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Transportation Infrastructure and Economic Growth in a Dissolving Country: (Ir)relevance of Railroads in the Ottoman Empire

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9 September 2013

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Abstract: The literature includes few studies and mixed findings on the impacts of the railroad construction for underdeveloped economies. Using the data on the population of judicial districts in the Ottoman Empire between 1893 and 1914, we examine the relationship between railroad access and economic growth in local economies of a transformation country on the eve of the First World War. Our empirical results show the size expansion in the affected areas of railroad access. This suggests positive impact of railroads on economic growth in the Ottoman Empire through higher employment opportunities and fertility rates. To deal with endogeneity problems, we use instrumental variable (IV) strategy. Our 2SLS results also indicate that the causality runs from access to railroads to population growth. The paper contributes to the previous literature by focusing on how transformation in road networks induced economic growth in an agricultural and dissolving economy.
Keywords: Railroads, The Ottoman Empire, Economic growth, Population growth, 2SLS
JEL classification numbers: N75, N95, O4

1 Introduction

Access to railroads is seen as one of the key drivers for long-run economic growth. The positive effect of railroads on trade, productivity, production, and population has been demonstrated for many countries from Germany to India (such as Donaldson (2014), Hornung (2015)). This positive effect of access to railroad works mainly through decreasing transportation costs, which provides new markets for goods and creates job opportunities (Wang & Wu 2015; Jedwab & Moradi 2016).

In this paper, we examine the impact of access to railroads on economic growth in the Ottoman Empire between 1893 and 1914, including railroad construction boom. Analysing the effect of railroads on the Ottoman economy is important for several reasons. First, the historical developments shed light on today's realities (See Nunn (2009)). Second, although the effects of historical railroads on economic performance in many countries have been investigated several times (such as Fogel (1964), Atack et al. (2011a), Caruana-Galizia & Marti–Henneberg (2013), Donaldson (2014), Hornung (2015), Donaldson & Hornbeck (2016)), there were not many papers for the Middle Eastern and transformation economies (see Akgungor et al. (2011, 2012), Banerjee et al. (2012), Wang & Wu (2015), Ansar et al. (2016), Jedwab & Moradi (2016)). Furthermore, the Ottoman Empire was a dissolving country, as wars by 1914 were related to land, workforce, and economic losses. In addition, there were reforms in both economic and

political life such as railroad construction, which could have mitigated the effects of the disruptions. Third, in the Ottoman Empire the main motivation for building railroads was not economic but political, which is econometrically addressed by our paper for the first time in the literature. The Ottoman state mainly desire to build railroads to exercise political control over the territories by mobilization of troops to fight against rebellions and wars in remote locations (See Quataert 1977). Duranton & Turner (2007) and Jedwab & Moradi (2016) argue that the political motive for construction does not guarantee that the effect of roads on economic growth is positive and strong. Last, whether railroads induced economic growth is not some a settled topic, while several papers (such as Fogel (1964), Haines and Margo (2008), Banerjee et al. (2012), Ansar et al. (2016)) evince that railroads were not indispensable for economic growth and higher agricultural output in the US and China.

Since the early nineteenth century, railroads emerged as a new form of transportation in Europe and US. In 1856, the construction of railroad lines in the Ottoman Empire began. Although many of its parts were isolated, railroad networks grew rapidly until 1914, which connected Rumelia[1] with its other parts such as Hejaz, Syria, Iraq, and Anatolia. In the historical literature, many researches argue a substantial increase in trade and agricultural production, as railroads linked ports with the interior.[2] There is a strand of literature pointing out that railroads were associated with lower production in connected places due to higher imports resulting in the domestic industry being hampered (Quataert 1996: 814). Another strand of the literature states the absence of economic growth due to railroads. This strand is based on the argument that railroad lines were not adequately connected to one another (Ortaylı 2010: 166),[3] and resultantly the passenger and good traffic was not intense. Another reason for the low level of the traffic is that railroads were not connected with highways (Eldem 1994: 105). Furthermore, as foreign firms abused kilometric guarantee system to get more money, they built the railroads in places that railroads were not needed (Schoenberg

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[1]Land of the Ottoman Empire in Europe

[2] See British Parliamentary Paper (1896: 10), Karkar (1972: 65, 82), Quataert (1977; 1996: 810–814; 2005: 126), Eldem (1994: 94), Gülsoy (1994: 245–246; 2010: 181–182, 270), and Hülagü (2010: 14–45).

[3] All major European powers (i.e., the UK, France, Germany, Russia, Italy, and Austria-Hungary) wanted to build railroads to control places politically and economically. The construction of the railroads by one power would create a threat to its rivals' economic and political dominance in the respective location. Competition among the major European powers to control the respective location via railroad investments would create conflicts, which was responsible for delays in the construction and un-built lines (Illich 2007: 91–93; Ortaylı 2010, 165–166; Geyikdağı 2011: 54–55).

1977; Karkar 1972: 111; Issawi 1982: 60; Owen 2002: 196–197). Similarly, the Ottoman state wanted railroads to be built in places of political and military importance even if that area had not high population. Moreover, several railroad lines were indeed located in less populated or economically important places where famines had been often seen (Karkar 1972: 111; Quataert 1977; Schoenberg 1977; Quataert 1977, 1996: 789; Erler 2010: 304–312; Gülsoy 2010: 27, 132, Hülagu 2010: 23–25).

In line with these arguments of the historical literature, the railroads might not have great benefits for the local economy and their effects could be relatively small, motivating our paper. The railroad construction in the Ottoman Empire also provides an important case to examine whether the railroads could imply a great transformation for its transportation infrastructure, since arguably its existing road networks were not well developed as compared with the other countries because of financial difficulties and lack of technological knowledge, resulting in low factor mobility (Schoenberg 1977; Quataert 1996: 804; Gülsoy 2010: 27). In sum, it is an empirical question whether access to railroads affected economic growth or not in the Ottoman Era. There is no data source with information about economic outcomes at the judicial district level for the Ottoman Empire. In this paper, we use population data for 628 judicial districts (known as *kaza*s) from 32 provinces (known as *vilayet*s) in the Ottoman Empire for the years between 1893 and 1914 to examine whether access to railroads induced economic growth in the Ottoman Empire. We conduct a similar analysis to Hornung (2015) using population data of urban areas to examine local economic growth due to railroads in Prussia during the industrial development. Hornung (2015) argues that when railroad access induced economic growth, which was positively related to employment opportunities in connected urban areas, people would move to find jobs resulting in higher population level in the respective places.[4] Our argument is that railroad lines would have been correlated with higher population of a judicial district in the affected areas, if increasing production level thanks to the railroads would have led to birth surplus and migration.[5]

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[4] Our sample consists of population in urban and rural places, while there is no such definition for the Ottoman Empire. Hornung (2015) uses urban population growth to examine the impact of railroads on economic growth, as human and physical capital was mostly located in these areas. Also, urban population should be correlated with income because a society needs significant surplus to support all those people who are not farming. See Table A2 showing that the coefficient estimate for the effect of railroads on population growth in mostly populated areas is not different much from the coefficient estimates obtained from full sample.

[5] There is no data to distinguish sources of population growth, i.e., migration or fertility.

Our OLS results indicate a positive relationship between railroad access and population in the affected areas. Under data constraints, we can argue that railroads were related to an inflow of people because of higher production and job opportunities together with increasing birth rate. But, as the previous literature underlines, the placement of railroad lines could be endogenous, which could lead to biased OLS estimates for the impact of railroads. To deal with this bias, they construct instrumental variables for measures of railroad access (Atack et al. 2010; Banerjee et al. 2009; Atack et al. 2011b; Kotavaara et al. 2011; Schwartz et al. 2011; Koopmans et al. 2012; Donaldson 2014; Berger & Enflo 2015; Hornung 2015). Following the previous literature, we estimate 2SLS by using historical trade routes as an instrumental variable for access to railroads. Our 2SLS results demonstrate that access to railroads was positively correlated with population growth. The OLS and 2SLS estimates are between 0.06 and 0.28, which are not much different from those in early constructers, i.e., the US, in magnitude (Hornung 2015).

We extend the previous literature on the impact of railroads by presenting evidence for an understudied region in which the effect of the railroads has been greatly debated by historians. The findings suggest that the transformation of road networks in the Ottoman Empire was crucial for stimulating economic growth, although their construction's major impetus was political and the location of the lines was not well designed due to political agendas of the major European powers. While the railroad network was not dense, pre-existing roads seem important for the positive impact. Our paper is different from previous studies on the Ottoman railroads (see Kolars & Malin (1970), Akgungor et al. (2011, 2012))[6] because of using population data at judicial district level, which consisted of many present-day countries.[7] In addition, our paper is the first to address the placement decisions of the railroad lines in the Ottoman Empire and various measurement errors in the historical data using an instrumental variable approach.

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6 Akgungor et al. (2011, 2012) investigate the effect of railroads on the development of cities in one of the successor states to the Ottoman Empire, i.e., Turkey, in an econometric context using kilometres of railroads as a measure of railroad access. There are also some descriptive studies—such as Kolars & Malin (1970)—that study on the effect of railroads in the Ottoman Empire and Turkey, using historical data.
7 These countries are Turkey, Greece, Syria, Iraq, Lebanon, Israel, Palestine, Jordan, Yemen, and some parts of Albania, Macedonia, Kosovo, and Saudi Arabia.

The remainder of the paper is organized as follows; next section discusses the contributions of previous literature on the effects of railroads in different countries. Section 3 provides information on the building of railroads and their impacts in the Ottoman Empire. Sections 4 and 5 undercover the data and empirical methodology applied. Section 6 canvasses the results and discusses, as Section 7 concludes. Appendix contains a description of the instrumental variable and robustness checks.

2 Literature Review

A recently growing interest for the impacts of railroads on economic outcomes in different countries from a historical context exists and provides conflicting evidence. Haines & Margo (2008), Atack et al. (2010), Atack et al. (2011), Atack & Haines (2011), and Donaldson & Hornbeck (2016) are comprehensive studies on the US, which was an agriculture-based economy during the examination period. Atack et al. (2010) use data on population density and the rate of urbanization on 287 counties for the years 1850 and 1860. Their results indicate higher development levels for the counties that were connected with railroads. Based on agricultural data of 278 counties for 1850 and 1860, Atack et al. (2011) indicate a positive relationship between railroad access and agricultural productivity. Using data for manufacturing establishments from 1850 to 1870, Atack & Haines (2011) provide evidence that railroad access increased the size of factories. Donaldson & Hornbeck (2016) study that railroads induced economic growth from 1870 and 1890, looking at county level agricultural data. They evince the presence of higher value for agricultural lands in connected places due to increasing population and economic growth. This positive effect works through increasing market access, as railroads enabled lower transportation costs. Haines & Margo (2008), on the other hand, fails to show a consistent impact for railroads on economic development from 1850 to 1860.

In a similar vein, several papers focus on the relationship between railroads and economic growth for European countries. Caruana–Galizia & Marti–Henneberg (2013) use regional GDP data for different European countries such as Britain, Spain and Italy from 1860 to 1911. Their findings suggest that railroads are positively associated with economic prosperity in the connected places. They also find that the lines located in the neighbours did not induce economic growth. Berger & Enflo (2015) study the effect of railroads on urban growth in Sweden between 1800 and 2010. They show a positive

association between railroad access and population growth, suggesting a higher economic activity in connected places. Hornung (2015) focuses on the impact of railroads on economic growth, looking at population and firm data for 978 cities in Prussia for the period 1840-1871. Different from many of previous studies, Hornung (2015) analyzes Prussia during the industrial development and provides weak evidence for the positive effect of railroads on economic growth in Prussia.

The literature includes several papers on developing countries. Jedwab and Moradi (2016) examine the effect of railroads on economic and demographic outcomes in Ghana, using data for the years 1850 and 2000. They find a positive relationship between railroad access and cocoa production due to decreasing transportation and input costs. Their results also imply that railroads are positively related to population growth in connected places, as increasing cocoa production attracted a large number of people which seek employment opportunities in places that gain access to railroads. Similar to our study, Akgungor et al. (2011, 2012) investigate the relationship between railroads and several outcomes in modern Turkey, using a sample from the Ottoman period. They find a positive impact of railroad access on agricultural production, as there is not a statistically significant effect on population density in the connected places.

In addition, Banerjee et al. (2012), Donaldson (2014), Wang & Wu (2015), and Ansar et al. (2016) are papers asking that railroad access is associated with economic and demographic outcomes in China and India. Based on data of per capita GDP and GDP growth, population and population growth of 353 counties in China from 1986 to 2003, Banerjee et al. (2012) find that the railroad access is associated with only increasing of GDP per capita growth. Donaldson (2014) provides evidence that railroad access led to higher real income and trade level, as there is a negative effect of railroad access on transportation costs in India between 1870 and 1930. Wang & Wu (2015) examine that the Qingzang railway of China induced economic development in connected places, based on county level data between 1997 and 2009. Their results show that railroads led to economic development in places that gained access. On the other hand, Ansar et al. (2016) fail to provide evidence that railroad access is statistically related to economic growth, using data for 19 provinces of China from 1918 to 2008.

3 Railroads and Economic Growth in the Ottoman Empire

3.1 *Railroad Construction in the Ottoman Empire*

In the 1850s, the length of railroads was 620 km in Italy, as Spain had less than 100 km of railroad lines. Austria-Hungary, the UK, and the US had 1,357, 9,800, and 14,480 km of railroad lines, respectively (Kasaba 1993: 40–41; Quataert 1996: 804). By the 1860s, no railroad line operated in the Ottoman Empire. In addition, it was argued that the existing road networks were in a poor condition (Kolars & Malin 1970; Schoenberg 1977).[8] There were many geographical, political and financial obstacles in building of railroads. Railroad construction began after 1855. As shown in Figure 1, its railroad network grew to 8,334 km by 1914 by the building of many lines (Schoenberg 1977; Eldem 1994: 103).

Figure 1. The Railraod lines in the Ottoman Empire (1860–1914)
Source: Author calculation based on data for the lines (see data section).
Notes: The orange lines began to operate after 1900, as yellow lines were built between 1880 and 1900. The blue lines began to operate between 1880 and 1870. The red lines were constructed by 1861.

The Ottoman state primarily desired the construction of railroads to increase its political control over its territories. The poor roads hindered wars in remote locations and mobilization of troops to fight against rebellions. It did not have the funds to finance building of railroads and the contemporary technological knowledge for building railways. This is the reason why the foreign railroad firms of major European powers constructed and operated many railroad lines, as seen in Table 1. Foreign firms built railroads to import raw materials cheaper and to extend their home countries' economic

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8 In 1914, there was 20,000 kilometres of highways, as the highways were not built well (Schoenberg, 1977; Engin 1993: 28–29; Quataert 1996: 818).

control (L. D. 1915; Kurmuş 1982: 48–49; Schoenberg 1977; Illich 2007: 91–93; Gülsoy 2010, p. 27; Geyikdağı 2011: 119-126).

Table 1 suggests that French firms mainly constructed railroads in Syria, Jaffa, and Jerusalem that had been the focus of French economic interests since the eighteenth century (Shorrock 1970; Gülsoy 2010: 43–44). The railroad line between İzmir and Aydın was constructed by a British company, i.e., Smyrna–Aydın Railroad Company. The UK imported figs and sultana raisins produced in Aydın through İzmir port (Karkar 1972: 65; Issawi 1982: 159; 1980: 183; Eldem 1994: 104). This line facilitated the transportation of agricultural products by shortening the travel time only to three hours. The UK imported raw materials and products, which was produced in Aydın, easier and cheaper than before (British Parliamentary Paper 1896: 5–8, 10; Karkar 1972: 65; Özyüksel 1988: 12).

The German firms constructed several railroad lines which were supposed to link the capital city of the Ottoman Empire (i.e., İstanbul) with Anatolia and Baghdad.[9] Industrialization in Germany was positively related to demand for the cheap agricultural products and mineral resources of the Ottoman Empire after the 1880s. Germany would import them easily through the railroads[10] (Dominian 1916; McMurray 2001: 40; McMeekin 2010: 36–37; Ortaylı 2010: 58). Railroad investments of German firms led to establishment of a threat to the British and French economic and political dominance in the Asia and the Ottoman Empire (Henderson 1948; Ökçün 1997: 15–56; McMurray 2001: 41; Illich 2007: 89; Gülsoy 2010: 43–44; Ortaylı 2010: 161–165). On 17 February 1911, *Tasvir-i Efkar*, an Ottoman newspapers, disseminated news on that the opposition by the UK due to the building of these lines (Tasvir-i Efkar 17 February 1911: 1).[11]

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9 Some of the lines are built by the participation of French financiers (Geyikdağı 2011: 92).
10 Additionally, since railroad companies of Germany had rights to exploit any mineral resources—such as oil—found within 20 km of tracks, German industry would gain access to mineral resources of the Ottoman Empire via railroad investments (Karkar 1972: 87, Engin 1993: 28–29; Owen 2002: 196–197).
11 The building of the lines became a source of international disputes and was accepted as one of the important reasons for the outbreak of the First World War (Earle 1966: 2–3, 147–208).

Table 1. The Railroad Lines in the Ottoman Empire (1856 and 1914)

Railroad Lines	Length of Lines	Dates of Concession	Dates of Opening	Origin of Firms/Financiers
Baghdad–Samarra	119	--	1914	Germany
Islahiye–Resulayn	453	--	1914	Germany
Toprakkale–İskenderun	59	--	1913	Germany
Babaeski–Kırkkilise	46	1910	1911–3	Austria
Soma–Bandırma	190	1888	1912	The UK
Aydın–Dinar–Eğridir	342	1879	1889–1912	The UK
Durak–Yenice	18	--	1912	Germany
Aleppo–Karkamış	203	--	1912	France/Germany
Ulukışla–Karapınar	53	--	1912	France
Bulgurlu–Ulukışla	38	--	1911	Germany
Damascus–Medina	1564	--	1908	The Ottoman Empire
Haifa–Deraa	161	--	1905	France
Konya–Bulgurlu	200	--	1904	Germany
Homs–Jarabulus	102	1891	1903	France
Rayak–Aleppo	331	1893–98	1902	France
Arifiye–Adapazarı	9	1898	1898–99	Germany
Eskişehir–Konya	455	1893	1896	Germany
Salonica–Dedeağaç	508	1892	1896	Austria
Alaşehir–Afyon	251	1884	1895	The UK
Beirut–Damascus–Muzeirib	258	1890	1894–95	France
Salonica–Monastır	219	1890	1894	Germany
Jaffa–Jerusalem	87	1888	1892	France
Mudanya–Bursa	42	1871	1892	France
İzmit–Ankara	486	1888	1892	Germany
Manisa–Soma	92	1885	1888	The UK
Mersin–Adana	67	1883	1886	The UK
Tire–Ödemiş–Çivril	137	1879–1882	1883–4	The UK
Kasaba–Alaşehir	75	1872	1875	The UK
Üsküb–Mitrovitza	119	--	1874	Austria
Pehlivanköy–Dedeağaç	149	--	1873	Austria

İstanbul–Edirne	318	1869	1873	Austria
İstanbul–İzmit	93	--	1873	The Ottoman Empire
Edirne–Philipopoli–Belova	243	--	1872	Austria
Salonica–Üsküb	244	--	1872	Austria
Tırnova–Yanboli	106	--	1872	Austria
Banialuka–Doberlin	102	--	1872	Austria
İzmir-Kasaba	98	1863	1866	The UK
Varna–Rustchuk	220	1860	1866	The UK
İzmir–Aydın	130	1856	1866	The UK
Chernovoda–Constantza	66	1856	1860	The UK

Notes: Table shows railroad lines that were within the border of the Ottoman Empire at the census dates. The information are gathered from sources given in the data section. All of the railroad line names are given in the form in which they appear in these sources.

Apart from these lines, despite the financial problems, the Ottoman state constructed several lines itself, such as ones linking Damascus with Medina.[12] They would bring the Arab provinces under the political control of the Ottoman state. The lines would connect the holy cities of the İslam to İstanbul (Gülsoy 1994: 45–46, 2010: 270; Hülagu 2010: 61–62, 148, 180–1) and would locate around old pilgrim road (The Times 2 September 1907: 3). In addition, in the 1870s to suppress the rebels in Rumelia the Ottoman state planned to build lines connecting Rumelia with İstanbul. It gave rights to an Austrian, Baron Maurice de Hirsch, who established a firm in Paris, i.e., Compagnie Generale d'Exploitation des Chemins de Fer de la Turquie d'Europe (Karkar 1972: 67; Engin 1993: 44–45, 49–61, 108–110). A well known British newspaper, *The Times*, reported that these lines would not provide an important economic effect, as compared with its political benefits (The Times 8 October 1908: 4).

To sum up, many lines were built and operated by the foreign railroad companies. The companies had engineers to survey routes. Similarly, when the Ottoman state had wanted to build railroads itself, engineers were hired to develop plans for the lines. All plans should have been approved by the Ministry of Public Works (Engin 1993: 65). Sometimes, the Ottoman state forced the foreign railroad firms to change locations of tracks due to political and strategic reasons (Schoenberg 1977). For instance, the line linking Ankara with Aleppo did not pass through rich places even if the German firm had planned to construct the lines in places that were not poor in agricultural resources (i.e., the Mediterranean coast). The Ottoman state wanted the lines to be built in places that were located further away from the coast which would be under attack if a war broke out (Schoenberg 1977; Quataert 1996: 806). Similarly, the construction of the lines in Rumelia, Black Sea region, and Eastern parts of the Ottoman Empire created political opposition of the major European powers such as Austria-Hungary and Russia. Since the placement of the lines was designed by their demands, there were unconnected parts and changes in the locations (Gyorgy 1908: 14; Karkar 1972: 74 Engin 1993: 34–35; Gülsoy 2010: 22–24). Furthermore, several lines would have passed through places, where the Ottoman state mobilized troops easily, as a resultant, the passenger traffic was low (The Times 8 May 1912: 5). Moreover, foreign firms built unnecessary railroad lines, to get more money due to payments of the Ottoman state to them per kilometre of railroad line that was put into operation, i.e., kilometric guarantee system. So, railroad

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12 The railroad lines were named as the Hejaz railway.

lines did not exactly pass through places, which were in their construction plans (Schoenberg 1977; Issawi 1982: 60).

3.2 *Economic effects of the Ottoman railroads*

One side of the previous literature finds positive relationships between trade, production, population and railroads for different countries (See Atack et al. (2010), Donaldson (2014), Jedwab & Moradi (2016)). This impact is attributed to decreasing transportation costs. Because of fall in transportation costs, consumers could buy goods in the cheapest places, as producers could sell goods in the most expensive ones. By creating new marketing opportunities for goods, railroads are associated with higher production in the respective places (Kotavaara et al. 2011; Schwartz et al. 2011; Koopmans et al. 2012; Marti-Henneberg. 2013; Berger & Enflo 2015; Wang & Wu 2015). Increasing trade and agricultural production are positively correlated with employment opportunities. This could attract an inflow of people seeking jobs. Higher income level also provides surplus to feed people better in the connected places, increasing fertility rates. Resultantly, the railroad access could be positively associated with population in affected places (Alvarez-Palau et al. 2013; Hornung 2015).

In the early nineteenth century, the Ottoman Empire had provinces in Europe, Anatolia, Africa, and Arab lands, as it lost almost all its territories in Rumelia and Africa by 1914. The Ottoman economy was a traditional agricultural economy based on agriculture and land-intensive production (Quataert 1996: 767–768; 2005: 126–130). By the 1830s, exports were restricted by the Ottoman state to prevent food shortages, which was responsible for lower trade. Over time, the Ottoman economy become more open to the world economy and total trade in nominal terms increased from 9 million pounds in 1830 to 70 million pounds in 1913, as its share in national income reached to 3 percent (Pamuk 1984: 25, 140). At the beginning the Ottoman Empire was able to produce and export manufacture goods. By 1914, due to lack of competitive power it gradually became producer and supplier of agricultural items such as wheat and barley, while it bought indigo, coffee, sugar, steel, and metal products. One of the important drivers for this transformation was the construction of railroads after 1860 through decreasing transportation costs and connecting ports with places that were rich in agricultural resources (Karpat 1972: 246). Quataert (1996: 814, 2005: 126) argues lower transportation costs thanks to railroads, leading to a gradual increase of trade in places that had gained access to railroads. For instance, as goods were easily carried

from Anatolia to ports by railroads, exports through the ports increased (Karkar 1972: 65, 82; Quataert 1977; 1996: 814). Figure 2 indicates an increasing trend of foreign trade from 1890 to 1913, as there were many railroad lines built in the Ottoman Empire.
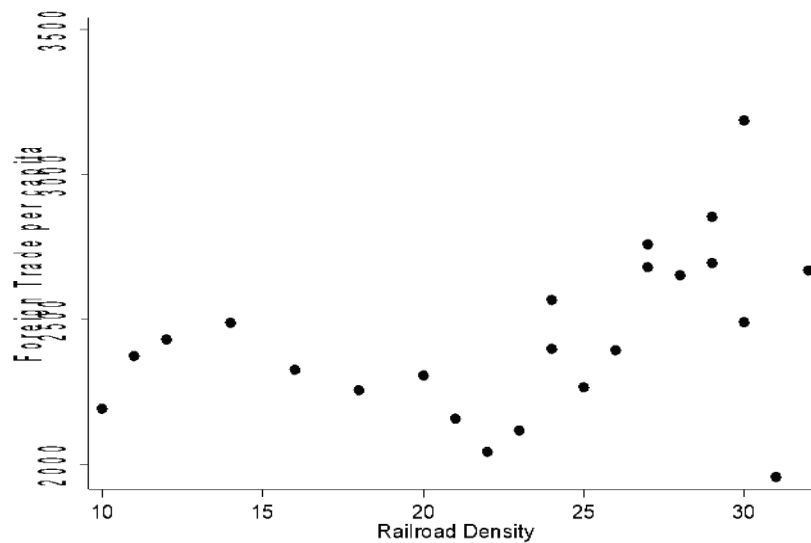

Figure 2. Foreign trade per capita and railroad density in the Ottoman Empire (1890–1913)

Source: The data come from Eldem (1994) and Banks and Wilson (2002).
Notes: The foreign trade values are expressed in constant British pounds. The railroad density is calculated as total miles of railroad lines in the Ottoman Empire in a given year divided by the area of the Ottoman Empire in square miles in a given year.

As shown in Figure 3, the number of rail passengers in the Ottoman Empire gradually increased to 14 million in 1913, which could imply higher mobility thanks to lower transportation costs. In addition, the railroads enabled a dramatic decline in the travel time, for instance, after the opening of the line between İzmir and Aydın people were able to transport goods from İzmir to Aydın only in three hours, as it took days before (British Parliamentary Paper 1896: 5–8; The Times 8 May 1912: 5). As a result, there were higher agricultural production in connected places through expanding available markets for goods (Hanioğlu 2008: 137). Using data for tax based on agriculture, Eldem (1994: 94) shows 114 % increase of agricultural production in places that had gained access to railroads between 1889 and 1911, as compared to 63 % increase in agricultural production of the remaining places. Because of increasing trade, agricultural production, safety, employment opportunities, and birth rates —in such areas as Damascus, Maan, Amman, Der'a, İzmir, Uşak, and Konya—, gaining access to the railroads was associated with higher population (British Parliamentary Paper 1896: 10; Quataert 1996: 813–814; Gülsoy 1994: 245–256, 2010: 181–182, 270; Hülagu 2010: 14–45).
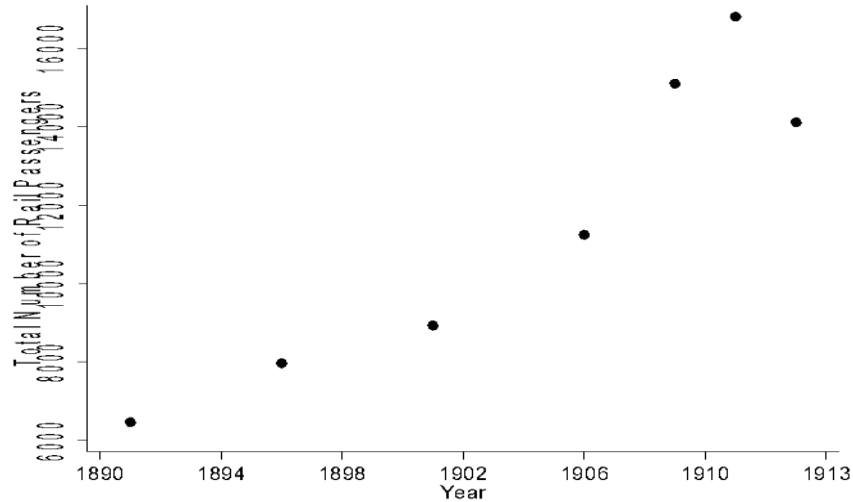
Figure 3. Total number of rail passengers in the Ottoman Empire (1891–1913)
Source: The data come from Eldem (1994: 102).
Note: All values are expressed in million persons.

4 Data

To examine whether railroad access induced economic growth in the Ottoman Empire, we use population of 628 judicial districts as a proxy. The data come from 1881/82–93[13] and 1914 censuses, which have been made available by Karpat (1985: 122–150, 167–190).[14] Karpat (1985) provides detailed information on the other censuses which were conducted in different years (e.g., 1831, 1844, 1866/73, 1877/78, and 1906/07 censuses). The female population was neglected in some of these censuses. In addition, several censuses did not include data on population in judicial districts. Finally, after administrative reforms of 1864, borders of administrative units in the Ottoman Empire changed (Sezen 2006). During the sample period, the Ottoman Empire lost some of its territories due to wars. There were changes in borders because of administrative reasons. It seems that the borders of the judicial districts in the sample remained

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[13] The 1881/82–93 was conducted since 1881 and submitted to the Sultan in 1893 (Karpat 1985, pp. 30–36). One concern with the censuses is the absence of clear information about the finishing time of the 1881/82–93 census. Population figures of the 1881/82–93 census can be used as a good proxy for total number of people which lived in the judicial districts in 1893, as suggested by Dölek (2007: 16) who compares the population figures of the 1881/82–93 census with the population figures in other reliable sources which provided detailed information on population of provinces. Karpat (1985: 33) argues that the censuses of most of territories in the Ottoman Empire were finished in 1889. We re-estimate regressions after considering 1889, as the completion year of the 1881/82-93 census. This exercise does not change the results much. There were not many lines that were built between 1881 and 1893.

[14] Several factors—such as undercounting of people living in several places due to religious reasons—cause measurement error in population data. Also, people living in distant locations could be undercounted (Karpat 1985: 10, 34). These measurement errors may lead to biased OLS estimates. Finally, as there is no available information for locations of several judicial districts in the historical maps and documents, the paper has missing observations, which is about 8 %.

relatively unchanged, as the findings are not sensitive to drop those that were affected by the administrative reforms and wars.

As a regressor of interest, we use the shortest distance between each judicial district centre and railroad line at the census dates. There are other measures of the road access, but they are not appropriate due to the absence of enough information on stations and borders as well as the lower number of lines in a judicial district (See Hanedar (2013: 127–129) for detailed discussions). A possible challenge is that the layout of railroad networks in the Ottoman Empire is not available in digital format. Several sources[15] give information on the location of tracks and railroad stations, building and opening dates of the lines. We construct a detailed map of the railroad lines in the Ottoman Empire that shows the placement of railroad lines by both location and year (See Figure 1).

The model includes several control variables to mitigate the bias due to omitted factors. These are the presence of the natural disasters and mines in the judicial districts. The data for natural disasters come from Evengelatou–Notora (2001: 99–121), Vogt (2001: 11–71), and Erler (2010: 102–131). The natural disasters were caused by rainfall shortages, drought, floods, and earthquakes. People in Ankara, Konya, and Sivas provinces, which were located in the central part of the Ottoman Empire, were frequently suffered from the disasters (Erler 2010: 106). The information on mines, such as coal, cooper, are extracted from Su (1939), Eldem (1994: 41–57), Quataert (1996: 55–64), Ökçün (1997: 111–205), Quataert (2006: 1–52), and Geyikdağı (2011: 119–126). Many mines were operated by foreign firms, as the mines were often located in Rumelia, the Black Sea, and eastern part of the Ottoman Empire (Su 1939: 6–12; Ökçün 1997: 111–205).

As instrument for the railroad access in 2SLS, we use the shortest distance between each judicial district centre and trade routes. There is no available map of trade routes in digital format. Several sources[16] provide detailed information on start and end points of the trade routes. Owen (2002: 48) contains a map of network for trade routes connecting various locations. To estimate the distance of the judicial districts, we use the links among places along the trade routes in the Ottoman Empire, which are generally straight lines between ports and important cities of production and trade.

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[15] Some of them are Kolars & Malin (1970), Karkar (1972), Schoenberg (1977), Eldem (1994), Geyikdağı (2011), and Özyüksel (2014).
[16] Some of them are Karkar (1972), Quataert (1995), and Owen (2002).

Summary statistics for the variables in the sample are presented in Table 2. The average population of a judicial district was 35,729. On average, a judicial district was 176 km away from a railroad line. This shows that railroad networks in the Ottoman Empire were not that dense. In 8 % of judicial districts, natural disasters were seen between 1800s and 1850s. There was at least one operating mine in 18 % of judicial districts over the sample period. On average, a judicial district was 89 km away from the trade routes.

Table 2. Descriptive Statistics

Variable	N. of obs.	Mean	Std. Dev.
Population	738	35,729	32,993
Distance to railroad lines	738	176	202
Presence of natural disasters	738	0.083	0.275
Presence of mines	738	0.182	0.386
Distance to trade routes	738	89	87

Notes: N. of obs. denotes the total number of judicial district-year observations. Std. Dev. displays standard deviations of variables in the sample. Number of judicial districts and provinces are 628 and 32, respectively.

5 Methodology

To test the effects of railroads on population, we run the following regression:

$$\ln(P_{icpt}) = \beta_0 + \beta_1 \ln(R_{icpt}) + \beta_2 D_{icp} \times \gamma_t + \beta_3 M_{icpt} + \rho_p + u_{icpt}$$

where i, c, p, and t index judicial district, county, province, and year, respectively. $\ln(P_{icpt})$ is the natural logarithm of population for judicial district i, located in county c of province p, in year t.[17]

$\ln(R_{icpt})$ is the natural logarithm of the distance between nearest railroad line and each judicial district, in year t. The previous literature on the impact of railroads uses a variety of control variables that measure initial conditions, climate, educational infrastructure, and physical geography.[18] The model does not include these variables, as there is an absence of data and maps on the Ottoman Empire. Instead, to control for initial conditions in a judicial district, we use D_{icp}. D_{icp} equals 1 if the judicial district i of county c located in province p, experienced natural disasters between 1800s and 1850s, and zero otherwise. The natural disasters were more destructive, leading to higher economic losses and mortality rates in the affected places such as Konya province (Quataert 1996: 789). M_{icpt} is a dummy variable which equals 1 if there was at least one

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[17] In this paper, the administrative division of the Ottoman Empire is based on Karpat (1985: 190) to maintain consistency in province borders. In Karpat (1985), the Ottoman Empire was divided to the 32 largest administrative units. These units were special districts (e.g., İzmit and Çatalca special districts), provinces (e.g., Aydın province), a county (i.e., Zor), and capital city of the Empire (i.e., İstanbul). In this paper, special district, Zor county, and the capital city are considered as provinces.
[18] See Hornung, (2015), Jedwab & Moradi (2016).

operating mine—such as coal, gold, and copper mine—in judicial district i of county c, located in province p, in year t, and zero otherwise. Historical literature underlines the presence of an increase in population and production of several places—such as Balya judicial district in Balıkesir—after coal mines in the 1900s had been operating in the respective locations (Su 1939: 6–12). Additionally, the regression includes the interaction of D_{icp} with year dummies (y_t) which control for the time varying effects of different initial conditions in each judicial district. p_p are province fixed effects which account for time-invariant characteristics at province level (e.g. presence of mountains, rivers, lakes, and geographic size).[19] Lastly, u_{icpt} is the error term while β_1 is coefficient of interest.

Being closer to a railroad line was positively correlated with economic growth through higher production and trade which attracted an inflow of workers and their families as well as fertility increase, implying a negative β_1. A positive coefficient estimate of β_1 supports that being closer to a railroad line led to a decrease in production and trade through higher imports which resulted in hampering of domestic industry, and consequently population went down due to increasing migration and lower fertility rate.

6 Results

6.1 *Basic results*

The findings are presented in Table 3. The OLS estimate for the effect of railroads in column (1) is statistically significant at 1 %. The point estimate reveals that 1 % decrease in the distance from a judicial district to the nearest railroad line leads to an increase in population of the respective judicial district by 0.07 %, on average. This finding indicates a positive impact of railroad access on population in the judicial districts of the Ottoman Empire through higher economic growth.

Table 3. The impact of railroads in the Ottoman Empire (1893 and 1914)

	Dependent variable: ln(Population)		
	OLS	2SLS	LIML

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19 Due to small sample size issues, we do not use judicial district dummies to control for time-invariant unobserved judicial district characteristics such as presence of mountains in judicial districts. Furthermore, this is a similar methodology applied by Banerjee et al. (2012) who examine the effect of railroads on economic and demographic outcomes in China. There is a concern with province fixed effects, as the difference between time-invariant characteristics of a province and those of a judicial district in the province in question might be large due to presence of many different judicial districts in a province. On the other hand, the magnitudes of the coefficients do change much, after removing unobserved judicial district characteristics by first differences.

	1	2	3
ln(Distance to railroad lines)	-0.071***	-0.281**	-0.281**
	(0.022)	(0.129)	(0.129)
Presence of natural disasters	0.287	0.161	0.161
	(0.181)	(0.199)	(0.198)
Presence of mines	0.396***	0.347***	0.347***
	(0.080)	(0.078)	(0.078)
Constant	9.706***	10.175***	10.175***
	(0.056)	(0.300)	(0.300)
N. of obs.	738	738	738
R^2	0.37	0.28	0.28
First-Stage F statistic	--	12.05	12.05
First Stage Results			
Dependent Variable: ln(Distance to Railroad Lines)			
ln(Distance to trade routes)		0.297***	0.297***
		(0.073)	(0.072)
R^2		0.62	0.62

Notes: Columns (1) reports the OLS estimates for equation (1). In column (2), regression is estimated by 2SLS. In column (3), regression is estimated by LIML. The dependent variable in columns (1)–(3) is the natural logarithm of the population in a judicial district in year *t*. The dependent variable in the first-stage regressions is the natural logarithm of distance to railroad lines in year *t*. Results for the control variables are not reported in the first-stage results. Heteroskedasticity-robust standard errors corrected for clustering at the province level are reported in parentheses. *** and ** denote statistically significantly different from zero at 1% and 5% levels, respectively. N. of obs. is number of observation. First-Stage F statistic implies F statistic on the excluded instrument in the first stage regression. Last, distance to trade routes is instrumental variable.

In column (2), we address the possibility that placement of railroad lines could be endogenous to population growth (i.e. reverse causality), leading to bias in the OLS estimate for the impact of railroads. This is because several railroad lines were allocated to commercially important places (i.e., İzmir and Aydın) (Kolars & Malin 1970; Karkar 1972: 65, 79). The Ottoman state wanted to be built some railroad lines in unpopulated places—such as Bandırma and Balıkesir—, that were affected by famines. The railroad lines would decrease food shortages and prevent future famines in the respective places (Quataert 1996: 789; Erler 2010: 304–312). Furthermore, since the Ottoman state aimed to extend its political control over distant areas via railroads, several railroad lines were assigned to politically important places where not many people lived. Foreign railroad firms had been paid for each kilometre of lines put into operation or the Ottoman state provided financial aid. For this reason, they agreed to build and operate lines in politically important places for the Ottoman state despite the low population (Karkar 1972: 75, 111; Quataert 1977; Schoenberg 1977; Issawi 1982: 60). Finally, due

to potential measurement errors in the population and railroad data, the OLS could underestimate the impact of railroads in absolute value in case of measurement error.[20]

Duranton and Turner (2007) and Baum-Snow (2007) provide evidence that new roads are likely to be built in places where initial roads are located. This is because initial roads are located in suitable places that construction of new roads is easy and inexpensive. Similarly, Quataert (1996: 820–821) argues that several railroad lines—such as line between İzmir and Aydın, and the Anatolian railway were built in places along the trade routes. Under these discussions, to deal with bias in the OLS estimate for the impact of railroads, we construct an instrumental variable for railroads based on trade routes (i.e., the natural logarithm of the shortest distance between each judicial district and the trade routes).[21] Column (2) reports statistically significant 2SLS estimate for the effect of railroads at 5%. The point estimate shows that 1% fall of the distance from a judicial district to the nearest railroad line was correlated with an increase in population of the respective judicial district by 0.28%, on average. The 2SLS estimate is larger than OLS coefficient in magnitude, which suggests that the OLS estimate is biased downward. The second stage result is presented in column (3) of Table 2. The F-statistic is larger than 10, implying that the instrument is not weak.

Although first-stage F-statistic is above the rule of thumb (10), it passes this threshold by a small margin. As it is known, the results of 2SLS are biased under weak instruments. In order to examine this suspicion, the Limited Information Maximum Likelihood (LIML) estimation is suggested, since this technique provides less biased estimators than those of 2SLS. Therefore, we also provide LIML results in the last column of Table A2 in appendix. As Angrist & Pischke (2009) underline, estimates and standard errors with 2SLS and LIML should be compared and if the results are almost same there is not much reason to worry. The findings in column (3) show that the coefficient and standard error provided by LIML are not so different than the one of the 2SLS.[22]

6.2 *Discussions*

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[20] See Hanedar (2013) for detailed discussion on this issue.

[21] See appendix for detailed discussion on the instrumental variable.

[22] There were several proposed lines in the Ottoman Empire such as Colonel Chesney's proposal in 1836 (von Pressel 1966). On the other hand, it seems that it is difficult to further address concerns regarding endogeneity by examining the effect of proposed lines, as some lines in such proposals were built later, leading to future research on un-built lines in the Ottoman Empire.

Our empirical results imply higher population figure in the connected judicial districts arguably because of inducing economic growth, under the lack of data on economic outcomes. The findings support one side of the historical literature, implying higher international and interregional trade due to lower transportation costs. Increasing trade level was correlated with agricultural production surplus in places that had gained access to railroads, leading to higher employment opportunities. There was an inflow of people looking for employment with a birth increase in the affected areas due to higher feeding possibilities (See British Parliamentary Paper (1896: 10), Karkar (1972: 65, 82), Quataert (1977; 1996: 810–814; 2005: 126), and Eldem (1994: 94)).

The findings from 2SLS and LIML regression could imply that railroad lines could be located in a place regardless its economic importance or population. This is because selection of a place for railroad construction in the Ottoman Empire was correlated with strategic, religious, and political rather than economic reasons. It could be also argued that measurement error is another concern.

The coefficient estimates for the effect of railroads are close to those in previous literature (See Hornung 2015). The average distance to railroads is not short (See Table 2) and long distance railroads might not have an impact (Fogel 1964). The railroad networks were not dense because of political and financial difficulties. There were some other shortcomings in the Ottoman railroad construction, as many lines might not be located in places which had not high population. Furthermore, the placement of the lines was not well designed due to political motives. Our findings, however, suggest that the railroads become an important mean of passenger and good transformation with the pre-existing roads that could have had lost their importance for the Ottoman economy to some degree long time ago (See appendix 1). Initial road networks might not so poor, while the long distance railroads induced growth in local economies.[23] Moreover, some lines were located in ports and wealthy places, which could be positively correlated with the impact of the railroads. Thus, we can argue that the lines had greatly benefited for the local economy through lowering transportation costs and increasing production.

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[23] Table A1 in appendix shows that the coefficient estimate for the distance to trade routes is statistically significant only at 11 percent, when the model includes the distance to railroad lines. As we do not report the findings, the interaction between the distance to the railroad network and trade routes has a positive effect on population, implying that lower distance to trade routes induced the positive impact of railroads. This also implies that 2SLS estimates for the effect of railroads are upper-bounds for the causal link between railroads and population, which could capture the impact of the other roads.

7 Conclusion

The construction of railroads between 1860 and 1914 are indeed considered key to promoting economic growth in the Ottoman Empire through increasing trade and production, which is attributed to simulation of regional and international accessibility. Here, the effect of railroads for population level in Ottoman Empire was not clear, since they were built to ensure military and political domination, heralding our research question. To shed further light on discussions for the effects of railroads on economic growth, we examine that being closer to a railroad line was related to higher population of a judicial district in the Ottoman Empire. Due to data constraints, we could only focus on the population growth and argue that higher production level could be associated with a birth and migration surplus in the affected areas.

We show that railroad access contributed population growth, as the growth effect is between 0.06 % and 0.28 %, on average, which was in line with previous findings on various country cases. This large impact was observed, although the Ottoman railroad networks were not rapidly expanding as compared with those of the other countries and the placement of several lines in less populated places due to political factors. Some lines, on the other hand, were located in wealthy places along the trade roads. This population growth suggests a production surplus in connected places, attracting people to seek jobs and increasing birth rates. Pre-existing road networks was positively related to the effect of the lines on population, while the railroad networks were not dense. We contribute to the previous literature, since the empirical findings firstly pointing out the role of railroads to induce economic growth in a dissolving country, even if political factors play an important role on their construction. The finding is also parallel to previous studies on Turkey, but added an empirical insight on an unsettled topic by considering discussions on motives for the construction of the railroad lines. Thus, an important extension of earlier researches is addressing endogeneity, which establishing causality between railroad construction and economic outcomes is a major challenge in the literature.

The paper could be refined if a dataset on economic outcomes were available. The absence of a data on migration at the judicial district level and border changes would lead to future work. For instance, Circassian immigrants from Russia were placed by the Ottoman state in areas that were close to the railroad lines. This led to population surplus without any production increase in the connected places. In addition, there is

limited information on changes in the borders of administrative units in the Ottoman Empire. Last, as only a few kinds of economic and financial data from the Ottoman Empire have yet been gathered, econometric models do not include important control variables.

Appendix 1 Instrumental variable approach

The exclusion restriction for instrumental variable requires that the instrumental variable in this study does not have an effect on population via any other channel such as physical geography. There are three potential concerns with the exclusion restriction.

The first potential concern is that commercial, production, and financial activities were concentrated in places along the trade routes. For instance, Bursa was an important cotton cloth manufacturing place as İstanbul and İzmir were the most important ports in the Ottoman Empire (Schoenberg 1977; Owen 2002: 45–50).

The instrumental variable is not strongly related to population via this channel. The trade routes—such as the route connecting Erzurum with Trabzon—declined in importance for the Ottoman economy in the nineteenth century due to several reasons. First, roads were not repaired due to financial difficulties. Second, wars and rebellions led to the presence of security problems in places along the trade routes. Also, several trade routes were disrupted by wars. Third, there were heavier taxes or corruption in locations along the trade routes, as prices of goods was high, which resulted in decreasing of trade. Last, other routes—such as the Suez Canal—bypassed the trade routes of the Ottoman Empire (Issawi 1970; Karkar 1972: 59–61; Engin 1993: 27–29; Quataert 1996: 768).

The historical literature argues that trade through ports in the Ottoman Empire were not high in nineteenth century.[24] The Ottoman state had limited funds for maintenance and improvement of the ports. Wars were negatively correlated with trade through the ports. Opening of new roads and ports in border countries reduced trade through the ports of the Ottoman Empire. For instance, railroads in Georgian coast hampered trade through port in Trabzon (Schoenberg 1977; Eldem 1994: 95–96; Quataert 1996: 767–768).

The second potential concern is the poor condition of the existing road networks of the Ottoman Empire. The trade routes were still in use for carrying goods and people

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24 This is in line with arguments and findings of Acemoglu et al. (2002). Acemoglu et al. (2002) show that trade through Mediterranean ports—such as ports of the Ottoman Empire—were not increasing as much as trade through Atlantic ports during the nineteenth century.

by camel caravans over the sample period (Karkar 1972: 59–61; Schoenberg 1977; Engin 1993: 28–29; Quataert 1996: 817–819). There are no reliable and available data on road networks of the Ottoman Empire that were used over the sample period. The regression includes many control variables, including time varying measure of operating mines, along with province and year fixed effects which can capture omitted road network.

The third potential concern is that places along the trade routes could be attractive destinations to live. As a result, the 2SLS estimate for the impacts of railroads could overestimate the relationship between railroads and population.

The column (1) of Table A1 provides the reduced form results. As expected, distance to trade routes is negatively and statistically significantly related with population. As we use distance to trade routes as an instrument for distance to railroad lines, the effect of distance to trade routes on population works through the distance to railroad lines. In order to test this, we add both the distance to railroad lines and the distance to trade routes simultaneously. Results in column (2) show that while the effect of distance to railroad lines is negative and statistically significant, the effect of distance to trade routes loses its significance. This result suggests that distance to trade routes had no strong direct effect on population when distance to railroad lines is added into the regression. Empirical findings in columns (1) and (2) show that distance to trade routes effects population through the distance to railroad lines. This implies that distance to trade routes can be used as an instrument for distance to railroad lines.

Table A1. Reduced Form Results

Dependent variable: ln(Population)		
	1	2
ln(Distance to railroad lines)	--	-0.054**
		(0.026)
ln(Distance to trade routes)	-0.083**	-0.067
	(0.037)	(0.040)
Presence of natural disasters	0.295	0.269
	(0.185)	(0.182)
Presence of mines	0.391***	0.382***
	(0.085)	(0.081)
Constant	9.778***	9.855***
	(0.102)	(0.094)
N. of obs.	738	738
R^2	0.37	0.38

Notes: Columns (1) and (2) report the OLS estimates. Heteroskedasticity-robust standard errors corrected for clustering at the province level are reported in parentheses. The dependent variable is the natural

logarithm of the population in a judicial district in year *t*. *** and ** denote statistically significantly different from zero at 1% and 5% levels, respectively. N. of obs. is number of observation.

Appendix 2 Robustness checks

It could be better to use urban population to examine the impact of railroads on economic growth, as suggested in Hornung (2015). This is because urban areas consist of large human and physical resources. Additionally, economic growth is more likely to be related to population change in urban areas, since there should be a surplus to feed people who are not farmers. To the best of our knowledge, there was an absence of definition of urban and rural areas in available resources on the Ottoman Empire. We estimate the model without places whose population was smaller than the population mean (i.e., 35,728). The OLS and 2SLS estimates are presented in column (1) and (2) of Table A2, respectively. This does not create much difference in the results, and therefore supports that railroads stimulated economic growth due to increasing fertility rates and migration to urban centres that were close to lines.

Table A2. Robustness Checks

Dependent variable: ln(Population)				
	1	2	3	4
ln(Distance to railroad lines)	-0.082***	-0.284**	-0.060**	-0.224*
	(0.028)	(0.103)	(0.022)	(0.118)
Presence of natural disasters	0.149	-0.015	0.289	0.192
	(0.141)	(0.163)	(0.182)	(0.197)
Presence of mines	0.276***	0.239***	0.372***	0.334***
	(0.062)	(0.059)	(0.078)	(0.077)
Constant	12.645***	13.087***	9.698***	10.064***
	(0.110)	(0.266)	(0.058)	(0.276)
N. of obs.	263	263	715	715
R²	0.38	0.10	0.32	0.26
F	--	7.42	--	10.90

Notes: Heteroskedasticity-robust standard errors corrected for clustering at the province level are reported in parentheses. ***, **, and * denote statistically significantly different from zero at 1%, 5%, and 10% levels, respectively. N. of obs. is number of observation. At the last row, F statistics on the excluded instrument in the first stage regression are reported. Last, distance to trade routes is instrumental variable.

Female population in several places such as Basra province could have been neglected in the 1881/82–93 census (Karpat 1985: 151). To address this issue, columns (3) and (4) report the OLS and 2SLS estimates after omitting judicial districts in these places from the analysis which leads to a decrease in the number of observations from 738 to 715. The results are not much sensitive to exclusion of these provinces.

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