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Research of Internal Migration by Compartment Models: The Case of Erzurum-Bursa

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Abstract

Migration, which consists of quite complex components, is a concept subjected in many scientific research areas. Internal migration refers a migration occurred in the boundaries of a country. Migration in Turkey usually tends to be directed towards larger and more industrialized provinces. Nevertheless, there exists a density on the direction of certain provinces such as migration from Erzurum to Bursa. Nowadays, the proceeding of the migration flows between Erzurum and Bursa since 1980's is another point which necessitates to be examined. The purpose of this study is to investigate the migration between Erzurum and Bursa by using compartment models in the 1980-2015 period. The paper performs compartment models to explain the changes of migration flows in terms of gross domestic product, unemployment rate, and time. According to the results, there is a significant increase in migration from Erzurum to Bursa depending on the time of migration and unemployment rate. Nonetheless, there is no significant change related with the gross domestic product. In addition, the study has shown that migration increases as unemployment rate decreases; but there is no significant change in migration depending on time and gross domestic product from Bursa to Erzurum.

Key words: *Internal migration, Compartmental Model, Nonlinear Model, Bursa, Erzurum*

JEL classification: *R23, C13, C36, Q56*

Introduction

The extent of migration concept is seen clearly when statistical data is examined. There is two times more increase in the number of immigrants from 1975 to 2000 compared to previous periods. When Turkish ABPRS (Address Based Population Registration System of Turkey) is considered, there were 19.544.539 people who migrated between 2008 and 2015, which corresponds to 25% of the total population number of Turkey. This shows that there is a remarkable increase in internal migration movements in latest years. Therefore, it is concluded that the factors cause internal migration are increased.

In migration, the most vital aspect is neglected, which is human itself. However, the most critical problems arise from the motion of people. Therefore, people, who are the center of the issue should be considered with the migration together. Social and cultural values are not measurable. Hence, internal migration concept can be analyzed by using statistical data. The statistical data obtained by two-way transfers can be made worthwhile by using valid and purposeful statistical analysis methods. Subsequently, necessary inferences can be made by interpreting the results.

Although the direction of intensity of migration seems like a straight line, it may not be consistent to claim that it will stay in the same direction. The meaning of flow in some large cities should be elaborated. Economic reasons cannot be the only cause of immigration to the cities like İstanbul, İzmir, Bursa, Samsun, Mersin, Adana and Antalya, but it is clear that they are some of the most important ones.

With approximately 80 million citizens, Turkey increased its population to six times more within the last century. Internal migration, which started after 1950's affected Bursa in 1960's for the first time; and this effect accelerated in 1980's. Bursa is the sixth most immigrated city from other provinces of Turkey. This situation caused the nature of the city to change in many aspect, especially in terms of economic, cultural, and social issues. Erzurum is one of the most effective cities in the change of Bursa.

The purpose of this study is to examine the migration between Erzurum and Bursa depending on the economic indicators, which are unemployment rate and gross domestic product per capita, in addition to time factor. In this manner, the study consists of five main parts. In the first section, the migration between Erzurum and Bursa considered according to the statistical data. In the second section, literature review regarding the subject is presented. In the third section, the compartment systems that take part in research are defined and their specifications are mentioned. In the fourth section, the data used is explained and the results are revealed. In the final section, the study is concluded by interpreting the revealed results.

Migration of Erzurum-Bursa

It is the fact that the most immigrant cities in Turkey are the large cities, such as İstanbul, İzmir and Ankara. Beside this fact, the cities, which are affected by the pull effect of the large cities, allow immigrants quite much. Bursa is one of the most important cities in this situation. Bursa is one of the fast growing cities, which have attractive specifications with its economic and social structure in addition to its location. The pulling effects of Bursa increased especially because of its industry and industrial agriculture level. In addition, the automotive industry and its subsidiary businesses increased employment level. Furthermore, Bursa is one of the important cities in forestry and furniture sector in Turkey. Specifically, the pioneer businesses of furniture sector in Turkey are located in İnegöl town of Bursa.

Bursa allows immigrants from the north-east provinces of Turkey more intensely. Obviously, the extensive employment opportunities are the main reasons of migration. However, the reason of preferring Bursa instead of the larger cities as İstanbul, İzmir, Ankara for the immigrants who migrated from north-east Turkey is the characteristics of geography and climate of Bursa. The nature of Bursa is similar to the nature of north east provinces of Turkey. This leads immigrants to feel as they are in their homelands. Moreover, as most of the people from north-east Turkey are traditionalist, so, they tend to prefer Bursa as its local culture is more similar to their own culture when compared to large cities. Bahçalı (2015) stated that the common reasons of migration from north-east provinces is harsh geographic conditions, socio-cultural specifications, and social relations, in addition to economic based issues. There are strong connections between the immigration reasons from the mentioned provinces and migration reasons to Bursa. It is stated that high life standards, geographic conditions, socio-cultural structure, and similarities to north-east provinces are effective in decision making. Kesgingöz and Dilek (2016) stated that an increase in productivity and development differences between regions are important reasons of migration. Furthermore, it is concluded that social network is effective for migrants from east Black Sea provinces to adapt in short time. This situation helped people of Bursa province to keep their own cultural identity.

As it is clear in Table 1 while 80 percent of population of Bursa is registered in Bursa in 1965, approximately 54 percent of population registered in 2015. Additionally, only 55 percent of birth is registered in Bursa by 2015. On the other hand, it is noticeable that cities such as, Erzurum, Artvin, Samsun have more population in Bursa, when compared to other cities. However, people who registered in Erzurum, Artvin, Samsun, and are residing in Bursa are more than people whose birth places are the stated cities, and who are residing in Bursa. The main reason of this circumstance is the children of migrants from these cities were born in Bursa.

Table 1: Bursa Population by Registration and Birth Place – 2015

2015	Bursa Population by Registered City (%)	Bursa Population by Birth Place (%)
Bursa	53,97	55,55
Erzurum	4,56	3,40
Samsun	2,91	2,13
Muş	2,68	1,86
Artvin	2,33	1,75
Balıkesir	1,85	1,40
Trabzon	1,67	1,28
Giresun	1,29	0,84
Diyarbakır	1,18	0,90
Ağrı	1,05	0,82
Kars	1,02	0,71
Ardahan	1,02	0,84
Yozgat	0,99	0,68
Kütahya	0,88	0,79

Note: *Formed based on the data of Turkish ABPRS (Address Based Population Registration System of Turkey)*

As seen on the table, People of Erzurum has an important dominancy in Bursa. Table 2 shows the percentage of migrants from Erzurum in total registered population of Bursa between the years 2007 and 2015. According to the data on Table 2, the population of Bursa is steadily increased by years, whereas the percentage of local people of Bursa steadily decreased. This situation is an indicator that the population of Bursa arises from immigrants. Another remarkable situation is people living in Bursa but registered in Erzurum gradually raised from 3,97 to 4,56.

Table 2: Population of Bursa and the proportion of Erzurum by Registered City - 2007-2015

YEARS	Population of Bursa		Registered in Bursa			Registered in Erzurum		
	Total	(%) Change	Total	Proportion in Bursa Population	(%) Change	Total	Proportion in Bursa Population	(%) Change
2007	2.439.876	0	1.458.123	60,05	0	96.295	3,97	0
2008	2.507.963	+2,79	1.468.980	58,86	-1,19	102.203	4,10	+0,13
2009	2.550.645	+1,70	1.477.097	58,25	-0,61	105.782	4,17	+0,07
2010	2.605.495	+2,15	1.494.993	57,70	-0,55	108.922	4,20	+0,03
2011	2.652.126	+1,79	1.501.017	56,86	-0,84	112.319	4,25	+0,05
2012	2.688.171	+1,36	1.501.760	56,15	-0,71	115.766	4,33	+0,08
2013	2.740.970	+1,96	1.507.806	55,47	-0,68	119.493	4,40	+0,07
2014	2.787.539	+1,70	1.512.721	54,74	-0,73	124.206	4,49	+0,09
2015	2.842.547	+1,97	1.518.571	53,97	-0,77	128.279	4,56	+0,07

Note: *Formed based on the data of Turkish ABPRS (Address Based Population Registration System of Turkey)*

There is numerical dominancy of people migrated from Erzurum in Bursa when compared to other cities of Turkey. The effect of Erzurum is perceivable in many areas like education, healthcare, politics, and commercial activities as there are more than 30 years of history that Erzurum started to influence Bursa.

Literature Review

The motion of people has become one of the most important aspects of life since the beginning of the history. After causing creation of national states and being a core element for international political system, the motion of people gains new meanings in political, economic and social aspects (Sallan Gül, 2002). Studies are usually intensified on the reasons of migration. In his study, Friedlander (1992) points out the inequities in economic and life standards between provinces as a main reason of internal migration. In addition, he observed that there is a motion towards the provinces, which employment opportunities are better. De Jong et al. (2000) explains taking decision to migrate in a model. In this model, it is stated that human capital, household resources, characteristics of society affect the action of migration; also, these factors affect if the migrants stay in destination province permanently. Doh (1984) claimed that the reason of migration is people in rural areas migrate, by leaving their profitless businesses, to urban areas, where modern sector is dominant. Additionally, he examined the relations between distance, employment structure, rural working conditions, and socio-economic factors by correlation analysis. It is concluded that there is a correlation between increase in agricultural and non- agricultural employment levels and the amount of immigration of provinces.

Another field that studies are intensely based on is gender and socio-economic conditions. Kulu and Billari (2004) concluded that the tendency of migration is higher for male individuals, and for the individuals excluded in labor force and unemployed, the tendency of migration is negative and high by analyzing settlement changes between 1989 and 1995 of 9608 people, from 15 to 73 years old included in the 1995 Estonia labor force survey. In addition, it is stated that as the education level increases, the tendency to migrate increases as well; on the other hand, tendency of migration decreases in older age groups. Molloy, Smith ve Wozniak (2011), asserted that there is a significant decrease in internal migration, and there is a differences between various demographic and socio-economic groups in the decrease of migration. In his study that focuses on effects of land ownership on international and internal migration in Mexico and internal migration in Thailand, VanWey (2005) claims that land ownership affects internal migration of males. Moreover, it is clarified that the size of land is negatively linked with the migration of small land owners, whereas there is a positive link between the size of land and migration. Jacobsen and Levin (2000) studied the effects of internal migration on the relative economic status of men and women, and concluded that decision to migrate is consistent with household preference model; beside this, the opportunities to migrate has very little effect on the earnings of single and married people.

The concept of migration, which refers motion of population that changes the structure of society in terms of economic, political and cultural, is a dynamic progress that should be considered with its reasons and results (Karabulut and Polat, 2007). As the concept of migration has many aspects, it is examined by various disciplines, such as anthropology Pang and Bakholdina, 2008; Kempny, 2012), sociology (Ruggiero, 1997; Lee, 2005), geography (Withers, 2010; Sharma, 2012), history (Rystad, 1992; Taylor, 1997), statistic (Mastromarco and Woitek, 2007, Abel, 2009; Nasir and Tahir, 2011), economics (Guardia and Pichelmann, 2006; McHale, 2007), international relations (Mitchell, 1989; Benam, 2011; Gui et al., 2012), political sciences (Miguet, 2008; Salucci, 2009), public administration (Andrews et al., 2012), labor economics (Dustmann, 1997; Mendola and Carletto, 2012), and business administration (Syed, 2008; Gimba and Kumshe, 2012). This multidimensional structure brings a multidisciplinary aspect (Çelik, 2012).

Whereas most of the studies on migration are qualitative, the number of quantitative studies that apply statistical data are in increase in recent years. Gaston and Nelson (2011) examined the relationship of migration with income and commercial activity by applying econometrics. As compartment models can be applied to systems that transitions are available, Grant and colleagues (1991) stated ecological migration as a Markov process and analyzed compartment models. Ma and Cao (2013), analyzed the migration between rural and urban areas by applying compartment models in their studies. They examined differences between provinces by using the compartment models. In the study, it is stated that compartmental approach both helps to establish a model, described by a completely deterministic system of dynamic equation and to use simpler mathematical instrument.

The first remarkable researches on compartment models was done by Sheppard (1962) and Rescigno and Segre (1966). Today, its usage is quite usual (Seber and Wild, 2003). As physiology, compartment models are applied in disciplines such as medicine, chemistry, biology, ecology, and economics. Atkins (1969) examined biological systems by applying compartment systems. Jacquez (1972) asserted the mathematical theory of compartment systems for physiologists and ecologists. Wagner (1975) applied compartment models on pharmacokinetics. Kalbfleisch and Lawless (1985) examined the probability of becoming sick of both healthy and sick individuals by applying compartment models, and defined the transitions in compartment models with Markov process. Cobelli and his colleagues (1986) tried to prove the benefits of using compartment analysis in the disciplines like economics and human geography. Therefore, they considered macroeconomic Philips model as a compartment model.

Data and Methodology

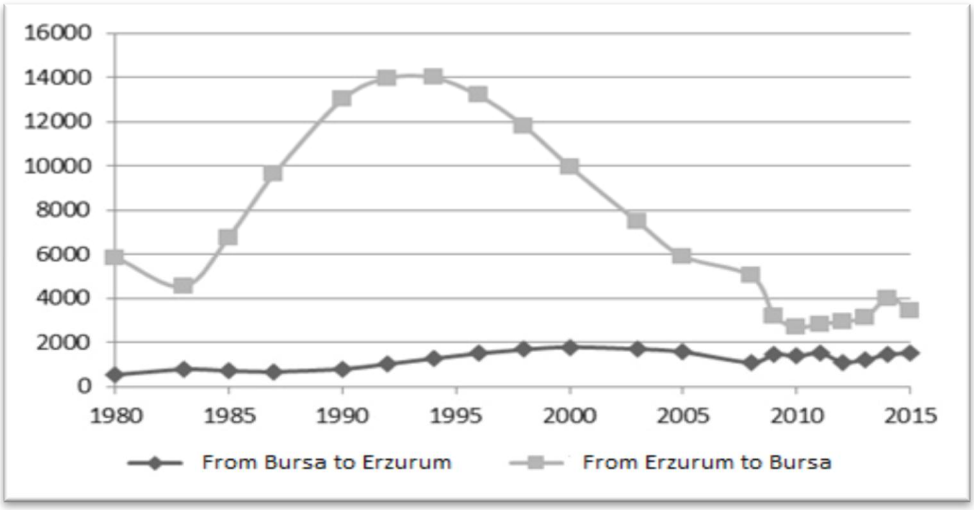
Different data resources are used in this study, which exposing periodical development, direction of flow and distribution, in addition to current situation of migration between Bursa and Erzurum is aimed. The data resources include migration statistics, published by Turkish Government State Institution (DİE), migration data regarding permanent residency of general population census, and the data obtained from address based population registration system. The data regarding the amount of migration is obtained from the publications of Internal Migration According to the Permanent Residency (DİE, 1985, 1989 ve 1997), and Migration Statistics (TÜİK, 2005) as five years of periods between 1975 and 2000 (except 1990-1995 period) from Bursa to Erzurum and Erzurum to Bursa. In addition the data regarding the years between 2007 and 2015 is acquired from Turkish Statistical Institute (TÜİK) Address Based Population Registration System (ABPRS), which published after 2007.

The statistical data that covers the period until 2000 is obtained from general population census results. There was 14 general population censuses until 2000, as first of them was 1927. However, information in relation to migration was included in the general population censuses in 1980, 1985, 1990 and 2000. Except the mentioned years, there are no other official data available. Therefore, migration information in regard to Erzurum and Bursa migration in the years of 1986, 1988, 1992, 1994, 1996, 1998, 2003, 2005 is obtained by applying third degree polynomial, with interpolation method in order to use in analyzes.

In addition to internal migration statistics, the data of gross domestic products per capita (GDPC), which published by TÜİK, and one of the independent variables of this study is acquired as a dollar for the years between 1980-1997 by using 1987=100 based GSMH series. As for the period from 1998 and later, population forecast and projections for 1986-2023 mid-year are used, so gross domestic product per capita was revised for 1998.

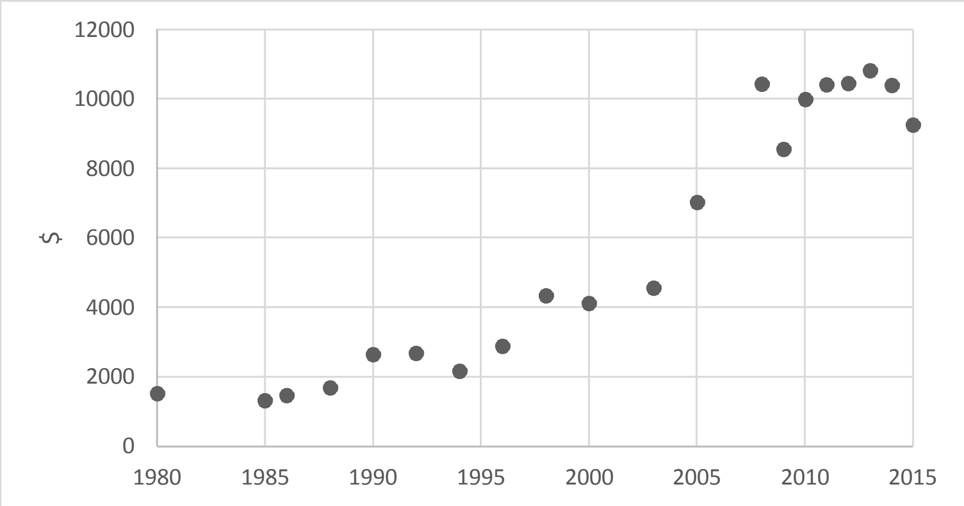
Another independent variable is unemployment levels of Turkey. The data before 2008 was formed according to "Household Labor Force Surveys, published by DİE (State Statistic Institute) city Indicators. The data regarding 2008 and later acquired by TÜİK Labor Force Statistics tables.

Graphic 1. shows the change in the numbers of migration from Erzurum to Bursa and from Bursa to Erzurum based on the years. It is obvious that the migration from Erzurum to Bursa is much more than the migration from Bursa to Erzurum in usual. In 2000, an outlier data in migration from Bursa to Erzurum is seen in 2000, however, the same situation is recognized in 2010 from Erzurum to Bursa. In general, migrations from Erzurum to Bursa continued to increase gradually. Nevertheless, differences occurred in migrations from Bursa to Erzurum, as it increased until 1990, but fluctuated after 2008. The data values before 2000 are higher when compared with the values of 2008 and later since they indicate total migration number of five years. Therefore, those values aren't included in arithmetic average as the values may be misleading.



Graph 1. Migration from Erzurum to Bursa and Bursa to Erzurum
Source: *General Population Census, ABPRS*

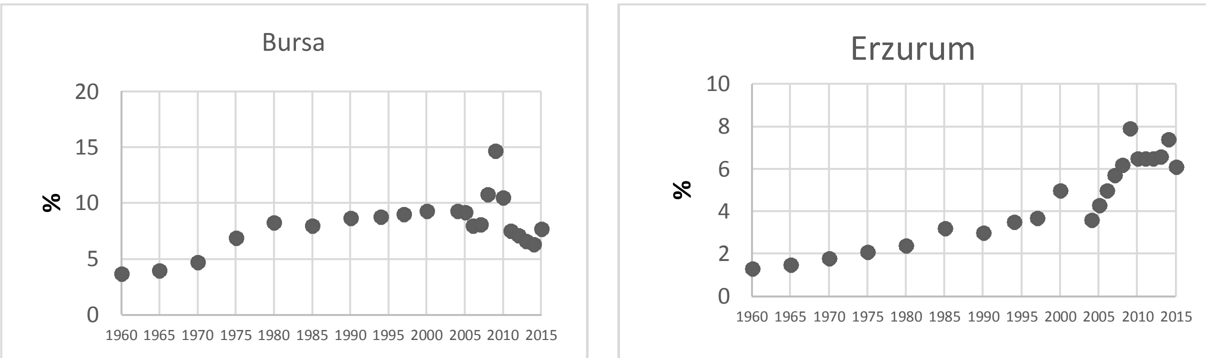
Graphic 2 shows gross domestic pro proceeds ducts per capita as dollars. In 2008 there is a remarkable increase. It can be seen that the increase continued until 2015.



Graph 2. GDP per capita in Turkey (%)

Note: *TÜİK, National Accounts, GDP with Spending Method*

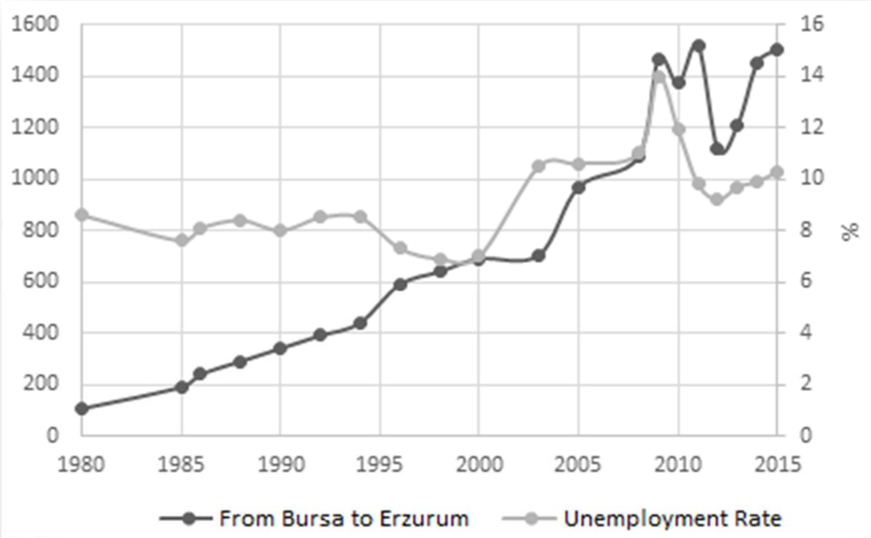
Graph 3 presents the change in unemployment levels in Erzurum and Bursa based on the years. Although unemployment levels are low in Erzurum, it is obvious that there is a gradual increase. Furthermore, it is remarkable that there is a sharp increase in 2000, when compared to previous years. Even the increase became steadier in later years, it continue to rise gradually. In addition, it is seen that the unemployment level in Bursa is in a downward trend even though it is higher than Erzurum. The data will not be included in analysis, but it will take part in conclusion section.



Graph 3. Erzurum-Bursa in Proportion to Unemployment Level

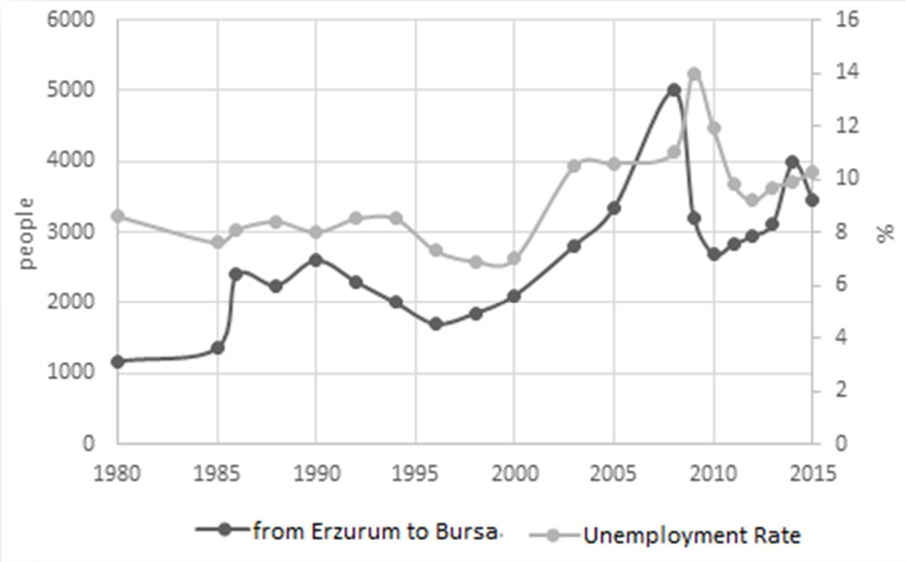
Sources*: DIE Household And Labor Force Survey Results, DPT Economics And Social Indicators, TUIK Household Labor Force Survey*

In graph 4, the number of migration from Bursa to Erzurum is seen. As the graph shows, there is a decrease in unemployment level until 2000, while the migration from Bursa to Erzurum gradually increased. After 2000, it is obvious that unemployment level and migration continued in parallel.



Graph 4. Migration from Bursa to Erzurum in Comparison with Unemployment Rate

Graph 5 represents the amount of migration from Erzurum to Bursa in comparison with the unemployment rate. As it is clear on the graph, unemployment rate fell until 2000, and the migration from Bursa to Erzurum continued in parallel with the unemployment rate between the years 1980 and 2015.



Graph 5. Migration from Erzurum to Bursa in Comparison with Unemployment Rate

When all the data sets and relations between them are examined, it is seen that the amount of migration from Erzurum to Bursa and Bursa to Erzurum increases reciprocally, depending on the unemployment rate. Additionally, it is obvious the amount of gross domestic product per capita is increased steadily between the years 1980 and 2015, however, the effect of this situation on migration is limited.

Modelling

A compartment system is designed by using the data from 1980 to 2015 for the migration transitions between Erzurum and Bursa. It is a system that includes reciprocal population transitions, and outflow of population. Multivariate nonlinear models are used in the solution of compartment systems. They are the revised versions of multivariate nonlinear models proposed by Galant (1987), and are solved in MatLab software, by coding an algorithm based on the obtained models.

In the designed compartment system, it is assumed that reciprocal transitions are subject to Markov process. In this case, at time t, the population numbers in compartments, as

$n_1(t), n_2(t)$ are the variables, the following model is determined:

$$\begin{bmatrix} n_1(t) \\ n_2(t) \end{bmatrix} = \begin{bmatrix} E[n_1(t)] \\ E[n_2(t)] \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \end{bmatrix} \tag{1}$$

The main purpose is to observe the current population numbers in $n_1(t_i), n_2(t_i)$, i=1,2,...,n, in the compartments at $t_1, t_2, \ldots, t_n$, and estimate the system parameters.

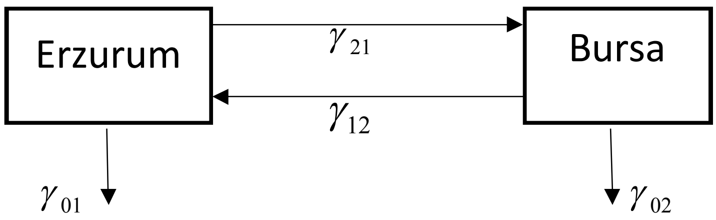


Figure 1. Erzurum-Bursa Compartment System

In Figure 8, reciprocal migration trends between Erzurum and Bursa are analyzed by the model suggested by Genç (1997).

Thus, for j = 0,1,2 and k = 0,1,2

$$\alpha_{00}(t)=0,\alpha_{01}(t)=\gamma_{01}\qquad,\alpha_{02}(t)=\gamma_{02}$$
$$\alpha_{10}(t)=0,\alpha_{11}(t)=-(\gamma_{21}+\gamma_{01}),\alpha_{12}(t)=\gamma_{12}$$
$$\alpha_{20}(t)=0,\alpha_{21}(t)=\gamma_{21}\qquad,\alpha_{22}(t)=-(\gamma_{12}+\gamma_{02})$$

So, instantaneous transfer-rate matrix

$$A=\begin{bmatrix}0 & \gamma_{01} & \gamma_{02}\\ 0 & -(\gamma_{21}+\gamma_{01}) & \gamma_{12}\\ 0 & \gamma_{21} & -(\gamma_{12}+\gamma_{02})\end{bmatrix}$$

written as

$$\mathrm{A}\;=\begin{bmatrix}0 & \underline{u}'\\ 0 & A^*\end{bmatrix}\tag{2}$$

so,

$$A^*=\begin{bmatrix}-(\gamma_{21}+\gamma_{01}) & \gamma_{12}\\ \gamma_{21} & -(\gamma_{12}+\gamma_{02})\end{bmatrix}\quad,\quad \underline{u}=\begin{bmatrix}\gamma_{01}\\ \gamma_{02}\end{bmatrix}$$

depending on $\underline{n}_0$ initial value,

$$E=\begin{bmatrix}n_0(t)\\ n_1(t)\\ n_2(t)\end{bmatrix}=e^{At}\begin{bmatrix}n_0(0)\\ n_1(0)\\ n_2(0)\end{bmatrix}=e^{\begin{bmatrix}0 & \underline{u}'\\ 0 & A^*\end{bmatrix}t}\begin{bmatrix}n_0(0)\\ n_1(0)\\ n_2(0)\end{bmatrix}\tag{3}$$

becomes

$$E\begin{bmatrix}n_1(t)\\ n_2(t)\end{bmatrix}=e^{A^*t}\begin{bmatrix}n_1(0)\\ n_2(0)\end{bmatrix}\tag{4}$$

When Spectral decomposition of A^* is

$$A^*=S\Lambda S^{-1}\tag{5}$$

the matrix

$$e^{A^*t}=\mathrm{I}+\frac{t}{1!}A^*+\frac{t^2}{2!}\left(A^*\right)^2+\ldots$$

can be written as (6)

$$e^{A^* t} = S e^{\Lambda t} S^{-1} \tag{7}$$

Here, the matrix Λ is a matrix of the eigenvalues of A^*. S is a matrix of eigenvectors, corresponding to the eigenvalues of A^*.

Characteristic polynomial of A^* is

$$\left| A^* - \lambda \mathrm{I} \right| = (\lambda + \gamma_{01} + \gamma_{21})(\lambda + \gamma_{12} + \gamma_{02}) - \gamma_{12}\gamma_{21} \tag{8}$$

and where

$$\lambda^2 + (\gamma_{01} + \gamma_{21} + \gamma_{02} + \gamma_{12})\lambda + \gamma_{01}\gamma_{02} + \gamma_{01}\gamma_{12} + \gamma_{21}\gamma_{02} = 0 \tag{9}$$

$$\Delta = (\gamma_{01} + \gamma_{21} - \gamma_{02} - \gamma_{12})^2 + 4\gamma_{12}\gamma_{21} \tag{10}$$

so, the roots of the characteristic equation are

$$\begin{aligned} \lambda_1 &= -\frac{1}{2}\left(\gamma_{01} + \gamma_{21} + \gamma_{02} + \gamma_{12} + \sqrt{\Delta}\right) \\ \lambda_2 &= -\frac{1}{2}\left(\gamma_{01} + \gamma_{21} + \gamma_{02} + \gamma_{12} - \sqrt{\Delta}\right) \end{aligned} \tag{11}$$

The eigenvector corresponding to the eigenvalue λ_1 is

$$A\underline{u} = \lambda_1 \underline{u}$$

where the homogeneous equation is

$$\begin{bmatrix} -(\gamma_{01} + \gamma_{21} + \lambda_1) & \gamma_{12} \\ \gamma_{21} & -(\gamma_{12} + \gamma_{02} + \lambda_1) \end{bmatrix} \begin{bmatrix} u_1 \\ u_2 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

the solution is

$$\underline{u} = \begin{bmatrix} 1 \\ \dfrac{\gamma_{01} + \gamma_{21} + \lambda_1}{\gamma_{12}} \end{bmatrix} \tag{12}$$

Similarly, the eigenvector, corresponding to the eigenvalue λ_2 is

$$\underline{v} = \begin{bmatrix} 1 \\ \dfrac{\gamma_{01} + \gamma_{21} + \lambda_2}{\gamma_{12}} \end{bmatrix} \tag{13}$$

Eigenvalue matrix is

$$\Lambda = \begin{bmatrix} \lambda_1 & 0 \\ 0 & \lambda_2 \end{bmatrix} \tag{14}$$

and, eigenvector matrix is

$$S = \begin{bmatrix} 1 & 1 \\ (\gamma_{01} + \gamma_{21} + \lambda_1)/\gamma_{12} & \gamma_{01} + \gamma_{21} + \lambda_2/\gamma_{12} \end{bmatrix} \tag{15}$$

The inverse of matrix S is

$$S^{-1} = \frac{\gamma_{12}}{\lambda_2 - \lambda_1}\begin{bmatrix} (\gamma_{01} + \gamma_{21} + \lambda_2)/\gamma_{12} & -1 \\ -(\gamma_{01} + \gamma_{21} + \lambda_1)/\gamma_{12} & 1 \end{bmatrix} \tag{16}$$

So,

$$e^{A^* t} = S e^{\Lambda t} S^{-1}$$

$$= \frac{1}{\lambda_2 - \lambda_1}\begin{bmatrix} (\gamma_{01} + \gamma_{21} + \lambda_2)e^{\lambda_1 t} - (\gamma_{01} + \gamma_{21} + \lambda_1)e^{\lambda_2 t} & \gamma_{12}(e^{\lambda_2 t} - e^{\lambda_1 t}) \\ \gamma_{21}(e^{\lambda_2 t} - e^{\lambda_1 t}) & (\gamma_{01} + \gamma_{21} + \lambda_2)e^{\lambda_2 t} - (\gamma_{01} + \gamma_{21} + \lambda_1)e^{\lambda_1 t} \end{bmatrix} \tag{17}$$

When

$$E\begin{bmatrix} n_1(t) \\ n_2(t) \end{bmatrix} = e^{A^* t}\begin{bmatrix} n_1(0) \\ n_2(0) \end{bmatrix} \tag{18}$$

is written in its place in (4.1)

$$\begin{bmatrix} n_1(t) \\ n_2(t) \end{bmatrix} = e^{A^* t}\begin{bmatrix} n_1(0) \\ n_2(0) \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \end{bmatrix} \tag{19}$$

is obtained.

With the expression

$$\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} n_1(t) \\ n_2(t) \end{bmatrix}, \begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} n_1(t) \\ n_2(t) \end{bmatrix}, \underline{f}(t,\underline{\theta}) = \begin{bmatrix} \underline{f_1}(t,\underline{\theta}_1) \\ \underline{f_2}(t,\underline{\theta}_2) \end{bmatrix} = e^{A^* t}\begin{bmatrix} n_1(0) \\ n_2(0) \end{bmatrix} \tag{20}$$

the two variables non-linear model below is acquired:

$$\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} \underline{f_1}(t,\underline{\theta}_1) \\ \underline{f_2}(t,\underline{\theta}_2) \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \end{bmatrix} \tag{21}$$

In the model, $\underline{\theta}_1$ and $\underline{\theta}_2$ are the vectors of parameters, which are the functions of $\gamma_{12}, \gamma_{21}, \gamma_{01}, \gamma_{02}$, exist in the equations.

Depending on the estimations $\hat{\gamma}_{01}, \hat{\gamma}_{02}, \hat{\gamma}_{12}, \hat{\gamma}_{21}$ of $\gamma_{12}, \gamma_{21}, \gamma_{01}, \gamma_{02}$ parameters, for matrix A, estimation $\hat{A}$ will be obtained, so, matrix $P(t) = e^{At}$, estimation $\hat{P}(t) = e^{\hat{A}t}$ will be obtained in the acquired two variables nonlinear model.

As

$$\hat{P}(t) = \begin{bmatrix} 1 & \hat{p}_{01}(t) & \hat{p}_{02}(t) \\ 0 & \multicolumn{2}{c}{\multirow{2}{*}{$e^{\hat{A}^* t}$}} \\ 0 & & \end{bmatrix} \tag{22}$$

$\hat{p}_{01}, \hat{p}_{02}$ can be calculated after $e^{\hat{A}^* t}$ is calculated from (15) (Genç, 1997).

Dependent variables are the same for all three models. (y_1) refers migration from Erzurum to Bursa, and (y_2) refers migration from Bursa to Erzurum.

For the first model, independent variable is time (t), for the second model independent variable is gross domestic product per capita (x_1), and for the third model, independent variable is unemployment rate (x_2). Related data set is available on Table 3.

Table 3. Data Set For Compartmental Model System

t	y_1	y_2	x_1	x_2
1980	1172	106	1518	8,6
1985	1357	143	1320	7,6
1986	2400	155	1459	8,1
1988	2250	186	1685	8,4
1990	2604	160	2655	8
1992	2300	150	2682	8,5
1994	2000	140	2173	8,5
1996	1700	140	2888	7,3
1998	1850	150	4338	6,9
2000	2110	356	4129	7
2003	2815	705	4565	10,5
2005	3350	970	7036	10,6
2008	5001	1087	10444	11
2009	3206	1466	8561	14
2010	2693	1372	10003	11,9
2011	2831	1518	10428	9,8
2012	2946	1115	10459	9,2
2013	3126	1212	10822	9,7
2014	3985	1454	10395	9,9
2015	3457	1502	9261	10,3

Model I is determined as following

$$\begin{bmatrix} f_1(t,\underline{\theta}_1) \\ f_2(t,\underline{\theta}_2) \end{bmatrix} = \frac{1}{\lambda_2-\lambda_1}\begin{bmatrix} (\gamma_{01}+\gamma_{21}+\lambda_2)e^{\lambda_1 t}-(\gamma_{01}+\gamma_{21}+\lambda_1)e^{\lambda_2 t} & \gamma_{12}(e^{\lambda_2 t}-e^{\lambda_1 t}) \\ \gamma_{21}(e^{\lambda_2 t}-e^{\lambda_1 t}) & (\gamma_{01}+\gamma_{21}+\lambda_1)e^{\lambda_1 t}-(\gamma_{01}+\gamma_{21}+\lambda_2)e^{\lambda_2 t} \end{bmatrix}\begin{bmatrix} N \\ 0 \end{bmatrix} \quad (23)$$

$$= \frac{N}{\lambda_2-\lambda_1}\begin{bmatrix} (\gamma_{01}+\gamma_{21}+\lambda_2)e^{\lambda_1 t}-(\gamma_{01}+\gamma_{21}+\lambda_1)e^{\lambda_2 t} \\ \gamma_{21}(e^{\lambda_2 t}-e^{\lambda_1 t}) \end{bmatrix}$$

For the amount of reciprocal migration in two compartments in $t_1, t_2, \ldots, t_n$ times, two variables nonlinear model is defined as below

$$\begin{bmatrix} y_{1i} \\ y_{2i} \end{bmatrix} = \begin{bmatrix} \frac{N}{\lambda_2-\lambda_1}\left[(\gamma_{01}+\gamma_{21}+\lambda_2)e^{\lambda_1 t_i}-(\gamma_{01}+\gamma_{21}+\lambda_1)e^{\lambda_2 t_i}\right] \\ \frac{N\gamma_{21}}{\lambda_2-\lambda_1}\left[e^{\lambda_2 t_i}-e^{\lambda_1 t_i}\right] \end{bmatrix} + \begin{bmatrix} \varepsilon_{1i} \\ \varepsilon_{2i} \end{bmatrix}, i = 1,6,7,\ldots,36 \quad (24)$$

As derivatives by γ_{01} and γ_{21} are the same, in the first equation of the model, for

$$\alpha = \gamma_{01} + \gamma_{21},\ \gamma_{21} = \gamma_{21},\ \lambda_1 = \lambda_1,\ \lambda_2 = \lambda_2 \quad (25)$$

reparameterized

$$\begin{bmatrix} y_{1i} \\ y_{2i} \end{bmatrix} = \begin{bmatrix} \dfrac{N}{\lambda_2 - \lambda_1}\left[(\alpha + \lambda_2)e^{\lambda_1 t_i} - (\alpha + \lambda_1)e^{\lambda_2 t_i}\right] \\ \dfrac{N\gamma_{21}}{\lambda_2 - \lambda_1}\left[e^{\lambda_2 t_i} - e^{\lambda_1 t_i}\right] \end{bmatrix} + \begin{bmatrix} \varepsilon_{1i} \\ \varepsilon_{2i} \end{bmatrix}, i = 1,6,7,...,36 \quad (26)$$

model is obtained. Parameter will be estimated by the model.

Model II determined as following

$$\begin{bmatrix} y_{1i} \\ y_{2i} \end{bmatrix} = \begin{bmatrix} \dfrac{N}{\lambda_2 - \lambda_1}\left[(\gamma_{01} + \gamma_{21} + \lambda_2)e^{\lambda_1 x_{1i}} - (\gamma_{01} + \gamma_{21} + \lambda_1)e^{\lambda_2 x_{1i}}\right] \\ \dfrac{N\gamma_{21}}{\lambda_2 - \lambda_1}\left[e^{\lambda_2 x_{1i}} - e^{\lambda_1 x_{1i}}\right] \end{bmatrix} + \begin{bmatrix} \varepsilon_{1i} \\ \varepsilon_{2i} \end{bmatrix}, i = 1,6,7,...,36 \quad (27)$$

As derivatives by γ_{01} and γ_{21} are the same, in the first equation of the model just as the first model, for

$$\alpha = \gamma_{01} + \gamma_{21}, \gamma_{21} = \gamma_{21}, \lambda_1 = \lambda_1, \lambda_2 = \lambda_2 \quad (28)$$

the following reparametrized model is acquired.

$$\begin{bmatrix} y_{1i} \\ y_{2i} \end{bmatrix} = \begin{bmatrix} \dfrac{N}{\lambda_2 - \lambda_1}\left[(\alpha + \lambda_2)e^{\lambda_1 x_{1i}} - (\alpha + \lambda_1)e^{\lambda_2 x_{1i}}\right] \\ \dfrac{N\gamma_{21}}{\lambda_2 - \lambda_1}\left[e^{\lambda_2 x_{1i}} - e^{\lambda_1 x_{1i}}\right] \end{bmatrix} + \begin{bmatrix} \varepsilon_{1i} \\ \varepsilon_{2i} \end{bmatrix}, i = 1,6,7,...,36 \quad (29)$$

Model III determined as following

$$\begin{bmatrix} y_{1i} \\ y_{2i} \end{bmatrix} = \begin{bmatrix} \dfrac{N}{\lambda_2 - \lambda_1}\left[(\gamma_{01} + \gamma_{21} + \lambda_2)e^{\lambda_1 x_{2i}} - (\gamma_{01} + \gamma_{21} + \lambda_1)e^{\lambda_2 x_{2i}}\right] \\ \dfrac{N\gamma_{21}}{\lambda_2 - \lambda_1}\left[e^{\lambda_2 x_{2i}} - e^{\lambda_1 x_{2i}}\right] \end{bmatrix} + \begin{bmatrix} \varepsilon_{1i} \\ \varepsilon_{2i} \end{bmatrix}, i = 1,6,7,...,36 \quad (30)$$

Since derivatives by γ_{01} and γ_{21} are the same, in the first equation of the model likewise the first and the second models, for

$$\alpha = \gamma_{01} + \gamma_{21}, \gamma_{21} = \gamma_{21}, \lambda_1 = \lambda_1, \lambda_2 = \lambda_2 \quad (31)$$

the following reparametrized model is obtained.

$$\begin{bmatrix} y_{1i} \\ y_{2i} \end{bmatrix} = \begin{bmatrix} \dfrac{N}{\lambda_2 - \lambda_1}\left[(\alpha + \lambda_2)e^{\lambda_1 x_{2i}} - (\alpha + \lambda_1)e^{\lambda_2 x_{2i}}\right] \\ \dfrac{N\gamma_{21}}{\lambda_2 - \lambda_1}\left[e^{\lambda_2 x_{2i}} - e^{\lambda_1 x_{2i}}\right] \end{bmatrix} + \begin{bmatrix} \varepsilon_{1i} \\ \varepsilon_{2i} \end{bmatrix}, i = 1,6,7,...,36 \quad (32)$$

Results and discussion

Parameter estimations are done by considering each equation of the model in (32) as a separate model. $\hat{\Sigma}$ is obtained by the errors of the model; and parameters of multivariate nonlinear models are estimated by least squares method.

Also, by assuming the two models uncorrelated, matrix I is used instead of. However, because of the common parameters, models are estimated as a multivariate nonlinear model. Since it is not possible to obtain the estimation of parameters analytically, iterative methods are used. Gauss-Newton model is used for parameter estimation of multivariate nonlinear models. The following are assumed as initial values for parameters in algorithm:

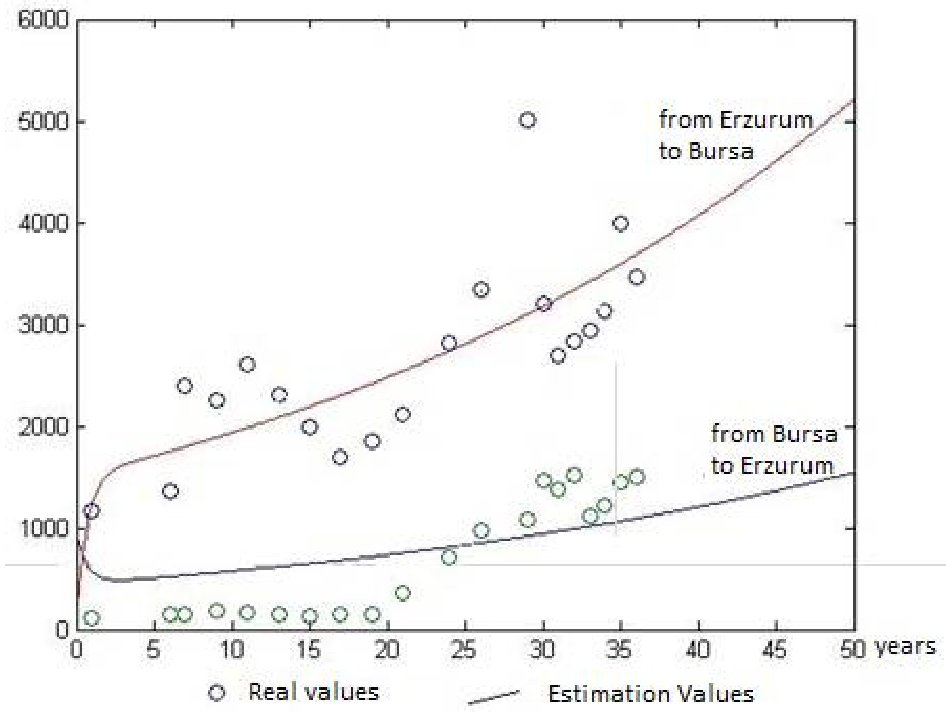
$$(\lambda_1)_0 = 1 , (\lambda_2)_0 = 0{,}5 , (\alpha)_0 = 0{,}5 , (\gamma_{21})_0 = 1$$

Estimations acquired by Model I is presented in Table 4.

Table 4. Estimation Results for Model I

Iteration Number	γ_{21}	γ_{12}	γ_{02}	γ_{01}
1	-1,2417	0,0299	0,7372	1,6682
2	-1,4615	0,0228	0,7675	2,3616
3	-1,5998	0,0255	0,8841	2,4077
4	-1,5459	0,0245	0,8380	2,3922
5	-1,5674	0,0249	0,8560	2,3996
6	-1,5592	0,0247	0,8490	2,3969
7	-1,5623	0,0248	0,08517	2,3980
8	-1,5611	0,0248	0,8507	2,3976
9	-1,5616	0,0248	0,8510	2,3977
10	-1,5615	0,0248	0,8510	2,3977

In the model, change in the amount of migration from Erzurum to Bursa and from Bursa to Erzurum depending on the time, in other words, change in the amount of reciprocal migrations depending on the time is determined as seen on Graph 6. In the graph, real values and estimation values until t=50 (For 1980, t=1) are shown. As seen on the graph, the increase in the amount of migration from Erzurum to Bursa is higher than the increase in the amount of migration from Bursa to Erzurum.



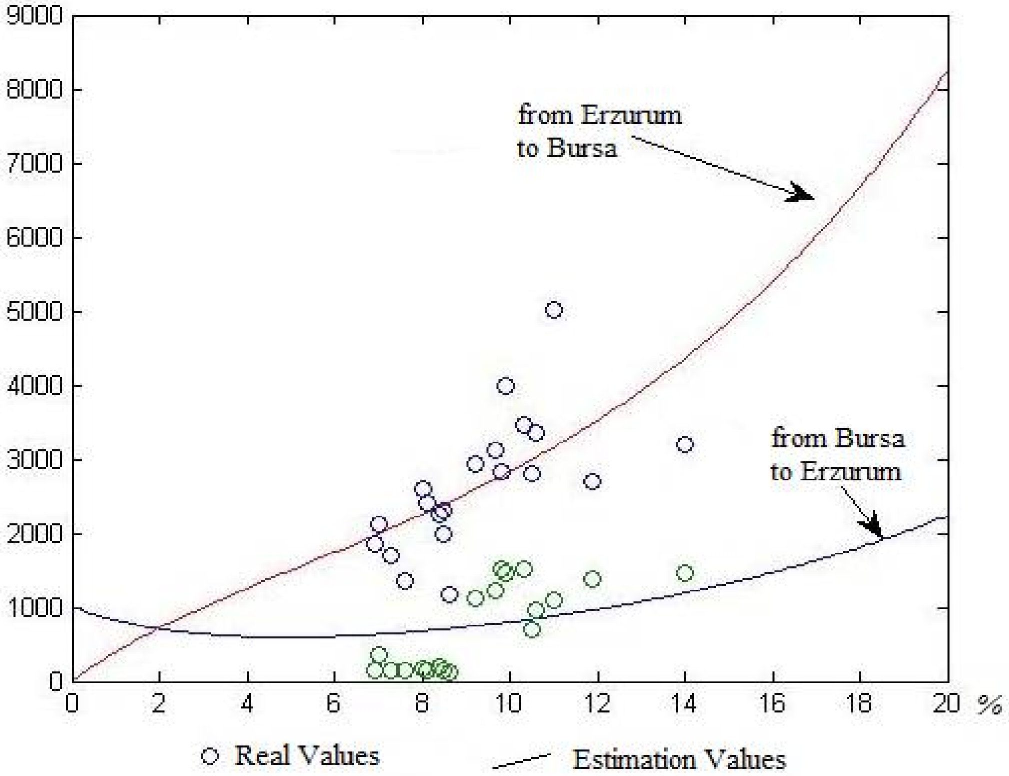
Graph 6. Migration from Erzurum to Bursa and From Bursa to Erzurum by Time

In the second mode, unemployment rate is used as an independent variable. Acquired estimations are placed in Table 5. As seen on the table, parameter estimations are obtained in the 12th iteration.

Table 5. Estimation Values for Model II

Iteration Number	γ_{21}	γ_{12}	γ_{02}	γ_{01}
1	-0,1162	0,0960	0,0713	0,2626
2	-0,5648	0,1094	0,3838	0,6360
3	-0,2851	0,1037	0,1810	0,3984
4	-0,3593	0,1070	0,2346	0,4558
5	-0,3222	0,1055	0,2076	0,4268
6	-0,3382	0,1062	0,2192	0,4391
7	-0,3308	0,1059	0,2138	0,4334
8	-0,3341	0,1060	0,2162	0,4360
9	-0,3326	0,1060	0,2151	0,4348
10	-0,3333	0,1060	0,2156	0,4353
11	-0,3330	0,1060	0,2154	0,4351
12	-0,3331	0,1060	0,2155	0,4351

In this model, change in the amount of migration from Erzurum to Bursa and from Bursa to Erzurum depending on the unemployment rate is examined. The change is presented in Graph 7. In the graph, both real values and estimation values depending on the change in unemployment rate are shown. According to the table, the increase in the amount of migration from Erzurum to Bursa become more rapid than the increase in the migration from Bursa to Erzurum as long as the unemployment rate increases. On the other hand, the amount of reciprocal migrations decreases as the rate of unemployment decreases. At 2% unemployment rate, it is observed that the amount reciprocal migrations are equal.



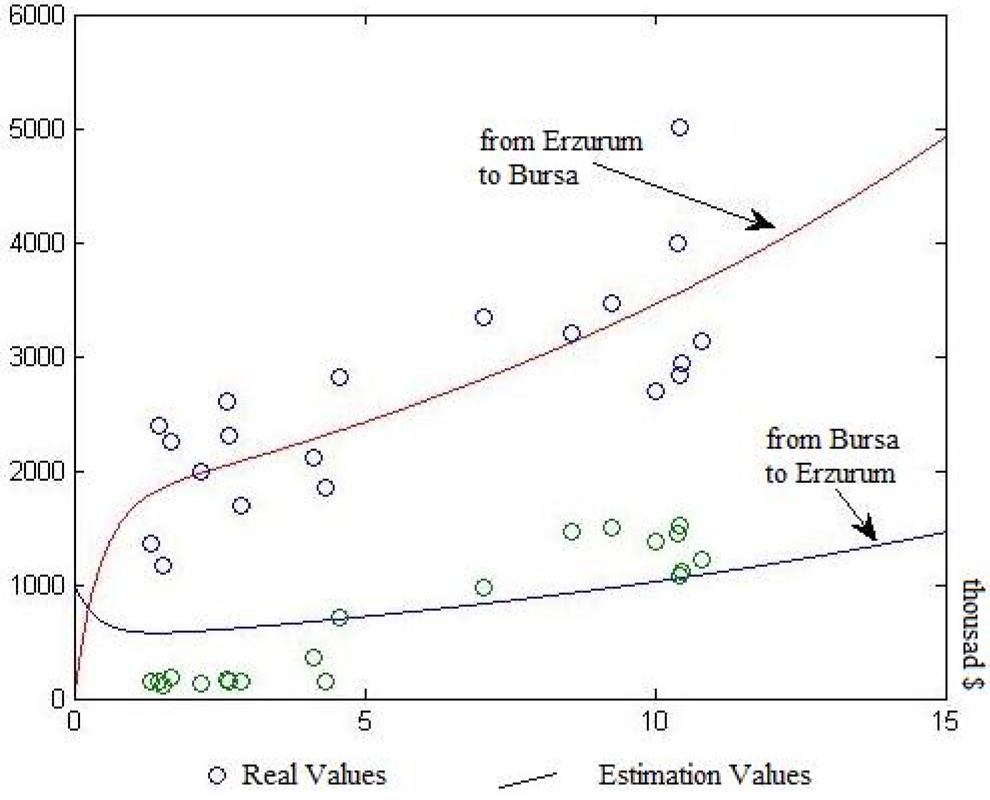
Graph 7. Migration from Erzurum to Bursa and from Bursa to Erzurum Depending on the Unemployment Rate

In the third model, gross domestic product per capita is determined as independent variable. Obtained results are seen on Table 6. As it is clear on the table, parameter value is acquired in the 11th iteration.

Table 6. Model Estimation Values for Model III

Iteration Number	γ_{21}	γ_{12}	γ_{02}	γ_{01}
1	-1,2675	0,0808	0,6321	2,1394
2	-2,1765	0,0651	1,0045	3,9863
3	-2,4317	0,0730	1,1852	4,1848
4	-2,2875	0,0700	1,0917	4,0349
5	2,3479	0,0711	1,1296	4,1028
6	-2,3250	0,0707	1,1152	4,0771
7	-2,3335	0,0708	1,1206	4,0867
8	-2,3304	0,0708	1,1186	4,0832
9	-2,3316	0,0708	1,1193	4,0845
10	-2,3311	0,0708	1,1191	4,0840
11	-2,3312	0,0708	1,1191	4,0841

In this model, change in the amount of migration from Bursa to Erzurum and from Erzurum to Bursa depending on the gross domestic product per capita is examined. The change is shown in Graph 8., which includes both real values and estimation values depending on the change in gross domestic product per capita. According to the table, the amount of migration rises as long as GDP per capita increases. For the amount of migration from Bursa to Erzurum, it increases as GDP per capita increase, however, it is clear that the amount of increase is tiny, when compared with the amount of migration from Erzurum



Graph 8. Migration from Bursa to Erzurum & Erzurum to Bursa by GDP per Capita

When all three models are examined by applying appropriate stopping rule, parameter estimations was done on 10th iteration in the first model, on 12th iteration in the second model, on 11th iteration in the third model. It is obvious that the amount of migration from Erzurum to Bursa is more than the amount of migration from Bursa to Erzurum in all of the models.

Conclusion

In this study, how the reciprocal migration from Erzurum to Bursa and Bursa to Erzurum flows; and how this flow will continue in future is analyzed. In addition to migration data, unemployment level based on years, and gross domestic products per capita is used in order to find out how these variables affect migration. A compartment system, which enables outflow and reciprocal transitions is designed in order to analyze migration transitions between Bursa and Erzurum. The solutions of multivariate nonlinear models, which are required for the solutions of designed system are handled by using MatLab software.

The migration between Erzurum and Bursa is examined with three models. In the first model, time factor included the model as an independent variable in order to examine the flows of the migration transitions between Erzurum and Bursa. According to the model, there is a strong increase in the amount of migration from Erzurum to Bursa. Estimation results of the model show that annual migration number will rise over 4000 in 2023 and later. There is also an increase in the amount of migration from Bursa to Erzurum. However, this increase is slighter than the increase of migration from Erzurum to Bursa. According to the results, the amount of immigrants from Bursa to Erzurum is 1267, whereas immigrants from Erzurum to Bursa is 4267. This situation shows that the net amount of migration is 3000 people per year and it means that the proportion of immigrants from Erzurum in

Bursa will increase up to 10 per cent in years. Subsequently, Erzurum, which has effects on Bursa for more than 30 years, will continue to rise its effectiveness, in commerce, education, healthcare, politics etc. in future.

In the model II, unemployment level of Turkey included as independent variable in order to analyze the change of amount of migration transitions between Erzurum and Bursa in proportion to unemployment level. The results of the model presented that the amount of migration from Erzurum to Bursa increased in parallel to unemployment level. It is estimated that there will be 8000 immigrants when the unemployment level is approximately 20 per cent. On the other hand, as unemployment level decreases, the migration amount will vanish.

A different situation takes attention for the migration from Bursa to Erzurum. In the case that unemployment level is zero, the amount of immigrants becomes more in comparison with other cases. This situation shows that people return back to their homelands if there is no concern regarding employment. Moreover, the change in unemployment rate and the amount of migration from Bursa to Erzurum are almost constant. Therefore, we can conclude that the reason of the migration from Bursa to Erzurum is not related with unemployment.

Although we concluded that the increase in unemployment rate rises the amount of migration from Bursa to Erzurum, the reason of rise may not be the unemployment rate, however, it may be related with the spontaneous increase in population. Furthermore, it is obvious that the unemployment rate of Bursa has always been higher than the unemployment rate of Erzurum. One of the causes of this situation may be the immigrants, coming from many other cities including Erzurum. The results point out that unemployment causes migration; and the migration causes unemployment in the destination provinces.

In the model III, gross domestic product per capita of Turkey is included to the model as an independent variable for the purpose of analyzing the change in the migration between Erzurum and Bursa, depending on the GDP per capita.

The results state that there is a meager relation between the migration from Bursa to Erzurum and GDP per capita. When the results are analyzed, no matter GDP per capita is high or low, the amount of migration changes very little. On the other hand, it is considered that there is a relation between the migration from Erzurum to Bursa and GDP per capita. Thus, the level of migration rises as GDP per capita rises.

According to the results of the model the variability between the migration from Bursa to Erzurum and GDP per capita is insignificant. On the other hand, there is a variability in the same way between the migration from Erzurum to Bursa and GDP per capita. In other words, the amount of migration from Erzurum to Bursa increase as GDP per capita increases.

It is possible to consider GDP per capita and the Erzurum-Bursa migration in different perspectives. Actually, it is concluded that the migration from Erzurum to Bursa will increase as long as GDP per capita increase. However, the fact that Bursa is an industrial city, which has high added value, should be taken into account since labor force is needed. Therefore, the city gets migration from many cities such as Erzurum. In consequence, by getting migration, production increases as labor force increases, so the city would contribute more to the national economy. From here, we can claim that increase in the migration from Erzurum to Bursa would cause GDP per capita to increase.

As a result of the analyses, it is concluded that the migration from Erzurum to Bursa will increase, the migration is closely related with unemployment, and it will increase as GDP per capita increases. On the other hand, relationship of time, unemployment, and GDP per capita with the migration from Bursa to Erzurum is not strong as the migration from Erzurum to Bursa. The migration from Bursa to Erzurum is more likely related with social and cultural reasons, rather than economic reasons. It may be occurred because of the people, who retired after long years or have no economic concerns, so prefer to live in their own homeland.

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