8. Estimating the Dynamics of Household Waste Management in Turkey

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Abstract

In the context of rapid urbanization, the household waste is an important issue that impacts environmental sustainability. This paper analyzes this crucial issue by building an empirical model to predict the dynamics of household waste management in Turkey that highlights the relationship between the rate of household growth, the household waste recycling rate, the infant mortality rate, and population growth, in a Simultaneous Equation System (SES) framework.The main results illustrate the fact that this dynamic can lead authorities to take actions for diminishing pollution and decreasing its effects on health and security of humankind.On top of that, waste management becomes a sine qua non condition of sustainability in Turkey and the efficient management of waste is promoted if the subsidized prices are available.

Keywords: environment economics, simultaneous equation system, household waste, recycling, pollution, waste management

JEL Classification: C22, C41, O44, Q53

1. Introduction

In order to achieve the objectives of sustainable development, the concept of zero waste deals with contemporary environmental issues such as waste recycling, achieving sustainability, biodiversity loss, climate change (Scheepens *et al.*, 2015; Yuan *et al.*, 2014;

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Zaman and Lehmann, 2013; Mayumi and Giampietro, 2019), and household waste management (Aparcana, 2017; Eriksson *et al.*, 2014).

One of the waste management solutions that are harmful to the environment relates to the transformation process of recycling household waste into a lifestyle of economic and social actions (Rada *et al.*, 2018; Laurent *et al.*, 2014). One pollutant of the natural ecosystem is waste, which is of concern to organizations that are dedicated to environmental protection and waste management (Van Caneghem *et al.*, 2019; Wang *et al.*, 2018).

Studies regarding the effectiveness of waste management systems and the implementation of household waste policies also show an increased tendency towards urban solid waste generation (Inglezakis *et al.*, 2018; Filho *et al.*, 2015). In this context, the level of waste production in cities seems to be correlated with the level of income, as well as with economic growth (Eriksson and Finnveden, 2017).

The insignificant prominence of municipal solid waste recycling in Turkey is the result of a deficiency in the process of separate collection of the generated waste (Berkun *et al.*, 2011). Wastes are disposed of at municipal dump sites, landfill sites, and also in unauthorized locations at the edges of settlements and along roads (Permana *et al.*, 2015).

As a consequence of these statistics, it is of great importance that the rate of separation at the source of domestic waste and the collection of waste at collection centres is increased. At the same time, environmental city municipalities in Turkey are obliged to establish or operate domestic solid waste disposal facilities (Keser *et al.*, 2012). According to Article 7 of Law No. 5216 of the Metropolitan Municipality Law, and Articles 14 and 15 of Municipality Law No. 5393 regarding the collection of solid waste at the source in accordance with the metropolitan municipal solid waste management plan and the transportation of the municipal municipalities to the transfer station, the re-evaluation, storage, and disposal of waste is a responsibility of the municipalities (Goren and Ozdemir, 2010; Permana *et al.*, 2015).

In this sense, similar progress has been recorded in Turkey, but the real problems were due to the financial and economic crises, and consisted in the purchase of bio/organic products (at high costs to the consumer) and in separate collection of waste in special containers (Keser *et al.*, 2012; Goren and Ozdemir, 2010).

Other causes that have led to the poor results obtained by Turkey with respect to the recycling of these products were the large recovery costs, the lack of education and ecological and environmental protection, the scarcity of economic and environmental information, differentiated tariffs, and very weak sanctions for those violating the legislation (Goren and Ozdemir, 2010).

On this background, this article brings a new look to the actual empirical studies that try to demonstrate the connection between the rate of household growth, the household waste recycling rate, the infant mortality rate, and population growth, in a Simultaneous Equation System (SES) framework.

To achieve this aim, in this study there are three reasons for estimating the impact of household waste management on infant mortality and socio-economic status in Turkey. First, the current research is particularly timely because of the recent spike in household waste management. Several authors claim that household waste could serve as a green fuel towards its eventual replacement by renewable energy sources (Li *et al.*, 2011; Johnstone and Labonne, 2004). However, there is also some dispute among experts and policy makers about the benefits of investment on recycling facilities for the public health and environment. In contrast with these concerns, there are many arguments for believing that the implementation of circular economy needs the support of outside forces (Wilson *et al.*, 2012).

Second, this study extends the growing literature on the protection of environment from pollution with waste and on infant mortality by using a novel model of variation from a country that has not been studied. Many of the existing studies have typically relied on the solid waste management practices (Lazarevic *et al.*, 2012; Johnstone and Labonne, 2004; Ma and Hipel, 2016) and sometimes estimate the effect of pollution concentrations on health (Fallah-Shorshani *et al.*, 2018). Our auxiliary analysis using statistical data suggests that the reductions in infant mortality are associated with the improvement of household waste management in Turkey. One argument might be that household waste penetration might have led to a rise in public awareness, especially among pregnant women, of the harmful effects of environmental pollution.

Third, this investigation exploits the relationship between waste management and the increase in household/population numbers. Actually, the effect of household waste recycling rate on population growth is largely due to the inefficient use of resources, and distorted investment decisions in recycling technologies. Wan and Shen (2013) empirically analysed household waste recycling rates and the household growth, and came to the conclusion that there is a unidirectional causality. By the same token, Misra *et al.* (2018) have substantiated the existence of a positive relationship between waste management and population growth, by examining the long-term dynamics of this relationship in the Turkish cities. Consequently, the relationship between waste management and household/population growth may even end up being bi-directional. This link necessitates policy efforts to suppress household waste, since lower rates of household waste recycling might lead to higher pollution.

Note that, in Turkey, there is considerable variation across regions in terms of recycling, the economic level and population growth. To gain further insights about these differences, the empirical model used the following variables: the population growth rate (PGR), the residential and non-residential diversion rate (RNRDR), the disposal rate of municipal solid waste (DRMSW), the waste diversion rate (WDR), the linear index of the losses registered in the household waste collection (LILRHWC). Therefore, it is not surprising that the investment on new recycling facilities require improvement in the price of the waste collected.

Overall, this study also evidences the possibilities of developing alternative solutions for the issue of household waste management in Turkey. Likewise, the framework developed in this paper is innovative in the sense that it provides an insight into how decision-makers can correlate the effects of household waste management variables with the demographic/economic variables, and how they can undertake a health impact assessment. In additional, the obtained results may contribute to solid waste management planning in Turkey and in other countries from this area.

The rest of this paper is organised as follows. Section 2 describes a brief presentation of the literature. Section 3 provides the methodology. Section 4 analyses the empirical results and discusses the implications. Section 5 drives conclusions.

II. Literature Review

Over time, several studies have shown that the increasing urbanization rate has caused an increase in the amount of domestic waste generated in cities, that the change in its composition has created a problem that is difficult to control, and that it has acquired a great economic value in the negative direction (Melikoglu, 2013; Şentürk *et al.*, 2016; Aparcana, 2017). As a consequence, Solid Waste Management is an increasingly important element in terms of efficiency and profitability for any municipality, particularly in the most important cities (Zaman and Lehmann, 2013). There are different techniques of municipal solid waste disposal but the common techniques are open dumps sites, incineration, composting and recycling (Ma and Hipel, 2016).

Other researchers have focused on the analysis of social aspects in the eco-efficiency of waste management systems (Arushanyan *et al*., 2017; Gamberini *et al*., 2013), or the economic aspects of waste recycling (Troschinetz and Mihelcic, 2009). Among the causes that have led to waste recycling, we mention the influence of the economic level, population awareness, business activities, social inclusion, quantity of waste generated, geographical area (Hashemi *et al*., 2014; Aranda Usón *et al.,* 2013), a growth in the population that collects waste at home as compared to their decreasing distance from recycling points (Kawai and Tasaki, 2016), and the lack of government support for the collection and recycling of waste from the general population and markets (Sekito *et al.,* 2013).

On the other hand, global concerns over the consequences of pollution from waste on public health and the environment have raised widespread awareness of an urgent need for recycling technologies, sanitary landfill, collection covering, population awareness, and the development of selective collection policies (Canzano *et al.,* 2014).

Despite this agreement, much of the literature has focused on the potential adverse health effects of different waste management options, particularly from landfill and incineration (Ma and Hipel, 2016). One of the common problems found in these studies relates to the toxicity of the individual substances as a result of occupational or accidental exposure to higher levels of certain substances, such as cadmium, arsenic, chromium, nickel, dioxins (Canzano *et al.,* 2014; Sapkota *et al.,* 2010). Therefore, the dioxins and organochlorines may be lipophilic and accumulate in fat-rich tissues, and they have been associated with reproductive or endocrine-disrupting endpoints (Claeson *et al.,* 2013).

At the same time, reproductive effects that are associated with open dump sites have been extensively researched, and these include low birth weight (less than 2500 g), fetal and infant mortality, spontaneous abortion, and the occurrence of birth defects (Andersson *et al.,* 2009). Likewise, trends in low birth weight and neonatal deaths were found to correspond closely with time and quantities of dumping at a large hazardous waste disposal site (Pereira *et al.,* 2016). Other studies described a significant risk of congenital malformations for mothers, which were assigned medium or high exposure with increasing proximity to a site (Andersson *et al.,* 2009; Canzano *et al.,* 2014).

2. Methodology

The method of estimating the size of household waste recycling in Turkey was conducted by using the Simultaneous Equation System (SES) framework construct with the intention of establishing a relationship among the variables under consideration (Pindyck and Rubinfeld, 1998; Bierens, 2005; Milunovich and Yang, 2018). This is followed by the issues pertaining to the empirical model and the methodology applied. Next, an econometric exercise was carried out, which helps us to document the comprehensive policy implications of this research.

This study concentrates completely on the endogenous relationship, as opposed to the exogenous theoretical arguments that already exist in the literature (Liao *et al.*, 2018; Porta *et al.*, 2009). The endogenous variables were the rate of household growth (HGR), the household waste recycling rate (HWRR), the infant mortality rate per 1000 births (IMR), the population growth rate (PGR), the residential and non-residential diversion rate (RNRDR), the adult literacy rate (ALR), the disposal rate of municipal solid waste (DRMSW), the waste diversion rate (WDR), the linear index of the losses registered in the household waste collection (LILRHWC), and the average price of household waste (APHW).

Under these circumstances, it is important to note the way in which the variables have been calculated (Turkish Statistical Institute, 2018):

- Residential and non-residential diversion rate (RNRDR) = defined as the percentage of waste diverted, relative to residential and non-residential sources;
- Adult literacy rate (ALR) uses the formula = divide the number of literates of a given age range by the corresponding age group population, and multiply the result by 100;
- Disposal rate of municipal solid waste (DRMSW) = defined as the percentage of waste diverted, relative to the total waste disposed from municipal sources;
- Waste diversion rate (WDR) = (Weight of Recycling/ (Weight of Recycling + Weight of Garbage)) × 100
- Linear index of the losses registered in the household waste collection (LILRHWC) = the calculations of losses rest entirely on the determination of the household waste collection.

The model is according to the following relationships:

$$HGR_t = a_1 + b_1 HGR_{t-1} + c_1 HWRR_t + d_1 IMR_t + e_1 LILRHWC_t + f_1 APHW_t + g_1 PGR_t + h_1 RNRDR_t + i_1 ALR_{t-1} + \mu \quad (1)$$

$$HWRR_t = a_2 + b_2 HGR_t + c_2 IMR_t + d_2 LILRHWC_t + e_2 APHW_t + f_2 ALR_{t-1} + g_2 PGR_t + h_2 WDR_t + \mu \quad (2)$$

$$IMR_t = a_3 + b_3 HGR_t + c_3 HWRR_t + d_3 WDR_t + e_3 IMR_{t-1} + f_3 RNRDR_t + g_3 PGR_t + \mu \quad (3)$$

$$PGR_t = a_4 + b_4 ALR_{t-1} + c_4 DRMSW_t + d_4 HGR_t + e_4 IMR_t + f_4 HWRR_t + \mu \quad (4)$$

The data for the variables used were compiled from the Turkish Statistical Institute (Turkish Statistical Institute, 2018), Organization for Economic Co-operation and Development: Municipal waste (OECD, 2018), and Eurostat (2018) over the period 1992–2017. The data on the adult literacy rate were available for an interval of 10 years, and so they had to be interpolated and extrapolated accordingly.

Assuming that all of the equations in the system were identified, this means that the model was identified (Kwiatkowski and Schmidt, 1990). It should be noticed that before we proceeded with the estimation of the model, checking the stationarity of the variables became necessary. To check for the stationarity of the variables, we used the Unit Root Test for every individual series with multiple structural breaks by applying the test statistic and the Akaike Information Criterion (AIC) with trends and intercepts, to know whether the series was trend stationary (TS) or difference stationary (DS).

Suitably, the model to test for the presence of unit roots is:

$$\Delta y_t = \mu + \rho t + \tau y_{t-1} + \sum_{j=1}^{k} \varphi_j \Delta y_{t-j} + e_t$$

where: μ is the constant; ρ is the coefficient on the time trend; and *j* is the order of lag of the autoregressive (AR) process and Δy_{t-j} captures the autoregressive moving average (ARMA) effects (Kwiatkowski and Schmidt, 1990).

The research was conducted through the 3SLS estimator, which involves estimation in three stages. First, one obtains the reduced form of the model. Estimation of the reduced-form equation parameters were obtained via simulations of the estimated structural equations. Then, the 2SLS estimates are obtained, and hence, the variance–covariance (Var–Cov) matrix of the 2SLS residuals is obtained. Finally, using the variance–covariance matrix of 2SLS residuals from the second stage, this was applied to the composite model to obtain the 3SLS estimator.

3. Empirical Results

The empirical model described above was applied to the centralized statistical information found in the data provided by the Turkish Statistical Institute (Turkish Statistical Institute, 2018).

Looking at Table 1, the endogenous variables were highly correlated, which points towards the presence of simultaneity. There was also a high degree of correlation among the other independent variables, such as waste diversion rate and the average price of household waste. Furthermore, the test process was performed under the null hypothesis of $\tau = 0$, tested against the alternative hypothesis of $\tau < 0$. If the null hypothesis is rejected, it may be concluded that there is no unit root, and the data is stationary.

Table 1

The Unit Root Results

Variables	Level of Stationarity	Test Statistic	Probability Value
HGR	Level	−6.03	0.00 *
HWRR	Level	−4.34	0.00 *
IMR	Level	−5.25	0.00 *
PGR	Level	−5.36	0.00 *
LILRHWC	Level	−6.81	0.00 *
APHW	Level	−6.07	0.00 *
RNRDR	Level	−5.68	0.00 *
WDR	Level	−4.91	0.00 *
ALR	Level	−5.13	0.00 *
DRMSW	Level	−6.62	0.00 *

Note: * denotes significance at the 5% level.

Source: Compiled by the authors in Stata 13.

Since there was no question of a co-integrated long-run relationship, the problem of simultaneity was solved by using the 2SLS mechanism (Table 2).

Table 2

The Results Using the 2SLS Mechanism

2SLS Estimates for the Rate of Household Growth (HGR) Function				
HGR	Coefficient	Standard Error	*t*-Statistic	*p* > |t|
HWRR	−2.62	1.12	−2.40	0.03 *
IMR	−2.35	0.68	−3.45	0.00 *
PGR	−8.01	3.04	−2.59	0.03 *
$HWRR_{t-1}$	−0.98	0.22	−4.44	0.00 *
LILRHWC	−1.79	0.51	−3.47	0.00 *
APHW	2.53	0.54	4.47	0.00 *
RNRDR	0.29	0.09	2.93	0.01 *
ALR_{t-1}	−0.13	0.15	−0.77	0.60
_Constant	16.38	35.73	0.45	0.80
2SLS Estimates for the Household Waste Recycling Rate (HWRR) Function				
HWRR	Coefficient	Standard Error	*t*-Statistic	*p* > |t|
HGR	−0.43	0.17	−2.63	0.02 *
IMR	−0.42	0.12	−3.53	0.00 *
PGR	−10.38	3.85	−2.65	0.02 *
LILRHWC	−0.33	0.12	−2.71	0.02 *
APHW	1.55	0.64	2.38	0.03 *
ALR_{t-1}	3.96	1.07	3.61	0.00 *
WDR	0.33	0.22	2.77	0.01 *
_Constant	19.22	18.53	1.02	0.30
2SLS Estimates for the Infant Mortality Rate per 1000 births (IMR) Function				
IMR	Coefficient	Standard Error	*t*-Statistic	*p* > |t|
HGR	−0.78	0.68	−5.05	0.00 *
HWRR	−7.42	1.35	−5.12	0.00 *
PGR	0.86	1.31	3.01	0.01 *
WDR	0.33	2.19	2.47	0.04 *
IMR_{t-1}	1.54	0.56	5.65	0.00 *
RNRDR	1.17	0.45	2.55	0.04 *
_Constant	−15.11	2.75	−5.42	0.00 *
2SLS Estimates for the Population Growth Rate (PGR) Function				
PGR	Coefficient	Standard Error	*t*-Statistic	*p* > |t|
ALR_{t-1}	−0.66	0.28	−2.37	0.05 *
DRMSW	1.86	0.22	8.46	0.00 *
HGR	−0.92	0.36	−2.47	0.04 *
HWRR	−0.90	0.34	−2.56	0.04 *
IMR	2.96	0.93	4.09	0.00 *
_Constant	12.08	15.40	0.77	0.60

Note: * denotes significance at the 5% level.
Source: Compiled by the authors in Stata 13.

By looking at the $p > |t|$ values in Table 2, it can be inferred that all of the variables, except for one, might explain the dependent variable, which is the rate of household growth for equations. Therefore, the null hypothesis was rejected for all variables, except for the adult literacy rate, which did not seem to play any role in explaining the findings, while the constant term also turned out to be insignificant. As reported in Table 2, the household waste recycling rate and the infant mortality rate per 1000 births performed well in explaining the variation in the rate of household growth. It should also be noticed that the disposal rate of municipal solid waste and the infant mortality rate per 1000 births were the estimates of the model.

The results from Table 2 do not change any of the correlations presented above. Consequently, the rejection of the null hypothesis for all these variables was bound to occur.

Following this, the 3SLS approach involved the estimation of all equations simultaneously. The 2SLS and 3SLS results were consistent with one another, as shown in Table 3

Table 3

The 3SLS Results of All of the Equations Simultaneously

Equations	RMSE	R^2	χ^2	Probability
HGR	1.71	0.978	38.55	0.000
HWRR	1.01	0.901	71.98	0.000
IMR	2.38	0.952	28.19	0.002
PGR	1.01	0.949	30.01	0.001
Equation No. 1	Coefficient	Standard Error	*t*-Statistic	*p* > |t|
HWRR	−2.85	1.00	−2.84	0.00 *
IMR	−1.17	0.54	−2.13	0.00 *
PGR	−30.26	9.76	−3.05	0.00 *
$HWRR_{t-1}$	−0.19	0.19	−1.98	0.00 *
LILRHWC	−0.03	0.01	−2.41	0.00 *
APHW	1.28	0.54	2.34	0.00 *
RNRDR	0.15	0.13	1.90	0.00 *
ALR_{t-1}	−3.60	1.51	−2.35	0.00 *
_Constant	36.13	32.51	22.66	0.00 *
Equation No. 2	Coefficient	Standard Error	*t*-Statistic	*p* > |t|
HGR	−0.44	0.18	−2.50	0.00 *
IMR	−0.42	0.13	−3.38	0.00 *
PGR	−50.41	12.96	−3.83	0.00 *
LILRHWC	−0.31	0.12	−2.57	0.00 *
APHW	1.56	0.65	2.35	0.00 *
ALR_{t-1}	0.12	0.09	2.19	0.00 *
WDR	0.52	0.12	1.78	0.00 *
_Constant	19.30	19.08	3.95	0.00 *
Equation No. 3	Coefficient	Standard Error	*t*-Statistic	*p* > |t|
HGR	−0.78	0.62	−3.20	0.00 *
HWRR	−7.01	0.33	−20.80	0.00 *
PGR	0.86	1.31	3.01	0.00 *
WDR	0.33	0.19	2.68	0.00 *
IMR_{t-1}	2.71	1.18	2.26	0.00 *
RNRDR	0.94	0.14	6.51	0.00 *
_Constant	−15.11	17.55	−14.88	0.00 *
Equation No. 4	Coefficient	Standard Error	*t*-Statistic	*p* > |t|
ALR_{t-1}	−1.41	0.40	−3.43	0.00 *
DRMSW	2.85	1.02	2.73	0.00 *
HGR	−1.11	0.58	−1.88	0.00 *
HWRR	−1.21	−0.50	−2.37	0.00 *
IMR	1.32	0.56	2.31	0.00 *
_Constant	17.99	5.58	3.17	0.00 *

Note: * denotes significance at the 5% level.
Source: Compiled by the authors in Stata 13.

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The results illustrated that the model fit into the data exceptionally well, with the R^2 estimates of 97.8%, 90.1%, 95.2%, and 94.9% for the rate of household growth, the household waste recycling rate, the infant mortality rate per 1000 births, and the population growth equation. From a methodological point of view, this is also evidenced from *t*-Statistic and the corresponding p-values reported in Table 3, which underscore the overall significance of all these variables once effects are accounted for.

Moreover, from Equation No. 3 of Table 3, the lagged value of the infant mortality rate per 1000 births had a positive and highly significant relationship with the residential and non-residential diversion rate. Thus, the results supported the adaptive ecology expectations hypothesis. The waste diversion rate turned out to be statistically significant, thereby affecting the infant mortality rate per 1000 births. There is a growing concern in this country about the importance of environmental quality in the effort to decrease the mortality rates.

Additionally, as suggested by Table 3, the rate of household growth turned out to be statistically significant in forecasting the infant mortality rate. The significance of the general disposal rate of municipal solid waste in the population growth equation was theoretically justified (Berkun *et al.*, 2011; Turan *et al.*, 2009; Melikoglu, 2013). The level of adult literacy negatively affected the population growth in this analysis.

Besides, this proves that the population growth rate is negatively related, as expected from the equations. We could notice in column 2 of Table 3 a positive and significant relationship with the residential and non-residential diversion rate, implying that with an increase in urban development, the rate of household growth will be boosted, and hence rise. In light of the results, the negative sign of the lagged values of the rate of household growth indicates that the convergence hypothesis holds true for the Turkish economy. Withal, there is a negative bi-directional relationship between the household waste recycling rate and the rate of household growth, which is also supported by other studies (Goren and Ozdemir, 2010; Berkun *et al.*, 2011).

The counter-intuitive (negative) sign of the adult literacy rate in the equation makes sense when it is analysed in conjunction with the result of another study (Turan *et al.*, 2009), which articulated that it may take about seven to nine years for the constructive effects of adult literacy to be felt on growth in Turkey. Therefore, adult literacy might positively affect the rate of household growth, but only with a substantial time-lag.

High significance and the negative sign of the infant mortality rate per 1000 births parameter showed that there are huge growth costs associated with the household waste recycling rate, because the authorities have manipulated the decrease in the future growth forecasts. The findings from Table 3 are consistent with the theoretical expectations discussed in the introduction section that we would expect the largest effects of pollution on health. Also, in the present study, the average price of the household waste parameter showed a positive sign in the equation, signifying a higher recycling rate in Turkey with a higher average price of household waste.

Last but not least, surprisingly, over the study period, the linear index of the losses registered in the household waste collection negatively influenced the rate of household growth, as well as the household waste recycling rate (the impact of the linear index of the losses registered in the household waste collection was negligible).

In order to reduce the gaps in the reuse and recycling of municipal solid waste, the Turkish authorities must provide the necessary resources to develop and implement effective waste management policies, establish the necessary infrastructure for the collection and recycling of waste, and set up business partnerships that support and improve the recycling process (Tozlu *et al.*, 2016).

Additionally, providing a modern sustainable recycling system involves, on the one hand, the efficient management of financial resources and infrastructure, plus the maintenance of equipment and machinery, and on the other hand, cost recovery and contribution to the development of the economy and society (Coelho and De Brito, 2013).

4. Conclusions

Despite its historically unprecedented economic performance, Turkey continues to maintain an incongruity between the rate of household growth and the growth rate of recycling. Currently, this country is going through a phase of high infant mortality rate, which has cast a negative impact on its population growth. Again, the findings of this investigation evidence demonstrate that any negative variation in the rate of household growth and the waste diversion rate has a positive impact on infant mortality rate and population growth rate.

In term of magnitude, as shown in Table 3, the results of this study prove the relationship between the household waste recycling rate and the infant mortality rate per 1000 births turned out to be significantly negative, contrary to the effective management of the solid waste policy. The effect of pollution on infant mortality appears to be driven by changes in the economic conditions.

Presented in this form, the model is a very suggestive tool and may, of course, constitute a serious informational base for analyses and discussions by the Turkish authorities to guide household waste policy. Accurate predictions of the household waste quantities produced can determine the successful planning and operation of a household waste management system in the country included in this study.

On the other hand, our results illustrated that the adult literacy rate supported a significant positive relationship with the household waste recycling rate, which implies that an increase in adult literacy led to a rise in the household waste recycling rate. It is well known that this relationship may be highly dependent on behavior (Abbasi *et al.*, 2013; Ripa *et al.*, 2017). The education level, awareness about related residential selective waste collection systems, and the income level are also the key determinants of the residents in Turkey (Şentürk *et al.*, 2016). With respect to the previous literature (Keser *et al.*, 2012; Abrate *et al.*, 2014), it is not surprising that the increase in literacy and awareness had a positive effect on the selective waste collection in our study.

From the economic point of view, the average price of the household waste parameter signified that a higher average price of household waste in Turkey was an indication of a rise in the household waste recycling rate (Bohm *et al.*, 2010; Dur and Vollaard, 2015). This also reveals the importance and scope of the research that is dealt with in this study, which seeks to model and optimize the assessment of household waste management in Turkey.

In light of the results obtained in this study, if the government recommends a policy for achieving the objectives of household waste recycling, then the objectives regarding the impact on human health must also be considered. In countries like Turkey, recycling is beneficial to both the environment and the economy, in providing cleaner raw materials, creating new jobs and stimulating innovation, and ensuring a cleaner and healthier environment for all. Accordingly, policies and regulations can play important roles in integrating and implementing household waste management programs. Finally, learning lessons from others can help Turkey take a better step towards household waste-to-energy processes in the near future.

In terms of limitations, there are significant differences in how to recycle household waste after sorting. This study did not take into account the household waste composition, which depends on several factors (*e.g.*, the geographical area, the climate zone and the total weight of residuals). Therefore, the results of the present study must be carefully interpreted because the available data cover only the household waste types, and this limited availability should be documented clearly in the next efforts to complement the data to cover all municipal waste. In Turkey, in the general framework of recycling policies, the emphasis is on high-volume residues that help to form a feeling built around a collective goal. This model might be improved if other methods of multi-criteria decision analysis were considered to enable the environmental decision making and sustainable economic growth planning. Also, there are many impediments to having an accurate assessment of the data on the adult literacy rate, as noted in a recent article by Turan *et al*. (2009), while infant mortality rate per 1000 births data has a low coverage.

For future research, and in order to obtain a better understanding of the underlying reasons for the dynamics of household waste management in Turkey, a qualitative analysis of the motivations behind the public awareness is needed. Nevertheless, we may conclude that their motivations could be different given the initiatives taken by the government for increasing levels of recycled household waste ratios in Turkey.

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