular ones – Abisola, Montelupo and Liguria are recorded separately in the dataset. The rest – Pesaro, Cerreto and Salerne are simply recorded as 'Italian States'

Imports from France are also divided into several production centres in the publication. However, since French imports are not present in any other site, these details were not recorded. These vessels are simply grouped under 'France'. There are also imports from Delft, England, Meissen and China.

François & Ersoy (2011) determine the quantity of the vessels by counting the minimal number of individuals. In their publication, there is also a separate category for 'loose sherds' which cannot be assigned to a pottery form and thus to an individual vessel. The number of these sherds is not included in this thesis' dataset.

Varna

Several publications by the late professor Valentin Pletnyov were used for quantifying the data for Ottoman Varna. The pottery data is gathered from multiple rescue excavations and digs across Varna's historical centre and particularly in the area where Christian families lived during the Ottoman era (Pletnyov, 2004a, p. 13).

Two booklets sold at the Archaeological Museum of Varna present the best examples of excavated Italian majolica, Miletus ware, Iznik, Kütahya, Chanakkale, European and Chinese porcelain in the city (Pletnyov, 2002; 2005a). The vessels illustrated in the figures in these booklets are counted in the dataset. The downside of this method is that it displays only a small fraction of the vast number of excavated vessels. Unfortunately, the actual amount of excavated imported pottery vessels is not available.

Pletnyov (2002) also presents examples of pottery tiles produced in Kütahya which are found in the Armenian church in the town of Provadia, close to Varna. However, since these tiles are not found in Varna itself and their function is mostly architectural, they are excluded from the final dataset. An earlier publication by Pletnyov (2002-2003) gives more insight into the early Ottoman ceramics found in the city. There are one Miletus bowl and nine Iznik pieces which are described in the article, but not present in the previously mentioned booklet. These ceramics are added to the dataset

In the second booklet made by Pletnyov (2005a), the majolica and porcelain pottery vessels are calculated in the same way - by visual analysis on the images. One image on p. 34 shows more than one Italian majolica vessels. Since the exact number of these vessels is not given in the image description, the number is based solely on a visual observation. Pletnyov has another published art-

icle on Italian majolica found in Varna (Pletnyov, 2004b), which presents the same vessels as in the booklets but with more background information and analysis on the finds.

Finally, the book *Household ceramics in Varna 15th-18th century,* again written by Pletnyov (2004a), mentions some imports found in the excavated trash pits in the old town of Varna. The focus of the book is to categorise the locally produced ceramics. Still, an overview of the contents of each excavated pit is given. This book lists several types of imports along with their exact numbers. However, most of them lack detailed descriptions, aside from their dating. As a result, it is unclear whether these vessels are the same as those already mentioned in the booklets discussed earlier and already included in the dataset. To address this, if the quantity of a specific type of import in Pletnyov (2004a) exceeds the number already recorded in the dataset, the higher number is taken as the total. In turn, if the quantity mentioned in the book is lower, it is ignored and not added to the dataset.

Unfortunately, Iznik and Kütahya finds are very commonly recorded as 'several Iznik plates', 'several Kütahya cups' and so on. These ceramics cannot be included in the network model database, as their amount is unclear.

Although it focuses mainly on local wares, several types of imported wares are also included in the catalogue. These are: three plates from Akchaalan, close to Iznik; two grey ware jugs from Northern Serbia or Hungary; six jugs from 'old Byzantine centres'. The six jugs from old Byzantine production centres are not included in the final dataset, since their source could be traced to several locations in the Aegean, including Thessaloniki and Corinth, which are far away from eachother geographically.

Sofia

The data collected for Sofia comes from various publications, related to a number of excavations in the historical centre of Sofia. The late professor Magdalena Stancheva did some of the earliest research on Ottoman material culture in Bulgaria. Thanks to her publications on pottery finds from Sofia, a huge amount of ceramic data could be obtained about the Ottoman and Early Modern period. Stancheva and Shangalova (1989) present 30 imported porcelain cups from Meissen, Thuringia, Vienna and England. In one of her earliest publications, Stancheva (1960) gives information about ninety-seven Iznik and Kütahya wares from Sofia dating between 16th and 18th century. Another article by Stancheva (1962), presents Italian majolica found in Sofia.

The data for the other imported ceramics comes from the work of Guergana Guinova. Two of her publications (Guinova, 2005b; 2012) give information about Miletus ware, Spanish ware, Chinese porcelain and more imports found in Ottoman Sofia. Guinova adds few of the vessels

present in Stancheva's publications in her own article on imported wares in Late Medieval to Early Modern Bulgaria (Guinova, 2012).

There are several particularities in the data collected for Sofia. Two out of the three pieces coming from the region of Valencia, Spain date from the 14th to the 15th century (Guinova, 2012, p. 683). However, the period of interest for this research is between 15th and 20th century. For this reason, the 14th century presence of these pots are disregarded in the final database.

Further, the six Monochrome turquoise glazed sherds found in Sofia, which are marked as originating from the region of Ephesus (Guinova, 2012, p. 685), might have been in fact local production. However, the glaze is categorised as an import and for that reason these sherds are also recorded as imports, since this still indicates a connection between the sites of Sofia and Ephesus.

Two red-glazed wares from Eastern Mediterranean are not included in the final dataset, because the paste of the two pieces differs from one another (Guinova, 2012, p. 685). This complicates the analysis since the clear origin of the pieces cannot be specified.

The data for the local ware is gathered from several other publications by Stancheva (1963; 1966; 1976; 1994).

Mytilini

The data for Mytilini was obtained from excavations conducted by the University of British Columbia between 1983 and 1990 and led by Hector Williams (2009). These excavations focused on the most prominent sites in Mytilini. All pottery from the Ottoman period comes from the Castle (*Kastro*). The *Kastro* is located on the north-west part of the Mytilini peninsula. Following the Ottoman conquest of the city in 1462, it functioned as a residential and defensive structure. The *Kastro* was kept in a good condition up until 1912.

The Ottoman material of these excavations was analysed by a group of students from Leiden University. Their Excel datasheets with recorded pottery was provided to me by Joanita Vroom. Some of the information present on these datasheets is: box number (unique identifier), date of processing, number of sherds, number of vessels, period, type of vessel, local or import, sherd measurements, slip, glaze and decoration.

Unfortunately, this data sheet was incomplete and some sherds were incorrectly categorised. Some of the imported sherds were not correctly assigned to a production centre. Since the material was analysed by a student group which is not specialised in the Ottoman period, such mistakes and normal and expected. There is always going to be a margin of error in any database, no matter who carries out the material analysis. Thanks to the detailed description in the datasheets, most sherds were placed in their correct category. I went through the available pottery photographs and drawings and with the help of prof. Joanita Vroom, the Excel datasheet was refined and corrected.

The main literature sources that were used to identify the pottery sherds recorded in the data sheet are the following: Atasoy & Raby (1989) - Iznik ware; Charleston & Ayers (1971)- European porcelain; Hayes (1992) - all types; Vroom (2005) - all types; Pletnyov (2002; 2005a) - Ottoman luxury wares, Majolica and Porcelain.

Unfortunately, some of the sherds were not very well visible on the provided photographs and their identifying number could not be determined. Other sherds did not have a corresponding photograph or a drawing. These sherds were left uncategorised and during the refining of the data, these entries were removed from the final dataset of Mytilini.

There are several particularities about the data of Mytilini. The dating of most sherds encompasses several centuries, since a more precise estimation could not be performed on this material in a digital form. This is the case especially for the locally produced ware. The most common centuries of a certain pottery type (e.g., Majolica, Iznik, Chinese porcelain, etc.) are set as a possible range. Pottery finds for which the production centre can be both Kütahya and Iznik were put into the category of Kütahya/Iznik.

Sherds that are possibly related are grouped as one vessel. This practice is the same for all other datasets in which the minimal number of individual vessels is recorded. The same goes for photographs which contain more than one sherds. Since it is hard to determine the exact number of individual vessels based only on a photograph, these sherds are recorded as one vessel.

3.1.2 Issues with the Data

Error is inevitable in data gathering and analysis not only in archaeology and network research, but in all fields of study. Every archaeological record contains incomplete data. Archaeologists frequently have to construct networks based on an incomplete sample of nodes and edges, due to insufficient knowledge (Peeples, 2019, p. 481). In this thesis, the term ‘error’ refers to the difference between the observed/recorded value and its likely true value. Since researchers often have no way of knowing what the ‘true value’ is, they deal with the concept of ‘uncertainty’ which is a method of evaluating the degree to which the measured value represents the likely true value, based on any known or potential sources of error (Brughmans & Peeples, 2023, p. 150).

According to Brughmans & Peeples (2023), there are many potential reasons why recorded archaeological data cannot match its true value. These sources of error can be attributed to lack of excavations, bad survey coverage, site destruction, looting and so on. Sampling and missing data should be major concerns in archaeological networks, yet there is still not a unified approach on dealing with missing data which can be applied to every network (Brughmans & Peeples, 2023, p. 156).

Data with a high degree of uncertainty can truly affect the quality of the analysis. In network modelling, both nodes and edges can be affected by missing data. Missing nodes can make it difficult to accurately characterise an archaeological network's structure and can affect the characteristics of other nodes and edges. Unfortunately, most often we are unable to determine where the missing nodes are within the network model and what are their features. Similarly, edges that are defined based on material culture depend on the quality and the availability of the sampled data (Brughmans & Peeples, 2023, p. 159-160).

During the data collection process, I also faced the issue of 'uncertainty'. The causes of this issue are addressed here, in order to provide a clear understanding of how the data is obtained and what potential biases the network models may have as a result.

One cause for the 'uncertainty' of the data is the low amount of vessels recorded for each site, which can lead to unrealistic representation of the 'actual' pottery situation at the sites. Excavated pottery material already represents a small fraction of the actual pottery that was in circulation during a period in the past. This fraction is once more reduced when the material is published. The best solution would be to increase the sample size, however, this is not possible for this dataset, due to the scarcity of pottery data from the Ottoman period. Some archaeologists may remove sites that have fewer than a certain number of samples. This allows for them to base their interpretations on the sites with the most prominent data. However, this could lead to throwing out the true zeros and low numbers from the dataset (Brughmans & Peeples, 2023, p. 162). This approach is also not optimal for this thesis database, since the research questions require the whole network model with all its nodes to be interpreted, no matter the degree of uncertainty.

The 'uncertainty' of the data is also affected by the different methodologies used for recording the number of vessels in the dataset. For all sites, except for Mytilini, datasets are created based only on published material. The raw data used for these publications has already gone through the process of cleaning and refining. The methodologies behind this process remain unknown to us, however, it is reasonable to assume that most researchers have different ideas of which pottery vessels to publish. This leads to variations in the level of detail provided. Some ceramic imports are presented in catalogues or detailed tables, like Izmir and Belgrade. On the contrary, only the best-preserved pottery vessels from Varna are featured.

Additionally, The ceramic data collected for each site comes from locations that vary in size. The ceramic material for some sites is collected from a larger geographical area than others. The smaller the geographical area the less representative the pottery sample collected from that area is. These variations in the scale of research result in differences in data accuracy, which increases the level of uncertainty.

A clear example of data uncertainty can be observed in the datasets for Belgrade and Varna. According to Popović and Bikić (2004, p. 142), the Iznik vessels found at the Belgrade fortress comprise of less than 1% of the total pottery assemblage. However, most excavated diagnostic Iznik fragments from Belgrade are published in the catalogue of the same book. In comparison, Varna is often mentioned as an important port city with numerous luxurious pottery, such as Majolica, Chinese porcelain, and especially Kütahya and Iznik ceramics. (Pletnyov, 2002-2003, p. 429; Pletnyov 2004a, p. 13). However, all publications on pottery imports deal only with the most complete examples and thus excluding a huge part of the diagnostic sherds which could be counted as separate vessels and used for the reconstruction of a trade network.

Table 1: All local, imported and Iznik pottery vessels from Belgrade and Varna (by Kodzhabasheva, 2024; sources: Popović & Bikić, 2004; Pletnyov, 2004a).

Pottery vessels:	**Belgrade**	**% of whole assemblage**	**Varna**	**% of whole assemblage**
Local	432	91%	985	92.3%
Imports	43	9%	70	6.7%
Iznik	29	6.7%	22	2%
All	475		1055	

The amount of imported and local ware gathered for this research from Belgrade and Varna is shown in Table 1. It is visible that the Iznik ware from Belgrade is about 6.7 % of the total assemblage of the site, instead of the 1% that is claimed by Popović and Bikić. Although Varna is supposed to have a huge proportion of imports, these are only 6.7 % of all recorded pottery. The Iznik ware is barely 2 % of all recorded pottery of the site. Both of these numbers are smaller than the ones for Belgrade. This leads us to question the accuracy of the collected data, if we assume that the statements of Popović and Bikić (2004) and Pletnyov (2002-2003; 2004a) are correct.

Although various (experimental) methods, such as probability measures and agent-based modelling, have been developed to address data uncertainty in network modelling (see: Brughmans & Peeples, 2023), the network model in this thesis is created solely based on the collected data. One of the goals of this research is to evaluate the capacity of network models alone to contribute to our understanding of trade and economy, no matter how fragmented the data is. These issues are common in archaeological research and they do not prevent the creation or analysis of the network. Despite these challenges, an imported vessel remains a clear indicator of a connection between the site and the pottery production centre, providing valuable data for our work.

3.2 Methodology

3.2.1 Data Preparation

Data preprocessing or preparation refers to the process of converting raw data into a clear and functional format for analysis or model creation. This is an essential phase in workflows related to data science, machine learning and artificial intelligence, since raw data often contains noise, missing values, inconsistent formats, or irrelevant information. Preprocessing ensures that the data is accurate, complete, and ready for modelling. This process typically includes several stages. The preparation of the data in this thesis follows the model of Han et al. (2012, p. 87; Figure 27).

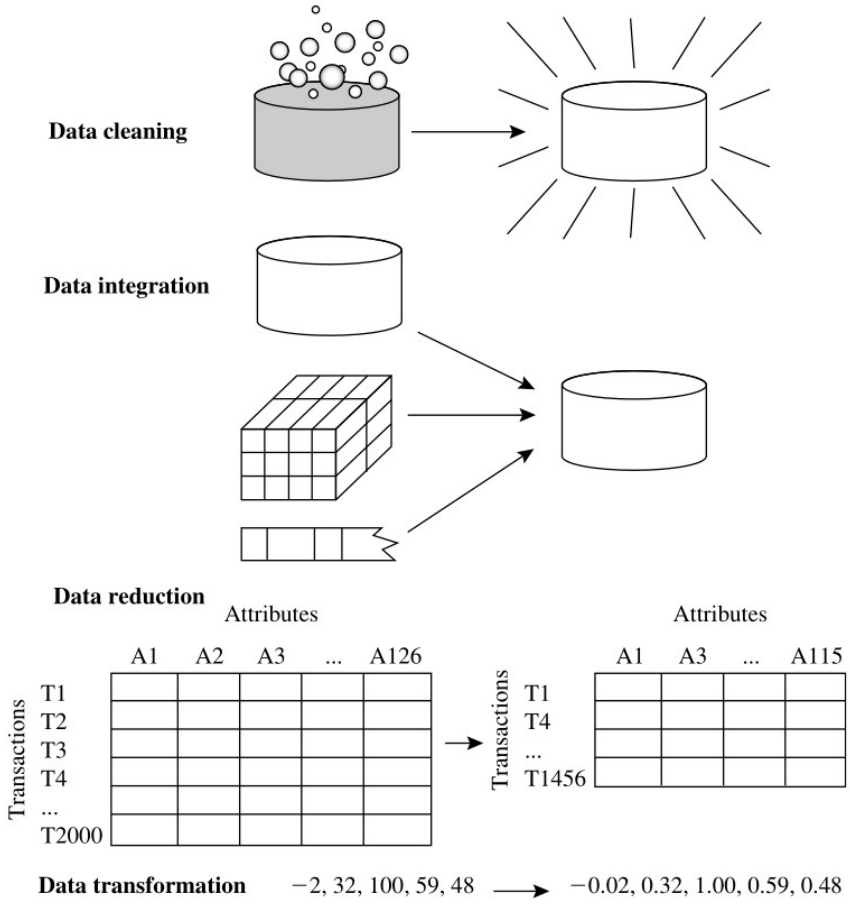

Figure 27: Main stages of Data preprocessing (Han et al., 2012 p. 87).

The first stage is *Data Cleaning* and it involves the filling in or the removing of missing values. Outliers and anomalies are further identified and dealt with, as well as any duplicate records. In the case of this research, most of the data cleaning is already done during the data collection stage, as described in the beginning of this chapter. Pottery imports that have unclear origin, for example, are simply not included in the final database. Outliers are, however, very important for the creation of the network model and they are not removed.

The next step is *Data Integration*, where the multiple data sources or datasets are combined into a single, unified dataset. This is also already done in the data collection stage, by recording all pottery imports for the different sites into one dataset. This way the data is converted into the same format.

Since the imported wares are the focus of this research, the data collected for the imports is the one that has been subjected to change and preparation. The data for locally produced wares is mostly left as it is, since it is used only for the comparison between the different types of pottery in a site and it is not included in the network model. The imported and the local pottery is separated into two datasets. The imports are grouped together based on the site they were found at and if they share the same dating and production centre. Each group is recorded as a separate entry in a table. The dataset for imported ceramics contains the following attributes (columns):

1) **Source Node** - The production centre of the group of pottery sherds. When the production centre is not clear, the region of production is referred to instead. All production centres and regions are consistently written in the same way, so that duplicate source nodes are visible. This is important for the creation of the network model.
2) **Target Node** - The site in which the group of pottery is found. This could be Belgrade, Sofia, Varna, Mytilini or Izmir.
3) **Quantity** – This column contains the *aoristic sum* of the vessels from each group. The aoristic analysis method is applied on the quantity of the pottery sherds, since most of them are with uncertain dating. This approach aims to distribute the uncertainty of an event (or artifact's dating) over the range in which it could have occurred (see Crema, 2012; Fischer-Ausserer et al., 2004). The aoristic analysis applied on this database is very simple and straight-forward, not only because of the small number of sherds, but also because there is a lot of unknown details about the pottery. Any contextual or stylistic cues that can point to a more likely dating are disregarded, since they are not always clearly visible and available for each pottery sherd.

   By default, the aim of this method is to equally distribute the sherd's probable dating across the uncertain range. For example, if there are two pottery sherds dated between 16th and 17th centuries, that means that the probability of each sherd to have originated in either of the centuries is 0.5 (50% probability). When we add this probability together (0.5+0.5), the aoristic sum for each century would be 1. This method is applied to all pottery sherds in the collected data with uncertain dating.
4) **Centuries** - There is a separate column for each century (15th to 20th). If the pottery group falls into a certain century, then this column is marked with an 'X'.

The next step - *Data Reduction*, is especially important for large datasets, as minimizing the quantity of features and dataset size without sacrificing representativeness is crucial. Although the data in this thesis is not as 'big', reducing it remains relevant.

The data is reduced, or simplified, by merging a few of the source nodes and their attributes together under one unified entry. All nodes and their merged groups are presented in Table 2. These are most commonly production centres which are geographically close together and produce similar ceramics. In many cases, pottery from these centres cannot be assigned to a specific site (e.g. Italian States, Iznik/Kütahya, German States, Central Europe). Grouping is essential for both the visual readability and analysis of the network. For example, if unidentified production centres from Italy are analysed separately from the identified Italian city-states, their influence and position within the network would differ. However, it is unclear whether the unidentified centres might actually include some of the identified ones. Additionally, Miletus, Iznik, and Kütahya ware are produced at multiple locations, making it often difficult to pinpoint the exact production site. For this reason, simplifying the network and grouping the nodes together provides a more accurate representation and results.

Table 2: The grouping of the nodes in the dataset (Appendix A) (Kodzhabasheva, 2024).

	Groups				
Individual Nodes	**Northwest Anatolia**	**Italian States**	**German States**	**Central Europe**	**Levant**
	Miletus	Italian States	German States	Central Europe	Levant
	Iznik	South Italy	Meissen	North Serbia/ South Hungary	Syria
	Iznik/ Kütahya	Abisola	Thuringia		
	Kütahya	Montelupo			
	Akchaalan	Orvieto			
		Liguria			
		Florence			
		Tuscany			
		Faenza			

After this process, the two versions of the dataset are saved. One contains the original detailed information about the production sites (Appendix B) and in the other one contains the grouped nodes (Appendix A). The network is created by using the dataset with the grouped nodes. When detailed information is required, such as types of pottery imports per site, the detailed dataset is referred to.

The final stage of data preprocessing is *Data Transformation*, which involves data normalisation and standardisation. Normalising the *Quantity* attribute in this dataset is crucial to account for size differences in pottery vessels between sites (target nodes). Some sites have significantly lar-

ger pottery quantities than others. Bringing these amounts onto the same scale allows for fairer comparison and prevents sites with larger ceramic assemblages from dominating the network (Carlson, 2017, p. 126). The focus is on the strength of the connection between a site and a production centre. To normalise the data, the aoristic sum for each node is converted into a percentage relative to the total amount of pottery imports for the site. These percentages are recorded as a separate attribute - *Percent Imports.*

After the dataset has undergone these preparations, it can be uploaded to the network modelling program for analysis and visualisation.

3.2.2 Creating the Network Model

Although network models are commonly associated with network graphs, which is the most common form of network visualization, they are not an essential component (Brughmans, 2012, p. 628). Network methods mainly focus on calculating various statistics to measure different aspects of the network structure, nodes, and edges. Visualisation, however, remains important as it provides an initial impression of the network model's key characteristics and it helps place the model in a more understandable context, making it less abstract and easier to understand.

Determining the spatial relationship between the locations and trade routes is one of the network's primary objectives. Since Belgrade, Sofia, Varna, Mytilini, and Izmir are situated in distinct economic regions of the Ottoman Empire and have access to different kinds of resources and trade networks, their geographic positioning is important. For this reason, mapping each site and pottery production centre can greatly enhance the interpretation of the network.

Creating a map and placing the nodes on it is easily achievable using Python 3, as existing software lacks the flexibility needed for visualising geo-spatial networks.

This network has several important features, one of which is that it is a *directed* network. This indicates a one-way interaction between the nodes because the edges connecting them have a fixed orientation. When these nodes serve as the hubs for the manufacture of the imported ceramics, they are labelled as *source nodes*. *Target nodes* are the five sites that are examined in this study. The connection between these nodes flows from the source node to the target node. The connections between the nodes are based on the pottery sherds found at the sites (similar to Brughmans, 2010; Brughmans & Poblome, 2012).

In addition to having a specific direction, the edges have another important attribute - *weight*. The *weight* attribute is a numerical value which represents the strength of the connection between two nodes. For this network, the *weight* is determined by the dataset attribute/ column *Percent Imports.* This column contains the normalised values of the column *Quantity* (see *Chapter 3.2.1*).

To create a network model, first the source nodes, target nodes and edges attributes should be well defined. This is already done in the *Data Preparation*, where the source nodes and target nodes are recorded. The value recorded in the column *Percent Import* is selected as the edge attribute weight. To build the network model, the program makes use of the following main Python libraries and packages:

- **matplotlib** – A Python library that visualises the network graph (Documentation: https://matplotlib.org/stable/).

- **networkx** – A Python package for building, modifying, and researching complex networks' dynamics, structure and operations (Documentation: https://networkx.org/).
- **numpy** – A Python numerical computing library that supports big, multi-dimensional arrays and matrices and offers a large number of mathematical functions to effectively work with these arrays (Documentation: https://numpy.org/).
- **pandas** – A Python package for handling structured data (Documentation: https://pandas.pydata.org/) and **geopandas** – a package which adds on to the pandas extension. This package makes working with geospatial data in Python easier and is used to create the map on which the nodes are positioned (Documentation: https://geopandas.org/en/stable/index.html).

Once the network has been built, it is important to visualise it appropriately. Visualisation is a crucial component of network analysis (Brughmans & Peeples, 2023, p. 194). It should be simple to comprehend and clear of assumptions or incorrect information.

The map is taken from Stadia Maps (https://stadiamaps.com/) and is chosen based on its simplified look and muted colours. In this way, the map would complement the network rather than draw attention away from it. The source and target nodes and their corresponding coordinates are put in a separate spreadsheet and uploaded to the map. The coordinates are recoded in the WGS84 coordinate system. For regions such as the Italian States, Northwest Anatolia, etc., the coordinates are places approximately in the middle of the region.

In addition to combining a network and a map, another visualisation method without geographical context is used. The layout is algorithm-based and known as *the spring layout* or *Fruchterman-Reingold force-directed layout.* It is often described with a physical 'string' analogy, where the edges between the nodes are strings of the same size. The idea of this algorithm is to position the nodes in a way to minimise the energy of the system. Unconnected nodes are dispersed, and connected nodes are arranged closer together. The *weight* of the edges is also added for a more accurate representation of the model - larger value means a stronger connection and a stronger attractive force (Fruchterman & Reingold, 1991). The purpose of this visualization is to highlight the nodes with the most robust connections - that is, the sites that may be identified as larger trading hubs.

The data cannot be shown in its entirety on a single network, since it spans over six centuries, from the 15th to the 20th, and this could result in inaccuracies. Another option is to visualise the data based on the historical periods from *Chapter 2.2*. However, this could also result in an inaccurate representation, as not every site is present in every century. Visualising sites from different centuries together could lead to misleading interpretations.

For this reason, the so-called filmstrip approach is used to visualise each century independently (Brughmans & Peeples, 2023, p. 226). This consists of a set of arranged snapshots throughout the different centuries of the network. The nodes in the first network visualisation that uses a map are always in the same location, at their correct coordinates. This means that the trade relations between the different nodes can easily be compared throughout the centuries. The nodes in the spring layout algorithm visualization are dispersed, but the better connected nodes are always located in the centre. This improves visibility and facilitates easy comparisons between the arguably most significant sites throughout the course of centuries.

Formal network research usually involves visualizing networks and calculating various statistics to measure different aspects of network structure, including the positions of nodes and edges. Besides visualization, the network is analysed further using specific algorithms that examine its features statistically. These algorithms are discussed in the next section of this chapter.

Finally, the code and data used for building the network are open-access and available on GitHub (Repository: https://github.com/wkllc/archeo-geo-graph). This aligns with the FAIR principles (see Wilkinson et al., 2016), which aim to improve the accessibility, transparency and reuse of data.

3.2.3 Centrality Measures Algorithms

A range of visual and statistical techniques can be used in network analysis in order to explore the structure of the network and the characteristics of the nodes and edges in them. These methods are very useful for summarising the structure of networks before further in-depth analysis (Brughmans & Peeples, 2023, p. 103).

The aim of this section is to describe all algorithms used for analysing the networks. The choice of what analytical methods to use depends on the research questions. In the context of this thesis, we aim to understand the significance or centrality of specific nodes, in order to gain a clearer understanding of the trade flow and the strength of the connections between the sites. We are seeking to identify groups of nodes with particularly strong interconnections and to trace the evolution of their relationships over time.

To achieve this, various centrality measures will be employed. Centrality refers to a family of metrics used to identify the most significant or prominent nodes within a network, depending on how prominence and importance are defined. Important nodes typically have a large number of edges and maintain diverse connections with other nodes. The most common methods for analysing these network aspects are *degree centrality*, *eigenvector centrality* and *PageRank* (Brughmans & Peeples, 2023, p. 133). In addition to these methods, we are going to employ also other centrality measures such as the *HITS algorithm* and *average neighbour degree*.

As each algorithm measures a slightly different aspect of centrality, it is crucial to examine the results provided by as many centrality measures as possible. Although analyses can be improved by incorporating edge weight, which represents the strength of connections between nodes, this approach is not adopted in this research. This is because of the high level of uncertainty in the values within the *Quantity* and *Percent Imports* data columns that could serve as edge weight.

All algorithms and their formulas are taken from the **NetworkX** (n.d.) documentation.

In-degree and Out-degree Centrality

Degree centrality is one of the most simple ways to evaluate the position of a node. This algorithm is developed by Freeman (1979) and refers to how many edges are adjacent to a node. For directed networks such as the network in this thesis, in-degree and out-degree methods can be further applied. In-degree centrality measures the incoming edges and out-degree centrality measures the outgoing edges (Brughmans & Peeples, 2023, p. 107).

Formula for In-degree Centrality:

$$C_i(i) = \sum_j A_{ji}$$

Where:

- $\mathbf{C_i(i)}$: In-degree centrality of node i.
- $\mathbf{A_{ji}}$: Element of the adjacency matrix A, where Aji=1 if there is a directed edge from node j to node i, otherwise Aji=0.

Formula for Out-degree Centrality:

$$C_o(i) = \sum_j A_{ij}$$

Where:

- $\mathbf{C_o(i)}$: Out-degree centrality of node i.
- $\mathbf{A_{ij}}$: Element of the adjacency matrix A, where Aij=1 if there is a directed edge from node i to node j, otherwise Aij=0.

Katz Centrality

Katz centrality computes the centrality for a node based on the centrality of its neighbours. It is a generalization of the eigenvector centrality, introduced by Katz (1953).

Formula:

$$x_i = \alpha \sum_j A_{ij} x_j + \beta$$

Where:

- $\boldsymbol{x_i}$: Katz centrality of node *i*.
- $\boldsymbol{\alpha}$: a weight parameter (controls the influence of distant nodes).
- $\boldsymbol{A_{ij}}$: an element of the adjacency matrix. If there is a link from node *j* to node *i*, A_{ij}=1, otherwise A_{ij}=0.
- $\boldsymbol{\beta}$: External bias or constant influence added to each node (by default is the same for all nodes).

PageRank

PageRank was originally designed as an algorithm to rank web pages (Page et al., 1999). However, this algorithm is applicable to many different types of networks as it ranks the nodes of a network based on the structure of their incoming links.

Formula:

$$PR(i) = \frac{1-d}{N} + d \sum_{j \in M(i)} \frac{PR(j)}{L(j)}$$

Where:

- ***PR(i)***: The PageRank score of node *i*.
- ***d***: The damping factor (by default set to 0.85).
- ***N***: Total number of nodes in the network.
- ***M(i)***: The set of nodes that link to node *i*.
- ***PR(j)***: The PageRank score of node *j* (a node linking to *i*).
- ***L(j)***: The number of outbound links from node *j*.

Average Neighbour Degree

Returns the average degree of connections which the direct neighbours of each node have. For directed networks, NetworkX gives the option to look at predecessors and successors of each node. We are focusing on the target nodes and their predeceasing nodes (source nodes).

Formula:

$$k_{nn,i} = \frac{1}{|N(i)|} \sum_{j \in N(i)} k_j$$

Where:

- ***N(i)***: the number of neighbours of node *I*
- k_j: the degree of node j which belongs to *N(i)*

HITS Algorithm

The HITS algorithm, developed by Kleinberg (1999), assigns two values to each node in the network: a *hub* score and an *authority* score. The authority score is based on incoming links, while

the hub score is determined by outgoing links. Both values depend on the hub and authority scores of a node's neighbours.

Hub Score Update Formula:

$$h_i = \sum_{j \in N(i)} a_j$$

Where:

- ***N(i)***: the set of neighbours of node *i*
- a_j: the authority score of neighbour *j*

Authority Score Update Formula:

$$a_i = \sum_{j \in M(i)} h_j$$

Where:

- ***M(i)***: the set of nodes that point to node *i*
- h_j :the hub score of node *j*

Chapter 4: Results

This chapter presents and describes the results from the network analyses conducted for each century. The analyses include a geospatial network model, a network model visualized using the *Fruchterman-Reingold force-directed algorithm* (described in detail in Chapter 3.2.2), and a table summarizing the outcomes of various *Network Centrality Measures*. Additionally, detailed graphs are provided to illustrate the types of imports identified at each site over time. The full dataset supporting these analyses is available in Appendices A and B. The results are presented chronologically per century.

All networks share the same visualisation characteristics. The target nodes are coloured in red, while the source nodes are in brown and blue. The source nodes located outside the borders of the Empire at the time, meaning they are part of the Ottoman's international trade network, are coloured in brown. The source nodes which are part of the domestic trade, within the borders of the Empire, are coloured in blue. The edges in the networks are coloured to match their source nodes and have arrowheads which point to the direction of the flow, for visualisation purposes.

The *edge weight* is represented by the transparency (alpha value) of the edges. This value ranges from 0.3 to 1, where 0 indicates full transparency and 1 represents a completely solid colour. This *weight* reflects the proportion of a specific type of imported pottery relative to the total imports (the value in column *Percent Imports*) for each site (target node). To regulate the transparency of the edges, the values in the *Percent Imports* column are normalized using a min-max scaling method, with 0.3 as the minimum and 1 as the maximum. All of these adjustments are made to enhance the visual clarity and readability of the network.

The networks are visualised and analysed by using the dataset with grouped nodes (Appendix A). This grouping is essential for visualising and analysing the results in a clean manner, as well as finding continuity and differences between the centuries. The details of the node grouping are further explained in Chapter 3.2.1, Table 2. Additional graphs illustrating the sites in detail are included at the end of the results for each century. These graphs are based on the dataset with the detailed nodes (Appendix B). They provide more information about these groups which is important for the discussion of the results later on.

The aoristic sum of pottery vessels per century and per site is presented in Table 3. A description of how this aoristic sum is created is provided in *Chapter 3.2.1: Data Preparation*. A more detailed explanation of what constitutes a pottery vessel can be found in *Chapter 3.1.1: Data Collection*.

Table 3: The aoristic sum of pottery vessels per century and per site (by Kodzhabasheva, 2024).

Century	Belgrade	Sofia	Varna	Mytilini	Izmir	Total
15th	0	19	2	8	0	29
16th	18	41.5	20	2.5	0	82
17th	22	45	20	8	0	95
18th	3	42	24.5	65.7	1005	1140.2
19th	0	10	3.5	7.2	0	20.7
20th	0	3.5	0	3.7	0	7.2

4.1 Results: 15th Century

The network model for the 15th century (Figure 28 and Figure 29) consists of three target nodes – Varna, Sofia and Mytilini, and five source nodes – Valencia, the Italian States, Ephesus, Northwest Anatolia and the Levant.

Visual inspection of the networks reveals that Sofia has the greatest variety of imports, followed by Mytilini and then Varna. When it comes to the ceramics export centres, the Italian States for the international trade and Northwest Anatolia for domestic trade connect to more sites than the other production centres – Levant, Valencia and Ephesus, which are connected with just one target node each.

The centrality measures conducted on this network are summarized in Table 4, with nodes organised in decreasing order of their connectivity and importance. *Katz Centrality*, and *In-degree Centrality* all position Sofia as the node with the most connections within the network. These three measures assess how important a node is based on the number of its connections. Mytilini and Varna are ranked on the same level after Sofia.

Figure 28: Geospatial network model of the Ottoman trade relations in the 15th century, using ceramic data (Kodzhabasheva, 2024; map source: Stadia Maps, Stamen Design: https://stadiamaps.com).

Sofia is also the most significant receiver of connections according to *PageRank* and *HITS Authority*. However, this time *PageRank* places Mytilini second in terms of importance while the

HITS algorithm places Varna second. This variation arises from differences in how the two algorithms assess the importance of a node, despite both focusing on the quality and quantity of its connections (directly connected nodes).

Yet, in the *Average Neighbour Degree* ranking, Varna is placed first, followed by Mytilini and Sofia. This indicates that overall, Varna receives connections from more influential and well-connected nodes compared to Mytilini and Sofia.

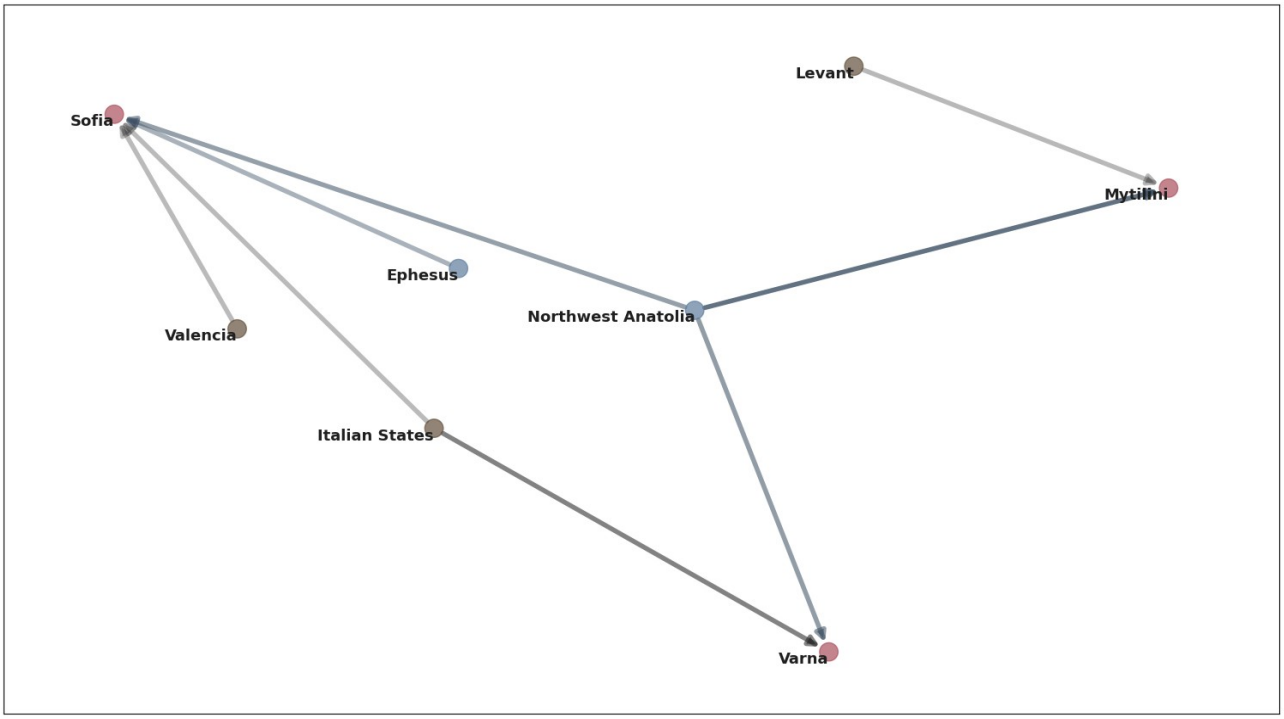

Figure 29: Network model of Ottoman trade relations in the 15th century, using ceramic data (Kodzhabasheva, 2024; Fruchterman-Reingold force-directed layout).

Table 4: Results of the centrality measures on the 15th century trade network (by Kodzhabasheva, 2024).

Node	PageRank	Katz Centrality	In-degree Centrality	Out-degree Centrality	Avg Neighbour Degree	HITS Authority	HITS Hub
Sofia	0.2782	0.4463	0.5714	0	1.75	0.4778	0
Mytilini	0.1741	0.3825	0.2857	0	2	0.2108	0
Varna	0.1395	0.3825	0.2857	0	2.5	0.3115	0
Northwest Anatolia	0.0816	0.3188	0	0.4286	0	0	0.3383
Italian States	0.0816	0.3188	0	0.2857	0	0	0.267
Ephesus	0.0816	0.3188	0	0.1429	0	0	0.1617
Valencia	0.0816	0.3188	0	0.1429	0	0	0.1617
Levant	0.0816	0.3188	0	0.1429	0	0	0.0713

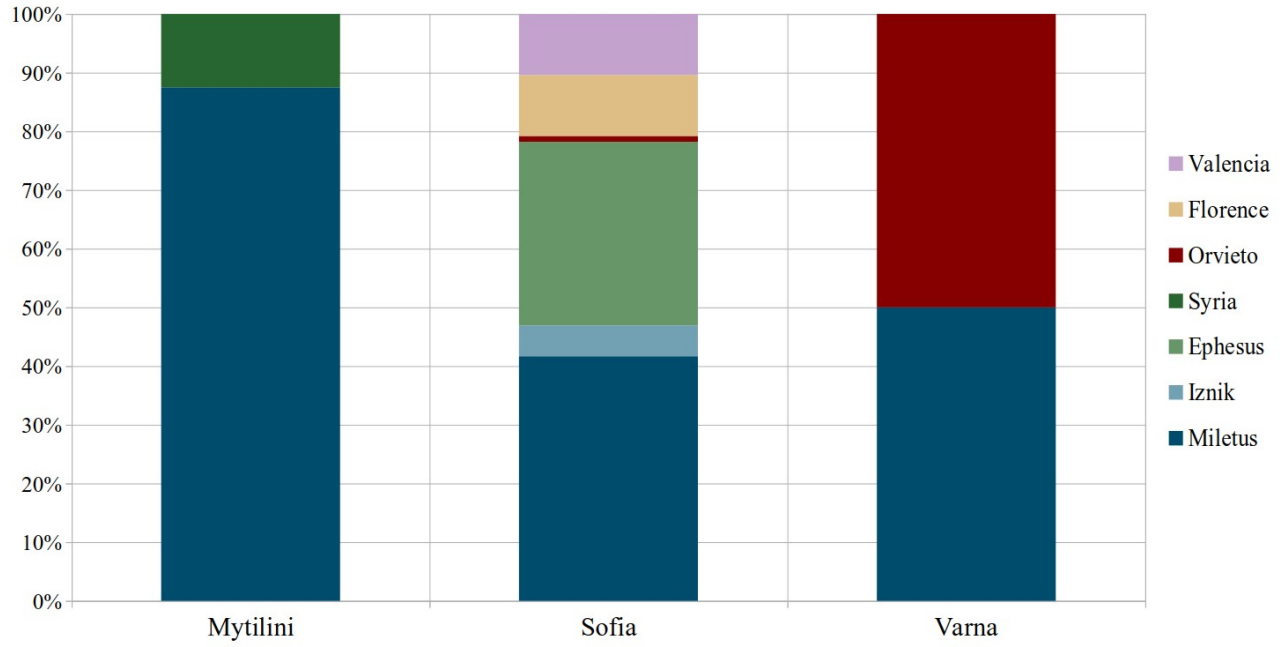

Figure 30: Proportion of each pottery type found at the sites - 15th century (by Kodzhabasheva, 2024).

All of the source nodes are placed on the same level in both PageRank and Katz centrality measures. However, Out-degree Centrality ranks Northwest Anatolia first, followed by the Italian States. This reflects that Northwest Anatolia has more direct connections, with the Italian States coming next, followed by the remaining source nodes. The HITS hub measurement aligns with this ordering but assigns a much lower value to the Levant, unlike other algorithms that placed the Levant on the same level as Ephesus and Valencia, the HITS hub score indicates that the Levant is primarily connected to target nodes that are less influential compared to the other source nodes.

Examining the source nodes in more detail, as depicted in Figure 30, reveals that imports from Northern Anatolia predominantly consist of Miletus ceramics, with some presence of Iznik products noted in Sofia. Meanwhile, imports originating from the Italian States come from Orvieto and Florence (Tuscany).

4.2 Results: 16th Century

Compared to the previous century, the 16th-century network (Figure 31 and Figure 32) now includes Belgrade as a target node, along with new source nodes: Central Europe and China. There are also two source nodes not present in this century – the Levant and Ephesus. Sofia clearly remains a central node in the network, while Varna's importance has increased compared to its previous position. Domestic exports remain dominated solely by production centres in Northwest Anatolia. However, there is a clear shift in international trade.

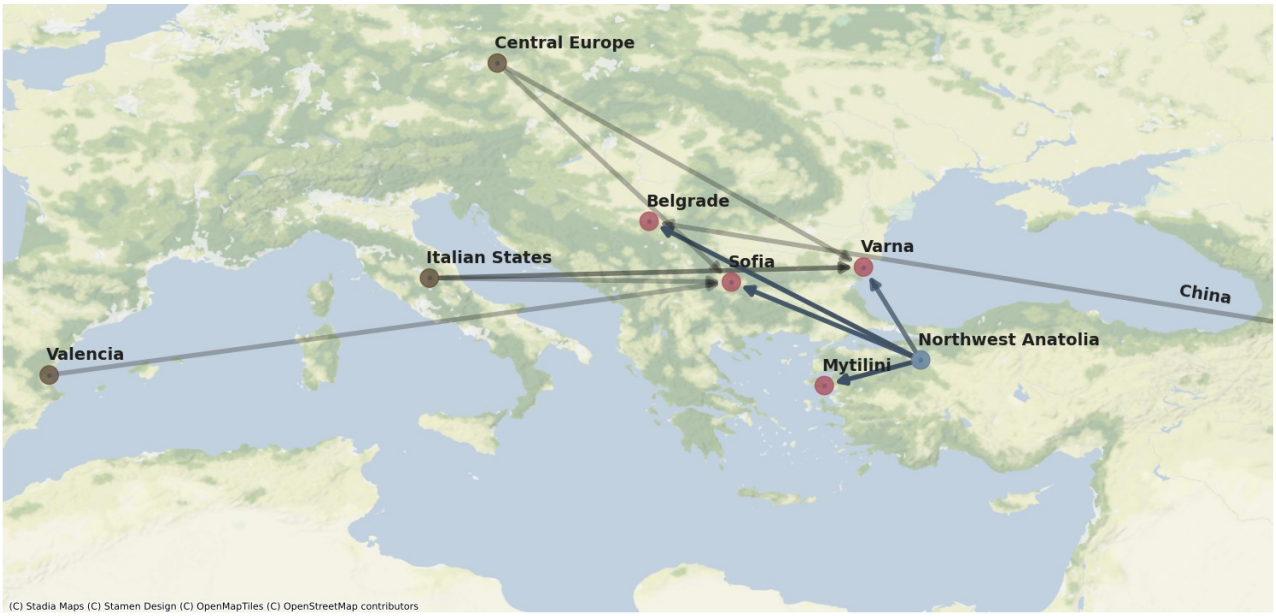

Figure 31: Geospatial network model of the Ottoman trade relations in the 16th century, using ceramic data (by Kodzhabasheva, 2024; map source: Stadia Maps, Stamen Design: https://stadiamaps.com).

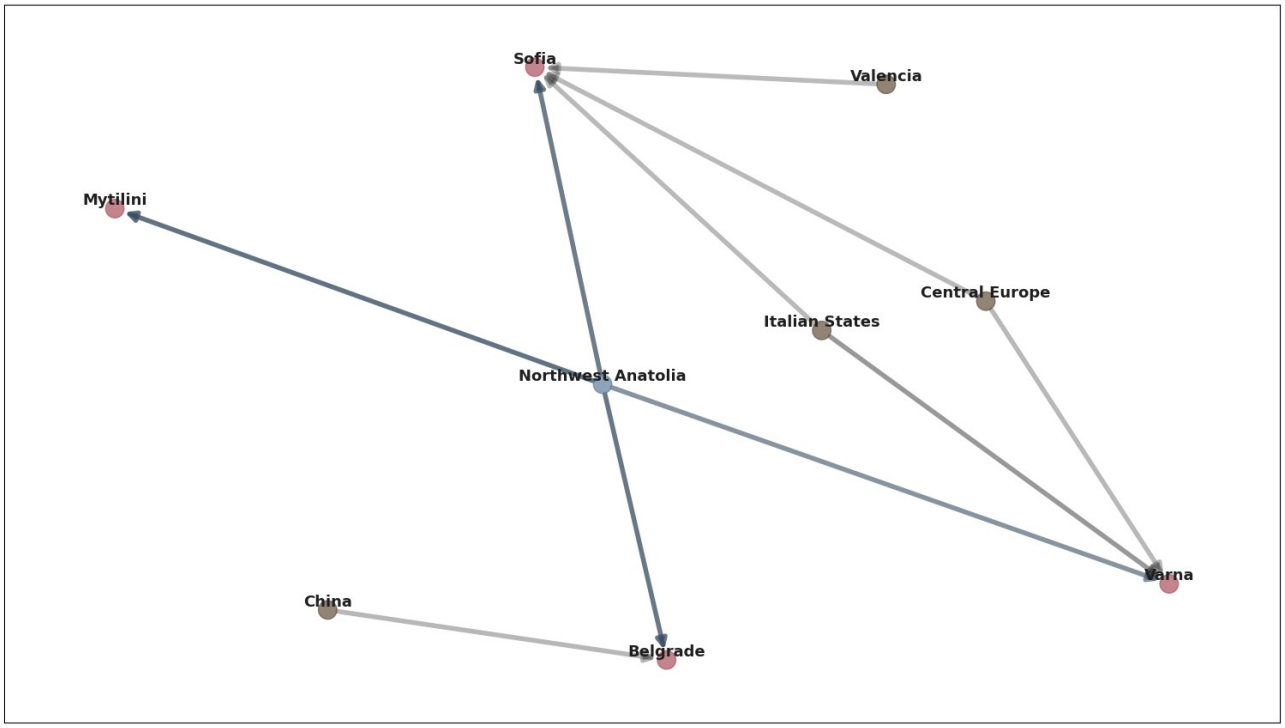

Figure 32: Network model of Ottoman trade relations in the 16th century, using ceramic data (by Kodzhabasheva, 2024; Fruchterman-Reingold force-directed layout).

The network analysis (Table 5) reveals results similar to the previous century. Sofia ranks first as the best-connected and most significant node according to *PageRank*, *Katz Centrality*, *In-degree Centrality*, and *HITS Authority*. Sofia is followed by Varna, Belgrade, and Mytilini. Notably, only the *PageRank* measure ranks Varna and Belgrade at the same level of importance directly after Sofia. Mytilini scores the highest based on the *Average Neighbour Degree* metric. Although Mytilini solely imports from Northwest Anatolia, this source node connects to all other target nodes in

the network, unlike other sources. Sofia, despite its connection to Northwest Anatolia, has the lowest *Average Neighbour Degree*. This suggests that Sofia links to more source nodes that themselves have fewer connections to target nodes, lowering its score.

Table 5: Results of the centrality measures on the 16th century trade network (by Kodzhabasheva, 2024).

Node	PageRank	Katz Centrality	In-degree Centrality	Out-degree Centrality	Avg Neighbor Degree	HITS Authority	HITS Hub
Sofia	0.2198	0.4165	0.5	0	2.25	0.3793	0
Varna	0.1557	0.3867	0.375	0	2.6667	0.3278	0
Belgrade	0.1557	0.357	0.25	0	2.5	0.1571	0
Mytilini	0.0915	0.3272	0.125	0	4	0.1358	0
Northwest Anatolia	0.0755	0.2975	0	0.5	0	0	0.3389
Italian States	0.0755	0.2975	0	0.25	0	0	0.2396
Central Europe	0.0755	0.2975	0	0.25	0	0	0.2396
Valencia	0.0755	0.2975	0	0.125	0	0	0.1286
China	0.0755	0.2975	0	0.125	0	0	0.0532

The target nodes maintain the same rankings in both *PageRank* and *Katz Centrality*. For *Out-degree Centrality*, Northwest Anatolia emerges as the node with the highest number of connections, followed by the Italian States and Central Europe, which share the same rank, and then Valencia and China. In terms of the *HITS Hub* score, the pattern is similar, except that China receives an even lower score than Valencia. This suggests that the target node China is linked to a less authoritative node, Belgrade, whereas Valencia is connected to Sofia which is a target node with more connections.

A closer look at the imports for each target node (Figure 33) shows that Iznik (Northwest Anatolia) imports make up the largest share across all target nodes. Italian imports are divided, with Faenza ceramics found in Varna, and ceramics from Tuscany and Montelupo in Sofia. There is also a notable amount of Italian ceramics with unknown production centres found in Varna. The imports from Central Europe come specifically from the region of North Serbia/ South Hungary. Smaller contributions include imports from Valencia to Sofia and Chinese porcelain to Belgrade.

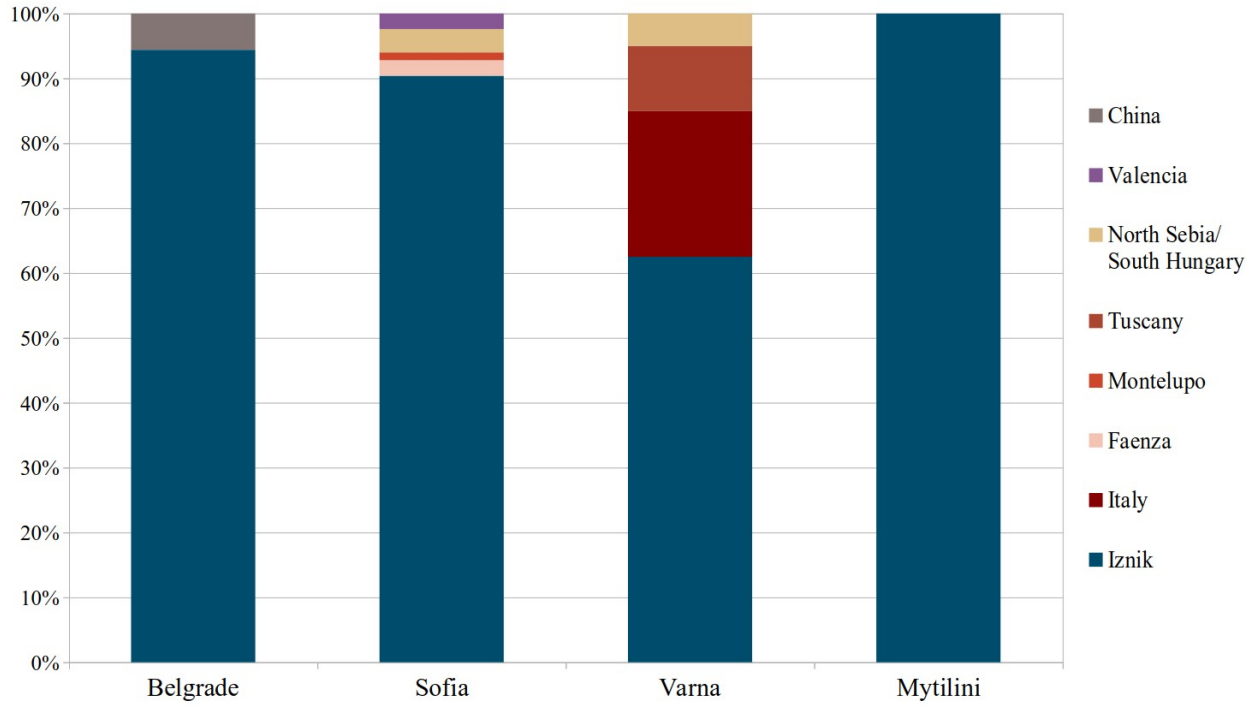

Figure 33: Proportion of each pottery type found at the sites - 16th century (by Kodzhabasheva, 2024).

4.3 Results: 17th Century

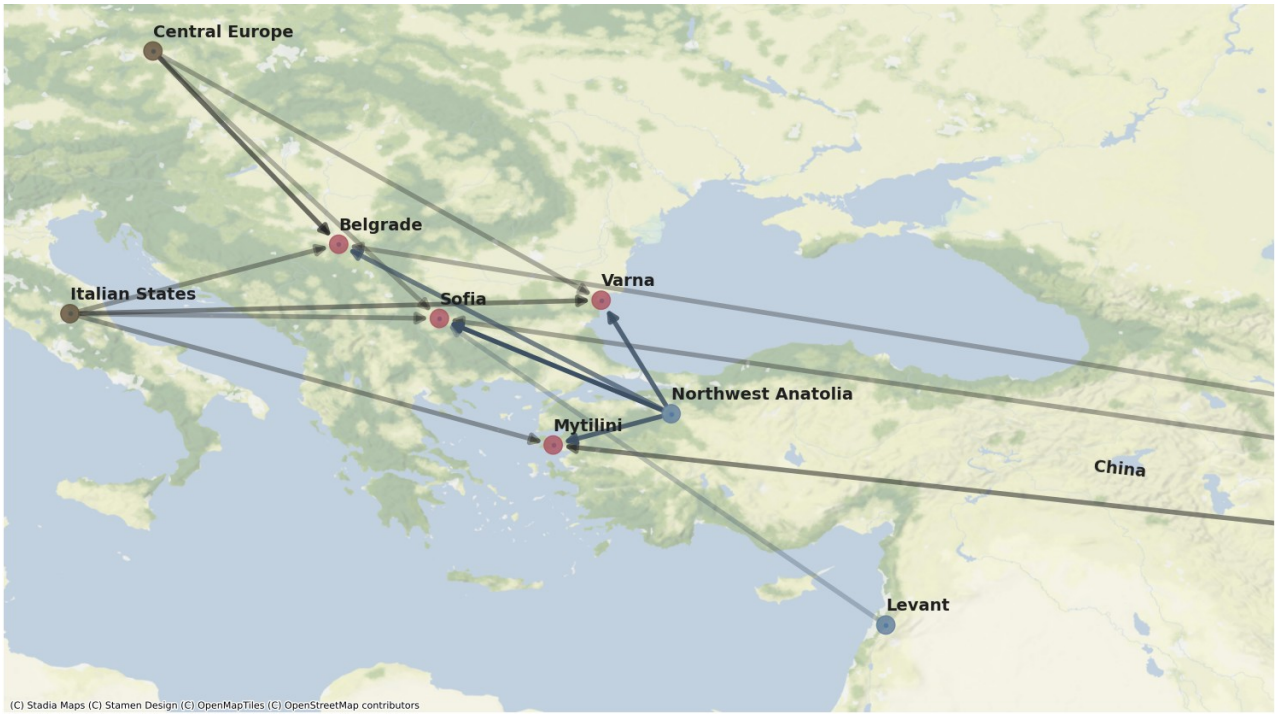

Figure 34: Geospatial network model of the Ottoman trade relations in the 17th century, using ceramic data (by Kodzhabasheva, 2024; map source: Stadia Maps, Stamen Design: https://stadiamaps.com).

At a first glance, the network model of the 17th century does not look very different than the one in the 16th century (Figure 34 and Figure 35). However, it can be observed that while Sofia re-

mains a key receiver of ceramics from various centres, Belgrade's role also expands during this century and surpasses both Varna and Mytilini. Two source nodes are no longer present in this network – the Levant and Valencia.

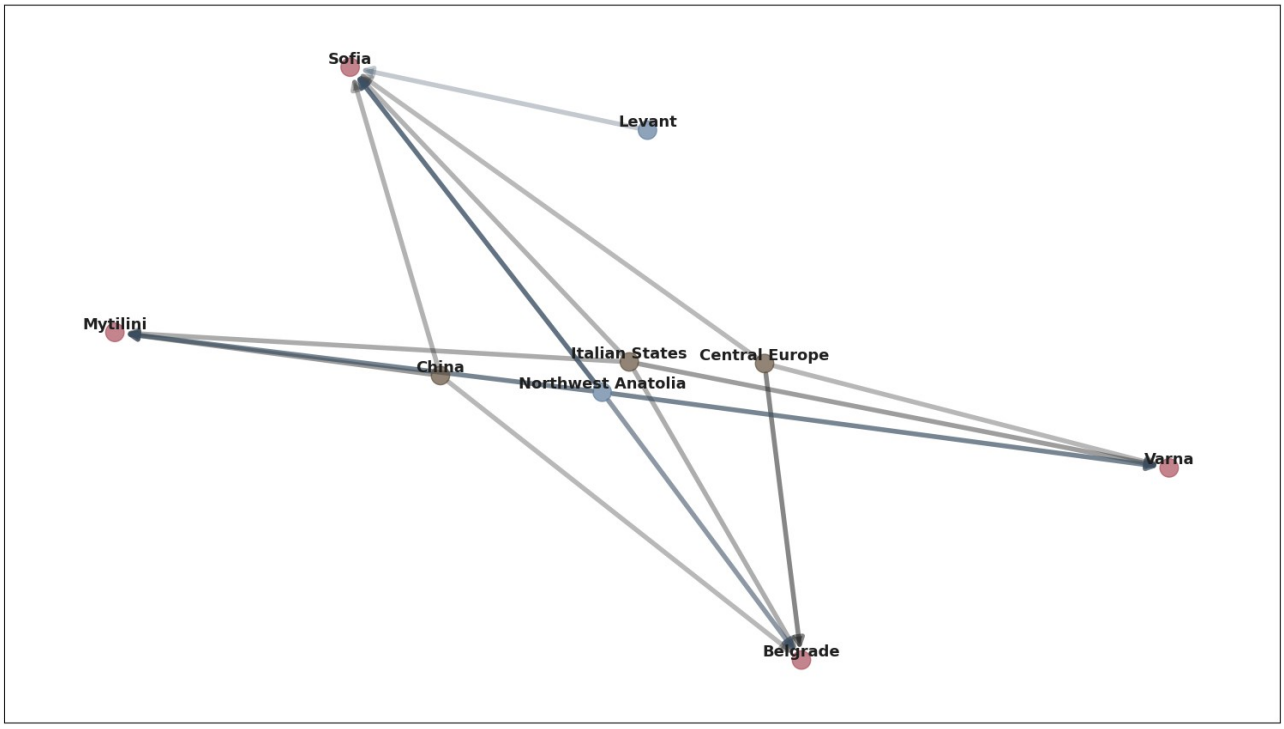

Figure 35: Network model of Ottoman trade relations in the 17th century, using ceramic data (by Kodzhabasheva, 2024; Fruchterman-Reingold force-directed layout).

In Table 6, we see that Sofia consistently ranks as the most influential node based on the *PageRank*, *Katz Centrality*, *In-degree Centrality* measures, and *HITS Authority* score. Belgrade is ranked second in influence, followed by Mytilini and Varna which both share the same ranking across all four of these measures. According to the *Average Neighbour Degree* measure, however, the order is reversed, with Varna and Mytilini taking the top positions, followed by Belgrade and then Sofia. This suggests that Sofia is connected to source nodes that have few or no other connections except to Sofia itself. On the other hand, Varna, Mytilini, and to a large extent Belgrade, receive connections from nodes that are well-integrated within the network of that time period.

The *Out-degree Centrality* measure and the *HITS Hub* score rank the source nodes in the same order of importance. Northwest Anatolia and the Italian States are tied as the nodes with the most connections to popular target nodes, placing them at the top. They are followed by China and Central Europe, while the Levant ranks last. Visually, we can see that the Levant only connects to Sofia, which explains its low score.

Figure 36 shows that the Northwest Anatolia node mainly includes the production centres of Iznik, Iznik/Kütahya, and the smaller nearby site of Akchaalan. Italian production centres contribute to the pottery imports in Belgrade, Sofia, and Varna. Ceramics from Montelupo, Italy, are found in

Mytilini and Sofia, Ligurian ceramics in Sofia, and pieces from Tuscany in Varna. Central European ware is present in Belgrade, Sofia, and Varna. In Sofia and Varna this ware is mainly linked to the North Serbia/ South Hungary region. Chinese porcelain is also becoming more wide-spread, appearing at every site except Varna.

Table 6: Results of the centrality measures on the 17th century trade network (by Kodzhabasheva, 2024).

Node	PageRank	Katz Centrality	In-degree Centrality	Out-degree Centrality	Avg Neighbor Degree	HITS Authority	HITS Hub
Sofia	0.2145	0.4227	0.625	0	3	0.2973	0
Belgrade	0.1503	0.3946	0.5	0	3.5	0.2745	0
Mytilini	0.1289	0.3664	0.375	0	3.67	0.2141	0
Varna	0.1289	0.3664	0.375	0	3.67	0.2141	0
Northwest Anatolia	0.0755	0.2818	0	0.5	0	0	0.2585
Italian States	0.0755	0.2818	0	0.5	0	0	0.2585
China	0.0755	0.2818	0	0.375	0	0	0.2031
Central Europe	0.0755	0.2818	0	0.375	0	0	0.2031
Levant	0.0755	0.2818	0	0.125	0	0	0.0768

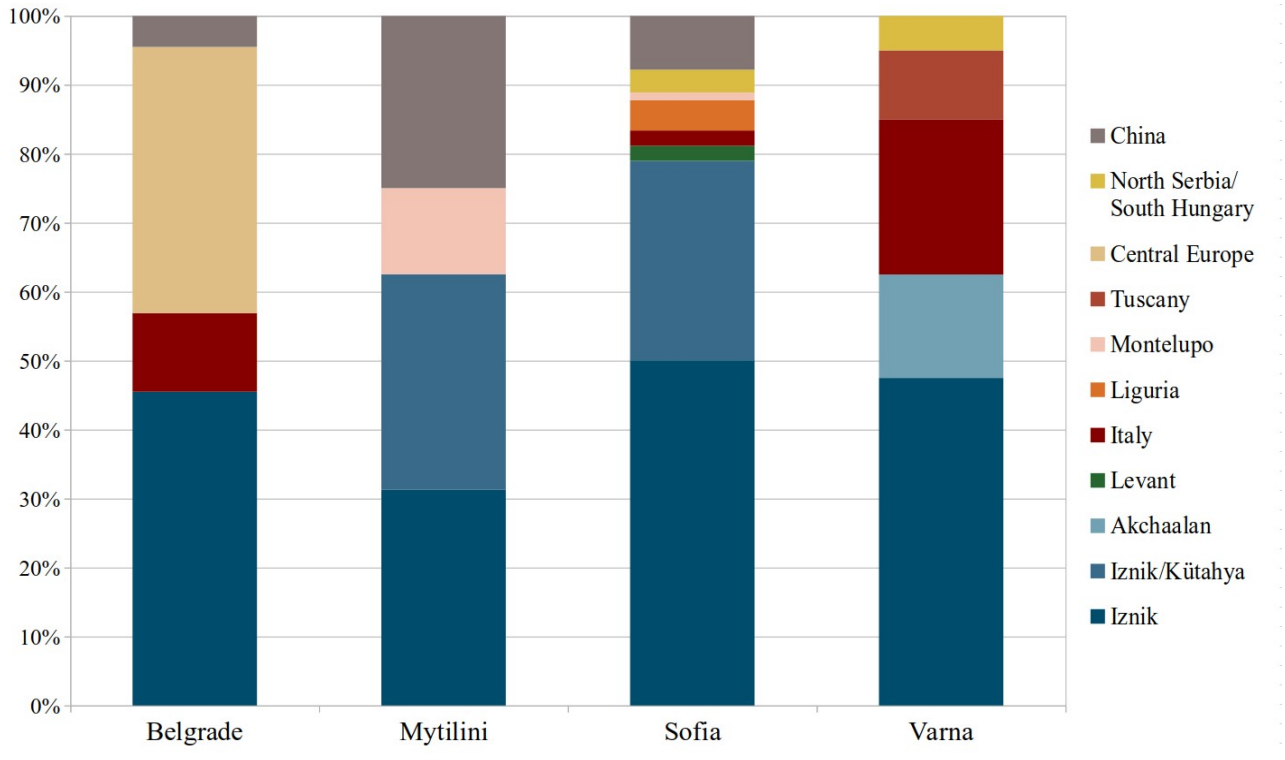

Figure 36: Proportion of each pottery type found at the sites - 17th century (by Kodzhabasheva, 2024).

4.4 Results: 18th Century

The 18th century provides the most detailed network in this research, since it is the period with the most pottery data available (Figures 37, 38, and 39). The target node for Izmir appears only during this century and represents the node with the largest amount of imported pottery in the dataset. Compared to the previous century, there are many new source nodes, particularly in Europe, including England, Delft, France, the German States and Vienna. Didymoteicho and Chanakkale (Çanakkale) also appear as domestic trade sources.

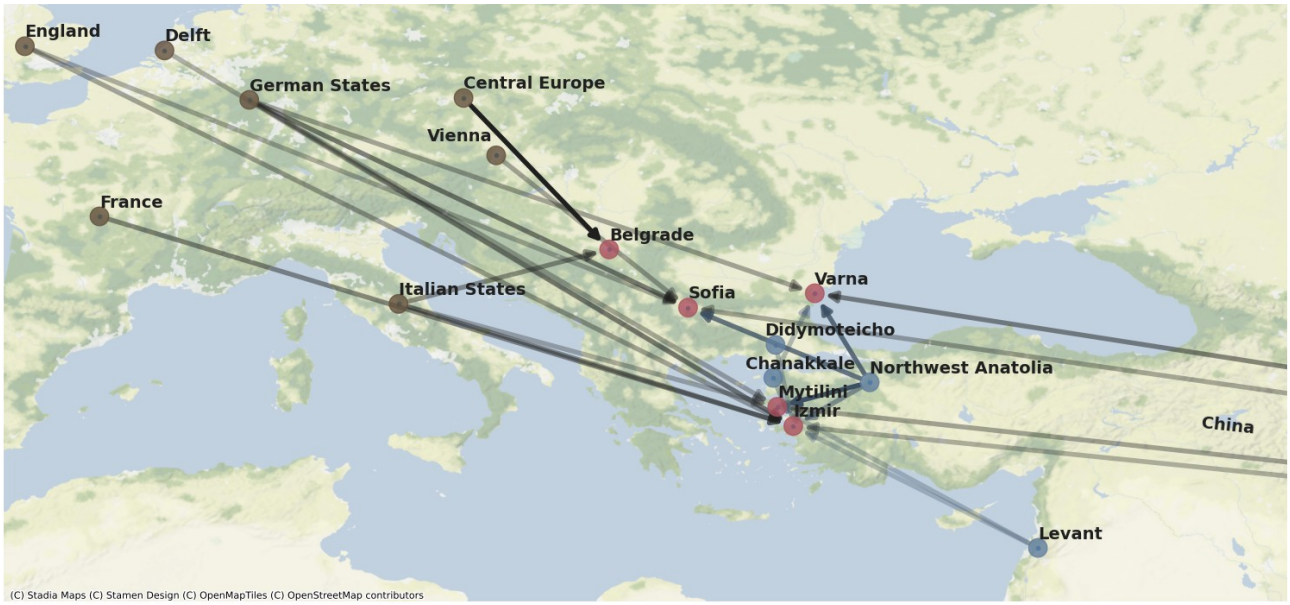

Figure 37: Geospatial network model of the Ottoman trade relations in the 18th century, using ceramic data (by Kodzhabasheva, 2024; map source: Stadia Maps, Stamen Design: https://stadiamaps.com).

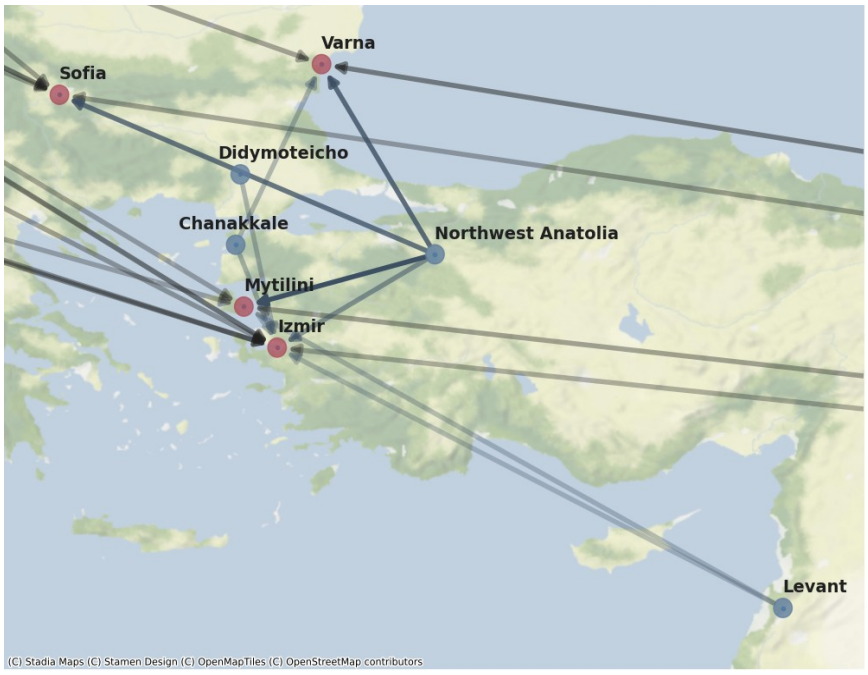

Figure 38: Focus on the 18th century Ottoman domestic trade (in blue) (by Kodzhabasheva, 2024; map source: Stadia Maps, Stamen Design: https://stadiamaps.com).

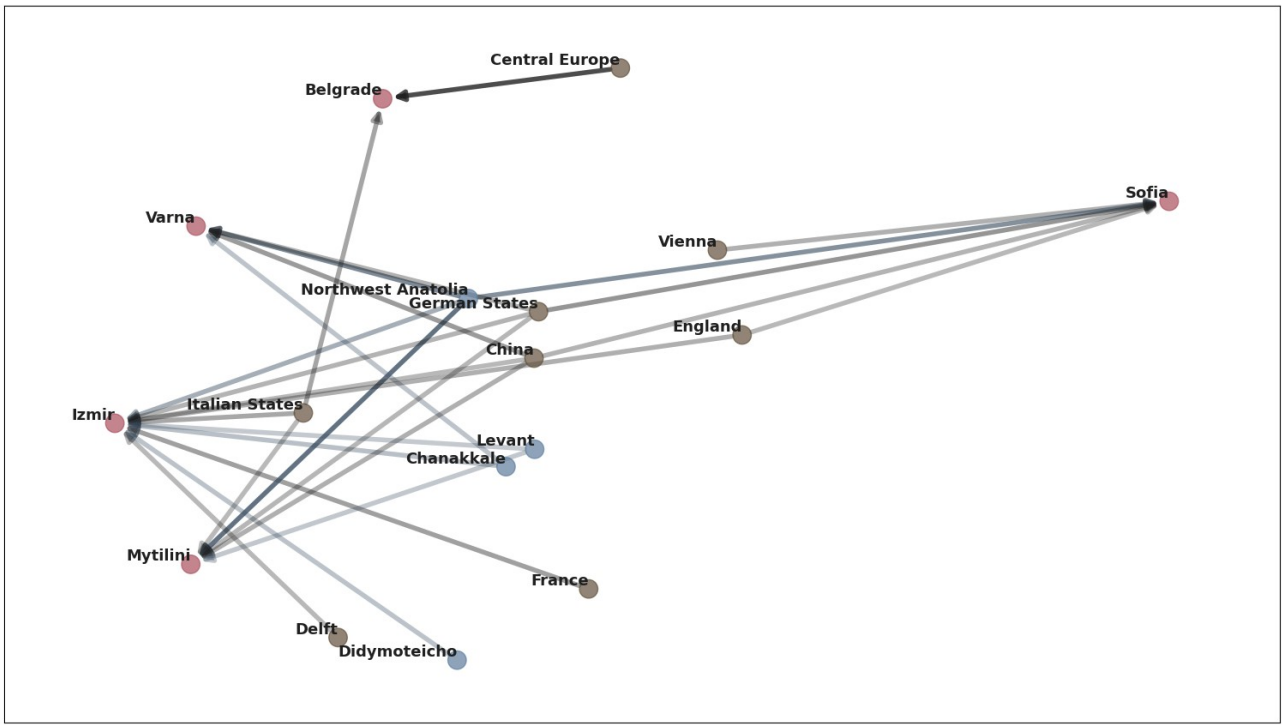

Figure 39: Network model of Ottoman trade relations in the 18th century, using ceramic data (by Kodzhabasheva, 2024; Fruchterman-Reingold force-directed layout).

Table 7 presents the centrality measures of this network. Among the target nodes, Izmir stands out as the most influential, with the highest number of connections, followed by Sofia, Mytilini, Belgrade, and Varna, according to the *PageRank* algorithm. In the rankings based on *Katz Centrality* and *In-degree Centrality*, Izmir again takes the top spot again, followed by Sofia and Mytilini (which share the same rank), then Varna, and finally Belgrade. The differences arise because *Katz Centrality* and *In-degree Centrality* focus purely on the number of incoming connections to a node, while *PageRank* also considers the importance of the nodes providing those connections. The *HITS Authority* ranking is quite different. It places Izmir first, followed by Mytilini, then Sofia, Varna, and Belgrade. This variation is due to the distinct algorithm used by *HITS Authority*. Overall, when considering all four measures together, Izmir consistently ranks first, followed by Sofia, then closely by Mytilini, with Varna and lastly Belgrade.

In terms of *Average Neighbour Degree*, Varna scores the highest. This indicates that it connects to nodes with a high number of connections themselves, indicating a well-integrated role within the network. Following Varna are Mytilini, Sofia, Izmir, and Belgrade.

The source nodes, analysed mainly through *Out-degree Centrality* and the *HITS Hub* score, are ranked as follows: Northwest Anatolia, the German States, and China occupy the top level. Next come the Italian States, followed by the Levant, Chanakkale, and England, which are slightly lower. At the bottom of the *Out-degree Centrality* ranking are Vienna, Didymoteicho, Delft, France, and

Central Europe. A similar pattern is seen in the *HITS Hub* score, though Vienna is ranked slightly lower than the rest, indicating it connects to less influential target nodes compared to the others.

Table 7: Results of the centrality measures on the 18th century trade network (by Kodzhabasheva, 2024).

Node	PageRank	Katz Centrality	In-degree Centrality	Out-degree Centrality	Avg Neighbor Degree	HITS Authority	HITS Hub
Izmir	0.2112	0.4091	0.625	0	2.4	0.3442	0
Sofia	0.1071	0.3068	0.3125	0	3	0.2027	0
Mytilini	0.0862	0.3068	0.3125	0	3.4	0.2265	0
Belgrade	0.0784	0.2455	0.125	0	2	0.0357	0
Varna	0.0758	0.2864	0.25	0	3.5	0.1908	0
Northwest Anatolia	0.0368	0.2046	0	0.25	0	0	0.1501
German States	0.0368	0.2046	0	0.25	0	0	0.1501
China	0.0368	0.2046	0	0.25	0	0	0.1501
Italian States	0.0368	0.2046	0	0.1875	0	0	0.0944
Levant	0.0368	0.2046	0	0.125	0	0	0.0889
Chanakkale	0.0368	0.2046	0	0.125	0	0	0.0833
England	0.0368	0.2046	0	0.125	0	0	0.0852
Vienna	0.0368	0.2046	0	0.0625	0	0	0.0316
Didymoteicho	0.0368	0.2046	0	0.0625	0	0	0.0536
Delft	0.0368	0.2046	0	0.0625	0	0	0.0536
France	0.0368	0.2046	0	0.0625	0	0	0.0536
Central Europe	0.0368	0.2046	0	0.0625	0	0	0.0056

Figure 40 illustrates the distribution of imports across the target nodes. The node Northwest Anatolia consists of ceramics produced in Iznik and Kütahya. The Levant node is divided between production centres in the broader Levant region and Syria. The Italian States node includes pottery from various production centres within the Italian peninsula, some of which are uncategorised (found in Belgrade and Izmir). Additionally, vessels from Liguria, Montelupo, and Abisola appear in Izmir, while Montelupo pottery is also found in Mytilini. The German States node, linked to Sofia, features ceramics from the pottery centres of Meissen and Thuringia. In the case of Mytilini, this node is not defined further.

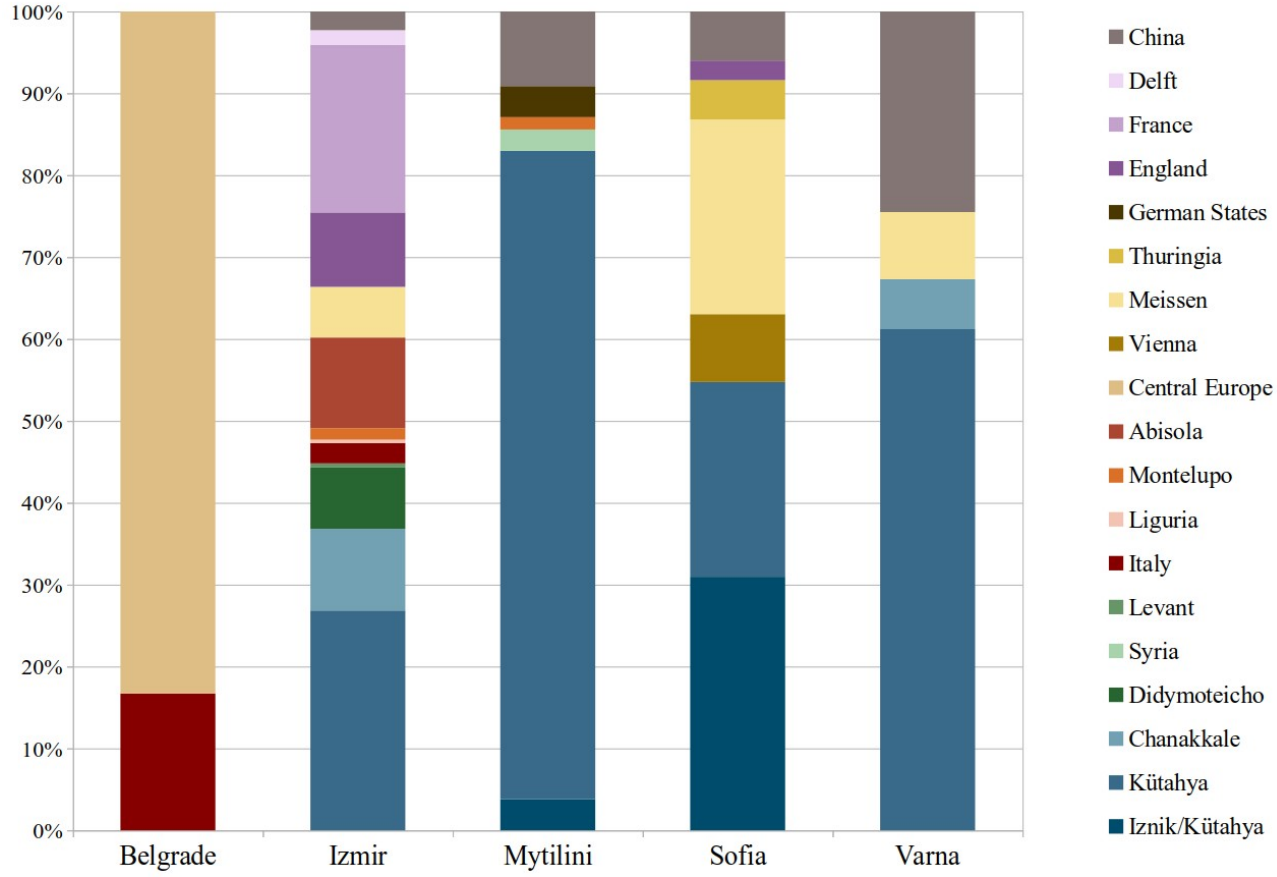

Figure 40: Proportion of each pottery type found at the sites - 18th century (by Kodzhabasheva, 2024).

4.5 Results: 19th Century

The network of the 19th century (Figures 41, 42 and 43) is considerably smaller than the network of the 18th century. In this network model, the target nodes Belgrade and Izmir are not present any more, together with many source nodes, including Delft, France, Central Europe, China, Northwest Anatolia. The only new source node is Japan, which is replacing the node China as the node furthest away from the Balkans and the Aegean.

The centrality measures shown in Table 8, which are *PageRank*, *Katz Centrality*, *In-degree Centrality*, and *HITS Authority* score, all consistently rank Mytilini as the most connected node, followed by Sofia and then Varna. The only exception is the *Average Neighbour Degree* measure, which places Varna at the top, with Mytilini and Sofia tied in second place. However, since Varna only has one connection with Chanakkale during this period, this measure does not contribute significantly to the analysis.

Figure 41: Geospatial network model of the Ottoman trade relations in the 19th century, using ceramic data (by Kodzhabasheva, 2024; map source: Stadia Maps, Stamen Design: https://stadiamaps.com).

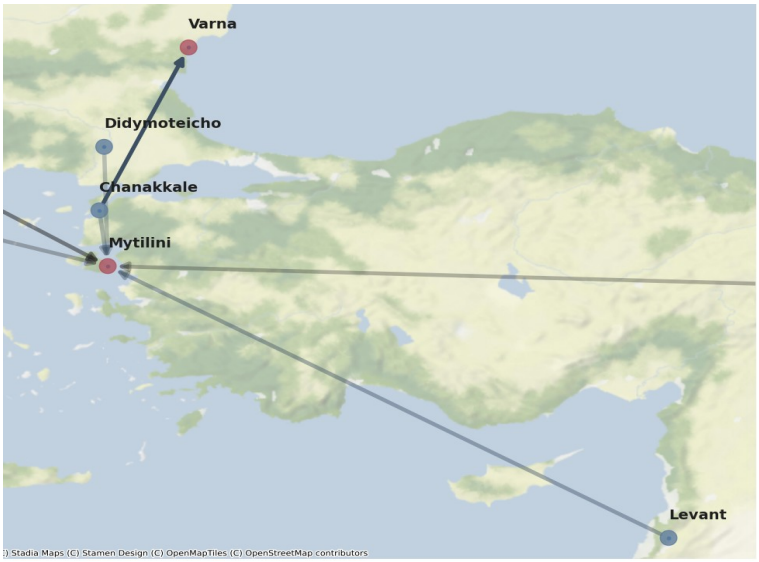

Figure 42: Focus on the 19th century Ottoman domestic trade (in blue) (by Kodzhabasheva, 2024; map source: Stadia Maps, Stamen Design: https://stadiamaps.com).

For the source nodes, the German States and Chanakkale are tied together under the *Out-degree Centrality* measure. However, the *HITS Hub* score of the German States is higher than Chanakkale, indicating that this node is connected to more influential target nodes in the network, namely Sofia and Mytilini. These nodes are followed by the Italian States, Didymoteicho, Japan, the Levant, England and Vienna, which are all ranked equally by the *Out-degree* Centrality measure. The *HITS Hub* score also places them on the same level, with the exception of England and Vienna, which have a slightly lower score than the rest. This is due to their connection with Sofia, which is not the most influential target node in the network.

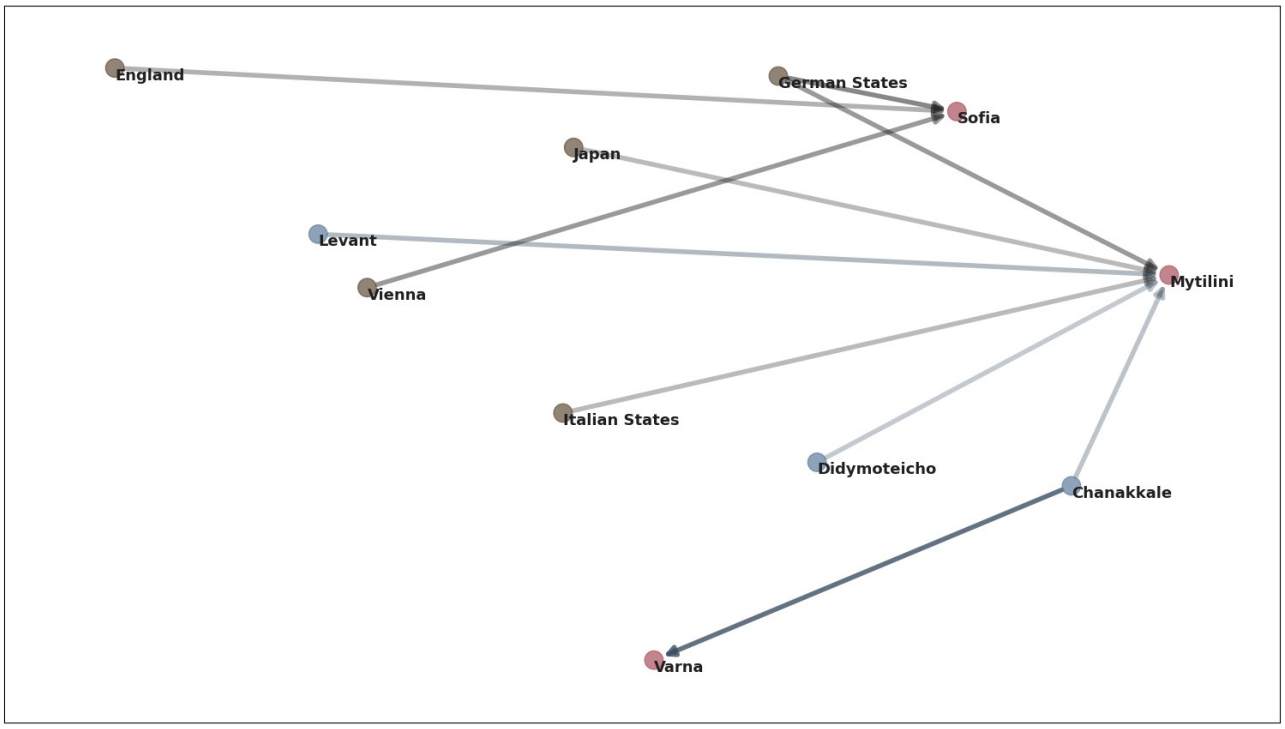

Figure 43: Network model of Ottoman trade relations in the 19th century, using ceramic data (by Kodzhabasheva, 2024; Fruchterman-Reingold force-directed layout).

Table 8: Results of the centrality measures on the 19th century trade network (by Kodzhabasheva, 2024).

Node	PageRank	Katz Centrality	In-degree Centrality	Out-degree Centrality	Avg Neighbor Degree	HITS Authority	HITS Hub
Mytilini	0.2949	0.4361	0.6	0	1.3333	0.6799	0
Sofia	0.1756	0.3543	0.3	0	1.3333	0.1959	0
Varna	0.0801	0.2998	0.1	0	2	0.1243	0
German States	0.0562	0.2726	0	0.2	0	0	0.1828
Chanakkale	0.0562	0.2726	0	0.2	0	0	0.1678
Italian States	0.0562	0.2726	0	0.1	0	0	0.1419
Didymoteicho	0.0562	0.2726	0	0.1	0	0	0.1419
Japan	0.0562	0.2726	0	0.1	0	0	0.1419
Levant	0.0562	0.2726	0	0.1	0	0	0.1419
England	0.0562	0.2726	0	0.1	0	0	0.0409
Vienna	0.0562	0.2726	0	0.1	0	0	0.0409

The pottery distribution per site in Figure 44, points out that the Italian States source node is divided between an uncategorised production centre and South Italy in Mytilini. The German States node includes the ceramic centres of Meissen and Vienna, whose pottery appears in Sofia, while in Mytilini, the node is not categorised further.

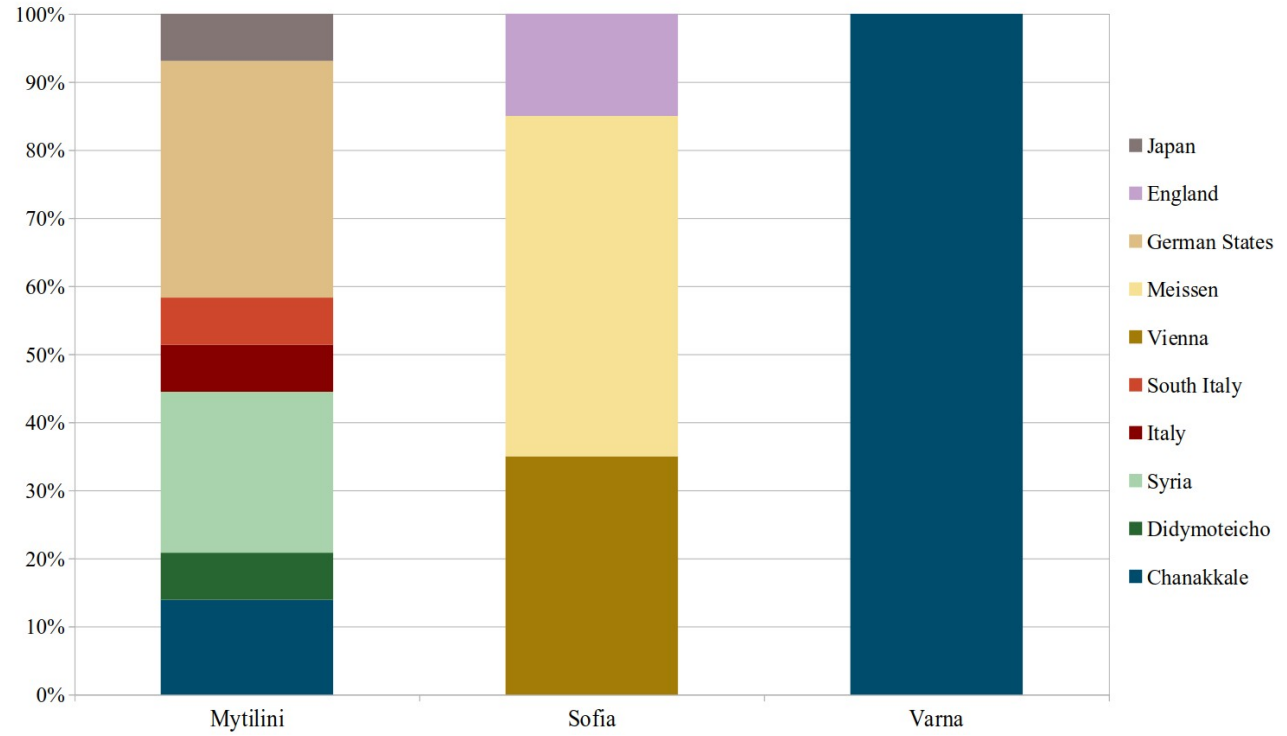

Figure 44: Proportion of each pottery type found at the sites - 19th century (by Kodzhabasheva, 2024).

4.6 Results: 20th Century

The network of the 20th century is the most fragmented one (Figure 45 and Figure 46). There are only two target nodes – Sofia and Mytilini, and only a few source nodes – England, German States, Italian States, Levant, Didymoteicho and Japan. The source nodes do not have shared target nodes any more. England and the German States being are connected only to Sofia, and Didymoteicho, Levant, Italian States and Japan are connected to Mytilini.

Figure 45: Geospatial network model of Balkan and Aegean trade relations in the 20th century, using ceramic data (by Kodzhabasheva, 2024; map source: Stadia Maps, Stamen Design: https://stadiamaps.com/).

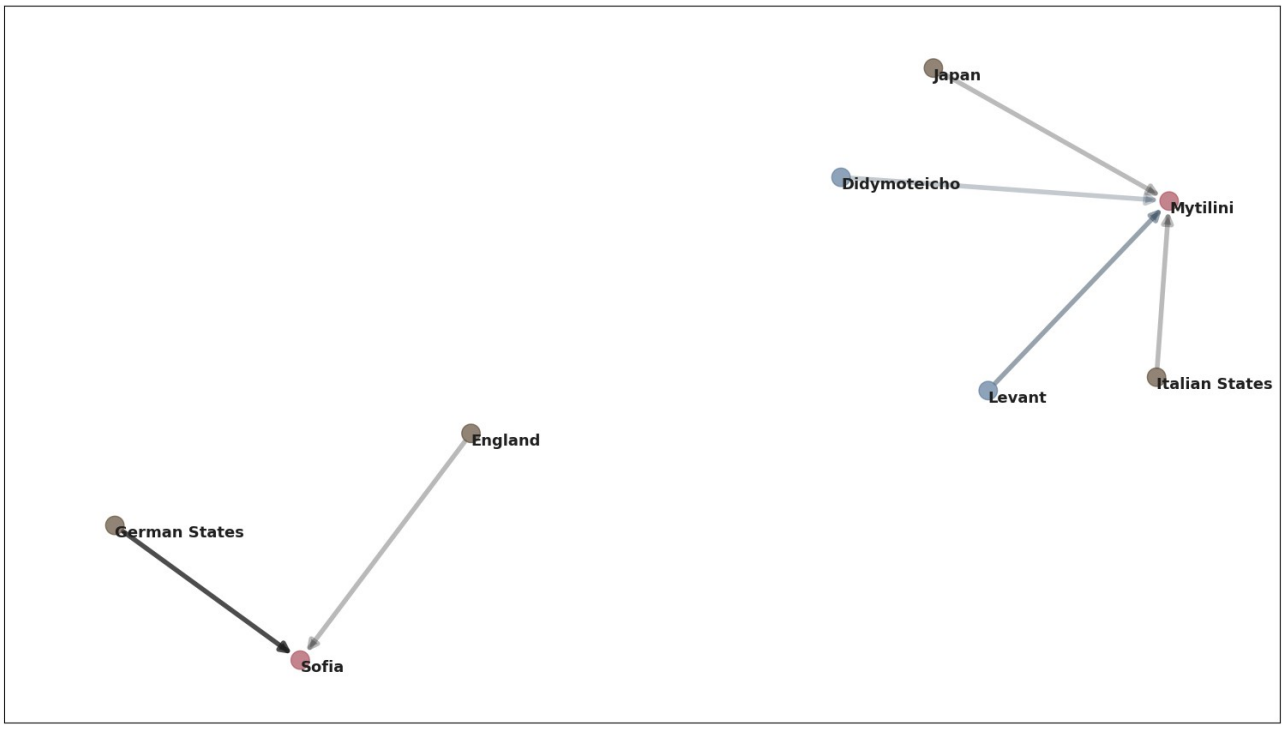

Figure 46: Network model of Balkan and Aegean trade relations in the 20th century, using ceramic data (by Kodzhabasheva, 2024; Fruchterman-Reingold force-directed layout).

The centrality measures (Table 9) done on this network do not provide much information which is not visible from visually inspecting the network models. Mytilini is the most connected target node, according to all measurements, followed by Sofia. The source nodes all have the same ranking.

Table 9: Results of the centrality measures on the 20th century trade network (by Kodzhabasheva, 2024).

Node	PageRank	Katz Centrality	In-degree Centrality	Out-degree Centrality	Avg Neighbor Degree	HITS Authority	HITS Hub
Mytilini	0.3359	0.4566	0.5714	0	1	1	0
Sofia	0.2061	0.3914	0.2857	0	1	0	0
Levant	0.0763	0.3262	0	0.1429	0	0	0.25
Didymoteicho	0.0763	0.3262	0	0.1429	0	0	0.25
Italian States	0.0763	0.3262	0	0.1429	0	0	0.25
Japan	0.0763	0.3262	0	0.1429	0	0	0.25
German States	0.0763	0.3262	0	0.1429	0	0	0
England	0.0763	0.3262	0	0.1429	0	0	0

Additional information on the imports is available in Figure 47, in which it is visible that most of Sofia's imports come from Meissen (German States node), while Mytilini mostly receives imports from Didymoteicho.

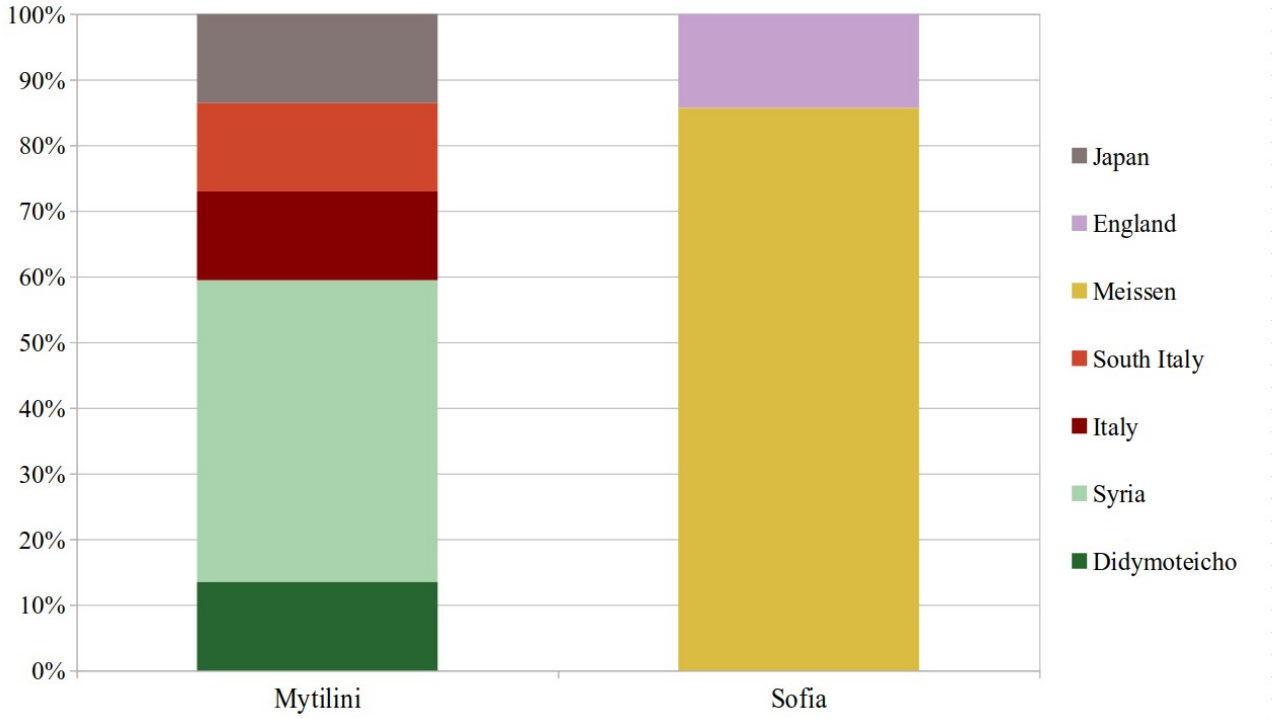

Figure 47: Proportion of each pottery type found at the sites - 20th century (by Kodzhabasheva, 2024).

4.7 Results: Summary

The results are overall consistent across the centuries, with Sofia emerging as the most influential node from the 15th to the 17th century. Following Sofia are Varna and Mytilini, which hold similar rankings in the 15th century. In the 16th century, Varna comes in second, followed by Belgrade and Mytilini. In the 17th century, Sofia is followed by Belgrade, with Mytilini and Varna ranking equally in last place. Overall, until and including the 17th century, all nodes, other than Sofia, frequently exchange positions. Izmir appears only in the network of the 18th century where it replaces Sofia as the most popular target node. Sofia takes second place, followed by Mytilini, Belgrade and Varna. Belgrade and Izmir no longer appear in the network after the 18th century. Mytilini rises to first place in terms of connectivity in the 19th century, followed by Sofia and Varna. By the 20th century, the only source nodes remaining are Mytilini and Sofia. What we can observe is a gradual decline in Sofia's influence and a steady rise in Mytilini's, as both are the only nodes present in every century's network.

Based on the *Average Neighbour Degree* measure, Varna ranks first in all networks it is present in. Varna is closely followed by Mytilini up to and including the 18th century. This means that their neighbours, on average, export to many other target nodes within the network. In contrast, other nodes, such as Sofia, Izmir, and Belgrade, often have connections from nodes that are linked to only a few target nodes.

Northwest Anatolia is the dominating domestic pottery production centre (target node) from the 15th to the 18th century. This node includes pottery types such as Iznik and Kütahya. In the 18th century, additional target nodes located within the empire's borders - Chanakkale, Didymoteicho and the Levant, appear. Northwest Anatolia is still the most influential domestic node, however, in the networks of the 19th and 20th centuries, it is not present any more. Still, the nodes Chanakkale, Didymoteicho and the Levant remain.

The nodes of the international trade network reveal many patterns. Italian imports are quite diverse, originating from various Italian states. Italian production centres are also the only ones present in the networks across all centuries. The node Central Europe appears from the 16th to the 18th century, but its influence begins to decline in the 18th century. Other source nodes in the same geographical region, such as Vienna and the German States, emerge. Nodes from Western Europe also appear, including England, Delft and France. The German states and England remain in the networks of the 19th and 20th centuries. From the 18th century onwards, source nodes in Central and Western Europe increasingly dominate the international trade network.

China is geographically the most distant node from the Ottoman Empire. The node enters the network in the 16th century and it gradually gains more influence. In the 19th century, however, China disappears from the network. It is then replaced by Japan which is also present in the network of the 20th century. Still, Japan has less influence than China.

An archaeological scenario based on these results is going to be constructed in the following chapter.

Chapter 5: Discussion

The aim of this chapter is to create an archaeological scenario for each century based on the results of the network analyses in Chapter 4. This archaeological scenario is then compared with the historical information presented in Chapter 2.2 Economy and Society, Chapter 2.3 The Sites and Chapter 2.4 Pottery Types.

The results are discussed chronologically by organising them in four groups: Classical Age (15th–16th century), Crisis and Transformation (17th century), Reforms and Decentralisation (18th century), Modernisation and Decline (19th–20th century). These are the same groups used in Chapter 2.2 to present the economic history of the empire.

A separate archaeological interpretation is created for each group. It starts with a discussion of the domestic trade network followed by a discussion of the international trade network. This includes an analysis on the position and the connection of the pottery production centres (source nodes). Next, the sites (target nodes) are discussed, by analysing their position within the network and the types of imports found in them. After constructing the archaeological scenario, it is compared with the available historical information, highlighting similarities and differences

A summary of the main similarities and differences between the archaeological and historical scenarios is presented at the end of the chapter.

5.1 The Classical Age (15th–16th century)

5.1.1 Archaeological Interpretation

The domestic trade in the networks of the 15th and 16th centuries is represented solely by Northwest Anatolia, which includes Miletus and Iznik ceramics. Northwest Anatolia is further the most influential pottery production centre in both networks. In the 15th century, it accounts for a bit less than half of Sofia's imports, half of Varna's imports and almost 90% of Mytilini's. In the 16th century, however, the influence of Northwest Anatolia significantly increases, accounting for 90% of Sofia's total pottery imports, more than 60% of Varna's imports and all imports found in Mytilini. Belgrade also connects almost exclusively to Northwest Anatolia. The presence of luxurious Ottoman ware in these cities indicates the presence of a wealthy urban class which could afford such ceramics. The big increase of Iznik pottery in the 16th century suggests an increased and strengthened connection with the imperial heartland. Domestic trade plays a significant role in overall trade during the 15th century. By the 16th century, however, trade becomes almost entirely domestic.

International trade in the 15th-century network is very diverse. It includes pottery production centres such as Ephesus, Levant, Valencia and the Italian city-states of Orvieto and Florence (Tuscany). This diversity persisted in the 16th century, although international imports made up a smaller percentage of the total imports for each site. Italy established itself as a dominant node in the international trade, including pottery from Faenza, Montelupo and Tuscany. Central Europe emerges in the network of the 16th century. It is on the same level of influence as the Italian city-states, followed by Valencia and China. This suggests that despite the increase of Ottoman influence and the dominance of domestic trade, most sites maintained their international connections.

Sofia

In both 15th and 16th centuries, Sofia stands out as the site receiving the largest variety of imports. Its last position in the *Average Neighbour Degree* ranking, highlights Sofia's role as an important trade hub, as it connects to ceramic production centres that are not well integrated into the Ottoman international trade network, such as Ephesus and Valencia. These production centres export to relatively few sites in the Empire, which themselves hold more significant trade roles.

In the 15th century, Sofia receives the fewest imports from the domestic centre of Northwest Anatolia compared to all other sites. This suggests that Sofia maintained its own trade network, likely established before the Ottoman occupation, and was not heavily dependent on the imperial trade system. Sofia has also the most diverse international connections, with imports from Ephesus, Orvieto, Florence and Valencia.

Despite the growing influence of Northwest Anatolia in the 16th century, Sofia continues to maintain its international trade relations, although on a smaller scale. Sofia retains its position as the city with the most diverse connections to pottery production centres. During this period, Sofia's trade network expands further north into mainland Europe, with pottery imports from the region of modern-day northern Serbia and southern Hungary (Central Europe). While the connection to Ephesus is lost, the connections to Valencia and Italy persist.

Varna and Mytilini

In the 15th century, Mytilini and Varna hold comparable levels of importance in the network. Both sites are well integrated into the Ottoman trade network, importing from major pottery production centres.

Varna receives an equal amount of imports from both Orvieto (Italy) and Northwest Anatolia. This indicates that while Varna has a strong connection with the imperial heartland, it also engages in extensive trade with the Italian states. Both production centres have the highest centrality scores for influence in the network. This further suggests that Varna's trade patterns closely align with those of other Ottoman cities, as it engages with key trade partners.

Mytilini receives pottery from the Levant in the 15th century. The region was not yet part of the Ottoman Empire as it was conquered only in 1516 during the Ottoman conquest of the Mamluk Sultanate of Egypt. This connection indicates that Mytilini was part of a regional trade network spanning the Eastern Mediterranean and the Levant, engaging with foreign merchants and likely following trade patterns established before Ottoman control. What is interesting is that although Ephesus is geographically closer to Mytilini than Sofia, no pottery from Ephesus is found in Mytilini during this period. This contradicts the previous statement, but there may be an explanation based on the nature of regional trade and the available archaeological data.

In the 16th century, the role of both sites changes. Varna's international trade connections expand. The site remains well connected to Northwest Anatolia and Italy, while also establishing a new link to Central Europe. An interesting observation is that Varna has the lowest proportion of imports from Northwest Anatolia during that century, indicating an important role in the global trade network, especially with Italy.

In contrast, in the 16th century, Mytilini's connections are limited only to Northwest Anatolia. This significantly reduces the ranking of Mytilini among influential nodes by placing the site in the last place as there is no evidence of international trade ties.

Belgrade

Belgrade appears as a node in the network only from the 16th century onwards. It ranks third in terms of connectivity and influence within the network. Similarly to all sites in the 16th century, Belgrade receives imports almost primarily from Northwest Anatolia.

In terms of international trade, Belgrade lacks a connection to Central Europe, unlike Sofia and Varna, despite being geographically the closest site to that region. What is particularly interesting is the connection between Belgrade and China. This marks the earliest occurrence of Chinese imports within the networks analysed in this research. Belgrade, unlike Sofia, was not a major trade hub, making it unlikely to attract such distant trade connections. Instead, this ware was most probably brought by high-ranking officials who migrated to the city after its Ottoman conquest.

5.1.2 Historical Comparison

Information on trade and economy of the Ottoman Balkans and Aegean right after the Ottoman conquest is scarce. For that reason, many of the trends observed in the archaeological network of the 15th century can be neither confirmed or challenged by available historical accounts.

For example, pottery evidence identifies Sofia as the best-connected node in both networks. This position is consistent with its status as the capital of the Rumelia *vilayet* from 1530 onward (Ishirkov, 1912, p. 2). However, Sofia shows a notable diversity in imports already in the 15th cen-

tury, before it was made the capital. This suggests that the city was already integrated into a diverse trade network. However, there is no historical data for comparison.

The connection between Sofia and Valencia in the 15th century is also not clearly reflected in the historical accounts. The only known historical connection is the migration of Jewish people from the Iberian Peninsula to the Ottoman Balkans in the 16th century (Ishirkov, 1912, p. 45), which occurred long after the Iberian ceramics are observed in the archaeological network. Similarly, there is no historical evidence of a direct relationship between Sofia and Ephesus in the 15th century, even though this connection is visible archaeologically.

Sofia's already established international trade network, Varna's connection to the Italian states and Mytilini's imports from the Levant most probably reflect a continuation of trade dynamics from earlier centuries, which are historically not very well recorded. Perhaps, only the cities' connection to Northwest Anatolia in the 15th century is more predictable, given their integration into the Ottoman Empire.

A major change takes place in the 16th century, which is characterised by a large increase of Northwest Anatolian ware in all sites. This trend could be linked to the rise of Iznik production and its spread all over the Empire and beyond. Trade with Miletus, Iznik and Kütahya ceramics was monopolised by the state, by granting concessions to merchants (Vroom 2017, p. 907). This reveals a strong influence of the Ottoman state on the domestic market. The monopolisation of mass-produced Miletus and Iznik ware is evident in the dominance of Northwest Anatolia within the network.

Additionally, the presence of these luxurious ceramics suggests the existence of a wealthy urban class. This could be linked to Ottoman colonisation policies, which are explained in the historical accounts. Settlers from Asia Minor were moved to the Balkans to populate towns along major roads (Eminov, 1997, p. 27). This expanded urban areas and created the opportunity for a wealthy urban class to emerge, visible in the archaeological record.

Varna's connection to the imperial hinterland is prominent in the 15th and 16th centuries, with imports from Northwest Anatolia dominating. Varna's primary role during the Ottoman period was exporting grain to Istanbul, in exchange for manufactured goods and ceramics (Faroqhi, 1984, p. 77; Pletnyov, 2002–2003, p. 429). Additionally, the revenue from Varna went directly to the central state treasury (Pletnyov, 2005b, p. 2), highlighting its close ties to Istanbul and the central government. Archaeological evidence shows that Varna was well integrated into the imperial system, receiving pottery from established Ottoman partners such as the Italians. However, this evidence alone does not clearly confirm whether Varna had stronger ties to Istanbul compared to other sites.

Sofia's role in the international trade network is largely explained by historical records. Its connection to Italy is well-documented, with Dubrovnik traders playing a key role in Balkan trade by exporting and importing goods to Italy, a connection reflected in both trade models. The relocation of some Dubrovnik merchants to Sofia in the 16th century further strengthened this link. The involvement of Ragusian traders, however, is not evident in the ceramic data, as middlemen are difficult to trace archaeologically.

In the 16th century, Italy plays a greater role in Varna's trade than in Sofia's. Venetian and Ragusian ships traded in the Black Sea until the mid-16th century. Ragusian ships continued to operate freely there until the end of the century. They transported goods between Varna and Italy in both directions (Çelik, 2010, p. 22). This strong connection is evident archaeologically, as Italy remains Varna's largest international partner throughout the period.

Central Europe's presence in the Balkans in the network of the 16th century could be linked to Sofia's growing connections with Europe, following the closure of the Black Sea to non-Ottoman foreign ships in that period (Ishirkov, 1912, p. 55). Interestingly, Varna's connections to Central Europe are absent from historical records. With the city closed to foreign sea trade and the Danube not used for transporting goods from Europe (Faroqhi, 1994, p. 483), any connection to Central Europe was likely overland. However, historical sources provide no details about this overland link. Despite Belgrade's geographical proximity to Central Europe, no archaeological evidence shows a connection between them. This may be due to Belgrade's role as a frontier city with the Habsburg Empire and its function as a military stronghold, which likely obstructed trade with Europe.

During this period, Belgrade undergoes a significant functional transformation. Its strategic role in the wars with the Habsburgs led to an influx of military settlers from Anatolia, eventually making it a more permanent base for the Ottoman army (Bikić, 2003, p. 176). This shift boosted the presence of tradesmen and craftsmen in the city. The growing urban population could explain the presence of Iznik ware, while the high-ranking military officers might account for the appearance of the most luxurious ceramic of that time - Chinese porcelain. However, as with other sites, historical records do not specify international trade connections, even though these are evident archaeologically. This highlights the challenges of interpreting trade networks solely through archaeology.

In the Aegean region, the port of Mytilini was closely linked to Izmir and its surrounding area. Until the 17th century, the Ottomans viewed Izmir and its region primarily as suppliers to the capital, with no significant developmental plans for the area (Goffman, 1999, p. 83–89). This is confirmed in the archaeological scenario, as Mytilini is well integrated into the domestic trade network during the 15th and 16th century. The site mainly receives imperial mass-produced pottery with minimal international connections.

The presence of European merchants in the Eastern Mediterranean and the Levant in the 16th century (İnalcık, 1994, p. 364), may not be clearly visible in Mytilini due to the specific nature of the trade, which is not reflected in the ceramic data. These merchants were primarily involved in the South Asian spice trade, which passed through the Ottomans to Europe. Additionally, Mytilini's close ties to the commercial activities of Chios, which faced an economic decline in the mid-16th century (Faroqhi, 1984, p. 115), may have also played a significant role.

5.2 Crisis and Transformation (17th century)

5.2.1 Archaeological Interpretation

The 17th-century network shows similar patterns to those of earlier periods. Domestic trade is again predominantly represented by the ceramic production centres in Northwest Anatolia, which remains the most influential pottery production centre overall. It contributes to more than half of the imports in Sofia, Varna, and Mytilini, and about 45% of the imports in Belgrade. However, its contribution is slightly reduced compared to the 16th century, indicating changes in trade patterns. Additionally, ceramics from Kütahya and Akchaalan, a site near Iznik, begin to appear as production centres of Northwest Anatolia, disrupting Iznik's dominance, which begins to diminish.

The other domestic production site, the Levant, is only connected to Sofia. This implies that ceramics from there were likely not widespread in the 17th century. Despite Mytilini's geographical proximity to the Levant, it does not have imports from the region. This is probably because Mytilini was a smaller trading centre compared to Sofia and it did not attract as diverse and unpopular connections.

In the international trade, Italy's influence remains dominant. Although its contribution to the imports of the sites is smaller than in the previous century, Italian ceramics are now present at all sites. This suggests an increased role for the Italian city-states in international commerce. Central Europe is on the same level of influence as Italy, expanding its reach to Belgrade during this period. Chinese porcelain becomes even more popular in the 17th century. While it was only found in Belgrade in the 16th century, it is now present in Mytilini and Sofia as well. This luxurious ware indicates the presence of an elite social class across all sites in the network.

Sofia

Sofia remains the most influential site in the network with the biggest variety of imports, based on all centrality measures. It again ranks last in the *Average Neighbour Degree*, indicating that it connects to the most pottery production centres, which, in turn, have few connections within the network. This trend mirrors earlier centuries, where Sofia controlled its own trade network, at-

tracting a wide range of imports without relying on established Ottoman international trade connections.

The largest proportion of Sofia's imports consists of domestic ceramics from Iznik and Kütahya (Northwest Anatolia). Sofia has the highest proportion of Northwest Anatolian ceramics compared to other sites from that period, indicating a strong connection with the imperial heartland. Due to its varied international connections, Sofia was likely positioned at the crossroads of major international trade routes, facilitating the flow of goods and traders to and from the imperial capital. This role has been central to Sofia since the 15th century.

Sofia's international connections remain similar to previous centuries, including the Italian states and Central Europe. In this century, Sofia also receives Chinese porcelain, which appears to have gained popularity among the elite social class.

Belgrade

In the 17th century, Belgrade's role in the trade network noticeably increases, making it the second most influential node. It also ranks second to last in *Average Neighbour Degree*, indicating that it belongs to a more independent trade network, as Belgrade's trading partners are less prominent in other Ottoman cities. This marks a significant shift compared to the previous century, when Belgrade was largely integrated into the Ottoman domestic trade network.

The contribution of Northwest Anatolian ceramics to Belgrade's imports is the smallest compared to other sites. This may be due to Belgrade's geographical location, as it is the furthest site from the main domestic pottery centre. Additionally, Belgrade's position on the border with the Habsburg Empire likely influenced its trade patterns. Nearly 40% of Belgrade's imports come from Central Europe, which includes the Habsburg Empire. Belgrade is not as well integrated into the imperial domestic network as the other Ottoman cities.

Apart from Central Europe, the other international connection of Belgrade is Italy. Although, Italian ceramics make up a small proportion of Belgrade's imports, this connection was not visible in the previous centuries, which indicates a growth in the international trade role of Belgrade.

Varna and Mytilini

Varna and Mytilini are ranked together as the least popular cities in this network. Both cities have the highest *Average Neighbour Degree* scores, indicating they are the best-integrated nodes in both domestic and international trade, receiving pottery from prominent production centres.

The connections of Varna are exactly the same as in the 16th century – the biggest proportion of imports is reserved for Northwest Anatolia, followed by the Italian states and Central Europe. Although Varna's trade practices do not seem to change in the 17th century, the role of the city does

decline within the trade network, since every other site in this analysis experiences an increase of international imports.

In contrast to the previous century, Mytilini rises in importance in this century's network. While over half of its imports still stem from domestic trade, the city now receives goods from Italy (Montelupo), and a larger share of imports from China. This shift highlights Mytilini's transition towards a more internationally oriented trading pattern.

5.2.2 Historical Comparison

The slight decline in Northwest Anatolia's contribution to the total imports of the sites indicates a shift in trade patterns during the 17th century. Historically, this century is associated with local leaders gaining more independence and authority (Goffman, 1999, p. 87). Additionally, the relationship between the Ottomans and Europe shifted, with Europe increasingly regarded as an economic and political equal (Eldem et al., 1999, p. 89). This is visible in the archaeological scenario due to the fact that other pottery production centres, such as Italy, Central Europe and China, start to account for a larger proportion of the imports per site.

The blooming of international trade in the Mediterranean in early 17th century and the increasing of Izmir's role as an international trade hub is noticeable in the network connections of Mytilini. The positioning of Izmir on the global trade map in the late 16th – early 17th century attracted migrant merchants to the region. (Goffman, 1999, p. 83). This also benefited the traders of Chios (Faroqhi, 1994, p. 522), with whom Mytilini's port was closely connected. Compared to 16th century, in the 17th century Mytilini has international connections that make up a large proportion of its pottery imports.

The 17th century is also categorised with the rise of the Balkan Orthodox merchant class, which had already started developing in the 16th century. The population in the major Balkan cities began to shift towards a higher proportion of Slavic and Albanian inhabitants. The Turkish population suffered a significant decline towards the end of the 17th century because of the prolonged wars with the Habsburgs and the Russians (Stoianovich, 1960, p. 250). This suggests that there might be a change in trade patterns, however, such change cannot be traced based on the archaeological evidence. Sofia remains an important trade hub, having diverse international connections, similar to last century.

The effect on the Habsburg wars can mostly be observed in the role of Belgrade. Located on the frontier, Belgrade was under Habsburg control from 1688 until 1690, when it was retaken by the Ottomans (Bikić, 2003, p. 10). Yet, the Habsburgs managed to reclaim nearly all of their territories that the Ottomans had acquired since 1526, conquering a big part of the Western Balkans (Stoianovich, 1960, p. 263). In the archaeological network, this is evident in the strong connection

Belgrade has with Central Europe. In the 16th century, Belgrade had no imports from Central Europe, as opposed to Sofia and Varna. In the 17th century, however, nearly half of Belgrade's imports come from Central Europe. This is a big difference, which marks a political change in the region.

One of the key trade routes in the 17th-century Balkans, mentioned in historical accounts, ran from Istanbul to Buda, passing through Edirne, Filibe, Sofia, Nis, and Belgrade (Faroqhi, 1994, p. 485). This reaffirms Sofia's role, as identified in the archaeological interpretation, as a key node for overland trade, located at the crossroads between major trade routes – the imperial heartland and Central Europe.

While Dubrovnik merchants remained important and active in the trade between the Balkans and Italy, their importance had significantly declined by 1700, due to the decrease of Venice's influence on the global market (Faroqhi, 1994, p. 512). This suggests that there should be a visible decline in Italian imports in the Balkans in the 17th century. Such change, however, cannot be detected in the archaeological scenario. Italy remains a significant node in the trade network, preserving its influence from the previous century and even extending it to include Belgrade.

Varna expresses the same characteristics in the network of the 17th century as in the one of the 16th century, with similar proportion of imports from Northwest Anatolia, Italy and Central Europe. Historical accounts do not point to any significant economic changes in Varna, except for the complete blockade of non-Ottoman ships in the Black Sea from 1592 to 1774 (Çelik, 2010, p. 22). This raises the issue of how Italian imports reached Varna. It is possible that these Italian imports arrived overland, through commerce hubs like Sofia. However, given their relatively high percentage and the persistent connection between Italy and Varna over three centuries, this does not fully explain the situation. There is no information in the historical accounts that can clarify this phenomenon.

5.3 Reforms and Decentralisation (18th century)

5.3.1 Archaeological Interpretation

The network of the 18th century is the most detailed one and has a complex archaeological interpretation. During this period, a significant shift is visible in both the Ottoman domestic and international trade networks.

Compared to previous centuries, there are more domestic pottery production centres in this network. Although Northwest Anatolia remains the most influential export centre, its contribution to the overall imports in the network is smaller than in the 17th century. In addition to the Levant, new production centres such as Chanakkale and Didymoteicho emerge. The introduction of these

new export centres suggests a degree of decentralisation in local authority, as the monopoly of state-controlled ceramics from Iznik and Kütahya gradually diminishes.

The international trade network in the 18th century is also more diverse than before, with the introduction of many new pottery centres. Yet, it is clear that Europe's role as a trade partner of the Ottomans has grown significantly. The German states, along with China, are the most influential nodes in the network, connecting to numerous sites. Both nodes have seen an increase in importance compared to the 17th century. Imports from China constitute a similar proportion of imports to the sites as earlier. However, the emergence of many new nodes has elevated China's role. Italy, once dominant in international trade, is now less influential, though still ranked highly. Other pottery production sites, such as England, Vienna, Delft, France, and Central Europe, account for the remaining international connections in this network. Central Europe is ranked last in influence, although its position was much higher in earlier centuries. This reflects a shift in Europe's most popular production centres. The rise of these new centres has overshadowed the older pottery centres with their large exports.

Izmir

Izmir is present only in the network of the 18th century and it replaces Sofia for the first time as the most popular site, receiving the highest number of connections. Izmir has also one of the lowest *Average Neighbour Degree* scores, which indicates that it is connected to pottery centres which are not exporting to many other sites. Izmir is a prominent trade hub, and as such, it is more likely to attract less established connections.

An interesting observation is that Izmir has a slightly bigger proportion of international pottery (55%) rather than domestic one (45%), which is seen rarely in the networks until now. Its domestic network is still very well developed as it connects to all domestic pottery production centres of the time – Northwest Anatolia (Kütahya), Didymoteicho , Chanakkale and the Levant. The proportion of Northwest Anatolian imports in Izmir is about 25%, representing, the lowest contribution this pottery centre makes to any site in the network. Yet, its diversity in domestic imports indicates that the city is not isolated from the processes happening inside the Empire.

Izmir trades excessively with Europe – England, France, Delft, Meissen, the Italian states, but also with China. This strong connection to Western Europe has not been observed in any other site until now. This reflects a shift in the global market and an increasing role played by Western Europe.

Sofia

Overall, Sofia and Mytilini are ranked at a similar level of influence after Izmir, with only minor variations arising from differences in the algorithms. Sofia further remains consistent in its

connections to less prominent pottery production centres, as reflected in its lower *Average Neighbour Degree* ranking. This suggests that the city continues to maintain its own trade network, likely due to its strategic trade position.

Sofia's domestic network constitutes for a bit more than half of the total imports of the site and it comprises only of Iznik/Kütahya ware from Northwest Anatolia. In terms of its international trade network, Sofia is connected predominantly to Central and Western European pottery centres – the German States (Meissen and Thuringia), Vienna and England. Even though Sofia's connections to Europe are not as diverse as Izmir's, it is clear that European pottery centres start the dominate the global market in the 18th century. This is further supported by the reduced influence of Northwest Anatolia compared to previous centuries

Mytilini

Although Mytilini is ranked similarly to Sofia in terms of popularity, over 80% of its imports come from the domestic centre of Northwest Anatolia. Compared to all other sites, Mytilini shows the greatest influence from the imperial heartland. A small portion of the domestic pottery also comes from the Levant (Syria).

The international trade network of Mytilini is small compared to its domestic one. The port continues to receive ceramics from Italy and China, as it did in the previous century. However, Mytilini also has a new connection to the German states, which makes Europe's influence evident.
The port is still very well integrated into the Ottoman international trade network, as it receives ceramics from influential pottery production centres that export to many other Ottoman cities.

The city's continued strong connection to the imperial heartland can be attributed to its smaller size compared to other ports in the region, likely resulting in fewer international ships passing through it.

Varna

Varna is placed last in terms of influence, together with Belgrade. Its domestic network accounts for about 65% of its total trade connections. The largest ceramic imports come from Northwest Anatolia (Kütahya), with a smaller portion from Chanakkale. Varna loses its connection to the Italian states for the first time since the 15th century, as no Italian ceramics are found in the city. Instead, Varna receives Meissen porcelain from the German States and even more Chinese porcelain. The presence of European ceramics in Varna further reaffirms the increasing economic role of European states in the 18th century.

Similarly to Mytilini, Varna is very well integrated into the Ottoman trade network, receiving imports mainly from influential production centres. The port of Varna relies on the well-established trade networks of the Empire, as it lacks the capacity to attract new, less influential traders.

Belgrade

Belgrade is placed last, together with Varna, in terms of popularity. The site also has the lowest *Average Neighbour Degree* score, indicating it is connected to less prominent nodes in the network. Combined with its low centrality ranking, this suggests that Belgrade can be considered an outlier in the network.

Belgrade is the only site in the network with no connection to any Ottoman domestic production centres. In contrast, the largest proportion of its imports comes from Central Europe, with some Italian imports as well. Belgrade stands out from the other sites, being completely cut off from the Ottoman domestic network. Its strong connection to Central Europe signals a shift away from Ottoman dominance towards a new political and economic ally—Europe.

5.3.2 Historical Comparison

The 18th century is generally viewed as a period of decentralisation, diminished central authority and the rise of provincial leaders (Anastasopoulos, 2006, p. 11; Stoianovich, 1960, p. 253). This is also clearly visible in the archaeological scenario, with the appearance of more Ottoman pottery production centres hat break away from the state-controlled monopoly of Iznik and Kütahya.

This decentralisation is also connected to the economic rise of Europe in the 18th century (Eldem et al., 1999, p. 89; Panzac, 1992, p. 191), which is clearly visible in the archaeological pattern. Pottery centres in Central and Western Europe began to gain more importance and for the first time they started to play a major role in international ceramics trade. This shift in global trade is particularly evident in the pottery imports of Sofia and Mytilini, where the proportion of European imports has increased compared to the previous century.

According to McGowan (1994, p. 730), trade involving German, English, Austrian, and Russian merchants in the Balkans expanded significantly during that period. While the trade with Germany, England and Austria is clearly visible in Sofia's imports, trade with Russia is not.

Izmir began to grow economically in the 17th century, attracting many European traders and becoming one of the largest and most important Ottoman ports (Goffman, 1999, p. 83; Kanberoğlu, 2023 p. 609, Stoianovich, 1960, p. 273). A large part of the Balkan Jewish population migrated to Izmir due to better trade opportunities (Stoianovich, 1960, p. 248). Many Ottoman subjects, as well as European traders – English, Dutch and French, also settled in the city, establishing strong trade connections with Europe (Faroqhi, 1994, p. 522). This is evident in the archaeological scenario, as Izmir is the most prominent site in the network with the most diverse connections and a wide range of imports from Europe.

Izmir has the smallest proportion of imports from Northwest Anatolia compared to the other sites, most probably because of its economic strategy. Goffman (1999, p. 89) notes that Izmir signi-

ficantly reduced its trade with cities in the north and northeast, including Istanbul, in favour of trade with Europe.

Historical accounts provide limited information about Mytilini. What is noted is the commercial rise of the East Aegean in the 17th century, driven by the economic development of Izmir and the surrounding region. Although the site's connection to Northwest Anatolia remains the strongest, this economic shift was already visible in the archaeological record of the 17th century. The international trade network becomes even more diverse in the 18th century. The scarcity of historical information on Mytilini is compensated by archaeological data, which offers a more detailed view of the city's economic development process.

Historical accounts also do not provide specific details about Varna in the 18th century. The Black Sea remained closed for non-Ottoman ships until 1783, when which Russian vessels were allowed to pass and sell their goods to any Ottoman buyer (Stoianovich, 1960, p. 240). However, this change is not necessarily reflected in the archaeological network.

Varna receives Chinese and Meissen porcelain. The presence of Meissen ceramics can be explained with the growing popularity of these imports all over the network. They could have arrived in Varna overland, similarly to the imports from Central Europe in the previous centuries, however, there are no historical accounts that trace this trade road.

The popularity of Chinese porcelain increased in the 18th century, as its value went down due to the many newly emerged porcelain factories in Europe (Faÿ-Hallé et al., 1983, p. 12). Varna's strong connection to Istanbul could explain its big proportion of Chinese porcelain, as the city commonly received luxurious goods from the capital. Chinese porcelain most probably arrived first in Istanbul, after which they were distributed by traders to other places in the Empire. Yet again, no historical information on this trade exchange is available to confirm the archaeological scenario.

Finally, Belgrade's complete detachment from the imperial domestic network can be attributed to the fact that the Habsburg Empire managed to gain control over the fortress in 1717 to 1739 and again in 1789 to 1791 (Bikić, 2003, p. 10). Belgrade was at the centre of armed conflict for much of the century, which likely disrupted its trade activities, particularly with the imperial heartland. The Ottoman's loss of power over the city is evident. In the early 19th century, Belgrade giants its independence after multiple uprisings against the Empire (Cox 2002, p. 42).

5.4 Modernisation and Decline (19th–20th century)

5.4.1 Archaeological Interpretation

The 19th and the early 20th centuries are analysed together as a period. There is little archaeological data available for these centuries, as they are fairly recent and they are often not well archaeologically studied. Belgrade and Izmir are missing from these networks, as no pottery data could be collected for them during these centuries. The analyses of these networks are less detailed compared to earlier centuries, due to the fragmented data.

The 19th century is categorised with the absence of the production centre Northwest Anatolia, as Iznik and Kütahya ceramics are not found in any of the researched sites. This marks the complete disbandment of the state-controlled Ottoman pottery production system for the first time since the 15th century. The domestic production centres of Chanakkale, Didymoteicho and the Levant continue to export ceramics throughout the 19th century. However, the domestic network is not as influential as it was before. Chanakkale ceramics are no longer found in the 20th-century network.

The international trade network of the 19th century remains dominated by European pottery. The most influential production centre is the German states, followed by the Italy, Japan and a small contribution from England and Vienna. Japan is the only new connection in the 19th century, replacing the connection with China as the far eastern trade partner. This clearly points to the decline of Chinese porcelain from the 19th century onward, most likely due to the emergence of new competitors in porcelain production, not only in Europe but globally.

In the early 20th century, Vienna is missing from the international trade network. The pottery production centres are not ranked by their influence in this century due to insufficient data. Overall, the general trend shows that Central and Western European production centres continue to dominate the network. An interesting observation is that Mytilini and Sofia are part of two completely different trade networks as no production centres export simultaneously to both sites. This indicates that both sites have their own individual trading strategies which is not seen in networks from earlier centuries.

Mytilini

What is clear about Mytilini is that its popularity has significantly increased, making it the site with the most diverse connections. Mytilini is well integrated into the domestic imperial trade network, as it receives pottery from all the available domestic production centres in both centuries. Additionally, it has the greatest diversity in international connections, as it is linked to Italy, Germany, and Japan.

Mytilini has kept increasing its importance in the network since the 17th century. It appears that in the 19th and early 20th centuries, the eastern Aegean region was one of the most economically developed areas of the Ottoman Empire, thriving and prospering compared to the other sites analysed.

Sofia

For the first time since the 15th century, Sofia is placed after Mytilini in terms of influence. The site does not connect to any domestic production centre in either century. Its connections are entirely orientated towards Europe: Vienna, Meissen (Germany) and England in the 19th century, and Meissen and England in the 20th century. Since the 18th century, Sofia has been concentrating more on European trade. This trend is clearly visible in the later period. By this time, Sofia is completely disconnected from Ottoman domestic trade and focuses solely on trade with Europe.

Varna

Varna is only present in the network of the 19th century, as no data for the site was gathered for the 20th century. The site is connected only to the domestic production centre of Chanakkale. Similarly to earlier periods, Varna is again the site that is best integrated into the Ottoman domestic system. The role of Varna throughout the centuries of Ottoman rule seems to have been mostly exclusively connected to the Ottoman imperial heartland.

5.4.2 Historical Comparison

The strong political and economic influence of Western Europe over the Ottomans in the 19th century is certainly visible in the archaeological network, as European ceramics are noticeably more than the Ottoman ones. This contradicts the statement of Quataert (1994, p. 828) that the amount of Ottoman domestic trade surpassed the amount of international commerce during the period 1800 to 1914. Quataert, however, further argues that the volume of Ottoman exports and imports rose significantly, with the European provinces leading in international trade. They were followed by Anatolia and the Arab provinces and trade relations with Egypt, Iran, and India were largely neglected (Quataert, 1994, p. 830). The leading role of Europe can be seen based on the imported ceramic amounts. However, the importance of Anatolia and the Arab provinces cannot be determined, neither can be the discontinuation of trade with Egypt, Iran and India. The most probable reason is that there are certain types of trade that cannot be traced only with ceramic data.

It is noteworthy that Japanese porcelain appears relatively late in the network, despite historical evidence indicating that Dutch traders had already shipped significant quantities to Europe in the 17th century (Faÿ-Hallé et al., 1983, p. 233). It is possible that the Ottomans did not participate in this exchange.

Historically, Izmir is considered one of the most prosperous Ottoman cities under the new European dominated economic system of the 19th century (Goffman, 1999, p. 126-128). There is no collected pottery data for Izmir during that period, however, Mytilini's economic situation is tightly connected to Izmir and the region, as seen in earlier centuries. The fact that Mytilini is the most popular site in the networks of 19th and 20th century can be seen as confirmation of the historical scenario.

The island of Lesvos was annexed by the Greek state in the first Balkan War (1912–1913), which shifted Mytilini's trade away from Anatolia and towards Greece and the Aegean (Giannopoulou and Demesticha, 1998). This is not clear in the ceramic imports of Mytilini from the 20th century. This is probably due to the limited amount of pottery data and because the ceramics were likely dated from before the annexation.

Sofia became the capital of the newly formed Principality of Bulgaria in the late 19th century. The loss of Ottoman control over its Balkan territories can be seen archaeologically, as Sofia does not have any Ottoman imports. Further, Sofia's extensive trade with Austria and Bohemia in the 19th centuries, recorded historically (Spasov et al., p. 73), is visible in the archaeological record. Sofia is almost solely connected to the German States and Austria.

The event that had the biggest effect on the economic situation of the Black Sea basin is the opening of the sea for no-Ottoman ships towards the end of the 18th century. This event, however, cannot be observed archaeologically as there is no visible change in the types of pottery imports Varna receives. Another historical scenario that is not visible archaeologically is the strengthening of Varna's connections with Western Europe in the beginning of the 19th century (Spasov et al., p. 73). Varna's only ceramic imports are domestic ones, which is opposite to what the general historical narrative presents. This discrepancy between history and archaeology might be due to the nature of trade happening which might not be able to be traced archaeologically and also due to insignificant archaeological data for that period.

5.5 General Remarks on Archaeological and Historical Differences

Overall, both the historical information and the archaeological scenarios provide similar information when dealing with global economic trends. However, both narratives also provide distinct insights into site-specific details and individual trade connections.

According to Stoianovich (1960), one of the key trends in the Ottoman Balkans after the 16th century is the emergence of two distinct types of Balkan merchants. In the western Balkans, merchants expanded in response to the Ottoman ambition to dominate Mediterranean commerce, while the central and eastern Balkan provinces developed primarily to secure supplies for Istanbul. This trend is visible in the archaeological scenario as Sofia has many more diverse connections that Varna from the 16th century onwards. However, these are only two sites, and further analysis of Stoianovich's argument requires additional information and data from more locations.

In the 17th century, major economic trends that are documented historically can be observed in the archaeological record. Yet, certain site-specific characteristics cannot be easily explained historically. For example, the closure of the Black Sea suggests that little to no international imports would be found in Varna. Yet, there is a strong Italian connection visible in the network in the 17th century.

It is also important to note that the presence of certain pottery, such as Iznik, Kütahya and Chinese porcelain, not only indicates trade connections but also reflects social status. These luxurious wares were affordable only to the wealthy, suggesting that the sites where these ceramics were found also had a presence of an affluent social class.

Some conclusions can also be drawn about what ceramics can and cannot reveal about trade activities. For instance, Quataert (1994, p. 828-834) argues that there is a significant trade happening between the Ottomans and Russia up until the 19th century. Yet, no connection with Russia can be traced through the pottery data. Additionally, Venice and Genoa are known to have established the earliest strong trade relations with the Ottomans. Ligurian ceramics are found in the archaeological networks, but Venetian pottery is not. While ceramics indicate a connection between two nodes, they cannot identify the specific trade actors involved. Middlemen, such as the Ragusians, who traded Italian goods, go undetected in the network. Pottery indicates a connection between two sites, but how it arrives at a specific location and who is the trader cannot be easily determined.

Many historical accounts highlight migrations and shifts in the dominant merchant ethnicity, which are difficult to trace through archaeology. For example, Quataert (1994, p. 839) notes that by the late 18th century, international merchants were dominant. However, by the early 19th century,

non-Muslim Ottoman merchants began to take control of European trade from foreign traders. This shift goes undetected in the archaeological scenario.

What is clear is that data availability is crucial, as network analysis is hindered by a significant lack of data. This is particularly evident for the 19th and 20th centuries. However, a similar lack of historical information can be found in some earlier periods, such as the 15th century. Here archaeological data offers valuable insights on the international connections of each site. Network methods further help evaluate the role of sites within the trade network, including their influence and integration. This is often not very well historically documented, as historical records tend to focus mainly on broader economic trends. In contrast, archaeology provides more detailed site information. This includes connections which are not mentioned in the historical accounts of the Ottoman economy, such as the pottery centres of Valencia, Ephesus, Levant, Japan, etc.

Chapter 6: Conclusion

This research examined the use of network theory in reconstructing trade relations during the Ottoman period and assessed the potential of network methods for working with limited archaeological data. While all archaeological data is inherently incomplete, material from the Ottoman period is particularly under-represented. This study aimed to explore whether network methods could help expand our understanding of the period, even with these limitations.

To address the main research question, I first aimed to answer several key sub-questions. The first sub-question focused on identifying the trends in the economy and trade of the Ottomans in the Balkans and the Aegean from the 15th to the 20th century, based on network models derived from ceramic data from Belgrade, Sofia, Varna, Mytilini, and Izmir. The key trends observed are as follows:

The dominant role of Northwest Anatolia in the network from the 15th to the 19th century highlights the control of the Ottoman state over the majority of domestic trade in the Balkans and the Aegean. Domestic trade is prevalent compared to international trade. The influence of Northwest Anatolia reached its peak in the 16th century, as it was the strongest connection to all sites within the network. The Ottoman state's impact was particularly pronounced in the East Balkans – Varna, as well as in Mytilini up until the 19th century. Varna remained well integrated into the Ottoman domestic trade network across all centuries, receiving pottery from established Ottoman trade partners.

In the West Balkans - represented by Sofia in the network, Ottoman influence on trade was also evident. However, Sofia's international connections point to a more globally oriented trade network in that region. Belgrade is an interesting case, since it is strongly connected to Ottoman domestic pottery production in the 16thcentury. However, by the 18th century, it had entirely shifted its trade strategies towards Central Europe, suspending all commerce with Ottoman production centres. This shift reflects a significant change in political and economic power in the north-west Balkans, marking the Ottoman frontier with European powers.

From the 17th century onwards, a decline in Ottoman central influence becomes evident, as the connections between Northwest Anatolia and the sites in the network gradually weaken. By the 18th century, new domestic pottery centres begin to emerge within the network, and by the 19th century, Northwest Anatolia is no longer represented. This shift reflects a process of decentralisation and the diminishing central authority of the Ottoman state.

The international trade of the Ottomans was highly diverse but consistently remained secondary to domestic trade for most centuries. Italy was the primary trade partner until the 18th century, with a peak of export between the 16th and 17th centuries. During this period, Varna had the

strongest connection to Italy, receiving the largest share of Italian imports. However, from the 18th century onwards, Italian influence declined, and the connection with Varna disappeared. In its place, pottery centres from Central and Western Europe began to take lead in international trade.

Connections with Central Europe, present since the 16th century, were initially limited to the Balkans. Over time, these connections expanded, and by the 18th century, Central and Western European ceramics were being traded across all the sites. From this point onwards, European influence became dominant within the Ottoman trade network.

China first appears in the network in the 16th century and it slowly increases its influence until the 18th century. However, the rise of European production centres in the network during this period reduces China's influence, marking a shift in global trade dynamics. Interestingly, from the 19th century onwards, Japan emerges as a new connection within the network, reflecting changes in the international trade policies.

Regarding the hubs of international trade within the network, Sofia stands out as the most prominent centre until the 18th century. The site has a well-established trade network predating the Ottoman period, thanks to its strategic location at the crossroads of major trade routes. This indicates that Sofia's prominence does not depend solely on Ottoman trade policies. However, in the 18th century Izmir is added to the network and replaces Sofia the site with the most diverse international connections. Izmir clearly establishes itself as an international port within the global trade network, receiving imports from numerous production centres. Its trade is primarily oriented towards European, as observed by its fewer domestic connections compared to international ones.

Based on its geographical proximity to Izmir, Mytilini's importance also grows from the 17th century onwards, marked by an increase in its international connections. From the 19th century onwards, Mytilini surpasses Sofia for the first time, becoming the most influential site within the network.

The next sub-question addresses the differences between the archaeological evidence and historical information. While the main economic trends observed in the archaeological record generally align with those outlined in historical accounts, there are some notable discrepancies. First, aspects that are described in historical sources but are not evident in the archaeological data are presented.

One such discrepancy is the presence of middlemen, like the Dubrovnik merchants who traded Italian goods. Historical accounts highlight their significant role in Balkan trade, yet they remain absent in the archaeological network. Trade actors are hard to identify in the archaeological record. Similarly, the migration of merchants from one site to another, often described in historical sources as key drivers of changes in trade practices, is challenging to detect archaeologically.

The closure of the Black Sea is another historical event that is not visible in the archaeological scenario. Varna continues to receive the same proportion of imports from Italy and Central Europe, even after the closure of the Black Sea in the mid-16th century. According to historical sources, the majority of Varna's imports came from overseas. Despite the possibility that these imports may have been brought overland, there is no clear indication of this in either the historical or the archaeological data. This could be due to the fact that we only have data from a single site on the Black Sea coast, meaning that we lack a broader understanding of the situation along the rest of the coast. It is also possible that again the role of middlemen is not accounted for, as it remains uncertain who brought Italian ceramics to Varna. However, this is difficult to trace archaeologically, and historical sources offer no further explanation.

Another aspect missing from the archaeological network is the export trade of goods beyond ceramics. Materials that are not well-preserved archaeologically, such as organics, are particularly difficult to trace. International trade, such as trade with Russia, is not visible in the network, possibly because ceramics were not involved. If organic materials were traded, there is no way to detect this archaeologically.

The final sub-question addresses aspects of trade visible in the archaeological networks that can enhance our understanding of trade in the region, which are not discussed by historical sources. For instance, in periods where Ottoman historical information is lacking, such as the 15th century, archaeological network models can help broaden our understanding. These models reveal imports and connections that are not mentioned in historical accounts, providing a more comprehensive view of the trade dynamics.

Additionally, archaeology offers much more detailed insights into the specific connections of sites, as imported pottery found at these locations clearly indicates some form of connection, even if an indirect one. Historical sources, on the other hand, often focus on broader economic trends and the larger picture of regional trade. By concentrating on the sites themselves, archaeology allows us to better understand these broader economic trends, as it takes local characteristics into account.

The absence of a particular import at a site does not necessarily mean that historical sources pointing to the presence of such imports were incorrect. It could simply be that the archaeological material was not preserved. However, the presence of ceramic imports at a site clearly indicates a connection. This can help us critically assess the historical sources and question them if such a connection is not mentioned. Moreover, this connection can raise further questions about how the pottery arrived at the site, sparking discussions that might not have otherwise occurred. For example, the presence of international pottery imports in Varna after the Black Sea was closed raises import-

ant questions. If the archaeological material from the site had not been analysed, we would not have questioned how the pottery ended up there, who the traders were, or how the trade route between Italy and Varna functioned.

Finally, to answer the main research question, network theory contributes to the reconstruction of trade relations in the Ottoman period in the Balkans and the Aegean by providing valuable insights. Despite limited data, the general trends observed in the archaeological record align closely with historical information, while also offering additional details about Ottoman trade and economy, particularly regarding specific sites and pottery production centres.

A simple pottery analysis alone could not have provided information on the influence of the sites and the pottery production centres or the strength of their connections. By comparing the sites with one another, we gained a deeper understanding of their integration and position within the Ottoman trade network. For this, network methods proved to be extremely useful, as network analysis adds an additional layer of interpretation, which allows us to observe shifts in economic trends and the increase and decrease of a site's influence over the centuries.

Archaeological networks alone, however, are not sufficient to explain all the economic characteristics of the Ottoman period, nor are historical accounts. Historical sources should not be relied upon entirely, as they often focus on broader events and trends. Archaeological research can either reaffirm the information from these sources or challenge it, while also provide additional details that might not be visible in historical accounts. The combination of archaeological network models and historical sources encourages us to ask questions that we might not have considered otherwise.

Overall, this research demonstrates the usefulness of network methods for examining the relationships between sites and production centres, and for reconstructing trade routes based on these connections. Network analysis can be effectively employed even with limited archaeological data, providing an additional tool for archaeological interpretation. It is important to note that neither archaeological nor historical data should be relied upon too heavily on their own. The best approach is to combine both sources of data and critically evaluate their strengths and limitations.

Network analysis will become increasingly complex with the availability of more archaeological data, leading to even more interesting observations, conclusions, and stimulating broader discussions. To further improve our understanding of the Ottoman period more research is needed. Further research and a more detailed analysis of Ottoman material will help refine network models, enhancing our understanding of trade relations within the Ottoman Empire and their role in global commerce.

Abstract

This study addresses challenges in Ottoman archaeology, where sites and materials are often neglected due to the complex legacy of Ottoman heritage. From its foundation in the 14th century to its dissolution in 1922, the Ottoman Empire left an lasting mark on the heritage of three continents: Southeast Europe, West Asia, and North Africa. Yet, in many of the successor states, Ottoman heritage is regarded as problematic, resulting in limited excavations and a sparse archaeological record that restricts our understanding of its material culture. In contrast, historical analyses of the Ottoman period provide significant insights into trade, economy, and global economic trends. However, historical sources cannot always be taken at face value, as they may disregard certain details or reflect subjective perspectives. While historical accounts often present the broader picture, archaeology has the potential to uncover specific details that could both support and challenge these narratives. The scarcity of Ottoman archaeological data, however, makes it difficult to critically evaluate historical hypotheses.

This research examines the use of network analysis to reconstruct domestic and international trade networks within the Ottoman Empire, with the aim of comparing archaeological findings with historical scenarios and identifying their areas of overlap and divergence. The study focuses on pottery data from five cities: Belgrade, Sofia, and Varna in the Balkans, and Mytilini and Izmir in the Aegean. These cities were strategically chosen as they are located in the heart of Ottoman political and economic influence. They represent regions closest to the imperial capital of Istanbul and thus central to the Empire's economy. By incorporating pottery data into network models and aligning these with historical sources on economic trends and trade routes, the study assesses both the strengths and limitations of network methods in archaeology.

The findings reveal that both historical and archaeological data capture broad trade patterns and shifts in economic focus over the centuries. However, archaeological data uniquely uncovers site-specific connections and can provide valuable insights into periods for which historical records are sparse. Additionally, archaeology offers concrete evidence of interactions between certain regions even when there is no historical information on such exchanges. This allows for new analyses that would not have been possible without the archaeological record. Nonetheless, the study highlights limitations inherent in archaeological methods. For instance, certain international trade relationships are challenging to detect archaeologically due to the nature of commerce, as some goods leave no material trace. Additionally, the role of middlemen (traders dealing in goods from third-party regions) is hard to detect archaeologically. These gaps underscore the importance of integrating multiple sources of evidence to develop a fuller understanding of trade networks.

This research not only offers insights into Ottoman economic networks, but also to the broader methodological discourse in archaeology. It demonstrates how network analysis can be effectively employed with limited archaeological data to enrich historical narratives. However, it advises against depending too heavily on these models, stressing that they should support, not replace, archaeological interpretation. This approach offers future researchers a way to combine archaeological evidence with historical records, improving our understanding of less-studied times and places.

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Appendix A: Dataset with Grouped Source Nodes

Source node	Target node	Quantity	Percent Import	15	16	17	18	19	20
Didymoteicho	Izmir	75	7.5				X		
Chanakkale	Izmir	100	10				X		
Northwest Anatolia	Izmir	270	26.9				X		
Levant	Izmir	5	0.5				X		
Italian States	Izmir	155	15.4				X		
France	Izmir	206	20.5				X		
Delft	Izmir	18	1.8				X		
England	Izmir	91	9.1				X		
German States	Izmir	62	6.2				X		
China	Izmir	23	2.3				X		
Northwest Anatolia	Belgrade	17	94.4		X				
Northwest Anatolia	Belgrade	10	45.5			X			
Central Europe	Belgrade	8.5	38.6			X			
Central Europe	Belgrade	2.5	83.3				X		
Italian States	Belgrade	2.5	11.4			X			
Italian States	Belgrade	0.5	16.7				X		
China	Belgrade	1	5.6		X				
China	Belgrade	1	4.5			X			
Northwest Anatolia	Sofia	9	47.4	X					
Levant	Sofia	1	2.2			X			
Valencia	Sofia	2	10.5	X					
Valencia	Sofia	1	2.4		X				
Ephesus	Sofia	6	31.6	X					
Central Europe	Sofia	1.5	3.6		X				
Central Europe	Sofia	1.5	3.3			X			
Italian States	Sofia	2	10.5	X					
Italian States	Sofia	1.5	3.6		X				
Italian States	Sofia	3.5	7.8			X			
China	Sofia	3.5	7.8			X			
China	Sofia	2.5	6				X		
Northwest Anatolia	Sofia	37.5	90.4		X				
Northwest Anatolia	Sofia	35.5	78.9			X			
Northwest Anatolia	Sofia	23	54.8				X		
German States	Sofia	12	28.6				X		
German States	Sofia	5	50					X	
German States	Sofia	3	85.7						X
England	Sofia	1	2.4				X		
England	Sofia	1.5	15					X	

Source node	Target node	Quantity	Percent Import	15	16	17	18	19	20
England	Sofia	0.5	14.3						X
Vienna	Sofia	3.5	8.3				X		
Vienna	Sofia	3.5	35					X	
China	Varna	6	24.5				X		
German States	Varna	2	8.2				X		
Northwest Anatolia	Varna	1	50	X					
Northwest Anatolia	Varna	12.5	62.5		X				
Northwest Anatolia	Varna	12.5	62.5			X			
Italian States	Varna	1	50	X					
Italian States	Varna	6.5	32.5			X			
Italian States	Varna	6.5	32.5		X				
Chanakkale	Varna	1.5	6.1				X		
Chanakkale	Varna	3.5	100					X	
Northwest Anatolia	Varna	15	61.2				X		
Central Europe	Varna	1	5		X				
Central Europe	Varna	1	5			X			
Chanakkale	Mytilini	1	13.9					X	
Northwest Anatolia	Mytilini	2.5	100		X				
Northwest Anatolia	Mytilini	54.5	83				X		
Northwest Anatolia	Mytilini	5	62.5			X			
Didymoteicho	Mytilini	0.5	6.9					X	
Didymoteicho	Mytilini	0.5	13.5						X
Japan	Mytilini	0.5	6.9					X	
Japan	Mytilini	0.5	13.5						X
Northwest Anatolia	Mytilini	7	87.5	X					
German States	Mytilini	2.5	3.8				X		
German States	Mytilini	2.5	34.7					X	
Levant	Mytilini	1	12.5	X					
Italian States	Mytilini	0.5	6.9					X	
Italian States	Mytilini	0.5	13.5						X
Levant	Mytilini	1.7	2.6				X		
Levant	Mytilini	1.7	23.6					X	
Levant	Mytilini	1.7	45.9						X
Italian States	Mytilini	1	12.5			X			
Italian States	Mytilini	1	1.5				X		
China	Mytilini	2	25			X			
China	Mytilini	6	9.1				X		
Italian States	Mytilini	0.5	6.9					X	
Italian States	Mytilini	0.5	13.5						X

Appendix B: Dataset with Detailed Nodes

Source node	Target node	Quantity	Percent Import	15	16	17	18	19	20
Didymoteicho	Izmir	75	7.5				X		
Chanakkale	Izmir	100	10				X		
Kutahya	Izmir	270	26.9				X		
Levant	Izmir	5	0.5				X		
Abisola_Italy	Izmir	112	11.1				X		
Montelupo_Italy	Izmir	14	1.4				X		
Italy	Izmir	25	2.5				X		
Liguria_Italy	Izmir	4	0.4				X		
France	Izmir	206	20.5				X		
Delft	Izmir	18	1.8				X		
England	Izmir	91	9.1				X		
Meissen	Izmir	62	6.2				X		
China	Izmir	23	2.3				X		
Iznik	Belgrade	17	94.4		X				
Iznik	Belgrade	10	45.5			X			
Central Europe	Belgrade	8.5	38.6			X			
Central Europe	Belgrade	2.5	83.3				X		
Italy	Belgrade	2.5	11.4			X			
Italy	Belgrade	0.5	16.7				X		
China	Belgrade	1	5.6		X				
China	Belgrade	1	4.5			X			
Miletus	Sofia	8	42.1	X					
Levant	Sofia	1	2.2			X			
Valencia_Spain	Sofia	2	10.5	X					
Valencia_Spain	Sofia	1	2.4		X				
Ephesus	Sofia	6	31.6	X					
North Serbia/ South Hungary	Sofia	1.5	3.6		X				
North Serbia/ South Hungary	Sofia	1.5	3.3			X			
Florence_Italy	Sofia	2	10.5	X					
Faenza_Italy	Sofia	1	2.4		X				
Liguria_Italy	Sofia	2	4.4			X			
Montelupo_Italy	Sofia	0.5	1.2		X				
Montelupo_Italy	Sofia	0.5	1.1			X			
Italy	Sofia	1	2.2			X			
China	Sofia	3.5	7.8			X			
China	Sofia	2.5	6				X		
Iznik	Sofia	1	5.3	X					
Iznik	Sofia	37.5	90.4		X				

Source node	Target node	Quantity	Percent Import	15	16	17	18	19	20
Iznik	Sofia	22.5	50			X			
Kutahya	Sofia	10	23.8				X		
Iznik/Kutahya	Sofia	13	28.9			X			
Iznik/Kutahya	Sofia	13	31				X		
Meissen	Sofia	10	23.8				X		
Meissen	Sofia	5	50					X	
Meissen	Sofia	3	85.7						X
Thuringia	Sofia	2	4.8				X		
England	Sofia	1	2.4				X		
England	Sofia	1.5	15					X	
England	Sofia	0.5	14.3						X
Vienna	Sofia	3.5	8.3				X		
Vienna	Sofia	3.5	35					X	
China	Varna	6	24.5				X		
Meissen	Varna	2	8.2				X		
Miletus	Varna	1	50	X					
Iznik	Varna	12.5	62.5		X				
Iznik	Varna	9.5	47.5			X			
Orvieto_Italy	Varna	1	50	X					
Tuscany_Italy	Varna	2	10		X				
Tuscany_Italy	Varna	2	10			X			
Italy	Varna	4.5	22.5		X				
Italy	Varna	4.5	22.5			X			
Chanakkale	Varna	1.5	6.1				X		
Chanakkale	Varna	3.5	100					X	
Kutahya	Varna	15	61.2				X		
Akchaalan	Varna	3	15			X			
North Serbia/ South Hungary	Varna	1	5		X				
North Serbia/ South Hungary	Varna	1	5			X			
Chanakkale	Mytilini	1	13.9					X	
Iznik	Mytilini	2.5	100		X				
Iznik	Mytilini	2.5	31.3			X			
Kutahya	Mytilini	52	79.1				X		
Iznik/Kutahya	Mytilini	2.5	31.3			X			
Iznik/Kutahya	Mytilini	2.5	3.8				X		
Didymoteicho	Mytilini	0.5	6.9					X	
Didymoteicho	Mytilini	0.5	13.5						X
Japan	Mytilini	0.5	6.9					X	
Japan	Mytilini	0.5	13.5						X
Miletus	Mytilini	7	87.5	X					

Source node	Target node	Quantity	Percent Import	15	16	17	18	19	20
German States	Mytilini	2.5	3.8				X		
German States	Mytilini	2.5	34.7					X	
Syria	Mytilini	1	12.5	X					
South Italy	Mytilini	0.5	6.9					X	
South Italy	Mytilini	0.5	13.5						X
Syria	Mytilini	1.7	2.6				X		
Syria	Mytilini	1.7	23.6					X	
Syria	Mytilini	1.7	45.9						X
Montelupo_Italy	Mytilini	1	12.5			X			
Montelupo_Italy	Mytilini	1	1.5				X		
China	Mytilini	2	25			X			
China	Mytilini	6	9.1				X		
Italy	Mytilini	0.5	6.9					X	
Italy	Mytilini	0.5	13.5						X

Appendix C: Overview of Imports and Local Pottery per Site and per Century

Table 3.1: Amount of Local Pottery per site and per century							
Site	**Quantity**	**15**	**16**	**17**	**18**	**19**	**20**
Izmir	822				X		
Belgrade	216		X				
Belgrade	216			X			
Sofia	17.5	X					
Sofia	20		X				
Sofia	14.5			X			
Sofia	19				X		
Sofia	19					X	
Varna	9.3	X					
Varna	105.8		X				
Varna	414.5			X			
Varna	398.2				X		
Varna	57.2					X	
Mytilini	33.3	X					
Mytilini	28.3		X				
Mytilini	30			X			
Mytilini	24.7				X		
Mytilini	25.7					X	
Mytilini	23						X

Table 3.2: Amount of local and imported pottery per site					
Site	**Imports**	**Imports %**	**Local/Regional**	**Local/Regional %**	**TOTAL**
Izmir	1005	55.0%	822	45.0%	1827
Belgrade	43	9.1%	432	90.9%	475
Sofia	161	64.1%	90	35.9%	251
Varna	70	6.6%	985	93.4%	1055
Mytilini	95	36.5%	165	63.5%	260
TOTAL	1374	35.5%	2494	64.5%	3868

Table 3.3: Belgrade						
	15	**16**	**17**	**18**	**19**	**20**
Imports	0	18	22	3	0	0
Imports %		7.7%	9.2%	100.0%		
Local/Regional	0	216	216	0	0	0
Local/Regional %		92.3%	90.8%	0.0%		
Total	0	234	238	3	0	0

Table 3.4: Sofia						
	15	**16**	**17**	**18**	**19**	**20**
Imports	19	41.5	45	42	10	3.5
Imports %	52.1%	67.5%	75.6%	68.9%	34.5%	100.0%
Local/Regional	17.5	20	14.5	19	19	0
Local/Regional %	47.9%	32.5%	24.4%	31.1%	65.5%	0.0%
Total	36.5	61.5	59.5	61	29	3.5

Table 3.5: Varna						
	15	**16**	**17**	**18**	**19**	**20**
Imports	2	20	20	24.5	3.5	0
Imports %	17.7%	15.9%	4.6%	5.8%	5.8%	
Local/Regional	9.3	105.8	414.5	398.2	57.2	0
Local/Regional %	82.3%	84.1%	95.4%	94.2%	94.2%	
Total	11.3	125.8	434.5	422.7	60.7	0

Table 3.6: Mytilini						
	15	**16**	**17**	**18**	**19**	**20**
Imports	8	2.5	8	65.7	7.2	3.7
Imports %	19.4%	8.1%	21.1%	72.7%	21.9%	13.9%
Local/Regional	33.3	28.3	30	24.7	25.7	23
Local/Regional %	80.6%	91.9%	78.9%	27.3%	78.1%	86.1%
Total	41.3	30.8	38	90.4	32.9	26.7