Waste and economic growth: lessons from EKC empirical framework

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Abstract:
This study applies the multiple imputation technique to re-examine the Environmental Kuznets curve (EKC) hypothesis for Municipal Solid Waste intensity (MSW) and tests the hypothesis of heterogeneity shapes in cross-country data for developed and developing countries. We use a panel data for 96 high and middle income countries over the period 1990-2010. The inverted-U shape does not characterize the relationship between per capita MSW and per capita income. Empirical results provide initial evidence that the income effect of economic growth on MSW is comparable in developed and developing countries. Parameter estimates suggest however that the economic growth has significant indirect effects on MSW through urbanization in developing countries. As concern developed countries, EKC framework is not adapted to capture environmental benefits from higher recovery rate.

Keywords: municipal solid waste, EKC, panel data, imputation method.

JEL classification codes : Q53, Q56

Introduction

As the twenty-first United Nations conference on climate change held in Paris (2015) point out it, environmental problematic has become a key challenge for all country. Beside the well-known international environmental problematic like climate change; scarce precipitation or polar ice melt etc., countries has also to face more national (and local) environmental degradation like municipal solid waste management (MSW). During the last two decades, MSW collected and their management cost have increased both in developed and developing countries. Furthermore, the World Bank estimated that in 2025, MSW management cost will be multiplied, compared to 2010 level, by 1.4 in high-income countries, by a range of 2.6 – 4.2 in middle-income countries and by 5.1 in low-income countries (Hoornweg & Bhada-Tata, 2012). Therefore, economists and policy makers are increasingly paying attention for MSW management and recovery. Then one important question is about the relation between MSW pollution and economic growth. Since waste generation is closely linked to consumption, which is very closely linked to income level, we may anticipate an increase of MSW generation with the increase of income level. However, this positive linked should be challenged by firms and consumer behaviors and/or by technological progress in product to reduce its waste component etc.

In order to shed light on the relationship between economic growth and environmental degradation[1], theoretical and empirical literature have studded the Environmental Kuznets Curves hypothesis (EKC) since 1990's [Grossman and Krueger (1991), Shafik and Bandyopadhyay (1992), Selden and Song (1995), Stokey (1998), Kelly (2003), Lieb (2004), Brock and Taylor (2010)]. The EKC hypothesis states that environmental degradation increases up to a certain level of income per capita, and then begins to decrease as the level of income per capita increases further. In other words, this hypothesis predicts that the "environmental income elasticity" decreases monotonically with income and that it eventually changes sign from positive to negative, thereby defining a turning point in the inverted U-shaped relationship. If the EKC hypothesis is corroborated, policy makers can consequently promote economic growth as a way of improving environment on the long run [Beckerman (1992), World Bank (1992), Panayotou (1993), Bartlett (1994)]. As a result, a large body of empirical studies has tried to find out whether or not environmental degradation rises with income at low-income levels, but falls at higher levels. In these studies, environment degradation is measured by

[1] Pollutions and resources depletion

pollutants indicators (air[2] and/or water[3] pollutants) and natural resources consumption or depletion indicators (lands, deforestation, fisheries, fossil energy, waste, etc.). For example, Cole (2004) estimates the impact of income per capita on air and water pollutants during the period 1980–1997 for a sample of OECD countries. He founds evidence to support the EKC hypothesis and the estimated turning point of income level is within sample income range for all pollutants except VOC[4] and CO_2. Kleemann and Abdulai (2013), and Lee et al. (2010) also examine the EKC relationship for natural resources consumption and air pollutants, respectively. Using a panel data for 90 countries, Kleemann and Abdulai (2013) valid the inverted U-shaped relationship for both developed and developing countries, and the set of developed and developing countries. Whilst Lee et al. (2010) find ambiguous results for CO_2, which is the mainly air pollutant analyzed in the literature. Actually, the nature of the environmental degradation analyzed seems to be determinant. Kelly (2003) and Lieb (2004) have showed that income-"flux pollutant" relationship and income-"stock pollutant" relationship may have different shapes. Further, the empirical evidence of the EKC hypothesis depends crucially on used econometric techniques (Nourry, 2007).

As point out by Mazzanti (2008 and 2009), empirical studies on EKC hypothesis as regards to the environmental waste indicators are very scarce, although there are many studies on other pollutants. The study of waste production in EKC framework is problematic because it concerns the two aspects of environmental degradation. First, its intensity, the quantity of MSW produced per habitant, is related to natural resources consumption in the economy and second, technologies used in its management is related to some pollutants. The amount of waste generated in an economy is an indicator of the efficiency of resource used in production and the quantities of goods produced and consumed. Also, the need to manage waste imposes pressures on environment (OECD, 2002). For example, landfilling and incineration in MSW management pollute air, soils, water, positively affect climate change (DEFRA, 2003).

Moreover, the EKC studies with MSW are more problematic than EKC studies with other environmental damage sources. The decreasing part of inverted U curve is theoretically explained by the development of more "green" production technology and the notion that when a country achieves a sufficiently high standard of living, people attach increasing value to

[2] SO_2: Sulphur Dioxide, NO_x: Oxides of Nitrogen, SPM: Suspended Particulate Matter, CO: Carbon Monoxide, CO_2: Carbon Dioxide.
[3] BOD: Biological Oxygen Demand, COD: Chemical Oxygen Demand, total coliform, heavy metals, etc.
[4] VOC: Volatile organic compounds.

environmental amenities and pays for clean technologies (Dinda, 2004). As concerns MSW, economic development can lead on the one hand to more "green" production function and then lower waste production but on the other hand, it can lead also to higher and better waste recovery system with the same production function. That is, with "greenest" production function, statistics based on collected MSW data must show the EKC hypothesis but if the recovery strategy is more important, the production of waste will not decrease and statistics based on collected MSW will not validate EKC hypothesis even if environmental damage decreased. Then from EKC methodology point of view, it is possible to have "recovery paradox" that is we can observe environmental progress everywhere through higher recovery rate but not in the EKC.

The present study's objective is to complete the existing EKC empirical literature on MSW intensity at cross-countries level by addressing two critical issues that produce bias in previous studies. The first issue concerns the slopes heterogeneity bias emphasized by Nourry (2007) and Dinda (2004). Previous estimations obtained from studies based on cross-sectional and panel database implicitly assume that all countries have the same EKC relationship. Nowadays, MSW data mainly allow for panel studies at cross-countries level. If panel estimations can help to deal with country-specific effects and endogeneity, results from wide panel including developed and developing countries may mechanically valid the evidence of EKC relationship for MSW. Indeed, developed countries are generally associated with a low variation in MSW intensity, while developing countries are associated with a high variation. Since no empirical study has concerned by developing countries at cross-country level (table 1), our study attempts to answer whether the relationship between MSW intensity and income is the same in developed and developing countries. Considering developing countries in our samples arises the second critical issue, which concerns the sample selection bias due to missing values. Regardless the increasing awareness of the external effects of MSW production and disposal, compilation of studies on EKC evidence of both MSW intensity and MSW management technologies has been constrained, mainly due to absence of data. Missing data problematic specially concerns developing countries, which are rarely involved in EKC studies[5]. To our knowledge, about fifteen studies focus on this problematic at macroeconomic level (Table 1). If missingness are not Missing Completely At Random (MCAR), estimation results for only observed values (listwise or complete cases) can be biased. MCAR hypothesis is hold when missingness patterns are unrelated to observed or missing values. So, to reach our objective and address these two critical issues, we provide estimations for 96 countries with a panel model over the period 1990-2010 by using Honaker and King (2010)'s multiple imputation model to deal with missing data.

This article is organized as follows. Section 1 presents a short summary of the empirical literature related to the application of the EKC to MSW intensity. Section 2 develops the model, describes the data and the econometric procedure, including the imputation method used for dealing with missing data. Section 3 is dedicated to the discussion of the results whereas the last section focuses on the conclusion and the policy implications of these results.

1. What do we know about MSW intensity and economic growth?

The empirical EKC literature dedicated to MSW intensity is recent and still incomplete (Table 1). A first wave of research has emerged in the mid-90. It mainly focused on *cross-country* analysis. Using cross-section or panel data analysis, these studies generally invalidate the EKC hypothesis and conclude that the production of MSW monotony increases with GDP. Only the recent study of Arbulú & al. (2015) supported the EKC hypothesis for European countries and estimated the turning-point at very high income level (45,000-52,000 euro/cap.).

More recently, another set of researches has emerged based on data at national, regional or urban level for a same country (within-country studies). These articles provide different conclusions than those relying on cross-country data. As a matter of fact, they all validate the EKC hypothesis. For example, Lim (1997), Song & al. (2008), Chen & Chen (2008), Mazzanti, et al. (2009), Ichinose et al. (2011-a and 2011-b) test the EKC for respectively South Korea, China, Taiwan, Italy and Japan on cross-session, panel and time-series data. They found the inverted U-shape relationship between income and MSW intensity, thus validating the EKC hypothesis. If we exclude Lim (1997) and Chen & Chen (2008) because of the very small number of observations, all the other studies highlight the existence of a turning-point. This point is located around the average income for the Japanese regions whereas it is located around the maximum income for Italian and Chinese regions. This suggests an absolute and relative decoupling respectively, i.e. there is more evidence of the existence of the decreasing part of the EKC in Japan than in Italy and China. Only Antczak (2014) confirms the inverted N-shape relationship between MSW intensity and income with sub-regional data in Poland and he finds that a majority of analyzed units is failed in the interval delimited by the two turning-points. Four sub-regions have achieved GDP level which is greater than the second turning point. In other words, there is a relative decoupling in Poland too. Ichinose et al. (2011-b) explain the difference between within-country studies and cross-section studies by the variation in MSW definition cross-country. They also support that geographical data aggregation inadvertently neglects the heterogeneity among municipality in the same country.

However, another way to explain this fact is that all countries do not have the same waste-income relationship. This is so called isomorphism or slopes heterogeneity hypothesis in cross-country studies. Nourry (2007) and Dinda (2004) argue that cross-section studies which include developed and developing countries should mechanically validate the EKC hypothesis, since low income countries are generally located on the increasing part of the curve; middle income countries are located around the turning point whereas high-income countries appear on the decreasing part of the curve. This isomorphism hypothesis is rejected by many authors for alternative pollution indicators (List and Gallet, 1999; Stern and Common, 2001; Lee et al, 2009; Lee et al., 2010) as well as for MSW intensity for European countries (Iafolla et al., 2010).

Other explanations for the mixed results with regard to the EKC assumption (Table 1) can also be found in the methodological issues: how income is measured (value added, taxable revenue, GDP per capita, final consumption, etc.); number and quality of control variables; the importance of the share of missing observations and how they are managed, etc. Eventually, it is interesting to note that both within-country and cross-country studies were focused on developed countries cases. Except Chen and Chen (2008); Song et al. (2008) and Shafik and Bandyopadhyay (1992), all authors in table 1 studied European or OECD countries cases. The model developed in the next section aims to fill this gap by proposing an appropriate and original methodology, especially regarding missing data and the selection of country groups.

Table 1: A summary of the empirical studies related to the MSW intensity-income relationship

Authors	Geographical focus and time period	Data	Nb. obs	Income indicator	Control var.	EKC assump
Within-country studies						
Antczak (2014)	Polish sub-regions (2005-2015)	Panel	528	GDP/cap (PLN)	yes	N-shape
Hossain & Miyata (2012)	Toyohashi city (1980-2005)	Time- series	26	Manufacturing, agriculture and trade output/cap.	yes	Valid
Ichinose et al. (2011-a)	Japanese municipalities (2005)	Cross-section	1,796	Taxable income/cap.	yes	Valid
Ichinose et al. (2011-b)	Japanese municipalities (2005)	Cross-section	1,798	Taxable income/cap.	yes	Valid
Mazzanti et al. (2009)	Italian cities (2000-2004)	Panel	515	Value added/cap.	yes	valid
Chen & Chen (2008)	Taiwanese county (1987-2003)	Panel	17	Income/household	yes	Valid
Song et al. (2008)	Chinese provinces (1985-2005)	Panel	-	GDP/cap	No	valid
Lim (1997)	South Korea	Time-series	11	GDP/cap.	yes	valid
Cross-country studies						
Arbulú et al. (2015)	European countries (1997-2010)	Panel	n.a.	GDP/cap.	yes	Valid
Iafolla et al. (2010)	EU_{15} (1997-2007)	Panel	195	Final consumption spending/cap	yes	Not valid
Mazzanti & Zoboli (2009)	EU_{25} (1995-2005)	Panel	275	Final consumption spending/cap.	yes	Not valid
Mazzanti (2008)	EU (1995-2000)	Panel	108	Final consumption spending/cap.	no	Not valid
Cole & Bates (1997)	OECD countries (1975-1990)	Panel	52	GDP/cap.	yes	Not valid
Shafik & Bandyopadhyay (1992)	Developed and developing countries (1985)	Cross-section	39	GDP/cap.	yes	Not valid

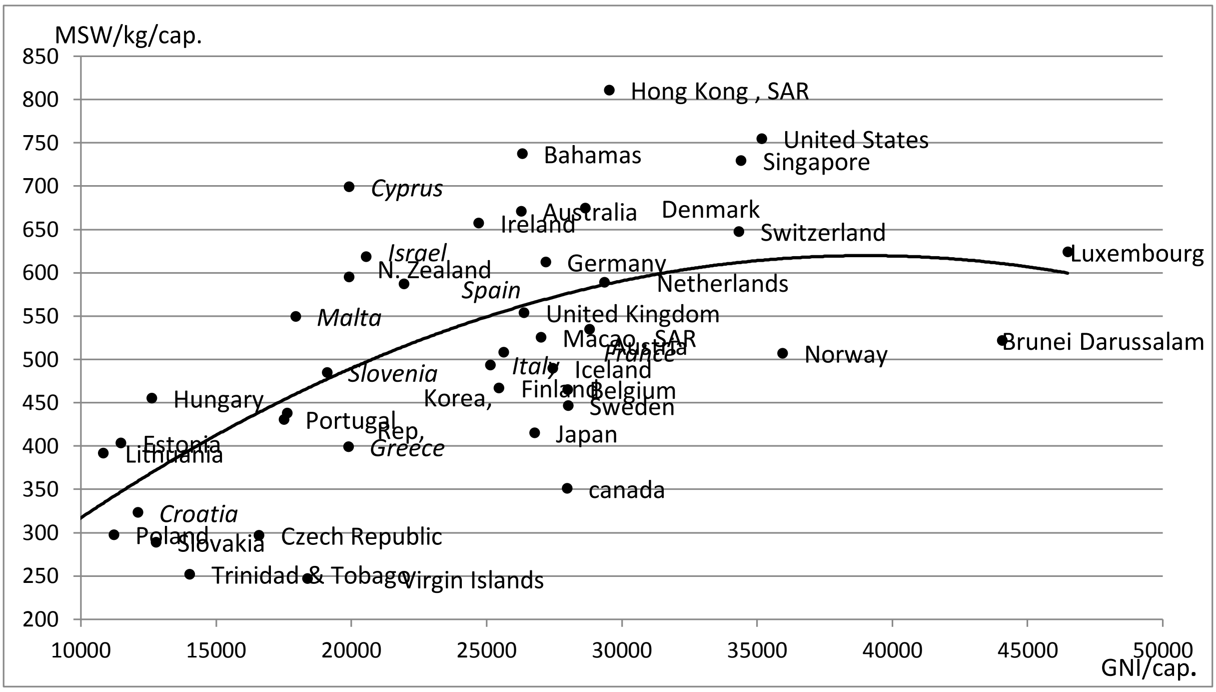
2. Data and empirical model

The dearth of MSW data leads us to gather data from three international sources, namely Eurostat, OECD and UN data-bases[6]. Our annual panel data cover the period from 1990 to 2010 for ninety six countries, which have at least one MSW observed data during this period[7]. MSW are measured by the MSW collected per inhabitant and per year, often called MSW intensity. In order to find out whether countries with different level of income have different relationships between income and MSW intensity, our sample is divided into two groups based on the World Bank income levels classification: 46 high income and 50 middle income countries. Table 2 summarizes descriptive statistics for our two groups.

The mean value of MSW collected per capita is 410 Kg/year when we consider all ninety-six countries of our sample (Table A1). However, this value increases with the income and ranges from 250 Kg in the middle-income countries group to 498 Kg in the high-income countries group. The graphical analysis (Figure 1 and 2) of the link between MSW and income level for each income countries group shows that this link is closed to inverted U-shape curve in high-income countries group whereas it appears to be linear in the middle-income countries. Further, Table A.1 and A.2 show that the coefficient of pairwise correlations for some explanatory variables (trade openness degree, working women, and density) has the opposite sign in two income groups.

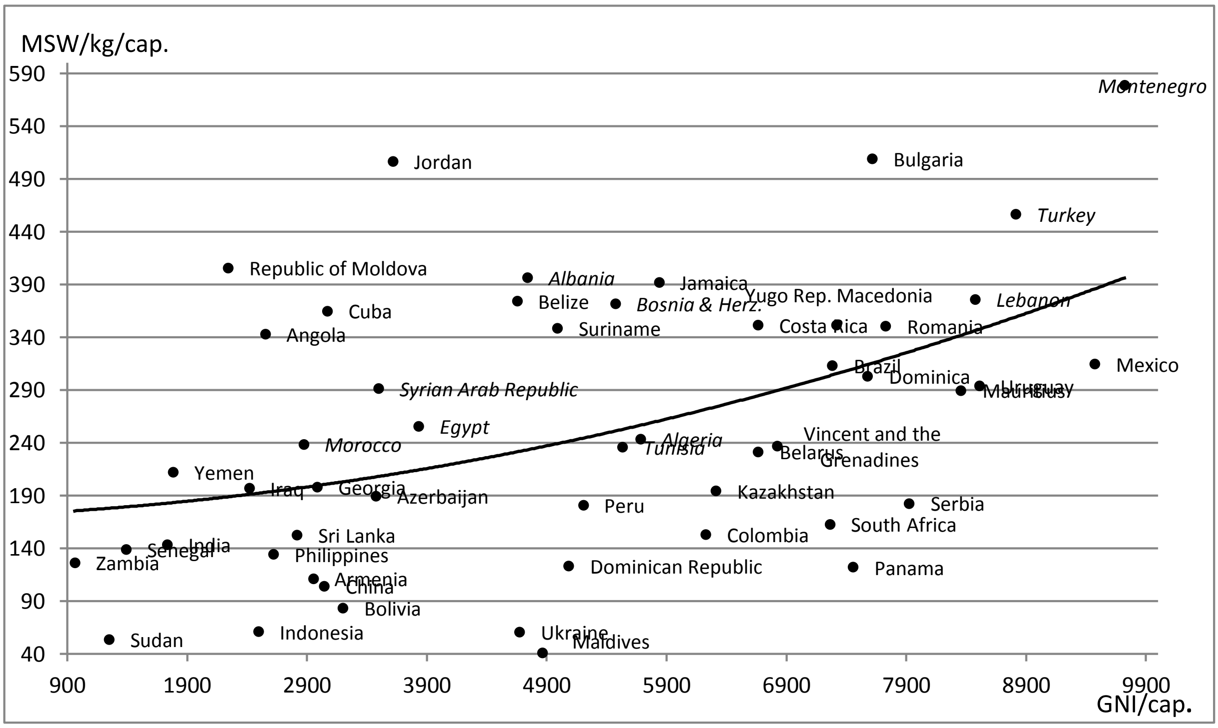
[6] These international sources have the same definition of MSW and use a joint questionnaire to collect data from national sources.
[7] Except Monaco, Kuwait, Qatar, United Arab Emirates because of their outliers of income level.

Figure 1: MSW and income relationship in high-income countries group [8]



Source: WDI, OECD, Eurostat and UN-data.

Figure 2: MSW and income relationship in the middle income countries group[9]



Source: WDI, OECD, Eurostat and UN-data.

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[8] Mean values for available data over 1990-2010. Note that Luxembourg and Brunei Darussalam appears like outliers but when they are deleted, the concave relationship between MSW and GNI/cap. does not change.

[9] Mean values for available data over 1990-2010.

To test the EKC hypothesis, we use the common quadratic specification[10] of the level of income per capita in empirical studies. This study establishes the reduced double-log form of the EKC model in panel framework as follows:

$$\ln MSW_{it} = \beta_0 + \beta_1(\ln Y_{it}) + \beta_2(\ln Y_{it})^2 + \beta_3(ln\, X_{it}) + \beta_4(\ln Z_{it}) + \beta_5(\ln V_{it}) + \beta_6 T_t + \beta_7 F_i + \varepsilon_{it}$$

Where MSW is the annual quantity of MSW collected per capita, Y and Y^2 refer to GNI/cap (in PPP US$) and its square, X represents the vector of economy composition and Z represents the trade openness. V refers to the vector of socio-demographic variables, whereas T, F are respectively the time and country fixed-effects and ε the error term. The indexes i and t denote country and time period, respectively.

Table 2: Descriptive statistics in each income country group (Mean over period 1990-2010)

Country group	High income countries				Middle income countries			
	Mean	S.d.	Min	Max	Mean	S.d.	Min	Max
MSW (kg/cap.)	498	149	102	961	250	148	15	785
Income ($ PPP/cap.)	22,916	11,198	4,270	67,990	4,936	2,994	680	15,530
Industry (% GDP)	30.73	9.54	7.38	74.11	31.80	10.87	10.29	84.37
Services (% GDP)	65.58	10.47	25.25	92.57	53.63	13.03	10.26	82.32
Trade openness degree	0.53	0.21	0.03	0.998	0.47	0.17	0.08	0.999
Working women (% pop)	51.10	8.15	26.7	71.7	43.21	16.10	8.9	75.2
Pop. aged 0-14 (% pop.)	19.88	4.36	11.51	35.38	31.43	8.83	13.50	53.02
Education	0.78	0.10	0.57	0.998	0.56	0.16	0.09	0.88
Pop. density	762	2,711	2	20,910	117	158	2	1,060
Urbanization rate	75.70	15.95	8.53	100	55.47	16.02	15.04	92.45

Source: WDI, Eurostat/UNdata/OCDE, S.d.: Standard deviation

The choice of other control variables is based on the extension of the existing EKC literature. These variables allow us to take into account the indirect effects of economic growth on the quantity of MSW collected (Holtz-Eakin and Selden, 1995). Indeed, they are endogeneous

[10] All empirical studies in table 1 used this specification.

consequences of economic growth and include the sector composition effects of Grossman and Krueger (1991), the international trade effects of Antweiler & al. (2001) and involving patterns effects such as urbanization, education, women activity, etc. All these variables are highly correlated to the GNI (Table A.1 and Table A.2) and they are fully described in Table 2.

As our main objective is to test the isomorphism hypothesis in panel analysis for developed and developing countries, we estimate the equation (1) with three samples: 1- complete sample with the set of 96 high and middle income countries; 2- only with the 46 high-income countries and 3- only with the 50 middle-income countries. As usual in the EKC literature, it is assumed that countries within the same income group share common endogenous characteristics with regard to the EKC. We estimate the panel fixed effects in order to control for country-specific factors that can affect MSW production. However, considering the middle-income countries in our samples arises the sample selection bias due to missing values. So, we use Honaker and King (2010) multiple imputation methodology to deal with this issue.

3. Methodology

Since database accounted numerous missing values especially for the middle-income countries, this study employs the multiple imputation technique proposed by Honaker and King (2010) to complete database and then to analyse the relationship between MSW intensity and income level. The type of missing data mechanism is important to apply relevant methodology for analysis. If data are missing completely at random then analysis can be performed without bias, but if data are missing at random (MAR) or missing not at random (MNAR) then the analysis with only complete cases leads to inefficient estimated coefficients. MAR hypothesis means that the probability of a particular observation being missing depends only on the observed data. In this case, the use of the multiple imputation approach is the most appropriate methodology to manage these data (King et al., 2001). It makes it possible to estimate missing observations while correcting the bias concerning the estimation of the variance (which is commonly found in simple imputations models) by accounting for the uncertainty related to missing observations. Basically, there are several models available for multiple imputations, e.g. Markov Chain, Monte-Carlo and Predictive Mean matching. Honaker and King (2010) have recently developed a model that combines the classic expectation-maximization algorithm and bootstrap approach for imputation for panel data.

This model can be summarized as follows. Starting from a matrix of data (D) which includes p variables (column) and n rows, each component x_{ijt} corresponds to the value of variable j $(j = 1, \ldots, p)$ for country i at year t. D includes both observed and missing variables. So, it's transformed into a matrix for missing values M and one for observed values D^{obs}. M is composed of elements which are equal to 1 if the observations are missing and 0 for observed values. In matrix D^{obs}, missing elements are replaced by zero: $D^{obs} = D * (1 - M)$ where the asterisk denotes an element-wise product. D is assumed to have a multivariate normal distribution: $D \sim N(\mu, \sigma)$ where μ and σ are the Gaussian unknown parameters (mean and standard deviation) and missing values are assumed to follow a MAR distribution. Consequently, the relationship between observed and missing values is a linear function as follow:

$$x_{ij}^{mis} = \beta_j x_{i,-j}^{obs} + \gamma_j t + \delta_{ij} + \delta_{ij} t + \epsilon_{ij} \quad (1)$$

Where x_{ij}^{mis} are the missing values which must be estimated for country i and variable j. $x_{i,-j}^{obs}$ are all other observed values for country i , except the variable j (we have omitted the time index for simplicity). β_j is the parameter corresponding to the cross-section between variable j and all the covariants (-j). γ_{jt} corresponds to the trend, δ_{ij} is the fixed-effect and δ_{ijt} is the interaction term between the trend and the fixed-effect. It makes it possible to specify the temporal trend for each country-observation. Finally, ϵ_{ij} is the error term of the model. Since D is made of p variables, the imputation model is also made of p equations, i.e. one corresponding to each variable. Finally, the unknown parameters μ and σ are estimated through iterative processes untill the convergence of the Expected Maximization (EM) algorithm (for additional details, refer to Honaker and King, 2010, p.576).

Table A.3 shows that 47% of the observations concerning the variable MSW are missing. The most numerous missing observations involve the middle income countries, although three databases have been used and combined, i.e. UN (1990-2009), Eurostat (1995-2010), OECD (1990-2010). Basically, the countries selected include all countries for which at least one observation of MSW is available over the period 1990-2010. As also observed in Table A.3, some independent variables include a significant number of missing observations. Dataset analysis shows that patterns of missing observations are monotone and missing mechanism is MAR (Missing At Radom). That means when the variable j_1 is missing, j_2 is always missing as well and the probability of a particular value being missing depends only on the observed data. Actually, missing data and variables are significantly correlated at 1% (table A.4)[11]. For example, missing data of the variable of MSW are highly correlated with observed values of GNI (-0.35), with observed values of the share of services in GDP (0.27) and with observed values of population aged 0-14 years (0.43).

According to the multiple imputation procedure, we select auxiliary variables[12] to help make the assumption of MAR more plausible and increase the predictive force of multiple imputation model. These variables presented in table A.3 are related to country-specific factor (climate), country size (GDP, international trade), country-governance (politic and civil liberties), and country-level sustainability (environmental degradation and environmental policy). Eventually, we impute five data sets with Amelia software[13] and combine the results of the econometric model with the Rubin (1987)'s rule.

4. Empirical results

This section presents the results of estimation of equation (1) for the relationship between income and MSW collected with listwise deletion and multiple imputations techniques. **Erreur ! Source du renvoi introuvable.** summarizes econometric results and tables A.5, A.6 and A.7 in appendix contain the detailed results for 96 countries as a whole (hereafter, sample-All), for 46 high-income countries group (hereafter sample-High) and for 50 middle-income countries group (here after sample-Mid), respectively.

Listwise deletion case

Listwise deletion results are from sample with only observable data which leads to the deletion of 47%-52%, 30%-38% and 65-68% of the observations, respectively, for the three samples used, then we have about 1000 observations of which a range of 336 to 373 are about developing country and a range of 664 to 676 are about high income countries (Table 3). We firstly note the relationship between income and MSW collected depends on the sample used with the listwise deletion technique. With the sample-All and sample-Mid, the EKC hypothesis is confirmed. The estimated coefficients of income per capita are positive and coefficients of

[11] We also run logit models to test if any other variables predict the probability that a given variable is missing and perform the t-test to see if the values of other variables vary between missingness groups. All results confirm the MAR hypothesis and are available on request.
[12] We carefully select the auxiliary variables in order to assure the convergence of multiple imputations model. We pay attention for the correlation between these variables and missingness and the percentage of the missing observations.
[13] The appropriate multiple imputation model is selected after several running of Amelia software and diagnostic tests of the results.

income square are significantly negative. This suggests that the quantity of MSW collected increases with the income per capita to a certain level and after that level, collected MSW decreases. In other words, the environmental quality improves with income level during the second stage of development. With the sample-All, the income peak estimated (turning point) decreases from 103,315$ PPP to 19,182$ PPP when we consider the effects of socio-demographic variables (table A.5). Only countries within high-income group have an income that falls in this peak range. Their income levels are included between 4,270$ PPP and 67,990$ PPP over the period under study. That is to say the improvement in environmental quality, through MSW prevention, is not yet attainable for the middle-income countries that have an income level greatly below the estimated turning points. This finding is confirmed by the results for the sample-Mid but not for the sample-High. Indeed, the turning points estimated for middle-income countries (20,653$ - 23,994$ PPP) is greater than the maximum income observed over 1990-2010 (15,530$ PPP); while the results for the sample-High show that the quantity of MSW collected monotonically increases with the income. Furthermore, the range of turning points for the sample-Mid is less wide than the results of sample-all (Table A.5 and table A.7). Considering separately the sub-samples of high and middle income countries allows to emphasize the difference in general tendency of MSW collected in developed and developing countries. Results with listwise deletion technique tend to validate the hypothesis of heterogeneity slopes.

As concerns socio-demographic variables measuring indirect effects of economic growth on collected MSW, the results with the listwise deletion technique show that only one variable has significant and robust effect on collected MSW: women labor participation rate, its estimated coefficient is significantly positive and stable cross samples. Higher women participation rate to labor market leads to higher collected MSW. Time dedicated to household works and particularly to cooking is reduced and thus families tend to consume more manufactured food and products which in turn leads to increase waste generation (Getahun & al., 2011). Another variable has a significant effect but non robust to alternative estimations. The share of child in population (pop. aged 0-14) has a negative coefficient, but only for the sample-All and for the sample-High and not for the sample-Mid. This result hold the theoretical assumption that the age has a positive effect on MSW generation, since consumption levels tend to increase as people grow older, at least to a certain point. Retired people produce less waste because they have more time on their hands to repair and maintain products for reuse (McCollough, 2012).

Table 3 : Summary of econometric results

	Listwise deletion			Multiple imputations		
	Sample-All	Sample-High	Sample-Mid.	Sample-All	Sample-High	Sample-Mid.
Income	+***	+**/ns[a]	+**	+***	+***	+***
Income square	-**	ns	-**	ns	ns	ns
Industry (% GDP)	ns	ns	ns	-**	ns	ns
Service (% GDP)	ns	ns	ns	ns	ns	ns
Trade openness degree	ns	ns	ns	ns	-*	ns
Working women (% pop)	+***	+**	+**	ns	ns	ns
Pop aged 0-14	-*	-*	ns	ns	ns	ns
Education	ns	ns	ns	ns	ns	ns
Density	ns	ns	ns	ns	ns	ns
Urbanization rate	ns	ns	ns	+**	ns	+**
N[b]	973-1049	664-676	336-373	2016	966	1050

[a] Not significant when working women variable is included. [b] depending on tested model (see tables A.5-A.7 in appendix for more details). * $p < 10\%$, ** $p < 5\%$, *** $p < 1\%$, ns: not significant.

However, the empirical studies that appraise the effect of this socio-demographic variable in the EKC framework, are limited. On the one hand, only three studies cited in Table 1 specify age as a determinant of MSW collection function [Mazzanti & Zoboli (2009) and Ichinose et al. (2011-a and 2011-b)] and on the other hand, the results depend on the age indicator used. Mazzanti & Zoboli (2009) find that the coefficient of the ratio of the population aged 60 years and over to the population aged 20-59 years is not significant. While Ichinose et al. (2011-a and 2011-b) show that age (measured as the proportion of households that are composed of the husband aged 65 years old of over and the wife aged 60 years old of over) negatively affects MSW collected.

Multiple imputations case

The multiple imputations technique implemented has permitted us to deal with the missing values bias and then the database is about 2016 observations for the sample-All and around 1000 observations for each country sub-group. The quantity of MSW collected has the same relationship with income regardless of the samples used and estimated coefficients are stable. The most interesting result shows that whatever the sample, the EKC assumption is rejected.

The relationship between income and MSW collected is positive and monotonous for our three samples, with an elasticity ranged from 0.2 to 0.4. This finding is comparable to the MSW elasticity estimated by Iafolla et al. (2010) and Mazzanti and Zoboli (2009). Compared to the listwise deletion method's results, conclusion about EKC hypothesis is more robust when we move from the left side to right side of Tables A.5, A.6 and A.7 and this especially for the high-income countries with the fewest missing data. To be more precise, with listwise deletion method, sample-All estimations are based on range of 973 to 1040 observations compared to 2016 observations with multiple imputations method, that is the double. For the high-income countries, correction of missing data concerns about one-third of observations compared to two-third observations for the middle-income countries. Then, we can not reject the hypothesis that results with listwise deletion technique are affected by the selection bias. As regard EKC methodlogy, our study illustrates how missing data affects conclusion and then underlines that we have to interprete carrefully results with cross-country data. However, EKC hypothesis is rejected for the high-income countries and this results is robust to model specification at cross-country level (Table 1). Relation between income level and MSW collected seems to be linear for the most developped countries. How can we explain this result ?

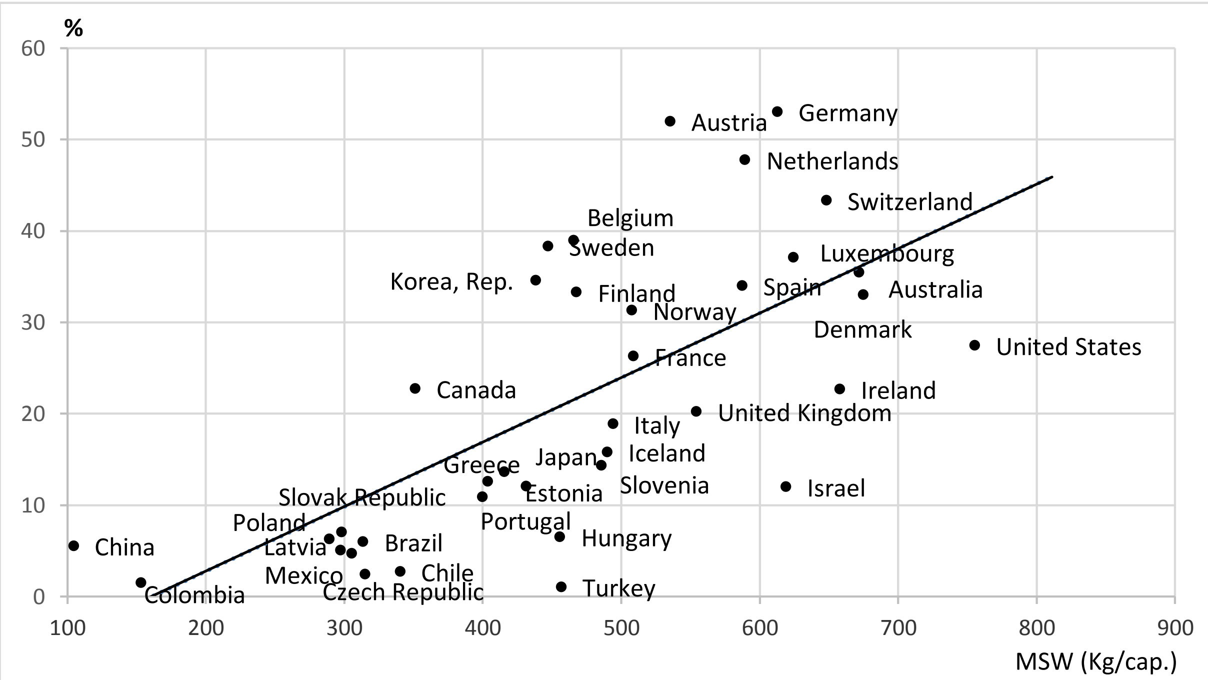
As pointed out by Holtz and Selden (1995), environmental regulation is an indirect consequence of economic growth. Since the beginning of the nineties, national governments and international organizations have promoted a number of environmental legislations and market-based incentives to internalize external effects of MSW production and management. This waste policy is oriented towards the MSW prevention and the promotion of recovery technologies as recycling, composting and incineration with energy recovery. However, MSW prevention remained the first priority for many developed countries (see for example the directive 2008/98/UE for European countries). Then, our results[14] suggest that public policies were most oriented towards MSW recovery rather than their decrease. This finding is supported by Figures 3 and 4 for OECD-countries. Figure 3 shows a positive correlation between collected MSW and the share of MSW recycled and composted during the period 1990-2010. Figure 4 suggests that waste policy efforts have provided stronger incentives towards increasing recovery (recycling and composting) than towards waste prevention. It shows that in most countries the recovery rate has sensitively increased during our study period. Then, in these

[14] We perform a sensibility analysis by rating the environmental sustainable policy on MSW intensity by using the Environmental Sustainable Index (2005) in a panel random effects. The coefficient of this variable is not significant. Results are omitted to save place but they are available on request.

countries the environmental damages from 1 kg of MSW has been reduced over the last two decades. The EKC hypothesis assumes that the only way the economic development can reduce environmental damages is to reduce the production of pollutant. But with MSW, recovery is a second way to reduce environmental damages and then EKC methodology is not adapted to shed on light this effect and faces to “recovery paradox”.

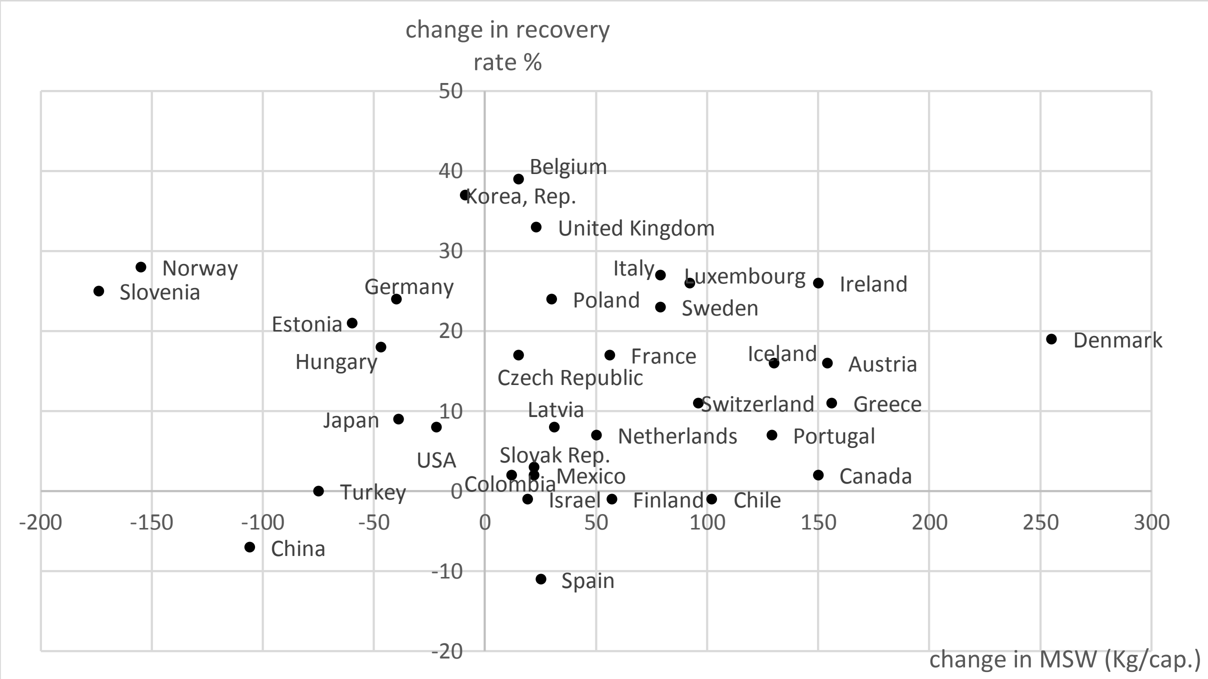
Main results regarding socio-economic variables are the following. Urbanization rate has a positive and significant effect on collected MSW for full sample and for the middle-income countries group but it has not significant effect for the high-income countries group. This result can illustrate two phenomena. First, it is well documented that lifestyle in urban area increases MSW production. For example, rural households have more options for in-house recycling, particularly for organic wastes, and then present less waste for municipal collection. This urbanization effect is not significant in the study of Johnstone and Labonne (2004) for OECD countries but it is significant in the study of Mazzanti and Zoboli (2009) for european countries.

Figure 3: MSW collected and share of MSW recovery (recycling-composting) in OECD countries



Source: OCDE, Eurosat, UN-data

Figure 4 : Change in MSW collected and in recovery rate (recycling and composting) over 1995-2010[15]



Source: OCDE, Eurosat, UN-data

The second effect could be called "statistical" effect, because the waste indicator analysed in this study is the quantity of MSW collected, and not the quantity produced. The "statistical" effect of urbanisation is related to the fact that in developing countries, the waste collection is better organized in urban area than in rural area and then the quantity of MSW collected is better measured in urban area than in rural area. In the region of Maghreb and Mashrek for example, the gap between the percentage of population deserved by municipal collection in urban and rural area is range from 25% to 82% (Arif, 2010). Consequently, when the urbanisation rate increases, the municipal collection rate and the quantity of MSW collected mechanically increase. Since, the urbanization rate increased 2.6 time more rapidly in the middle-income countries than in the high income countries (Figure A.1), both lifestyle and "statistical" effects have impacted collected MSW in developing countries. As regard to the developed country, the level of urbanization is yet very high, then lifestyle and "statiscal" effects are not significant for these countries.

[15] Austria, Chile, Estonia, Italy Iceland, Ireland Korea, Rep., USA (1995-2009), Canada (1996-2010), China (2001-2009), Colombia (2005-2008), Israel (2004-2010), Latvia (2001-2009).

5. Conclusion and policy implications

Despite the growing interest in examining the EKC hypothesis, few empirical studies are dedicated to MSW pollution. More precisely, the existing studies do not concern developing countries mainly because of lack of data. This study aimed to re-examine the relationship between income and MSW intensity for developed and developing countries by testing the hypothesis of heterogeneity slopes on cross-country scale in panel framework. Our analysis focuses on three questions: does MSW intensity follows the conventional inverted-U shape? Is this relationship the same in developed and developing countries? How missing data problem impacts results?

Firstly, missing values have an important impact since the results with listwise deletion technique is affected by sample selection bias. Moreover, due to "recovery paradox", EKC methodology fails to reveal the environmental progress due to higher recovery rate. Secondly, the results with multiple imputations method indicates that the EKC hypothesis does not hold neither for developed countries nor for developing ones, and both countries have a comparable income-waste relationship. This relationship is monotonous with an elasticity ranges from 0.2 to 0.4. Finally, our results suggest that the heterogeneity slope of income-MSW curve among developed and developing countries can be explained by the indirect effects of growth mainly by the effect of economy composition, the effect of international trade and an important lifestyle and "statistical" effect from urbanization in developing countries.

The main policy implication is that a reduction at source of waste generation must be explicitly pursued. In the short or medium run, economic growth cannot be used to reach this objective and alternative policies must be implemented, especially in developing countries because of the detrimental impact of urbanization on MSW pollution. These countries must carry out an appropriated and ambitious public policy dedicated to MSW. In this regard, they should start thinking about the efficiency of some incentive market-based policies applied in the developed countries (Extended Producer Responsibility and pay as you through system, tax on landfill waste, etc.). Developed countries are still far from waste prevention objective even if the environmental damages from 1 kg of MSW have been reduced by waste-recovery strategy over the period of our study. In any case, this may be seen as a second best of MSW policies in developed countries, considering that first that waste prevention is at the top of waste hierarchy, and secondly, and more important one, prevention at source is probably the most effective way to promote sustainable waste.

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Table A. 1 : Pairwise correlation for high income countries group

	MSW	GNI	IND	SERV	TI	WORK_WOM	CHILD	EDUC	DENS
MSW	1								
GNI	0.60	1							
IND	-0.46	-0.19	1						
SERV	0.53	0.36	-0.96	1					
TI	-0.05	0.07	0.29	-0.23	1				
WORK_WOM	0.16	0.29	-0.23	0.20	-0.16	1			
CHILD	-0.05	-0.19	0.35	-0.40	-0.03	0.08	1		
EDUC	0.23	0.44	-0.21	0.27	0.01	0.40	-0.31	1	
DENS	0.16	0.15	-0.28	0.34	0.11	0.05	-0.01	-0.17	1
URB	0.37	0.31	-0.41	0.41	-0.05	0.13	0.04	0.19	0.36

Table A. 2 : Pairwise correlation for high income countries group

	MSW	GNI	IND	SERV	TI	WORK_WOM	CHILD	EDUC	DENS
MSW	1								
GNI	0.45	1							
IND	-0.30	-0.12	1						
SERV	0.37	0.49	-0.74	1					
TI	0.11	0.12	0.30	-0.10	1				
WORK_WOM	-0.30	-0.05	0.12	-0.16	0.06	1			
CHILD	-0.30	-0.51	0.09	-0.18	-0.11	-0.22	1		
EDUC	0.29	0.56	-0.12	0.32	0.24	0.33	-0.76	1.	
DENS	-0.14	0.10	-0.21	0.24	0.05	-0.06	-0.04	0.01	1
URB	0.31	0.49	0.03	0.28	0.01	-0.10	-0.28	0.44	-0.32

Table A. 3 **:** Variables of imputation model

Variables	Definition	Mean	S.d.	Miss.	Sources
MSW	Waste collected per capita	410	190	47%	Eurostat/ OECD/ UN-data
GNI	Gross national income (GNI) converted to international dollars using purchasing power parity rates.	13,622	12,081	3%	WDI
IND	Industry, value added (% of GDP)	31.31	10	9%	WDI
SERV	Services, value added (% of GDP)	59.10	13	9%	WDI
TI	Intensity of international competition16 (%).	0.50	0.19	7%	WDI
WORK_WOM	% of the population aged 15 and older that is economically active.	47.10	13.40	3%	WDI
CHILD	Population between the ages 0 to 14 as a % of the total population	25.84	9.10	1%	WDI
EDUC	Educational HDI component[17]	0.67	0.17	9%	HDI
URB	% of population living in urban areas.	64.80	18.82	0%	WDI
DENS	Population density (people per sq. km of land area)	426	1907	0%	UN-data
IMP_PIB	Imports of goods and services (% of GDP)	45.93	27.40	4%	WDI
GDP	Gross domestic product (current US $)	3.80e+11	1.27e+12	3%	WDI
EXPORT	Exports of goods, services and primary income (BoP, current US$)	7.57e+10	3.35e+07	6%	WDI
LIB_POL	Index of the condition of political rights	2.82	2.13	3%	Freedom House
LIB_CIV	Index of the condition of civil liberties	2.93	1.82	3%	Freedom House
ESI	Environmental Sustainability Index (2005)	52.28	8.73	18%	(Esty, 2005)
MTF	Average daily temperature in °F	59.34	14.91	0%	WDI
CO2	CO2 emissions in metric ton/capita produced during consumption of solid, liquid, and gas fuels and gas flaring	5.86	5.04	4%	WDI
OTHER_GASES	Other greenhouse gas of hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride in thousand metric tons of CO2 equivalent	42,001	166,773	2%	WDI
WATER_URB	% of urban population with access to improved water source	96.76	5.80	3%	WDI
WATER_RURAL	% of rural population with access to improved water source	86.15	16.60	6%	WDI
SANI_FACIL	% of population with access to improved sanitation facilities	84.19	19.16	8%	WDI

[16] $TI = \frac{X}{GDP} + \left(1 - \frac{X}{DGP}\right)\left(\frac{M}{GDP+M-X}\right)$

[17] Human Development Indicator 2005-2010

Table A. 4: Pairwise correlation between missingness and variables at 1%

	Miss_ MSW	Miss_ GNI	Miss_ IND	Miss_ SERV	Miss_ TI	Miss_ IMP_GDP	Miss_ WORK_WOM	Miss_ CHILD	Miss_ EDUC	Miss_ LIB_POL
MSW	-	-0.06	0.03	0.03	-0.02	-0.06	0.02	-0.04	-0.10*	-0.05
GNI	-0.35*	-	0.07*	0.07*	-0.07*	-0.08*	-0.07*	-0.05	-0.15*	-0.09*
IND	0.07*	0.06	-	.	0.17*	0.20*	-0.15*	-0.14*	-0.04	0.08*
SERV	-0.27*	-0.05	.	-	-0.26*	-0.15*	0.05	0.05	-0.08*	-0.12*
TI	-0.12*	0.01	0.13*	0.13*	-	0.06*	-0.01	-0.01	0.06	0.156*
WORK_WOM	-0.16*	-0.05*	-0.05	-0.05	-0.01	-0.11*	-	.	0.04	0.01
CHILD	0.43*	0.05	-0.05	-0.05	0.01	0.10*	-0.07*	-	0.06*	-0.04
EDUC	-0.36*	-0.03	0.11*	0.11*	-0.03	-0.07*	0.03	-0.01	-	-0.01
DENS	-0.05	0.01	0.02	0.02	-0.04	-0.03	-0.03	-0.02	-0.04	-0.03
URB	-0.21*	0.00	0.13*	0.13*	0.02	0.04	-0.05	0.01	-0.07*	-0.25*
IMP_GDP	-0.03	0.02	0.12*	0.12*	0.05	-	0.06	0.05	0.14*	0.06*
MTF	0.32*	0.06*	0.01	0.01	-0.08*	0.09*	-0.00	0.09*	0.04	-0.01
LIB_POL	0.24*	0.07*	-0.04	-0.04	0.07*	0.07*	-0.04	-0.08*	0.13*	-
LIB_CIV	0.25*	0.06*	-0.00	-0.00	0.07*	0.07*	-0.09*	-0.11*	0.11*	.
GDP	-0.18*	-0.03	-0.05	-0.05	-0.05	-0.03	-0.04	-0.03	-0.09*	-0.05
EXPORT	-0.25*	-0.05	-0.05	-0.05	-0.03	-0.05	-0.06	-0.05	-0.13*	-0.08*
ESI	-0.14*	-0.10*	-0.09*	-0.09*	-0.09*	-0.19*	.	.	-0.14*	-0.16*
CO2	-0.22*	-0.03	0.11*	0.11*	0.10*	-0.04	-0.09*	-0.09*	-0.13*	0.16*
OTHER_GASES	0.03	-0.04	-0.07*	-0.07*	-0.03	-0.04	-0.02	-0.03	-0.07*	-0.05
WATER_URB	-0.22*	0.06	0.13*	0.13*	0.06*	0.09	0.04	-0.02	-0.20*	-0.00
WATER_RURAL	-0.30*	0.01	0.14*	0.14*	0.01	-0.05	0.09*	0.03	-0.04	0.04
SANI_FACIL	-0.27*	0.04	0.15*	0.15*	0.09*	0.03	0.05	-0.01	-0.05	-0.00

Table A. 4 continued

	Miss_ LIB_CIV	Miss_ GDP	Miss_ EXPORT	Miss_ ESI	Miss_ CO2	Miss_OTHER_ GASES	Miss_ WATER_URB	Miss_ WATER_ RURAL	Miss_ SANI_ FACIL
MSW	-0.05	-0.06	-0.02	0.21*	-0.07	-0.00	0.241*	0.26*	0.213*
GNI	-0.09*	-0.06	-0.06*	0.21*	-0.08*	-0.05	0.28*	0.25*	0.15*
IND	0.08*	0.24*	0.10*	-0.21*	0.10*	-0.07*	0.02	-0.00	-0.01
SERV	-0.12*	-0.19*	-0.20*	0.26*	-0.17*	0.03	0.10*	0.06	0.04
TI	0.16*	.	.	0.24*	-0.00	0.01	0.21*	0.22*	0.15*
WORK_WOM	0.01	-0.13*	0.10*	0.01	0.09*	0.03	0.06	0.07*	0.07*
CHILD	-0.04	0.07*	-0.06	0.00	-0.05	-0.08*	-0.04	-0.05	-0.04
EDUC	-0.01	-0.06	0.04	0.00	0.05	0.05	0.03	0.02	0.08*
DENS	-0.03	-0.03	-0.04	0.36*	-0.03	-0.03	0.65*	0.59*	0.41*
URB	-0.25*	0.03	0.02	0.14*	0.01	-0.07*	0.25*	0.25*	0.19*
IMP_GDP	0.06*	-0.02	0.04	0.50*	-0.02	0.03	0.27*	0.42*	0.17*
MTF	-0.01	0.05	-0.11*	0.36*	-0.06*	-0.08*	0.20*	0.21*	0.08*
LIB_POL	.	0.08*	-0.01	0.01	-0.02	0.01	0.34*	0.32*	0.23*
LIB_CIV	-	0.08*	-0.02	-0.04	-0.02	-0.04	0.30*	0.28*	0.18*
GDP	-0.05	-	-0.05	-0.13*	-0.04	-0.03	-0.05	-0.06*	-0.08*
EXPORT	-0.08*	-0.04	-	-0.12*	0.01	-0.04	-0.01	-0.00	-0.06
ESI	-0.16*	-0.16*	0.01	-	0.01	.	-0.07*	-0.04	-0.01
CO2	0.16*	-0.04	0.17*	0.06*	-	-0.01	0.11*	0.11*	0.07*
OTHER_GASES	-0.05	-0.03	-0.03	-0.11*	-0.03	-	-0.05	-0.06*	-0.07*
WATER_URB	-0.00	0.04	0.08*	0.10*	0.08*	0.07*	-	0.05	0.03
WATER_RURAL	0.04	-0.03	0.09*	0.19*	0.11*	0.09*	.	-	0.07*
SANI_FACIL	-0.00	0.04	0.11*	0.13*	0.11*	0.07*	.	0.07*	-

Table A. 5: Empirical Results for the set of the high and the middle income countries (sample-All)

Dependent variable : log MSW/cap./ year	Listwise deletion					Multiple imputation				
	1	2	3	4	5	1	2	3	4	5
Income	1.24**	1.22**	1.81***	1.73***	1.74**	0,41	0,32***	0,34***	0,32***	0,24***
	(0.39)	(0.43)	(0.42)	(0.39)	(0.56)	-0,38	-0,05	-0,05	-0,09	-0,06
Income square	-0.05**	-0.05**	-0.09***	-0.09***	-0.09**	0				
	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	-0,02				
Industry		0.04					-0,3**	-0,32**	-0,3**	-0,31**
		(0.19)					-0,14	-0,14	-0,14	-0,12
Service		0.19					-0,08	-0,1	-0,08	-0,06
		(0.30)					-0,19	-0,19	-0,19	-0,18
Working women			0.68***	0.74***	0.75***			-0,17		
			(0.18)	(0.16)	(0.20)			-0,23		
Pop aged 0-14				-0.38*	-0.38*				-0,01	
				(0.20)	(0.20)				-0,26	
Urbanization rate					-0.01					0,92**
					(0.33)					-0,46
Constant	-1.04	-1.73	-6.09**	-4.28*	-4.29*	2,37	4,09***	4,75***	4,15**	0,95
	(1.84)	(2.10)	(2.32)	(2.27)	(2.36)	-1,76	-1,15	-1,53	-1,82	-2,01
Turning point	103,315	87,566	35,179	19,182	19.230	-	-	-	-	-
N	1049	973	1040	1040	1040	2016	2016	2016	2016	2016
N_g	95	90	93	93	93	96	96	96	96	96
rho	0.90	0.90	0.92	0.93	0.93	0,49	0,5	0,49	0,5	0,51

* $p < 10\%$, ** $p < 5\%$, *** $p < 1\%$. Robust standard errors in parentheses. All insignificant variables neither in listwise model nor in multiple imputation model have been omitted to save place. R^2 are not shown as not highly meaningful as fit measure in panel settings

Table A. 6: Empirical Results for high income countries group (Sample-High)

Dependent variable : log MSW/cap./year	Listwise deletion					Multiple imputation				
	1	2	3	4	5	1	2	3	4	5
Income	-0.20	0.12*	0.19***	0.10	-0.02	0,69	0,24***	0,3***	0,27***	0,23***
	(0.98)	(0.06)	(0.05)	(0.06)	(0.10)	(1,3)	(0,06)	(0,05)	(0,08)	(0,08)
Income square	0.02	-	-	-	-	-0,02	-	-	-	-
	(0.05)					(0,07)				
Industry		-0.15					-0,21			
		(0.22)					(0,13)			
Service		0.29					0,16			
		(0.51)					(0,3)			
Trade openness degree			-0.15**	-0.07	-0.04			-0,13*	-0,13*	-0,12*
			(0.07)	(0.06)	(0.07)			(0,07)	(0,07)	(0,07)
Working women				0.77**	0.88***				0,3	
				(0.25)	(0.23)				(0,33)	
Pop aged 0-14					-0.38*					-0,26
					(0.22)					(0,22)
Constant	6.23	4.27	4.14***	2.10**	4.04**	1,29	3,79**	3,06***	2,17**	4,53***
	(4.86)	(3.00)	(0.54)	(0.83)	(1.44)	(6,43)	(1,64)	(0,51)	(0,88)	(1,36)
Turning point	-	-	-	-	-	-	-	-	-	-
N	676	601	664	664	664	966	966	966	966	966
N_g	45	41	45	45	45	46	46	46	46	46
Rho	0.79	0.78	0.80	0.85	0.89	0,31	0,32	0,3	0,34	0,34

* $p < 10\%$, ** $p < 5\%$, *** $p < 1\%$. Robust standard errors in parentheses. All insignificant variables neither in listwise model nor in multiple imputation model have been omitted to save place. R^2 are not shown as not highly meaningful as fit measure in panel settings

Table A. 7: Empirical Results for the middle income countries group (Sample-Mid)

Dependent variable : log MSW/cap./ year	Listwise deletion					Multiple imputation				
	1	2	3	4	5	1	2	3	4	5
Income	2.12**	1.91*	2.30**	2.57**	3.21**	-0,13	0,39***	0,4***	0,39***	0,28***
	(0.93)	(0.96)	(0.93)	(1.00)	(1.27)	(0,72)	(0,07)	(0,07)	(0,07)	(0,09)
Income square	-0.11*	-0.10	-0.12**	-0.13**	-0.16**	0,03				
	(0.06)	(0.06)	(0.06)	(0.06)	(0.07)	(0,04)				
Industry		0.29					-0,41**	-0,42**	-0,41**	-0,4**
		(0.28)					(0,19)	(0,2)	(0,19)	(0,19)
Service		0.29					-0,2	-0,23	-0,2	-0,17
		(0.38)					(0,25)	(0,25)	(0,25)	(0,24)
Working women			0.48**	0.67**	0.81**			-0,25		
			(0.23)	(0.23)	(0.27)			(0,24)		
Education				-0.25*	-0.17				-0,01	
				(0.14)	(0.15)				(0,13)	
Urbanization rate					-0.66					0,99*
					(0.67)					(0,58)
Constant	-5.04	-6.11	-7.68*	-9.96**	-10.76**	4,36	4,28***	5,17***	4,27***	1,04
	(3.85)	(4.11)	(4.25)	(4.44)	(4.18)	(2,97)	(1,39)	(1,86)	(1,35)	(2,56)
Turning point	22,812	21,170	21,012	23,994	20,653					
N	373	372	364	336	336	1050	1050	1050	1050	1050
N_g	50	49	48	46	46	50	50	50	50	50
Rho	0.86	0.87	0.89	0.91	0.93	0,47	0,48	0,45	0,48	0,48

* *p* < 10%, ** *p* < 5%, *** *p* < 1%. Robust standard errors in parentheses. All insignificant variables neither in listwise model nor in multiple imputation model have been omitted to save place. R^2 are not shown as not highly meaningful as fit measure in panel settings.

Figure A.1: Change in the urbanization rate