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ORIGINAL PAPER

Generation of food waste in the hospitality and food retail and wholesale sectors: lessons from developed economies

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Abstract
Food wastage is a major challenge in the global food value chain. In an attempt to explain and better understand the determinants of food waste across the supply chain, this paper closely examines the Hospitality, Restaurants and Canteens/Cafeterias (HORECA) as well as food retail and wholesale sectors, as being interrelated with the final consumer at the post-harvest and post-processing levels. Data from 33 developed countries in North America, Europe, Asia and Oceania were compiled from secondary sources and analyzed by means of a regression model in order to identify the macroeconomic factors contributing to generation of food waste in the HORECA industry at the national level. The results of our analysis suggest that a well-defined and inclusive legislative framework, awareness campaigns as well as fiscal incentives significantly reduce generation of food waste by an average of 17.6, 21.3 and 14.3%; respectively. Accordingly, these measures can be used in conjunction as effective schemes for controlling food wastage in the HORECA industry. On the other hand, non-legally binding initiatives by government authorities among other actors did not seem to have any significant impact on the food waste generated and quantities reported.

Keywords Food waste · HORECA · Fiscal initiative · Legislation · Legally non-binding initiatives

1 Introduction

Food is wasted across all stages of the supply chain, with an estimated 35% occurring at final consumption (FAO 2011, 2013; Lipinski et al. 2013). The amount of food wastage varies drastically among countries, mainly driven by income, industrialization as well as developmental level (Abiad and Meho 2018; Chalak et al. 2016). In developing or low-income countries, nearly two thirds of the food is usually lost at the pre- and post-harvest and the processing levels. This is mainly attributed to poor agricultural practices; technological, financial and labor limitations; as well as poor infrastructure for storage, processing and transport among other factors (Gustavsson et al. 2011). Alternatively, in developed countries, a considerable portion of food waste rather occurs at the consumption level and is largely driven by the consumers' values, behaviors and attitudes (Bond et al. 2013).

Furthermore, food waste has become a major ethical concern and its reduction a primary locus for policy action; indeed more than 925 million people worldwide are suffering from chronic undernourishment (FAO 2011, 2015; Oelofse and Nahman 2013). Food waste compounds the ethical dilemma and policy-making challenge, as it increases the global pressure to meet the growing demand for food while inefficiently using scarce resources, such as land, water and energy, while undermining the natural ecosystems (FAO 2014). In addition to its grave impact on the environment, economy and natural resources, food waste poses a serious nutritional security concern on the availability of food which was initially intended for human consumption but rather ends up wasted (Abiad and Meho 2018).

Although there is no conformity on the difference between 'food waste' and 'food loss', the Food and Agriculture Organization (FAO) differentiates between unintended 'food

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losses' early on in the supply chain and 'food waste' generated at the consumers' end and most likely to be the result of intended decisions (FAO 2015). While food waste includes unavoidable matters such as egg shells, pineapple skin, apple cores, bones, tea bags, coffee grounds among others, an important portion of it can be easily identified as 'wasted food'. This includes plate wastes in restaurants and homes as well as food bought but not consumed. Subsequently, the FAO excluded 'unavoidable' or 'inedible' material from the definition of food waste and limits it to good quality food along the value chain suitable for human consumption but ultimately discarded (FAO 2011; Gustavsson et al. 2011).

It is evident that food wastage exists at every stage of the food value chain (FAO 2011) and is mainly ascribed to mishandling as well as lack of coordination between the various activities from harvest and transportation, to manufacturing and storage, to distribution (Hodges et al. 2011). To these must be added the role of consumers' attitudes and behaviors in generating such wastes (Hodges et al. 2011). Beyond these direct reasons, several factors within the food supply chain, such as package sizes and sales promotions, play indirect roles by influencing consumers' behavior. Yet a lack of systematic evidence conceals the real reasons behind generation of food waste, presenting national and global challenges to efforts aimed at mitigating waste generation as well as measurement of their effects (Abiad and Meho 2018; Halloran et al. 2014; Parfitt et al. 2010). Although interest in food waste reduction and recovery has increased globally (Pearson et al. 2013; Platt et al. 2014), yet data and evidence on how to prevent food waste throughout the food supply chain – at both the pre-consumer level as well as at the retail and consumption levels – is relatively limited (Bond et al. 2013; Buzby and Hyman 2012; James and Ngarmsak 2011; Langelaan and Da Silva 2013; Lipinski et al. 2013; Quested et al. 2013; Stenmarck et al. 2011; Stuart 2009; Verghese et al. 2013, 2015). In this manuscript, we compile national data on generation of food waste in the hospitality and food retail and wholesale sectors to better understand the global determinants of food wastage along the food supply chain, complementing our previous work on global determinants of waste generation at the household level (Chalak et al. 2016).

2 Causes of food waste in the HORECA and retail/wholesale food sectors

Before delving into discussing the different measures adopted to reduce generation of food waste in the HORECA and retail/wholesale businesses, it is worth shedding light on some factors that shape this problem through examples from the sector under consideration. For instance, in retail, the major causes of food wastage are usually associated with oversupply of foodstuffs as a result of inappropriate projections of food demand (Monier et al. 2011a, b) and efforts to meet customers' needs for the provision of full display shelves in retail stores (Stenmarck et al. 2011). Consumers also tend to buy the freshest food products while steering away from those nearing "expiry", "best by" or "use by" dates (Priefer et al. 2013, 2016). Moreover, consumers often refrain from buying products they perceive as aesthetically flawed or appear imperfect (Stenmarck et al. 2011). Improper handling and storage of food items shorten their shelf life and subject them to early and quick spoilage. On the other hand, errors in packaging and labeling or cross-contamination and adulteration also contribute to food waste along the supply chain (FAO 2011; Monier et al. 2011b; Stenmarck et al. 2011).

On another note, generation of food waste in the hospitality sector – hotels, restaurants, cafeterias, pubs and catering services as well as workplace canteens, hospitals, schools, prisons and retirement homes – is mainly the result of standardized portion sizes which more often than not exceed the needs of individuals (Gunders 2012; Monier et al. 2011a). Other factors such as cooking practices and difficulties in anticipating demand are also among the contributors to increased food wastage (Monier et al. 2011b). In addition, in schools, mealtimes, fixed portion sizes and lack of motivation to improve quality increase such wastes (Monier et al. 2011b; Stenmarck et al. 2011). Similarly, the lack of autonomy over mealtimes, portion sizes and available menu choices in hospitals usually result in an increased quantity of discarded foods (Priefer et al. 2013).

3 Schemes to mitigate generation of food waste

Food waste in developed countries is generally related to consumers' behavior, as well as to policies and regulations that address such wastes. In response to food waste and in an attempt to mitigate it along the food supply chain in general and in the HORECA and retail/wholesale food sectors in particular, various social, regulatory, fiscal as well as business interventions have been implemented across different parts of the world. Examples of schemes designed to mitigate food waste in HORECA are provided hereafter. For a survey of measures mitigating generation of food waste in the household, see Chalak et al. (2016).

3.1 Awareness campaigns

Harnessing knowledge and education can be an effective way of influencing and changing individual behavior in such a way as to to reduce food waste. In this context, awareness campaigns emphasizing the problematic nature of food waste and highlighting potential management solutions have been keen on significantly affecting consumers' improvident behavior

(Lipinski et al. 2013). In Portugal, for example, LIPOR, a waste management company, initiated 'Menu Dose Certa' (i.e. 'the right size') with the aim of raising awareness and encouraging restaurants to serve balanced portions that are proportionate to what customers can eat. The goal of the project was to reduce restaurants' food waste by 48.5 kg per customer (FAO 2013, 2014; Priefer et al. 2013); subsequently, if restaurants met the specified criteria, they would receive the campaign's seal (Priefer et al. 2013). Another example worth highlighting is 'Poubelle.org', a Belgium site that raises awareness through treating waste with humor. The motto of the site is "I buy a product, I buy its waste" and thus provides the public with information on waste generation including food waste along with solutions for sustainable consumption patterns (Lords 2014). On the other hand, the Danish 'Stop Spild of Mad' campaign (i.e. 'stop wasting food') launched in 2008, tackles food waste mitigation through reaching out to children, consumers, communities and government agencies (Priefer et al. 2013). 'Love Food Hate Waste' is yet another example on the role of education in reducing the amount of wasted edible food. This initiative was developed by the local government of New South Wales, Australia, and provides grant funding to local government and community organizations to help them deliver education projects tailored for reducing food waste. Through social media and community engagement, Love Food, Hate Waste provides tips, advice and other practical resources which help businesses as well as households to reduce their food waste (Mason et al. 2011).

3.2 Policies and legislation

Policies and regulations can advocate the development of voluntary and even compulsory strategies aimed at reducing and/or preventing food wastage. In order to be effective, such policies need to be holistic, i.e. engaging all stakeholders along the food value chain, acceptable and easy to implement (FAO 2013). Acknowledging the scale and repercussions of the problems associated with food waste, some governments have attempted to address them through the development and adoption of policies and legislation which mainly target not only reduction but also recycling of these wastes. Similarly, these governments developed time-framed food waste reduction targets while raising awareness among stakeholders and hence directing their efforts more efficiently towards developing and monitoring national as well as regional waste-reduction strategies. The adoption of defined targets, strategies or waste management plans above and beyond the simple presence of waste and food waste related legislation is an essential element for successful policy implementation.

In 2009, food waste legislation in Ireland made food waste segregation compulsory for businesses, who were prohibited from disposing food waste in the residual waste collection service but rather had to use a specialized bin service which charged on a weight basis (FAO 2013). Similarly, in Scotland, the Ministry of Environment issued waste regulations in 2012 and implemented them in 2014 stipulating, among other items, that food businesses segregate food waste from other recyclables. These regulations ban incineration of food waste and by 2021 organic wastes will be diverted away from landfills (FAO 2013).

Legal action can also facilitate the process of donating food, as is the case in Belgium and other EU countries, especially when foodstuffs near their 'best before' date (O'Connor et al. 2014). Accordingly, a range of fiscal tools are being successfully used in support of saving edible food from being wasted. These initiatives include the abandonment of VAT liability and the use of corporate tax credits for donated food. Although one option is to consider the value of donated food as fairly low or zero for tax purposes, this may negatively impact Member States that offer a (percentage) corporate tax credit to companies on the value of food they donate, nullifying the value of that tax credit. On the other hand, it is suggested that "abandoning" VAT on donated food, rather than valuing donated food at zero, may be a more effective incentive, given its compatibility with other (potentially more significant) fiscal incentives such as tax credits which appear to be the most effective incentive for food donation (O'Connor et al. 2014).

Moreover, the Policy Document on Sustainable Food prepared by the Dutch Ministry of Agriculture, Nature and Food Quality in 2008 has set a food waste reduction target of 20% throughout the food chain, to be met by 2015 (The Ministry of Agriculture 2008). According to the Food Waste Monitor (Monitor Voedselverspilling) issued by the Dutch Ministry of Economic Affairs, this goal was not reached; on the other hand, a new goal to reduce food waste in The Netherlands by 50% by 2025 was established (Aramyan and Valeva 2016; EU Parliament 2012; Soethoudt and Timmermans 2013).

3.3 Legally non-binding governmental and non–governmental initiatives

Besides the legally-binding policies and directives, both governmental and non-governmental organizations and authorities in developed economies launched various initiatives in an attempt to mitigate generation of food waste in the HORECA and retail/wholesale sectors. However, in the most part these initiatives are legally non-binding by nature. In the following sections, we have highlighted a few examples of such initiatives.

3.3.1 Governmental initiatives

Many governments in the developed world have encouraged and developed non-compulsory programs that aim at controlling and mitigating generation of food waste. For example, in

2008 the 'National Waste Prevention Programme', a part of the Irish EPA, launched the 'Green Hospitality Award' (GHA) targeting the hotel and catering sectors. This program aimed at developing environmental best practices for the hospitality industry through setting measurement techniques and targets for waste reduction with a specific focus on food wastes while acknowledging top performers in the sector (European Commission 2015).

In Norway, the 'ForMat' project stands as the most significant initiative to address food waste in the retail sector, as well as for other stakeholders in the food value chain (ForMat 2012). The project, launched in 2009 and financed by the Norwegian ministries of the Environment and Agriculture, is a cooperative effort among the government, retailers, producers and research institutions to quantify and minimize food waste in Norway (Lords 2014). The ForMat project aims to assist in reducing avoidable food waste in Norway by 25% before the end of 2015 (Priefer et al. 2013, 2016).

Many governmental authorities issue guidelines to help businesses in adopting efficient measures to reduce generation of food waste. Some examples are Belgium's good practice guide for restaurants (Marthinsen et al. 2012) and Ireland's 2010 'Less Food Waste More Profit' that assists catering facilities in reducing generation of food waste by means of better food management (FAO 2013). Other guidelines include the United Kingdom's 2011 revised guidance on the application of food-related date labeling, the purpose of which is to clear consumers' misunderstanding of the meaning and safety implications of different date labels, as well as help businesses and retailers remove 'sell by' and 'display until' to avoid confusion and stop selling food after the 'use by' and not the 'best before' date (Lipinski et al. 2013).

3.3.2 Non-governmental initiatives

In the United Kingdom, members of the Food and Drink Federation made a commitment in 2010 to meet individual targets for food reduction and monitor their generation of waste and divert it from landfill. The final goal was to eliminate food waste sent to landfills by 2015 (FAO 2013). Two of the largest retail stores in the country adopted individual initiatives related to food waste total diversion from landfills through food donations, composting and recycling (FAO 2013). One of them, Marks & Spencer, achieved a 20% drop in its food waste in 2009 compared to the previous year by offering price discounts on products with a short shelf life (FAO 2013). The leading Finnish private canteen operator, Faser Food Services, launched and adopted in 2011 the 'Key Performance Indicator' system to track their canteen and restaurant operations. A weekly feedback on waste generation was also included, where a traffic light system designates whether the waste level is tolerable or not (Marthinsen et al. 2012).

In Italy, the COOP Group launched the project 'Buon Fine o Brutti ma Buoni' to recover food products that were not sold due to packaging defects or nearing expiry dates and donate them to associations and non-profit organizations. In 2010, the project was redistributing more than 2990 tons of food (Rutten et al. 2013). In an attempt to save shelf time in stores, retail sector players in Denmark made a general agreement to the effect that the biggest suppliers of bread, beverages etc. deliver products immediately to the stores instead of the company warehouses from where food is generally distributed (Stenmarck et al. 2011).

In France, the Inglorious Fruits & Vegetables campaign started by Intermarché in 2014 encouraged customers to buy odd-shaped or visually flawed fruit and vegetables that were 30% cheaper than regular items. The success of this initiative encouraged similar ideas around the world with Woolworth's Odd Bunch in Australia; Giant Eagle, Whole Foods and Walmart in the US; Loblaws and IGA in Canada; Tesco, Aldi and Waitrose in the UK; Delhaize in Belgium, Eroski in Spain; among many others (Di Muro et al. 2016; Figueiredo 2016).

3.3.3 Fiscal and economic measures

In this paper, we also investigate the impact of taxes (landfill and incineration) and fiscal incentives (tax credits/deductions and VAT exemption on food donations) on the wasteful behavior of hospitality and retail/wholesale businesses. Landfill and incineration taxes are environmental taxes that present market-based solutions with the aim of shifting waste away from landfills and incineration, respectively and promoting more sustainable waste disposal practices such as separation at source and recycling. The environmental costs of landfilling and incinerating food waste are embedded in the value of the taxes, which are generally incurred by any company, household, local authority and other waste generators in exchange for adopting such disposal methods. Most commonly, landfill site operators are liable for paying landfill taxes. However, they will pass the costs on to businesses and local councils on top of normal landfill fees. When waste incineration is practiced in a country but no incineration tax is imposed, recycling efforts decrease as authorities are obliged to provide determined and guaranteed waste quantities to incinerater operators (Ares and Bolton 2002).

In an attempt to overcome the economic barriers to food donations, many governments and local authorities introduced tax credits and deductions as well as VAT exemptions to incentivize food donors to redistribute food surplus instead of discarding it. In France, food donors can deduct 60% of the value of donated food from their income corporate tax, while in Spain 35% of the value can be claimed as corporate tax credit (O'Connor et al. 2014). Other countries treat food donations as a deductible tax expense that can reduce the taxable income subject to certain limits and thresholds. In Germany, donations in the form of cash or in-kind (donated food by supermarkets) are tax-deductible expenses, on condition that the deduction does not surpass 20% of the company's income (O'Connor et al. 2014). Portugal, on the other hand, has an elaborate tax deduction scheme that enables donors to subtract 140% of the value of the food at the time of donation, provided that the food is used for a social purpose (e.g. supplying food banks) and limited to 8/1000 of the donor's turnover (O'Connor et al. 2014). While some countries like Canada, Australia, Japan and Spain still impose VAT rates on donated food, others like France, Germany, Italy and Hungary have abandoned VAT liability on food donated to food banks and charities, if certain conditions are fulfilled (O'Connor et al. 2014).

Although examples of measures aimed at reducing food waste are abundant in the literature, to the best of the authors' knowledge their comparative impact on food waste within the HORECA and food retail/wholesale sectors has not been systematically quantified on a global scale. To this end, in the present work we have compiled and analyzed data from across 33 developed countries in order to compare and evaluate the impact of various schemes on mitigating the generation of food waste along the food supply chain.

4 Method

An ordinary least squares (OLS) model was used to estimate the impact of fiscal, regulatory and other legally non-binding measures and initiatives aimed at reducing the generation of food waste in the hospitality, food retail/wholesale sectors. The analysis was based on data compiled from 33 developed countries in North America and Oceania, East Asia and Europe summarized in Table 1. The availability of quantitative data on generation of food waste in the HORECA and retail/wholesale sectors served as the inclusion criterion while constructing the dataset. Since only one country from the low-income developing world (Sri Lanka) meets this criterion, we decided to exclude it from the dataset and restrict the study to developed economies. All the variables forming the dataset are itemized in Table 2, and their summary statistics depicted in Table 3. Furthermore, the quantities of food waste generated by the HORECA and retail/wholesale sectors for the countries that comprise our dataset are summarized in Table 4.

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

Region	Countries
North America and Oceania	Australia, USA, Canada
East Asia	Japan
Europe	Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxemburg, Malta, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, The Netherlands, United Kingdom

4.1 Data considerations and analysis

While searching for quantitative information on generation of food waste within the hospitality and food retail/wholesale sectors, we have observed certain issues we thought are worth mentioning regarding the collected data:

1. Data source/origin – Some countries such as the United Kingdom (Waste and Resources Action Programme (WRAP) 2013; WRAP 2007) and Finland (Katajajuuri et al. 2014) generate primary data by means of waste composition analysis, waste diaries, reviews and surveys, while others like the USA adopt secondary data taken from waste characterization studies (GMA/FMI 2012) or even base their evaluations on assumptions whenever national studies are missing. For example, European countries like Cyprus, Bulgaria and the Czech Republic use the assumption of 8.89 kg per capita per year in retail waste based on British, Danish and Swedish data (Monier et al. 2011b);
2. Geographical coverage – some figures represent national estimates, as is the case of Germany (University Stuttgart-Institute for Sanitary Engineering Water Quality and Solid Waste Management (ISWA) 2012), while others, such as Spain, data was collected at the local/regional level (O'Connor et al. 2014);
3. Scope – in some studies conducted in the UK (Waste and Resources Action Programme (WRAP) 2013), Denmark and Sweden (Marthinsen et al. 2012), figures for hospitality food waste include waste generated from the cost sector (i.e.: catering not intended for profit such as school lunch or staff catering in some companies), while in other cases only the hotel and catering sectors were considered, mainly due to lack of comprehensive data; this applies to the Netherlands for instance (NetherlandsNutritionCentre 2014). It is also worth mentioning that the data we have surveyed for this study does not distinguish between the causes of waste, and whether or not the wasted food was raw, cooked or processed. Accordingly, the study accounts for all food waste combined;
4. Timeframe – it is worth noting that the data points considered in this study were collected any time between years 2001 and 2013. It should be stressed that for any country, the observation collected pertained to any point in time within this range, depending on the availability of information that differed across countries. Moreover, our analysis was bound to be cross-sectional, as only one data point could be identified within this timeframe for most

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

Variable	Label	Description
Hospitality and retail food waste	log_waste	Natural logarithm of the annual quantity of Hospitality/Retail food waste generated, in kg per capita. Logging this variable was performed in order to control for the wide variations in the scale of these two variables in proportion to population size.
Gross national income	log_gni	Natural logarithm of Gross National Income for 2014, in per capita terms and based on purchasing power parity (PPP), at international dollars. Logging this variable was performed in order to control for the wide variations in the scale of these two variables in proportion to population size.
Size of accommodation and food services sectors	ac_fs	Share of sales of accommodation and food services to GDP in 2013 (%). Institutional facilities are excluded.
Fiscal instruments	fi	Fiscal instruments are prevalent when either tax penalties (landfill tax, incineration tax) or tax credits/deductions on food donations are in use. To test for causality in the model, the occurrence of FI are accounted for only if they have been set/put in practice before the estimation date of Hospitality/Retail food waste
VAT exemption	vatex	VAT exemption is another form of fiscal incentives where entities donating food are exempted the VAT on the value of the donations. VATex are accounted for only if they have been set/put in practice before the estimation date of Hospitality/Retail food waste
Legislations	leg	National legislation is prevalent when 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 Hospitality/Retail food waste
Legally non-binding governmental initiatives	init_gov	Legally non-binding governmental initiatives by national or regional authorities and of national/regional geographical scale in either the Hospitality or the retail sector. Excluded are governmental initiatives with limited audience and small-scale impact. Init_Gov are accounted for only if they have been set/put in practice before the estimation date of Hospitality/Retail food waste
Legally non-binding non –governmental initiatives	init_nongov	Legally non-binding non-governmental initiatives (from big players in the sector/ group of players/associations, organizations/ voluntary agreements) in either the Hospitality or the retail sector. Init_NonGov are accounted for only if they have been set/put in practice before the estimation date of Hospitality/Retail food waste
Legally non-binding governmental + non –governmental initiatives	init_all	This is the interaction term between Init_Gov and Init_NonGov
Awareness campaigns	aware	Prevalence of awareness campaigns as an indicator of waste reduction social and community initiatives to diffuse information on waste prevention and reduction practices. Aware are accounted for only if they have been set/put in practice before the estimation date of Hospitality/Retail food waste

countries. We have identified the expanse of this time range as a limitation and developed our model with this fact in mind.

As for data sources, data were made available partly from a previous study Chalak et al. (2016) that analyzed the regulatory and economic determinants of household food waste in which we investigated, among others, the effects of food waste awareness campaigns, economic instruments (landfill taxes, incineration taxes and pay-as-you-throw schemes) and related legislative frameworks on household generation of food waste. In addition, an extensive literature search was conducted to collect data on the presence of fiscal incentives (such as taxes and subsidies), legislation, legally non-binding initiatives as well as awareness campaigns in the various countries included in the sample. Information on per capita gross national income (GNP – adjusted to purchasing power parity – PPP – at current international dollars) in 2015 was adopted from the values available from the World Bank (2017). As for the share of sales of accommodation and food services (excluding institutional facilities) to GDP[1] in 2013 (except for Australia), references for European countries,[2] U.S.,[3] Canada,[4] Japan[5] and Australia[6] are included in the footnotes.

[1] GDP (current LCU) of 2013 taken from the World Bank Database

[2] Data comprises the turnover for accommodation and food service activity, taken from Eurostat (sbs_na_1a_se_r2)

[3] Data represents the estimated annual sales of accommodation and food services. Information is taken from the Monthly & Annual Retail Trade of United States Census Bureau database.

[4] Data represents the Gross Domestic Product for the Accommodation and Food Services (NAICS 72) and are taken from the Canadian Industry Statistics (CIS)

[5] Data represents sales of Food services (Otsuka 2015)

[6] Data represents income generated by cafes and restaurants, catering businesses, accommodation services and clubs, pubs and taverns and bars. Data is for 2006–2007 for all components except for clubs, pubs and taverns and bars (2004–2005). Source: Australian Bureau of Statistics- Hospitality Industries

Table 3 Summary statistics of the explanatory variables of the OLS model ($N = 33$)

Variable	Mean	Std. dev.	Min	Max
log_waste	3.340	0.377	2.651	4.174
log_gni	10.466	0.350	9.696	11.102
ac_fs	1.230	0.448	0.525	2.337
fi	0.727	0.452	0	1
vatex	0.091	0.292	0	1
leg	0.424	0.502	0	1
init_gov	0.273	0.452	0	1
init_nongov	0.303	0.467	0	1
init_all	0.151	0.364	0	1
aware	0.333	0.479	0	1

Fiscal instruments are present when either tax penalties (landfill tax, incineration tax) or tax credits/deductions on food donations are implemented. In order to minimize the effect of the variation in the time when the data was collected, the occurrences of fiscal instruments are accounted for only if they have been put in practice before the date of the latest estimate of hospitality/retail food waste. The same applies to VAT exemption and food waste awareness campaigns. Additionally, legislation follows the same assumptions as in Chalak et al. (2016), and is recorded as present whenever the overarching legal framework represented by waste-related laws or national acts or decrees is supported by detailed and traceable actions. This includes 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 the variables above, the occurrence of legislation is accounted for only if they have been put in practice before the latest estimation of hospitality/retail food waste included in the dataset.

On the other hand, legally non-binding governmental initiatives cover those implemented by national or regional authorities and with a national/regional geographical scale of impact, in either the hospitality or the retail sectors. Initiatives with limited audience and small-scale impact are not considered. In parallel, non-governmental initiatives include actions made by big players (or groups of players) in the sector, associations, and organizations in either the hospitality or the retail sectors. Governmental and non-governmental initiatives are accounted for only if they have been put into practice before the latest estimate of hospitality/retail food waste.

The natural log of Gross National Income (log_gni) and size of accommodation and food services (ac_fs) are treated as continuous variables while fiscal instruments (fi), VAT exemption (vatex), legislations (leg), legally non-binding governmental initiatives (init_gov), legally non-binding non-governmental initiatives (init_nongov), legally non-binding governmental and non–governmental initiatives (init_all) and awareness campaigns (aware) are included as indicator variables.

Table 4 Hospitality and retail/wholesale generation of food waste by country: data and sources

Country	Hospitality generation of food waste (kg/c/y)	Retail/ Wholesale generation of food waste (kg/c/y)	Hospitality and retail/wholesale generation of food waste (kg/c/y)
USA[1]	52.07	12.89	64.95
Australia[2]	39.89	7.23	47.12
Canada[3]	23.60	32.45	56.05
Japan[4]	15.10	11.33	26.43
Austria[5]	12.13	31.28	43.41
Belgium[5]	27.32	8.89	36.21
Bulgaria[5]	11.98	8.89	20.87
Cyprus[5]	11.98	8.89	20.87
Czech republic[5]	11.98	8.89	20.87
Denmark[5, 6]	14.21	8.10	22.31
Estonia[5]	18.70	8.89	27.59
Finland[7]	14.64	12.81	27.45
France[8]	16.31	17.37	33.68
Germany[9]	17.01	4.37	21.38
Greece[5]	27.32	8.89	36.21
Hungary[5]	11.98	8.89	20.87
Ireland[5]	27.32	8.89	36.21
Italy[5]	27.32	4.30	31.62
Latvia[5]	11.98	8.89	20.87
Lithuania[5]	11.98	8.89	20.87
Luxemburg[5]	27.32	8.89	36.21
Malta[5]	11.98	8.89	20.87
The Netherlands[10]	21.60	13.88	35.48
Norway[6, 11]	34.36	8.89	43.25
Poland[5]	11.98	8.89	20.87
Portugal[5]	27.32	8.89	36.21
Romania[5]	11.98	8.89	20.87
Slovakia[5]	11.98	8.89	20.87
Slovenia[5, 12]	6.77	8.89	15.66
Spain[13]	5.53	8.64	14.17
Switzerland[14, 15]	20.00	21.00	41.00
Sweden[6,] 16	36.12	4.02	40.15
United Kingdom[17, 18]	14.26	3.52	17.78

[1] GMA/FMI (2012); [2] Environment Protection and Heritage Council (EPHC) (2010); [3] Waste Not Waste Not Consulting (2013); [4] WARP (2015); [5] Monier et al. (2011b); [6] Marthinsen et al. (2012); [7] Katajajuuri et al. (2014); [8] Viel and Prigent (2011); [9] University Stuttgart-Institute for Sanitary Engineering Water Quality and Solid Waste Management (ISWA) (2012); [10] NetherlandsNutritionCentre (2014); [11] Gjerris and Gaiani (2013); [12] Laznik (2009); [13] O'Connor et al. (2014); [14] Beretta et al. (2013); [15] Switzerland (2012); [16] Eriksson et al. (2016); [17] WRAP (2007); [18] Waste and Resources Action Programme (WRAP) (2013)

5 Results

The results of the OLS model estimation are summarized in Table 5. The overall model fit is satisfactory with an R^2 of 73% which indicates that most of the variation in generation of food waste can be explained by the joint variation in our explanatory variables. We further investigated the normality of the error terms by implementing the joint/skewness normality test proposed in D'Agostino et al. (1990) and indeed could not reject the assumption of normality. We also investigated multicollinearity by looking at the variance inflation factors (VIF) of each of the regressors, and these ranged between 1.21 for 'ac_fs' (Size of accommodation and food services sectors) to 3.81 for 'init_all' (legally non-binding governmental + non–governmental initiatives). With all the VIF values comfortably below the threshold of 10 (Gujarati 2003, p. 362), high collinearity can be ruled out for any of the variables.

As for the model estimates, higher GNI appears to induce wasteful behavior in both the retail and hospitality sectors. In addition, the positive and significant coefficient for 'log_gni' suggests that a 10% increase in 'per capita income' is associated with a 6.1% increase in per capita generation of food waste, all else being equal. This is naturally correlated with consumers' purchasing power and attitudes that govern food consumption and waste generation. The results also conform to those previously obtained by Chalak et al. (2016), showing a positive impact of income on household generation of food waste.

Additionally, the coefficient for 'ac_fs' turned out to be significantly negative, suggesting that a 10% increase in the size of the hospitality industry (approximated by the sales of this sector to the country's GDP) decreases per capita food waste generated by around 1.8%. One possible explanation is that good management practices including food safety and waste are adopted more rigorously the bigger this sector is in any country. As to awareness campaigns, we deduce from the significantly negative coefficient for 'aware' that knowledge among retailers and actors in the hospitality industry about food waste (e.g. nature and composition of waste, causes and possible mitigation solutions) reduces the amount of food waste generated per person, and hence stands as an effective technique in fighting food wastage. The efficiency of awareness campaigns was similarly highlighted in reducing household food waste (Chalak et al. 2016).

Table 5 Model estimation results for the OLS analysis

Variable	Coefficient	Std. Error	t-value	*p* value
Constant	−2.660	1.236	−2.15	0.031
log_gni	0.608	0.118	5.14	0.000
ac_fs	−0.178	0.083	−2.15	0.032
fi	−0.149	0.086	−1.73	0.084
vatex	0.304	0.157	1.94	0.053
leg	−0.189	0.797	−2.37	0.018
init_gov	0.397	0.129	3.08	0.002
init_nongov	0.371	0.130	2.85	0.004
init_all	−0.853	0.181	−4.71	0.000
aware	−0.236	0.090	−2.62	0.009

N = 33; R^2 = 0.73; Adjusted R^2 = 0.63

Note that in order to estimate the percentage change in hospitality and retail/wholesale food waste associated with having the dummy variable, the exact computation of the impact of having the variable is different from the coefficient that appears in Table 5 and is calculated as $\frac{e^{\beta}}{e^{0.5*\sigma^2}}-1$ (Giles 2011; Halvorsen and Palmquist 1980), where β is the coefficient of the indicator variable and σ^2 its corresponding variance. This calculation applies to 'fi', 'vatex', 'leg', 'init_gov', 'init_nongov', 'init_all' and 'aware'. Therefore, our results suggest that awareness campaigns reduce generation of food waste in the HORECA industry by an average 21.3%.

As with household food waste (Chalak et al. 2016), a defined and inclusive legislative framework proved effective in reducing hospitality and retail/wholesale food waste. As results demonstrate, the significantly negative coefficient for 'leg' implies that in countries with comprehensive and proactive legislative frameworks, 17.6% less food is wasted compared to those with absent or non-comprehensive ones. Similarly and as effectively, the enforcement of fiscal measures – represented by taxes (landfill and incineration) upon waste generation and tax incentives upon food observed for 'fi'; donation – entail a reduction in generation of food waste as per the negative. Also the significance of the coefficient results show that hospitality and retail/wholesale industries in countries with either of these established fiscal instruments experience 14.3% less waste compared to their counterparts in countries lacking them.

Conversely, the case of VAT exemption on food donations is surprising in that the significant and negative computed coefficient of 'vatex' shows that generation of food waste in hospitality and retail/wholesale is actually 33.2% higher in countries that implement VAT exemption on food donations compared with others where donations are taxable. Intuitively, one would expect that this measure would decrease waste generation as businesses are incentivized to donate food instead of wasting it. Results are possibly explained by the way food waste quantities are reported in the examined countries, where many might measure and report food waste without excluding the portions to be donated from the results. Alternatively, 'vatex' might well be an endogenous variable since its implementation is precisely a response to, and hence a function of, too much food waste being generated in the HORECA sector. Discerning its true effect in reducing food waste might necessitate the use of more sophisticated regression tools that are not feasible with such a small sample size. Either way, we acknowledge the limitations of this dataset and recommend that food waste quantities be investigated in more countries and over longer time horizons, using more harmonized and consistent measurement and reporting techniques.

Similarly, legally non-binding initiatives appear to be counter-effective in the model, as per the significant and positive coefficients for 'init_gov' and 'init_nongov', suggesting that all else being equal, these initiatives actually increase food wastage. The 'main' effects of these two variables reflect the impact of each in the absence of the other. The interaction coefficient 'init_all' represents the additional impact, over and above the sum of the two main effects, of the simultaneous presence of both governmental initiatives and non-governmental initiatives on generation of food waste. Results suggest that the joint effect of governmental and non-governmental initiatives, calculated by adding the computed coefficients of 'init_gov', 'init_nongov' and 'init_all', is to decrease household generation of food waste by 12.5%; yet this result remains statistically insignificant. Therefore it seems that legally non-binding initiatives are counter-productive if each is considered alone and marginally effective at best when used in combination.

6 Discussion

It has been established that while in developing countries food waste is more likely to occur in the early stages of the supply chain, due to supply chain inefficiencies, developed countries typically experience waste at the end of the supply chain (Parfitt et al. 2010). In high-income countries, large quantities and varieties of food products are put on display in retail stores to please consumers' expectations with filled shelves and wide ranges of choices (Gustavsson et al. 2011). Based on our results, higher GNI appears to induce wasteful behavior in both the hospitality and retail sectors. This is naturally correlated with consumers' purchasing power and attitudes that govern food consumption and waste. Food may be wasted due to a number of structural, economic, personal or social issues, such as packaging (Verghese et al. 2013, 2015), inability to properly interpret the date label (Van Boxstael et al. 2014), lack of planning skills and habits related to shopping and utilizing leftovers (Stancu et al. 2016), feelings of disgust towards the thought of food going 'bad', anxieties related to food safety (Watson and Meah 2013), preferences over re-using leftovers (Cappellini and Parsons 2012; Graham-Rowe et al. 2014), or social norms and the consumers' perceptions towards doggy bags (Aschemann-Witzel et al. 2015). The results also conform to those obtained by Chalak et al. (2016), showing a positive impact of income on household generation of food waste.

As to awareness campaigns, our results suggest that knowledge among retailers and actors in the hospitality industry about food waste (e.g. nature and composition of waste, causes and possible mitigation solutions) reduces the amount of food waste generated per person, and hence stands as an effective technique in fighting food wastage. This is also evident in the successful "Inglorious Fruits & Vegetables" campaign conducted by Intermarché and replicated by many other retail chains across the globe (Figueiredo 2016). The efficiency of awareness campaigns was similarly highlighted in reducing household food waste (Chalak et al. 2016). Moreover, a defined and inclusive legislative framework proved effective in reducing hospitality and retail/wholesale food waste as in the case of households. Similarly and as effectively, the enforcement of fiscal measures – represented by taxes (landfill and incineration) upon waste generation and tax incentives upon food donation – entail a reduction in generation of food waste.

On the other hand, the case of VAT exemption on food donations is surprising. Intuitively, one would expect that this measure would decrease waste generation as businesses are incentivized to donate food instead of wasting it. However, our results show that generation of food waste in hospitality and retail/wholesale is actually higher in countries that implement VAT exemption on food donations as compared to others where donations are taxable. This is possibly explained by the way food waste quantities are reported in the examined countries, where many might measure and report food waste without excluding the portions to be donated from the results. Similarly, legally non-binding initiatives appear to be counter-effective suggesting that all else being equal, these initiatives actually increase food wastage. Our results also suggest that legally non-binding initiatives are counter-productive if each is considered alone and marginally effective at best when used in combination.

In terms of the validity of our results, a caveat is in order: we speculate that there might be an endogeneity problem with respect to some factors such as VAT exemption and legally non-binding initiatives. In either case, countries where such measures were enforced could be those which governmental authorities, businesses or organizations were alerted by the high and/or increasing wastage volumes in the hospitality and retail/wholesale sectors, even before solid reporting of waste quantities. Another explanation could be that the majority of the initiatives we have collected in our database are still relatively recent (most started seven years ago) and thus their coefficients may well be capturing short-term spurious effects. That is, we may well have a case where implementing these measures was a reaction to high food waste, with not enough time having elapsed before they in turn started affecting waste reduction as would be assumed by our model. Accordingly, data availability over the longer term could resolve this issue and hence is strongly recommended for future research in this field.

Further caveats include discrepancies in methods of collecting food waste data and procedures as well as the time span over which these values were collected. However, the model that has been constructed, using cross-sectional cross-country data from 33 developed countries, investigated the impact of various actions on the global hospitality and retail/wholesale generation of food waste. Moreover, the macro-economic analysis that was undertaken may have overlooked some micro-determinants of generation of food waste within the hospitality and food retail/wholesale sectors. These include, but are not limited to, country-specific price changes, cultural predispositions, as well as consumer and business attitudes towards food waste. For such global studies to be robust, they will need to be augmented with country or region-based data that would capture all these considerations.

7 Conclusion

This paper investigates the impact of various actions on global hospitality and retail/wholesale generation of food waste using cross-sectional cross-country data from 33 developed countries. Accounting for the countries' income levels, the OLS model indicates that well-defined legislative frameworks, awareness campaigns and fiscal incentives are effective measures in the fight against food wastage in the hospitality industry and food retail/wholesale sectors. Jointly deployed nationwide, they may well reduce generation of food waste in the HORECA sector by a half or even more. Future research should therefore investigate how such policy tools, usually designed and implemented by different entities that are often oblivious of each other, can best be designed as components of a comprehensive framework. This way, synergies between these components can be exploited to achieve further food waste reductions.

On the other hand, the fact that legally non-binding initiatives from governmental authorities and other actors did not seem to have any solid impact on the waste quantities reported did not come as a surprise to us, though more research is needed in this area to truly capture the effect of such initiatives. This is not a trivial point, for it supports with hard numbers the skepticism that has long been expressed against claims by many NGOs and the private sector that such 'soft' initiatives can be effective food waste reducers. We hope that this paper presents evidence in support of the centrality of the 'hard' public sector and state interventions to any food waste reduction endeavors, whether in the HORECA sector or the national economy at large.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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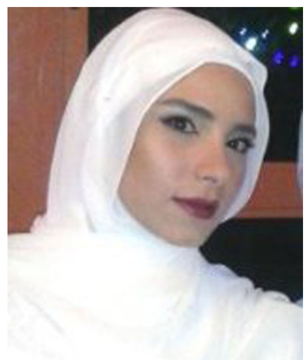

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