# Infrastructure and the international export performance of Turkish regions

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# Infrastructure and the international export performance of Turkish regions*

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**Abstract**

We estimate the Anderson and van Wincoop model of trade by using the data on the bilateral export flows from 26 Turkish regions to 180 countries for the years 2002 through to 2010. Regional transportation and communication infrastructure capacity, the positioning of point infrastructure in a region, and geography are explicitly accounted for. Our results highlight that land infrastructure, air transport capacity, and private maritime infrastructure presence, together with the distance of regional economies to exit nodes such as ports and airports, are important determinants of export performance. Based on our preferred regression where multilateral resistance terms are accounted for, we estimate that increases in the current land infrastructure, air transport capacity, and number of private ports of 1 per cent increases exports approximately by 0.38 per cent, 0.14 per cent, and 0.045 per cent respectively.

**Key words**: Infrastructure, trade, regions, transportation costs.

**JEL Classifications**: F14, O18, O24, R10, R40, R58.

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# 1 Introduction

Since the early 2000's, Turkey has been ambitiously investing in its transportation infrastructure. This period of increase in infrastructure investment has been accompanied by a surge in export performance, but at the same time has been coinciding with an increase in the current accounts deficit. Roughly at the same time as this upward trend in infrastructure investments and exports in Turkey, the economic literature focusing on the relationship between infrastructure and trade has also become enriched with many new research results. A positive effect of infrastructure on trade through the reduction of transport costs has been documented by: Bougheas et al. (1999) for a sample of Eurpean countries; Limao and Venables (2001), Nordas and Piermartini (2004), Carrre (2006), Iwanow and Kirkpatrick (2009) and Portugal-Perez and Wilson (2012) for samples consisting of a range of countries around the world, Vijil and Wagner (2012) for a sample of developing countries, and Celbis et al. (2013) by means of meta-analysis, among others. In accordance with these results, the 2009 OECD/WTO report on aid for trade underlines the significance of infrastructure as "one of the most important regional public goods with enormous potential to facilitate cross-border trade, growth and development" (OECD/WTO, 2009).

A recent study on Turkey by Kustepeli et al. (2012) found no significant relationship between country-wide highway infrastructure[1] and international trade. However, the authors also point out that there is a negative correlation between highway infrastructure investment and highway length[2]. Considering that road infrastructure represents only a part of all trade-related infrastructure[3], and that infrastructure is not uniformly distributed among regions, it would be beneficial to focus on the infrastructure-trade relationship with explicit emhasis on different infrastructure categories and on the po-

[1]The authors measure infrastructure interchangeably in two ways: the share of highway expenditures in the public budget, and highway length.

[2]We assume that a possible reason for their finding could be that investment could have been made for removing older, curvier roads, and replacing them with straighter roads (or for example, building a tunnel) which would reduce the length of a highway from one point to another.

[3]As of 2009, the distribution of Turkish exports by modes of transportation were as follows: Roads 41.7%, Sea 46.0%, Air 9.5%, Rail 0.9%, and other modes 1.8% (Karacadag Development Agency, 2011).

sitioning of infrastructure in space. Therefore, this study aims to answer the following two questions: Firstly, how much of the recent expansion and the sub-regional differences in Turkey's export performance can be attributed to trade-related infrastructure? Secondly, how did the different types of infrastructure impact on exports? The answer to these questions can potentially provide some valuable information not only for Turkey but also for other emerging economies and LDC's where infrastructure deprivation remains as a crucial issue. Additionally, we note that many trade studies measure point infrastructure in terms of traffic (such as port or airport traffic). We aim to answer the above questions with a focus on capacity rather than traffic in order to reduce endogeneity concerns.

## 2 Theoretical framework

We follow the Anderson and van Wincoop (2003) (henceforth AvW) gravity model of trade, in which consumers in region $j$ maximize the following utility function:

$$U_j = \left( \sum_i^n \beta_i^{\frac{1-\sigma}{\sigma}} c_{ij}^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}, i \neq j \tag{1}$$

subject to:

$$\sum_i^n c_{ij} \tau_{ij} p_i = y_j \tag{2}$$

where $\sigma$ is the elasticity of substitution, $c_{ij}$ is the consumption of the unique product of region $i$ by the consumers in region $j$, $\beta_i > 0$ is a distribution parameter for determining the weight assigned by consumers in $j$ on the unique product of $i$, and the supply price of the exporter is $p_i$. AvW define $p_{ij}$ as the price for goods of region $i$ that the consumers in $j$ face. The supply price $p_i$ is scaled by a trade cost factor ($t_{ij} > 1$) that applies to the trade from $i$ to $j$ such that $p_i t_{ij} = p_{ij}$. Consequently, the budget constraint for region $j$ in the AvW model is $\sum_i c_{ij} t_{ij} p_i = y_j$. In our adaptation of the AvW model, we define $\tau_{ij}$ as the trade costs divided by the export capacity of region $i$ denoted by $s_i$:

$$\tau_{ij} = \frac{t_{ij}}{s_i} \tag{3}$$

where $0 < s_i < 1$. If $s_i$ could equal to 1, then the export capacity of region $i$ is at a maximum, so that the c.i.f. price to consumers in region $j$ is at a minimum. Alternatively, if $s_i$ is close to zero, region $i$ has virtually no capacity to export and the cost of exporting from $i$ to $j$ would be prohibitively high. Therefore, exports from $i$ to $j$ are subject to two constraints: (1) the budget constraint of region $j$ and (2) the export capacity constraint of region $i$. The following market clearing condition is imposed:

$$y_j = \sum_{i}^{n} x_{ji} \tag{4}$$

where $x_{ji}$ is the value of exports of $j$ to $i$ and $p_j \tau_{ji} c_{ji} = x_{ji}$.

Equation (4) says that the income of region $j$ is the sum of all exports of $j$ to all other regions $i$. Solving the above defined model leads to the gravity equation:

$$x_{ij} = \frac{y_j y_i}{y_w} \left( \frac{t_{ij}/s_i}{P_j P_i} \right)^{1-\sigma} \tag{5}$$

where $y_w$ is the world income. A common proxy for $t_{ij}$ in trade literature is the distance between origin and destination economies. However, it has been emphasized by Beckerman (1956) that *relative distance* should be taken into consideration rather than absolute distance when examining the impact of distance on trade flows. Beckerman (1956) also suggested using prices in the origin and destination economies for measuring the relative distances. The author highlights two distance elements and defines them as follows: "the relative distance of every other country to the given country, which will influence the import pattern of the given country in one way" and "the relative distance of the given country to each other country, which will affect the export pattern of each other country and will thereby also have an effect on the import pattern of the given country" Beckerman (1956, p.36). In the Anderson and van Wincoop (2003) model this concept is refined as "multilateral resistance" and formalized as price indices in the terms $P_j$ and $P_i$ where:

$$P_j^{1-\sigma} = \sum_i^n \left(\frac{\tau_{ij}}{P_i}\right)^{1-\sigma} \frac{y_i}{y_w} \tag{6}$$

$$P_i^{1-\sigma} = \sum_j^n \left(\frac{\tau_{ij}}{P_j}\right)^{1-\sigma} \frac{y_j}{y_w} \tag{7}$$

AvW assume symmetry of trade barriers ($\tau_{ij} = \tau_{ji}$). This condition translates to our adaptation as $\frac{t_{ij}}{s_i} = \frac{t_{ji}}{s_j}$ which assumes that the trade costs that $i$ and $j$ face relative to their own export capacities are equal.

The log-linearization of (5) yields:

$$lnX_{ij} = lny_j + lny_i - lny_w + (1-\sigma)lnt_{ij} - (1-\sigma)lns_i - (1-\sigma)lnP_j - (1-\sigma)lnP_i \tag{8}$$

Assuming that $\sigma > 1$, the closer region $i$ is to its full capacity to export, the higher the export flows from $i$ to $j$ conditional on the level of income of the consumers in $j$.

Trade costs $t_{ij}$ are defined by Anderson and van Wincoop (2004) as:

$$t_{ij} = \prod_m^M (z_{ij}^m)^{\gamma_m} \tag{9}$$

where $z_{ij}^m$ is the $m$'th observable factor for regions $i$ and $j$ that is associated with trade costs $t_{ij}$, and $\gamma_m$ is the parameter measuring the role of the $m$'th factor in trade costs. Substituting (9) into (8) gives:

$$lnX_{ij} = lny_j + lny_i - lny_w + (1-\sigma)\sum_m^M \gamma_m lnz_{ij}^m + (\sigma-1)lns_i - (1-\sigma)lnP_j - (1-\sigma)lnP_i \tag{10}$$

which yields our regression equation to be estimated after adding an error term to the right hand side. Section 4 explicitly shows the variables corresponding to each term in equation (10).

## 3 Data and descriptive statistics

The system of reporting the regional output data for Turkey has gone through several modifications in the last decade. The spatial scale has been changed to NUTS 2 from NUTS 3[4] and the indicator of output has been changed to gross value added from gross domestic product. This change in reporting also corresponds time-wise to a two year gap in the data between 2001 and 2004. Moreover, the regional public investments data are reported only if province (NUTS 3) specific, but not if an investment was directed to more than one NUTS 3 level province. To cope with these issues in the data, we use the adjusted NUTS 2 level GVA and public investment figures compiled by Celbis et al. (2014). To summarize, the adjusted series for both these variables account for the differences in spatial scale in the officially reported data by (1) aggregating NUTS 3 (provincial) figures to NUTS 2 (regional) ones, (2) adjusting for the change of measurement from GDP to GVA, and (3) imputing the two consecutive missing years. Celbis et al. (2014) also show for a sample of three regions, that inflating the public investment figures by an estimated amount[5] for each region in order to account for the unreported province-specific investments cause roughly a parallel shift upwards in the investment trend lines for these regions and advocate that using the officially reported data should not cause biases.[6]

Table 1 lists the 26 regions that form the basis of the empirical analysis. The boundaries of these regions are displayed in Figure 1.[7] Table 2 presents the sources and definitions of the variables used in the estimations. We use a set of covariates that consist of both continuous and dummy variables. Several of the variables, especially the geographical ones and some of the infrastructure capacity variables are either completely time invariant, or only exhibit very small changes over time. In our estimations this causes some information to be lost or some coefficients to be estimated imprecisely if regional fixed effects are included. Additionally, some variables such as *Air capacity* and

[4]NUTS stands for “Nomenclature of Units for Territorial Statistics”.

[5]This estimation is the result of meticulous extraction of investment figures reported seperately by project name with attached locational information.

[6]Celbis et al. (2014) use the GVA data for the year 2011 in their adjustments while in our study their adjustment process is replicated including the GVA figures up to the year 2010.

[7]These regions are not administrative units but only statistical regions. The largest administrative sub-national units in Turkey are provinces. All regions consist of at least two provinces, except for Istanbul, Ankara, and Izmir which are provinces and regions at the same time.

*EU customs union* are constant for some regions or countries throughout the time range while some variation is present for other trading units. This implies that the fixed effects estimation would still keep such variables even though for many observations in the sample the figures would be absorbed by the fixed effects. Therefore, in our fixed effects estimations, we manually drop such "mostly constant" variables for consistency. We employ distance based variables as in Granato (2008) from regional cores to exit nodes as a component of transport costs. These variables are also constant since they are defined in terms of Eucledian distance rather than road distance.

The descriptive statistics of the variables in our panel are presented in Tables 3.A and 3.B for region specific and general variables respectively. All summaries are based on observations for nine years[8]. These tables show that for some regions certain types of air and, naturally, maritime infrastructure does not exist at all. The summarized variables in levels enter the econometric estimations in natural logarithms as suggested by the theoretical model presented in Section 2 (except the dummy variables).

Figures 2 to 4 show the trends in country-wide exports, public investments in transportation and communication, and gross value added respectively for the years 2002 through 2010. A general upwards trend can be observed for all three indicators. Figure 5 plots the relationship between exports and public investments in transportation and communication observed during the nine-year period. A positive association is present, however higher values of investment are not always corresponding to higher values of exports. This can be attributable to a possible satiation effect: after a certain point, investments and exports may no longer be strongly related. It is also important to note that no implication on causation can be made at this point. In order to explore the spatial dimension for these figures, we plot the regionally disaggregated trend lines for the five economically largest regions[9] in natural logarithms:[10] Figures 6 and 7 show the trends in exports and investments respectively for these regions. The largest economy of the country, Istanbul, is persistently higher than the other four largest economies in both exports and investments. While for exports, smoother trend lines are observed, the trend

[8]The continuous variables that enter the estimations in natural logarithms are transformed to *ln* form after adding one if they include minimum values of zero in order to avoid values of *ln(0)*.

[9]As of 2008.

[10]We use the logarithmic transformation to avoid a large gap in the graph between the region with the highest GVA and the other four.

lines for investments are rather erratic except for Istanbul. Since the investment allocation is subject to central decision-making in Turkey where the decision-makers consider a range of factors before directing regional public investments (Celbis et al., 2014), relatively smooth trends would have implied that investment decisions are mostly unchanged from one year to another while this figure suggests otherwise.

The spatial variation in the export and investment figures for the years 2002 and 2010 are presented in Figures 8a, 8b, 9a and 9b respectively. These maps which present a snapshot of the geographic distribution for the first and last years of the sample suggest that the relative export performances of the regions did not change drastically[11,12] while for investments there is not such a persistence over time. It is also important to underline that the infrastructure investment figures may not coincide with the regional distribution of infrastructure stock. For a closer examination of the infrastructure-export relationship, Section 4 discusses the estimation of equation 10. All estimations are conducted after dropping importer partner countries that have zero imports through the covered nine years with 23 or more of the regions of Turkey. We are then left with 180 countries in our dataset out of the original 186 countries.[13]

[11]Except for region TRC:3 in the south-east.

[12]All maps have been made by using the *spmap* command in Stata developed by Pisati (2007). NUTS 3 provinces in the originally available shapefile have been aggregated to NUTS 2 regions using the Stata module *mergepoly* by Picard and Stepner (2012).

[13]Among the six countries dropped, Sudan has been dropped due to missing years in the data.

## 4 Estimation and empirical results

There are two methods that are common in the trade literature for controlling for the unobservable multilateral resistance terms $P_j$ and $P_i$, namely by estimating the gravity model with importer and exporter fixed effects or by implementing the approach suggested by Baier and Bergstrand (2009) for approximating the MRT's expressed as price indices in equation (5). The Baier and Bergstrand (2009) method is adapted to our split-sample (non-symmetric trade matrix) case for the distance variable as follows; replacing their GDP-share weighted averages with simple averages (i.e. there is no GDP weighting of the variables in our study), we adjust the distance variable for MRT's as: $ln\ MRT\ adjusted\ distance_{ij} = lnDistance_{ij} - \left(\frac{1}{n}\right)\sum_{j}^{n} lnDistance_{ij} - \left(\frac{1}{m}\right)\sum_{i}^{m} lnDistance_{ij} + \left(\frac{1}{mn}\right)\sum_{i}^{m}\sum_{j}^{n} lnDistance_{ij}$ where $n$ is the number of importing countries and m is the number of exporting regions. The first term on the right-hand-side is the unadjusted *ln* distance of the exporting region $i$ to the importing country $j$, the second term is the average *ln* distance of the exporting region $i$ to all importing countries, the third term is the average *ln* distance of all exporting regions to the importing country $j$, and the fourth term is the average *ln* distance of all exporting regions to all imporing countries. Additionally, if a random distribution of multilateral resistances is assumed, the specification can be estimated using a random effects model (Shepherd, 2012). We use all three approaches in our estimations. However, a pair random effect estimation is ruled out in favor of fixed effects estimation by the Hausman test statistic reported in table 5.

We define the terms in equation (10) as functions of several empirical variables as follows:

$$
\begin{aligned}
X_{ij} &= Exports_{ij} \\
y_i &= Region\ (exporter)\ GVA_i \\
z_{ij}^m &= f(Distance_{ij}, Average\ minimum\ distance\ to\ major\ airports_i, \\
&\quad Average\ minimum\ distance\ to\ major\ ports_i, Common\ open\ border_{ij}) \\
s_i &= g(Land\ transport\ infrastructure_i,\ Public\ port\ capacity_i, \\
&\quad Air\ capacity_i,\ DSL\ lines\ per\ capita_{it})
\end{aligned}
$$

As the parameter $\sigma$ is associated with the terms $\sum_m^M \gamma_m lnz_{ij}$ and $lns_i$ in equation (10), and these terms are determined by a multitude of empirically specified variables, we do not attempt an explicit estimation of this parameter of the structural model. In order to augment the theoretical gravity model with variables that account for region and country characteristics and their connectedness, the following variables are added to the specification: *Partner country exchange rate*$_j$*, Similar language*$_{ij}$*, EU customs union*$_{ij}$*, Country (importer) population*$_j$*, Regional (exporter) population*$_i$*, and Partner country is landlocked*$_j$.

After including the time index $t$, constant and error terms, the final specification is:

$$
\begin{aligned}
lnExports_{ij,t} = a &+ \beta_1 lnRegional\ (exporter)\ GVA_{it} + \beta_2 lnCountry\ (importer)\ GVA_{jt} \\
&+ \beta_3 lnDistance_{ij} + \beta_4 ln(Partner\ country\ exchange\ rate)_{jt} \\
&+ \beta_5 EU\ customs\ union_{jt} + \beta_6 Similar\ language_j \\
&+ \beta_7 Land\ transport\ infrastructure_{it} \\
&+ \beta_8 lnDSL\ per\ capita_{it} + \beta_9 lnAir\ capacity_{it} \\
&+ \beta_{10} lnPublic\ port\ capacity_i + \beta_{11} Number\ of\ private\ ports_i \\
&+ \beta_{12} lnAverage\ minimum\ distance\ to\ major\ airports_i \\
&+ \beta_{13} lnAverage\ minimum\ distance\ to\ major\ ports_i \\
&+ \beta_{14} lnRegional\ (exporter)\ population_{it} \\
&+ \beta_{15} lnCountry\ (importer)\ population_{jt} \\
&+ \beta_{16} Partner\ country\ is\ landlocked_j + Common\ open\ border_{ij} + \epsilon_{ij,t}
\end{aligned}
\tag{11}
$$

Table (4) presents estimation results of pooled OLS models with and without year dummies, and of an OLS model with MRT adjusted distance variable. Additionally, because in our dataset 19,379 observations of zero exports exist, which is 46 percent of all trade flows, we also report the results of a Heckman sample selection model developed by Heckman (1979) to cope with possible selection bias.[14] We hypothesize that the adjacency of two economies would increase their probability to trade, but would not impact the amount of trade once trade has begun. Therefore, the variable *Common open border*$_{ij}$ is the only selection term we employ.[15] We separately discuss this estimation in (Appendix A).

[14]These results are presented in Table A.1 in the annex.

[15]The Heckman model is estimated by maximum likelihood.

### Transport costs and export capacity

Our results highlight the importance of air transportation infrastructure in enhancing export performance. *ln Aircapacity* is significant and positive in all models at Tables 4 and 5. As mentioned earlier, we include the variables that are measured in terms of distance as proxies for the trade costs $t_{ij}$. Therefore, role of air transport infrastructure accessibility is also examined by the variable *ln (Avg. min distance to airports)*. This variable yields negative but insignificant results in our estimations; we do not observe conclusive evidence that economies which are further away from airports export less than those that are closer to these exit nodes, but we find robust evidence that the transport capacity of these nodes are important.

Port infrastructure related variables present interesting results. While *ln Public port capacity* is negative and significant in all our models, *Number of private ports* yields positive and significant coefficients. This could be a sign of a crowding-out effect, or could underline that regions with more privately operated ports are much more efficient while those with a high public port capacity are adversely affected. Our results show that distance to ports also has a negative impact on regional exports, further highlighting the importance of this infrastructure type in export performance. This observed difference in the role of distance for airports and ports is easy to explain; distance would matter for ports because of bulky and heavy goods being transported, but not for airports because of high-value but small-volume exports.

The land infrastructure index is associated significantly and positively with regional export performance according to our results except in the models with importer and exporter fixed effects and pair fixed effects. These results provide evidence supporting the importance of road, highway, and railroad stocks for regional export performance with an estimated elasticity of approximately 0.38%. This finding is not very far from the estimated infrastructure elasticity of trade of about 0.42% for a developing economy estimated in the meta-analytic study of Celbis et al. (2013). Our estimations suggest that for Turkey, land infrastructure is the type of infrastructure that has the most impact on regional exports, which is another result that is consistent with the above mentioned meta-analytic study. This finding may also be related to the fact that Turkey is adjacent to a trade block such as the EU to which it is connected mainly through land routes. Therefore, regions within Turkey can be seen as heavily reliant on land infrastructure regarding their trade with the EU.

Our estimations present inconclusive results considering the impact of communication infrastructure, represented by *DSL per capita*. Contrary to expectations, we observe a a negative sign on the elasticities obtained from the OLS model with time dummies, OLS model with multilateral resistance terms, and the regression results with importer fixed effects while models 2 and 3 in table 5 yield positive but insignificant results.

Finally, distance between trading pairs, as expected, is always found to impact on exports negatively and significantly. This result is consistent with the common findings in the trade literature such as those by Limao and Venables (2001) who find a positive effect of distance on trade costs and a negative impact on trade flows, Carrre and Schiff (2005) who observe that for a majority of countries the impact of distance on trade has become increasingly important over time, Berthelon and Freund (2008) who attribute the increasing effect of distance on industrial distance sensitivities, and the meta-analitic studies of Linders (2005) and Disdier and Head (2008), among others.

### Geography

*Common open border* positively and significantly affects exports according to most of our results from the models estimated by OLS, OLS with time dummies, and OLS with multilateral resistance terms. This variable is dropped from the model in the importer-exporter and pair fixed effects estimations as it is bilaterally constant through our sample period. Results suggest that adjacency of a region and a country significantly and positively affects regional exports and that it is a relevant control variable. There is also some evidence based on our results from the OLS models with and without year dummies that if a partner country is landlocked, regional exports are negatively affected. However, this effect is no longer observable if multilateral resistances or importer fixed effects are taken into account in column 3 of Table 4 and column 1 of Table 5 respectively.

### Regional demographic characteristics and other core gravity variables

Coefficients on regional population are positive and significant in all our models, suggesting that agglomeration economies export more. On the other hand, while destination country population yields positive estimates, out of these coefficients, those estimated using importer, importer and exporter, and pair fixed effects respectively in the columns of Table 5 are not significant.

The remaining variables are other commonly used factors in trade studies that stem from the theoretical gravity model. We observe the expected positive and significant coefficients for importer country GVA, emphasizing on the role of the destination demand. On the other hand, some evidence is also observed for the positive effect of the origin GVA.

As expected, the larger the value of the Turkish lira in the currency of the trading partner, the less are the export flows. On the other hand, if a country enters into a EU customs union agreement with Turkey, regional exports are positively impacted according to the majority of our results. Finally, language similarity exhibits the expected positive impact.

## 5 Concluding remarks

Celbis et al. (2013) conducted a meta-analysis on the infrastructure elasticities of trade obtained from 36 previous studies. According to their results, estimations that used a land transport infrastructure variable found significantly higher infrastructure elasticities of trade relative to estimations using other infrastructure types. Our results in Tables 4 and 5 are in line with this observation except for the models using importer-exporter and pair fixed effects, which yield insignificant elasticities of land transport infrastructure. The authors also find that estimations focusing on maritime or air transport infrastructure find a significantly higher estimate of the impact of importer's infrastructure. While in our study, we focus on only exporter's infrastructure, our results regarding these two types of infrastructure reinforce the conclusion that they play an important role in trade facilitation, except for public port capacity, as seen in both Tables 4 and 5. Therefore, the continuation of public investments in these types of public infrastructure are recommended. Results on ports yield a different story; as the number of private ports exhibit a positive impact on exports, public port capacity does not. This may point to certain efficiency differences between publicly and privately managed ports. However, access to public ports measured in terms of distance still has a positive effect on regional exports. Thus, our results also show that the location of point infrastructure is important for regions regardless of a public-private distinction. As a result, the findings of this study underline the roles of land, port, and airport transport infrastructures in the exports of Turkey, and also the importance of the spatial distribution of point infrastructures as exit nodes for exports.

## Tables and Figures

Table 1: Region Codes and Names

| |
|---|
| TR10: Istanbul |
| TR21: Tekirdag, Edirne, Kirklareli |
| TR22: Balikesir, Canakkale |
| TR31: Izmir |
| TR32: Aydin, Denizli, Mugla |
| TR33: Manisa, Afyon, Kutahya, Usak |
| TR41: Bursa, Eskisehir, Bilecik |
| TR42: Kocaeli, Sakarya, Duzce, Bilecik |
| TR51: Ankara |
| TR52: Konya, Karaman |
| TR61: Antalya, Isparta, Burdur |
| TR62: Adana, Mersin |
| TR63: Hatay, Kahramanmaras, Osmaniye |
| TR71: Kirikkale, Aksaray, Nigde, |
| TR72: Kayseri, Sivas, Yozgat |
| TR81: Zonguldak, Karabuk, Bartin |
| TR82: Kastamonu, Cankiri, Sinop |
| TR83: Samsun, Tokat, Corum, Amasya |
| TR90: Trabzon, Ordu, Giresun, Rize |
| TRA1: Erzurum, Erzincan, Bayburt |
| TRA2: Agri, Kars, Igdir, Ardahan |
| TRB1: Malatya, Elazig, Bingol, Tunceli |
| TRB2: Van, Mus, Bitlis, Hakkari |
| TRC1: Gaziantep, Adiyaman, Kilis |
| TRC2: Sanliurfa, Diyarbakir |
| TRC3: Mardin, Batman, Sirnak, Siirt |

Table 2: Variable Definitions

| Name | Year Coverage | Description |
|---|---|---|
| $Exports_{ij,t}$ | 2002-2010 | Bilateral value of regional total exports of region $i$ to country $j$ in constant 2005 100,000 USD. Source: Turkstat. |
| *Regional (exporter)* $GVA_{it}$ | 2002-2010 | Regional gross value added in constant 2005 100,000 USD. Modified as specified in the Appendix. Source: Turkstat |
| *Country (importer)* $GVA_{jt}$ | 2002-2010 | Partner country gross value added constant 2005 100,000 USD. Modified as specified in the Appendix. Source: UN: http://unstats.un.org/unsd/snaama/Introduction.asp. |

Table 2: Variable Definitions (cont'd)

| Name | Year Coverage | Description |
|---|---|---|
| $Distance_{ij}$ | Constant | Euclidean distance between the most populous province of the region and the capital of the partner country. Source for region coordinates: http://www.tageo.com/index-e-tu-cities-TR.htm. Coordinates for Sakarya, Artvin, Agri, Ardahan, Tunceli are obtained from from www.wikipedia.org.. Source for country coordinates: UN: http://esa.un.org/unup/CD-ROM/Urban-Agglomerations.htm. The coordinate for Belgium is from www.wikipedia.org, converted to decimal degrees using webtool at: http://transition.fcc.gov/mb/audio/bickel/DDDMMSS-decimal.html..[16] |
| $Partner\ country\ exchange\ rate_{jt}$ | 2002-2010 | Partner country exchange rate to Turkish Lira. Source:Penn world table 7.1 (Version 2 for China). |

[16]The center of a region is taken as its most populous city of the region in 2008 (Turkstat). Generated from coordinates using Stata command *spmat* (Drukker et al., 2011). MRT corrected as suggested by Baier and Bergstrand (2009).

Table 2: Variable Definitions (cont'd)

| Name | Year Coverage | Description |
|---|---|---|
| *Land transport infrastructure*$_{it}$ | 2002-2010 | Index made from highway, road, and railroad lengths per 1000 square meters. National export shares that go through these type of infrastructure are used as the weights. |
| *Avg. min. euclidean distance to major airports*$_{it}$ | constant | Regional average distance of each provincial center to the closest major airport. Added 1 km in cases where the point infrastructure is at the provincial center in order to avoid values of ln(0). Source: Airport data and coordinates from http://www.dhmi.gov.tr/havaalanlari. Coordinates for Sabiha Gokcen airport added from: http://www.istanbulairports.com/gene informations.htm Data for Adiyaman airport is from http://en.wikipedia.org/wiki/ Ad%C4%B1yaman˙Airport. |

Table 2: Variable Definitions (cont'd)

| Name | Year Coverage | Description |
|---|---|---|
| *Avg. min. euclidean distance to major ports*$_{it}$ | constant | Regional average distance of each provincial center to the closest major port. Added 1 km in cases where the point infrastructure is at the provincial center in order to avoid values of ln(0). Source: Port coordinates are obtained from http://www.searates.com/ maritime/turkey.htm, converted to decimal degrees using webtool at http://transition.fcc.gov/mb/audio/ bickel/DDDMMSS-decimal.html (Mersin Port Administration was privatizated on 11.05.2007). |
| *Public port capacity*$_{it}$ | constant (as of 2006) | Port handling capacity in major ports in 100,000 tons (General cargo and dry bulk). |

Table 2: Variable Definitions (cont'd)

| Name | Year Coverage | Description |
|---|---|---|
| *Air capacity*$_{it}$ | 2002-2010 | Total passenger capacity (in 100,000 persons) of the region's airports. Compiled from the information on area and establishment dates available at several websites of the Republic of Turkey: Ministry of Transport, Maritime Affairs and Communication. |
| *Similar language*$_{ij}$ | constant | Equals to 1 if parner country has a Turkic language as an official language, zero otherwise. |
| *EU customs union*$_{ij,t}$ | 2002-2010 | Dummy = 1 if the partner country is a EU member, therefore being in customs union with Turkey. |
| *DSL lines*$_{it}$ | 2002-2010 | Number of DSL/ADSL lines in the PTT offices per 1000 persons. Source: Republic of Turkey - General Directorate of PTT. Values for 2002 and 2005 are imputed as shown in the Appendix. |

Table 2: Variable Definitions (cont'd)

| Name | Year Coverage | Description |
| --- | --- | --- |
| *Country (importer) population*$_{jt}$ | 2002-2010 | Partner country population (100,000 persons). Source: World Bank. |
| *Regional (exporter) population*$_{it}$ | 2002-2010 | Regional population (100,000 persons). Source: OECDstat. |
| *Common open border*$_{ij}$ | constant | Equals to 1 if the region and the partner country share a common border that is open to trade, zero otherwise. |
| *Partner country is landlocked*$_{j}$ | constant | Equals to 1 if the partner country is landlocked, zero otherwise. |

Table 3.A Summary statistics for exporting regions

| Variable | Mean | Std. Dev. | Min. | Max. | N |
|---|---|---|---|---|---|
| *Regional Exports*$_{it}$ | 1764.69 | 5156.16 | 0 | 47666.66 | 1620 |
| *Regional (Exporter) GVA*$_{it}$ | 133058.42 | 178652.48 | 19622.32 | 1072149.75 | 234 |
| *Land transport infrastructure*$_{it}$ | 75.73 | 17.57 | 50.78 | 139.82 | 234 |
| *DSL lines per cap.*$_{it}$ | 0.046 | 0.038 | 0.0005 | 0.31 | 234 |
| *Air capacity*$_{it}$ | 35.03 | 59.92 | 0 | 285 | 234 |
| *Public port capacity*$_{i}$ | 6.57 | 11.21 | 0 | 32.47 | 234 |
| *Number of private ports*$_{i}$ | 2.42 | 5.36 | 0 | 27 | 234 |
| *Avg. min. dist. to major airports*$_{i}$ | 3.61 | 3.08 | 0.14 | 10.24 | 234 |
| *Avg. min. dist. to major ports*$_{i}$ | 2.40 | 1.85 | 0.09 | 6.98 | 234 |
| *Region (exporter) Population*$_{it}$ | 27.32 | 20.36 | 7.33 | 129.15 | 234 |

Table 3.B Summary statistics for importing countries

| Variable | Mean | Std. Dev. | Min. | Max. | N |
|---|---|---|---|---|---|
| *Country (importer) GVA*$_{jt}$ | 2379450.86 | 10587286.74 | 955.01 | 132041000 | 1620 |
| *distance*$_{ij}$ | 5897.20 | 4061.41 | 449.86 | 17401.78 | 1620 |
| *MRT corrected dist.*$_{ij}$ | 0.0002 | 0.00004 | 0.0001 | 0.0003 | 1620 |
| *Exchange rate*$_{ij,t}$ | 384.62 | 1486.86 | 0.19 | 21226.34 | 1548 |
| *EU customs union*$_{ij,t}$ | 0.11 | 0.32 | 0 | 1 | 1620 |
| *Similar language*$_{ij}$ | 0.028 | 0.16 | 0 | 1 | 1620 |
| *Country (importer) Population*$_{jt}$ | 345.41 | 1337.89 | 0.28 | 13378.25 | 1620 |
| *landlocked importer*$_{j}$ | 0.22 | 0.42 | 0 | 1 | 1620 |
| *Common open border*$_{ij}$ | 0.028 | 0.16 | 0 | 1 | 1620 |

Table 4: Estimation results for equation (11)

| | (1) | (2) | (3) |
|---|---|---|---|
| | OLS | OLS | MRT |
| *ln Regional (exporter)* $GVA_{it}$ | 0.442*** | 0.337*** | 0.377*** |
| | (0.0969) | (0.117) | (0.128) |
| *ln Country (importer)* $GVA_{jt}$ | 0.311*** | 0.309*** | 0.343*** |
| | (0.0166) | (0.0166) | (0.0172) |
| *ln (Distance)*$_{ij}$ | -0.777*** | -0.779*** | |
| | (0.0326) | (0.0327) | |
| *ln (Exchange rate)*$_{jt}$ | -0.0659*** | -0.0663*** | -0.0807*** |
| | (0.00872) | (0.00870) | (0.00963) |
| *EU customs union*$_{ij,t}$ | 0.319*** | 0.314*** | 0.792*** |
| | (0.0900) | (0.0906) | (0.0872) |
| *Similar language*$_{ij}$ | 1.153*** | 1.152*** | |
| | (0.144) | (0.144) | |
| *ln (Land transport infrastructure)*$_{it}$ | 0.406*** | 0.390*** | 0.382** |
| | (0.151) | (0.151) | (0.161) |
| *ln (DSL per capita)*$_{it}$ | 0.220 | -1.467*** | -1.394** |

| | | | |
|---|---|---|---|
| | (0.394) | (0.521) | (0.553) |
| *ln (Air capacity)$_{it}$* | 0.141*** | 0.141*** | 0.137*** |
| | (0.0173) | (0.0173) | (0.0189) |
| *ln (Public port capacity)$_{i}$* | -0.145*** | -0.147*** | -0.152*** |
| | (0.0290) | (0.0291) | (0.0324) |
| *Number of private ports$_{i}$* | 0.0427*** | 0.0453*** | 0.0453*** |
| | (0.00577) | (0.00596) | (0.00680) |
| *ln (Avg. min. distance to airports)$_{i}$* | -0.0107 | -0.0580 | -0.0585 |
| | (0.0358) | (0.0412) | (0.0455) |
| *ln (Avg. min. dist. to major ports)$_{i}$* | -0.325*** | -0.326*** | -0.339*** |
| | (0.0540) | (0.0542) | (0.0602) |
| *ln Regional (exporter) Population$_{it}$* | 0.427*** | 0.491*** | 0.445*** |
| | (0.111) | (0.123) | (0.133) |
| *ln Country (importer) Population$_{jt}$* | 0.0733*** | 0.0742*** | 0.0944*** |
| | (0.0162) | (0.0161) | (0.0172) |
| *Landlocked importer$_{j}$* | -0.484*** | -0.486*** | 0.0765 |
| | (0.0534) | (0.0533) | (0.0539) |
| *Common open border$_{ij}$* | 0.870*** | 0.867*** | 2.132*** |

| | | | |
|---|---|---|---|
| | (0.162) | (0.163) | (0.154) |
| *ln (MRT corrected distance)*$_{ij}$ | | | -1.360*** |
| | | | (0.204) |
| Constant | -4.634*** | -3.491*** | -22.36*** |
| | (1.059) | (1.209) | (2.150) |
| Observations | 42120 | 42120 | 42120 |
| Number of pairs | 4680 | 4680 | 4680 |
| Year Dummies | No | Yes | Yes |
| Standard errors clustered by | Pair | Pair | Pair |
| R-squared | 0.471 | 0.472 | 0.422 |

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5: Additional estimation results for equation (11)

| | (1) importer FE | (2) Imp-exp FE | (3) Pair FE |
|---|---|---|---|
| *ln Regional (exporter)* $GVA_{it}$ | 0.309*** | -0.103 | -0.103 |
| | (0.105) | (0.164) | (0.164) |
| *ln Country (importer)* $GVA_{jt}$ | 0.701*** | 0.701*** | 0.701*** |
| | (0.0900) | (0.0898) | (0.0895) |
| *ln (Distance)*$_{ij}$ | -1.327*** | -1.360*** | |
| | (0.164) | (0.161) | |
| *ln (Exchange rate)*$_{jt}$ | -0.250*** | -0.250*** | -0.250*** |
| | (0.0674) | (0.0671) | (0.0669) |
| *EU customs union*$_{ij,t}$ | 0.315*** | 0.315*** | 0.315*** |
| | (0.0690) | (0.0688) | (0.0686) |
| *Similar language*$_{ij}$ | 0.905* | | |
| | (0.465) | | |
| *ln (Land transport infrastructure)*$_{it}$ | 0.395*** | -0.378 | -0.378 |
| | (0.137) | (0.270) | (0.269) |
| *ln (DSL per capita)*$_{i}$ | -1.519*** | 0.408 | 0.408 |

| | | | |
|---|---|---|---|
| | (0.461) | (0.360) | (0.359) |
| *ln (Air capacity)$_{it}$* | 0.143*** | | |
| | (0.0149) | | |
| *ln (Public port capacity)$_{i}$* | -0.143*** | | |
| | (0.0249) | | |
| *Number of private ports$_{i}$* | 0.0454*** | | |
| | (0.00535) | | |
| *ln (Avg. min. distance to airports)$_{i}$* | -0.0576 | | |
| | (0.0369) | | |
| *ln (Avg. min. dist. to major ports)$_{i}$* | -0.316*** | | |
| | (0.0483) | | |
| *ln Regional (exporter) Population$_{it}$* | 0.524*** | 0.992*** | 0.992*** |
| | (0.111) | (0.172) | (0.171) |
| *ln Country (importer) Population$_{jt}$* | 0.0163 | 0.0163 | 0.0163 |
| | (0.225) | (0.223) | (0.223) |
| *Landlocked importer$_{j}$* | -0.461 | | |
| | (0.431) | | |
| *Common open border$_{ij}$* | -0.630 | | |

| | | | |
|---|---|---|---|
| | (0.479) | | |
| Constant | -2.043 | 6.759** | -7.180*** |
| | (2.172) | (3.159) | (2.414) |
| Observations | 42120 | 42120 | 42120 |
| Number of pairs | 4680 | 4680 | 4680 |
| Year Dummies | Yes | Yes | Yes |
| Standard errors clustered by | Pair | Pair | Not clustered |
| R-squared | 0.534 | 0.547 | 0.2556 |
| Hausman test statistic | | | 141.005 |

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

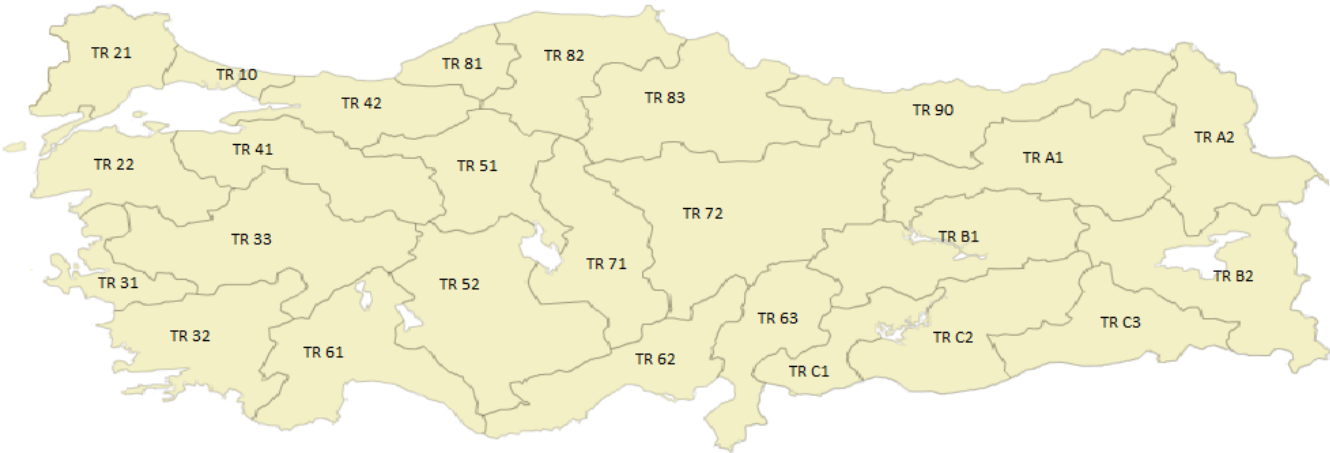



Figure 1. NUTS-2 level regional map of Turkey.

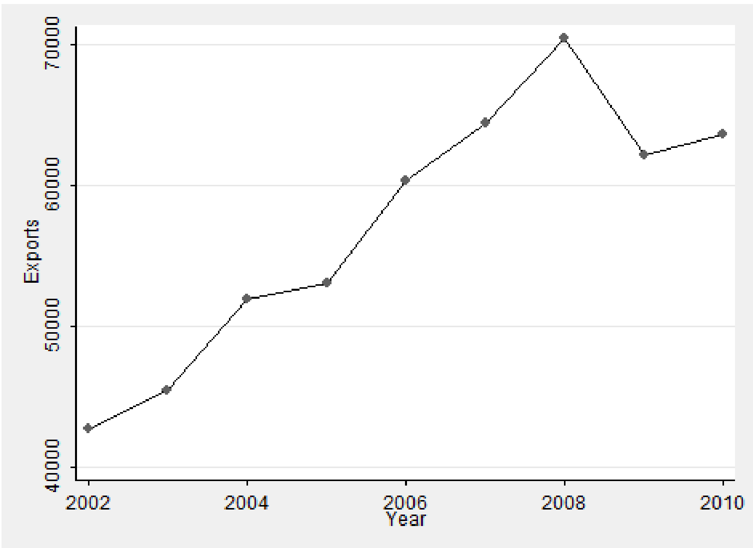



Figure 2. Exports, Turkey (constant 2005 millions of USD).

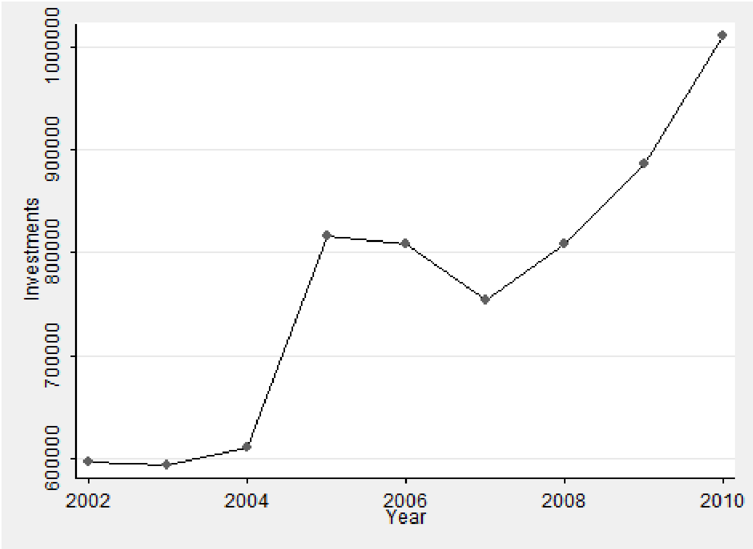



FIGURE 3. Public Investments in Transportation and Communication, Turkey (constant 2005 millions of USD).

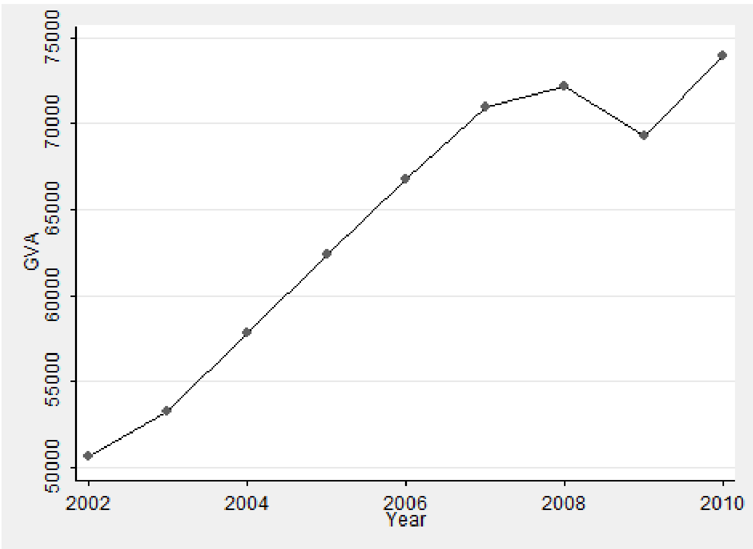



FIGURE 4. Gross value added, Turkey (constant 2005 billions of USD).

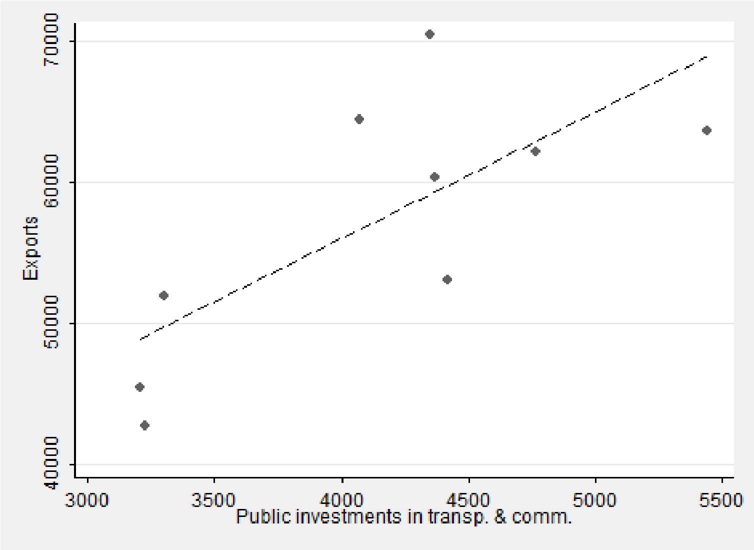



FIGURE 5. Exports and public investment in transportation and communication, Turkey (constant 2005 millions USD).

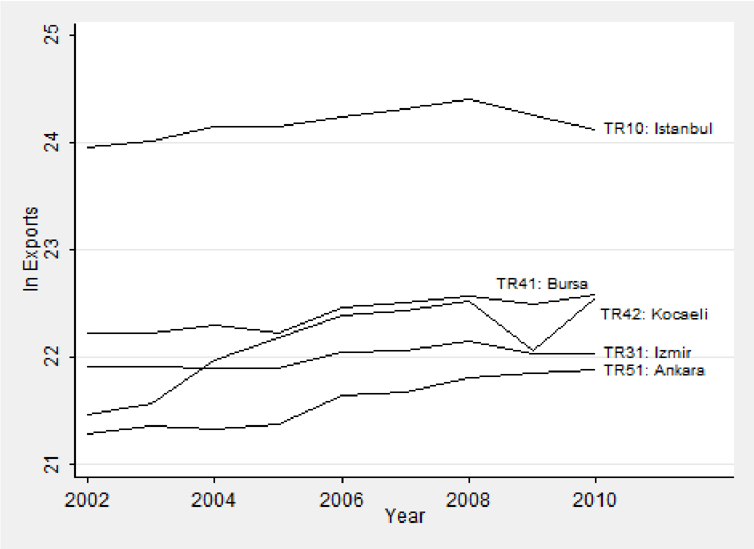



FIGURE 6. The natural logarithm of regional exports for the five largest regions, Turkey (constant 2005 millions of USD).

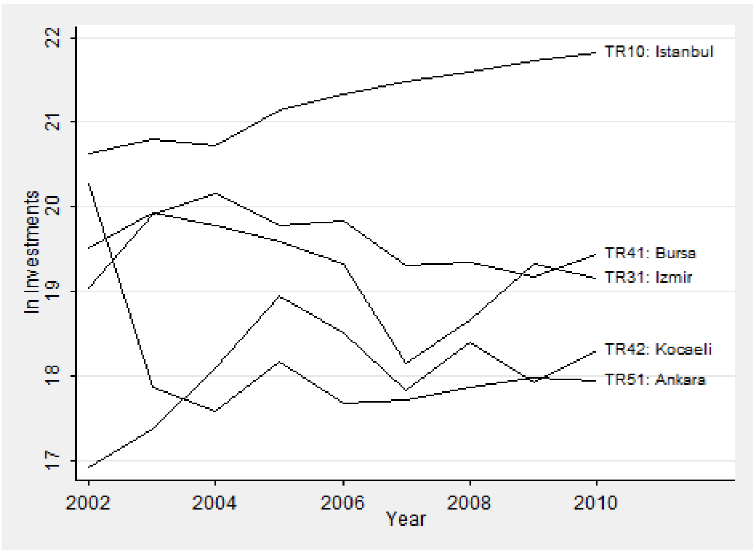
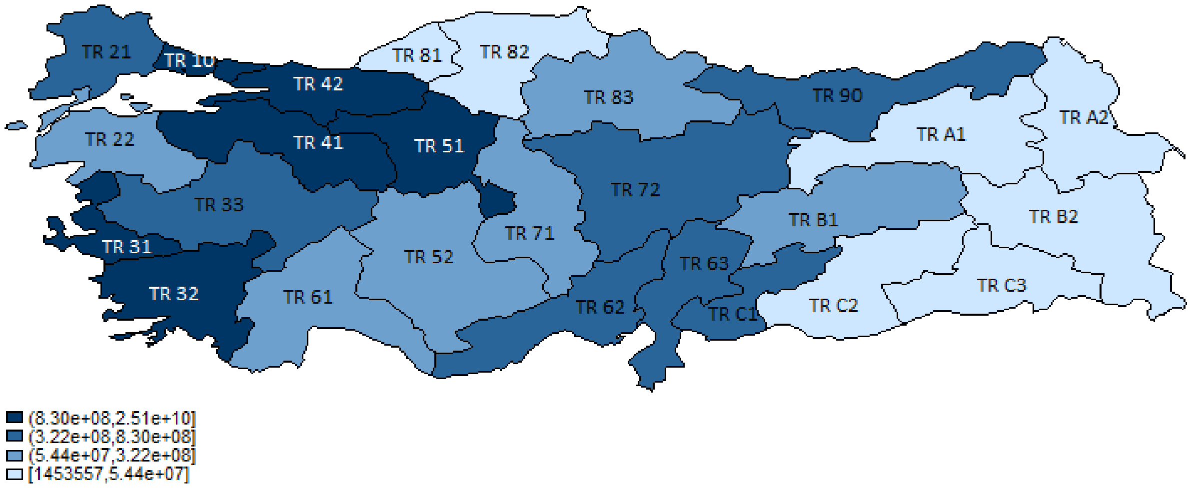



FIGURE 7. The natural logarithm of public investments in transportation and communication for the five largest regions, Turkey (costant 2005 millions of USD).

Figure 8: Regional exports

(a) 2002




(b) 2010

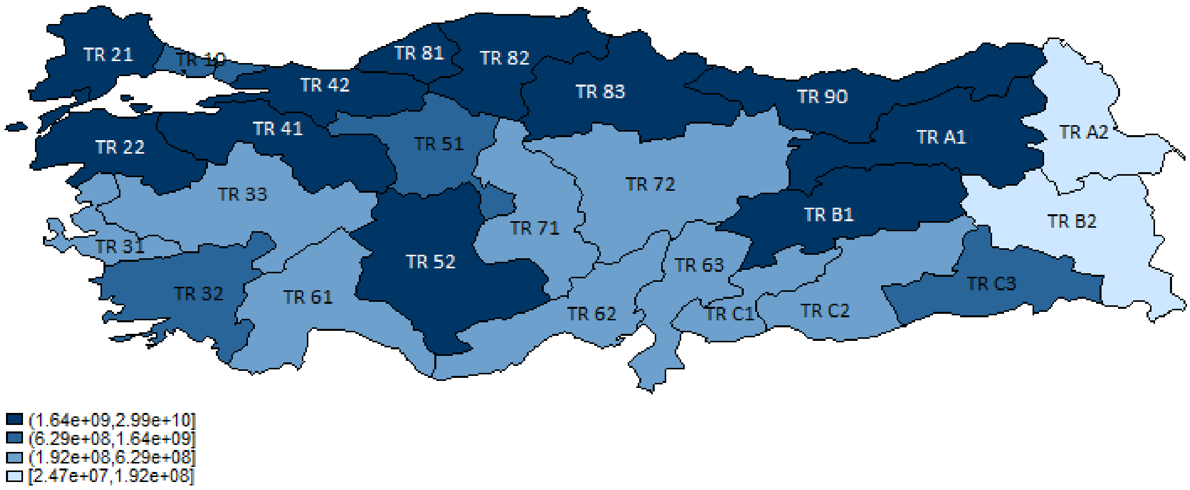
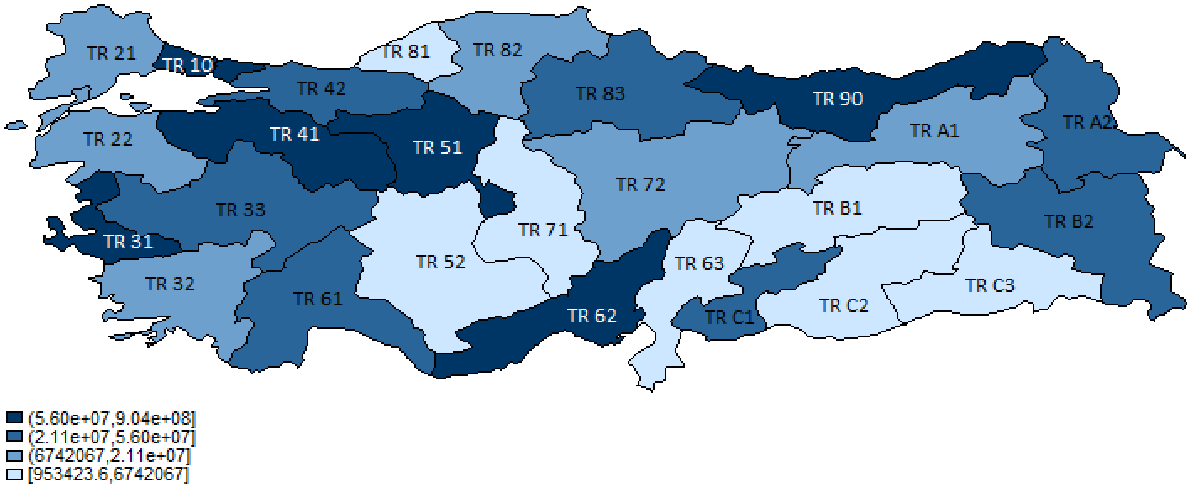
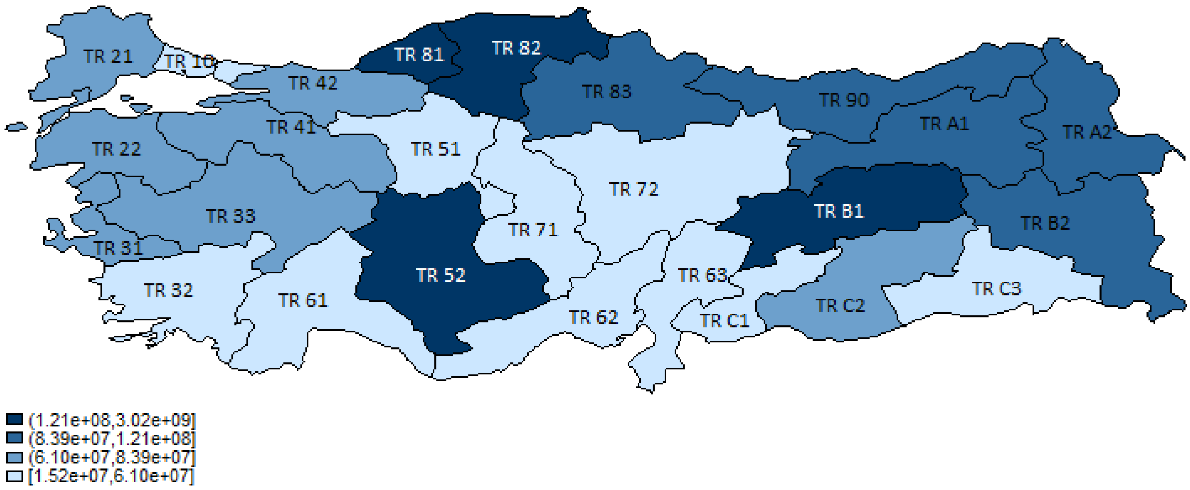


FIGURE 9. Public investment in transportation and communication

(A) 2002




(B) 2010



# A Appendix

## A.1 Additional estimation results

Column 1 in table A.1 presents the results of the panel estimation with random effects. While most of the coefficients are similar to those from our previous results, the earlier reported Hausman test suggests that we favor the pair fixed effects results reported in column 3 of table 5. On the other hand, the pair fixed effects regression drops many key variables due to them being constant, causing loss of valuable information.

Sample selection bias can potentially arise in trade research as only those countries that engage in trade are used in the regression analyses (Helpman et al., 2008). We conduct a maximum likelihood estimation of a Heckman sample selection model for our emirical specification.[17] Column 2 of table A.1 suggests that sample selection is not an issue in our analyses, as the inverse Mill's ratio is insignificant. The selection variable is *Open common border* as mentioned in section 4. The neighbors of Turkey are Georgia, Armenia, the Nakhchivan enclave of Azerbaijan[18], Iran, Syria, Iraq, Bulgaria, and Greece. Due to political frictions, the border between Armenia and Turkey is closed, hence the name Common *open* border for this variable. On the other hand, Armenia is dropped from the sample due to too little trade in the procedure detailed in section 3. Therefore the term "open" in this variable is no longer relevant in the analysis. The most important difference of the results from the Heckman estimation compared to our other results is that communication infrastructure has the expected positive and significant coefficient. On the other hand, land transport infrastructure has an insignificant coefficient.

[17] Puhani (2000) suggests that the full-information maximum likelihood estimator can be preferred over the two-step method of Heckman (1979) if collinearity problems are not present.

[18] We do not consider Azerbaijan as a neighbor of Turkey as the enclave represents only a very small part of its economy.

Table A.1: Pair RE and Heckman estimation results for equation (11)

| | (1) | (2) | |
|---|---|---|---|
| | Pair RE | Heckman MRT | |
| | | Outcome | Selection |
| *ln Regional (Exporter) GVA*$_{it}$ | 0.0508 | 1.185$^{***}$ | 0.775$^{***}$ |
| | (0.0989) | (0.200) | (0.113) |
| *ln Country (importer) GVA*$_{jt}$ | 0.325$^{***}$ | 0.452$^{***}$ | 0.295$^{***}$ |
| | (0.0163) | (0.0307) | (0.0138) |
| *ln (distance)*$_{ij}$ | -0.770$^{***}$ | | |
| | (0.0318) | | |
| *ln (Exchange rate)*$_{jt}$ | -0.0658$^{***}$ | -0.139$^{***}$ | -0.00769 |
| | (0.00866) | (0.0162) | (0.00764) |
| *EU customs union*$_{ij,t}$ | 0.319$^{***}$ | 0.940$^{***}$ | 0.577$^{***}$ |
| | (0.0575) | (0.0899) | (0.0589) |
| *Similar language*$_{ij}$ | 1.156$^{***}$ | | |
| | (0.144) | | |
| *ln (land transport infrastructure)*$_{it}$ | 0.133 | 0.232 | 0.0627 |
| | (0.138) | (0.255) | (0.136) |

| | | | |
|---|---|---|---|
| *ln (DSL per capita)$_i$* | 0.295 | 0.691 | 1.543*** |
| | (0.346) | (0.816) | (0.431) |
| *ln (Air capacity)$_{it}$* | 0.110*** | 0.114*** | -0.0182 |
| | (0.0173) | (0.0307) | (0.0147) |
| *ln (Public port capacity)$_i$* | -0.195*** | -0.287*** | -0.208*** |
| | (0.0289) | (0.0486) | (0.0229) |
| *Number of private ports$_i$* | 0.0530*** | 0.0518*** | -0.00124 |
| | (0.00573) | (0.00886) | (0.00425) |
| *ln (Avg. min. distance to airports)$_i$* | -0.111*** | 0.197*** | -0.00594 |
| | (0.0376) | (0.0604) | (0.0396) |
| *ln (Avg. min. dist. to major ports)$_i$* | -0.426*** | -0.564*** | -0.608*** |
| | (0.0533) | (0.0891) | (0.0423) |
| *ln Regional (exporter) Population$_{it}$* | 0.833*** | 0.253 | -0.0111 |
| | (0.106) | (0.214) | (0.118) |
| *ln Country (importer) Population$_{jt}$* | 0.0627*** | 0.292*** | 0.119*** |
| | (0.0161) | (0.0301) | (0.0138) |
| *landlocked importer$_j$* | -0.468*** | 0.203** | -0.0550 |
| | (0.0536) | (0.0925) | (0.0423) |

| | | | |
|---|---|---|---|
| *Common open border*$_{ij}$ | 0.883$^{***}$ | | 1.289$^{***}$ |
| | (0.163) | | (0.120) |
| *ln (MRT corrected distance)*$_{ij}$ | | -1.720$^{***}$ | -0.450$^{***}$ |
| | | (0.285) | (0.151) |
| Constant | -0.122 | -35.63$^{***}$ | -16.03$^{***}$ |
| | (1.142) | (3.178) | (1.615) |
| Observations | 42120 | 42120 | |
| Censored observations | | 18226 | |
| Uncensored observations | | 23894 | |
| Number of pairs | 4680 | 4680 | |
| Year Dummies | Yes | Yes | |
| Standard errors clustered by | Not clustered | Pair | |
| Log likelihood | | -70703.7 | |
| Lambda (Inverse Mill's ratio) | | 0.0488 | |
| SE Lambda (SE of Inverse Mill's ratio) | | (0.130) | |

Standard errors in parentheses

$^{*}$ $p < 0.10$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$

### A.2 Conversion to constant prices

The GVA and public investment (PI) data has been compiled in terms of 1998 national currency. According to the T.R. Ministry of Development, the external currency deflator to 2005 for 1998 (national currency) is 0.1415[19]. The regional GVA and PI figures were divided by this deflator to convert them to 2005 prices. The USD conversion rate specified in the same source was 1 USD = 1.67 TL for 2005. Therefore the GVA and PI values in 2005 constant national currency were divided by 1.67 and converted to dollars.

### A.3 Land infrastructure index construction

The weights presented in footnote (3) were used to create the land infrastructure index using road length, highway length, and railroad length per 1000 sqm as follows: the total share of road and railroad in exports in 2009 was $0.417 + 0.09 = 0.507$ (so about half of total exports in were made through these types of infrastructure).
$0.417 \div 0.507 = 0.82249$ is the weight of roads in land infrastructure and $0.09 \div 0.507 = 0.17751$ is the weight of railroads in land infrastructure. The index "land" is calculated as follows:

$$\begin{aligned} land = {} & 0.822485207100592 \times [ln\ (road\ per\ area) + ln\ (highway\ per\ area)] \\ & + 0.177514792899408 \times [ln\ (railroad\ per\ area)] \end{aligned}$$

### A.4 Exchange rates

Exchange rates to USD for each partner country are from Penn World Table 7.1 (Heston et al., 2012)[20]. Each country's exchange rate to USD was divided by Turkey's exchange rate to USD in a given year so that all observations express the amount of the corresponding foreign currency one Turkish lira can buy within a specific year.

[19] Retrieved from:www2.dpt.gov.tr/kamuyat/2005/2005deflator.xls
[20] The rates for China are from "version 2" of this table

### A.5 DSL data imputation

The observations for 2002 and 2005 for each region is missing for the DSL (or ADSL) data.[21] The missing values were imputed using the regional public investments in transportation and communication (TPI) by predicting the missing values for each region $i$ using the coefficients from the OLS estimation of the below equation:

$$ln(adsl)_t = a + \beta(TPI)_{t-1} + \epsilon$$

[21] For 2003, the figure is reported as "DSL" where as for the rest of the years they are reported as "ADSL."

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