



The global economic and regulatory determinants of household food waste generation: A cross-country analysis



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ABSTRACT

Food is generally wasted all along the supply chain, with an estimated loss of 35 percent generated at the consumer level. Consequently, household food waste constitutes a sizable proportion of the total waste generated throughout the food supply chain. Yet such wastes vary drastically between developed and developing countries. Using data collected from 44 countries with various income levels, this paper investigates the impact of legislation and economic incentives on household food waste generation. The obtained results indicate that well-defined regulations, policies and strategies are more effective than fiscal measures in mitigating household food waste generation.

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1. Introduction

According to the Food and Agriculture Organization (2011) 1.3 billion tons of edible foodstuffs produced for human consumption – a third of the global food production – are wasted every year (Gustavsson et al., 2011). This is enough to lift one eighth of global population out of under-nourishment (FAO, WFP & IFAD, 2012) and mitigate global pressure on increasing food production to meet the projected increase of 50–70 percent in demand by 2050 (FAO, 2009). Moreover, the FAO (2014) estimates that 3.49 billion tons of CO₂-equivalent of greenhouse gases is generated by lost or wasted food along the supply chain. The same report estimates that the annual bulk-trade value of produced and unconsumed food is as high as \$936 billion.

Food wastage occurs at all stages along the supply chain, with 35 percent occurring at the level of final consumption (Lipinski et al., 2013). It varies drastically across countries, mainly depending on income, industrialization and developmental levels. In developing countries, more food (two thirds) is lost at the post-harvest and processing levels. This is mostly attributed to poor agricultural practices, technological, financial and labor restrictions, in addition to poor infrastructure for storage, processing and transport. On the other hand, in developed countries, a considerable fraction of food wastage rather occurs at the level of

consumption largely driven by consumers' values, behaviors and attitudes (Bond et al., 2013). Most of the food is wasted either after excessive cooking, preparation or serving (along with improper storage), as well as not being consumed in due time, a direct result of over-shopping that is driven by poor planning and impulse and/or bulk purchasing (Priefer et al., 2013; Bond et al., 2013; WRAP, 2007).

1.1. Economic incentives, legislations, food redistribution programs and awareness campaigns: solutions to fight food wastage

Various governmental, regional and local authorities around the globe have introduced regulatory and economic measures in an attempt to mitigate food wastage at the household level. In countries including the United States, Canada, Japan, Taiwan, Korea, Thailand, Vietnam and China 'Pay-as-you-throw' (PAYT) schemes are implemented (Herszenhorn et al., 2014). Such schemes involve a fee that is charged to consumers/households in proportion to their generated waste upon collection designed as a monetary incentive to reduce this waste. In Japan, a law to encourage reduction and recycling of food waste was enacted in 2001 (Herszenhorn et al., 2014). In a similar vein, in 2011 the European Commission set a target to reduce avoidable food waste by 50 percent by 2020 (Priefer et al., 2013). Furthermore, as part of the EU's Waste Framework Directive, member states are required to set mandatory targets for food waste reduction and devise prevention plans (Priefer et al., 2013).

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1.1.1. Awareness campaigns

Consumer's behavior regarding food and waste is affected to a great extent by the level of knowledge and education one has on these issues. For this reason, many civil societies have collaborated with governments and private actors to launch active awareness campaigns that aim to inform the public opinion on the problematic nature of food waste and useful prevention practices.

One of the most successful in Europe is the British "Love Food Hate Waste" campaign, operated by WRAP, a private non-profit company sponsored by governments across the United Kingdom and Europe. For the aim of providing consumers with tools to lower waste, WRAP works with a range of partners, such as private UK retailers and businesses, local authorities and communities (Priefer et al., 2013). Since its launch in 2007, the campaign claimed to have reached out to two million households in two years and helped them reduce waste, hence preventing 137,000 tons of food waste (Priefer et al., 2013). More recently, the LFHW campaign in West London contributed towards the reduction of avoidable food waste by 14 percent at the household level, in six months (from October 2012 until March 2013) (Priefer et al., 2013). WRAP has achieved a reduction of household food waste by 13 percent nationwide in the period 2007–2011, through public campaigns, in-depth research and services oriented to the recycling, reduction and reuse of food waste (Priefer et al., 2013).

1.1.2. Food redistribution programs

Redistributing surplus food that is still fit for human consumption contributes to reducing food waste and fighting food scarcity for underprivileged people around the globe. Charities such as 'FareShare' in the UK, 'Fondazione Banco Alimentare' in Italy or 'Die Tafeln' in Germany and Switzerland channel food donated by producers, manufacturers, retailers or actors in the food services to vulnerable people in need. In Australia, the non-profit organization 'Second Bite' links farmers and retailers with food banks and community groups, redirecting 3000 metric tons of fresh food in 2012 (Lipinski et al., 2013).

1.1.3. Economic incentives

The incentives being investigated in this paper are the landfill tax, incineration tax and "Pay-as-you-throw" PAYT schemes.

Landfill Tax is an environmental tax incurred by any company, local authority or other waste generators in exchange for the disposal of waste by landfilling. Most commonly, landfill operators are subject to the tax and costs are passed on to end users in the form of higher charges; local authorities—such as HM Customs and Excise in the UK—collect the tax. The main purpose of this tax is to shift waste away from landfills and promote more sustainable practices like recycling, through embedding the environmental costs of landfilling in its price.

In conjunction with the present landfill tax, incineration tax is a market-based solution that would first prevent the automatic switch from landfilling into incinerating waste and promote separation at source and recycling practices. In the absence of incineration tax where this disposal method is applied, efforts to recycle are often limited since authorities have liabilities to provide guaranteed waste quantities to incineration operators (Ares and Bolton, 2002).

PAYT charges fees according to the weight or volume of municipal waste upon collection. It gives households and businesses financial incentives to minimize the amount of food and drinks they waste, hence cutting down their expenses. These measures are best implemented by municipalities, at the level of local authorities or taken in charge by contracted private waste management companies. Nonetheless, prerequisites for these actions to be efficient are supportive public opinion that recognizes the

rationale of the fees they are paying. Also, fee rates should be carefully set, because if charges are too high they might encourage illegal dumping or burning of waste (Priefer et al., 2013).

As part of an EU-funded PAYT project, a study was carried out in 157 local authorities in the Czech Republic, with the participation of 2.6 million participants. Authorities were given the freedom to choose whether they will implement PAYT or a flat fee on waste collection in their areas. The 92 authorities that implemented PAYT system witnessed 12.1 percent recycling rate while it was only 6.9 percent with those who adopted the flat fee approach (Herszenhorn et al., 2014).

Economic instruments are counted as present in the model when either of the landfill tax, incineration tax and Pay-As-You-Throw scheme is in use.

To test for causality in the model, the occurrence of economic incentives is accounted for only if they have been set/put in practice before the estimation date of household food waste.

1.1.4. Policy and legislations

The impact of policies on food wastage is sensitive and complicated. Regulations and legislations can advocate and even impose food waste reduction strategies to achieve food waste prevention and reduction. For policy to be effective it needs to be comprehensive and flexible enough to involve all stakeholders in the food chain (FAO, 2013). On a more practical level, setting food waste, time-bound targets could raise awareness and mobilize institutional efforts into formulating and monitoring strategies regulated by legislations.

As we are interested in evaluating the impact of the effective policy actions on food wastage, we looked beyond the simple presence of waste and food waste related legislations to check for countries' defined targets, strategies or plans to stimulate and support the general legal framework in fighting household food waste. To this end, legislations are counted as present in the model whenever the general legal framework represented by waste-related laws or national acts or decrees is supported by specific actions such as strategies or targets or waste management plans, related either directly or indirectly to food waste (i.e. targets to reduce the land-filling of biodegradable waste). To test for causality in the model, the occurrence of legislations is accounted for only if they have been set/put in practice before the estimation date of household food waste.

This section presents examples of enacted legislations and strategies directed to lower food wastage.

Japan issued in 2001, the Law for the Promotion of Recycling and Related Activities for the Treatment of Cyclical Food Resources that targets the reduction of food waste generation and the promotion and support of food waste recycling into animal feed and fertilizers. To better monitor such action, data was collected from food manufacturing, wholesale, retail and services; businesses producing food waste of more than 100 tons, whereby they are required to report regularly the amount of food wasted as well as food that was recycled as feed, fertilizer, etc.; as for those producing less than the before mentioned amount are required to answer a sample survey to supplement the national data (Herszenhorn et al., 2014).

South Africa's Draft Waste Classification and Management Regulations of 2010 promotes composting of organic waste and aims to ban the landfilling of organic waste by setting criteria for the progressive restriction on waste disposal mechanisms (FAO, 2013).

Tackling another side of the food value chain, many countries enacted laws that protect food donors from civil and criminal responsibility regarding the food they donate, except where there is considerable negligence or intentional mishandling of food (FAO, 2013). The best known regulation of this kind is the United States of America's Bill Emerson Good Samaritan Food Donation

Act, enacted in 1996 and the Food Donation Act (2008) (FAO, 2013).

To define, impose and monitor reduction targets, Malaysia implemented the Waste Minimization Master Plan & National Strategic Plan for Food Waste Management in 2005, complemented by National Strategic Plan for Municipal Waste and Solid Waste Management and Public Cleansing Act in 2007 (FAO, 2013). The Plans set targets of 100 percent separation at source 20 percent recycling of organic waste by 2020 and discuss strategies for composting food waste and promoting the investments for alternative food waste treatments (FAO, 2013).

Sweden's 2012–2017 National Waste Management Plan sets targets for 20 percent waste reduction by 2015 (with 2010 baseline) and 40 percent recycling of food waste generated from households, restaurants, shops, etc., by the means of anaerobic digestion (FAO, 2013).

Yet despite the wealth of instances of such measures, their comparative effectiveness, to the best of the authors' knowledge, has not been systematically quantified, not least on a global scale. Accordingly, this paper examines data from across 44 countries to assess the impact of legislative, regulatory and economic measures on household food waste generation. This data has never been, to our knowledge, previously aggregated and compiled to perform comparative analysis.

2. Methodology

The effect of various policy and economic factors on average national household food waste (HFW) generation across 44 countries from eight different regions across the world (Table 1) was estimated by means of an ordinary least squares (OLS) regression, using STATA. The criterion to include these countries was based on the availability of quantitative information about HFW generation. To this end, a database was constructed consisting of the variables summarized in Table 2 and further econometrically analyzed in Table 3.

2.1. Data analysis

The available data on HFW quantities exhibit discrepancies at various levels. These are summarized below:

- i. *Data source/origin* – part of the information we gathered is based on primary data (weighting food waste or performing waste composition analysis), while another part was adapted from secondary figures taken from mass balances

Table 1
List of countries included in the cross country analysis.

Income group	Region	Countries
Medium & high income	North America and Oceania	Australia, USA, New Zealand
	East Asia	Japan, China, South Korea, Taiwan
	Europe	Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxemburg, Malta, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, The Netherlands, United Kingdom
Low income	Sub-Saharan Africa	Ethiopia, Lesotho, South Africa
	West Asia	Iraq, Turkey
	South and Southeast Asia	Malaysia, Nepal, Sri Lanka
	Latin America	Mexico

Table 2
List of variables included in the data analysis and their corresponding descriptions.

Variable name	Variable symbol	Description
LOG household food waste	LOG HFW	Natural logarithm of the annual quantity of household food waste generated, in kg per capita
LOG population	LOG_POP	Natural Logarithm of the population for the year of 2012
LOG gross national income	LOG_GNI	Natural logarithm of Gross National Income for 2012, in per capita terms and based on purchasing power parity (PPP)
Economic incentives	EI	Economic instruments are prevalent when either of the landfill tax, incineration tax and Pay-As-You-Throw scheme is in use. To test for causality in the model, the occurrence of EI are accounted for only if they have been set/put in practice before the estimation date of household food waste
Legislations	LEG	National legislations are present whenever the general legal framework represented by laws or national acts or decrees is supported by specific actions such as strategies, targets or waste management plans, related directly or indirectly to food waste. LEG are accounted for only if they have been set/put in practice before the estimation date of household food waste
Food redistribution programme	FRP	Prevalence of food redistribution programs as an indicator of waste reduction social initiatives
Awareness campaigns	AWAR	Prevalence of awareness campaigns as an indicator of waste reduction social and community initiatives to diffuse information on waste prevention and reduction practices

Table 3
Summary statistics of the various variables included in the OLS model.

Variable	Observation	Mean	Std. dev.	Min	Max
LOG_GNI	44	10.064	0.809	7.139	10.968
LOG_POP	44	16.529	1.667	12.947	21.024
LEG	44	0.500	0.506	0	1
EI	44	0.682	0.471	0	1
FRP	44	0.818	0.390	0	1
AWAR	44	0.659	0.479	0	1

(e.g. loss-adjusted national food availability data) or statistics (e.g. EUROSTAT for household food waste in some European countries).

- ii. *Geographic coverage* – some waste figures were collected at the national level while others were local/regional.
- iii. *Scope* – some studies quantify food directly thrown away by households whilst others consider household organic waste and kitchen leftovers as proxies for HFW; moreover, some waste figures include enterprises, public services, small businesses, among others, in addition to households.
- iv. *Food waste estimation methodologies* – data on food waste generation was collected using different approaches, namely household surveys, questionnaires/interviews, diaries, waste sampling and composition analysis, national waste audits, direct waste management, national statistics and mass balances; and finally.

Data collection period – the data collected in the 44 countries under consideration spans eight years (between 2005 and 2012).

2.2. Assumptions and restrictions on selected independent variables

Economic instruments are counted as present in the model when either of the landfill tax, incineration tax and

Pay-As-You-Throw scheme is in use. To test for causality in the model, the occurrence of economic incentives is accounted for only if they have been set/put in practice before the estimation date of household food waste data collected and included in the model.

Additionally, as we are interested in evaluating the impact of the effective policy actions on food wastage, we looked beyond the simple presence of waste and food waste related legislations to check for countries' defined targets, strategies or plans to stimulate and support the general legal framework in fighting household food waste. To this end, legislations are counted as present in the model whenever the general legal framework represented by waste-related laws or national acts or decrees is supported by specific actions such as strategies or targets or waste management plans, related either directly or indirectly to food waste (i.e. targets to reduce the landfilling of biodegradable waste). Similar to economic incentives, the occurrence of legislations is accounted for only if they have been set/put in practice before the estimation date of household food waste data collected and included in the model. On another note, data concerning the countries' gross national income (GNI) were adopted from The World Bank Statistics, except for Taiwan for which the data represents GDP per capita (adjusted to PPP) were taken from IMF's *World Economic Outlook (October 2014)*. Data on countries' population was taken from the World Bank Statistics. An extensive literature search was undertaken to collect the data on the presence of economic incentives, legislations, food banks and awareness campaigns (refer to Appendix 1 for a full list of references consulted to this end). GNI was treated as a continuous variable while *LEG* and *EI* and *FRP* and *AWAR* were accounted for by means of indicator variables.

3. Results and discussion

Through an iterative process, and starting with a large database of explanatory variables, we ran the OLS model and took out the ones that achieved statistical significance with at least 90 percent confidence, until we reached a working model. Once this has been done, we conducted a sensitivity analysis to check the individual response of HFW to each of the explanatory variables selected from the dataset. Regressions for *LOG_GNI* and *LEG* turned out to be significant at 95 percent confidence, and in both cases, the signs of the coefficients corresponded to the relative signs in the general model. Other variables were unfortunately not significant in one-by-one regressions; this is no doubt the result of the small data set along with high variance in the dependant variable. We acknowledge the limitations of this dataset and hope that future research will investigate the issue of Household food waste in more countries and promote the adoption of homogeneous quantification techniques.

For the comprehensive model, estimation results were interpreted with 90 percent confidence. In terms of model estimates, a positive and significant coefficient for *LOG_GNI* was obtained. This conforms to the expectations of economic theory; a 10 percent increase in 'per capita income' is associated with a 7 percent increase in 'per capita HFW' generation, all else being constant. Population appears to have a positive impact as well: as we can see, a 10 percent increase in population count induces a 1 percent increase in HFW/person on average: the model suggests that the surge in food waste patterns go above and beyond the proportionate rise in population. Additionally, the coefficient of *FRP* is significantly negative, suggesting that setting up food banks is a social measureable to encourage the reduction in HFW by 30 percent, since food is redistributed before it qualifies as wastage. Note that in the case of indicator variables (*EI*, *LEG*, *FRP* and *AWAR*), we need to estimate the percentage change in HFW associated with having

Table 4
Model estimation results for the OLS analysis.

LOG HFW	Coefficient	Std. error	t-Statistic	P > t
C	−4.417	1.227	−3.60	0.001
LOG_GNI	0.716	0.108	6.64	0.000
LOG_POP	0.142	0.354	4.02	0.000
LEG	−0.920	0.211	−4.36	0.000
EI	−0.572	0.196	−2.92	0.006
LEG−EI	0.557	0.258	2.16	0.037
FRP	−0.341	0.179	−1.91	0.065
AWAR	−0.253	0.144	−1.75	0.088

R-squared = 0.684.

Adjusted R-squared = 0.622.

the dummy variable, with all others held constant. The exact computation of the impact of having *FRP* is different than the coefficient that appears in Table 4 and is calculated as such: $\frac{e^{-0.341}}{e^{0.5 \times 0.179^2}} - 1$. The same applies for the other indicator variables (Giles, 2011).

Investigating awareness campaigns, we conclude from the significant computed coefficient (−0.23) that information diffusion about matters on food waste is negatively correlated with the amount of HFW generated per person, which shows that enhanced knowledge on the problematic nature and possible solutions to reduce HFW is an effective agent in the fight against food wastage.

In addition, the significantly negative coefficient for *LEG* implies that household food waste generation is 61 percent less in countries with defined legislative frameworks compared to those lacking, or having incomprehensive, ones. Similarly, but less effectively, economic incentives were observed to effect a reduction in HFW generation as per the negative sign of the coefficient observed for *EI*; according to our results, countries with established economic instruments would witness 45 percent less waste compared to their counterparts lacking any.

The 'main' effects of *EI* and *LEG* are both negative and significant, reflecting the impact of each variable in the absence of the other. Conversely, the interaction coefficient *LEG−EI* represents the additional impact, over and above the sum of main effects, of the presence of a legal framework supported by economic measures on HFW generation. Our results suggest that the combined effect of legislations and economic incentives, which is the sum of the computed coefficients of *EI*, *LEG* and *LEG−EI* (0.69), is not higher than the *LEG* main effect. In parallel, we note that while economic instruments reduce HFW by 45 percent in the absence of legislation, their impact drops considerably to a mere 1.5 percent when regulations and policies are both present. This leads us to suggest that the enforcement of food-waste-related legislation and regulation would be highly effective at reducing HFW quantities as a stand-alone policy framework (if of course adequately designed). Indeed such a framework would obviate the need for potentially burdensome economic measures that might come at a high monetary cost to consumers and municipalities.

4. Conclusion

The impact of legislations and economic incentives on global household food waste generation was evaluated using cross-sectional cross-country data from 44 countries at various developmental statuses. Accounting for the countries' income levels, the OLS model indicates that well-defined regulations, policies and strategies are more effective than fiscal measures against household food waste generation. Therefore, we contend that in the presence of effective and enabling legislative and regulatory frameworks, fiscal and economic incentives seem to have a limited added-value in reducing household food waste.

This being said, some caveats are warranted. In terms of data quality, it should be noted that the discrepancies between data sources (e.g. data collection methods, year of data collection, etc.) has resulted in many incongruences that could potentially limit the power of our estimated model. Moreover, our cross-country type of macro-analysis potentially overlooks many micro-determinants of household food waste generation that include, but not limited to, socio-economic household characteristics, and would include cultural predispositions, behavioral and attitudinal patterns and environmental awareness. Therefore, such global studies are best complemented with country or region-based data sourced from household surveys that would gauge all these factors.

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Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at <http://dx.doi.org/10.1016/j.wasman.2015.11.040>.

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