Intercity Trade Networks in Turkey: Shocks and Spillovers

ALPER DUMAN

May 2, 2016

Abstract

Intercity trade can be considered as a network. This trade network can be represented as a directed, weighted, incomplete, and asymmetric graph in which each city is a node and the bilateral trade links are the edges. The network is directed as each city is unlikely to trade at equal amounts from each other. The network is weighted because all links reflect some value of payment that is different for each city and each flow. The network is incomplete as not all cities in Turkey are connected with each other through trade. Finally, the network is asymmetric because for most cities customer partners (out-links) differs from the number of supplier partners (in-links). The ministry of Science, Technology and Industry provides intercity trade data for the year 2014. First we construct the intercity trade network derived from the data. Second we follow, Kireyev and Leonidev (2015) method to model and trace the network spillovers of a given shock (i.e. conflict with Russia or military operations in the South East of Turkey) on the overall income and intercity trade volume.

JEL Codes: C45, F14, F41, F42, F47
Keywords: Networks, Shocks, Spillovers, Trade

1 Introduction

Despite the globalization process national economies continue to be the dominant venues for the incomes of the majority of citizens. The importance of internal markets for national economies can not be over-exaggerated. Most of commodity and service flows that constitute the GDP of an economy run through internal domestic markets.

On a greater scale national economies have a similar structure with the international trade markets. As the multinational firms pick various countries for their subsidiaries, national firms locate the affiliated enterprises across cities. Both as input providers and output producers these firms supply the bulk of commodities and services in a given national economy.

International trade is based on flows across countries. Recent studies underline the fact that almost half of all international trade is intra-firm based on the coordination of the giant multinationals such as GM or Exxon. Similarly, inter-city trade occurs mostly through transactions among enterprises. There are mainly two channels: (I) Intra firm and (2) Inter firm. In contrast to the international trade, data concerning these channels are scarce.

Intercity trade can be considered as a network. This trade network can be represented as a directed, weighted, incomplete, and asymmetric graph in which each city is a node and the bilateral trade links are the edges. The network is directed as each city is unlikely to trade at equal amounts from each other. The network is weighted because all links reflect some value of payment that is different for each city and each flow. The network is incomplete as not all cities in Turkey are connected with each other through trade. Finally, the network is asymmetric because for most cities customer partners (out-links) differs from the number of supplier partners (in-links).

In Turkey, The Ministry of Science, Technology and Industry provides intercity trade data for the year 2014 [1].

First we construct the intercity trade network derived from the data for the year 2014. Second, we analyse the network. Third, we follow, Kireyev and Leonidev (2015) method to model and trace the network spillovers of a given shock (i.e. conflict with Russia) on the overall income and intercity trade volume.

The main contribution of this paper is its employment of network approach on inter-city trade flows. Although network analysis has been widely used for international trade, such a perspective is missing for domestic trade. Apart from enabling us to visualize the trade flows and make the most important agents (countries, cities or firms) visible, network analysis helps us to systematically examine the diffusion and spillovers of an initial shock through the intercity trade network. In this paper we find that the overall network effect (covering not only the first-round but all-round spillovers) can be twice as large as the direct effect. For example, %50 drop in incomes of ten cities in the South East region due to Kurdish conflict or Russian trade loss will directly reduce the total inter-city trade by 13.85 billion TL whereas the total network effect covering all rounds of network spillovers will be 137.87 billion TL.

International trade theory and empirical analysis have benefited substantially from the network approach as this method provides new tools and important ideas. For example, international trade has moved on simple gravitational models to more sophisticated weighted and directed network models in which not only the bilateral links but overall network configurations matter.

This paper is the first paper on both inter-city trade flows and on Turkey. In the second section we briefly discuss the related literature. In the third section, we explain the data source and summarize the data. Fourth section is devoted to the basic network analysis applied to the inter-city sales network data. The fifth

[1] http://gbs.sanayi.gov.tr/Raporlar.aspx

section covers the model of spillovers and the results of simulations in different scenarios. The final section is a discussion of the results and the suggestions with regards to further research. We hope that this paper can initiate a new research agenda for Turkey.

2 Related Literature

Network analysis has become a major framework in the analysis of growth performances of firms, sectors and economies in the last decade or so. Aggregate effects based on idiosyncratic shocks over firm networks have been studied (see Gabaix (2011) [4]). Carvalho (2014) [1] links firm level connections to sectoral effects and derive results for aggregate economy based on US data.

The links between input-output networks and aggregate outcomes have been thoroughly examined by Acemoğlu et. al. (2015) [2]. Considering both supply shocks and import demand shock,. they find that quantitatively, the network-based propagation is larger than the direct effects of the shocks. Their results suggest that the transmission of various different types of shocks through economic networks and industry interlinkages could have first-order implications for the macroeconomy.

Network analysis of international trade has also been widely employed. For instance Fagiolo and Mastrorillo(2014) [3] have linked global migration flows to the structure of international trade networks.

The closest study is on international shocks and spillovers over international trade networks. by Kireyev and Leonidov (2015) [5]. They propose a method for assessing international spillovers from nominal demand shocks. It quantifies the impact of a shock in one country on all other countries. The paper underlines the fact that the network effects in shock spillovers can be substantial, comparable, and often exceed the initial shock.

3 Data and Descriptive Analysis

Network analysis requires network data. International trade network data have been available for a long time. However, intercity trade network data has been lacking. Fortunately we have the data currently.

In Turkey, MIST (Ministry of Science and Technology) collects information based on tax forms of about 3 million enterprises. The database covers majority of the enterprise space. There exists a threshold of 5000 TL for reporting the transaction in Forms Ba and Forms Bs, the forms contained by the database. Therefore, all the transactions are above this threshold. Place of Registry of the enterprise is critical. An enterprise operating in city Y can be officially registered in city X and hence trade flows will be assumed to be originating from city X rather than city Y.

Total intercity trade flows amount to approximately 2.5 trillion TL in 2014. The GDP of Turkey in the same year is 1.75 trillion TL. Intercity trade flows, although not matching value added flows one to one , have a certain relationship with the value added flows. The ratio of total trade flows to GDP is 2.5/1.75 that is 1.43 so we may argue that if trade flows decline 143 billion TL the GDP will go down by 100 billion TL.

There is substantial heterogeneity in trade flows. The following Table 1 illustrates the diversity of sales strength across cities.

Table 1: Total Sales in billion TL

	2013	2014
Min	0.086	0.10
Max	1050	1246
Median	3.94	4.30
Mean	26.8	31

The lowest sale is just 100 million TL in 2014. The median is 4.3 billion TL. However, the mean sale is much greater at 31 billion as İstanbul by itself contributes 1.24 trillion sales and hence raises the average.

Local city sales (loops) are very important. By local city sales or loops we mean firms registered in a given city selling their goods and services in the same city. Biggest loop weight is for İstanbul, that is %68 of İstanbul's sales target İstanbul based firms. The out-sales turn out to be significantly lower.

Table 2: Total Out Sales in billion TL

	2013	2014
Min	0.066	0.07
Max	364	426
Median	2.44	2.84
Mean	12.92	15.12

Both the median and mean of out-sales decline considerably once we take out own city sales.

The nominal growth in sales from 2013 to 2014 was about % 18 The out-sales nominal growth turned out to be % 17 Kütahya, Artvin and Kilis are among the star performers. However, this cities are small players as they their out-sales do not exceed 3 billion TL range.

İstanbul is also the biggest consumer. It is a complete hub for all cities. İstanbul consumes more than % 10 of total sales of almost all cities It acts as a wholesale trader. Probably, enterprises produce inputs for İstanbul based enterprises. As a local market İstanbul also accounts for almost % 20 of Turkish households.

A weak negative relationship between own-city sales and sales to İstanbul. Bigger home markets imply lower input production.

Figure 1: Sales Growth

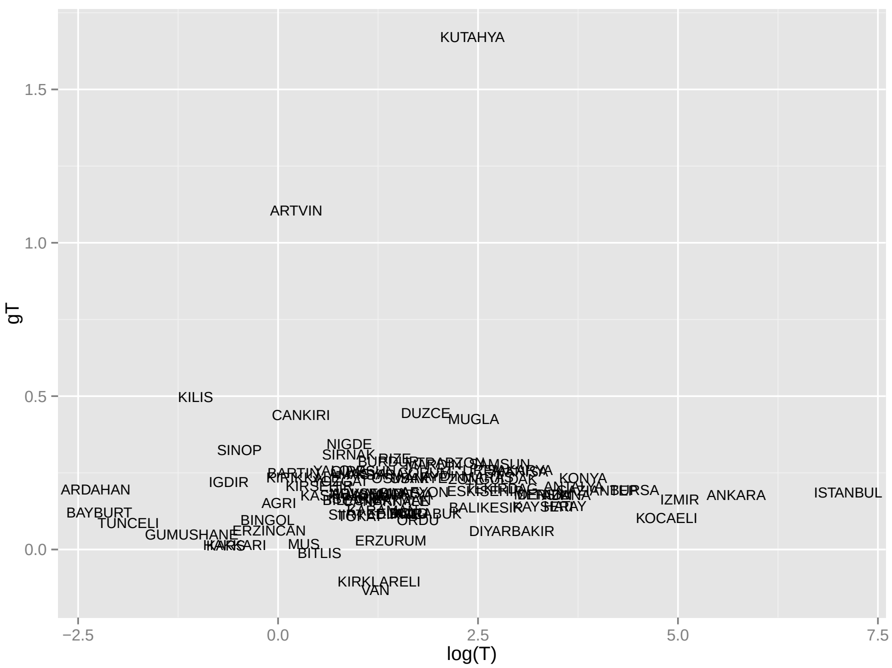
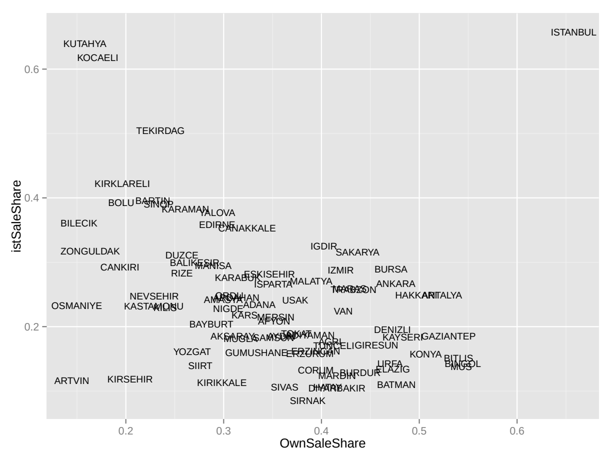


Figure 2: Own Sales and Sales to İstanbul



4 Network Analysis

Intercity trade can be considered as a network. This trade network can be represented as a directed, weighted, incomplete, and asymmetric graph in which each city is a node and the bilateral trade links are the edges. The network is weighted because all links reflect some value of payment that is different for each city and each flow. The network is asymmetric because for most cities customer partners (out-degree) differs from the number of supplier partners (in-degrees).

In order to simply illustrate the network in the weighted adjacency matrix form we pick the inter-city trade flows of the biggest five cities.

Table 3: Inter-city Flows among 5 Cities, in Billion TL

	ANKARA	BURSA	ISTANBUL	İZMİR	KOCAELİ
ANKARA	146.39	3.79	81.97	7.44	7.11
BURSA	4.42	40.66	24.98	2.00	2.30
İSTANBUL	89.93	29.29	819.90	39.89	28.46
İZMİR	6.83	2.53	43.79	63.81	1.63
KOCAELİ	7.00	3.35	79.60	3.22	22.07

The network approach takes the trade flows and converts it into a weighted adjacency matrix A, that is

$$A_{i,j} = \begin{bmatrix} a_{1,1} & a_{1,2} & \cdots & a_{1,n} \\ a_{2,1} & a_{2,2} & \cdots & a_{2,n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n,1} & a_{n,2} & \cdots & a_{n,n} \end{bmatrix}$$

As we have argued, the simplified network (network without loops) has a very high density. The following figure gives a glimpse of the dense weighted and directed nature of the network.

According to Figure 4, there are 81 vertices and 6272 edges. The density is 0.968. Diameter is only 2 as İstanbul acts as a central hub for all cities. Without the self-loops total edges decline by 81 and equal to 6191.

Most of cities' sales are small. We assume a cut-off level of 3 billion TL to

Figure 3: Intercity Trade Network 2014

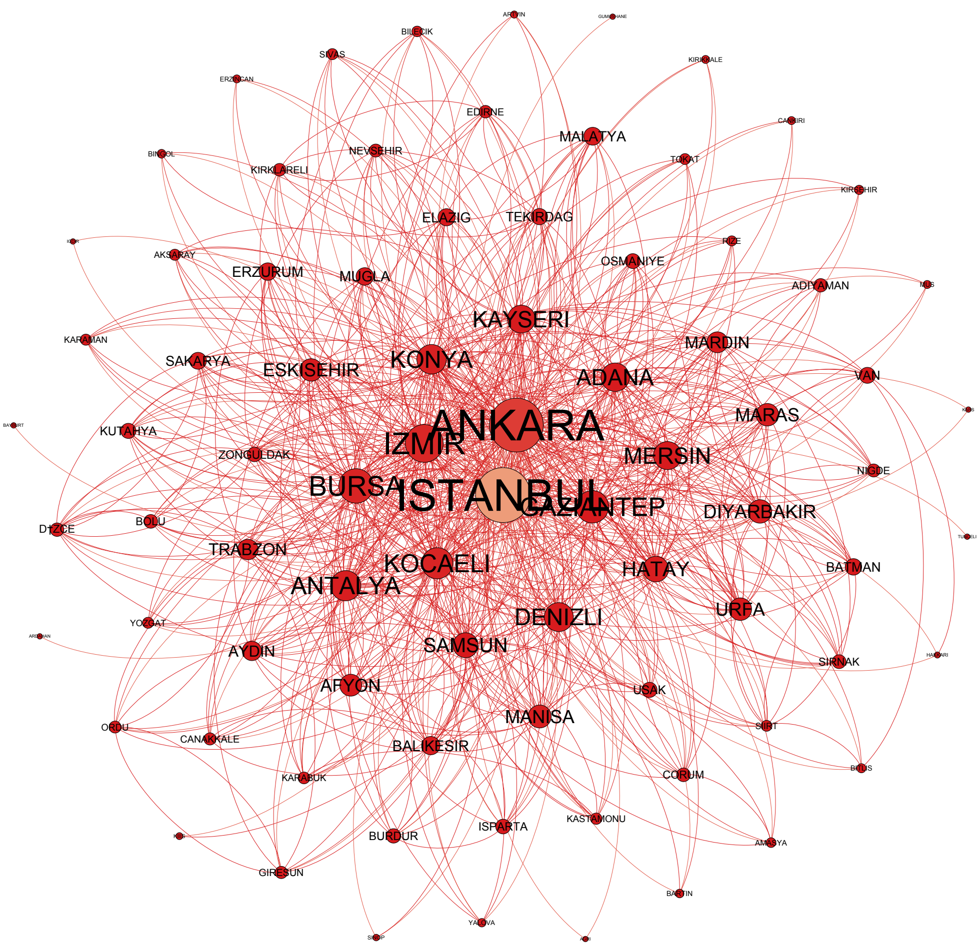
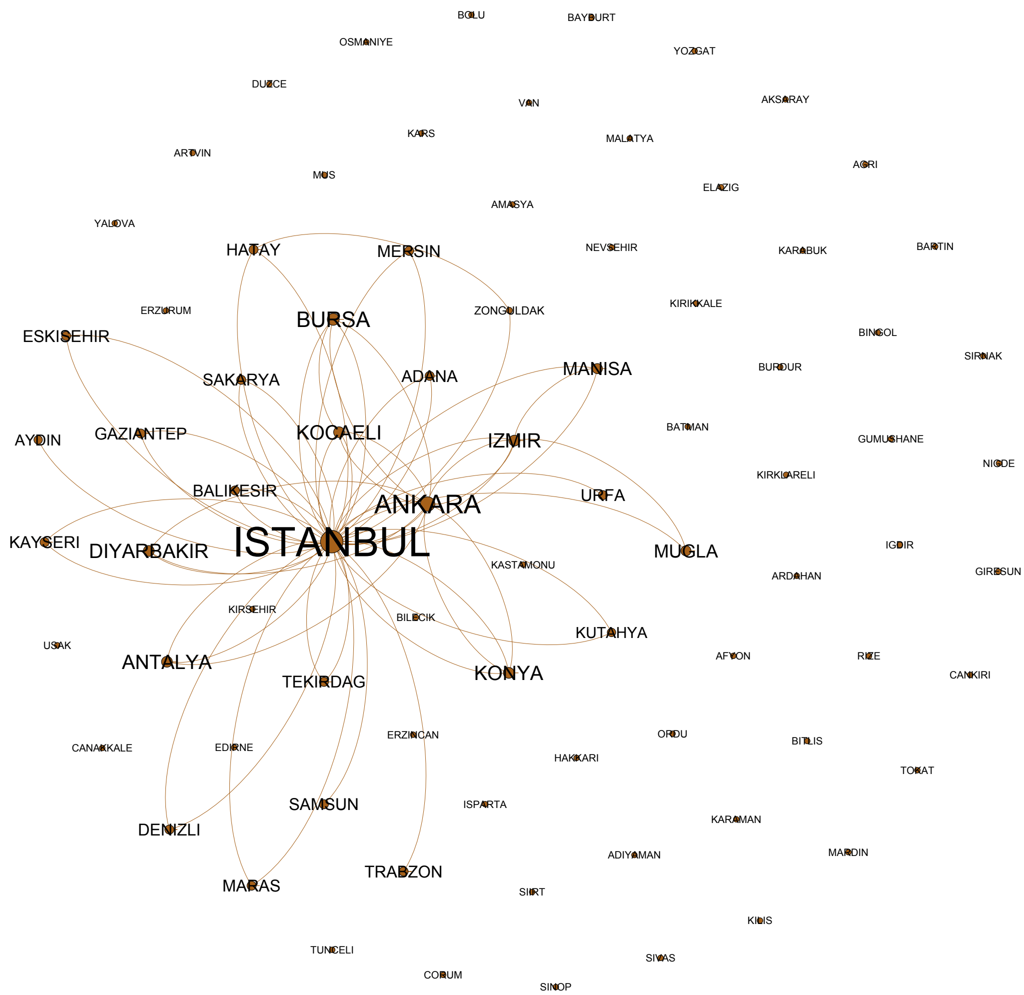


Figure 4: Intercity Trade Network, Trimmed Edges with Threshold of 3 Billion TL



focus on meaningful connections.

The outcome is a multi-star network in which İstanbul, Ankara and İzmir are the central nodes. Thus, apart from İstanbul, Ankara and İzmir also serve as hubs and authorities.

In the trimmed network in Figure 4, there remains only 21 cities with 83 edges. İstanbul's dominant position is related to its economic power. According to the last available regional GDP data, İstanbul produces % 27 of Turkish GDP. It is city in which most of the conglomerates are established. It acts as the main import and export port for the country. According to the eigenvector centrality measure its score is 5 times higher than the next city that is Ankara.

5 Shocks and Spillovers

Assume a negative shock on any city. Its purchases will be affected negatively. Assuming that its marginal propensity to consume is 1, the decline in nominal demand of the epicenter city is ΔY_i. It follows immediately that its purchases decline by ΔM_i.

The immediate neighbour cities will suffer. The initial shock will be distributed among its immediate neighbours according to their sales shares to the epicenter city. The variably lower income growth rate of the immediate trading partners, due to their declining sales, of the epicenter country will translate in a demand shock for their trading partners, which at this stage is not uniform but rather proportional to the decline in export revenue of each of the immediate partners at the first round. Assuming again the marginal propensity to consume at unity, demands of the epicenter country's first neighbors from their immediate neighbors should decline in proportion to the change in their sales revenue.

A sales-matrix where rows denote the sales of cities and columns denote the purchases of the cities is W_{ij}. The initial demand shock ΔM_i is distributed proportionally among suppliers to the epicenter country and by definition creates a vector of shocks to their sales revenue. The shock to sales revenue creates reduce their demand and creates a cascade of sales shocks in first neighbours $\Delta\overrightarrow{M_j}$. The key assumption on the spillover dynamics is that for some, but not for all countries, decline in sales revenue can lead to a drop in income and hence demand, contemporaneously or with a lag.

A negative purchasing power shock of an epicenter city will translate to sales shocks of the cities directly selling to the epicenter city. That is

$\Delta M_j = \sum_{i=1}^{n} \Delta w_{ij}$ where Δw_{ij} is the drop of sales of city i to city j. Naturally declines will be proportional to the city i's sales share in city j's total purchases.

$$\Delta w_{ij} = w_{ij}\frac{\Delta M_j}{M_j} \tag{1}$$

Consequently new inter-city sales matrix $\overrightarrow{W} = W - \Delta W$ will be obtained. The decline in sales revenue $\overrightarrow{S} = W\frac{\Delta\overrightarrow{M}}{M}$.

In some cities decline is sales revenue will lead to decline in purchases.

$$\frac{\Delta\overrightarrow{M_i}}{M_i} = \alpha_i + \beta_i(\frac{\Delta S_i}{S_i}) + \epsilon_i \tag{2}$$

Equivalently,

$$\Delta\overrightarrow{M_i} = M_i(1 - (1 - \frac{\Delta S_i}{S_i})^{\beta_i}) \tag{3}$$

Suppose there are three cities with a inter-city sales matrix

$$W_{ij} = \begin{bmatrix} 60 & 30 & 30 \\ 10 & 50 & 60 \\ 50 & 40 & 30 \end{bmatrix}$$

and suppose there are % 10 shocks to city 1 and 2, so that their purchases will decline by 12 units each. City 2 will lose 1 units of sales to city 1 and city 3 will lose 5 units of sales to city 1. Similarly City 1's sales to city 2 will go down by 3 units whereas city 3's sales to city 2 will be reduced by units.

$$\Delta w_{ij} = \begin{bmatrix} 6 & 3 & 0 \\ 1 & 5 & 0 \\ 5 & 4 & 0 \end{bmatrix}$$

Assume that sensitivities of each city's purchases to their sales β_i's are 0.5. That is if a city loses 4 units of sales then its purchases will decline by 2 units.

After the first-round effects, the new sales matrix will be

$$\overrightarrow{W_{ij}} = \begin{bmatrix} 54 & 27 & 30 \\ 9 & 45 & 60 \\ 45 & 36 & 30 \end{bmatrix}$$

Thus total first-round effects will be 24 units of decline in overall sales. However, once we take into account second-round and further spillover effects the total network effect will be much larger. Assume we have 50 rounds, then the result will be

$$W_{ij}^{t=50} = \begin{pmatrix} 49.67 & 25.27 & 27.74 & \\ 8.28 & 42.11 & 55.48 & \\ 41.39 & 33.69 & 27.74 & 0 \end{pmatrix}$$ Therefore overall network effect (decline in total sales) will be 48 units, the double of the first-round effects.

5.1 Shock Absorbing Scenarios

We assume that each city is homogeneous in terms of its dependence of sales on purchases. We take that sensitivity parameter, β, to be 0.5. If input purchases go down by 100, then the final product sales will decline by 50 for all cities. The decline however will be distributed across cities according to their weights as customers.

Our first result is due to a % 20 shock on İstanbul, so that İstanbul's purchases decline by % 20. The immediate effect (direct effect) is a decline of overall sales by 239.7 billion TL, that is % 10 reduction. However, if all the indirect effects are considered the total decline due to network spillovers amounts to 473 billion TL, %18 almost double of the immediate effect.

Our second result concerns a decline of % 10 for 10 cities suspected to be suffering from the Russian conflict. We assume that the sensitivity parameter, β, is still 0.5. The immediate effect is 12.9 billion TL, that is only % 0.5 compared to the overall decline due to all network effects which is 28 billion TL, % 1.

5.2 Shock Magnifying Scenarios

We vary the shocks to İstanbul's income, hence its total purchases from other cities decline % 5 to % 23 and simultaneously change the sensitivity parameter β from 0.5. to 0.95. The non-linear distribution of total network effects are illustrated in the Figure 5 below.

We vary the shocks to the income, hence purchases of the ten cities in the South East Turkey from % 5 to % 50 and simultaneously change the sensitivity parameter β from 0.5. to 0.95. The non-linear distribution of total network effects are illustrated in the Figure 6 below.

The total network effect derived from %50 shock to the incomes of the ten cities from the South East region at its peak (1200 billion TL) is far less than the network effect due to a % 23 shock to İstanbul's income.

This counter-intuitive result can be explained by the hub-authority configuration of the inter-city sales network. As İstanbul is the most central hub and

Figure 5: Loss in Total Trade due to Shocks to İstanbul

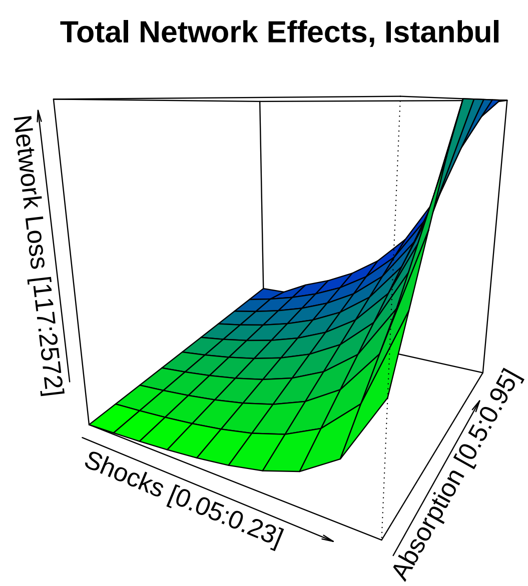
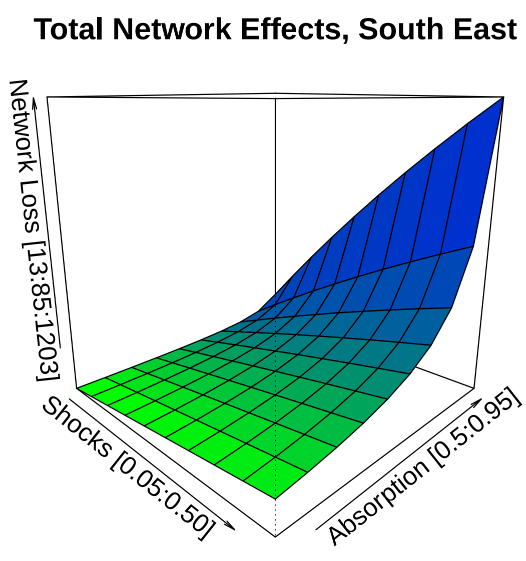


Figure 6: Loss in Total Trade due to Shocks to 10 South East Cities



authority in the network any shock to its purchases or sales will be reflected on the overall network, whereas the ten cities from the South East region are largely peripheral cities thus their connections matter much less.

6 Discussion and Conclusion

Inter-city sales are crucial for the functioning of a national economy. There are scant studies on the structure of inter-city sales. A network perspective offers a unique angle in order to take second-round and further round effects of a given shock into account. In most cases these effects outweigh the first-round (direct) effects.

The propagation of shocks depends on the sensitivities of the cities. One important limit of the current study is the unavailability of the data to estimate these sensitivity coefficients

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