Analysis of the impact of bilateral and transit quotas on Turkey's international trade by road transport: An integrated maximum flow and gravity model approach

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ABSTRACT

We explore whether bilateral and transit quotas applied by EU countries on Turkey have a negative impact on Turkey's international trade by road transport. Therefore, Turkey's exports by road transport to selected European countries are analyzed in a panel-data framework for the period 2005–2014. We estimate the aggregate effect of different quota types on trade between Turkey and European countries by using an approach that integrates the max-flow and gravity models. In the gravity model, for each country, a single value representing the aggregate restricting effect of different quota types is needed. The single values are obtained by solving multiple max-flow problems, where constraining effects of different quota types are modeled as arc capacities. The results of the gravity model suggest a loss in Turkish exports by road transport because of the quotas imposed by other countries. Most of the negative impact results from bilateral quotas rather than from transit quotas, whose effect is rather marginal.

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1. Introduction

There is a conventional wisdom that has traditionally accepted that a close relationship exists between world trade and gross domestic product (GDP). In fact, trade volumes have grown twice as fast as global economic output (Liu & Xin, 2011). However, in the last quarter of 2008, according to the World Trade Organization (WTO), there has been a sudden collapse in world trade flows with a decline by approximately 12% in 2009. This figure is much greater than the decline of 5.4% in GDP for the same period. Since 2012, this trend is even more accentuated in such a way that the rate of increase in world trade volumes is less than the global GDP growth rate. Additionally, the growth in the value of trade has significantly underperformed compared to global growth. Although CPB World Trade Monitor underlines that in the third quarter of 2015, the increase in trade volumes is 2% higher than that in the previous quarter, this does not necessarily indicate an improvement in the world economy.
When the situation of Turkey is analyzed in this respect, it can be observed that since 2000, Turkey's business sector has shown a strong and dynamic growth. A robust public finance and a sustainable banking sector were the major support of the economic performance. However, Turkey's growth is highly dependent on domestic demand and foreign finance, its domestic savings are very low, and its external competitiveness is volatile. To rebalance demand, important measures should be taken to improve external competitiveness. In this respect, the decrease in inflation level, and thus a restrictive monetary policy, is indispensable. However, according to the 2015–2016 Global Competitiveness Report (Sala-i Martin 2015), Turkey fell six places to 51st, with a general decline in almost all factors that drive competitiveness.

The EU has been the largest economic partner of Turkey for many years. In fact, the EU’s exports to and imports from the country have increased rapidly since 1995. Although there has been a decline in trade volumes after the 2007 economic crisis, they have recovered with a particularly strong rebound in exports since then. In 2013, 48% of Turkish export was to EU countries and 35% of Turkish import was from EU countries. Directorate-General of Trade of the European Commission identified Turkey as the EU's 7th largest source of imports and 5th largest export market. Germany, Italy, France, Spain, and the UK are the most important exporters to Turkey and provide the largest EU markets for Turkish goods on a value basis. Eurostat data highlight the importance of chemicals, food, wood products, basic metals, and machinery in the EU’s exports to Turkey and food, textiles, and machinery from Turkey to the EU (Pastori et al. 2014).

However, during the last 5 years in particular, Turkey’s trade with other regions has grown much faster than its trade with the EU. Along with Andorra, Monaco, and San Marino, Turkey is one of the four countries in a Customs Union (CU) with the EU that are not members of the EU. Therefore, according to the CU regulations, EU countries cannot apply any trade quotas to Turkish products. However, the EU countries can apply road transport quotas to Turkish trucks because Turkey is not in the EU. In other words, Turkey is the only country subject to a “road transport quota” but not to a “trade quota.”

Road transport services that operate between the EU Member States and Turkey are regulated by bilateral intergovernmental agreements signed by individual EU Member States. These agreements set the conditions under which transport services can be operated and, in particular, establish the number and nature of the permits that are required to perform a transport operation between the signatory Member State and Turkey.

In 2013, the 25 EU Member States with which Turkey has bilateral road transport agreements (only Cyprus, Ireland, and Malta did not sign the agreements) issued 961,087 permits of all types to Turkish road transport companies. The majority were bilateral or transit permits (42% and 31%, respectively). Over the last 5 years (2009–2013), the allocation of all types of bilateral permits granted by the Member States remained broadly unchanged. The routes connecting Turkey to its most important trading partners in the EU (Germany, Italy, France, United Kingdom, and Spain) require road freight operators to pass through the territory of third countries (mostly other EU Member States). This transit traffic is not only mostly concentrated in Greece and Bulgaria but also extends to Slovenia, Austria, Hungary, Poland, Czech Republic, and other Member States. Despite these constraints, EU–Turkey trade has grown rapidly over the past decade (Pastori et al., 2014).

The EU regulations dictate that practices resulting in unnecessary costs for the import or export of a commodity are considered charges, which have the equivalent effect of a customs duty. Turkish industrialists must pay for the unnecessary fuel consumed by Turkish road carriers and any additional costs that arise due to the prolonged transport period. Therefore, Turkish industrialists face unfair competition and unfair trade. This is not only Turkey's problem but also negatively affects the foreign investors in Turkey. As more than 70% of foreign investors are from the EU, one can conclude that the quotas also negatively affect the international competitiveness of the EU economy.

As stated by Pastori et al. (2014), full liberalisation could boost total trade by more than €3 billion per year. In all scenarios, liberalisation increases the EU’s road-freighted exports to Turkey at a lower rate than imports from Turkey. The analysis suggested that full liberalisation would increase the value of EU–Turkey trade by an estimated €3.5 billion, out of which €1.9 billion are additional imports from Turkey and €1.6 billion are exports to Turkey. The largest expected effect is an increase in imports from Turkey to Germany, France, and the Netherlands.

According to Turkish authorities, the country’s annual export loss due to quotas is at least US$7 billion, and that the quota for goods shipped from Turkey are arguably one of the most important reasons for the decline of Turkey's exports to the EU. Therefore, the aim of this paper is to analyze the validity of the hypothesis that quotas negatively affect trade volume between Turkey and European countries. There are several types of quotas or road transport licenses, including a bilateral permit, transit permit, third-country permit, multiple permits, and CU permits. For example, to export goods from Country X to Country Y by road transport, the truck carrying the freight must have transit permits for all transit countries on the route from Country X to Country Y and a bilateral permit for Country Y. Moreover, bilateral and transit permits can be used only once by a truck; another permit is necessary for the next transport movement using the same truck. Conversely, multiple permits can be used as often as required during the specified year. Moreover, European countries issue multiple permits that can be used as either transit or bilateral permits.

In this study, we analyzed the quota effect on Turkey’s export by road transport. The basic reason for concentrating solely on the export by road transport is that 35.3% of Turkey’s export to European countries is transported by road. Additionally, Turkey will lose its competitive advantage if a switch from road to sea or airway will be done. The basic reason is that, as mentioned above, the main goods exported from Turkey to EU countries are food, textiles, etc., and a switch to maritime transport will increase the lead times, and thus, the food will be perished and the textile products will be outdated, while a switch to airways will substantially increase the costs. Therefore, the road transport is very important for Turkey’s export to Europe.

We consider transit, bilateral, and multiple permits and exclude third-country and return load permits because they are not directly related to the trade between Turkey and European countries, and these permits are rarely used and generally issued in sufficient numbers. Therefore, Turkey’s exports to selected European countries are analyzed in a panel-data framework for the period from 2005 to 2014. The analysis is conducted through an econometric study based on the gravity model.

The gravity model analyzes spatial interactions among different variables according to the theory of gravity in physics. Its first application in the econometric domain was concerned with international trade relations (Timmergen, 1962). Since then, the gravity equations have been frequently used as a basic tool for international trade for many years (Brun et al., 2002; Liu & Xin, 2011; Novy, 2013; Redding and Venables, 2004). A detailed literature review about the application of gravity models in international trade was presented by Ülengin et al. (2015). In the past decade, most of the empirical studies in the gravity model literature were based on a cross-sectional methodology. However, rather than using data averages over a certain period, a panel framework may be used to capture the relationships among relevant variables over a longer
period. By using panel data, it is also possible to understand country-specific effects and interpret the elasticity (Egger, 2000). However, when the gravity models are based on panel data, it is necessary to decide whether a random effect model (REM) or a fixed effect model (FEM) should be used. Because we analyze the trade relations between Turkey and specific European countries, REM assumptions cannot be used in our setting. Therefore, we use the FEM, similar to that used in related studies (Antonucci & Manzocchi, 2006; Egger, 2000).

The present paper is an extension of the study by Ülengin et al. (2015), which investigated only the effect of bilateral road transport quotas on Turkish foreign trade with European countries by using a gravity model. They developed the fixed effect gravity model and used panel data that covered 18 European countries for 2005–2012. According to their results, quotas have a significantly negative effect on Turkish exports by road transport. The gravity model estimated that in the absence of quotas, Turkey’s exports by road transport could be increased by US$4.7 billion. The main drawback of Ülengin et al. (2015) is the use of bilateral quotas alone. We believe that, besides the bilateral quotas, the transit quotas applied by European countries to Turkish trucks may also have an effect on the export of other countries. Therefore, in this study, we investigate the effect of both bilateral and transit quotas on the Turkish export to European countries. This requires a single value representing the restrictive effect of the transit quotas issued by the countries on the routes from Turkey to the considered European countries. We estimate the single values by using a max-flow model-based approach and use them in a gravity model to analyze the aggregate effect of the quotas. To the best of our knowledge, this is the first study integrating max-flow problem with the gravity model to analyze the aggregate effect of both transit and bilateral quotas.

The paper is organized as follows. The second section describes the max-flow methodology to find the total quota effect. The third section presents the gravity model proposed to investigate the impact of quotas on international trade. The empirical results of Turkey’s exports by road transport are also given in the third section. Finally, we offer conclusions and further suggestions in the fourth section.

2. A methodology to find the total quota effect

In the gravity model, a single value representing the restriction (i.e., bilateral and transit quotas in our case) on trade from origin countries to the destination countries is needed. Each quota type has a different restrictive effect. Bilateral quotas issued by a country directly restrict the trade to this country. However, transit quotas affect the trade to countries other than the issuing country. Therefore, in this study, as the aim is to find the effect of both bilateral and transit quotas on Turkish export, a max-flow-based methodology is used to approximate the total quota effect. Furthermore, the gravity model is developed on the basis of the results of the max-flow methodology. We also estimate the expected loss in export because of the quotas by using the results of the gravity model.

2.1. Max-flow methodology to find the quota effect

To use the gravity model, the effects of different quota types, such as bilateral and transit quotas, should be summarized in a single value. Therefore, for a given European country X, we need to find the maximum number of allowed vehicles to Country X, which is a function of the bilateral quota issued by Country X and the transit quotas issued by the European countries on the route from Turkey to Country X. To calculate the maximum number of allowed vehicles precisely, it is necessary to know exactly how many transit quotas of each country on the route from Turkey to Country X are used for the vehicles travelling to Country X. Unfortunately, such data are not available. Therefore, a max-flow based methodology is used to approximate the maximum number of allowed vehicles for each European country included in this study.

In the maximum-flow problem, the main purpose is to send as much flow as possible from a source node s to a sink node t in a given capacitated network \(G = (N, A)\) without exceeding the capacity of any arc. Let \(N\) be the set of nodes and \(A\) be the set of arcs in a network \(G\). The capacity of an arc \((i, j) \in A\) is denoted by \(u_{ij} \geq 0\). Let \(x_{ij}\) be the flow on arc \((i, j) \in A\) and \(v\) be the total flow from \(s\) to \(t\). The problem can be stated formally as follows:

\[
\begin{align*}
\max & \quad \sum_{j(i) \in A} x_{ij} - \sum_{j(i) \in A} x_{ji} = v & \text{for} & i = s \\
& \sum_{j(i) \in A} x_{ij} - \sum_{j(i) \in A} x_{ji} = 0 & \text{for} & i \in N / \{s, t\} \\
& \sum_{j(i) \in A} x_{ij} - \sum_{j(i) \in A} x_{ji} = -v & \text{for} & i = t \\
0 & \leq x_{ij} \leq u_{ij} & \text{for each} & (i, j) \in A.
\end{align*}
\]

In the above model, the first set of constraints calculates the net flow (outflow - inflow) for each node and guarantees that a flow with value \(v\) will be sent from \(s\) to \(t\) through the other transition nodes in the network. The net flow of the source node \(s\) is \(v\), which implies that this node will supply a flow with value \(v\) to the network. Similarly, the net flow of node \(t\) is \(-v\), which implies that node \(t\) will remove a flow with value \(v\) from the network. In addition, the net flow of a transition node should be zero (outflow = inflow) as they are used only to transfer the flow from \(s\) to \(t\). The second set of constraints defines the capacity of every arc.

The max-flow problem has diverse applications including scheduling, transport, and location theory. There are many well-known computationally efficient algorithms in the literature to solve max-flow problem, such as Shortest Augmenting Path Algorithm and FIFO Preflow-Push Algorithm. It is also possible to solve a max-flow problem by using a generic solver such as CPLEX. In this study, we use GAMS/CPLEX solver to solve our model. Interested readers are referred to Ahuja et al. (1993) for a detailed analysis of the max-flow problem and its different applications.

In the present study, first, a network is developed where the nodes represent the countries and the arcs represent the possible road transport links including ROROs. This network is called the base network. The nodes representing countries that issue bilateral and transit quotas were then split into multiple nodes joined by arcs whose capacities are equal to bilateral or transit quotas issued by the corresponding country. The network obtained at the end of the splitting process is called the final network. The splitting process is extremely important and not standard for all countries because each country has a different quota portfolio. However, in general, the following principles are applied:

(i) The freight can enter a country by different transport modes. For each possible transport mode and each country, we define an arrival node.
(ii) Each node in (i) is connected to a corresponding node by an arc whose capacity is a function of the quotas corresponding to the related transport mode.
(iii) The freight can leave a country by different transport modes. For each possible transport mode and each country, we define a departure node.
(iv) A sink node is defined for each country.
(v) The nodes in (ii) are connected to the possible nodes in (iii) by some arcs whose capacities are functions of the transit quotas issued by the country.
(vi) The possible nodes generated in (ii) are connected to the sink nodes generated in (iv) by some arcs whose capacities are functions of the bilateral quotas issued by the country.
(vii) All sink nodes generated in (iv) are connected to a single general sink node by using infinite capacity arcs.
(viii) A general source node is connected to all departure nodes of Turkey.

We should remark that by using the above procedure, a different final network is produced for every year because the quotas are issued annually with changing quantities and types.

In Fig. 1, three examples of the splitting process are given for France, Hungary, and Austria with the quotas in 2011. Hungary and Austria have unique arrival nodes (\(h_1\) and \(a_1\), respectively), whereas France has two arrival nodes for road and ship transport separately (\(f_1\) and \(f_3\), respectively). This is mainly because of the transport modes that are used to travel to these countries by Turkish carriers. Similarly, for Hungary and Austria, there are single departure nodes (\(h_3\) and \(a_3\), respectively), but for France, there are two departure nodes (\(f_5\) is for road transport and \(f_6\) is for ship transport). Hungary–Austria border is one of the important gateways that are used by Turkish trucks. This is depicted by the thick line joining the nodes \(h_3\) and \(a_1\). It is clear that at most 18,000 Turkish trucks can enter Austria in 2011. The maximum number of Turkish trucks that can transit Austria is 15,000. Therefore, the remaining part of the total 18,000 quotas can be used as bilateral quota. The quota types issued by Austria in 2011 are as follows: 3000 bilateral permits and 15,000 permits that can be used either as a transit or as a bilateral permit. Hungary also issues general permits, which can be used either as a bilateral permit or as a transit permit. However, some of these permits are free, and the remaining permits are payable. In 2011, Hungary issues 21,500 free general permits and 16,400 paid general permits, which is the reason of the links between \(h_1\) and \(h_2\) and between \(h_1\) and \(h_4\). France issues 5000 special permits for towing from Toulon port in addition to 65,000 general permits, which is depicted by two arrival nodes (\(f_1\) and \(f_3\)) in the figure, where \(t_2\) is the departure node of Turkey corresponding to ship transport (including ROROs).

To obtain an approximation of the maximum number of allowed vehicles into a given country in a given year, we solve two max-flow problems defined on the final network obtained at the end of the splitting process by using the quotas in the given year. In the first max-flow problem, we find the maximum flow from the general source node to the general sink node. In this way, we find the maximum number of vehicles that can be sent to Europe from Turkey. In the second max-flow problem, we maximize the flow from the general source node to the sink node of the given country under the constraint that the solution of the first max-flow problem is still satisfied. In this way, we calculate the largest portion that the given country can take from the maximum number of possible shipments from Turkey to EU under the restrictions of bilateral and transit quotas. This calculated value is used in the following gravity model as a proxy of the maximum number of allowed vehicles into the given country.

The main motivation of this approach is that the first max-flow problem has many alternative optimal solutions. In this approach, we choose the optimal solution that favors the trade with the given country. This is why the quota values estimated by this approach are always larger than the actual maximum number of allowed vehicles. This fact makes the interpretation of the gravity model easier when using approximated values instead of actual ones. Suppose that the gravity model, which is developed by using the approximated values estimated by our approach, shows that the approximated quota variable has a negative impact on trade. This directly implies that the actual quotas also have a similar (or maybe stronger) negative effect because the actual values are always smaller and, hence, more restrictive for trade.

### 2.2. Results of the max-flow methodology

The results obtained by solving the max-flow problems for each country is given in Table 1. The table also compares the max-flow solutions and the bilateral quotas; and the significant differences are highlighted in the table. The results indicate that Turkey cannot use the overall bilateral quota for Belgium, Germany, Netherlands, Poland, and Switzerland because of the transit quotas applied by the other countries to Turkey. In other words, the trade amounts to

![Fig. 1. Splitting example for 2011.](image-url)
these countries are lower than their bilateral quotas because of the transit quotas. For instance, in 2005, the bilateral quota for Germany is 130,500; however, because of the transit quotas applied by the other countries on route from Turkey to Germany, the maximum flow from Turkey to Germany is just 112,000. Thus, 18,500 of the bilateral quotas cannot be used by Turkey. Another interesting case is The Netherlands for which the transit quotas applied by other countries start to negatively affect the export from Turkey after 2009. Before this year, the transit quotas allow unlimited number of Turkish trucks, the trucks are allowed to transport routes of Turkish carriers and with which trade volume is more than 1% of total Turkish export. The selected countries are Austria, Belgium, Bulgaria, Croatia, France, Germany, Greece, Hungary, Italy, Italy, Netherlands, Poland, Serbia, Slovak Republic, Spain, Switzerland, UK, and Ukraine. All data used in the paper were obtained from Turkish Statistical Institute (TSl, 2014).

Fig. 2 summarises the models considered in this study; Table 2 defines the variables. We investigate the effect of total quotas and other factors on Turkey's total exports by road transport.

### 3. The gravity model

The analysis is based on panel data and covers 18 countries (i = 1, ..., 18) for the period between 2005 and 2014 (t = 2005, ..., 2014). Therefore, the data set consists of 180 entries for each variable of the panel. Turkey's European trade partners have been chosen from the countries that are on the frequently used transport routes of Turkish carriers and with which trade volume is more than 1% of total Turkish export. The selected countries are Austria, Belgium, Bulgaria, Croatia, France, Germany, Greece, Hungary, Italy, Netherlands, Poland, Romania, Serbia, Slovak Republic, Spain, Switzerland, UK, and Ukraine.
The dependent variable used in the empirical estimation is \( ERD_{it} \). The explanatory variables used in different specifications are as follows (\( i \) denotes Turkey):

\[
SUMGDP_{it} = \ln(GDP_i + GDP_j),
\]

(1)

where \( GDP_i \) is the gross domestic product of country \( i \) in year \( t \). \( RELENDOW_{it} \) measures relative factor endowments. The proxy used is the difference in per-capita GDP. It is aimed at capturing a possible Linder effect. This is an accurate proxy when there are only two factors of production, namely capital and labor, and all goods are traded freely. The impact of factor endowments might go in either direction. (i) A negative coefficient would suggest that an inter-industry trade structure prevails (Antonucci & Manzocchi, 2006), where the inter-industry trade refers to the exchange of different types of goods between countries. A significant volume of inter-industry trade between two countries implies that the countries trade because they are different in technology or factor endowments. It is formulated as follows:

\[
RELENDOW_{it} = \left( \ln \frac{GDP_i}{POP_i} - \ln \frac{GDP_j}{POP_j} \right).
\]

(2)

\( SIMSIZE_{it} \) represents a measure of size similarity, which takes values in the range from \( -\infty \) (perfect dissimilarity) to \( 0 \) (perfect similarity), and may have either a positive or a negative effect. The larger this measure, the more similar the two countries are in terms of GDP and the higher is the share of intra-industry trade. If their exchanges are of an inter-industry nature, the coefficient should be negative (Antonucci & Manzocchi, 2006). It is defined as follows:

\[
SIMSIZE_{it} = \ln \left[ 1 - \left( \frac{GDP_i}{GDP_i + GDP_j} \right)^2 - \left( \frac{GDP_j}{GDP_i + GDP_j} \right)^2 \right].
\]

(3)

\( AQUOTA_{it} \) is the maximum number of Turkish trucks that can reach country \( i \) in year \( t \). This variable aims to incorporate the effect of bilateral and transit quotas on the trade between Turkey and country \( i \) into the gravity model. Therefore, this variable is extremely important with regard to the main purpose of this paper. The values of this variable are estimated by the max-flow method presented in Section 2, and the values are given in Table 1. When \( AQUOTA_{it} \) increases, the number of Turkish trucks whose final destination is country \( i \) in year \( t \) also increases. Therefore, this variable has a positive effect on the dependent variables in a coherent model. The \( AQUOTA_{it} \) variable is incorporated into the standard gravity model (without quota) by multiplying the standard gravity equation (before taking natural logarithms) by a fraction, which is a function of the quota. In this way, only a fraction of the total export potential, which is represented by the standard gravity model, will be obtained. The fraction, which is a function of \( AQUOTA_{it} \), is \( e^{-\frac{AQUOTA_{it}}{C}} \) in this study. Note that this function increases monotonously with increase in \( AQUOTA_{it} \) when \( a > 0 \), and it always takes values in the unit interval.

The basic formulation of the gravity models, which is obtained by taking natural logarithms, is as follows:

\[
\ln ERD_{it} = \delta_i + \beta_1 SUMGDP_{it} + \beta_2 SIMSIZE_{it} + \beta_3 RELENDOW_{it} + \beta_4 AQUOTA_{it}^{-1} + \ln e_{it}.
\]

(4)

In the literature, there is a long tradition of log-linearizing as given in Equation (4) and estimating the parameters of interest by using this equation. The validity of this procedure depends critically on the assumption that the error terms and, hence, \( e_{it} \) are statistically independent of the regressors. Silva and Tenreyro (2006) found overwhelming evidence that the error terms in the usual log-linear specification of the gravity equation are heteroskedastic, which violates the independence assumption and suggests that Equation (4) leads to inconsistent estimates of the elasticities of interest (Silva & Tenreyro, 2006).

An important problem of making analogy between Newtonian gravity and trade is that the gravitational force can be very small but never zero. However, the trade between several pairs of countries may be zero because these pairs of countries did not trade at all in a given period. The zero observations will cause an additional problem in Equation (4). Hence, in this study, the regression model in Equation (4) is estimated using the Poisson Pseudo Maximum Likelihood (PPML) estimator (for the details of the method see Silva & Tenreyro, 2006). We add country dummy variables in regression to monitor unobservable individual effects of different countries. These effects are represented by coefficients \( \delta_i \) in the regression equations. However, as our panel of data intends to extract information about the quota effect, the time-invariant fixed effect of our equation may not remove the potential time series correlation bias. To handle this potential source of bias it is important to perform an analysis that includes time dummies as suggested by Olper and Raimondi (2008) and Baldwin and Taglioni (2007). However, as the models without time dummies outperform the models with time dummies as described in Ülengin et al. (2015), we do not include the time dummies in the proposed gravity model.

### 3.1. Turkish exports by road transport

We develop a fixed effect panel data regression model to analyze the effect of quotas on Turkish exports by road transport, which is specified as ERD. We use balanced panel data, and the number of observations in each regression is 180 (18 trading
partners and 10 years). The output of the PPML fixed effect model is given in Table 3. According to the results from Equation (4) (see Table 3), the annual total export volume by road transport is significantly negatively affected by the quotas applied to Turkish road carriers. All coefficients are found to be significant for $t = 1.96$.

The results are very similar to those of Ülengin et al. (2015). The RELENDOW and SIMSIZE variables are statistically significant in ERD. The signs of the coefficients of these variables are positive and negative, respectively, which indicates that the exports by road transport are of an inter-industry nature (Antonucci & Manzocchi, 2006). Therefore, we can conclude that road transport is an important transport mode in inter-industry trade between Turkey and European countries. Examples of materials in inter-industry trade include chemical raw materials, cereals, fruits, and vegetables.

Finally, AQUOTA $^{-1}$ has a significant negative impact on exports by road transport. This finding shows that Turkey’s road transport is significantly negatively affected by the reduced number of quotas. It is clear that when the number of quotas decreases, the exports based on road transport decreases significantly.

### 3.2. Quota effect on Turkey’s exports by road transport

In this section, we intend to find the true effect of the quotas on Turkey’s exports. We compare real export data with the estimated export data, assuming that there is no quota on the road transport (the so-called quota-free exports).

The first step is to investigate the effect of the quotas on Turkey’s exports by road transport. Therefore, the coefficients of the good fitting model are used to estimate quota-free exports by road transport. By using the coefficients given in Table 3, the ERD model is formulated as follows:

$$
ERD_{it} = \delta_1 + 0.741 \text{SUMGDP}_{it} - 1.099 \text{SIMSIZE}_{it} + 0.570 \text{RELENDOW}_{it} - 1309.866 \text{AQUOTA}_{it}^{-1}, \tag{5}
$$

where country-specific fixed factors, $\delta_i$ values, are presented in Table 4. In the quota-free export scenario, all AQUOTA $^{-1}$ values will be zero and will have no effect on the exports by road transport. According to the results presented in Table 4, Turkey’s expected export loss (to the countries under consideration) in 2005–2014 is about US$13.60 billion, which is 5.6% of the realized exports. The most important effect of the quotas is on exports to Spain.

When we compare these results with those of Ülengin et al. (2015), although the approximated quotas are different from the bilateral quotas for some of the countries, their effects on the Turkish export by road transport are very similar. This is because, first, in the gravity model result, the coefficient of QUOTA $^{-1}$ variable obtained by Ülengin et al. (2015), which is $-1247.532$, is very close to that obtained in the present study ($-1309.866$). Subsequently, the effects of the approximated quota and the bilateral quota on the total export by road transport are roughly the same (their effects are 5.6% and 5.5% of the realized export, respectively) (Ülengin et al., 2015). Therefore, as bilateral quota and aggregate quota (i.e., bilateral plus transit) effects are approximately the same, we can conclude that the quota effect on the export is especially due to the bilateral quotas while the impact of transit quotas is rather marginal.

### 4. Conclusions

Turkey is among the most important trading partners for the EU. The EU’s exports to and imports from the country have increased rapidly since 1995. Although trade volumes decreased after the 2007 economic crisis, they have since recovered with the rebound in exports being particularly strong. Germany, Italy, France, Spain, and the UK are the most significant exporters to Turkey and provide the largest EU markets for Turkish goods. In value terms, 45% of Turkey’s trade with the EU in 2013 was transported by road. Road transport services operating between EU member states and Turkey are regulated by bilateral intergovernmental agreements (Pastori et al., 2014).

This study investigated the impact of bilateral and transit quotas on the trade level between Turkey and European countries. A novel max-flow model was proposed to forecast the aggregate quota of a

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**Table 3**

Output of the model for Turkish exports by road transport.

<table>
<thead>
<tr>
<th></th>
<th>ERD</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUMGDP</td>
<td>0.741</td>
</tr>
<tr>
<td>SIMSIZE</td>
<td>-1.099</td>
</tr>
<tr>
<td>RELENDOW</td>
<td>0.570</td>
</tr>
<tr>
<td>AQUOTA $^{-1}$</td>
<td>-1309.866</td>
</tr>
<tr>
<td>Pseudo R²</td>
<td>0.973</td>
</tr>
</tbody>
</table>

**Table 4**


<table>
<thead>
<tr>
<th>Country</th>
<th>$\delta_i$</th>
<th>Realized Exports (billions US$)</th>
<th>Estimated Exports (billions US$)</th>
<th>Estimated quota-free exports (billions US$)</th>
<th>Difference (billions US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>-2.0476</td>
<td>18.468</td>
<td>18.469</td>
<td>18.872</td>
<td>0.404</td>
</tr>
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country, which includes the bilateral quota (between Turkey and each of the other countries with which it trades) and transit quotas (imposed by the countries the goods travel through). Subsequently, a gravity model was developed to hypothesize the quota effect on Turkish exports. The results show that Turkey’s expected export loss (to the countries under consideration) in 2005–2014 was about US$13.60 billion, which represents 5.6% of the actual exports over that period. These results underline that regulatory reforms will provide overall benefits in terms of growth in trade and that the benefits will accrue to both the EU and Turkey.

The max-flow method proposed in this study is an original approach in a transport analysis context for predicting the effect of both bilateral and transit quotas (namely aggregate quotas) simultaneously. The results showed that Turkey cannot use the overall bilateral quota for some of the European countries because of the transit quotas applied by other countries on Turkey. It is especially significant that the countries that do not actually have any bilateral quotas with Turkey are restricted by the transit quotas imposed by other countries.

Although the aggregate quotas resulting from the max-flow method were different from the bilateral quotas, the quota effects on exports, which were estimated using the gravity model, were not significantly different from the ones obtained by Ülengin et al. (2015), where merely the bilateral quotas were considered. This shows that the bilateral quotas are the ones that have the main impact on exports, while the impact of transit quotas is rather marginal. Therefore, the abolition of only bilateral quotas rather than a full liberalization, which would involve the abolition of both bilateral and transit quotas, would be enough to increase trade.

An important caveat is that given that the present study focuses on the effects of quotas on Turkey’s exports by road transport only, the results ignore losses in Turkish exports by other modes. Furthermore, data from Eurostat show that chemicals, food, wood products, basic metals, and machinery exports from the EU to Turkey are very important, as are iron, textiles, mechanical parts, and machinery exports from Turkey to the EU (Pastori et al., 2014). Future research could analyze the loss in trade separately for these specific sectors. In fact, for some of these sectors, such as textiles, food, and chemicals, it may not be appropriate to shift from road to other modes of transport such as sea or rail due to the products’ characteristics. Therefore, the loss for these specific industries may be even more significant than what the estimates in this study suggest. However, for some other export goods, it may be possible to make a modal shift from road to other modes such as sea, rail, air, or inter-modal transport. However, such a shift could result in higher costs and/or lower customer satisfaction. Future studies can include analyses of the effects of quotas on the transport costs, lead times, and total exports.

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References