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# DOMESTIC ROAD INFRASTRUCTURE AND INTERNATIONAL TRADE: EVIDENCE FROM TURKEY

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# Domestic Road Infrastructure and International Trade: Evidence from Turkey

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## Abstract

Poor domestic transportation infrastructure in developing countries is often cited as an important impediment for accessing international markets. Yet, evidence on how transportation infrastructure improvements affect the volume and composition of exports is scarce. Drawing on the large-scale public investment in expressways undertaken in Turkey during the 2000s, this paper contributes to our understanding of how internal trade costs affect regional exports and specialization. Two results emerge. First, we estimate that this road infrastructure project accounts for 15 percent of the export increase from interior regions, generating a 10-year discounted stream of additional export revenues that amount to between 9 and 14 percent of the value of the investment. Second, while the exports of all industries within a given region increase in response to improvements in connectivity to the international gateways of the country, the magnitude of this increase is larger the more time sensitive an industry is. Accordingly, we also observe an increase in the regional employment and revenue shares of such industries. Our results support the hypothesis that internal trade costs can be a determinant of international specialization and comparative advantage.

*JEL Codes:* F14, R11, R41.
*Keywords:* international trade, infrastructure, transportation costs, time-sensitive industries.

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# 1 Introduction

Analyses of transportation costs in international trade rarely consider the domestic segment of shipments in isolation. Gravity-based quantitative models estimate bilateral trade costs as a residual after controlling for the distance between countries and other bilateral characteristics related to trade costs, such as contiguity. Studies using direct evidence of international shipping costs either focus on port-to-port costs, or are unable to distinguish international segments from intranational ones within trade partners. Intuition and evidence suggest that this intranational component may account for a nonnegligible part of the overall cost of shipping goods across borders. Rousslang and To (1993) document that domestic freight costs on US imports are in the same order of magnitude as international freight costs. Atkin and Donaldson (2012) estimate that intranational trade costs in Ethiopia and Nigeria are 7 to 15 times larger than the estimates obtained for the United States. Consistent with this evidence, recent policy initiatives emphasize that inefficient and inadequate trade-related infrastructure such as transportation and logistics can severely impede developing countries' ability to compete in their export markets (WTO 2004; WB 2009; ADBI 2009). Thus, quantifying the effect of internal transportation costs on international trade and understanding its channels are important for assessing the trade-related benefits of transportation infrastructure investments.

In this paper, we analyze the outcomes from a large-scale public investment in Turkey aimed at improving the quality of the road network. Between 2003 and 2012, the country increased the share of four-lane expressways in its national road stock from 12 to 35 percent. The expansion of existing two-lane roads into divided four-lane expressways significantly improved the quality of roads while the quantity of roads (i.e., the total length of the road network) remained essentially unchanged. Important for our study, these investments affected regions differently depending on where they were made, improving the connectivity of some regions to the international trade gateways of the country more than others. Exploiting this variation, we estimate that the investment under study generates a 10-year stream of export revenues that amounts to between 9 and 14 percent of the cost of the investment. Next, we show that time-sensitive industries displayed higher export growth in regions with above-average improvements in connectivity. This constitutes a plausible channel for the aggregate response of regional exports. Finally, we document an increase in employment and revenue of time-sensitive industries relative to other industries in the very same regions, confirming that transportation infrastructure can be a source of regional specialization and comparative advantage.

Recent work highlights the prevalence and importance of the issues that we explore. As noted above, Atkin and Donaldson (2012) estimate large internal trade costs in Ethiopia and Nigeria. Cosar and Fajgelbaum (2013) develop a model in which these costs lead to regional specialization in export-oriented industries close to ports, and verify this prediction in China. Allen and Arkolakis (2013) incorporate realistic topographical features of geography into a spatial model of trade and estimate the rates of return to the US Interstate Highway System. We complement these studies by providing evidence on how a major improvement in transportation quality in a developing country affects the volume and composition of regional exports as well as within-country specialization patterns.

Our paper also contributes to a strand of literature that focuses on estimating the effect of transport infrastructure on trade and sectoral productivity. Using cross-country data, Limao and Venables (2001) and Yeaple and Golub (2007) find that infrastructure is an important determinant of trade costs, bilateral trade volumes, and sectoral productivity.[1] We differ from these studies in our focus on a single country, in our ability to measure road quality and its effect on transport costs more precisely, and in our exploration of the channels through which transportation infrastructure exerts its effects. Investigating sectoral mechanisms, Duranton, Morrow, and Turner (2013) estimate the effect of the US highway system on the value and composition of trade between US cities, and find that cities with

[1] Besides the length of roads, paved roads, and railways per sq km of country area, the infrastructure index used by Limao and Venables (2001) contains telephone main lines per person as well, making it impossible to tease out the isolated effect of the transportation infrastructure. In contrast, Yeaple and Golub (2007) investigate roads, telecom, and power infrastructure separately and find roads to have the biggest effect.

more highways specialize in sectors producing heavy goods. Similarly, Fernald (1999) shows that the US highway system increased productivity in vehicle-intensive industries. Using a multiregion general equilibrium model of trade, Donaldson (2012) and Donaldson and Hornbeck (2013) analyze the welfare gains from railroads in India and the United States, respectively. While improved market access through reduced transport costs is the major mechanism in these two papers, all trade studied is domestic—which is consistent with the historical episodes they consider. We add to this literature by analyzing the impact that a recent infrastructure project of similar scale had on the international trade of a developing country and by showing that increased exports in time-sensitive industries constitute a major channel through which aggregate gains may accrue. To the extent that exporting time-sensitive goods helps developing countries move up in the global value chain, our results have important developmental implications.

Other studies of particular developing country experiences typically measure the effect of road quantity rather than quality. Volpe Martincus and Blyde (2013) use the 2010 Chilean earthquake as a natural experiment to estimate the response of firm-level exports to the resulting geographical variation in access to ports. Volpe Martincus, Carballo, and Cusolito (2013) use historical routes in Peru to instrument for the location of new roads and find a sizeable impact on firm-level exports. In a rare attempt to incorporate road quality, Blyde (2012) relies on the International Roughness Index (IRI), which is based on engineering studies measuring the roughness of roads. Using cross-sectional geographical data from Colombia, he finds a relatively small effect of road quality on exports. The nature of the road quality investment under consideration in our paper relies less on external measurement and allows for an alternative identification.

The next section discusses the conceptual framework and the empirical strategy. Section 3 introduces the data and describes the measurement of transport costs. The results are presented in section 4. Section 5 concludes.

# 2 Conceptual Framework

In a wide range of models, trade costs affect trade volumes and specialization patterns. Estimates of gravity-type equations using data on international or intranational trade flows find a persistent role for distance. Among the various distance-related costs of delivering goods to consumers, transportation constitutes an important component. In turn, transportation costs are a function not only of the distance between the producer and consumers but also of the availability and quality of infrastructure, such as roads and ports.

If a transaction takes place across borders, transportation involves both domestic and international segments with a possible transhipment across different modes at a harbor, an airport, or a border crossing.[2] In our empirical investigation, we treat the aforementioned infrastructure investments in Turkey as an observable shock to the cost of domestic transportation. Since we do not observe internal trade flows, the analysis is restricted to the effect that these investments had on the international trade of regions within the country. Given their locations, regions benefited from reductions in transportation costs involved in accessing foreign markets to different degrees. Our first results exploit this spatial variation: regions whose connectivity to the international trade gateways improved more than others experienced a higher-than-average increase in exports.

The identification of regional market access is based on the premise that the widening of two-lane roads to divided four-lane expressways reduced transportation costs. There are several mechanisms for such an effect. Reduced congestion implies a higher cruising speed for the vehicles on the road. Increased road capacity can also be associated with the observed fall in accidents: traffic-related fatalities per vehicle-km decreased by 40 percent from 2004 to 2011. A direct benefit of reduced accident rates is a possible reduction in freight insurance costs. Average cruising speed may also increase due to a lower probability of a road closure following an accident. All these benefits are likely to improve the timeliness

[2] Anderson and van Wincoop (2004) estimate an ad valorem tax equivalent of trade costs between industrialized countries around 170 percent. Of this, 21 percent is international transportation costs, and 55 percent is domestic distribution costs.

and predictability of deliveries. Better road quality may also reduce transportation costs through reduced maintenance and depreciation costs in the logistics sector.

While direct evidence is scarce, several quantitative studies estimate the trade-cost-reducing effects of better road quality. Allen and Arkolakis (2013) find that the cost of a coast-to-coast shipment in the United States via the interstate highway system is around a third the cost of the same trip via the old motorway system. Using data from Colombia, Blyde (2012) estimates that the cost of delivering exports from remote locations to the ports decreases by 20-30 percent when the quality of road pavement on the route increases from poor to good.

In order to uncover the channels through which province-level exports respond, we rely on the idea that trade in some goods is more sensitive to the length and precision of delivery times. For some agricultural goods, this may arise simply due to perishability. Since we use export data on manufacturing industries, this factor is not prevalent in our setting. The literature recognizes other causes of time sensitivity: for some intermediate inputs that are part of international supply chains, timeliness and predictability of delivery times are crucial. Industries with volatile demand for customized products display high demand for fast and frequent shipments of small volumes (Evans and Harrigan 2005). Time-in-transit also constitutes a direct inventory-holding cost itself. Using data on US imports disaggregated by mode of transportation, Hummels and Schaur (2012) exploit the variation in the premium paid for air shipping and in time lags for ocean transit to identify the consumer's valuation of time. They estimate an ad valorem tariff of 0.6-2.3 percent for each day in transit.

In our context, one would expect a higher increase in exports of such goods from provinces experiencing a higher than average improvement in connectivity. We find support for this prediction. This is in line with Evans and Harrigan (2005), who provide evidence on the importance of timeliness in determining international trade patterns.

We now move on to the description of the data and the measurement of transport costs.

# 3 Data and Measurement

## 3.1 Background

Turkey is an upper-middle-income country with a large population (76 million as of 2012) and a diversified economy. The country is the world's 17*th*-largest economy and 22*nd*-largest exporter by value. It has been in a customs union for manufactured goods with the European Union since 1996, which accounts for more than half of the country's exports. Turkey is the fifth-largest exporter to the European Union and its seventh-largest importer.

Administratively, Turkey is divided into 81 contiguous provinces (*il* in Turkish) of varying geographic and economic size.[3] Each province is further composed of districts (*ilçe*). Some of these districts jointly form the provincial center (*il merkezi*), which is typically the largest concentration of urban population in a province. While municipalities are responsible for some services, including urban roads, many essential services, such as security, health, and education, are provided by the central government, which also plans, constructs, and maintains interprovincial roads outside of urban centers.

Road transport is the primary mode of freight transport in Turkey. It accounts for about 90 percent of both freight (by weight) and passenger traffic. Despite the importance of trucks and light commercial vehicles in freight transportation, the quality of interprovincial roads was considered quite inadequate until recently. In order to relieve the congestion and reduce the high rate of road accidents, the authorities launched a large-scale public investment in 2002 aimed at improving the quality of the country's road infrastructure. The project primarily envisaged the transformation of two-lane roads into divided four-lane expressways. As a result, the length of divided four-lane expressways increased by more than threefold during the 2003-2012 period, while total road stock remained essentially unchanged (figure 1). This observation constitutes one of the distinguishing features of our paper with respect to the related literature; while existing studies focus mostly on how construction of new

[3] Provinces correspond to the NUTS 3 (Nomenclature of Territorial Units for Statistics) level in the Eurostat classification of regions.

roads affects exports, we focus on how improvements in the quality of existing roads affect regional exports.

External evidence confirms our conviction that the investments described above improved road transport quality in Turkey. Since 2007, the World Bank has been conducting a worldwide survey among logistics professionals every two years. The results are aggregated into the Logistics Performance Index (LPI). LPI values range between 0 and 5; a higher LPI value indicates a more developed transportation sector as perceived by industry experts. In 2007, Turkey's score was 2.94, lower than the OECD average of 3.61. In 2012, Turkey's LPI value of 3.62 almost caught up with the OECD average of 3.68. Broken down into its components, the LPI covers the following six areas: customs, infrastructure, international shipments, logistics competence, tracking and tracing, and timeliness. In 2007, Turkey ranked $39th$ among 150 countries for the quality of trade- and transport-related infrastructure, and $52th$ for the timeliness of domestic shipments in reaching the destination. In 2012, Turkey scored higher on both indices; the country moved up 14 places in the infrastructure ranking, and 25 places in the timeliness ranking.[4] This evidence supports the claim that the large-scale public investment in road infrastructure undertaken in Turkey during the 2000s has improved the quality of its transport infrastructure.

One may argue that Turkey's improvement in the LPI rankings resulted not from improvements in the quality of road infrastructure, but from improvements in other transport infrastructure. The Global Competitiveness Report, published by the World Economic Forum, provides direct evidence of an overall improvement in the quality of road infrastructure in Turkey over the 2006-2012 period. The Global Competitiveness Report publishes country rankings based on the quality of their road infrastructure. The ranking is constructed based on a survey question that asks respondents to rate the quality of roads in their countries from 1 ("extremely underdeveloped") to 7 ("extensive and efficient—among the best in the world"). Turkey improved its score from 3.72 in 2006-2007 to 4.87 in 2012-2013 and moved

[4]The number of countries covered increased to 155 in 2012.

up 10 places to $43th$ among 148 countries.[5]

For such improvements to have some effect on regional exports, they should reduce the time it takes to transport goods within the country. One of the components of the domestic LPI is "export lead time," which measures the time it takes to transport goods from the point of origin to ports/airports. The LPI data show that the median export lead time in Turkey decreased from 2.5 days in 2007 to 2 days in 2012. Considering time as a trade cost, such evidence further motivates us to test the hypothesis that quality-enhancing investment in road infrastructure in Turkey increased regional exports during the 2003-2012 period.

The way in which this large-scale investment in road infrastructure was undertaken in Turkey makes it possible to identify the effect of improvements in transport infrastructure on regional exports. First, the project aimed at connecting provincial centers across Turkey to form a complete grid network (figure 2).[6] It also aimed at meeting additional demand arising from rapid economic growth and increases in urban population (WB 2012). In short, the investment was not designed to boost exports. Second, the public investment was centrally planned and financed from the central government's budget. Therefore, local administrations were not directly involved in the decision-making process or in financing. Third, the fact that Turkey is a small open economy reduces the likelihood that two Turkish regions compete directly with each other in a foreign market. In other words, improvements in transport infrastructure are likely to create more trade rather than divert it across cities.

### 3.2 Data

We employ data from two sources. Data on the stock of total and divided roads at the province level for the 2003-2012 period are provided by the Republic of Turkey General Di-

[5] Demir (2011) also uses the quality indices published by the World Economic Forum and reports that the elasticity of Turkey's trade with respect to the quality of its overall transport infrastructure is around unity.

[6] Banerjee, Duflo, and Qian (2012) document that railroad construction in China followed a similar investment strategy of connecting historical cities. While their research question is different—they use this exogenous variation to identify the effect of transportation infrastructure on the differential growth rates of regions between historical urban centers—there is a similarity in the sources of exogeneity: both infrastructure projects aim to form a wide network rather than benefit certain parts of the country.

rectorate of Highways.[7] Data on province-level manufacturing exports and imports for the 2003-2012 period are provided by the Turkish Statistical Institute (TUIK). Province-level exports are disaggregated by country of destination and 22 manufacturing industries (classified according to ISIC Rev.3). Similarly, imports are reported by industry and source country. We complement our dataset with data on province-level population and the distances between provincial centers, provided by TUIK, and destination-level GDP as published in World Development Indicators, 2013.

### 3.3 Measurement

Constructing a measure of transport costs that captures the variation in the connectivity of provinces to foreign markets is crucial for our exercise. The measure should vary across provinces and time so as to reflect the variation induced by the large-scale public investment in roads undertaken during the period under consideration. Since we are interested in the effect of improvements in the quality of roads on province-level exports, the measure should be informative about the cost of transporting goods to the international gateways of the country.

To construct the measure, we consider each province's connectivity to seven gateway provinces, which together account for more than 90 percent of total exports.[8] For each province-gateway pair $pg$, we find the fastest route and construct a set of provinces that one has to pass through on the way from province $p$ to the gateway province $g$, which is denoted by $J_{pg}$. Figure 3 illustrates an example. To travel from province $P_1$ to gateway province $G$, one has to pass through province $P_2$. Thus the set $J_{P_1G}$ consists of $P_1$, $P_2$, and $G$.

[7] To be precise, our data inform us about the length of total roads and divided roads within provincial boundaries at each year in our panel. We do not have information about particular segments between provincial centers or districts.

[8] These gateway provinces are Bursa, Istanbul, Izmir, Kocaeli, Mersin, Samsun, and Gaziantep. The first six are home to major maritime ports, whereas the last one contains the border crossing to Syria. The port of Istanbul accounts for around half of total exports.

Next we calculate the share of divided roads in the total road stock on route $pg$:

$$div\_road\_shr_{pgt} \ = \ \frac{\sum_{j \in J_{pg}} divided\_road_{jt}}{\sum_{j \in J_{pg}} total\_road_{jt}},$$

where $divided\_road_{jt}$ is the length (in km) of the divided road stock in province $j$ in year $t$, and $total\_road_{jt}$ is the length of total road stock. The ratio above measures the quality of the road stock on the route $pg$ for each year and thus captures the time variation in improved connectivity between provinces and international gateways. Let us go back to our example. On the route between province $P_1$ and gateway province $G$, the stock of total roads is illustrated in the second panel of figure 3, and the stock of divided roads in the third panel.

We specify the transportation cost between province $p$ and gateway $g$ as

$$\tau_{pgt} = [z + (1 - div\_road\_shr_{pgt})] \cdot dist_{pg},$$

where the component $z \cdot dist_{pg}$ with $z > 0$ captures the time-invariant lower bound. $\tau_{pgt}$ is increasing in $dist_{pg}$, the distance between the provincial centers of $p$ and $g$ (as illustrated in the lower panel of figure 3), and decreasing in the fraction of the route covered by divided roads. Our province-level transport cost measure is a weighted average of transport costs between province $p$ and seven gateway provinces:

$$\widetilde{TC}_{pt} = z \sum_{g} ExpShr_{g,2002} dist_{pg} + \sum_{g} ExpShr_{g,2002}(1 - div\_road\_shr_{pgt}) dist_{pg},$$

where $ExpShr_{g,2002}$ denotes the share of exports shipped through the gateway $g$ in 2002.[9] The first component is time-invariant and reflects the overall remoteness of a province. Since we will capture this component by province fixed effects in our empirical analysis, we exclude

[9] Export shares of gateways do not change dramatically during the period under consideration.

it from our transport cost measure. So, we use the following in our empirical analyses:

$$TC_{pt} = \sum_g ExpShr_{g,2002}(1 - div\_road\_shr_{pgt})dist_{pg}.$$

When we control for invariant geographic factors, $TC_{pt}$ measures the international connectivity of province $p$ over time. As mentioned earlier, we include province fixed effects in all specifications to control for time-invariant province-level factors, such as overall remoteness.

Our transport cost measure displays considerable variation both across provinces and over time. Figure 4 plots the period change in $TC_{pt}$ against the remoteness of provinces. On the $x$-axis, provinces are ranked in decreasing order of remoteness, defined as a weighted average of their distance from the seven major gateway provinces:

$$\sum_g ExpShr_{g,2002} \cdot dist_{pg}.$$

The 81$st$ province on the $x$-axis is Istanbul, and the 1$st$ one is Hakkari—a province located in the far east of Turkey. On the $y$-axis, we plot $TC_{pt}$ over time such that the top of each line represents the year 2003 and the bottom represents the lower level attained in 2012. For all provinces, our measure shows a decrease in transport costs, albeit to varying degrees, during the 2003-2012 period. The decrease in transport costs within this period is increasing with a province's remoteness, which is increasing from right to left in the figure. This implies that remote provinces have benefited more from road infrastructure improvements in terms of their access to foreign markets.

We are now ready to present the results of our empirical investigation, which puts the transport cost measure to use.

# 4 Empirical Results

## 4.1 Transport Costs and Regional Exports

We begin our analysis at the province level by estimating

$$\ln(exp_{pt}) \;=\; \alpha_p + \gamma_t + \beta \cdot TC_{pt} + \epsilon_{pt}, \tag{1}$$

where $exp_{pt}$ denotes the value (in USD) of exports of province $p$ in year $t$, and $TC_{pt}$ is the transport cost, measured in 100 km, of province $p$ in year $t$.[10] In the estimating equation (1), we include province fixed effects $\alpha_p$ to control for time-invariant province characteristics, such as remoteness. We also include year fixed effects to account for time-varying, country-level factors, such as exchange rate fluctuations. Our parameter of interest $\beta$ measures the responsiveness of province-level exports to a decrease in transport costs caused by the increased share of expressways in the road stock, and its expected sign is negative. We also estimate equation (1) in differences in order to eliminate time-invariant province characteristics and the potential serial correlation problem:

$$\Delta \ln(exp_{pt}) \;=\; \beta_t^d + \beta_1^d \cdot \Delta TC_{pt} + \epsilon_{pt}, \tag{2}$$

where $\Delta X_{ct} = X_{ct} - X_{c,t-1}$. To gauge the long-run effect, we estimate

$$\Delta \ln(exp_p) \;=\; \beta_0^d + \beta_2^d \cdot \Delta TC_p + \epsilon_p, \tag{3}$$

where $\Delta X_c = X_{c,2012} - X_{c,2003}$ is the difference between the initial and terminal years in our dataset. Table 2 reports the results.

Column 1a in table 2 presents the results obtained from estimating (1) using the entire sample. Our parameter of interest $\beta$ has the expected sign and is highly significant at the

[10] Summary statistics are presented in table 1.

1 percent level. The coefficient estimate is also economically significant: a 1 km decrease in our transport cost measure increases province-level exports by about 0.5 percent. In column 1b, we check whether the effect differs between interior and gateway provinces. As gateway provinces already have good access to international markets, we expect to see a bigger effect for interior provinces. The results conform with this expectation. While the coefficient estimate for gateway provinces is -0.29 and significant only at the 10 percent level, the estimate for interior provinces is about -0.50 and significant at the 1 percent level.

Columns 2a and 2b of table 2 present the results from the estimation of (3) using first differences to eliminate province fixed effects. The estimated effect of domestic transport costs slightly increases in absolute value to 0.56. While the effect for gateway provinces loses its significance, the effect for interior provinces is still significant at the 1 percent level.

In our next specification, presented in columns 3a and 3b of table 2, we consider the effect of a period decrease in domestic transport costs on the period change in province-level exports. A 1 km fall in domestic transport costs between 2003 and 2012 increases province-level exports by almost 0.6 percent for the entire sample, as well as for interior provinces. Both effects are highly significant. As for the previous specification, we fail to find a significant effect for gateway provinces. The $R^2$ in these two specifications suggest that long-term changes in transport costs account for 15 percent of the export variation at the province level. To put this into perspective, we note that the (population-weighted) average drop in the $TC$ measure of interior provinces ($\overline{\Delta TC_p}$) was around one (i.e., 100 km) from 2003 to 2012. The coefficient in column 3b implies a 59 percent increase in exports. Interior provinces experienced an average export increase of around 380 percent during that time period. The mechanism we explore thus accounts for around 15 percent (59/380) of that increase.

Next, we break down province-level exports into extensive and intensive margins. The former refers to the number of export destinations (i.e., countries), and the latter to the average value of exports to a destination at the province level. If goods exported to a destination must be shipped through a particular port, then an improvement in the quality of road infrastructure may facilitate a province's access to destinations that would otherwise be prohibitively expensive to export to. So we expect the number of export destinations to increase with a decrease in transport costs:

$$n_{pt} = \alpha_p + \gamma_t + \beta^{ext} \cdot TC_{ct} + \epsilon_{pt}, \tag{4}$$

where $n_{pt}$ denotes the number of export destinations served by province $p$ in year $t$. Also, a fall in trade costs, induced by an improvement in the quality of road infrastructure, may increase exports to current destinations:

$$\ln(exp_{pt}/n_{p,2002}) = \alpha_p + \gamma_t + \beta^{int} \cdot TC_{ct} + \epsilon_{pt}. \tag{5}$$

Table 3 reports the results. When estimating (4) and (5), we control for province and time fixed effects. The results are in line with our expectations. A fall in domestic transport costs increases the number of export destinations, and the effect is robust only for interior provinces. In particular, a 1 km fall in transport costs, driven by improved road quality, increases the number of destinations that an interior province exports to by about 0.26 percent. The effect on the intensive margin of exports is slightly smaller: a 1 km decrease in domestic trade costs increases average exports to an existing destination by 0.21 percent. For gateway provinces, the effect is insignificant on the extensive margin of exports, but significant at the 5 percent level on the intensive margin.

Next, we exploit the richness of our dataset and control for time-varying destination and industry characteristics. First we estimate the following specification with destination-year fixed effects, which control for, among other things, importers' demand:

$$\ln(exp_{pdt}) = \alpha_p + \gamma_{dt} + \beta \cdot TC_{pt} + \epsilon_{pdt}, \tag{6}$$

where $exp_{pdt}$ denotes the value (in USD) of exports of province $p$ to country $d$ in year $t$, and $\gamma_{dt}$ are destination-year fixed effects. Another factor that could affect our results is the industry composition of province-level exports. Exports of some industries could have increased during the period under consideration. If the export share of such industries is large in provinces that have experienced a reduction in the cost of accessing international gateways, then our parameter of interest would be biased. To control for this possibility, we include industry-year fixed effects $\eta_{it}$ and estimate the following specification:

$$\ln(exp_{pit}) = \alpha_p + \eta_{it} + \beta \cdot TC_{pt} + \epsilon_{pit}, \tag{7}$$

where $exp_{pit}$ denotes the value (in USD) of exports of province $p$ in industry $i$ and year $t$. Table 4 reports the results. Across all specifications, our parameter of interest is estimated to be both statistically and economically significant. When we control for time-varying destination characteristics in columns 2a and 2b, the coefficient estimates shrink (in absolute value), but they are still highly significant. This may be suggestive of a negative bias in the previous estimates of $\beta$. A number of free trade agreements signed during the 2003-2012 period could constitute one potential source of such bias. For instance, a free trade agreement between Turkey and Georgia came into force in November 2008, and Turkey's exports to Georgia increased from about \$400 million in 2006 to above \$1,250 million in 2012. If Turkish provinces close to Georgia have experienced a considerable reduction in their transport costs and an increase in their exports, then our previous estimates might also be capturing the effect of the free trade agreement between the two countries. Controlling for such effects seems to lower the size of the effect of domestic transport costs on regional exports.

Even the most conservative estimates we obtain show that a fall in domestic transport costs, driven by an improvement in the quality of domestic infrastructure, has a sizeable effect on regional exports. In particular, 100 dollars spent on quality-improving investment in transport infrastructure generates a 10-year discounted stream of export revenues between

9 and 14 dollars.[11] It is worth noting that welfare gains should be much larger, as we do not take into account, among other things, trade between provinces. For instance, Allen and Arkolakis (2013) estimate a rate of return on investment on the US Interstate Highway System of at least 100 percent.

## 4.2 Transport Costs and Time-Sensitive Exports

Having documented the export-enhancing effect of expressway construction, we now explore a potential channel through which this increase may have materialized. As we argued in section 2, improved road transportation may have a bigger impact on trade in industries that produce time-sensitive goods. Also, in section 3, we provided external evidence that the median time it takes to transport goods from the point of origin to ports/airports in Turkey decreased from 2.5 days in 2007 to 2 days in 2012. One may expect such an improvement in export lead times to affect some industries more than others, depending on their time sensitivity.

Since our data inform us about the exports of each province in 22 manufacturing industries over time, we would like to estimate the following relationship:

$$\ln(exp_{pit}) \;=\; \gamma Z_{pit} + \delta \cdot TC_{pt} \times TS_i + \epsilon_{pit}, \tag{8}$$

where $TC_{pt}$ is our province-level transport cost measure, and $TS_i$ is an industry-level measure that is increasing in time sensitivity. Depending on the specification, $Z_{pit}$ includes various other controls and fixed effects. If provinces with a higher decrease in trade costs experienced

[11] The calculation is based on the estimate presented in column 1a of table 4. We consider a hypothetical route with the mean divided road share in 2002, which is about 25 percent. To reduce transport costs by 1 km on this route, 1.33 km of roads have to be transformed into divided roads. The General Directorate of Highways publishes annual activity reports that provide information on the cost of building 1 km of a four-lane road. Using the average cost over the 2003-2012 period, we calculate the cost of building 1.33 km of a four-lane road. Next, we use our most conservative estimate, -0.181 from column 1a of table 4, to calculate the value of exports (at the mean) generated by a 1 km decrease in transport costs. The numbers provided in the text are the present value of a 10-year stream of exports generated by a one-dollar investment in road infrastructure for discount factors between 0.15 and 0.05.

a larger increase in the exports of time-sensitive goods, the coefficient $\delta$ will be negative.

In order to estimate this channel, we propose a measure of time sensitivity that is guided by the empirical literature investigating the mode of shipping decisions in international trade. As Hummels and Schaur (2012) demonstrate, exporters pay a premium for expensive yet fast air cargo, depending on the value that consumers attach to fast delivery. Motivated by this observation, we start with the air share of industry $i$ imports into a country other than Turkey. In particular, we use imports into the United Kingdom in 2005.[12] The choice of air shipping over alternative modes is, however, affected by other product characteristics, such as the weight per unit value shipped (Harrigan 2010). Thus, in order to construct a measure of time sensitivity based on the air intensity of import shipments, we purge the effect of heaviness by estimating the following equation:

$$\frac{air\_val_i}{air\_val_i + ves\_val_i} = \theta_0 + \theta_1 \frac{ves\_val_i}{ves\_wgt_i} + TS_i, \tag{9}$$

where $air\_val_i$ denotes the value of air shipments into the United Kingdom in industry $i$ in 2005, and $ves\_val_i$ ($ves\_wgt_i$) the value (weight) of shipments by ocean vessel. The dependent variable is the share of air shipments in industry $i$ imports, and $\frac{ves\_val_i}{ves\_wgt_i}$ is the value-to-weight ratio of maritime imports in the industry. We obtain our measure of time sensitivity as a residual from estimating (9). It measures the intensity of air shipping in an industry after taking out the effect of value-to-weight ratio—air shipping is less suitable for goods with a low value-to-weight ratio.[13] Table 5 presents the measure of time sensitivity for all 22 manufacturing industries.[14] Time-sensitive industries include chemicals and electrical/office machinery; time-insensitive industries include wearing apparel and tobacco products. The list largely overlaps with the one presented by Djankov, Freund, and Pham (2006), which is

[12]Time sensitivity imputed from US imports generates a measure that is highly correlated with the one imputed from the UK data. To preserve space, we only report the results based on UK imports. Alternative results using US imports are available from the authors upon request.

[13]Estimation of (9) yields $\theta_1 = 0.038$ with a t-value of 5.44. The $R^2$ of the regression is 0.57.

[14]Note that we focus on manufacturing industries only. Otherwise, one would expect to see perishable agricultural products in the list of time-sensitive goods.

based on the measure of time sensitivity suggested by Hummels and Schaur (2012).[15]

When estimating equation (8), we include province-year and province-industry fixed effects. Including the latter is particularly important as ignoring industry specialization of provinces might create bias in our estimates. Results are presented in the first three columns of table 6. The first column does not control for province-year fixed effects, thus our transport cost measure is still identified. Its coefficient estimate has the expected sign and is highly significant. The interaction term is also of the expected sign and significant at the 1 percent level. To understand the economic significance of our estimates, let us work through an example. Consider two provinces: one at the $90th$ percentile of the distribution of our transport cost measure, and the other at the $10th$ percentile. We are interested in how exports of these two provinces respond to a fall in transport costs in the most and the least time-sensitive industries. Our estimates suggest that the effect of time sensitivity is economically significant: a 1 km decrease in transport costs increases exports of the more remote province relative to the less remote one by 3 percentage points more in the most time-sensitive industry compared to the least time-sensitive one.

In columns 2 and 3, we include province-year fixed effects. Our transport cost measure cannot be identified in this specification. The coefficient of the interaction term remains highly significant both in the entire sample as well as in the subsample excluding the provinces with the trade gateways. The size of the coefficient estimate is also stable across different specifications.

In our next specification, we use the full dimensionality of our data at the province-industry-destination-time ($pidt$) level:

$$\ln(exp_{pidt}) \;=\; \gamma Z_{pidt} + \delta \cdot TC_{pt} \times TS_i + \epsilon_{pidt}. \tag{10}$$

In columns 4 and 5 of table 6, we report the results from estimating equation (10) using destination GDP among the regressors to control for market demand. We add province-year

[15] This is a working paper version of Djankov, Freund, and Pham (2010).

fixed effects to control for any time-varying province characteristics, province-industry fixed effects to control for industry specialization of provinces, and province-destination fixed effects to control for the composition of exports from a province to a particular destination. Compared to the first three columns, the coefficient of the interaction term is larger in absolute value and still highly significant at the 1 percent level. When we exclude trade gateways from the sample, the size of the coefficient estimate becomes larger. This is consistent with our earlier results in table 2, where the province-level export effects were stronger for interior provinces.

In column 6 of table 6, we try to control for selection. In particular, we worry that missing province-destination exports might create bias in our estimates. Consider the case where transport costs for a province-destination pair are high, yet the province is exporting to the destination. Our specification in (10) implies that in such cases some unobserved factors included in $\epsilon_{pidt}$ correlate positively with our variable of interest, transport costs, creating a positive bias in our parameter of interest. In our data, more than 90 percent of missing exports are missing at the province-destination-year level: almost all missing exports at the $pidt$ level are also missing at the $pdt$ level. In other words, factors that we think might positively correlate with our transport cost measure should be varying at the province-destination-year level. To eliminate this potential bias, we benefit from the richness of our data and include province-destination-year fixed effects together with province-industry fixed effects in (10). The interaction coefficient remains stable and highly significant in column 6 of table 6.

Finally, we estimate the effect by taking log differences between the initial and terminal years in our dataset and present the results in columns 7 and 8 of table 6. Province and destination fixed effects control for the general increase in exports due to regional supply and destination-specific demand factors. The magnitude of the coefficient is consistent with the panel data estimates above and remains highly significant.

### 4.3 Transport Costs and Imports

Our analysis so far has used export data only. We focus on exports mainly because there are different levels of trade intermediation involved in exporting and importing. Firms can engage in international trade either directly or through trade intermediaries and wholesalers. If a firm located in a certain province imports (exports) directly, the true destination province (source province) of this transaction will be accounted for in our data. If, on the other hand, a trade intermediary is involved, the transaction will be added to the trade of the province in which the intermediary is located. Since trade intermediaries and wholesalers are more likely to be located in the country's big port cities, this will lead to mismeasurement in geographical destination (source province) of imports (exports). While our dataset does not contain information about the export mode, there is reason to suspect that trade intermediation, and thus mismeasurement, is more prevalent in importing. Using a survey of Turkish exporters, Abel-Koch (2013) documents that only 17 percent of exports are intermediated. On the other hand, anecdotal evidence suggests that wholesalers based in Istanbul act as distributors of many imported products to the entire country. With this qualification in mind, we now replicate our main specifications with the import data and report the results in tables 7 and 8.

The first two columns of table 7 correspond to columns 1a and 3a in table 2. While both the panel and difference specifications (i.e., estimating equations (1) and (3) with imports as the dependent variable) yield negative coefficients, the magnitudes and the significance levels in the latter specification are smaller compared to the export responses reported in table 2. The same holds for the extensive margin specification (i.e., equation (4) estimated with the number of import source countries as the dependent variable) reported in the third column of table 7, which can be compared to column 1a of table 3. In the remaining specifications, where we investigate the response in the intensive margin (column 4) or control for source country-year and industry-year fixed effects (columns 5 and 6), however, we fail to find significant results for province-level imports.

In table 8, we report the coefficients from the import-side estimation of equations (8) and (10) featuring the interaction between province-level imports and industry-level time sensitivity. These results correspond to the results from the pooled sample in table 4. As in the province-level aggregate results, we find either coefficients that are not significant at the 5 percent level (columns 3 and 5), or coefficients that are smaller in magnitude when they are significant (columns 1 and 4).

To sum up, our empirical analysis so far has revealed three findings: first, provinces whose trade costs to international trade gateways decreased more than the average experienced a higher increase in their exports. Second, part of this increase is coming from a higher level of exports in time-sensitive goods. Third, the response in the import side seems to be weaker. We now move on to check other implications of these findings on regional specialization and wages.

## 4.4 Transport Costs and Regional Specialization

Our finding that regional exports in time-sensitive industries increased more than regional imports implies that import penetration (in terms of import/export ratio) decreases in such industries. In this final subsection, we investigate whether this response can be associated with regional employment and revenue reallocation across industries. We would expect provinces with increased exports in time-sensitive industries to display a corresponding revenue increase in these industries. The responses of employment and wages are ambiguous and depend on labor mobility. If labor is geographically immobile (as in Kovak 2013) and industry-specific human capital plays a major role in production (as in Cosar 2013), we would expect relative wages in time-sensitive industries to increase in provinces with increased exports of such industries. If, on the other hand, labor is somewhat mobile across industries and regions, the wage effect may be muted. In that case, we would expect to see increased regional employment in time-sensitive industries.

In order to check these predictions, we supplement our dataset with information on industry employment, revenue, and wage bills at the NUTS 2 regional level obtained from TUIK. Unfortunately, such data are not available at the province level. Therefore, we aggregate our original exports data containing 81 provinces to the level of 26 regions. Also, we average our transport cost measure across provinces within regions to obtain a regional transport cost measure. We then estimate a specification similar to equation (10) with the logarithm of industry-level regional employment $\ln(emp_{pit})$, revenue $\ln(rev_{pit})$, and average wage $\ln(wage_{pit})$ as dependent variables. As before, we expect the interaction coefficient to be negative. The first and last three columns of table 9 present the results from the estimation in levels and differences, respectively.

The results confirm our prediction of increased regional revenues in industries positively impacted by the investments in expressways (columns 2 and 5). The labor market effects suggest that labor is mobile enough to accommodate increased labor demand at the region-industry level: we see increased regional specialization in industries (columns 1 and 4) but fail to find an effect on average wages (columns 3 and 6).

# 5 Conclusion

This article investigates the effects of Turkey's large-scale investment in improving the quality and capacity of its road transportation network on the level and composition of exports from its provinces. Transport cost reductions brought about by this investment lead to increased exports from regions whose connectivity to the international trade gateways of the country improved most. A 100-dollar investment on this infrastructure project implies an additional 10-year discounted stream of exports between 9 and 14 dollars. Given the additional benefits that we do not explore, this is a high rate of return. Our results thus support the idea that improved transportation infrastructure may play an important role for exporters in developing countries wishing to reach international markets.

A particular channel for this regional response appears to be increased exports of time-sensitive goods from regions that experience the largest drop in transport costs. This is in line with the recent empirical literature emphasizing time costs in international trade. While existing studies typically emphasize time in transit between countries or time lost in customs, our results highlight the importance of domestic transportation infrastructure in moving goods from the factory gate to the ports in a timely and predictable fashion. To the extent that efficient logistics in time-sensitive goods enable countries to take part in global supply chains and exploit their comparative advantages, our findings have important developmental implications.

## References


Abel-Koch, J. (2013): "Who Uses Intermediaries in International Trade? Evidence from Firm-level Survey Data," *The World Economy*, 36(8).

ADBI (2009): "Infrastructure for a Seamless Asia," Discussion paper, Asian Development Bank Institute, Tokyo.

Allen, T., and C. Arkolakis (2013): "Trade and the Topography of the Spatial Economy," Northwestern University.

Anderson, J. E., and E. van Wincoop (2004): "Trade Costs," *Journal of Economic Literature*, 42(3), 691–751.

Atkin, D., and D. Donaldson (2012): "Who's Getting Globalized? The Size and Nature of Intranational Trade Costs," Yale University.

Banerjee, A., E. Duflo, and N. Qian (2012): "On the Road: Access to Transportation Infrastructure and Economic Growth in China," NBER Working Paper No. w17897.

Blyde, J. (2012): "Paving the Road to Export: Assessing the Trade Impact of Road Quality," *International Economic Journal*, pp. 1–19.

Cosar, A. K. (2013): "Adjusting to Trade Liberalization: Reallocation and Labor Market Policies," University of Chicago Booth School of Business, mimeo.

Cosar, A. K., and P. Fajgelbaum (2013): "Internal Geography, International Trade, and Regional Specialization," NBER Working Paper No. 19697.

Demir, B. (2011): "Transport Costs and Turkey's International Trade," Background Paper for Turkey Transport Sector Expenditure Review (2012).

Djankov, S., C. Freund, and C. S. Pham (2006): "Trading on time," Policy Research Working Paper Series 3909, The World Bank.

——— (2010): "Trading on Time," *The Review of Economics and Statistics*, 92(1), 166–173.

Donaldson, D. (2012): "Railroads of the Raj: Estimating the Impact of Transportation Infrastructure," NBER Working Paper No. w16487.

Donaldson, D., and R. Hornbeck (2013): "Railroads and American Economic Growth: A Market Access Approach," NBER Working Paper No. w19213.

Duranton, G., P. Morrow, and M. A. Turner (2013): "Roads and Trade: Evidence from the US.," *forthcoming, The Review of Economic Studies*.

Evans, C. L., and J. Harrigan (2005): "Distance, Time, and Specialization: Lean Retailing in General Equilibrium," *American Economic Review*, pp. 292–313.

Fernald, J. G. (1999): "Roads to Prosperity? Assessing the Link Between Public Capital and Productivity," *American Economic Review*, pp. 619–638.

Harrigan, J. (2010): "Airplanes and Comparative Advantage," *Journal of International Economics*, 82(2), 181–194.

Hummels, D., and G. Schaur (2012): "Time as a Trade Barrier," NBER Working Paper No. 17758.

Kovak, B. K. (2013): "Regional Effects of Trade Reform: What Is the Correct Measure of Liberalization?," *American Economic Review*, 103(5), 1960–76.

Limao, N., and A. J. Venables (2001): "Infrastructure, Geographical Disadvantage, Transport costs, and Trade," *The World Bank Economic Review*, 15(3), 451–479.

Rousslang, D. J., and T. To (1993): "Domestic Trade and Transportation Costs as Barriers to International Trade," *Canadian Journal of Economics*, pp. 208–221.

Volpe Martincus, C., and J. Blyde (2013): "Shaky Roads and Trembling Exports: Assessing the Trade Effects of Domestic Infrastructure Using a Natural Experiment," *Journal of International Economics*, 90(1), 148–161.

Volpe Martincus, C., J. Carballo, and A. Cusolito (2013): "Routes, Exports and Employment in Developing Countries: Following the Trace of the Inca Roads," Inter-American Development Bank, mimeo.

WB (2009): "World Development Report: Reshaping Economic Geography," Discussion paper, World Bank, Washington, DC.

——— (2012): "Turkey Transport Sector Expenditure Review," Discussion paper, World Bank, Washington, DC.

WTO (2004): "World Trade Report 2004: Exploring the linkage between the domestic policy environment and international trade," Report WTO/WTR/2004, World Trade Organization (WTO), Geneva.

Yeaple, S., and S. Golub (2007): "International Productivity Differences, Infrastructure, and Comparative Advantage," *Review of International Economics*, 15(2), 223–242.

# Appendix: Figures and Tables

Figure 1: **Road Stock over Time: All Roads and Divided Roads**

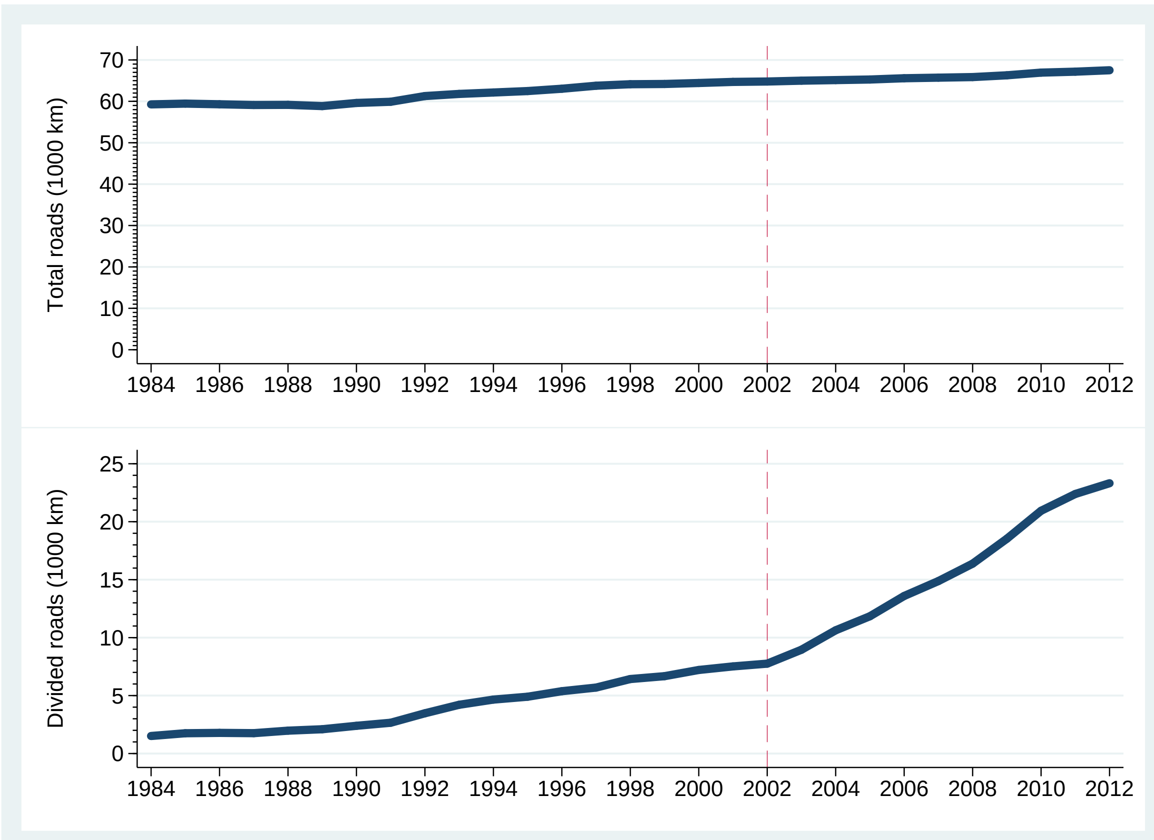
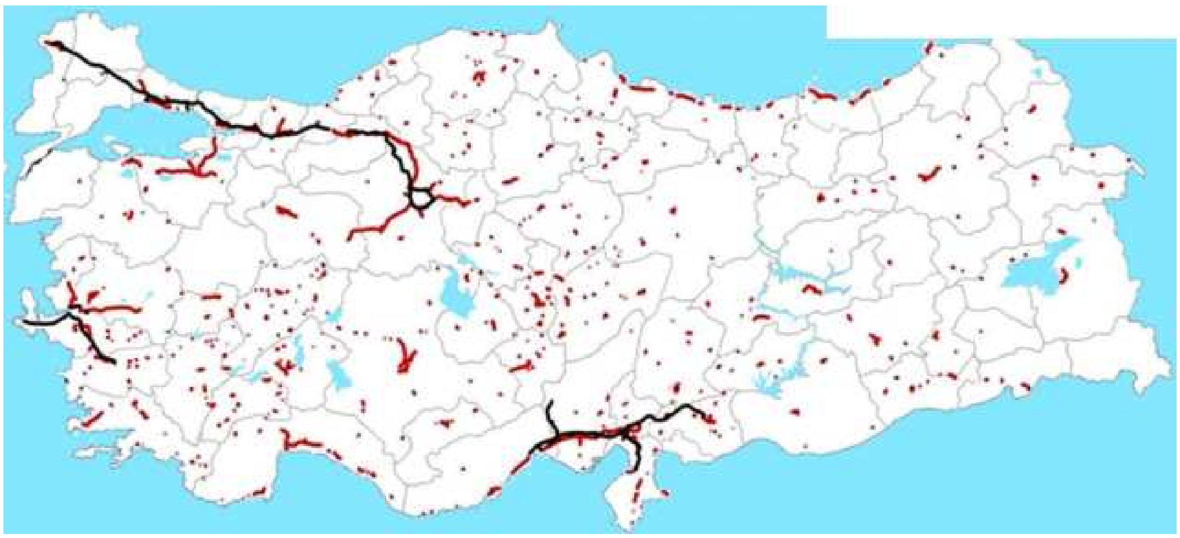


Figure 2: **Divided Road Network in 2002 and 2012**

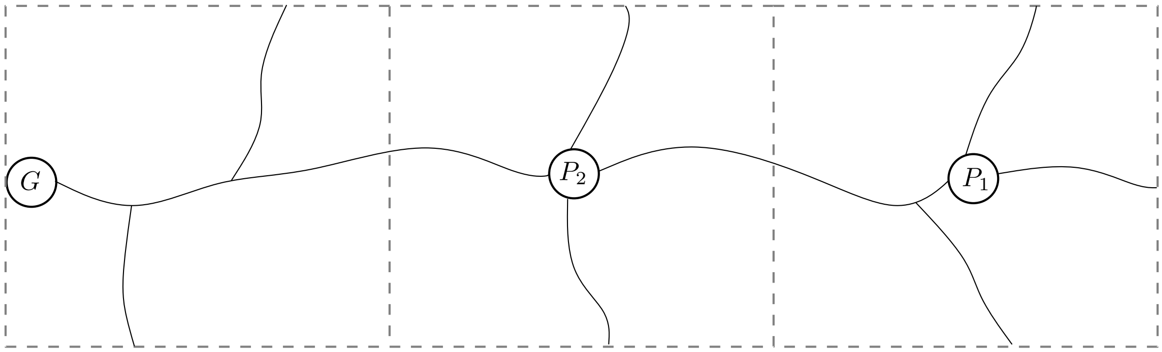


Divided road network in 2002

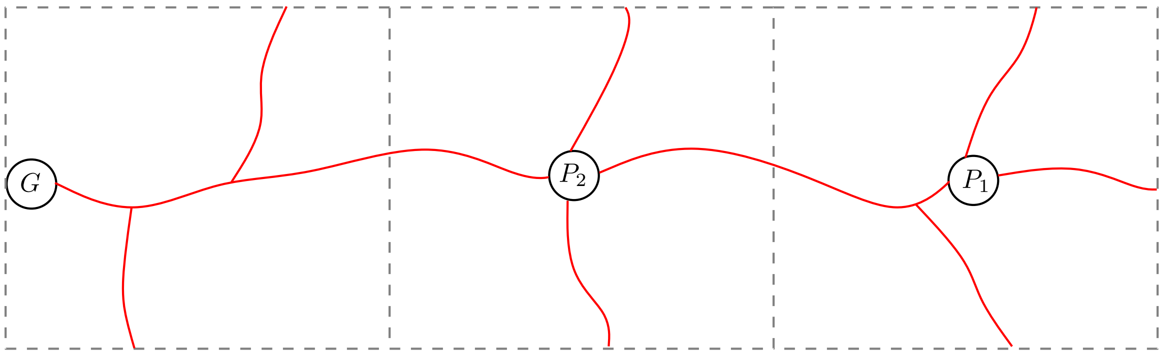
Divided road network in 2012

*Notes:* Map of the divided road network in 2002 and 2012, obtained from the website of the General Directorate of Highways. Red lines indicate completed projects, blue lines indicate works in progress, and green lines indicate planned projects.

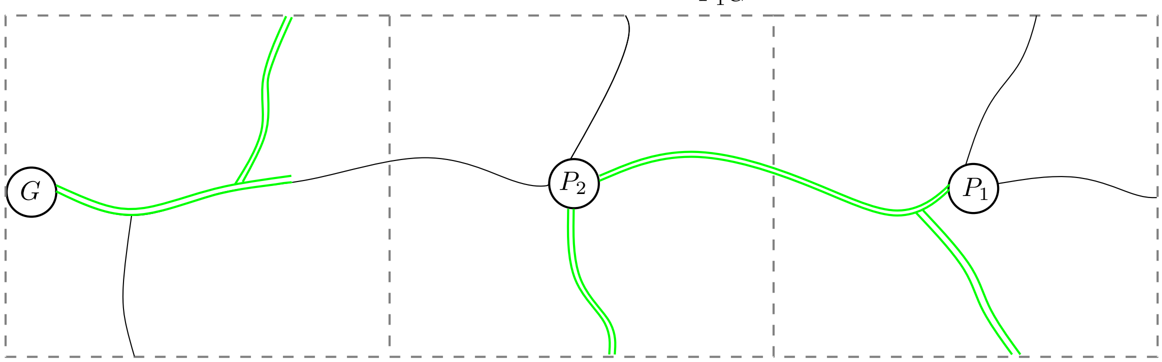
Figure 3: **Distance, Roads, and Divided Roads on a Route**



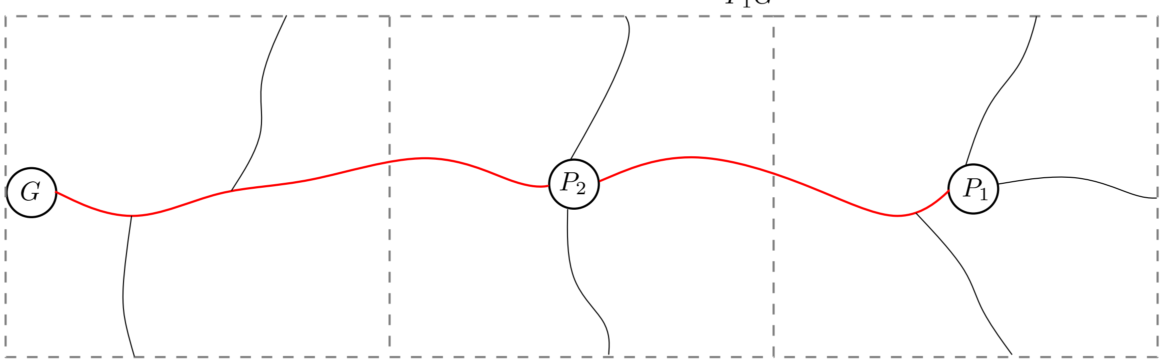

Route $J_{P_1G} = \{P_1, P_2, G\}$




Total roads on $J_{P_1G}$

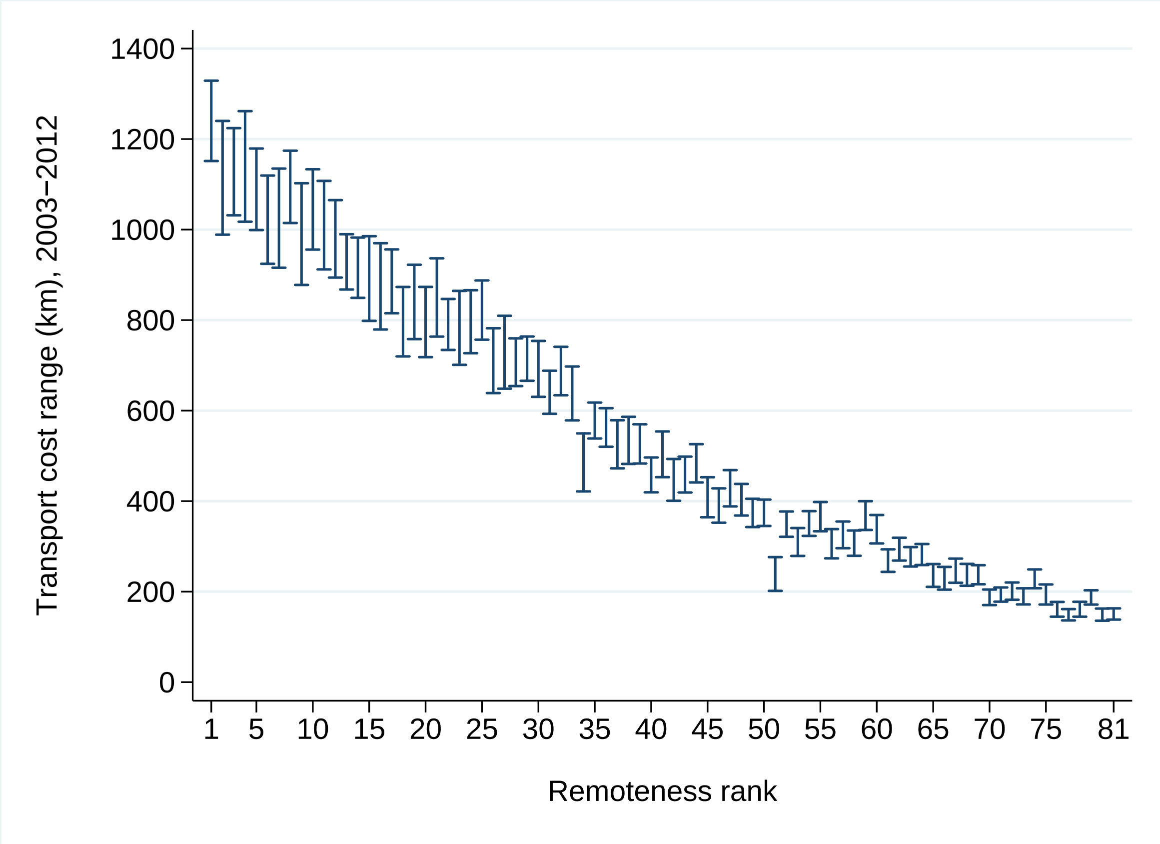



Divided roads on $J_{P_1G}$




Distance between $P_1$ and $G$

Figure 4: **Variation in the Transport Cost Measure**




*Notes:* This range plot shows the transport cost measure throughout the data period ($y$-axis) across 81 provinces ranked in terms of remoteness in the $x$-axis. The rank of 1 represents the most remote province (Hakkari), and 81 represents the least remote province (Istanbul). In the $y$-axis, the top of the range line for each province represents the year 2003 and the bottom represents 2012. Costs are monotonically decreasing over time.

Table 1: **Summary Statistics**

| Variable | Observation | Mean | St. Dev. | Range | Median |
|---|---|---|---|---|---|
| $\ln(exp_{pt})$ | 803 | 18.08 | 2.55 | [8.98, 25.04] | 18.17 |
| $\ln(exp_{pidt})$ | 295,484 | 11.09 | 2.98 | [4.41, 22.65] | 11.10 |
| $\ln(imp_{pt})$ | 807 | 17.81 | 2.69 | [5.79, 25.53] | 17.72 |
| $\ln(imp_{pidt})$ | 201,875 | 11.18 | 3.19 | [4.61, 22.14] | 11.18 |
| $TC_{pt}$ (100 $km$) | 810 | 5.54 | 3.11 | [1.42, 13.29] | 4.73 |
| $TS_i$ | 22 | 0 | 0.21 | [-0.29, 0.38] | -0.09 |

*Notes:* *exp* and *imp* stand for exports and imports, respectively. *pt* subscript denotes province-year level variables. *pidt* subscript denotes province-industry-destination-year level variables. In the case of imports, destination denotes the source country. $TC_{pt}$ is the time-varying measure of transport costs at the province level. $TS_i$ is industry-level measure of time sensitivity. See the text for the construction of these measures.

Table 2: **Province-Level Results**

| | (1a) $\ln(exp_{pt})$ | (1b) $\ln(exp_{pt})$ | (2a) $\Delta\ln(exp_{pt})$ | (2b) $\Delta\ln(exp_{pt})$ | (3a) $\Delta\ln(exp_{p})$ | (3b) $\Delta\ln(exp_{p})$ |
|---|---|---|---|---|---|---|
| $TC_{pt}$ | -0.525*** | | | | | |
| | (0.097) | | | | | |
| Gateway $TC_{pt}$ | | -0.286* | | | | |
| | | (0.158) | | | | |
| Interior $TC_{pt}$ | | -0.507*** | | | | |
| | | (0.0.095) | | | | |
| $\Delta TC_{pt}$ | | | -0.556*** | | | |
| | | | (0.174) | | | |
| Gateway $\Delta TC_{pt}$ | | | | -0.135 | | |
| | | | | (0.279) | | |
| Interior $\Delta TC_{pt}$ | | | | -0.529*** | | |
| | | | | (0.170) | | |
| $\Delta TC_{p}$ | | | | | -0.595*** | |
| | | | | | (0.148) | |
| Gateway $\Delta TC_{p}$ | | | | | | -0.475 |
| | | | | | | (0.298) |
| Interior $\Delta TC_{p}$ | | | | | | -0.585*** |
| | | | | | | (0.147) |
| Regression | WLS | WLS | WLS | WLS | WLS | WLS |
| Robust SE | Yes | Yes | Yes | Yes | Yes | Yes |
| N | 803 | 803 | 640 | 640 | 79 | 79 |
| $R^2$ | 0.985 | 0.985 | 0.154 | 0.157 | 0.191 | 0.192 |
| Year FE | Yes | Yes | Yes | Yes | | |
| Province FE | Yes | Yes | | | | |

*Notes:* All regressions are estimated with weighted least squares (WLS) using province populations as weights. Significance: * 10 percent, ** 5 percent, *** 1 percent.

Table 3: **Extensive and Intensive Margins**

| | (1a) $n_{pt}$ | (1b) $n_{pt}$ | (2a) $\ln(exp_{pt}/n_{p,2002})$ | (2b) $\ln(exp_{pt}/n_{p,2002})$ |
|---|---|---|---|---|
| $TC_{pt}$ | -0.252*** | | -0.198** | |
| | (0.037) | | (0.089) | |
| Gateway $TC_{pt}$ | | -0.027 | | -0.333** |
| | | (0.054) | | (0.131) |
| Interior $TC_{pt}$ | | -0.257*** | | -0.208** |
| | | (0.037) | | (0.089) |
| Regression | Poisson | Poisson | WLS | WLS |
| Robust SE | Yes | Yes | Yes | Yes |
| N | 803 | 803 | 803 | 803 |
| $(pseudo)R^2$ | 0.847 | 0.848 | 0.978 | 0.978 |
| Year FE | Yes | Yes | Yes | Yes |
| Province FE | Yes | Yes | Yes | Yes |

*Notes:* Significance: * 10 percent, ** 5 percent, *** 1 percent.

Table 4: **Controlling for Demand Effects**

| | (1a) $\ln(exp_{pdt})$ | (1b) $\ln(exp_{pdt})$ | (2a) $\ln(exp_{pit})$ | (2b) $\ln(exp_{pit})$ |
|---|---|---|---|---|
| $TC_{pt}$ | -0.181*** | | -0.519*** | |
| | (0.063) | | (0.107) | |
| Gateway $TC_{pt}$ | | -0.332*** | | -0.463** |
| | | (0.103) | | (0.235) |
| Interior $TC_{pt}$ | | -0.178** | | -0.515*** |
| | | (0.063) | | (0.108) |
| Regression | WLS | WLS | WLS | WLS |
| Robust SE | Yes | Yes | Yes | Yes |
| N | 51,506 | 51,506 | 13,553 | 13,553 |
| $R^2$ | 0.823 | 0.823 | 0.820 | 0.820 |
| Destination-Year FE | Yes | Yes | | |
| Industry-Year FE | | | Yes | Yes |
| Province FE | Yes | Yes | Yes | Yes |

*Notes:* Significance: * 10 percent, ** 5 percent, *** 1 percent.

Table 5: **Time Sensitivity of Manufacturing Industries**

| **Industry** | $TS$ |
|---|---|
| Furniture; manufacturing n.e.c. | 0.379 |
| Chemicals and chemical products | 0.335 |
| Radio, television, and communication equipment | 0.259 |
| Electrical machinery and apparatus n.e.c. | 0.259 |
| Office, accounting, and computing machinery | 0.226 |
| Fabricated metal products, exc. mach and equip | 0.209 |
| Machinery and equipment n.e.c. | 0.187 |
| Publishing, printing and reproduction of recorded media | 0.033 |
| Medical, precision and optical instruments, watches, and clocks | 0.029 |
| Other nonmetallic mineral products | -0.054 |
| Textiles | -0.083 |
| Food products and beverages | -0.093 |
| Rubber and plastics products | -0.110 |
| Paper and paper products | -0.117 |
| Basic metals | -0.121 |
| Coke, refined petroleum products, and nuclear fuel | -0.154 |
| Wood and products of wood and cork, except furniture | -0.157 |
| Tobacco products | -0.207 |
| Motor vehicles, trailers, and semitrailers | -0.214 |
| Other transport equipment | -0.227 |
| Tanning and dressing of leather; luggage mfg., etc. | -0.242 |
| Wearing apparel; dressing and dyeing of fur | -0.290 |

Table 6: **Time Sensitivity Results for Exports**

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| | $\ln(exp_{pit})$ | $\ln(exp_{pit})$ | $\ln(exp_{pit})$ | $\ln(exp_{pidt})$ | $\ln(exp_{pidt})$ | $\ln(exp_{pidt})$ | $\Delta \ln(exp_{pid})$ | $\Delta \ln(exp_{pid})$ |
| $TC_{pt}$ | -1.537*** | | | | | | | |
| | (0.058) | | | | | | | |
| $TC_{pt} \times TS_i$ | -0.553*** | -0.551*** | -0.564*** | -0.917*** | -1.011*** | -1.026*** | | |
| | (0.180) | (0.190) | (0.197) | (0.129) | (0.156) | (0.147) | | |
| $\Delta TC_p \times TS_i$ | | | | | | | -0.960*** | -1.106*** |
| | | | | | | | (0.238) | (0.263) |
| Regression | OLS | OLS | OLS | OLS | OLS | OLS | OLS | OLS |
| Sample | All | All | Interior | All | Interior | All | All | Interior |
| Robust SE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| N | 13,553 | 13,175 | 11,748 | 271,157 | 172,711 | 281,122 | 48,686 | 33,758 |
| $R^2$ | 0.873 | 0.893 | 0.867 | 0.576 | 0.496 | 0.628 | 0.141 | 0.136 |
| Province-Year FE | | Yes | Yes | Yes | Yes | | | |
| Province-Industry FE | Yes | Yes | Yes | Yes | Yes | Yes | | |
| Province-Destination FE | | | | Yes | Yes | | | |
| Province-Destination-Year FE | | | | | | Yes | | |
| Province FE | | | | | | | Yes | Yes |
| Destination FE | | | | | | | Yes | Yes |

*Notes:* Significance: * 10 percent, ** 5 percent, *** 1 percent. Columns 4 and 5 control for destination GDP.

Table 7: **Import Results**

| | (1) $\ln(imp_{pt})$ | (2) $\Delta\ln(imp_p)$ | (3) $n_{pt}$ | (4) $\ln(imp_{pt}/n_{p,2002})$ | (5) $\ln(imp_{pdt})$ | (6) $\ln(imp_{pit})$ |
|---|---|---|---|---|---|---|
| $TC_{pt}$ | -0.332*** | | -0.085*** | -0.0935 | -0.047 | -0.143 |
| | (0.098) | | (0.028) | (0.092) | (0.085) | (0.110) |
| $\Delta TC_p$ | | -0.305* | | | | |
| | | (0.164) | | | | |
| Regression | WLS | WLS | Poisson | WLS | WLS | WLS |
| Robust SE | Yes | Yes | Yes | Yes | Yes | Yes |
| N | 807 | 80 | 805 | 805 | 34,761 | 13,635 |
| $(pseudo)R^2$ | 0.951 | 0.051 | 0.795 | 0.984 | 0.826 | 0.852 |
| Year FE | Yes | | Yes | Yes | | |
| Province FE | Yes | | Yes | Yes | Yes | Yes |
| Source-Year FE | | | | | Yes | |
| Industry-Year FE | | | | | | Yes |

*Notes:* Significance: * 10 percent, ** 5 percent, *** 1 percent.

Table 8: **Time Sensitivity Results for Imports**

| | (1) $\ln(exp_{pit})$ | (2) $\ln(exp_{pit})$ | (3) $\ln(exp_{pidt})$ | (4) $\ln(exp_{pidt})$ | (5) $\Delta\ln(exp_{pid})$ |
|---|---|---|---|---|---|
| $TC_{pt}$ | -1.910*** | | | | |
| | (0.170) | | | | |
| $TC_{pt} \times TS_i$ | -0.0950*** | -0.992*** | -0.250* | -0.344** | |
| | (0.036) | (0.193) | (0.135) | (0.155) | |
| $\Delta TC_p \times TS_i$ | | | | | 0.457 |
| | | | | | (0.372) |
| Regression | OLS | OLS | OLS | OLS | OLS |
| Sample | All | All | All | All | All |
| Robust SE | Yes | Yes | Yes | Yes | Yes |
| N | 13,635 | 13,635 | 181,056 | 187,803 | 31,934 |
| $R^2$ | 0.513 | 0.887 | 0.544 | 0.603 | 0.102 |
| Province-Year FE | | Yes | Yes | | |
| Province-Industry FE | Yes | Yes | Yes | Yes | |
| Province-Source FE | | | Yes | | |
| Province-Source-Year FE | | | | Yes | |
| Province FE | | | | | Yes |
| Source FE | | | | | Yes |

*Notes:* Significance: * 10 percent, ** 5 percent, *** 1 percent. Column 3 controls for destination GDP.

Table 9: **Regional Specialization Results**

| | (1) $\ln(emp_{pit})$ | (2) $\ln(rev_{pit})$ | (3) $\ln(wage_{pit})$ | (4) $\Delta \ln(emp_{pi})$ | (5) $\Delta \ln(rev_{pi})$ | (6) $\Delta \ln(wage_{pi})$ |
|---|---|---|---|---|---|---|
| $TC_{pt} \times TS_i$ | -2.055*** | -2.122*** | -0.283 | | | |
| | (0.291) | (0.475) | (0.534) | | | |
| $\Delta TC_p \times TS_i$ | | | | -2.381*** | -2.226*** | -0.107 |
| | | | | (0.615) | (0.713) | (0.447) |
| Regression | OLS | OLS | OLS | OLS | OLS | OLS |
| Robust SE | Yes | Yes | Yes | Yes | Yes | Yes |
| N | 3,133 | 3,011 | 2,479 | 375 | 368 | 351 |
| $R^2$ | 0.763 | 0.796 | 0.722 | 0.056 | 0.046 | 0.054 |
| Region-year FE | Yes | Yes | Yes | | | |
| Region-industry FE | Yes | Yes | Yes | | | |
| Region FE | | | | Yes | Yes | Yes |
| Industry FE | | | | Yes | Yes | Yes |

*Notes:* Significance: * 10 percent, ** 5 percent, *** 1 percent.