ERF WORKING PAPERS SERIES

Market Integration in the Ottoman Balkans and the Middle East from the Sixteenth Century Until World War I

Pınar Ceylan, K. Kıvanç Karaman and Sevket Pamuk

ECONOMIC RESEARCH FORUM
منتدى البحوث الاقتصادية

Working Paper No. 1805
December 2025

MARKET INTEGRATION IN THE OTTOMAN BALKANS AND THE MIDDLE EAST FROM THE SIXTEENTH CENTURY UNTIL WORLD WAR I

Pınar Ceylan,[1] K. Kıvanç Karaman[2] and Şevket Pamuk[3]

Working Paper No. 1805

December 2025

We would like to thank Fuat Öztürk, Tutku Akın, Sümmeral Karadaş, and Yavuz Selim Kaçmaz for excellent research assistance. Earlier versions of this study were presented at XIX World Economic History Congress, XV European Historical Economics Society Conference, IX CEPR Economic History Symposium, Harvard University, the Martin-Luther University Halle-Wittenberg, Marmara University and ERF 31st Annual Conference. We are grateful to the organizers of these meetings and the audiences for many useful comments and criticisms. TUBITAK 1001 Program project number 220K345 provided support for the research. This work was sponsored by the Economic Research Forum (ERF) and has benefited from both financial and intellectual support. The views expressed in this work are entirely those of the author(s) and should not be attributed to ERF, its Board of Trustees or donors. This paper was originally presented during the ERF 31st Annual Conference on "Youth, Demographic Dividend and Migration in MENA: Challenges and Opportunities in Uncertain Times", April 27-29, 2025.

Send correspondence to:
K. Kıvanç Karaman
Boğaziçi University
kivanc.karaman@boun.edu.tr

[1] Ghent University, Department of Languages and Cultures, Ghent, Belgium. Email: pinar.ceylankotan@ugent.be
[2] Boğaziçi University, Department of Economics, Bebek, Istanbul, Turkey. Email: kivanc.karaman@boun.edu.tr
[3] Boğaziçi University, Ataturk Institute for Modern Turkish History, Bebek, Istanbul, Turkey and CEPR. Email: pamuk@retired.bogazici.edu.tr

First published in 2025 by
The Economic Research Forum (ERF)
21 Al-Sad Al-Aaly Street
Dokki, Giza
Egypt
www.erf.org.eg

Abstract

Using a large body of mostly archival price data, this study examines wheat market integration across the Ottoman Empire and puts it in the context of broader European trends. We find that rates of Ottoman market integration fluctuated without a clear trend during the early modern era followed by greater international integration and geographically uneven domestic integration in the nineteenth century. Overall, Ottoman gains were slower than those in Western Europe in both periods. Our regression analysis points to the role of geography and technological and institutional changes including changes in state capacity as the main forces shaping integration patterns.

Keywords: Market integration, Ottoman Empire wheat market.
JEL Classifications: N1, N8, N9.

ملخص

باستخدام مجموعة كبيرة من بيانات الأسعار الأرشيفية في الغالب، تدرس هذه الورقة تكامل سوق القمح في جميع أنحاء الإمبراطورية العثمانية وتضعها في سياق الاتجاهات الأوروبية الأوسع. ونجد أن معدلات تكامل السوق العثمانية تقلبت دون اتجاه واضح خلال أوائل العصر الحديث، أعقبها تكامل دولي أكبر وتكامل محلي غير متكافئ جغرافيا في القرن التاسع عشر. وبشكل عام، كانت المكاسب العثمانية أبطأ من تلك التي حققتها أوروبا الغربية في كلتا الفترتين. يشير تحليل الانحدار الذي أجريناه إلى دور الجغرافيا والتغيرات التكنولوجية والمؤسسية بما في ذلك التغيرات في قدرة الدولة باعتبارها القوى الرئيسية التي تشكل أنماط التكامل.

1. Introduction

Recent studies on wheat market integration in Europe, China and other regions have begun to provide new insights into the broader discussion of the role of market integration in the Great Divergence and more specifically, the onset of the Industrial Revolution and modern economic growth. Studies using historical wheat prices have shown that market integration in Europe was a long-term, continent-wide process that began in the mid-fifteenth century and continued into the nineteenth century with accelerations and setbacks. Chilosi et al. and Federico et al. and others have also suggested there were strong regional variations in the timing and pace of integration within the continent.[4] In contrast, evidence about early modern wheat market integration in Asian countries is scarce and findings that have emerged in recent years are rather mixed. Most notably, Shiue and Keller and Keller et al. have undertaken quantitative comparisons between China and Western Europe and their findings suggest grain markets functioned with comparable levels of efficiency in the two areas on the eve of the Industrial Revolution.[5]

Making use of large volumes of mostly archival price data, this study examines wheat market integration in the Ottoman Balkans and the Middle East against a background of trends across Europe during the same period. We first construct a wheat price dataset for the Ottoman Empire relying on both primary and secondary sources. This dataset is the most comprehensive in the literature, covering 2,551 annual wheat price observations for 25 Ottoman cities from the sixteenth to the twentieth century. To put Ottoman trends in context, we also use price series for 37 European cities from the same period, based on Federico et al. and other country-specific data.[6]

We then use the new dataset to construct several market integration indices. Measuring market integration is complex due to its multidimensional nature and the variety of methodologies available, each with distinct data requirements and advantages. To provide a comprehensive perspective, we adopt a diverse methodology, constructing indices for domestic and international integration based on the coefficient of variation, bilateral price differences and factor analysis. We also undertake regression analysis of the bilateral price differences to explore the determinants of market integration across time and space.

While the Ottoman Empire participated in the broader European trend towards greater market integration, there were significant differences in timing and pace. For the early modern centuries, our empirical findings indicate that integration of wheat markets inside the empire was marked by short and medium-term fluctuations without a long-term trend. Levels of market integration in the core areas of the empire connecting coastal areas close to the capital city in the Balkans, the Black Sea and western Anatolia were broadly comparable to parts of western Europe such as Spain and

[4] Chilosi, Murphy, Studer, and Tunçer, 'Europe's many integrations'; Federico, Schulze, and Volckart, 'European goods'.
[5] Shiue and Keller, 'Markets in China'; Keller, Shiue, and Wang, 'Capital markets'.
[6] Federico, Schulze, and Volckart, 'European goods'.

France. As one moved away from this core region, however, levels of market integration declined markedly. In contrast, the nineteenth century brought significant progress in domestic market integration between port cities and between them and those areas of the interior connected by railroads. In areas of the interior without railroads, however, gains in market integration remained limited. As a result, Ottoman domestic market integration, both in the core areas and for the empire as a whole, lagged behind western Europe by the early twentieth century.

Regarding the international integration of Ottoman wheat markets, our results show that while Ottoman prices remained below those in most European locations and while there were periods of significant Ottoman exports of wheat to southern Europe, there was no sustained trend toward convergence before the nineteenth century. In contrast, from the 1840s onward, Ottoman port cities experienced greater integration with European markets while the gains in the interior were uneven.

In order to learn about the determinants of wheat market integration in the Ottoman context, we also made use of regression analysis of bilateral price gaps. Our results point to three broad sets of variables as determinants of the timing and pattern of Ottoman market integration: i) geography; ii) technological change and iii) institutional change.

Our results point to a statistically significant positive relationship between bilateral price gaps, on the one hand, and distance or estimated trade costs, on the other. Moreover, unlike many parts of Europe, most of the rivers in the Ottoman Empire were not suitable for year-round navigation and costs of overland transportation remained high. As a result, we find large differences between the degree of integration of locations on the coast and the interior. During the seventeenth and eighteenth centuries the Ottoman political system was relatively decentralized and local notables could develop autonomous fiscal and military capacity and bargain with the center. As one moved away from the core region close to the capital city, the central authority weakened, resulting in different measurement standards, inadequate transportation infrastructure, and occasional local conflicts—all of which disrupted markets.

Significant increases in market integration emerged in the nineteenth century, driven by new technologies, institutional reforms, centralized state-building and open trade policies. Our regression results indicate that both technological changes such as the steam engine and telegraph and institutional changes including changes in Ottoman state apparatus and capacity contributed to the integration of Ottoman wheat markets. Railroads built mostly by European companies arrived relatively late, in the third and especially the last quarter of the nineteenth century, and gave priority to the needs of international trade. On the eve of World War I, areas in the interior without railroads remained isolated from international trade networks. Overland transportation costs remained high and markets remained fragmented in these regions.

The rest of the article proceeds as follows. The next section reviews the debates on the patterns and causes of market integration in Europe and Asia until World War I. Section three introduces the dataset and discusses the empirical methodology. Section four presents our empirical findings and section five situates them within the broader context of debates on market integration and economic growth and on Ottoman economic history. The final section concludes. Appendices provide details on the dataset, methodology, and robustness checks.

2. Studies and debates on market integration until World War I

Economists and economic historians have for long regarded the expansion of markets and the resulting increase in the division of labor and specialization as powerful sources of economic growth, especially in the pre-industrial era. Among recent explanations of the Great Divergence, for example, an influential view holds that well-functioning and efficient markets supported by a certain set of institutions in Europe, not only led to higher per capita incomes during the early modern period but also contributed to the emergence of the Industrial Revolution and its rapid spread in the continent during the nineteenth century. Alongside complementary institutions like a non-distortionary pricing system, robust legal frameworks, and well-defined property rights, the integration and increased efficiency of markets from the Middle Ages onward are believed to have fostered effective resource allocation and productivity gains in Europe.[7] This phenomenon, often referred to as Smithian growth, is compared with the situation in other regions of the world where the absence of an institutional environment conducive to trade and the underperformance of markets are argued to have hindered pre-industrial growth.[8]

In recent decades, along with the shift of scholarly focus to markets and institutions in explaining long-term economic growth and divergence, there has been an increase in studies of wheat market integration, not only for Europe but also for Asia. Wheat prices are among the best quantitative evidence available especially for earlier periods: they are abundant and, given the fairly homogenous nature of wheat, relatively easy to standardize. As economic historians increasingly used wheat price data, market integration has emerged as one of the topics where quantitative methods have made major inroads into research on pre-modern economic history.

Markets integrate when trading costs decline, enabling profitable trade over longer distances. These costs involve various costs associated with trade such as transportation costs, information costs, costs associated with different measures and currencies, policy barriers including tariff and non-tariff barriers, negotiation and contract enforcement costs, legal and regulatory costs and local distribution costs.[9]

---

[7] de Vries, 'The Industrial revolution'; Persson, *Pre-industrial economic growth*; van Zanden, 'Wages and standards'; idem, 'The "Revolt of the early modernists'.
[8] Studer, 'India and the great divergence'.
[9] O'Rourke and Williamson, 'When did globalisation begin?'; Federico, 'How much do we'.

One important cause of market integration or the decline in trade costs is technological change. Technological innovations decrease material and time costs of trade by curtailing transportation and information costs, as well as costs concerning storage and spoilage. While these innovations were relatively limited in number, freight charges tended to decline during the early modern era.[10] The key breaks that the literature has focused on were the invention of steam engine which led to the proliferation of steam ships and railroads and later of telegraph during the nineteenth century.

There is growing recognition in recent decades that institutional change and improvement could be an at least equally powerful cause of market integration in the long run. Those who emphasize the role of institutions argue that technological innovations only set the potential upper bound for market integration. The degree of actual market integration actually depended on how closely historical economies operated in relation to the technological frontier. This view argues that higher transaction costs (information, negotiation, enforcement, exaction costs, and the like) associated with inefficient institutions were more important than freight charges in hampering trade.[11] Consequently, market integration literature considers institutional innovations which spread risks (i.e., marine insurance), increased the mobility of capital (i.e., bills of exchange, improvements in the banking system), and reorganized commercial activity (i.e., new firm models), as important in fostering integration.[12]

Within institutions and institutional change, one area the recent literature has placed a good deal of emphasis on is the role of the state and state capacity which began to increase in many parts of Europe well before the nineteenth century.[13] State capacity is conjectured to have contributed to market integration by making it possible to build physical infrastructure for deploying old or new transportation technologies. It also allowed the building, standardizing and enforcing of the institutional infrastructure, including the legal system, measurement units, monetary system, and tariffs and taxation. More broadly, it has been pointed out that well-functioning markets need to be supported by a wide range of institutions that provide the critical functions of monetary and fiscal stability, regulation, redistribution and conflict management. The state played key roles in the development of these institutions.[14]

Pre-modern states have for long been actively involved in grain markets. Many of them adopted the provisioning of major urban centers, especially of grains, as a key policy objective and implemented various policies including price controls, and restrictions on the movement of goods. The example of the Roman *annona* which provided free grain and later bread to parts of the population of the capital city and which continued in more limited form in the Byzantine empire

[10] Harley, 'Ocean freight rates'; Albers and Pfister, 'Climate Change'.
[11] Epstein, *Freedom and growth*; Ogilvie and Carus, 'Institutions and economic growth'.
[12] Jacks, 'Market integration'.
[13] Karaman and Pamuk, 'Different Paths'.
[14] Besley and Persson, 'The origins'; Dincecco, 'Fragmented authority'; idem, 'The rise of effective states'.

is well known.[15] In medieval Europe, city administrations sought to secure adequate food deliveries to their markets by developing a range of provisioning policies designed to protect the interests of urban consumers. Early modern Chinese governments also adopted various policies including the maintenance of public granaries in order to stabilize grain markets in both urban and rural areas.[16]

From the sixteenth and seventeenth centuries, states in northwest Europe began a process of fiscal centralization. Tax revenues of central administrations first in the Netherlands and later in England exceeded 10 percent of GDP.[17] (Karaman and Pamuk 2013). State capacity also began to rise in other regions of the continent during the seventeenth and eighteenth centuries. Along with the rise in state capacity, infrastructure investment in roads, canals, rivers and ports increased. Improvements occurred also in market supporting institutions, including the legal system, monetary system, measurement units, tariffs and taxation.[18] Not unrelatedly, there also emerged a retreat from the more interventionist policies and growing reliance on markets which contributed to further market integration.[19]

Although technological and institutional change are acknowledged in market integration studies, few quantitative works explore their role in pre-modern times.[20] Using European wheat prices, Chilosi et al. and Federico et al. show that integration was a gradual, continent-wide process that began well before nineteenth-century technological improvements.[21] This evidence supports the view that trajectory of pre-industrial commodity markets also depended on the improvements in the institutional environment.

Evidence on early modern wheat market integration in Asia is limited and mixed. Shiue and Keller and Keller, Shiue and Wang provided econometric evidence that grain markets in China and Western Europe operated with similar efficiency before the Industrial Revolution, suggesting that both formal and informal institutions effectively facilitated trade in pre-industrial China.[22] However, more recent studies indicate a decline in Chinese market integration from the 1760s, even in advanced regions like the Lower Yangzi, with European markets outperforming China before 1800.[23] This decline is largely attributed to political instability and weakening state capacity. Studer also found significant gap in market integration between Europe and India from

[15] Teall, 'The Grain Supply'; de Vries, *The Price of Bread.*
[16] Will, Wong, and Lee, *Nourish the people.*
[17] Karaman and Pamuk, 'Different Paths'.
[18] Ogilvie, 'State capacity'.
[19] Bateman, 'The Evolution of markets'; Chilosi, Murphy, Studer, and Tunçer, 'Europe's many integrations'; Federico, Schulze, and Volckart, 'European goods'.
[20] Jacks, 'Market Integration'; idem, 'What drove'; Uebele, 'National and International'; Uebele and Gallardo-Albarrán, 'Paving the way'; Chilosi and Federico, 'Early globalizations'.
[21] Chilosi, Murphy, Studer, and Tunçer, 'Europe's many integrations'; Federico, Schulze, and Volckart, 'European goods'.
[22] Shiue and Keller, 'Markets in China'; Keller, Shiue, and Wang, 'Capital markets'.
[23] Bernhofen, Eberhardt, Li, and Morgan, 'The Evolution of Markets'; idem, 'Sources of market disintegration'; idem, 'Assessing market integration'; Cui, Yang, and Xiong, 'The decline'.

1750 to 1914.[24] Indian wheat markets remained largely isolated due to high transportation costs and political fragmentation, with no observable gains before the mid-nineteenth century.

Some studies of market integration have also been undertaken for the Ottoman Empire and the Middle East in recent years. Ozmucur and Pamuk did not find price convergence between Ottoman and European markets during the period before 1800.[25] Ceylan examined Ottoman wheat markets from 1660 to 1840, finding medium-term fluctuations but no convergence.[26] Li et al. used Bayesian dynamic factor models to analyze prices from Istanbul and 19 European cities (1469–1914), revealing persistent linkages until the early nineteenth century, followed by declining convergence.[27] Panza studied the impact of the Ottoman Empire's collapse on regional and colonial markets in the Near East, showing that integration strengthened through the nineteenth century until WWI, but declined during the interwar period.[28]

At the present state of research, however, empirical evidence from the non-Western world is still insufficient to conclude whether Europe had a distinct advantage in the levels of market integration during the early modern era. Moreover, empirical studies are lacking on the determinants of market integration, specifically on the role of technological and institutional change. With a quantitative study of wheat market integration in the Ottoman Empire and the role of technological and institutional change in that process, we hope to contribute to a better understanding of market integration and its determinants before World War I.

3. Data and methodology

This section outlines the data sources and empirical strategy. It begins by describing the construction of the new wheat price dataset and related variables, including distance, transportation costs, war intensity, monetary instability, state capacity, climate shocks, and transportation connectivity. It then gives an overview of the methodology used to measure price convergence and market efficiency.

A major contribution of the study is to build the first comprehensive historical price dataset for the Ottoman Empire and more broadly the Middle East and the Balkans from the sixteenth century to early twentieth century. For this purpose, we collected wheat price data from a large number of archival records, including Ottoman court registers, inheritance registers, public foundation records and consular reports, as well as secondary sources. Because the measurement and monetary units varied greatly across different parts of the Empire and over time, we standardized

[24] Studer, 'India and the great divergence'.
[25] Ozmucur and Pamuk, 'Did European commodity prices'.
[26] Ceylan, 'Essays on'.
[27] Li, Panza, and Song, 'The evolution of'.
[28] Panza, 'From a common empire'.

them. We then cross verified price data across different sources and regions, corrected them when possible, and recorded any remaining issues. The resulting dataset covers 25 cities and a total of 2551 annual price observations.[29] The sources, the conventions used in data collection, and potential issues with the data are discussed in Appendix A.

Figure 1. Map of cities in the sample

Figure 1 illustrates the geographic coverage of our price dataset. We compile wheat price series for 25 Ottoman cities, marked with black dots, spanning the Middle East and the Balkans. To better interpret patterns of market development within the Ottoman Empire, we place the Ottoman data in comparative perspective by relying on price data for 37 European cities, marked with different colors based on country or region. European price data is mainly taken from Federico et al. dataset.[30] For London, Vienna, Lisbon, Madrid, Valencia, we also rely on other sources.[31]

---

[29] In the empirical analysis, we drop the observations for Belgrade after 1867 and for Braila after 1878 as they gained formal independence from the Ottoman Empire, leaving 2447 observations.

[30] Federico, Schulze, and Volckart, 'European goods'.

[31] For London, Clark ('Farm wages and living standards'). For Vienna, Zechner ('Prices and wages') before 1850, Allen ('The great divergence') afterwards. For Lisbon, Palma and Reis ('From convergence') before 1850, Reis ('A «Lei da Fome»') afterwards. For Madrid, Losa and Zarauz ('Spanish subsistence wages') before 1800, Segova series from Federico, Schulze, and Volckart ('European goods') for 1800-1857. For Valencia between 1806-1855, Hernández Sempere, ('El trigo y el Arroz').

Figure 2. Sample of annual price observations

Figure 2 presents the availability of wheat price data for each Ottoman city and year. Each dot represents a year for which price data exists while gaps indicate missing data. The figure illustrates substantial variation in both the availability and the starting date of the price series across cities. The most comprehensive data is available for four cities at the core of the Empire: Istanbul, Edirne, Bursa, and Manisa. For these cities, it is possible to construct a balanced dataset from the 1560s to 1914 with some reliance on interpolation. Geographically, this core area is comparable in size to medium-sized European states. For seven additional cities (Ankara, Konya, Antep, Salonica, Damascus, Kayseri, Cairo), a balanced price dataset can be constructed from 1680 to 1914, although it requires more interpolation and is thus of lower overall quality. For the remaining fourteen cities, the price data is only available for select periods, allowing only the construction of an unbalanced dataset. In the empirical analysis that follows, different subsets of cities and time periods are used depending on the econometric requirements of the model.

We also compile data on a range of variables that may influence trade integration. A key variable is the great circle distance between city pairs, defined as the shortest path between two points along the Earth's surface. In historical trade analysis, great circle distance is widely used as a proxy for transport costs, particularly in the absence of detailed route-level data.[32]

In addition to great circle distance, we construct a second proxy for historical trade costs by utilizing data from Scheidel et al. transport cost estimation model.[33] This model estimates transportation costs for the Roman Empire's transportation network, which includes roads, rivers, and sea routes. It accounts for different modes of transport and terrain to determine the most cost-effective routes between cities for transporting wheat. Crucially, the model captures substantial differences in land and sea transport costs, crucial in historical contexts where maritime routes were much cheaper. Given the stability of transport technology from Roman to early modern times, and since what matters for empirical analysis is the relative rather than absolute costs, this provides a reasonable proxy for Ottoman transportation costs.[34]

A third variable we construct is war pressure. Wars disrupted production, damaged agricultural output, diverted labor and resources toward military needs, and impeded trade routes through insecurity and destruction of infrastructure. To capture the severity of these disruptions, we proxy war pressure using annual war casualties, based on Clodfelter.[35] If Ottomans were involved in multiple wars within a year, we aggregate the casualty figures across conflicts. We compute this index separately for wars fought on the western front with European powers and on the eastern front with Iran, the Mamluks, and the Wahhabis, recognizing that different theaters may have had different economic impacts.

To control for monetary instability, we use the series developed by Karaman et al., which measures the annual rate of decline in the silver content of the Ottoman currency.[36] Monetary instability could have disrupted market functioning by generating uncertainty, undermining trust in transactions, and impeding trade and integration.

To capture variation in state capacity, we employ the tax revenue per capita series (expressed in days of wages) from Karaman and Pamuk.[37] Higher per capita tax revenues, as a proxy for stronger state capacity, may have supported trade integration by enabling investment in both physical infrastructure, such as roads and ports, and institutional infrastructure, including legal enforcement, contract protection, and suppression of banditry. These functions were critical for lowering transaction costs and ensuring the security and predictability necessary for trade.

---

[32] To assess the validity of this proxy, the Figure A1 in the appendix plots the great circle distance from Istanbul to various cities against official freight rates from the early 1800s based on Aynural (*İstanbul değirmenleri ve fırınları*), and finds a strong positive relationship.
[33] Scheidel, Meeks, and Grossner, ORBIS.
[34] Appendix A discusses the estimation procedure and the resulting transportation cost estimates.
[35] Clodfelter, 'Warfare and armed conflicts'.
[36] Karaman, Pamuk, and Yıldırım-Karaman, 'Money and Monetary Stability'.
[37] Karaman and Pamuk, 'Ottoman State Finances'.

To account for climatic shocks, we use annual Drought Severity Index values from the Great Eurasian Drought Atlas (GEDA). The index is based on historical temperature and precipitation data reconstructions and is calibrated to make results comparable across regions. Negative values indicate dry conditions, while positive values reflect wetter-than-normal years. For each city pair, we compute the bilateral difference in their drought index values to capture relative drought severity. This difference serves as a proxy for asymmetric supply shocks: when one city experiences drought while the other does not, local shortages may contribute to observed price gaps between them.

Finally, we construct a series indicating the dates when steamship and railroad connections reached each city. Steamships were introduced in the Ottoman Empire in the 1830s and rapidly extended to major port cities, significantly reducing maritime transport times and increasing reliability. Railroads began to be developed in the 1870s, but their expansion was slower and remained limited in geographic scope by the end of the empire. Together, these technological advances would be expected to lower transport costs and contribute to integration.[38]

As for the methodology of measuring market integration, the literature distinguishes between two key dimensions: price convergence and market efficiency.[39] Price convergence denotes the extent to which equilibrium prices across spatially distinct markets tend to equalize over time, in accordance with the law of one price. Market efficiency, by contrast, refers to the speed and completeness with which price differences across locations are corrected following a shock. While related, these dimensions are analytically distinct and require different measurement strategies.

Reflecting this methodological diversity, we construct indices for both convergence and efficiency. For price convergence, we compute the coefficient of variation and examine bilateral price gaps. For market efficiency, we employ factor models and pairwise correlation analysis to assess price co-movement across markets. This methodological diversity is warranted for three reasons: convergence and efficiency may diverge and offer distinct insights into integration; different methodologies vary in data requirements and aggregation levels, enabling more nuanced analysis; and consistent findings across methods strengthen the robustness and credibility of the results. However, due to the annual frequency and partial interpolation in our data, which constrain the reliable measurement of market efficiency, our focus is on price convergence, which is less affected by these limitations. The next section and the appendix provide detailed accounts of each method used in the analysis.

[38] The dates for steamship and railroad connections for each city is listed in Appendix A. Railroad data is based on Hanedar and Uysal ('Transportation Infrastructure'). Table A3 in the appendix lists the summary statistics of the variables used in the empirical analysis.

[39] Federico, 'How much do we'.

4. Evidence on market integration

The empirical results are presented in two subsections. We begin with domestic integration, tracing how prices converged and co-moved across Ottoman cities. We then turn to international integration, investigating the extent to which Ottoman markets integrated with their European counterparts.

4.1. Domestic integration

This subsection combines three metrics, the coefficient of variation, bilateral price gaps, and domestic factor co-movement indices to map the timing and geography of integration in the Empire and benchmark it against European countries.

We begin by calculating a fundamental indicator of price convergence: the coefficient of variation. For each year, this measure is computed by dividing the standard deviation of wheat prices across cities within a country by the country-wide average:

$$COV_t = \frac{\sqrt{\frac{1}{N-1}\sum_{i=1}^{N}\left(p_{i,t} - \mu_t\right)^2}}{\mu_t} \quad (1)$$

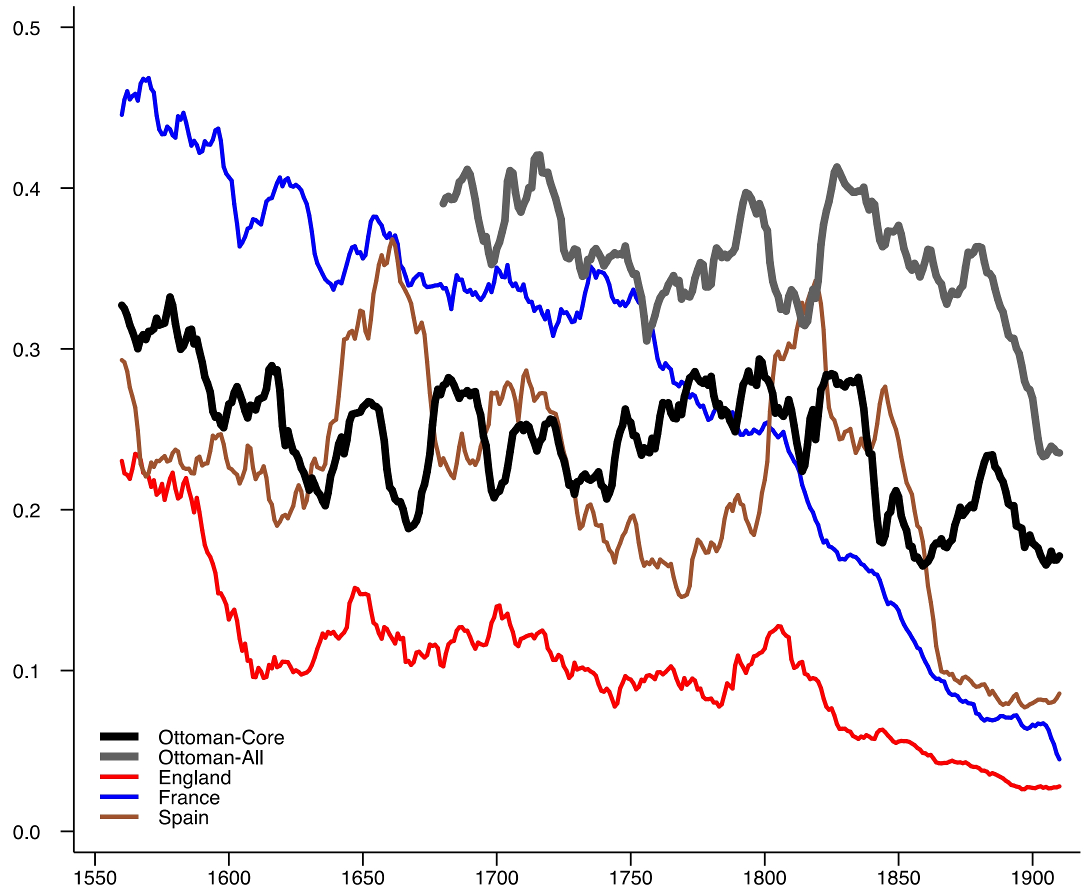
In the formula, $p_{i,t}$ denotes the wheat price in city i at year t, and μ_t is the average price across all cities in year t. The underlying logic is that as markets become more integrated, price dispersion across cities diminishes, resulting in a lower coefficient of variation.

Figure 3 presents the domestic coefficient of variation series for two Ottoman city samples. The black line represents a core group of four cities: Istanbul, Manisa, Edirne, and Bursa. For this group, a relatively complete and balanced dataset is available from 1560 to 1914, requiring minimal interpolation. The gray line corresponds to an extended sample of eleven cities, which also includes Ankara, Konya, Antep, Salonica, Damascus, Kayseri, and Cairo. A balanced price series for this broader group can be constructed beginning in 1680, although it requires more interpolation. To place the Ottoman case in comparative context, the figure also includes coefficient of variation series for England, France, and Spain. All series are smoothed using 21-year moving averages to improve readability and highlight long-term trends.

For the core cities (black line), the figure reveals two periods of significant convergence: the latter half of the sixteenth century, associated in the literature with commercial expansion, and the nineteenth century, a period marked by modernization and reform. These visual trends are substantiated by Bai–Perron structural break tests, which identify significant breaks in 1626 and 1845 at 10% confidence level.[40]

The wider 11-city sample (gray line), spanning 1680 to 1914, displays greater volatility but no sustained convergence until the second half of the nineteenth century. From this point onward, a pronounced decline in the coefficient of variation is evident. Structural break analysis detects five breaks in this sample: 1714, 1748, 1782, 1818, and 1858.

Figure 3. Domestic coefficient of variation indices for Ottoman Empire and other European states, 1560-1910



Source: Authors' estimations

When placed in comparative context, the coefficient of variation for the Ottoman core in the sixteenth century was similar to that of Spain and lower than France. Over time, Spain's coefficient remained relatively stagnant until the nineteenth century, when it declined sharply. France, by contrast, experienced a more gradual and continuous decline. As a result, by the early twentieth

[40] Bai and Perron, 'Computation and analysis'.

century, the Ottoman coefficient of variation stood significantly higher than both, despite the gains during the nineteenth century.

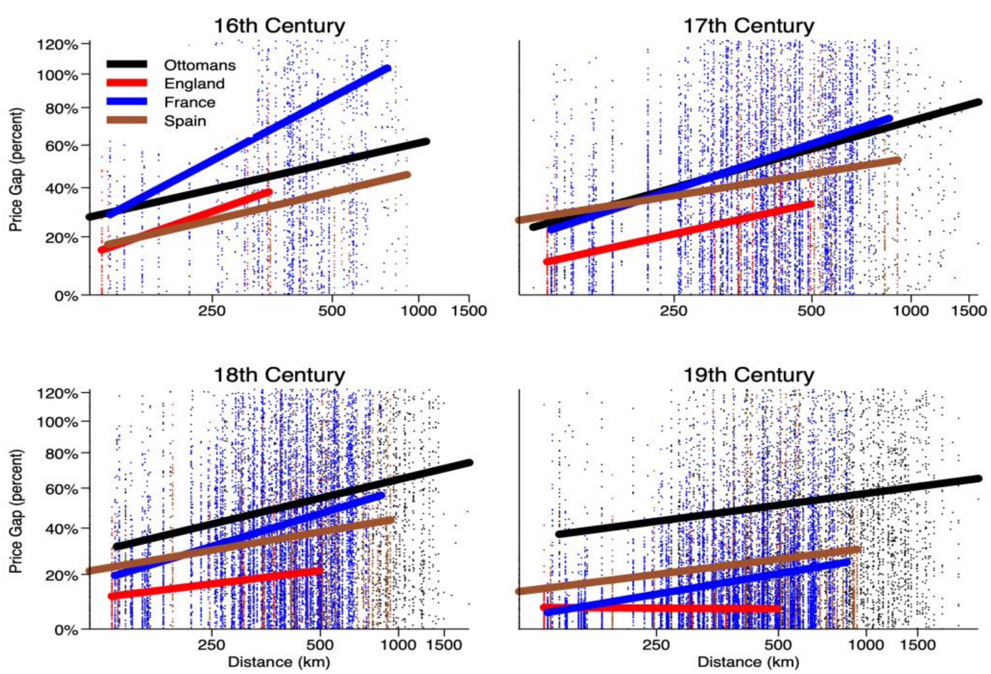
The coefficient of variation analysis, however, has several limitations. First, it does not account for geographic scale. Larger countries typically face higher transportation costs and greater regional price variation, which can artificially inflate the coefficient. Second, the method requires balanced panel data, leading to the exclusion of cities with fragmented price series and necessitating interpolation for those retained. Third, while the coefficient provides a useful overview of integration trends, it does not allow for disaggregation by region or by individual city pairs.

To overcome these limitations, we next turn to an analysis of bilateral price gaps between city pairs within each country. Our proxy is the log absolute bilateral price gap, defined as:

$$\log(\text{pricegap}_{i,j,t}) = \left|\log\left(p_{i,t}\right) - \log\left(p_{j,t}\right)\right| \quad (2)$$

This metric captures the absolute value of the difference in logarithmic prices between cities i and j in year t. Unlike the coefficient of variation, this approach allows for analysis at the city-pair level and does not require interpolation; we calculate the price gaps directly for all available city-year observations.

Figure 4. Bilateral price gap between pairs of cities within different countries



Source: Authors' estimations

Figure 4 presents bilateral price gaps for an unbalanced panel of four countries. The y-axis shows the absolute price gaps, expressed as percentages, while the x-axis plots the great circle distance between city pairs in log scale. Observations are grouped by century: sixteenth, seventeenth, eighteenth, and nineteenth. Each point represents a single city pair in a given year. Best-fit lines are included for each country to illustrate the relationship between distance and price gap.

Several patterns emerge from the figure. First, there is a consistent positive relationship between price gaps and distance, as indicated by the upward slopes of the best-fit lines. However, the strength and evolution of this relationship vary across countries and over time. In the sixteenth century, conditional on distance, price gaps between Ottoman cities were smaller than those in France but slightly larger than those in Spain and England. During the seventeenth and eighteenth centuries, the Ottoman trend line remains largely unchanged, suggesting limited progress in market integration. In contrast, the lines for the three European countries shift downward, indicating steady integration even after controlling for distance. The Ottoman trend begins to decline only in the nineteenth century but continues to lie above its European counterparts. These findings are consistent with Figure 3 and further underscore that the Ottoman Empire experienced slower and later market integration compared to Western Europe.

To further explore the determinants of price convergence, we estimate variants of the following regression model:

$$\log(\mathrm{pricegap}_{i,j,t}) = \beta \cdot \log(\mathrm{distance}_{i,j}) + \sum_{s}(\gamma_s \cdot \mathrm{decade}_s) + \sum_{i}(\alpha_i \cdot \mathrm{city}_i) + \sum_{j}(\alpha_j \cdot \mathrm{city}_j) + \delta' Z_{i,j,t} + u_{i,j,t} \quad (3)$$

In this model, $\log(\mathrm{pricegap}_{i,j,t})$ is the log absolute price gap between cities i and j in year t. The term $\log(\mathrm{distance}_{i,j})$ captures the effect of great circle distance between cities, decade_s are decade fixed effects, city_i and city_j are city fixed effects, and $Z_{i,j,t}$ is a vector of additional variables that vary by city pair and period. The error term is denoted by $u_{i,j,t}$. Reported standard errors are based on White's heteroskedasticity-consistent covariance matrix estimator, commonly referred to as robust standard errors. The underlying premise of this model is that price gaps can be decomposed into a common time trend (γ_s), city-specific factors (α_i), the effect of distance (β), and additional pair-specific or time-varying determinants (δ).[41]

[41] See Schulze and Wolf ('On the Origins of') and Uebele (National and international) for related empirical specifications.

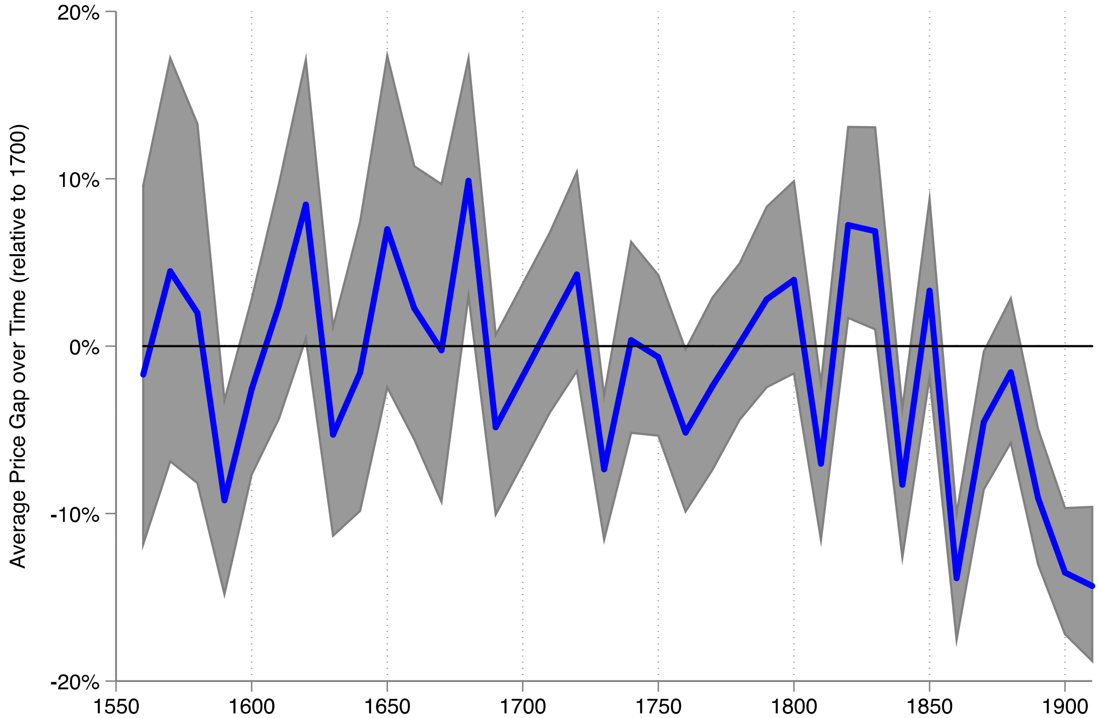
Table 1. Determinants of bilateral price gaps

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Distance (log)	0.073***		0.063***		0.071***		0.064***	
	(9.88)		(15.77)		(9.57)		(5.64)	
Transportation Cost (log)		0.029***		0.016**		0.029***		0.019**
		(4.92)		(2.53)		(4.94)		(2.08)
State capacity					-0.007***	-0.007***	-0.013***	-0.012***
					(-5.36)	(-5.28)	(-6.12)	(-5.57)
Monetary instability					0.003***	0.003***	0.004***	0.004***
					(6.54)	(5.77)	(6.78)	(6.69)
Steamship connection					-0.107***	-0.101***	-0.082***	-0.091***
					(-8.25)	(-7.75)	(-4.45)	(-4.82)
Railroad connection					-0.063***	-0.071***	-0.01	-0.015
					(-2.63)	(-2.94)	(-0.32)	(-0.50)
War pressure (west)					0.054***	0.051***	-0.008	-0.005
					(3.33)	(3.12)	(-0.39)	(-0.23)
War pressure (east)					0.118	0.093	-0.025	-0.027
					(1.02)	(0.81)	(-0.14)	(-0.15)
Climate shock					0.006**	0.008***	0	0.001
					(2.49)	(3.05)	(0.05)	(0.26)
Observations	8654	8273	7306	7190	8654	8273	3691	3678
City FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Decade FE	Yes	Yes	No	No	No	No	No	No
19th century × City FE	No	No	Yes	Yes	No	No	No	No
Sample	Full	Full	Full	Full	Full	Full	Restricted	Restricted

*Notes: The dependent variable is log absolute bilateral price gap. Robust standard errors. T-statistics in parentheses. Levels of statistical significance: * 0.1 ** 0.05 *** 0.01*

We estimate several specifications of the empirical model, with the results presented in Table 1. Specification 1, the baseline model, includes controls for log distance, decade fixed effects, and city fixed effects. For the impact of distance, the table shows that the estimated coefficient is positive and statistically significant, as would be expected. For the decade fixed effects, the estimated coefficients are not reported in the table for the sake of brevity but are instead presented in Figure 5. In this figure, the x-axis represents decades, while the y-axis shows changes in the average price gap between Ottoman city pairs relative to the baseline period, 1700 to 1709, along with the 95 percent confidence intervals. The figure reveals fluctuations in price gaps over time, with a sustained decline emerging only in the late nineteenth century. This pattern is consistent with the earlier results shown in Figures 3 and 4, which also associate lasting improvements in market integration with the nineteenth century.

Figure 5. Evolution of average price gap between Ottoman cities over time

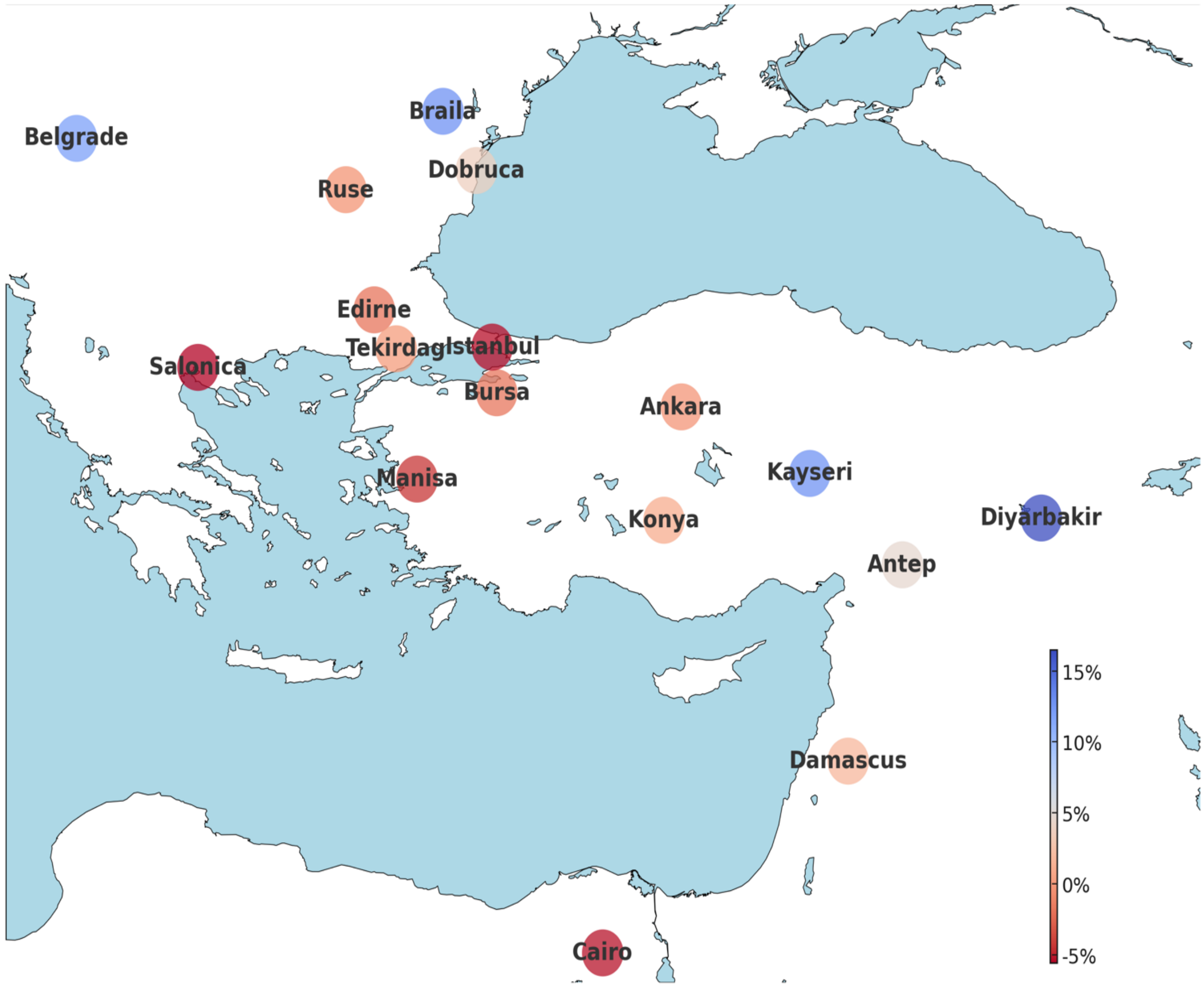


Source: Authors' estimations

As for the city fixed effects estimated in Specification 1, they are mapped in Figure 6. These estimated effects reflect each city's average contribution to bilateral price gaps after controlling for distance and temporal variation. Cities shaded in red have lower average price gaps with other cities, indicating stronger market integration, while those in blue exhibit higher gaps, suggesting weaker integration. The geographic pattern highlights that the core regions around Istanbul and the coastal cities were more integrated into the domestic market, whereas inland cities located farther from core tended to show lower levels of integration.[42]

[42] Figure C3 in the appendix plots pairwise price correlations, a measure of market efficiency, between 11 Ottoman cities. The figure also shows that integration levels were higher in core regions and lower in the periphery, as consistent with Figure 6.

Figure 6. Estimated impact of individual cities on price gaps (% change), controlling for great circle distance



Source: Authors' estimations

Next, for robustness, Specification 2 re-estimates the baseline model in Specification 1, replacing great circle distance with the logarithm of estimated transportation costs based on Scheidel et al. as the proxy for trade costs.[43] This alternative measure accounts for the lower cost of maritime transport and thus better captures the advantages of coastal access. The results remain broadly consistent with those of Specification 1. Estimated transportation costs are positively associated with price differences between cities. The decade fixed effects and city fixed effects, plotted respectively in Figure C1 and C2 in the appendix, also indicate a decline in price gaps during the nineteenth century and lower price gaps for the core cities.[44]

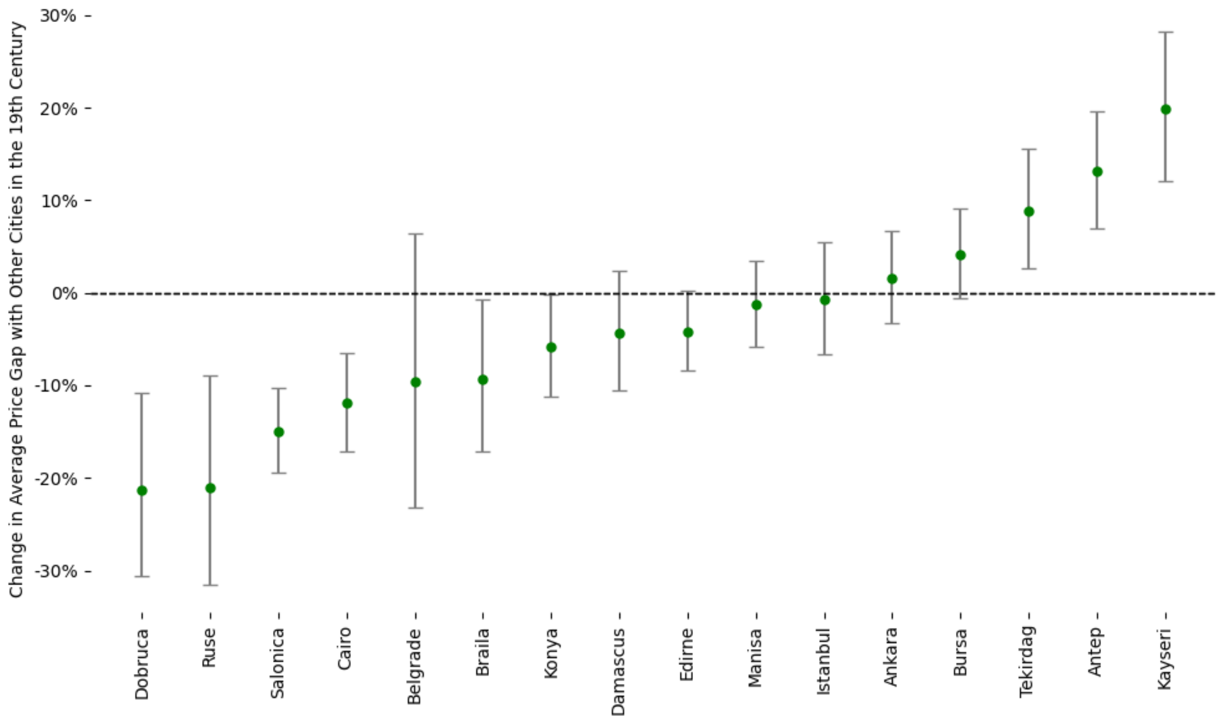
---

[43] Scheidel, Meeks, and Grossner, ORBIS.

[44] The pattern in which the core region around Istanbul emerges as the most integrated, even after controlling for sea access, suggests that factors beyond geography contributed to integration outcomes. In particular, administrative proximity to the imperial center, where state capacity and the provision of public goods were most concentrated, may have played a significant role. This interpretation is further supported by the regression estimates from Specifications 5 through 8, discussed below.

Specification 3 explores regional variation in the time trends of market integration. While Figure 5 documents a general decline in price gaps during the nineteenth century, it does not account for potential differences across cities. Some cities may have experienced substantial integration during this period, while others may have seen little or no change. To examine this heterogeneity, Specification 3 includes interaction terms between a nineteenth-century indicator and city fixed effects. These interaction terms measure how each city's average price gap with other cities changed in the nineteenth century. The estimated coefficients are plotted in Figure 7.

Figure 7. Change in price gaps in the nineteenth century



In Figure 7, the x-axis lists individual cities, while the y-axis plots the corresponding interaction coefficients with 95% confidence intervals. Negative coefficients indicate that a city experienced a decline in price gaps with others in the nineteenth century, reflecting increased integration, whereas positive coefficients suggest the opposite.

The results show that reductions in price gaps were concentrated in coastal cities (Cairo), in the western regions of the Empire (Ruse), or in cities combining both characteristics (Dobruca, Salonica, Braila). These areas likely benefited from modernization reforms, the growth of steamship connectivity, and intensifying economic ties with Western Europe. In contrast, cities in the eastern interior—such as Antep and Kayseri—experienced rising price gaps, suggesting limited participation in these integrative dynamics. There is also an increase in average price gap for Tekirdag, while for the other cities the change is not statistically significant.

Specifications 5-6 go beyond reviewing patterns and test specific explanations for the drivers of market integration. In particular, we test the impact of state capacity (measured per capita tax revenues), monetary instability (measured by the annual decline in the silver value of monetary unit), war pressure (measured by war casualties on eastern and western fronts), climate shocks (measured by relative drought severity) and steamship and railroad connection. Specification 5 controls for trade costs by including distance, and specification 6 by estimated trade costs.

The results support a multi-causal interpretation of market integration, highlighting the importance of both institutional and technological factors. On the institutional front, greater state capacity is associated with lower price gaps, while monetary instability corresponds to wider gaps. Technological factors such as steamship and railroad connections contribute to price convergence, with both variables exhibiting negative and statistically significant coefficients. In contrast, wars on the western front and asymmetric climate shocks are linked to increased price gaps. Wars on the eastern front, however, show no significant effect, likely due to their distance from core urban centers and their more limited impact on major market activity.

Finally, specifications 7–8 re-estimate the models from specifications 5–6 using a restricted sample limited to city pairs either connected by navigable waterways or located within 100 kilometers of each other. This restriction addresses the theoretical concern that price gaps serve as meaningful indicators of market integration only when trade is feasible and price differentials can trigger arbitrage. Accordingly, we exclude land-connected pairs whose distance likely precludes regular trade.

In the restricted sample, the effects of distance, transportation costs, state capacity, monetary instability, and steamship connections remain robust. However, the results for three additional variables diverge from those in the full sample. While railroad connections are associated with lower price gaps in the full sample, they have no significant effect in the restricted sample, likely because railways were introduced relatively late and primarily served inland city pairs that are excluded from this subsample.[45] Similarly, wars on the western front and asymmetric climate shocks increase price gaps in the full sample but show no significant effect in the restricted one. This pattern suggests that coastal and well-connected cities were more resilient to such shocks, whereas more isolated inland locations were more vulnerable.[46]

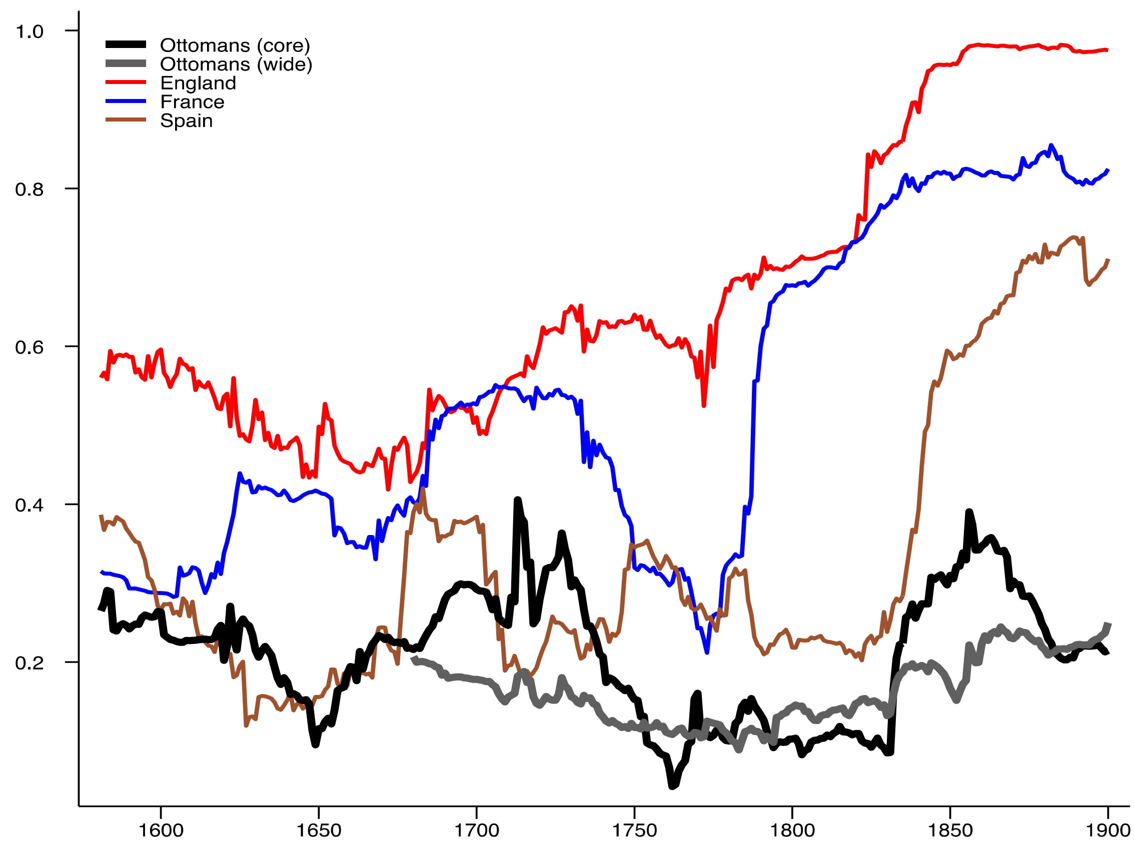
---

[45] The estimation results indicate that the estimated impacts were not only statistically significant but also were substantial. For per capita taxation, it hovered around the equivalent of 2 days of wages until the nineteenth century, then rose to 12.6 days by 1914. When combined with the estimated coefficients from various specifications, this increase implies that higher taxes in the nineteenth century were associated with a 6.9 to 12.5 percent reduction in bilateral price gaps. Steamship connections are estimated to have reduced price gaps by 7.9 to 10.1 percent, while railroad connections, where statistically significant, are associated with a 6.5 to 7.4 percent decrease.

[46] Table C1 in the Appendix explores alternative specifications to test robustness and assess different mechanisms. One specification replaces city fixed effects with city pair fixed effects to control for time-invariant dyad-level characteristics; the core results hold, with transport and state capacity reducing price gaps, and war, monetary instability, and climate shocks increasing them. A second specification applies two-way clustering by city pair and decade to address serial correlation and spatial dependence; while some coefficients lose significance, key variables like state capacity and steamship links remain robust. A third specification interacts state capacity with distance from the capital to examine whether fiscal capacity had a greater impact on market integration in regions

Next, we examine the second dimension of market integration: market efficiency. For this purpose, we implement a static version of the co-movement analysis by Federico et al. We begin by applying the HP filter to the interpolated price series to isolate cyclical components. Using the filtered data, we estimate a rolling window factor model over 51-year intervals, separately for each country. Within each window, we apply maximum likelihood factor analysis to the panel of city-level wheat prices and extract a single common factor. For each city, we compute the communality, defined as the share of variance explained by the common factor, as a measure of its integration with the domestic price system. Country-level averages of these communalities yield domestic co-movement indices, which reflect the degree of price synchronization across cities within a country. Higher values of these indices indicate stronger domestic market integration.

Figure 8. Domestic co-movement indices for different polities/regions, 1580-1900



Source: Authors' estimations

---

farther from the imperial center. The results indicate a negative and significant interaction effect, suggesting that improved state capacity contributed more strongly to reducing price gaps in peripheral areas, where administrative and infrastructural reach had historically been weaker. A final specification introduces a post-1841 dummy to test for structural change following the commercial treaties of 1838–1841 which abolished domestic monopolies and reduced trade barriers; the dummy is associated with lower price gaps but only marginally significant, and other effects lose precision, highlighting the difficulty of disentangling overlapping reforms and potential collinearity among their effects.

Figure 8 plots the estimated co-movement indices, with the black line representing the Ottoman core sample (four cities) and the gray line the wider Ottoman sample (eleven cities). The indices show marked fluctuations that correspond with major political disruptions. For example, significant declines occur during the early seventeenth and late eighteenth centuries, both periods characterized by declining central authority and reduced public security. While the indices indicate modest improvements in the nineteenth century, long-term gains remain limited.

In comparative perspective, the Ottoman co-movement indices in the early sixteenth century are broadly similar to those of Spain and France. However, whereas the French index rises over the subsequent centuries and the Spanish index surges in the nineteenth century, the Ottoman series remains relatively flat. This divergence points to an increasing gap in domestic market efficiency between the Ottoman Empire and Western Europe.[47]

Overall, the domestic indicators, including the coefficient of variation, bilateral price gaps, and co-movement indices, reveal a long period marked by fluctuation rather than consistent convergence, with a clear but geographically uneven improvement emerging in the mid to late nineteenth century. The most substantial reductions in price gaps occurred in coastal and western cities, while many inland eastern cities experienced limited progress or rising gaps.

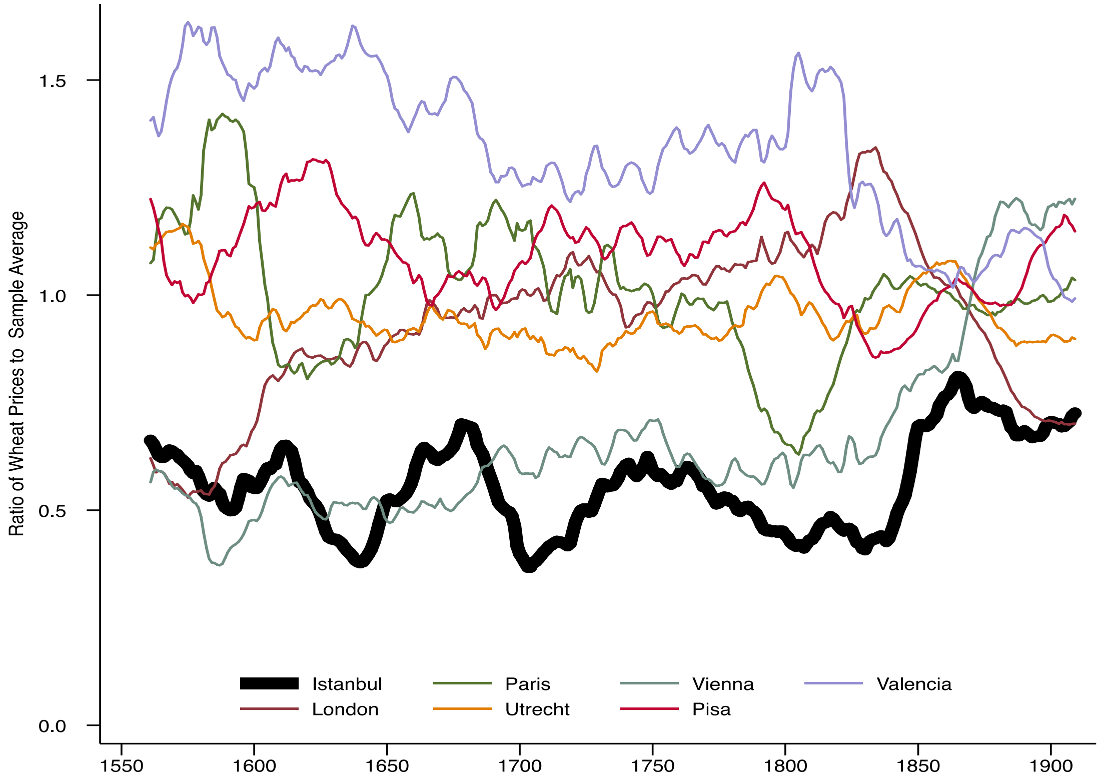
4.2. International integration

Shifting to cross-border links, this subsection estimates bilateral price gap regressions and international co-movement indices to investigate the integration of Ottoman markets with the rest of Europe.

As a starting point, Figure 9 presents the ratio of wheat prices in Istanbul and selected European cities to the sample average over time. While this approach is relatively basic, it provides a useful first approximation for assessing international price convergence. The figure shows that wheat prices in Istanbul consistently remained below the European average with no evidence of long-run convergence. However, in the second half of the nineteenth century, a clear pattern of convergence emerges. This pattern suggests that the nineteenth century was not only a period of domestic price convergence within the Ottoman Empire but also one of increasing integration with European markets.

[47] In Appendix C, we also replicate the original factor model specification of Federico, Schulze, and Volckart, ('European goods'). The procedure involves applying an HP filter and estimating a one-factor dynamic factor model with autoregressive error structure via Bayesian MCMC. As shown in Figures C5 the results are broadly consistent with those of our pared-down model. However, we report the results of the pared-down version of the model in the main text. The key difference lies in the dynamic error structure specified in Federico, Schulze, and Volckart, ('European goods'), which includes high-order autoregressive processes. We are cautious about applying such structure to interpolated data, given its low frequency and reconstructed nature.

Figure 9. Ratio of wheat prices in Ottoman and European cities to sample average



Source: Authors' estimations

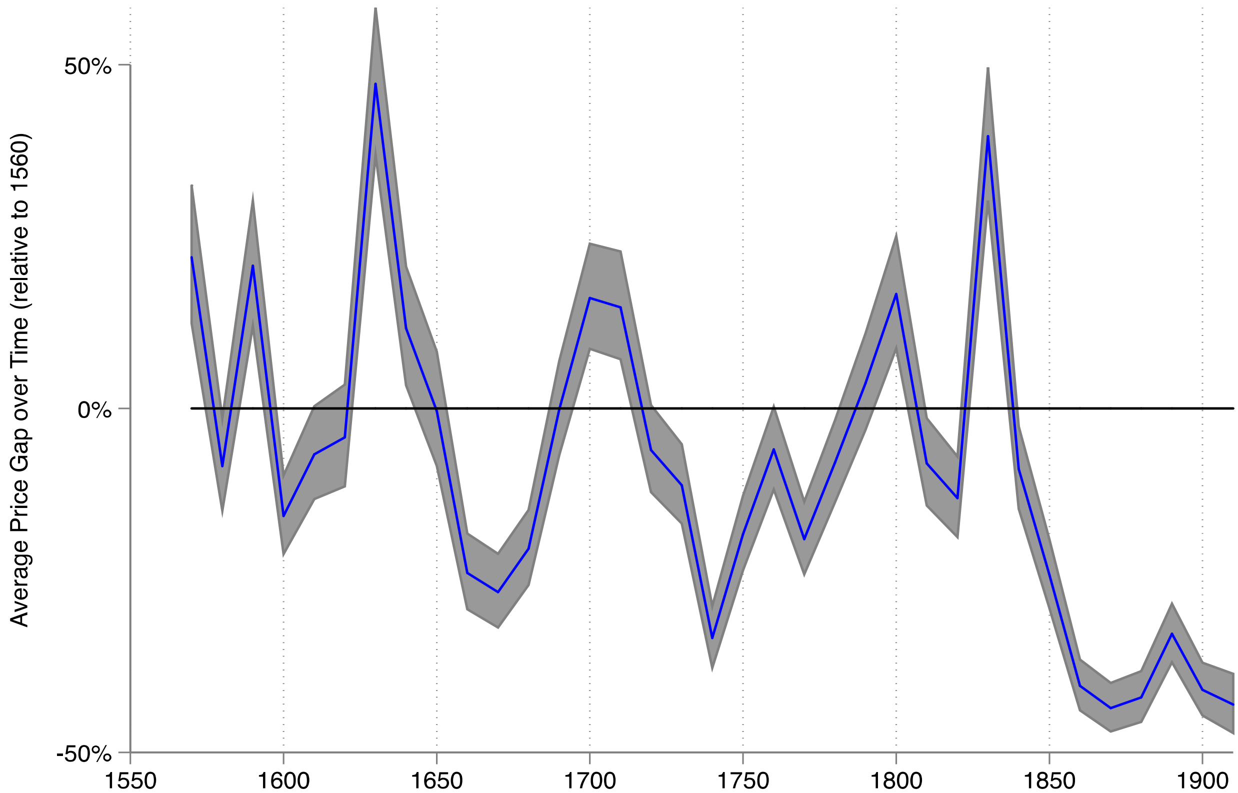
To provide a more formal measure of international price convergence, we next estimate a model of bilateral price differences between Ottoman cities and European cities located along the Mediterranean coast.[48] The focus on Mediterranean cities reflects the fact that both legal and illicit trade between the Ottoman Empire and Europe was primarily conducted through these ports. The estimated model is as follows:

$$\log(\text{pricegap}_{i,j,t}) = \beta \cdot \log(\text{distance}_{i,j}) + \sum_{s}(\gamma_s \cdot \text{decade}_s) + \sum_{i}(\alpha_{i\in Ott} \cdot \text{city}_{i\in Ott}) + \sum_{j}(\alpha_{j\in Med} \cdot \text{city}_{j\in Med}) + u_{i,j,t} \quad (4)$$

In this equation, i indexes the Ottoman cities in our sample and j indexes nine European Mediterranean cities. The equation captures the average bilateral price difference as a function of distance (β), time trends (γ_s), and city-specific effects (α_i, α_j).

[48] These cities are Valencia, Barcelona, Gerona, Avignon, Pisa, Rome, Naples, Padua, Udine.

Figure 10. Evolution of the average price gap between Ottoman cities and Mediterranean Europe cities over time



Source: Authors' estimations

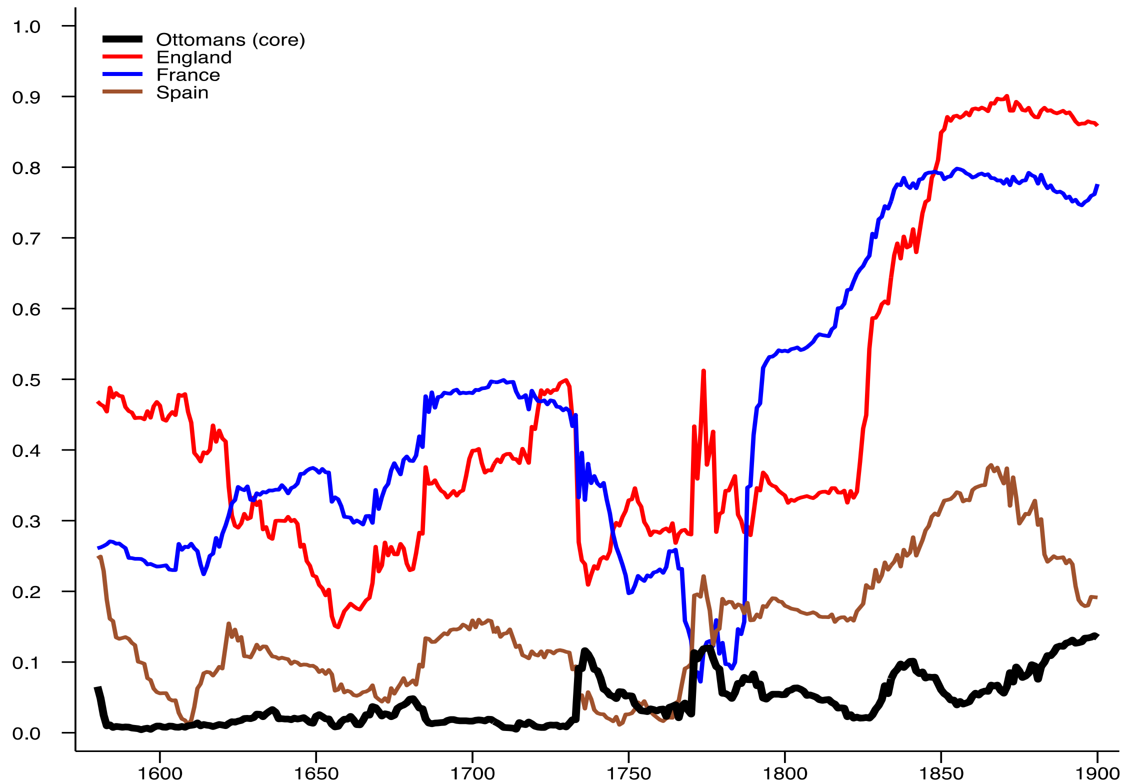
Figure 10 presents the estimated coefficients for the decade fixed effects (γ_s), with 1560–1569 as the baseline. The y-axis reports the average price gap relative to this benchmark decade, controlling for distance and city-specific characteristics. The figure reveals substantial short-term fluctuations but no sustained convergence trend until the nineteenth century.[49] In the nineteenth century, however, there is a marked and permanent decline in the price gap, consistent with growing Ottoman integration into European markets.[50] This pattern indicates that the nineteenth century marked a period of significant advancement not only in domestic but also in international market integration.

[49] The observed price fluctuations may be partially driven by monetary shocks. Specifically, two significant periods of widening price gaps with Europe—the 1620s–1650s and the 1830s–1840s—directly align with severe monetary instability within the Ottoman Empire. During both episodes, the Ottomans sharply debased their silver currency, a move that likely intensified these price disparities.

[50] Figure C1 in the Appendix replicates Figure 10, but uses as the dependent variable the price gaps between Ottoman cities and all 37 European cities in the sample, rather than only Mediterranean cities. The estimated time trends remain very similar, indicating that the earlier findings are not driven solely by the Mediterranean subsample.

To further evaluate the degree of integration with international markets, we construct international co-movement indices to assess how closely Ottoman price movements tracked broader European trends. The methodology follows the same procedure used earlier for domestic co-movement indices, but now applies it to the broader European context. Specifically, we estimate a factor model over rolling 51-year windows using a combined panel of wheat prices from four core Ottoman cities and thirty-nine European cities. The HP filter is first applied to each series to isolate cyclical components. Within each window, we then estimate a single common factor that captures the dominant pattern of price variation across the entire European dataset. For each city, we compute the communality, defined as the proportion of variance explained by this common European factor, as a measure of its integration with the broader European market system. Country-level averages of these communalities yield international co-movement indices, which are presented in Figure 11 for the Ottoman Empire, England, France, and Spain.

Figure 11. International co-movement indices for different polities, 1580-1900

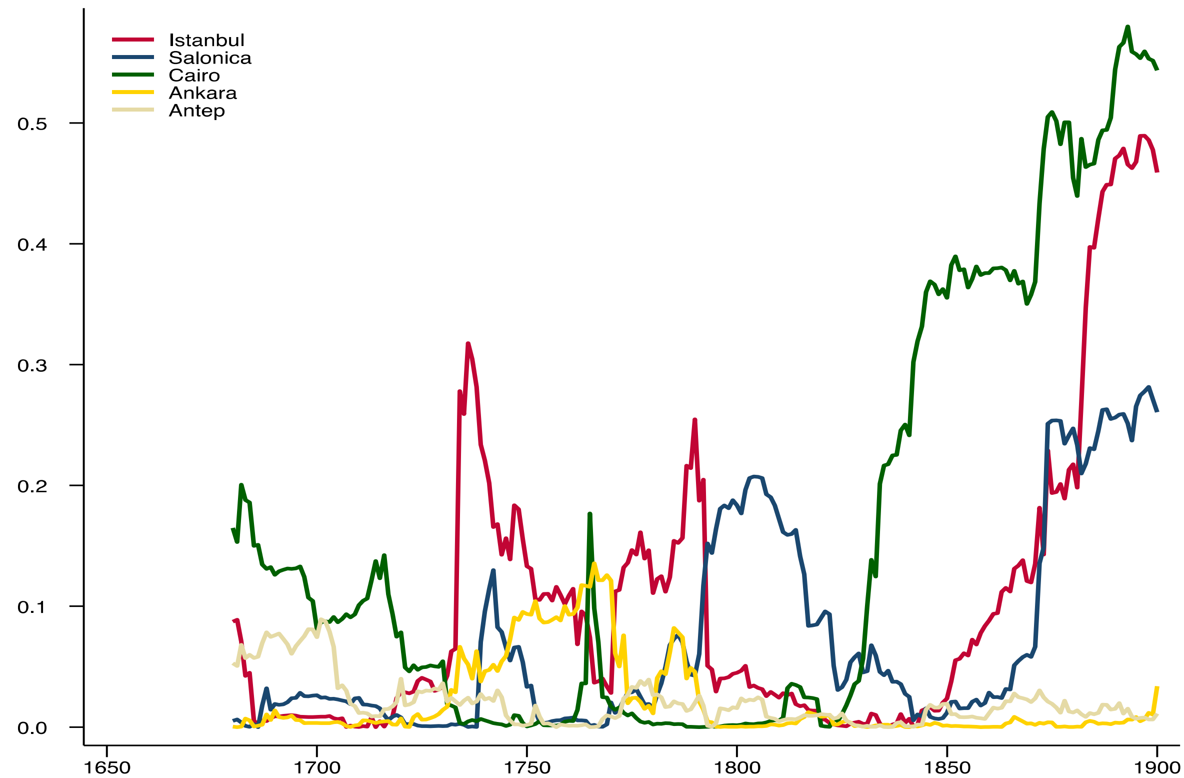


Source: Authors' estimations

Figure 11 suggests that the Ottoman Empire, along with Spain, remained at the lower end of integration into European markets. While there are notable improvements during the nineteenth century, the gap relative to England and France remains substantial, indicating limited catch-up.

These results are consistent with the price convergence evidence and further affirm the significance of nineteenth-century gains.[51]

Figure 12. International co-movement indices for different Ottoman cities, 1680-1900



Source: Authors' estimations

To examine geographic variation in international integration within the Ottoman Empire, we re-estimate the factor model for the post-1680 period using the eleven-city Ottoman sample and compute city-level co-movement indices. Figure 12 presents the results for five representative cities: the capital (Istanbul), two major port cities (Salonica and Cairo), and two inland cities (Ankara and Antep). The figure shows that gains in international market efficiency were concentrated in Istanbul and the port cities, whereas the inland cities experienced minimal improvement. This pattern underscores the uneven geography of international integration within the Ottoman Empire.

To sum up the findings on international integration, these results reveal a trajectory broadly parallel with domestic integration trends. Ratios of Ottoman to European wheat prices, decade fixed-effect

[51] Figure C6 in the Appendix replicates the original dynamic factor model of Federico, Schulze, and Volckart ('European goods') to recalculate the international comovement index for the Ottoman Empire. It also finds an increase in international integration after the 1840s, with the magnitude of the rise somewhat greater than in Figure 11.

regressions for Ottoman–Mediterranean pairs, and international co-movement indices all indicate limited convergence before the mid-nineteenth century. From the 1840s onward, average price gaps vis-à-vis Mediterranean Europe narrow and co-movement with a European factor rises. Istanbul and the main port cities drive most of this progress, while inland centers record modest gains. Despite these gains, the Empire continued to lag behind in terms of international market integration by 1914.

5. Discussion

We begin the discussion by placing the Ottoman wheat market integration patterns into the European context. Recent studies of European wheat markets show a gradual trend of increasing wheat market integration across Europe dating back to the sixteenth century. This trend gained momentum in the early nineteenth century but decelerated towards its end. Geographically, there were notable regional differences in the timing of integration. Northwest Europe led in both domestic and international market integration, while Southern and Eastern Europe joined the broader trend later and at a slower pace.[52]

Our findings presented in the previous section indicate that even though the Ottoman Empire took part in the broader European trend towards greater market integration in wheat, there were significant differences in timing and pace. Integration of wheat markets inside the empire was marked by short and medium-term fluctuations often correlated with political and military developments rather than a clear trend during the early modern centuries. Core areas of the empire connecting coastal areas close to the capital city in the Balkans, the Black Sea and western Anatolia stand out with a higher degree of wheat market integration. Levels of integration in this area was broadly comparable to parts of western Europe such as Spain and France in the early modern era. As one moved away from this core region, however, levels of integration declined markedly (Figures 3, 6 and 7).

The nineteenth century brought significant progress in Ottoman domestic market integration. The smaller price gaps and greater price comovement among Ottoman markets (Figures 3, 4, 5, 7 and 8) indicate that the period from the 1840s until World War I marked a new phase of greater integration of Ottoman wheat markets. However, domestic market integration across most parts of Europe proceeded more strongly during this period. Ottoman domestic market integration thus lagged behind France and Spain and more generally Western Europe on the eve of World War I (Figures 10, 11 and 12).

Regarding the international integration of Ottoman wheat markets, our results reveal a trajectory broadly parallel to domestic integration trends. For the early modern centuries, we find that while

[52] Chilosi, Murphy, Studer, and Tunçer, 'Europe's many integrations'; Federico, Schulze, and Volckart, 'European goods'.

Ottoman wheat prices remained below prices in most European locations, ratios of Ottoman to European wheat prices, decade fixed-effect regressions for Ottoman–Mediterranean pairs, and international comovement indices do not show a sustained trend toward convergence. Greater integration with European markets in the nineteenth century was led by Istanbul and other port cities. In contrast, centers in the interior recorded more modest gains and the empire as a whole continued to lag behind in terms of international market integration until 1914 (Figures 9-12).

Our results align partially with previous research on market integration in the Middle East. Regarding domestic integration, our findings are broadly similar to those of Ceylan and Panza.[53] Using a similar methodology and dataset from various Ottoman locations, Ceylan found no evidence of increasing integration across empire's wheat markets before the nineteenth century.[54] Analyzing pairwise price differences between Cairo, Aleppo, and Istanbul, Panza identifies statistically significant negative trends in bilateral price gaps, indicating convergence during the periods 1790–1799 and 1847–1913.[55] In contrast, our findings on international integration diverge from those of Li et al., which reports a decline in price convergence during the second half of the nineteenth century between Istanbul and European cities.[56] Our analysis, which draws on a much broader Ottoman sample and thus allows the use of more conventional indicators of price convergence and market efficiency, points to a trend of increasing integration with Europe during the same period.

In order to learn more about the determinants of wheat market integration in the Ottoman context, we made use of regression analysis. Our results point to three broad sets of variables as determinants of the timing and pattern of Ottoman market integration: i) distance, climate and more generally geography; ii) technological change and iii) institutional change. While it is not easy to disentangle and measure the impact of each separately, it is clear that all three factors contributed to integration of Ottoman wheat markets during this second period.

For both periods, our results show a clear positive relationship between price gaps and distance, as evidenced by the upward slopes of the best-fit lines in Figure 4 and statistically significant distance and estimated trade cost variables in our regressions. In addition, our statistically significant climate shock variable suggests that relative drought severity or asymmetric climate shocks and asymmetric local shortages also increased price gaps between pairs of locations. More generally, geography was a significant factor inhibiting integration of the empire's markets. Unlike many parts of Europe, most of the rivers in the Ottoman realm were not suitable for year-round navigation and costs of overland transportation remained prohibitively high. In many interior regions of the empire, "the tyranny of distance" thus applied in full force. Available estimates

[53] Ceylan, 'Essays on'; Panza, 'From a common empire'.
[54] Ceylan, 'Essays on'.
[55] Panza, 'From a common empire'.
[56] Li, Panza, and Song, "The evolution of'.

suggest that the price of wheat almost doubled as it was transported 100 kilometers overland.[57] Maritime transport thus remained central to the food supply of large urban areas and the interior regions including large parts of Anatolia continued to rely primarily on their own vicinity for grains in the nineteenth century and even until the interwar period.[58]

Another related and important determinant of trade costs and market integration was technological change. Our results show that steamship and railroad links significantly reduced interregional price gaps (Table 1). In the Ottoman Empire, technological innovations that facilitated trade remained limited during the early modern era and the available evidence suggests that costs of transportation both overland and over water did not decline appreciably until the nineteenth century.[59] During the nineteenth century, key technological improvements began with the arrival of the steamships and continued with telegraph, railroads and other innovations.[60] Steamships arrived early in the century linking Ottoman ports to each other and to European ports, ensuring significant decline in transportation costs between Ottoman and European markets.

In contrast, railroad construction inside the Ottoman Empire began in the second half of the century and proceeded slowly.[61] The influence of railroads on the integration of wheat markets was intricately tied to the liberalization of trade policies and the institutional transformations that accompanied European economic expansion within the empire. Built and operated by European companies, they primarily linked regions with high potential for primary products to port cities. The Anatolian Railway, linking Istanbul to central Anatolia, a wheat growing region, began operations in the 1890s. Export shipments of agricultural goods and raw materials, particularly grain, accounted for 80 to 85 percent of total freight.[62] The railway facilitated significant price convergence between Ankara and Konya in the interior and coastal as well as international markets until World War I (Figures 6, 7, 12 and Table 1). Its reach, however, was limited to an area of approximately 125 thousand square kilometers, serving a population of about 2 million.[63] Our results also show that other interior regions lacking railroad access remained largely isolated from both domestic and international trade networks. In these latter regions, overland transportation costs remained high and markets remained fragmented (Figures 7 and 12).

Two other and related variables that are statistically significant in our regressions are war pressure on the European front and debasements, the annual rate of decline in the silver content of the currency. Our findings complement those of Li et al. on the disruptive impact of conflict on

---

[57] Grehan, *Everyday life and consumer culture*; Ceylan, 'Essays on'.
[58] Panzac, 'International and'; Quataert, 'Limited revolution'; İnalcık and Quataert, '*An economic and social history of',* pp. 179-379.
[59] Quataert, 'Limited revolution'; Aynural, *İstanbul değirmenleri ve fırınları.*
[60] Lewis, *Wired Ottomans.*
[61] Schoenberg, 'The evolution of transport'.
[62] Quataert, 'Limited revolution', pp. 147-8.
[63] Idem.

integration between Ottoman and European markets, suggesting that warfare hindered integration within the empire.[64] Indirectly, warfare also undermined market integration through increased state intervention: military demands strained public finances, compelling the government to prioritize immediate strategic needs over broader economic concerns.[65] [66] Debasements which occurred frequently during the late eighteenth and early nineteenth centuries was often but not always related to wars. While the speed of local market responses to changes in coinage remains uncertain, our findings suggest that uneven adjustments across locations gave rise to price differentials in regional commodity markets. Monetary instability also disrupted wheat market integration by generating uncertainty, undermining trust in market transactions and impeding trade as our regressions confirm (Table 1).

Thirdly, we focus on institutional changes as a determinant of the timing and pattern of Ottoman wheat market integration. Recent literature has emphasized that the timeline and geography of market integration in Europe overlapped with the rise of modern states. It pointed out that early modern Europe witnessed the transformation of states with fragmented fiscal, military and judicial systems into high-capacity states with centralized administrative systems. This transformation also involved gradual standardization of laws, tariffs and taxation, development of monetary systems and public and private finance as well as declines in levels of domestic violence.[67]

We used per capita tax revenues of the central government normalized by urban wages as the main indicator for Ottoman state capacity in our regressions. During the seventeenth and eighteenth centuries, the central government's reach over the provinces, as well as the level of cooperation and coordination with local *ayan* or urban notables varied over time and from region to region.[68] The central state exerted greater control over the core regions and physical infrastructure investments by the central government also concentrated in the core provinces. As a result, a large part of the tax collections in the provinces was retained by local elites. Tax revenues of the central government fluctuated around two to three days of wages of unskilled construction workers in the capital city or about 3 percent of the empire's GDP until the end of the eighteenth century, lower than most states in Europe.[69]

One important variable which was related to state capacity and which had influence on wheat market integration was trade policy, both domestic and external. Because we do not have detailed information on the number and location of internal customs zones, the various tariffs that applied to domestic and external trade and how these changed over time, we could not include trade policy

[64] Li, Panza, and Song, "The evolution of"; Quataert, *The Ottoman Empire.*
[65] Genç, 'XVIII.yüzyılda Osmanlı ekonomisi'; idem, *Osmanlı İmparatorluğu'da devlet*.
[66] Wars on the eastern front are not statistically significant in our regressions probably because we do not have many locations close to the eastern front in our dataset and the locations in the east are mostly landlocked.
[67] Epstein, *Freedom and Growth*; Ogilvie and Carus, 'Institutions and Economic Growth'.
[68] Sadat, 'Rumeli ayanlari'.
[69] Karaman and Pamuk, 'Ottoman State Finances'.

for the early modern centuries in our regressions. However, we were able to include a dummy variable for free trade for the post-1841 period which is statistically significant and we include trade policy in our discussion below as it was directly related to outcomes in wheat markets in both periods.

During the early modern centuries, central government policy with respect to wheat focused mostly on the capital city because of its large population and political importance. The central government made use of a large set of measures including export prohibitions, delivery quotas on grain producing coastal regions, state purchases at below market prices and licenses to designated merchants to secure the wheat supply of the capital city and the army from a large area along the Black Sea and the Mediterranean. However, aware of the limitations on its capacity, the central government intervened selectively in markets and relied more on markets and private merchants during normal times.[70]

Our regression results as well as the secondary literature suggest that in regions where the local elites and their networks cooperated with the central government, domestic markets remained better integrated.[71] In contrast, in areas where the local elites pursued alternative strategies, coordination failures and rent-seeking behavior became more prevalent. For example, in Salonica during most of the eighteenth century and Egypt during the seventeenth and especially the eighteenth century, local elites gained greater autonomy in the marketing of local wheat and other grain supplies including exports.[72] On the whole, our empirical findings thus suggest that the rise of urban notables in the provinces and low levels of tax revenue and state capacity at the center before the nineteenth century did not lead to greater market integration.

The nineteenth century was a period of major institutional changes for the Ottoman Empire. The modernizing reforms in military, administration, tax collection, law and other areas that began in the last decades of the eighteenth century reduced political fragmentation and introduced a modern, centralized bureaucratic apparatus across the empire. Per capita tax collections of the central government increased steadily during this period and exceeded 10 percent of GDP on the eve of World War I.[73] Consequently, the central government was better able to reassert its authority over the provinces and improve the conditions for domestic and external trade. Key measures included improving the security of trade routes, modernization of the harbor infrastructure, constructing new ports, establishing modern postal services and standardizing measurement units.

---

[70] Güçer, *18. yüzyıl ortalarında*; idem, *XVI-XVII. Asırlarda*; Bulgaru, 'Contribution au Problème'; idem, 'L'approvisionnement d'Istanbul'; Murphey, 'Provisioning Istanbul'; Güran, 'İstanbul'un iaşesinde'; Aynural, *İstanbul değirmenleri ve fırınları*; Yıldırım, 'Bread and empire'; Pamuk, 'Institutional change'; Ağır, 'The evolution of grain policy'; Kazdağlı, '18. Yüzyılda İstanbul'da'.

[71] Yıldırım, 'Bread and empire'; Veinstein, 'Ayan de la Région d'Izmir'; Salzmann, 'An ancien regime revisited'; Gounaris, 'Reassessing wheat crises'; Mikhail, *Nature and empire.*

[72] Gounaris, 'Reassessing wheat crises'; Mikhail, *Nature and empire.*

[73] Pamuk, *Uneven centuries* (2018), pp. 101-3.

The Ottoman Empire entered a new era in economic policies after 1838 when the central government agreed to sign free trade treaties with European countries that would keep tariffs on both imports and exports at low levels until World War I in return for support for the territorial integrity of the empire and its ongoing reforms.[74] This shift towards free trade, accompanied by an emphasis on market-oriented policies, led to the abandonment of previous food supply measures for the capital city and other urban areas. These changes significantly enhanced the empire's integration into the European trade network (Figures 8, 10-12 and Table 1).

As a result, wheat prices in the coastal areas of the Ottoman Empire and of Egypt which was also covered by the free trade treaties converged towards the prices of ports in other free trade countries across Europe such as the United Kingdom. However, after countries in continental Europe including France, Germany, and Italy raised their tariffs in order to protect their wheat producers against imports from North America during the second half of the century, prices between these countries and Ottoman and Egyptian ports diverged significantly until World War I.[75]

Our empirical results also show that while integration of Ottoman port cities to international markets increased significantly after the 1830s, the pattern and extent of domestic market integration remained uneven. Domestic market integration was strongest between the ports and between them and the interior regions where the railroads were constructed. The results also indicate the gains in regions of the interior without railroads was lower, and in some cases close to zero (Figures 7, 12 and Table 1). This pattern was similar to the pattern observed in many other regions of the developing world during the nineteenth century and reveals the importance of international integration in shaping the dynamics of domestic integration.[76]

6. Conclusion

Expansion of markets and the resulting increase in the division of labor and specialization have for long been regarded as powerful sources of economic growth, especially in the era before the Industrial Revolution. It has also been argued that unequal market development was one of the key differences that led to divergence in economic performances within Europe and across different parts of the world. Technological change was initially identified as the main source of market integration. However, there is growing recognition in recent decades that institutional change could be an at least equally powerful cause. Within institutions and institutional change, the recent literature has placed a good deal of emphasis on the role of the state and state capacity. Thanks to the availability of large amounts of wheat price data for many countries, wheat market integration

[74] Özveren, 'Ottoman economic thought'.
[75] Findlay and O'Rourke, 'Commodity market integration', Uebele, 'National and international'; Federico, Schulze, and Volckart, 'European goods market'.
[76] Tirado-Fabregat, Badia-Miro, and Willebald, *Time and space.*

is one area where quantitative history may provide new and comparative answers to these questions.

This study examined wheat market integration in the Ottoman Empire and around the Eastern Mediterranean from the second half of the sixteenth century until World War I against a background of trends across Europe during the same period. We found that rates of integration in the Ottoman Empire fluctuated without a clear trend during the early modern era followed by greater international integration and spatially uneven domestic integration in the nineteenth century. Overall, gains in market integration were slower than those in western and central European regions and countries in both periods. Our findings align with Federico, Schulze, and Volckart's study, which highlights significant regional variations in the timing and pace of integration across the continent.[77]

One debate our findings offer insights on is how Ottoman political evolution affected its economic performance. Since technological change remained limited, patterns of market integration in the Ottoman Empire during the early modern centuries was related mostly to institutional and political changes. From late sixteenth to early nineteenth century, the Ottoman political system was relatively decentralized and local notables could develop autonomous fiscal and military capacity and bargain with the center. There is a debate in Ottoman historiography regarding whether this decentralized political equilibrium was a flexible and effective governance model, or a tenuous settlement born out of necessity with negative economic consequences. Our findings for wheat markets lend support to the latter view, as we find that the seventeenth and eighteenth centuries were characterized by medium term fluctuations but no secular trend towards greater market integration. Consistent with this view, the nineteenth century state-building reforms, together with introduction of steam engine and telegraph, resulted in market integration gains.

The timing of the gains in market integration as well as our comparisons between western Europe and the Middle East suggest that patterns of market integration during the early modern centuries were closely related not only to technological changes but also to institutional changes and the rise of centralized states. During the early modern period, Europe underwent a significant institutional transformation, with the rise of state capacity at its core. This transformation started in northwest Europe and gradually spread to the east and south of the continent, but did not occur in other parts of the world. Although this rise in state capacity is empirically well documented, its economic impact and role in preparing the ground for the take-off modern growth in the nineteenth century need further study. Our findings for the Ottoman Empire suggest that increases in state capacity and market integration may be closely related. Our results point to similarities between Ottoman case and China and India in this respect. This pattern challenges the notion that states and markets are alternative and rival mechanisms for resource allocation. Historically, the evidence suggests,

[77] Federico, Schulze, and Volckart, 'European goods', pp. 293–294.

states and markets complemented each other. We hope future research will shed additional light on the relationship between the rise of state capacity and market integration.

References

Ağır, S., "The evolution of grain policy: The Ottoman experience', *Journal of Interdisciplinary History,* 43, 4 (2013), pp. 571-598.

Albers, H., and Pfister, U., 'Climate change, weather shocks, and price convergence in pre-industrial Germany', *European Review of Economic History,* 25, 3 (2021), pp. 467-489.

Allen, R. C., 'The great divergence in European wages and prices from the Middle Ages to the First World War', *Explorations in Economic History*, 38, 4 (2001), pp. 411-447.

Aynural, S., *İstanbul değirmenleri ve fırınları: Zahire ticareti, 1740-1840* (Istanbul, 2002).

Bai, Jushan, and Pierre Perron. 'Computation and analysis of multiple structural change models'. *Journal of Applied Econometrics*, 18, 1 (2003), pp. 1-22.

Bateman, V. N., 'The evolution of markets in early modern Europe, 1350–1800: A study of wheat prices', *The Economic History Review*, 64, 2 (2011), pp. 447-471.

Baten, J., Keywood, T., and Wamser, G., 'Territorial state capacity and elite violence from the 6th to the 19th Century', *European Journal of Political Economy*, 70 (2021).

Bernhofen, D. M., Eberhardt, M., Li, J., and Morgan, S. L., 'The evolution of markets in China and Western Europe on the eve of industrialisation', *Research Paper Series, China and the World Economy,* 12 (2017).

Bernhofen, D. M., Eberhardt, M., Li, J., and Morgan, S. L., 'Sources of market disintegration in 18th century China' (2018). https://lezme.github.io/markuseberhardt/qing_new.pdf

Bernhofen, D. M., Eberhardt, M., Li, J., and Morgan, S. L., 'Assessing market integration in the early modern Period' (2022). https://ssrn.com/abstract=4190880

Besley, T., and Persson, T., 'The origins of state capacity: Property rights, taxation, and politics', *American Economic Review*, 99, 4 (2009), pp. 1218-1244.

Bonfatti, R., Brzezinski, A., Karaman, K. K., and Palma, N., 'Monetary Capacity', Discussion Paper Series 15299, Department of Economics (Oxford, 2020).

Braudel, F., *Civilization and Capitalism, 15th-18th Century, Vol. III: The Perspective of The World* (New York, 1982).

Bulgaru, A.-D., M., M., 'Contribution au Problème de L'approvisionnement en Blé de Constantinople Dans la Seconde Moitié du XVIIIe Siècle', *Studia et Acta Orientalia, Bucharest,* 1 (1958), pp. 13-37.

Bulgaru, A.-D., M., M., 'L'approvisionnement d'Istanbul Par les Principautés Roumaines au XVIIIe Siècle: Commerce ou Réquisition', *Revue des Mondes Musulmans et de la Méditerranée,* 66, 1 (1992), pp. 73-78.

Ceylan, P., 'Essays on markets, prices, and consumption in the Ottoman Empire (Late-seventeenth to mid-nineteenth centuries)', unpub. PhD thesis, London School of Economics and Political Science (2016).

Chilosi, D., and Federico, G., 'Early globalizations: The integration of Asia in the world economy, 1800–1938', *Explorations in Economic History,* 57 (2015), pp. 1–18.

Chilosi, D., Murphy, T. E., Studer, R., and Tunçer, A. C., 'Europe's many integrations: Geography and grain markets, 1620–1913', *Explorations in Economic History,* 50, 1 (2013), pp. 46-68.

Clark, G., "Farm wages and living standards in the industrial revolution: England, 1670-1869', *Economic History Review* (2001), pp. 477-505.

Clodfelter, M., *Warfare and armed conflicts: a statistical encyclopedia of casualty and other figures, 1492-2015* (North Carolina and London, 2017).

Cui, C., Yang, X, and Xiong, H., ‘The decline of China’s intraregional market integration in the Qing Dynasty’, in A. Le Riche, A. Parent, and L. Zhang, eds., *Institutional Change and China Capitalism: Frontier of Cliometrics and Its Application to China* (London, 2022).

de Vries, J., ‘The industrial revolution and the industrious revolution’, *The Journal of Economic History*, 54, 2 (1994), pp. 249-270.

de Vries, J., *The price of bread: Regulating the market in the Dutch Republic* (New York, 2019).

Dincecco, M., ‘Fragmented authority from ancient régime to modernity: A quantitative analysis’, *Journal of Institutional Economics*, 6, 3 (2010), pp. 305-328.

Dincecco, M., ‘The rise of effective states in Europe’, *Journal of Economic History*, 75, 3 (2015), pp. 901-918.

Epstein, S. R. *Freedom and growth: The rise of states and markets in Europe, 1300-1750*. Vol. 17 (London and New York, 2000).

Federico, G.. ‘How much do we know about market integration in Europe?’, *The Economic History Review*, 65, 2 (2012), pp. 470-497.

Federico, G., Schulze, M.-S., and Volckart, O., ‘European goods market integration in the very long run: From the Black Death to the First World War’, *The Journal of Economic History*, 81, 1 (2021) pp. 276-308.

Findlay, R., and O'Rourke, K. H., ‘Commodity market integration, 1500-2000’, in M. D. Bordo, A. M. Taylor, and J. G. Williams, eds., *Globalization in Historical Perspective* 13-64 (Chicago, 2003).

Genç, M., ‘XVIII. yüzyılda Osmanlı ekonomisi ve savaş,’ *Toplumsal Araştırmalar Dergisi*, 49, 4 (1984), pp. 52-61.

Genç, M., *Osmanlı İmparatorluğu'nda devlet ve ekonomi* (Istanbul, 2000).

Global Economic Data API (GEDA). University of Memphis. Center for Economic Education. http://drought.memphis.edu/GEDA/Default.aspx

Gounaris, B. C., ‘Reassessing wheat crises in eighteenth-century Thessaloniki’, *The Historical Review/La Revue Historique*, 5 (2008), pp. 41-65.

Grehan, J., *Everyday life and consumer culture in eighteenth-century Damascus* (Washington, 2007).

Güçer, L., *18. yüzyıl ortalarında İstanbul’un iaşesi için lüzumlu hububatın temini meselesi* (Istanbul, 1952).

Güçer, L., *XVI-XVII. asırlarda Osmanlı İmparatorluğunda hububat meselesi ve hububattan alınan vergiler* (Istanbul, 1964).

Güran, T., ‘İstanbul'un iaşesinde devletin rolü (1793-1839)’, *İstanbul Üniversitesi İktisat Fakültesi Mecmuası*, 44, 1-4 (1988), pp. 245-275.

Hanedar, A. Ö., and Uysal, S., ‘Transportation infrastructure and economic growth in a dissolving country: (Ir)relevance of railroads in the Ottoman Empire’, *Economic History of Developing Regions*, 35, 3 (2020), pp. 195–215.

Harley, C. K., ‘Ocean freight rates and productivity, 1740–1913: The primacy of mechanical invention reaffirmed’, *Journal of Economic History*, 48, 4 (1988), pp. 851-876.

Hernández Sempere, T.-M., ‘El trigo y el Arroz’, Estudis: *Revista de Historia Moderna,* 7 (1978), pp. 157-167.

İnalcık, H., and Quataert, D., eds., *An economic and social history of the Ottoman Empire, 1300-1914* (New York, 1994).

Jacks, D. S., ‘Market Integration in the North and Baltic Seas, 1500-1800’, *Journal of European Economic History*, 33, 3 (2004), pp. 285-329.

Jacks, D. S., ‘What drove nineteenth century commodity market integration?’, *Explorations in Economic History*, 43, 3 (2006), pp. 383-412.

Karaman, K. K. and Pamuk, Ş., ‘Ottoman state finances in comparative European perspective, 1500-1914’, *The Journal of Economic History*, 70 (2010), pp. 593-627.

Karaman, K. K. and Pamuk, Ş., ‘Different paths to the modern state in Europe: The interaction between warfare, economic structure, and political regime’, *American Political Science Review*, 107, 3 (2013), pp. 603-626.

Karaman, K. K., Pamuk, Ş. and Yıldırım-Karaman, S., ‘Money and monetary stability in Europe, 1300–1914’, *Journal of Monetary Economics*, 115 (2020), pp. 279-300.

Kazdağlı, B., ‘18. yüzyılda İstanbul’da Unkapanı tüccarları’, unpub. M.A. thesis, 29 Mayıs University (2022).

Keller, W., and Shiue, C. H., ‘Institutions, technology, and trade’, Working Paper 13913, National Bureau of Economic Research (Cambridge, September 2019).

Keller, W., and Shiue, C. H., ‘Market integration and institutional change’, *Review of World Economics*, 156 (2020), pp. 251-285.

Keller, W., Shiue, C. H., and Wang, X., ‘Capital markets in China and Britain, 1770-1860: Evidence from grain prices’, *American Economic Journal: Applied Economics*, 13, 3 (2021), pp.31-64.

Lewis, P. L., *Wired Ottomans: A sociotechnical history of the telegraph and the modern Ottoman Empire, 1855-1911* (Los Angeles, 2018).

Li, Z., Panza, L., and Song, Y., ‘The evolution of Ottoman–European market linkages, 1469–1914: Evidence from dynamic factor models’, *Explorations in Economic History*, 71 (2019), pp. 112-134.

Losa, E. L., and Zarauz, S. P., ‘Spanish subsistence wages and the little divergence in Europe, 1500–1800’, *European Review of Economic History*, 25, 1 (2021), pp. 59-84.

Mikhail, A., *Nature and empire in Ottoman Egypt: An environmental history* (New York, 2011).

Murphey, R., ‘Provisioning Istanbul: The state and subsistence in the early modern Middle East’, *Food and* Foodways, 2, 1 (1987), 217-263.

Ogilvie, S., and Carus, A. W., ‘Institutions and economic growth in historical perspective’, in P. Aghion, and S. N. Durlauf, eds., *The Handbook of Economic Growth* Vol. 2. (Oxford, 2014), 403-513.

Ogilvie, S., ‘State Capacity and Economic Growth: Cautionary Tales from History’, *National Institute Economic Review*, 262 (2022), 28-50.

O’Rourke, K. H. and Williamson, J. G., ‘When did globalisation begin?’, *European Review of Economic History*, 6,1 (2002), pp. 23-50.

Ozmucur, S. and Pamuk, Ş., ‘Did European commodity prices converge during 1500-1800?’, in T. J. Hatton, K. O’Rourke and A. Taylor, eds., *The New Comparative Economic History, Essays in Honor of Jeffrey Williamson* (Massachusetts, 2007), pp. 59-85.

Özveren, E., ‘Ottoman economic thought and economic policy in transition’, in M. Psalidopoulos and M. E. Mata, eds., *Economic Thought and Policy in Less Developed Europe: The Nineteenth Century* (London, 2001), 53-144.

Palma, N., and Reis, J., ‘From convergence to divergence: Portuguese economic growth, 1527–1850’, *The Journal of Economic History*, 79, 2 (2019), pp. 477-506.

Pamuk, Ş., ‘Institutional change and the longevity of the Ottoman Empire, 1500–1800’, *Journal of Interdisciplinary History*, 35, 2 (2004), pp. 225-247.

Pamuk, Ş., 'Changes in factor markets in the Ottoman Empire, 1500–1800', *Continuity and Change*, 24, 1 (2009), pp.107-136.
Pamuk, Ş., 'The evolution of fiscal institutions in the Ottoman Empire, 1500–1914', in B. Yun-Casalilla, P. K. O'Brien, and F. Comín, eds., *The Rise of Fiscal States* (New York, 2012), pp. 304-332.
Pamuk, Ş., *Uneven centuries: Economic development of Turkey since 1820* (Princeton and Oxford, 2018).
Panza, L., 'From a common empire to colonial rule: Commodity market disintegration in the Near East', *Economic History Review*, 77, 2 (2024), pp. 584-611.
Panzac, D., 'International and domestic maritime trade in the Ottoman Empire during the 18th century', *International Journal of Middle East Studies*, 24, 2 (1992), pp. 189-206.
Persson, K. G., *Pre-industrial economic growth, social organization and technological progress in Europe* (Oxford, 1988).
Pomeranz, K., *The Great divergence: China, Europe, and the making of the modern world economy* (Princeton, 2000).
Quataert, D. *The Ottoman Empire, 1700-1922* (New York, 2005).
Quataert, D., 'Limited revolution: The impact of the Anatolian railway on Turkish transportation and the provisioning of Istanbul, 1890–1908', *Business History Review*, 51, 2 (1977), pp.139-160.
Reis, J., 'A «Lei da Fome»: As Origens do Proteccionismo Cerealífero (1889-1914)', *Análise Social*, 15, 60 (1979), pp. 745-793.
Sadat, D. R., 'Rumeli ayanlari: The eighteenth century', *The Journal of Modern History*, 44, 3 (1972), pp. 346-363.
Salzmann, A., 'An ancien regime revisited: 'Privatization' and political economy in the eighteenth-century Ottoman Empire', *Politics & Society*, 21, 4 (1993), pp. 393-423.
Scheidel, W., 'The shape of the Roman world: Modelling imperial connectivity', *Journal of Roman Archaeology*, 27 (2014), pp. 7–32.
Scheidel, W., Meeks, E., and Grossner, K., 'ORBIS: The Stanford Geospatial Network Model of the Roman World', Stanford University (2012), https://orbis.stanford.edu
Schmelzing, P., 'Eight centuries of global real interest rates, R-G, and the "Suprasecular" Decline, 1311–2018', Working Paper 845, Bank of London (London, January 2020).
Schoenberg, P. E., 'The evolution of transport in Turkey (Eastern Thrace and Asia Minor) under Ottoman rule, 1856–1918', *Middle Eastern Studies*, 13, 3 (1977), pp. 359-372.
Shiue, C. H., and Keller, W., 'Markets in China and Europe on the eve of the industrial revolution', *American Economic Review*, 97, 4 (2007), pp. 1189-1216.
Schulze, M.-S., and Wolf, N., 'On the origins of border effects: Insights from the Habsburg Empire', *Journal of Economic Geography*, 9, 1 (2009), pp. 117-136.
Studer, R., 'India and the great divergence: Assessing the efficiency of grain markets in eighteenth- and nineteenth-century India', *The Journal of Economic History*, 68, 2 (2008), pp. 393-437.
Teall, J. L. 'The grain supply of the Byzantine Empire, 330-1025', *Dumbarton Oaks Papers*, 13 (1959), pp. 87-139.
Tirado-Fabregat, D. A., Badia-Miro, M., and Willebald, H., eds., *Time and space, Latin American regional development in historical perspective* (Cham, 2020).
Uebele, M. 'National and international market integration in the 19th century: evidence from comovement', *Explorations in Economic History,* 48, 2 (2011), pp. 226-242.

Uebele, M., and Gallardo-Albarrán, D., ‘Paving the way to modernity: Prussian roads and grain market integration in Westphalia, 1821–1855,’ *Scandinavian Economic History Review,* 63, 1 (2015), pp. 69-92.

Will, P.-E., Bin Wong, R., and Lee, J., *Nourish the people: The state civilian granary system in China, 1650–1850* (Ann Arbor, 2020).

van Zanden, J. L., ‘Wages and standards of living in Europe, 1500-1800’, *European Review of Economic History*, 3, 2 (1999), pp. 175-97.

van Zanden, J. L., ‘The “revolt of the early modernists” and the “first modern economy”: An assessment’, *The Economic History Review*, 55, 4 (2002), pp. 619-41.

Veinstein, G., ‘Ayan de la Région d'Izmir et le Commerce du Levant (Deuxième Moitié du XVIIIe Siècle)’, *Revue des Mondes Musulmans et de la Méditerranée*, 20, 1 (1975), pp. 131-147.

Yıldırım, O., ‘Bread and empire: The workings of grain provisioning in Istanbul during the eighteenth century’, in B. Marin and C. Virlouvet, eds., *Nourrir Les Cités de Méditerranée: Antiquité-Temps Modernes* (Paris, 2003), pp. 251-272.

Zechner, A., Knapp, E., and Adelsberger, M., ‘Prices and wages in Salzburg and Vienna, c. 1450–1850’, *Vierteljahrschrift für Sozial-und Wirtschaftsgeschichte*, 108, 4 (2021), pp. 504-521.

Appendix A: Data

Wheat price data

For this study, we compiled yearly wheat price data from 25 Ottoman cities, between 1550 and 1914, drawing on secondary literature and archival material. We examined over 1,000 Ottoman court registers sourced from various archives. To ensure data quality and reliability, we were selective in our choice of prices, focusing on several key historical documents.

Primary among these sources are waqf account books, which document the prices paid by pious foundations and their soup kitchens, and probate inventories, providing valuations of stored grain in barns and cellars or crops in the field at the time of the owner's death. These documents are available for numerous Ottoman towns, covering extended timeframes from the fifteenth to the nineteenth century. Past empirical studies have demonstrated the reliability of these sources, affirming that the prices they recorded are consistent, accurately reflecting local market prices (Barkan 1975; Faroqhi 1984; Güran 2006; Pamuk 2000; Orbay 2001, 2007a, 2007b; Ceylan 2016).

Additionally, for the nineteenth century, we incorporated price series that had been previously compiled by other authors for various Eastern Mediterranean port cities, drawing from consular reports. To maintain the uniformity and consistency of the price series and address concerns about accuracy, we chose to exclude data from various other sources, such as tax registers, palace kitchen account books, commodity exchange records, and ceiling price listings, from the database.

In terms of its geographical and chronological scope, the resulting database is the most comprehensive price repository compiled for the pre-industrial and nineteenth-century Eastern Mediterranean, to date. Nevertheless, historical records of Ottoman prices are relatively less accessible for earlier time periods, as well as for medium-sized and smaller towns, in contrast to larger urban centers and more recent periods. Consequently, our data distribution is influenced by the availability of historical sources, leading to a smaller number of observations from inland and remote regions, as well as from earlier historical periods.

A second problem that affects quality of our data is the frequency of observations, underlying the annual prices. Unlike price series available for several European markets, which are the product of decades-long research, and which generally derive from monthly observations, our prices mostly reflect an average figure for two or three random observations detected in the historical sources for a certain year. While the inability to control for seasonal fluctuations in wheat prices might be a serious problem in studies with short-term focus, our very long-term approach mitigates the effect of this limitation on the robustness of the results. Finally, conversion of prices originally reported in local weight and volume units, such as various local *kile*s, the Egyptian *ardabb*, the Damascene *gharara*, etc., into metric units was a challenging task. An investigation was conducted to determine metric equivalents of these local units, and we made some assumptions in certain cases.

The primary and secondary sources used in creating the database and converting local units into standardized units are listed below.

Sources

Istanbul

- Secondary sources: Pamuk 2000; Quataert 1973; Güran 2006; Öztürk 1993
- Primary sources: Üsküdar Court Records (1514-85, 1627-41), Presidency of the Republic of Turkey, Directorate of State Archives, Ottoman Archives, İSTM.ŞSC.06.d.

Edirne

- Secondary sources: Barkan 1965; Pamuk 2000; Orbay 2012a; Orbay and Oruç 2012; Barkan 1966; Sahillioğlu 1999; Büyük 2009
- Primary sources: Edirne Court Records (1740-1912), Presidency of the Republic of Turkey, Directorate of State Archives, Ottoman Archives, MŞH.ŞSC.d.

Bursa

- Secondary sources: Orbay 2007b; Üzümçeker 2014; Orbay 2012c; Orbay 2012b; Orbay 2011; Pamuk 2000; Gökçurak 2016; Yıldız 2019; Öztürk 1992
- Primary sources: Bursa Court Records (1655-1667, 1716-1785, 1854-1910), Presidency of the Republic of Turkey, Directorate of State Archives, Ottoman Archives, MŞH.ŞSC.d.

Manisa

- Secondary sources: Ceylan 2016
- Primary sources: Manisa Court Records (1840-1912), Presidency of the Republic of Turkey, Directorate of State Archives, Ottoman Archives, MŞH.ŞSC.d.

Ankara

- Secondary sources: Danık 2020
- Primary sources: Ankara Court Records (1610-1685, 1761-1914), Presidency of the Republic of Turkey, Directorate of State Archives, Ottoman Archives, MŞH.ŞSC.d.

Konya

- Secondary sources: Orbay 2007a; Pamuk 2000
- Primary sources: Konya Court Records (1817-1913), Presidency of the Republic of Turkey, Directorate of State Archives, Ottoman Archives, MŞH.ŞSC.d.

Antep

- Secondary sources: Ceylan 2016
- Primary sources: Ayntab Court Records (1541-1638, 1794-1910), Presidency of the Republic of Turkey, Directorate of State Archives, Ottoman Archives, MŞH.ŞSC.d.

Kayseri

- Primary sources: Kayseri Court Records (1550-1913), Presidency of the Republic of Turkey, Directorate of State Archives, Ottoman Archives, MŞH.ŞSC.d.

Damascus

- Secondary sources: Grehan 2007; Headr 2015; Allen 2018

Salonica

- Secondary sources: Asdrachas 1972 (taken from Svoronos 1956); Balta 1992 (taken from Vasdravellis 1952); Gounaris 1993

Veria

- Primary sources: Probate inventories from Veria Court Records (1671-1890), Greek State Archives, Ottoman Administration Archive, GRGSA-IMA_OJC001

Alexandria

- Secondary sources: Allen 2018; Saleh 2021

Cairo

- Secondary sources: Raymond 1973, 1974; Cuno 1993

Rodosçuk

- Primary sources
- Rodosçuk Court Records (1553-1881), Presidency of the Republic of Turkey, Directorate of State Archives, Ottoman Archives, MŞH.ŞSC.d.

Wallachia

- Secondary sources: Jacks 2004; 2005 (taken from Popa 1978); Black Sea Project Prices of Grain Exports Database (taken from Cernovodeanu, Marinescu, and Gavrilă 1978; Cernovodeanu, and Marinescu 1979, Axenciuc 2000)

Athens

- Secondary sources: Jacks 2004; Jacks 2005; Federico, Schulze and Volckart 2021

Ruse

- Primary sources: Probate inventories from Ruse Court Records (1694-1880), St. Cyril and Methodius National Library of Bulgaria (NBKM), Oriental Department Collection

Palestine

- Secondary sources: Allen 2018

Baghdad

- Secondary sources: Allen 2018

Amasya

- Secondary sources: Orbay 2007a

Patmos

- Secondary sources: Asdrachas 1972

Ermoupoli

- Secondary sources: Federico, Schulze and Volckart 2021

Aleppo

- Secondary sources: Allen 2018

Candia

- Secondary sources: Balta 1992 (taken from Stavrinidis, 1975, 1976, 1978, 1984, 1985)

Dobruja

- Primary sources: Probate inventories from Dobruja Court Records (1792-1883), St. Cyril and Methodius National Library of Bulgaria (NBKM), Oriental Department Collection

Tokat

- Secondary sources: Orbay 2007

Diyarbakır

- Secondary sources: Öztürk 1990

Çankırı

- Secondary sources: Elibol 2005

Conversion rate sources

- Hinz 1990; Emecen 1989; Eldem 1970; İnalcık 1994; Barkan 1964; Svoronos 1956; Taşkın 2005; Jacks 2004; Balta 1992; Öztürk 1990; Arseven 1966

References

Allen, Robert C. "Middle East Wages, Prices, and Trade Data", https://robert-c-allen.net/data/middle-east-wages-and-prices/ (accessed 20 October 2023).

Arseven, Celal Esat. *Sanat Ansiklopedisi. Vol. III*. Ankara: Milli Eğitim Bakanlığı Yayınevi, 1950.

Asdrachas, Spyros I. "Marchés et Prix du Blé en Grèce au XVIIIe Siècle." *Südost Forschungen* 31 (1972): 178-209.

Axenciuc, Victor. *Evoluţia Economică a României: Cercetări Statistico-Istorice, 1859–1947*. Vol. 3. Bucharest: Editura Academiei Române, 1992.

Balta, Evangelia. "The Bread in Greek Lands During the Ottoman Rule." *Tarih Araştırmaları Dergisi* 16, no. 27 (1992): 199-226.

Barkan, Ömer Lutfi. *Edirne ve Civarındaki Bazı İmâret Tesislerinin Yıllık Muhasebe Bilançoları*. Ankara: Türk Tarih Kurumu Basımevi, 1965.

Barkan, Ömer Lutfi. "Edirne Askerî Kassamına Ait Tereke Defterleri, 1545-1659." *İstanbul Üniversitesi İktisat Fakültesi Mecmuası* 27, no. 3-4 (1966): 357-385.

Black Sea Project, "Prices of Grain Exports Database" https://blacksea.gr/ (accessed 22 October 2023).

Büyük, Orhan. "Şer'iyye Sicillerine Göre XVII. Yüzyılın Ortalarında Edirne'de Sosyo-Ekonomik Hayat." MA diss., Trakya Üniversitesi, 2009.

Cernovodeanu, Paul and Beatrice Marinescu. "British Trade in the Danubian Ports of Galatz and Braila Between 1837 and 1857." *Journal of European Economic History* 8, no. 3 (1979): 707-742.

Cernovodeanu, Paul, Beatrice Marinescu and Irina Gavrilă. "Comerțul Britanic Prin Galați și Brăila Între 1837–1852." *Revista de Istorie* 31, no. 4 (1978): 629–650.

Ceylan, Pinar. "Essays on Markets, Prices, and Consumption in the Ottoman Empire (Late-Seventeenth to Mid-Nineteenth Centuries)." Ph.D. diss., London School of Economics and Political Science, 2016.

Cuno, Kenneth M. *The Pasha's Peasants: Land, Society and Economy in Lower Egypt, 1740–1858*. New York: Cambridge University Press, 1993.

Danık, Sevda. "Orta Anadolu'da Para ve Fiyatlar (1688-1760)." Ph.D. diss., Fırat Üniversitesi, 2020.

Eldem, Vedat. *Osmanlı İmparatorluğunun İktisadi Şartları Hakkında Bir Tetkik*. İstanbul: Türkiye İş Bankası Yayınları, 1970.

Elibol, Ahmet. "Yakınçağ Başlarından Tanzimat'a Kadar Çankırı." Ph.D. diss., Gazi Üniversitesi, 2005.

Emecen, Feridun M. *XVI. Asırda Manisa Kazası*. Ankara: Türk Tarih Kurumu Basımevi, 1989.

Faroqhi, Suraiya. Towns and Townsmen of Ottoman Anatolia: Trade, Crafts and Food Production in an Urban Setting, 1520–1650. New York: Cambridge University Press, 1984.

Federico, Giovanni, Max-Stephan Schulze, and Oliver Volckart. "European Goods Market Integration in the Very Long Run: From the Black Death to the First World War." *The Journal of Economic History* 81, no. 1 (2021): 276-308.

Gounaris, Basil C. "Steam over Macedonia, 1870-1912: Socio-Economic Change and the Railway Factor." Ph.D. diss., Oxford University, 1993.

Gökçurak, Tuğba. "31 nolu Bursa Tereke Defterine Göre Bursa Şehrinin Sosyo-Ekonomik Hayatı (1510-1512)." MA diss., Balıkesir Üniversitesi, 2016.

Grehan, James P. *Everyday Life and Consumer Culture in Eighteenth-Century Damascus*. Washington, D.C.: University of Washington Press, 2011.

Güran, Tevfik. *Ekonomik ve Mali Yönleriyle Vakıflar: Süleymaniye ve Şehzade Süleyman Paşa Vakıfları.* Istanbul: Kitabevi Yayınları, 2006.

Headr, Deaa. "Osmanlı İdaresinde Şam'ın (Dimaşk) İktisadî Vaziyeti (1800-1850)." Ph.D. diss., Fırat Üniversitesi, 2015.

Hinz, Walther. Islamische Masse und Gewichte: Umgerechnet ins Metrische System. Leiden: E. J. Brill, 1955

İnalcık, Halil, and Donald Quataert, eds. *An Economic and Social History of The Ottoman Empire, 1300-1914*. New York: Cambridge University Press, 1994.

Jacks, D.S. "Market Integration in the North and Baltic Seas, 1500-1800." *Journal of European Economic History* 33(3), 2004: 285-329.

Jacks, David Steven "Intra- and International Commodity Market Integration in the Atlantic Economy, 1800–1913." *Explorations in Economic History* 42, no. 3 (2005): 381–413.

Orbay, Kayhan. "Economic Development of the Imperial Waqfs: A Study in the Institutional and Local Economic History in the Transformation Period." Ph.D. diss., University of Vienna, 2007a.

Orbay, Kayhan. "16. ve 17. Yüzyıllarda Bursa Ekonomisi Sultan Çelebi Mehmed Yeşil İmareti'nin Mali Tarihi (1553-1650)." *Osmanlı Tarihi Araştırma ve Uygulama Merkezi Dergisi OTAM* 22, (2007b): 125–158.

Orbay, Kayhan. "Bursa'da Sultan II Murad Vakfı'nın Mali Tarihi (1608-1641)." *İstanbul Üniversitesi İktisat Fakültesi Mecmuası* 61, no. 2 (2011): 293–322.

Orbay, Kayhan. "Edirne II. Bayezid Vakfı'nın Mali Tarihi (1597-1640)." *Güneydoğu Avrupa Çalışmaları Uygulama ve Araştırma Merkezi Dergisi (GAMER)* 1, no. 1 (2012a):113–141.

Orbay, Kayhan. "Emir Sultan (Mehmed El-Buhari) Vakfı'nın Mali Tarihi (1608-1634)." *Uludağ Üniversitesi Fen-Edebiyat Fakültesi Sosyal Bilimler Dergisi* 13, no. 22 (2012b): 23–42.

Orbay, Kayhan. "Orhan Gazi Vakfı'nın Malî Tarihinden Bir Kesit (1593-1641)." *Vakıflar Dergisi* 38, (2012c): 65–84.

Orbay, Kayhan and Hatice Oruç. "Sultan II. Murad'ın Edirne Cami'-i Şerîf ve Darü'l-Hadîs Vakfı (1592-1607)." *Tarih Dergisi* 2, no.56 (2012): 1–24.

Mustafa Öztürk. "Güneydoğu Anadolu'da Fiyatlar." In *V. Milletlerarası Türkiye Sosyal ve İktisat Tarihi Kongresi Tebliğler*, Ankara: Türk Tarih Kurumu Yayınları, 1990.

Öztürk, Mustafa. "Bursa'da Hububat Fiyatları (1775-1840)." *Tarih İncelemeleri Dergisi* 7, no. 1 (1992): 167–190.

Öztürk, Sait. "XVII. Yüzyıl Askerî Kassam Defterlerinin Sosyo-Ekonomik Tahlili." Ph.D. diss., Marmara Üniversitesi, 1993.

Pamuk, Şevket. *500 Years of Prices and Wages in Istanbul and Other Cities.* Ankara: State Institute of Statistics, Republic of Turkey, 2000.

Popa, Mircea N. *La Circulation Monetaire et L'Evolution des Prix en Valachie (1774–1831)*. Association Internationale D'études du Sud-Est Européen, vol. 8. Bucarest: L'Association, 1989.

Quataert, Donald. "Ottoman Reform and Agriculture in Anatolia, 1876-1908." Ph.D. diss., University of California, 1973.

Raymond, André. *Artisans et Commerçants au Caire au XVIIIe Siècle*. Tome 1. Damas: Institut Français de Damas, 1973.

Raymond, André. *Artisans et Commerçants au Caire au XVIIIe Siècle*. Tome 2. Damas: Institut Français de Damas, 1974.

Sahillioğlu, Halil. "1640-1740 Edirne'de Buğday Fiyatları." In *Cumhurbaşkanımız Sayın Süleyman Demirel'in Himayelerinde "I. Edirne Sarayı Sempozyumu" Bildirileri,* edited by Ender Bilar. Edirne: Trakya Üniversitesi Yayınları, 1999.

Saleh, Mohamed. "Globalization and Labor Coercion.". Unpublished Manuscript, 2021.

Stavrinidis, Nikolaos S. *Translations of Turkish Documents Concerning the History of Crete. Vol. 1*. Heraklion: Vikelaia Vivliotheke, 1975.
Stavrinidis, Nikolaos S. *Translations of Turkish Documents Concerning the History of Crete. Vol. 2.* Heraklion: Vikelaia Vivliotheke, 1976.
Stavrinidis, Nikolaos S. *Translations of Turkish Documents Concerning the History of Crete. Vol. 3.* Heraklion: Vikelaia Vivliotheke, 1978.
Stavrinidis, Nikolaos S. *Translations of Turkish Documents Concerning the History of Crete. Vol. 4*. Heraklion: Vikelaia Vivliotheke, 1984.
Stavrinidis, Nikolaos S. *Translations of Turkish Documents Concerning the History of Crete. Vol. 5.* Heraklion: Vikelaia Vivliotheke, 1985.
Svoronos, Nikos G. *Le Commerce de Salonique au XVIIIe Siècle*. Paris: Presses Universitaires de France, 1956.
Taşkın, Ünal. "Osmanlı Devleti'nde Kullanılan Ölçü, and Tartı Birimleri." MA diss., Fırat Üniversitesi, 2005.
Üzümçeker, Ramiz. "Rural Economy and Vakif Finances in Sixteenth-Century Anatolia: A Study on Çelebi Sultan Mehmed Vakfı in Bursa, 1558-1591." Ph.D. diss., Boğaziçi Üniversitesi, 2014.
Vasdravellis, Ioannis K. Historical Archives of Macedonia I, Archives of Salonica 1695-1912. Thessaloniki: Society of Macedonian Studies, 1952.
Yıldız, Sema K. "18. Yüzyılın İlk Yarısında Bursa'da Sosyal ve İktisadi Hayat." Ph.D. diss., Marmara Üniversitesi, 2019.

Other data

Figure A1 plots the great circle distance from Istanbul to various cities against official freight rates from the early 1800s and finds a strong positive correlation.

Figure A1. Relationship between great circle distance and freight costs with Istanbul for 1809-1815

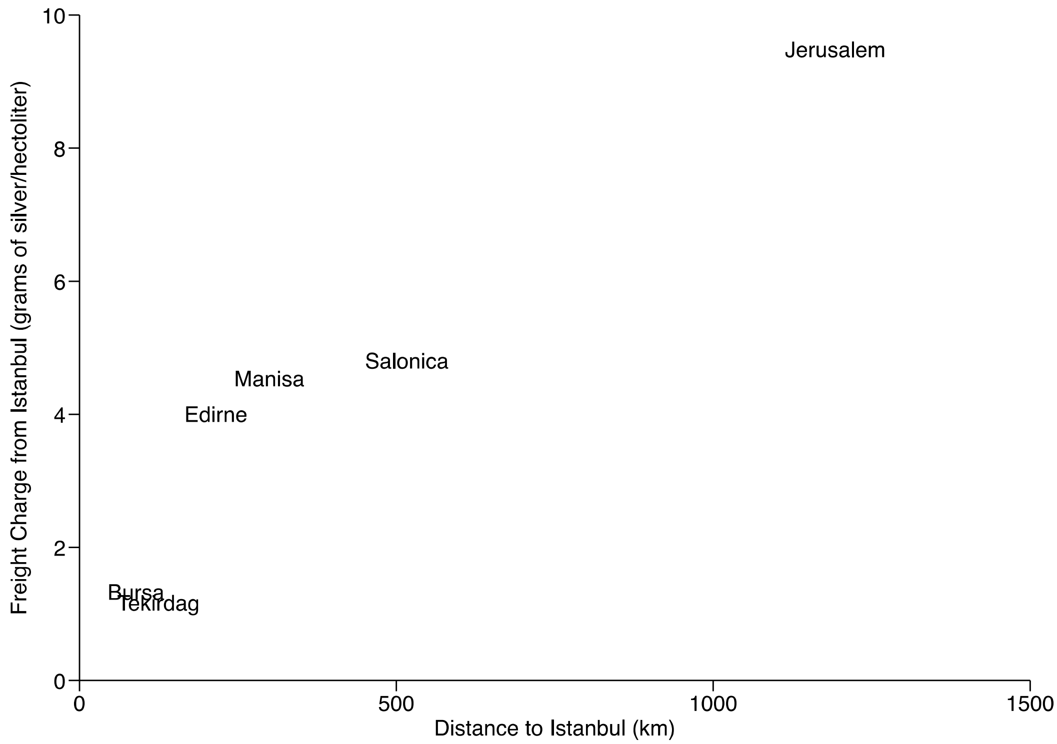


Table A1 reports the connection dates for both steamship and railroad networks. Railroad connection dates are drawn from Haznedar and Uysal (2020). A railroad line linking Haifa and Daraa was completed in 1905; however, by 1912, this segment remained unconnected to the broader Ottoman rail network. For Jerusalem, we adopt this 1912 date despite the Haifa–Jerusalem connection being completed later. The analysis remains robust to alternative codings for Jerusalem's connection date. Steamship connection dates are based on a range of sources, with the coding criterion being the commencement of regular commercial steamship operations. For some cities, however, the precise timing of these operations is more ambiguously documented.

Table A1. Steamship and railroad connection dates

City	Steamship Connection	City	Railroad Connection
Athens	1837	Aleppo	1912
Bursa	1840	Ankara	1892
Cairo	1830	Damascus	1912
Canakkale	1837	Edirne	1873
Dobruca	1839	Istanbul	1873
Istanbul	1828	Jerusalem	1912
Jerusalem	1840	Konya	1896
Tekirdag	1846	Salonica	1896
Ruse	1834		
Salonica	1853		
Belgrade	1834		
Manisa	1836		
Braila	1836		

Table A2 lists the Roman cities used to estimate transportation costs based on the algorithm in Scheidel et al. (2012). To apply Scheidel et al. (2012) model, we first identify Roman cities whose locations geographically overlap with the Ottoman cities in our sample. We then use the model to calculate the minimum cost paths and associated costs for wheat transport between pairs of cities, providing a second proxy for historical trade expenses.

Table A2. Ottoman cities and corresponding roman cities used in transportation cost estimation

Ottoman City	Roman City	Ottoman City	Roman City
Aleppo	Beroia	Edirne	Hadrianoupolis
Ankara	Ancyra	Ermoupoli	Syros
Antep	Cyrrhus	Istanbul	Constantinopolis
Athens	Athenae	Jerusalem	Ierusalem
Belgrade	Singidunum	Kayseri	Caesarea
Braila	Troesmis	Konya	Iconium
Bursa	Prusias	Manisa	Magnesia
Cairo	Heliopolis	Patmos	Patmos
Canakkale	Kallipolis	Ruse	Novae
Candia	Chersonasos	Salonica	Thessalonica
Damascus	Damascus	Tekirdag	Perinthus
Dobruca	Marcianopolis		

Scheidel (2014) compares the sea-to-land transportation cost ratio used in the Scheidel et al. (2012) model with recorded cost ratios from medieval and early modern Europe and China. He finds them broadly comparable, though the model assigns a somewhat lower cost to sea travel than historical estimates from these regions. This discrepancy may reflect the greater security of Roman sea lanes relative to those of later periods. Consequently, the model's figures serve as a robustness check against great circle distance measures, which tend to overstate the relative cost of maritime transport.

Figure A2 illustrates the relationship between great circle distance and estimated transportation costs for city pairs. In the figure, city pairs are color-coded by waterway access: blue indicates that both cities have access to major rivers or the sea, light blue indicates that only one city has such access, and yellow indicates that neither city does. The figure clearly shows that city pairs with waterway access tend to have lower estimated transportation costs relative to their distance, whereas city pairs lacking such access generally face higher costs.

Figure A2. Relationship between great circle distance and estimated transportation cost based on Scheidel (2012)

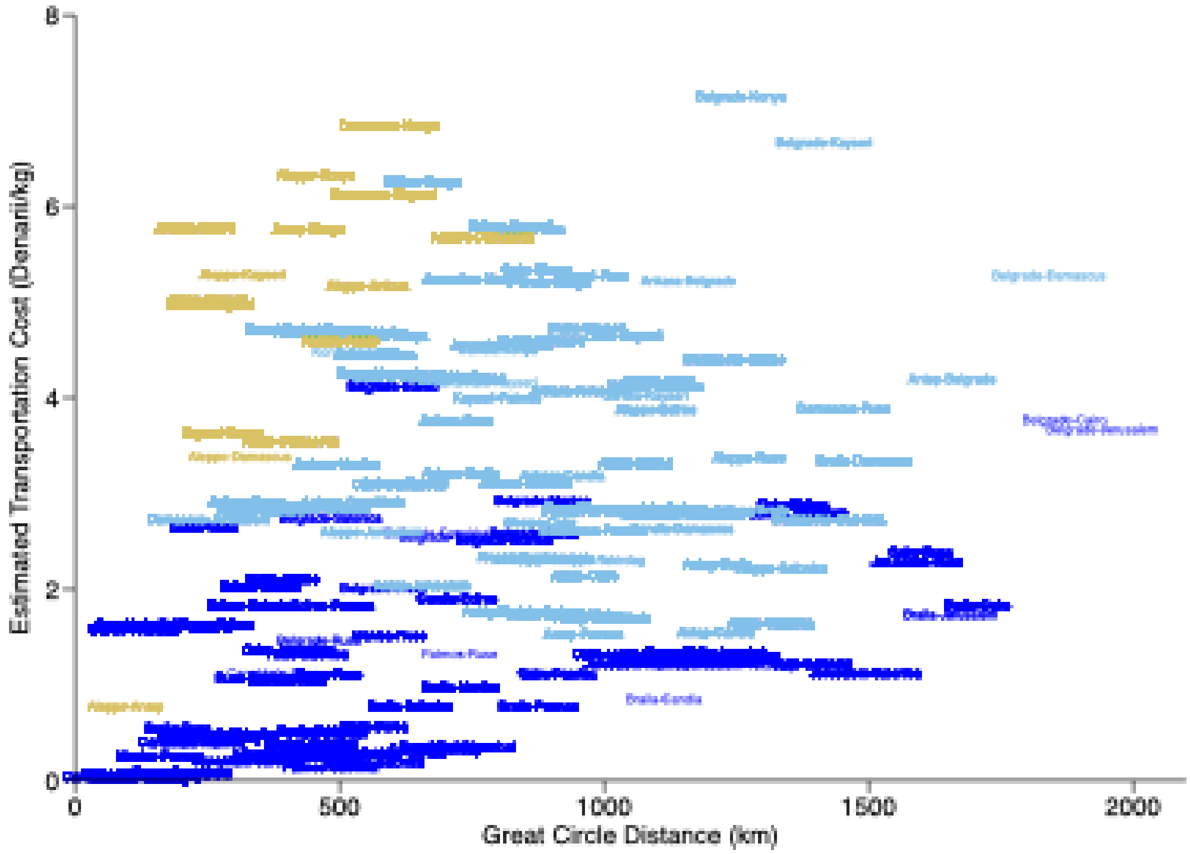


Table A3 lists the summary statistics of the variables used in the empirical analysis.

Table A3. Summary statistics for variables

Variable	Description	N	Mean	Std Dev.	Min	Max
Absolute bilateral price gap	Log of the absolute price difference between city pairs in grams of silver per hectoliter of wheat	8654	0.43	0.34	0.00	2.58
Distance	Great circle distance between pairs of cities (km)	8654	629.09	368.54	71.78	1942.15
Transportation cost	Estimated summer wagon transport cost of wheat on the least-cost route, averaged across directions (denarii/kg)	8273	8.38	5.88	0.10	23.59
State capacity	Annual per capita tax revenues normalized by daily wages of unskilled workers (days of wages)	8654	4.71	3.34	1.36	13.61
War pressure (west)	War casualties on the western front (100,000 casualties)	8654	0.08	0.25	0.00	2.45
War pressure (east)	War casualties on the eastern front (100,000 casualties)	8654	0.01	0.03	0.00	0.16
Monetary instability	Annual depreciation rate of the monetary unit (%)	8654	3.02	9.43	0.00	58.37
Climate shock	Difference in annual Drought Severity Index between city pairs (−10 = extremely dry, +10 = extremely wet)	8654	1.86	1.58	0.00	14.04
Railroad connection	Dummy variable for domestic railway connection (1 = connected)	8654	0.02	0.12	0.00	1.00
Steamship connection	Dummy variable for steamship connection (1 = connected)	8654	0.10	0.30	0.00	1.00

Appendix B: Methodology of factor analysis

For factor analysis, we estimate the following model:

$$p_{i,t} = \alpha_i + \sum_{k=1}^{K} \beta_{k,i} f_{k,t} + \varepsilon_{i,t}$$

where i are the cities, t are the years, k are the factors, $p_{i,t}$ is the Hodrick–Prescott filtered wheat price for city in year t, α_i are city specific constants, $f_{k,t}$ is the value of the kth common factor in year t, $\beta_{k,i}$ is the correlation or factor loading of city i with the kth common factor and $\varepsilon_{i,t}$ is the idiosyncratic shock for city i in year t.

The estimated common factors, f_k are used to decompose the price variance of city i, σ_i^2, into variances that can be explained by the k factors and the idiosyncratic variance as follows:

$$\sigma_i^2 = \sum_{k=1}^{K} \beta_{k,i}^2 \sigma_k^2 + \sigma_{i,\varepsilon}^2$$

The fraction of the city i's volatility explained by the K common factors is:

$$\widehat{\sigma_i^2} = \frac{\sum_{k=1}^{K} \beta_{k,i}^2 \sigma_k^2}{\sigma_i^2} = 1 - \frac{\sigma_{i,\varepsilon}^2}{\sigma_i^2}$$

For each city i, we iteratively calculate this fraction for 51-year windows and use it to build the city i's co-movement index.

Finally, to build country level co-movement index, we average the city level co-movement indices for cities in that polity:

$$\overline{\sigma_R^2} = \frac{\sum_{i \in R} \widehat{\sigma_i^2}}{n(R)}$$

Figure 8 presents results from a one-factor model estimated separately for the core and wide Ottoman samples, as well as for cities in England, France, and Spain, over 51-year rolling windows between 1580 and 1900. For each city i, the correlation between its prices and the common factor, denoted $\beta_{1,i}$, is calculated. These city-level correlations are then averaged within each polity to construct domestic co-movement indices at the polity level.

For Figure 11, a one-factor model is estimated iteratively over 51-year windows after 1580 for four core Ottoman cities and 37 European cities to construct city-level international co-movement indices. These indices are then averaged by polity to produce polity-level international co-movement measures. Figure 12 re-estimates the model for an expanded set of 11 Ottoman cities and the same 37 European cities for the post-1680 period, and plots the resulting city-level international co-movement indices for five Ottoman cities.

Appendix C: Alternative specifications for domestic integration

Table C1 presents the regression analysis for robustness specifications and tests alternative explanations. Specification 1 replaces city fixed effects with city-pair fixed effects, reflecting a different assumption about the nature of unobserved heterogeneity. By including city-pair dummies, the specification controls for all time-invariant characteristics unique to each dyad, such as geographic proximity, historical trade relationships, or enduring cultural ties. While this approach prevents the estimation of bilateral variables that do not vary over time, such as distance, it allows for a cleaner identification of the effects of time-varying shocks or policy changes within each city-pair. This contrasts with the baseline specifications presented in the main text, which include city fixed effects. The latter control for persistent city-level characteristics, such as administrative status, market scale, or infrastructure quality, that may influence a city's overall level of integration. Hence, city fixed effects assume additive and symmetric contributions of each city to bilateral price gaps, whereas city-pair fixed effects absorb all dyad-specific heterogeneity and isolate variation over time within each pair.

Under this specification, earlier results remain robust. State capacity, steamship, and railroad connections are estimated to have decreased price gaps, whereas war on the eastern front, monetary instability, and asymmetric climate shocks are estimated to have increased them.

Specification 2, estimated with two-way clustering on city-pair and decade, offers a more robust framework for accounting for heteroskedasticity and serial correlation. By clustering on both dimensions, it allows for correlated shocks within city pairs over time and across observations within the same decade, capturing a broader structure of temporal and spatial dependence. It also comes at the cost of reduced degrees of freedom and more conservative standard errors, potentially resulting in more conservative standard errors and lower statistical significance of some estimates.

In this more conservative specification, estimated effects are generally weaker but most remain statistically significant. State capacity, monetary instability, and steamship connections retain significance. War on the western front has a positive estimated effect and the railroad connection a negative one, though both are marginally insignificant. Asymmetric climate shocks also lose significance.

Specification 3 tests whether the impact of state capacity on market integration increases with distance from the capital. By interacting tax revenue per capita with distance from the capital, we assess whether fiscal gains more strongly reduced price gaps in peripheral regions. The underlying idea is that rising fiscal capacity reflects a broader strengthening of state institutions, enabling the central government to more effectively enforce rules, lower transaction costs, and integrate peripheral markets into the domestic economy. A negative and significant interaction term would indicate that these effects were especially pronounced in areas historically beyond the routine administrative or military reach of the capital. The estimated interaction effect is negative and significant, lending credence to the idea that growing state capacity mainly benefited peripheral regions in terms of integration.

In Specification 4, we include a post-1841 dummy in the regression to test whether the period following the commercial treaties of 1838–1840 marked a structural shift in price integration. The motivation for this specification lies in the broader context of the Balta Limanı Treaty of 1838 and the subsequent agreements with major European powers, including France, Austria, and Prussia. These treaties established a regime of reduced tariffs and granted extensive trade privileges to foreign merchants. Crucially, they also mandated the abolition of domestic monopolies, dismantling guild controls and state trading privileges. While primarily aimed at promoting foreign trade, these reforms may also have contributed to internal market integration by facilitating freer movement of goods within the empire and weakening barriers to interregional commerce. At the same time, the post-1841 dummy is a blunt proxy and may not accurately isolate the impact of these treaties, as it coincides with other significant transformations during the same period, including the expansion of steamship networks and broader commercial reforms.

The results indicate that the post-1841 dummy is associated with lower price gaps, but the effect is only marginally significant at the 10 percent level. In this specification, state capacity, steamship, and railroad connections also have lower statistical significance compared to the corresponding specification 5 in Table 2 in the main text, highlighting the difficulty of untangling these overlapping processes without a more accurate proxy for trade policy.

Table C1. Alternative Specifications for Determinants of Bilateral Price Gaps

	(1)	(2)	(3)	(4)
Distance (log)			0.070***	0.071***
			(7.04)	(9.58)
State capacity	-0.005***	-0.006*	0.021**	-0.004*
	(-3.89)	(-1.75)	(2.25)	(-1.71)
Monetary instability	0.003***	0.003**	0.003***	0.003***
	(6.59)	(2.35)	(6.45)	(6.52)
Steamship connection	-0.143***	-0.139***	-0.116***	-0.103***
	(-8.62)	(-3.40)	(-8.64)	(-7.85)
Railroad connection	-0.068***	-0.065	-0.077***	-0.061**
	(-2.71)	(-1.59)	(-3.19)	(-2.54)
War pressure (west)	0.049***	0.049	0.054***	0.056***
	(3.08)	(1.46)	(3.35)	(3.49)
War pressure (east)	0.154	0.146	0.11	0.1
	(1.34)	(0.34)	(0.95)	(0.87)
Climate shock	0.005**	0.005	0.006**	0.006**
	(2.21)	(1.14)	(2.51)	(2.42)
Distance to capital (log)			0.015	
			(0.69)	
State capacity × Distance to capital			-0.005***	
			(-2.96)	
Post-1841 dummy				-0.027*
				(-1.66)
Observations	8654	8654	8654	8654
City pair FE	Yes	Yes	No	No
City FE	No	No	Yes	Yes
Decade FE	No	No	No	No

*Notes: The dependent variable is log absolute bilateral price gap. Robust standard errors in (1), (3), (4); clustered standard errors (City-pair × Decade) in (2). T-statistics in parentheses levels of statistical significance: * 0.1 ** 0.05 *** 0.01.*

Figures C1 and C2 replicate Figures 6 and 7 from the main text, but use specification 2 from Table 2, which relies on estimated transportation costs instead of great circle distance. The resulting patterns closely resemble those in the original figures, suggesting that the findings are robust to this alternative measure of trade cost.

Figure C1. Evolution of average price gap between Ottoman cities over time, controlling for estimated transportation cost

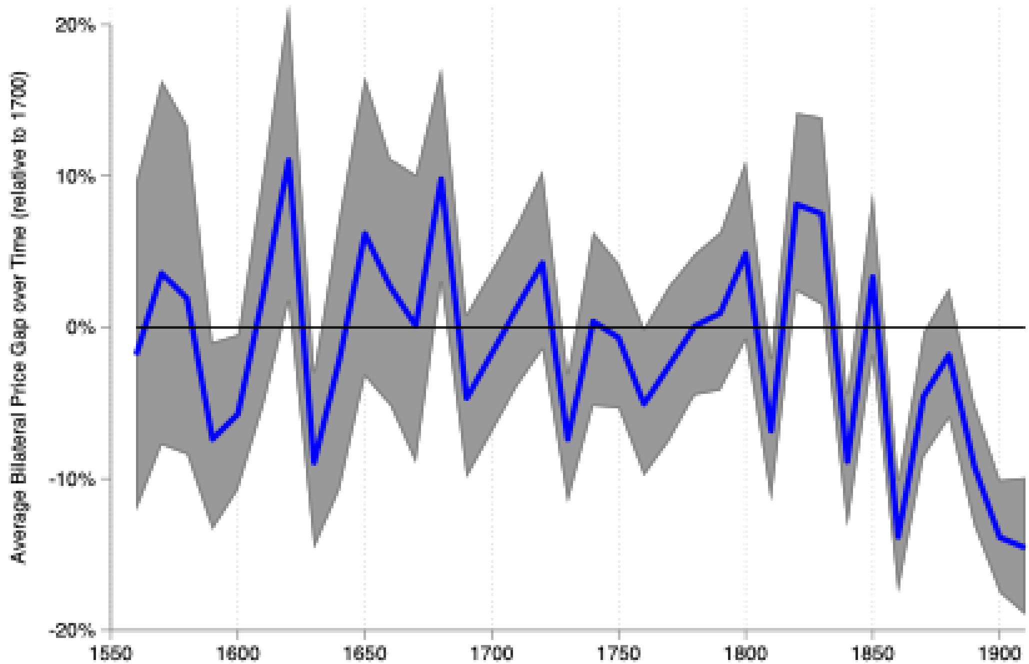


Figure C2. estimated impact of individual cities on price gaps (% change), controlling for estimated transportation cost

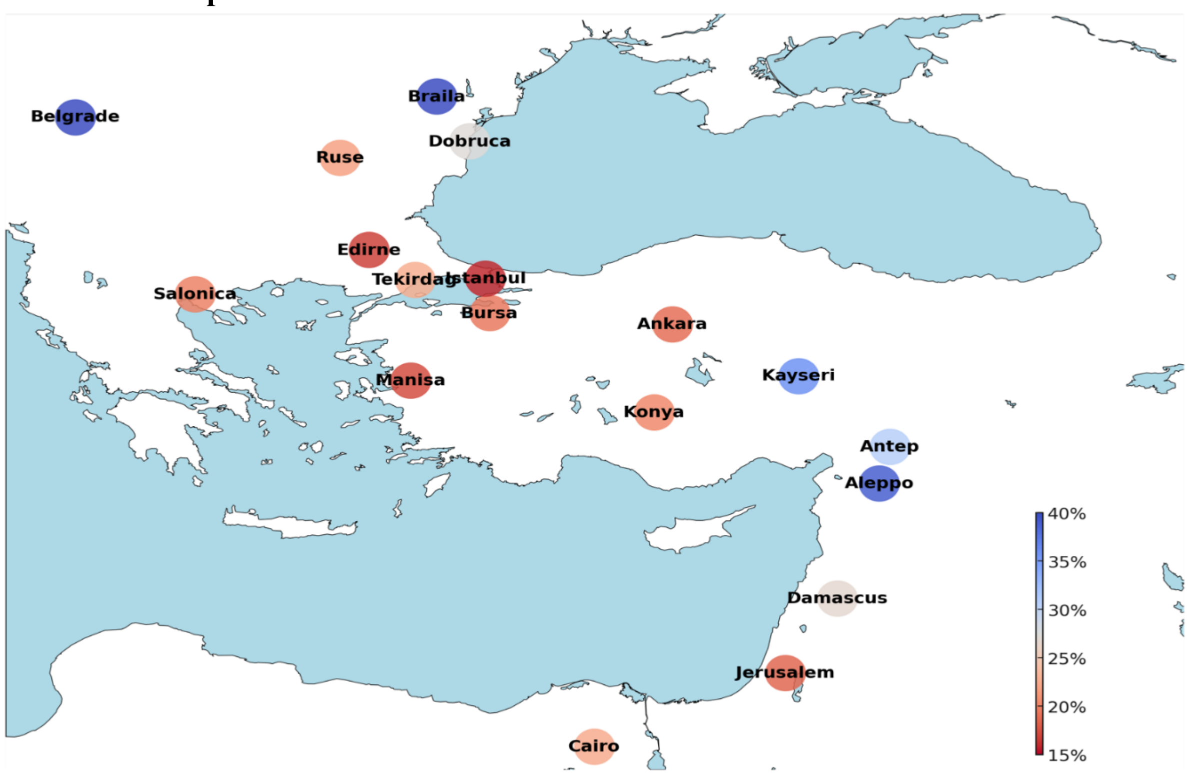


Figure C3 plots pairwise correlations of prices between 11 Ottoman cities from 1680 to 1900. The figure indicates a concentric pattern of market integration for Ottoman cities. Core cities around the capital and to a lesser extent cities with access to the Mediterranean have relatively synchronized price movements. In contrast, peripheral and inland cities not only had low price correlations with core cities but also between themselves.

Figure C3. Bilateral price correlations between Ottoman cities, 1680-1900

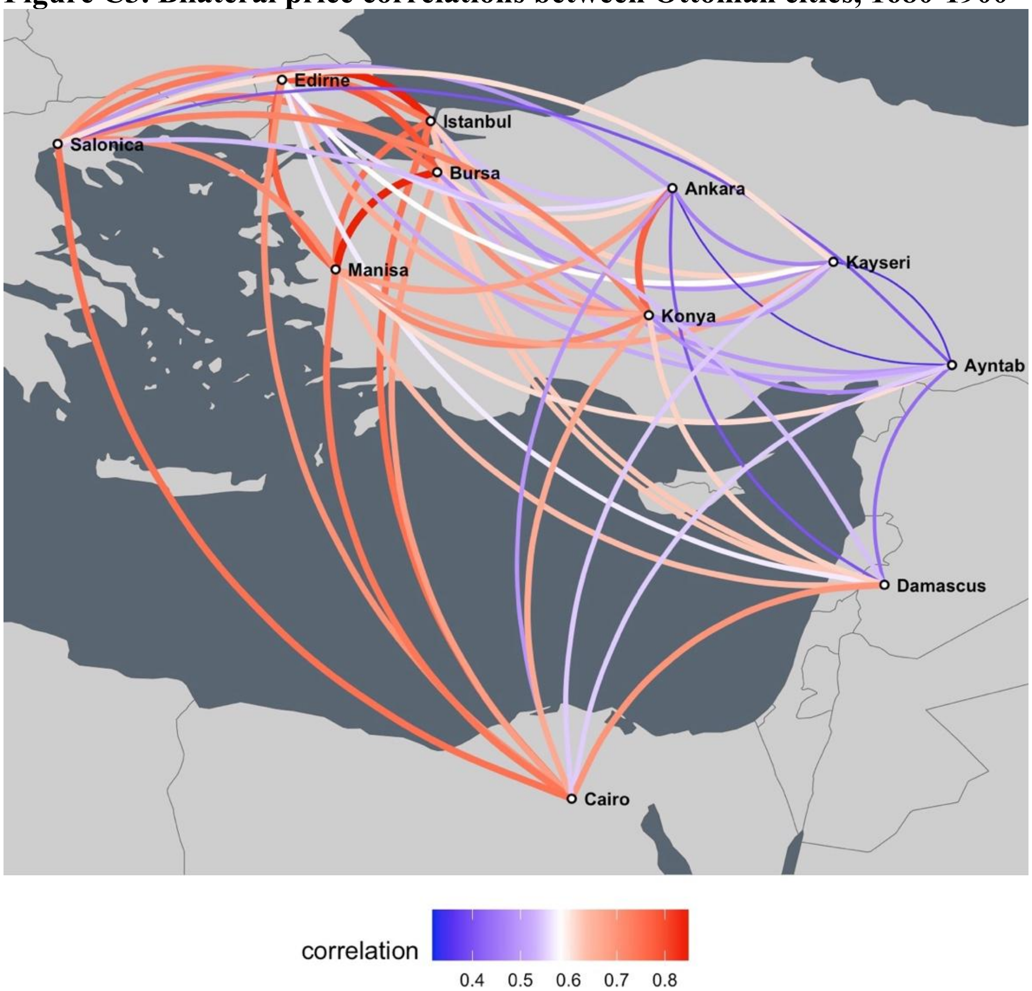
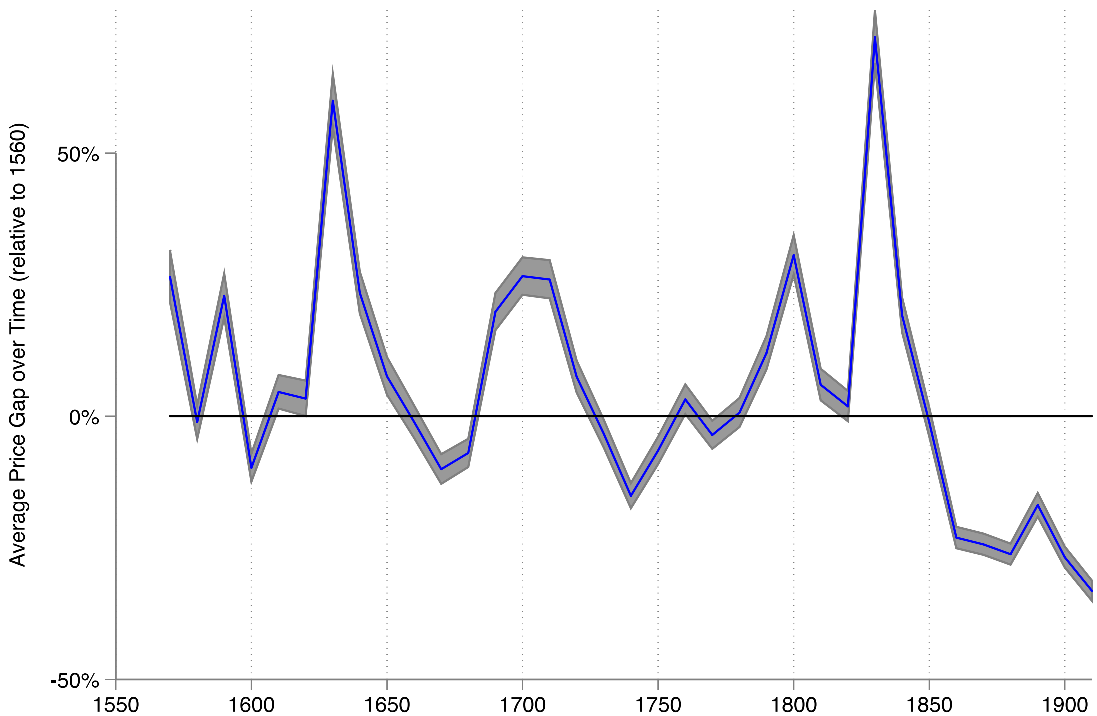


Figure C4 replicates Figure 11 in the main text , but instead of displaying the decade fixed effects from the regression of price gaps between Ottoman cities and European Mediterranean cities, it shows the results using price gaps between Ottoman cities and all 39 European cities in the sample. The figure presents the estimated coefficients for decade dummies along with 95% confidence intervals. The x-axis represents decades, and the y-axis indicates the change in average price gap relative to the reference decade, the 1700s. While price gaps fluctuate over time, a sustained decline appears only around the mid-19th century. Overall, the trend is consistent with Figure 11, though the confidence intervals are narrower.

Figure C4. Evolution of the average price gap between Ottoman cities and European cities over Time



Source: Authors' estimations

Figures C5 and C6 estimate a factor model based on the methodology of Federico et al. (2021). The model first applies a Hodrick-Prescott filter to the price series, then estimates a one-factor structure, modeling each series with AR(3) dynamics and allowing the latent factor to follow an AR(8) process. Gaussian priors are imposed on the parameters, and estimation is conducted using Bayesian MCMC techniques with 10,000 iterations following a 2,000-draw burn-in. A Gibbs sampler is used to iteratively draw from the posterior distributions of parameters, factor loadings, and latent factor paths. The posterior median of the factor and the R-squared values from the factor regressions are used to assess the degree and evolution of market integration over 51-year rolling windows. The results align broadly with the simplified model presented in the main text. For domestic co-movement, no marked improvement is observed in the four-city core sample, though moderate gains appear in the broader 11-city sample during the 19th century. For international co-movement, more pronounced gains are evident in the same period.

Figure C5. Domestic Co-movement Indices for Ottoman Empire, Dynamic Factor Model, 1580-1900

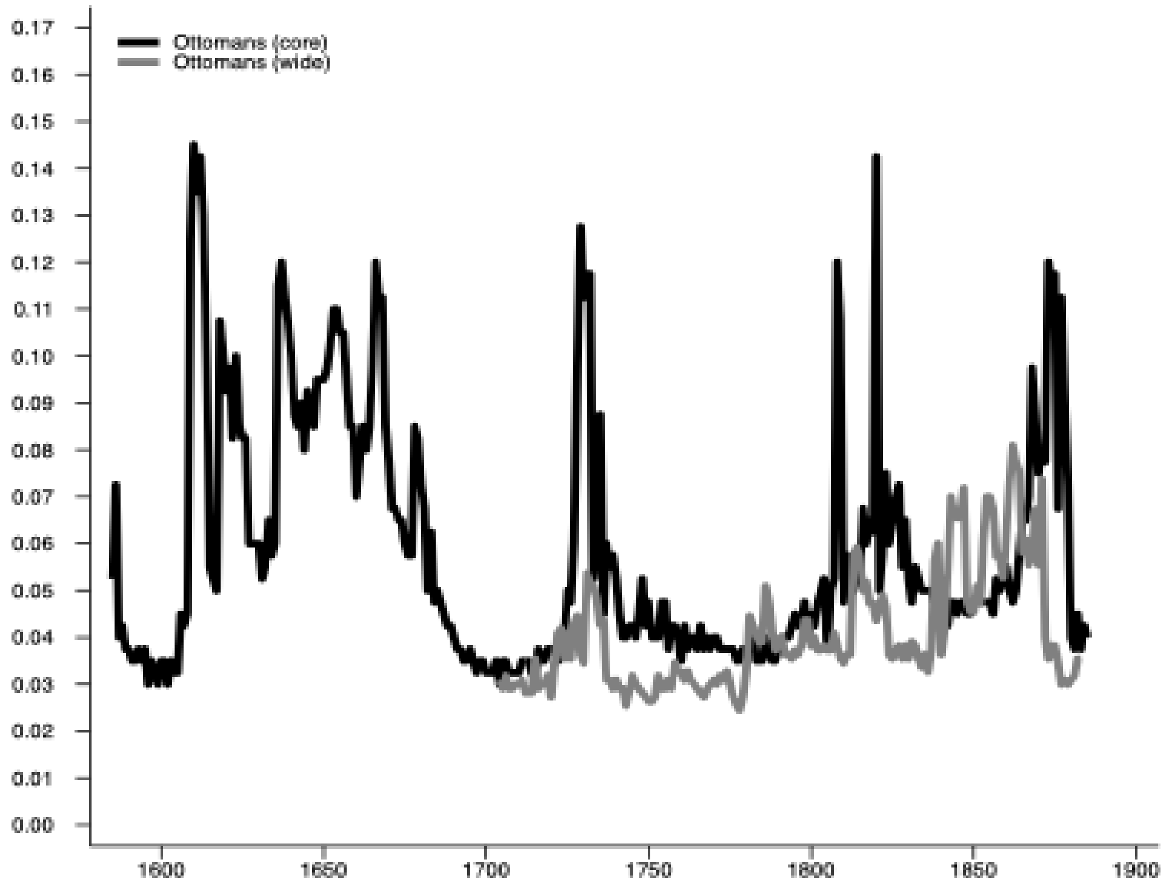


Figure C6. International co-movement indices for Ottoman empire, dynamic factor model, 1580-1900