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Sustainable Governance of Coastal Areas and Tourism Impact on Waste Production: Panel Analysis of Croatian Municipalities

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Abstract: The research problem this paper is concerned with is the effect of tourism on solid waste generation in Croatia's coastal area. We are aware of the fact that this has not been thoroughly addressed, especially considering tourism's share in the Croatian economy and the pressure it generates on sustainable coastal management. This is of particular importance considering the governing complexity of coastal areas. Thus, we ask a simple question regarding the role of the tourism industry in the solid waste generation in the Croatian coastal area: Do tourists generate relatively more solid waste than the domestic population? The falsifiable hypothesis is stated in terms of the difference in the production of communal waste between domestic population and tourists, taking into account local idiosyncratic factors, when such a difference is recoverable through statistical analysis of measurable tourist presence in panel data. The first hypothesis is thus: The amount of solid waste produced by local residents in Croatian coastal municipalities diverges significantly in statistical terms from the amount of solid waste produced by tourists. The second hypothesis is: The amount of waste-streams is influenced by local idiosyncrasies of coastal settlements, their economic structure, per capita GDP and/or cultural background of local people. Our dataset is a panel of 160 municipalities in the Croatian coastal area spanned across a time period of 12 months during 2019, giving us a total of 1920 panel observations. We performed a Panel Estimated Generalized Least Squares cross-section fixed effects analysis with Panel Corrected Standard Errors on domestic population and tourist overnight stays and their solid waste generation. We used the above mentioned method to achieve better results with higher significance, and lower Standard Errors than comparable methods. We complemented the analysis with a dynamic Panel Generalized Method of Moments First Differences test. Results show a relatively larger relative impact of tourist overnight stays on municipal solid waste generation than what is to be expected from the locals only. Our different methods of analysis ended with non-contradicting results. The number of tourist overnight stays in some municipalities shadows the overnight stays of the local population as an indicator of solid waste generation, exacerbating the problem of sustainability of waste disposal. We conclude that the relative waste disposal impact of the tourists is at least 22% greater and possibly up to 55% greater than the one of local inhabitants, contradicting some other research. We also found evidence of possible Environmental Kuznets Curve behavior.

Keywords: sustainable governance; coastal zone management; solid waste generation; tourism

1. Introduction

Tourism is one of the major drivers of environmental pressure on the coastal area in Croatia, and the importance and consequences of tourism and tourist behavior on the environment is not to be neglected. Growth of urban settlements, due to growing tourism, challenges coastal ecosystems. Tourism creates pollution on land, at sea, and in the air. In Croatia, the sea bathing water quality on beaches is monitored during the bathing season. The air quality is monitored continuously during the year, and data about the quantities of the waste disposal is collected at the level of the municipalities. Waste generation is a global problem [1], and a problem in Croatia [2]. Nevertheless, to the best of our knowledge, the effects of tourism on solid waste generation in Croatia's coastal area has not yet been addressed, although the production of municipal solid waste in Croatia was a dependent variable in a previous study [2]. Considering that tourism shares in the Croatian economy, and the pressure it generates on sustainable coastal management, it is necessary to at least know the relative impact of tourism on waste creation and disposal. Tourism is strongly dependent on food processing, and over 30% of processed food is thrown away [3]. Restaurants are usually less able to manage their inventories against food being thrown away than a household is. If most of the disposed waste comes from processed food, it is not unusual that municipalities strongly specialized in tourism, have waste disposal problems that are not proportional to the number of inhabitants. Municipal waste disposal causes several environmental problems from excessive greenhouse gas emissions [4], plastic accumulation, and other pollution. One of the issues that exacerbates the problem of pollution through waste disposal is the fact that the entire Croatian coastline is characteristic of karstic landforms, extremely porous to pollutants, and subject to other forms of degradation due to waste disposal and other forms of soil pollution [5,6] making the waste disposal on karstic terrains also hazardous for tourists. The impact of tourism is important, considering the governing complexity of coastal areas. This study should be able to address this issue on a static and dynamic basis, and to obtain more robust results by combining the data about the number of tourists' overnight stays, the number of inhabitants represented as domestic population overnight stays, and quantities of disposed waste at the level of the municipalities' land disposal sites and landfills.

We propose two hypotheses for the analysis. The first: The amount of solid waste produced by local residents in Croatian coastal municipalities diverges significantly from the amount of solid waste produced by tourists. The second: The amount of waste streams is influenced by the size and location of coastal settlements (city or rural), and the per capita income (above or below average), consistent with an Environmental Kuznets Curve hypothesis.

2. Literature Review

A coastal zone is a complex and fragile environmental system [5–7]. Sustainable Governance of Coastal Areas in Croatia needs to account for the impact of tourism on solid waste generation. Beigl et al. [8] stress the importance of environmentally relevant outputs from human processes and regional characteristics as a prerequisite for planning and implementing ecologically sustainable strategies. Tourism is one such human activity, with both positive and adverse economic, environmental, and social consequences [9]. An understanding of positive effects, as well as unintentional positive and negative externalities, is essential for planning, management, and policy determination [9]. Therefore, an integrated coastal zone management [8–11] is often advocated, with 'integrated' meaning an integration of all relevant stakeholders [12], with the coastal zone being a complex economic good [10]. One of the special cases of integrated coastal zone involving the growing problem of plastics disposal is analyzed by [13].

Waste management in major European cities was analyzed in [14] and in the tourism sector in [15]. A specific weight in agro-tourism of two regions in Romania and Italy, was considered as a case study in the paper by Giurea et al. [16] in order to promote good practices and actions for sustainable municipal solid waste management. The authors suggest and analyze criteria for the adaptation of sustainable consumption of beverages and food and for the sustainable use of packaging of various types. For this, the authors propose the adoption of a single indicator [16].

Chaabane et al. focused on solid waste generated by the tourism industry in Tunisia [17]. Their finding is that waste generation doubles during summer in most large tourism cities like Hammamet, and complicates its management. Municipalities lack financial means to ensure sustainable Solid Waste Management (SWM) in tourist areas, and need an intervention from all actors to reduce financial and technical pressures and implement sustainable solutions. The authors propose a collaboration of different stakeholders with stronger material recovery through recycling, supporting the system. In numbers, of the 2.8 million tons of municipal solid waste generated in Tunisia, only 20% to 30% being recyclable, the total recycling does not exceed 5%, making waste management inefficient and unsustainable [17]. So, recycling is the primary determinant of an efficient SWM. Godfrey at al. analyzed recycling policies within the SWM hierarchies in South African policies [18]. Their focus was on compliance competitiveness in local and global markets. Large and active informal waste sectors, specializing in SWM, have formed across the country in the absence of separation at source, but also find it difficult to be more efficient when faced with gated communities. The authors define the South African SWM sector in terms of four main stages of development: (1) Landfilling; (2) Emergence of Recycling; (3) Regulation; (4) Extended Producer Responsibility (EPR); and, just emerging, (5) The Circular Economy [18]. In the field of SWM, extended producer responsibility (EPR) is a policy to include the costs from negative environmental externalities associated with a product through its life cycle. Social, economic and environmental benefits of internalizing the social costs of such negative externalities, according to the authors and with our full intellectual support, must be balanced against the costs of doing so, and these costs are ultimately borne by the society, as the final consumer. Thus, a comprehensive cost-benefit analysis is indispensable for efficient SWM. The paper by Falcone [19] is aimed at eliciting, by means of a multi-level perspective, potential drivers and barriers of the tourism industry in order to generate valuable information for policy makers to improve policy strategies for an effective transition towards sustainability. Sustainability evaluation of MSW systems for Hanoi (Vietnam) and the choice of the 'Waste-to-Energy' concept as a criterion of efficiency of the circular SWM as in Hoang and Fogarassy [20]. They [20] recently tried to determine the best sustainable solid waste management system for Hanoi from the ones proposed by the World Bank. They compare four alternatives: Firstly, improving waste collection and transportation; secondly, reducing, reusing, and recycling waste at source; thirdly, mechanical–biological treatment; and lastly, mechanical–biological treatment for classifying, composting, and use in waste-to-energy/incineration plants. According to the analytic hierarchy process, the mechanical-biological treatment plants have the highest ranking in terms of sustainability. Thus, the authors have proposed a comprehensive management system according to criteria-based analytics [20].

Malinauskaite et al. [21] focus their research onto the identification of different practices of municipal waste management employed in selected EU member states and their circular economy approaches. Urbanization and more demanding standards of living lead to increased generation of waste. The authors [21] propose to use the approximately 10 MJ of available energy per kg of waste by deriving fuel or in incineration processes, and thus, minimizing waste and resource use, and additionally, generating energy in the form of electricity and/or heat. Besides waste to fuel and waste to electricity generation, some authors [22] reviewed management of solid wastes using solid-state fermentation in the production of fuels. This could, at least in part, alleviate the problem of competition between food production and biofuel production from food crops, simultaneously avoiding the negative external effects from incineration in form of air pollution. Moreover, it is not clear whether incineration is a cost-effective method. Organic waste in traditional landfills is broken down by microorganisms and forms leachate that can contaminate the groundwater [22]. These insights could help in creating future SWM policies for Croatia. Coastal karstic terrain is not adequate for the filtration of leachate which could quickly and easily contaminate the groundwater and show on beaches, adversely affecting the health of people and the tourism industry, creating a boomerang effect [5,6]. Thus, failures in waste management may lead to environmental and public health hazards [22,23]. Solid-state fermentation is presented as a potential technology for waste valorization through conversion of organic wastes into substrate [22–24]. Every method has its pros and cons. The methane produced from solid-state fermentation, if not captured and burned, is several times more dangerous as a greenhouse gas than carbon dioxide [25].

Different sources, in terms of households or industries, produce different types of solid waste. This created a need for classification of Municipal Solid Waste (MSW). Buenrostro et al. conceptualize the classification of solid waste generated within the territorial limits of a municipality, independently of its source of generation. Based solely on economic activity, they create a hierarchical source classification of MSW. The classification recognizes: residential, commercial, institutional, construction/demolition, agricultural–animal husbandry, industrial, and special categories [26]. A classification of MSW should enable an easier assessment of the volume and type of MSW generated, in a municipality, region or state [26–28]. Nas et al. [27] were able to present a general overview of current MSW management in Gümüşhane Province, Turkey, with a detailed percentage of its components as well as specific weight, composting parameters, organic matter content, calorific value and heavy metal concentrations. Such an analysis is useful to us, as our two countries share a common karstic underground. Under assumptions of similar tourist behavior, any information about heavy metal concentration in MSW may give us valuable insights for our MSW management policies.

For the purposes of economic efficiency, detailed cost-benefit analyses are necessary, encompassing not only private but also social costs in the form of negative externalities and opportunity costs from non-realized opportunities. To internalize negative externalities from solid waste generation, the European Union legislation has introduced an Extended Producer Responsibility (EPR). This introduced a complex system of financial transfers that have a function of incentives for the industry and the local community, ultimately being responsible for the separated collection of waste and its recovery [2]. The role of the circular economy on economic development and economic growth in Croatia was discussed in several papers [2,29,30], and for us, represents more of a starting position stating the necessity of the approach. Our analysis, for the first time, tries to measure and to differentiate the influence of the solid waste generation by the most important domestic industry: tourism. The literature about the waste management system in Croatia and the consequences thereof for the environment are sparse and scarce. Vego et al. [31] analyze the efficiency of a waste management system in the southern coastal part of Croatia consisting of four Dalmatian counties. They used multi-criteria decision-making methods to assist with the systematic analysis and evaluation of management alternatives. The analysis tried to find the optimal number of waste management centers resulting from possible inter-county cooperation. The problem was analyzed according to ecological, economic, social and functional criteria [31]. Ahel et al. [32] analyze the impact of 5 million tons of waste disposed at the main landfill of the city of Zagreb directly above the highly permeable alluvial sediments. The investigation was aimed at assessing the impact of contamination from the landfill on underlying soil. The contaminants were shown to infiltrate the leachate from the solid waste into the groundwater with a strong impact on the contaminant distribution in soils below the landfill [32]. One of the most hazardous contaminants of soil and groundwater is certainly the medical waste [33]. Even though Croatian regulations define all steps in the waste management chain, its implementation is still an issue, especially in the case of medical waste from hospitals that do not implement existing legislation to the full extent, due to the lack of education and funds [33]. According to Marinkovic at al. [33], information on quantities, type and flow of medical waste are inadequate, as is sanitary control. The authors propose an integrated approach to medical waste management based on a hierarchical structure from the point of generation to its disposal. A structuralism approach to waste management would give priority according to the potential for harm. Croatia is, only now, starting to implement fully the European Landfill Directive (99/31/EC) [34], starting with sorting and separating in households, pre-treatment, safe transportation, and final treatment and disposal [33,34]. Landfilling is predominant in Croatia, although [34] believe that incineration is the most appropriate method, with a large number of small incinerators being most economical [33]. Due to the potential for air pollution with biohazards, we tend to disagree. Stanic-Maruna et al. [35] show that Croatia has transposed the European Landfill Directive (99/31/EC) [34] into its own legislation and started to fulfill its obligation accordingly with mechanical biological pre-treatment in conjunction with separate collection of recyclables. The obligations of municipal solid waste management in Croatia are subsidiarily devolved to local municipalities. Presently, Croatian municipalities have different management policies.

Lastly, but most importantly, conforming to the two main hypotheses of our research, there is some evidence of the Environmental Kuznets Curve (EKC) hypothesis. The EKC postulates an inverted U-shaped relationship between pollution and per capita income [36]. Firstly, pollution rises with rising per capita income, and then comes to a standstill when the opportunity costs of the environment rise for the majority of the inhabitants. At some point of the rising income, the environment stops being a sink, and starts to become a worthy cause for the population. There has been a lot of critique of this relationship from prominent economists [37]. The rise and the potential fall of the idea of an Environmental Kuznets Curve is summarized in a paper by Stern [38].

Dasgupta et al. are not so pessimistic about the EKC [39]. Their critique is based on the argument that the critics' empirically estimated curves are tendentious cross-sectional snapshots that mask actual development. Recent evidence fosters an optimistic view by suggesting that the curve is actually flattening [39]. We try to corroborate the conjecture that the role of economic structure has an influence on the EKC [40]. Industrial development decreases emissions through technologies that are energy efficient and environmentally friendly [40]. In our case, tourism is not commensurate with any form of pollution that would jeopardize this municipality's source of revenue. High opportunity cost of environment prohibits its degradation. EKC depends on factors such as natural resources, technology, economic structure, and institutions [40].

3. Materials and Methods

As material data dictates the method of inquiry and not vice versa, we start with the choice of the appropriate panel analysis method. There are 12 periods included representing the 12 months of the year 2019, and 160 cross-sections represented by the coastal municipalities of Croatia, totaling 1920 observations for a balanced panel. Panel analysis is a growing method of analyzing three-dimensional data—a combination of cross-section analysis with time series analysis. For further testing for the existence of cross-section idiosyncratic and time effects, it is important in panel data analysis since the presence of these effects could lead to an incorrect specification of the regression and consequently, to an improper inference [41–43]. The primary choice of a test statistic in a panel analysis is between Random Effects (RE), Fixed Effects (FE), and First Differences (FD) dynamic methods. The central assumption in RE estimation is the assumption that the RE are uncorrelated with the explanatory variables. One common method for testing this assumption is the so-called Hausman test [44]. The Hausman Test statistics for correlated RE compares two sets of estimates, one that is consistent under both the null and the alternative, and another, consistent solely under the null hypothesis. If the idiosyncratic effects are random, then the RE estimator is more efficient. If the idiosyncratic effects of the RE and FE estimators converge to different values, the FE estimator is solely consistent [44]. A large statistical difference between the two sets of estimates is taken as evidence in favor of the alternative FE hypothesis. After deciding on the choice between RE, FE, and FD, a decision on the correct subtest should be given. This decision addresses the questions of consistency and efficiency. The statistical method that is going to be used shall address any issues of heteroscedasticity in a particular dimension. Panel data models can have heteroscedasticity and autocorrelation between errors both contemporaneously and over time. In such cases, it is advised to use the Panel EGLS method. The Seemingly Unrelated Regression (SUR) method, also known as the multivariate regression, estimates the parameters of the system, accounting for heteroscedasticity and contemporaneous correlation in the errors across equations. The estimates of the cross-equation covariance matrix are based upon parameter estimates of the unweighted system. Cross-section SUR setting allows for contemporaneous correlation between cross-sections, clustering by period. By selecting Cross-section SUR, we estimate a feasible GLS specification correcting for heteroscedasticity and contemporaneous correlation. Cross-section weights allow for heteroscedasticity in the relevant dimension. Period weights allows for period heteroscedasticity, but due to only one year, the method is not applicable. This study uses the Panel Estimated Generalized Least Squares (EGLS) cross-section Fixed Effect (FE) method with Panel Corrected Standard Error (PCSE) estimates. This estimate is robust to heteroscedasticity across cross-sections. We complement the Panel EGLS with the Generalized Methods of Moments (GMM)—to cross-check the results and strengthen the findings. If the fixed effect method is widely used, but sometimes criticized [30], the GMMs, using the Arellano–Bond conditions, represent a robust method instead [41,45]. Type II errors, biased coefficients and imprecise standard errors, misleading *p*-values, and misguided causal claims, are just a few of the critiques of the FE method [46]. Panel GMM FD has several advantages over other tests including the FE. By differencing, the fixed effect, the possible autocorrelation, and any unit-root processes are removed from the data. In this way, we control for unobserved heterogeneity among observed countries when this heterogeneity is constant over time. Since lags of the dependent variable are necessarily correlated with the idiosyncratic error, we test the residuals with the Arellano-Bond GMM estimator [45]. The results are interpreted at the usual level of 5% statistical significance.

4. Results

The root of our investigation starts with a simple Panel Least Squares between municipal solid waste (MSW) disposal, measured in kilograms per person (local inhabitants and tourists) per overnight stay as a dependent variable on the left side of the equation, and local inhabitant overnight stays and tourist overnight stays as independent variables on the right-hand side of the equation (Table 1). In terms of our principal null hypothesis of no difference between municipal solid waste generation by domestic population and tourists, we may state that the null was successfully falsified.

Table 1. Panel Least Squares of the MSW (Municipal Solid Waste) as a dependent variable.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Population	0.990126	0.006585	150.3635	0.0000
Tourists	1.133553	0.031662	35.80182	0.0000
R-squared	0.929080	Mean dependent var		281,062.2
Adjusted R-squared	0.929043	S.D. dependent var		644,159.7
S.E. of regression	171,589.9	Akaike info criterion		26.94464
Sum squared resid	5.65×10^{13}	Schwarz criterion		26.95044
Log likelihood	−25,864.86	Hannan-Quinn criter.		26.94677

Calculation: EViews 9.0.

The results of the Panel Least Squares analysis presented in Table 1 show the potential for further analysis with more stringent statistical tests. According to these simple statistics, tourist overnight stays produce 14.5% more waste than the local population does. The constant was eliminated because of statistical insignificance. The standard error of the tourist overnight stays is much larger than the standard error of the local population, as tourist overnight stays vary not only seasonally, but also across municipalities—a cross-sectional variation due to a different degree of tourism specialization of municipalities. The differences in municipalities, i.e., the cross-section differences have an impact on the intercept. Due to this unobserved heterogeneity, the estimates are both biased and inconsistent. With our waste disposal, there is a large difference between municipalities in terms of their endowments with cultural, natural, and other resources that at the end of the day, are the determinants of the number of tourists, tourists' overnight stays, and MSW creation.

In a Panel analysis, one of the first questions that should be answered is whether to use Fixed Effects (FE) or Random Effects (RE). If there is a statistically significant difference between municipalities and their intercepts, and if there is some covariance between unobserved heterogeneity between municipalities and independent variables, the RE effects would be inconsistent. If independent variables vary across time, for example, due to seasonality, and across municipalities due to differences in the number of inhabitants, as well as tourist capacity, the FE should be solely consistent. We proceed with the falsification of the conjecture of Random Effects by running a Hausman test on a Panel OLS with cross-section random effects (Table 2).

Table 2. Correlated Random Effects—Hausman Test.

Test Summary		Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-Section Random		16.243109	2	0.0003
Variable	**Fixed**	**Random**	**Var (Diff.)**	**Prob.**
Population	0.379826	0.990730	0.032162	0.0007
Tourists	1.067787	1.071561	0.000060	0.6258

Calculation: EViews 9.0.

As expected, the results of the Hausman correlated random effects test point to a high probability that the RE are biased and inconsistent. To be unbiased and consistent, an independent variable should have zero covariance with idiosyncratic municipality dependent factors such as geography, demographics, cultural heritage, etc., for all cross-sections and across time. Table 3 shows the coefficients for the cross-section random effects equation on waste disposal as dependent variable.

Table 3. Cross-section random effects test equation on MSW as dependent variable.

Dependent Variable: Waste Disposal. Method: Panel Least Squares				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
Constant	142,882.7	41,805.04	3.417834	0.0006
Population	0.379826	0.179933	2.110929	0.0349
Tourists	1.067787	0.031485	33.91446	0.0000
R-squared	0.957317	Mean dependent var		281,062.2
Adjusted R-squared	0.953408	S.D. dependent var		644,159.7
S.E. of regression	139,043.5	Akaike info criterion		26.60356
F-statistic	244.9009	Schwarz criterion		27.07269
Prob(F-statistic)	0.000000	Hannan-Quinn criter.		26.77617

Calculation: EViews 9.0.

The results of the random effects test show that the standard errors of the regression and of the population variable are suspiciously high, which forces us to make some additional tests. The first one is the Breusch–Pagan test for heteroscedasticity of residuals in a linear regression model (Table 4). If the null hypothesis of no heteroscedasticity is rejected at $p < 0.05$, we need to use alternative statistical methods resistant to heteroscedasticity due to unobserved idiosyncratic heterogeneity.

Table 4. Residual Cross-Section Dependence tests.

Null Hypothesis: No Cross-Section Dependence (Correlation) in Residuals			
Test	**Statistic**	**d.f.**	**Prob.**
Breusch-Pagan LM	24,767.22	12,720	0.0000
Pesaran scaled LM	74.52841	-	0.0000
Pesaran CD	33.34876	-	0.0000

Calculation: Eviews 9.0.

The Residual Cross-Section Dependence tests show that the null hypothesis of no cross-section dependence (correlation) in residuals may be rejected at a $p < 0.001$ level. It means that—nevertheless, the well-behaved properties of coefficients in Table 3—we may not accept those results to be unbiased and consistent due to correlation or heteroscedasticity in residuals.

We need another type of estimator that circumvents the problem of unobserved heterogeneity. Should we use Cross-section weights, or Period weights? The Seemingly Unrelated Regression (SUR) method, estimates the parameters of the system, accounting for heteroscedasticity and contemporaneous correlation in the errors across equations. The estimates of the cross-equation covariance matrix are based upon parameter estimates of the unweighted system. Cross-section SUR allows for contemporaneous correlation between cross-sections, clustering by period. We estimate a feasible GLS specification correcting for heteroscedasticity and contemporaneous correlation. Cross-section weights allow for heteroscedasticity in the relevant dimension. Period weights allow for period heteroscedasticity, but due to only one year, the method is not applicable. We settled for a Panel Estimated Generalized Least Squares (EGLS) with cross-section fixed effects, panel weights and Panel-Corrected Standard Errors (PCSE) analysis. The method achieves better results with higher significance, and lower Standard Errors (S.E.) than comparable methods. We used PCSE to preserve the weighting of observations for autocorrelation. Due to differences in population and tourist capacities in Croatian coastal municipalities, the municipalities with low tourist overnight stays served well as a placebo group for the purpose of separating the tourist impact on waste disposal from that of the inhabitants.

After performing the Hausman test on a Panel EGLS cross-section random effects equation, we showed the data was not suitable for a Random Effects analysis due to large differences in municipality sizes and, consequently, their constants' coefficients (Table 5).

Table 5. Panel EGLS (PCSE) (Panel Estimated Generalized Least Squares (Panel Corrected Standard Error)) of the MSW as a dependent variable.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Population	0.915112	0.008195	111.6665	0.0000
Tourists	1.194279	0.019471	61.33675	0.0000
R-squared	0.916123	Mean dependent var		459,511.8
Adjusted R-squared	0.916079	S.D. dependent var		458,112.7
S.E. of regression	168,074.0	Sum squared resid		5.42×10^{13}
Durbin-Watson stat	0.649844	-	-	-

Calculation: Eviews 9.0. Total panel observations: 1920.

We observe a higher level of relative impact from tourists in waste generation than from the local population as both the locals and the tourists are normalized as overnight stays. By adding a constant in Table 6, we are able to grasp the possible influence of the time and cross-section independent influence from, for example, local industries. The addition of a constant, on one hand, gives us a clear cut differentiation between communally-generated waste from local population, from tourists, and from other sources that cannot clearly be attributed to either of the previous two sources. These might be local industries, directly or indirectly attributable to the tourism industry, but also any other idiosyncratic source of waste generation. If we imagine the constant to represent waste-creating industries that are population and tourist (but not necessarily tourism) independent—which is, we are aware, almost impossible—the difference in the correlation between population and tourist-created waste is even greater whereby the rise in the constant was mostly at the cost of the local population (Table 6).

Table 6. Panel EGLS (PCSE) of the MSW as a dependent variable.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	66,545.47	21,430.52	3.105173	0.0019
Population	0.703272	0.092515	7.601737	0.0000
Tourists	1.092482	0.018262	59.82151	0.0000
R-squared	0.956703	Mean dependent var		588,166.9
Adjusted R-squared	0.952737	S.D. dependent var		440,830.8
S.E. of regression	138,584.0	Sum squared resid		3.38×10^{13}
F-statistic	241.2722	Durbin-Watson stat		1.320620
Prob(F-statistic)	0.000000	-	-	-

Calculation: Eviews 9.0. Total panel observations: 1920.

Thus, although the constant in Table 6 is statistically significant at $p < 0.05$ level, and the Panel EGLS estimation in Table 6 has a lower standard error then the estimation from Table 5, the difficulties to interpret the constant makes us revert to other methods of coefficient estimation such as the General Method of Moments (GMM). GMM is both intuitive and elegant: The estimator is derived from a set of minimal assumptions, the so-called moment conditions that the model should satisfy. The GMM estimator is consistent and asymptotically normal, and for a large sample, the consistent GMM estimator is close to the true value, where the variance of the estimator depends on the weight matrix. These conditions are satisfied as we have 160 cross-sections during 12 months. After losing 1 month to differencing, and 1 month to a lag, we still have 1600 balanced observations to work with. In continuation, we present the test results of a Panel Generalized Method of Moments (GMM) First Differences (FD) equation (Table 7).

Table 7. Panel GMM (FD) Panel (Generalized Method of Moments (First Differences) equation) of the MSW as a dependent variable.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Waste (−1)	0.133513	0.003147	42.42070	0.0000
Population	0.906744	0.010012	90.56483	0.0000
Tourists	1.107096	0.006993	158.3189	0.0000
Mean dependent var	1979.237	S.D. dependent var		130,152.5
S.E. of regression	102,262.0	Sum squared resid		1.67×10^{13}
J-statistic	69.76240	Instrument rank		55
Prob(J-statistic)	0.050583	-	-	-

Calculation: Eviews 9.0. Total (balanced) observations: 1600.

The results of a Panel Generalized Method of Moments (GMM) First Differences (FD) equation confirm the results of the Panel EGLS (Cross-section weights) and Period weights (PCSE). The J-statistic null hypothesis states that the instruments are uncorrelated with the error term and the Prob(J-statistic) significantly different from zero (0.05) shows that the null hypothesis cannot be rejected, giving us the confidence that our instrument set is appropriate. To further test for model consistency, we test the residuals for biasness, i.e., their serial correlation with the variables (Table 8).

Table 8. Arellano-Bond Serial Correlation test.

Test Order	m-Statistic	rho	SE(rho)	Prob.
AR(1)	−2.660320	−3,613,599,941,661.5728	1,358,333,020,193.6658	0.0078
AR(2)	−0.521926	−349,215,927,553.70688	669,090,750,723.63624	0.6017

Calculation: Eviews 9.0.

The Arellano-Bond Serial Correlation test statistic shows the AR(1) statistic is significant, while the AR(2) statistic is not, pointing to the residuals being serially uncorrelated in levels [13]. Thus, these statistics make us confident of the primary result. Being a robust method, GMM supported our results from the Panel EGLS cross-section FE with PCSE. We may conclude that tourists create relatively (and absolutely) more solid waste than the local population, and that some additional waste is also created by the tourist industry.

To test the EKC hypothesis, we divided our sample of municipalities with dummy variables into two groups: rural and coastal tourism-oriented (although they are all part of coastal counties). We repeated the Panel EGLS test from Table 6 in Table 9 by adding three dummy variables standing for three different types of municipalities. First, the rural type without a large number of tourist overnight stays. Second, the seashore tourism-specialized municipality or a large city. The third dummy was assigned to the wealthiest municipalities with clear-cut environmental MSW recycling policies.

Table 9. Panel EGLS (FE) (Fixed Effects) of the MSW as a dependent variable.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D1 Tourists	0.945682	0.218215	4.333714	0.0000
D1 Population	0.629914	0.023498	26.80668	0.0000
D2 Tourists	1.199025	0.015737	76.18948	0.0000
D2 Population	0.984147	0.014188	69.36478	0.0000
D3 Tourists	0.835152	0.036840	22.66966	0.0000
D3 Population	0.847999	0.028162	30.11191	0.0000
R-squared	0.936797	-	Mean dependent var	519,363.5
Adjusted R-squared	0.936632	-	S.D. dependent var	561,739.3
S.E. of regression	165,753.5	-	Sum squared resid	5.26×10^{13}

Calculation: Eviews 9.0. Total panel observations: 1920.

Conforming to the EKC hypothesis, the average MSW of the tourists first rises, and then falls. As for the domestic population, there is also a change between rural and coastal municipalities, as well as a decrease in average MSW between average and wealthy tourism-oriented municipalities. We wish to express some caution regarding the total standard error of the regression being somewhat higher than in previous regressions. Nevertheless, according to the results of the Panel EGLS summarized in Table 9, we cannot reject the hypothesis of an EKC.

5. Discussion

The principal research problem this paper is concerned with is the effect of tourism on Municipal Solid Waste (MSW) generation in Croatian coastal area municipalities. Considering a large share of tourism industry in the Croatian economy and the pressure it generates on sustainable coastal management, it was reasonable to pursue the trial of hypotheses going from tourism to solid waste generation. Thus, we ask several research questions regarding the role of the tourism industry in MSW generation in the Croatian coastal area. Firstly, does the tourism industry produce relatively more solid waste than the domestic population alone? Secondly, are we able to distinguish the tourist industry's MSW generation from other industries? Lastly, is the solid waste generation in Croatia any different than in any other comparable tourist country?

From our panel of 160 municipalities in the Croatian coastal area across a time period of 12 months during 2019, giving us a total of 1920 panel observations, we arrive at several conclusions related to the relative differences in municipal waste creation resulting from the tourism industry.

The major problem in the assessment of the correct coefficient values of the variables is to separate them into the one conjectured to be caused by the inhabitants from the one assigned to tourist overnight stays. Thus, the true coefficient value of the MSW measured in kg per day generated by tourists may be assessed as a range going from a minimum of 1.06 for the ordinary least squares with a constant, and 1.19 for a Panel EGLS without a constant, whereby the constant represents municipal solid waste generation due to activities that are neither directly attributable to the number of inhabitants nor to tourists, although tourism is the largest direct and indirect employer in coastal Croatia. According to the GMM FD, the value of the MSW generated by the local inhabitants is 0.91 kg per day and 1.11 kg per day in the case of tourists: a difference of 22%. This value might be the closest to the true value, as the GMM method has the lowest standard error of the regression among the used methods, and the Panel Generalized Method of Moments (GMM) First Differences (FD) is the method least susceptible to the heteroscedasticity of the residuals, additionally tested with the Arellano-Bond test.

The estimates of MSW generation do not diverge significantly across different methods—from 0.91 kg per inhabitant per day in case of GMM and 0.92 kg per day in case of EGLS. The minimum difference across methods between quantities of MSW generated by the local population against tourists is 22% when not taking into account the constant, and the maximum is 55% when including the constant in the regression. The constant represents mostly fixed factors of MSW generation neither directly contributable to domestic population nor tourism. However, But the major industry in the coastal municipalities is tourism, thus fixed effects are hard to separate into their population-generated and tourism-generated components. All results containing the constant must be taken with reserve.

It is certainly helpful to compare the results of our analysis with similar studies. Mateu-Sbert et al. [47] analyzed the impact of tourism on MSW generation on the Menorca Island (Spain) and found that one more tourist in Menorca generates 1.31 kg of MSW per day while one more resident generates 1.48 kg of MSW per day. The estimates are based on dynamic methods. Curiously enough, their results contradict ours, probably due to a higher per capita income of the Balearic population. Another study on the neighboring island of Mallorca done by Villanueva [48], shows MSW generation by tourists of 1.25 kg per tourist per day, while simultaneously, the domestic population generates 585.78 kg of MSW per resident per year which is equal to 1.60 kg per resident per day. According to the author [46], the Balearic region has the highest average amount of MSW generation per capita in Spain, and the highest per capita income, thus, not rejecting the first (rising) half of the Environmental Kuznets Curve hypothesis.

The two studies of the Balearic Islands: Menorca [47] and Mallorca [48] come to somewhat different results from ours in terms of coefficient size—tourists, on average, produce less MSW than the local population but still more than the tourists in Croatia. The difference in numbers is not huge. It seems that the Environmental Kuznets Curve is not only present in the case of the local population, but also in the case of the tourist population—to some degree, both the domestic population of the Balearic Islands, and the tourists present there, generate more MSW per day per capita compared to their Croatian counterparts. Higher per capita income is commensurate with higher per capita MSW generation, not only for the local population, but also tourists. Furthermore, in the case of Croatia, we come to the conclusion that these relationships vary across local communities. By additionally analyzing the averages in these communities, we came to the conclusion that there are probably behavioral (income and/or culturally induced) reasons for creating more or less MSW. Rural communities in the coastal hinterland generate much less MSW per capita than more developed cities, giving possible evidence of Environmental Kuznets Curves. However, tourists staying in these rural communities also generate much less MSW than tourists in other coastal communities. It seems that local formal and informal institutions, as well as the culture of the local population regarding consumption, recycling and waste disposal, shape the behavior [49] of the tourist population.

In the case of Croatian coastal municipalities, when we interpret the Table 9 data, we may conclude that there is some evidence of the EKC with the rural municipalities generating a significantly lower amount of waste. One inhabitant of the rural municipality generates 0.63 kg of solid waste per day, and one tourist generates 0.95 kg per day. An average tourist in an average coastal municipality generates about 1.2 kg of solid waste per day, while a local inhabitant generates just under 1 kg per day. A better situation is found in the extremely wealthy municipalities with explicit SWM policies. There, both the locals as well as the tourist generate around 0.84 kg per person per day. Taking into account the total averages without disintegrating them into the local population and tourists, and without dummy variables for municipalities, the MSW generation amounts to almost exactly 1 kg per person per day with a standard deviation of 0.6 kg per day. According to the relatively high measure of the standard deviation, we may reasonably conclude that there are large discrepancies between municipalities. The reasons for this numerical divergence might be several. For one, they might be behavioral, culturally, or income conditioned—small, rural communities generate less MSW and recycle more. Our disaggregation of data shows that municipalities' policies, as well as the culture of the local population may make a difference. Institutional incentives, when adequately enforced, probably make most difference. Another reason for the large standard deviation might be of a methodological nature—community borders concerning MSW data generation is not fully commensurate with given census borders, thus making space for errors in data collection. We tried to address this issue by including the largest possible number of municipalities into the study, thus watering down the problem.

In continuation, we will analyze a potential for an Environmental Kuznets Curve (EKC) on the basis of uneven development between municipalities. We divided the Croatian coastal municipalities into three groups and assigned dummy variables. One group consists of municipalities that fulfill at least one of the following conditions: They are either rural, found in the hinterland with no immediate access to sea, or the municipality belongs to Areas of Special State Concern (ASSC). The latter is an official Croatian Government classification, meaning the area is relatively underdeveloped compared to the rest of the country. The second group consists of coastal municipalities, cities or not, that have a primary tourist orientation or have a higher than average income per capita because of some other industry present in the municipality. The third group consists of extremely wealthy municipalities in terms of municipal budget and per capita income, enabling the municipality to pursue policies concentrated on enhancing the quality of the environment with tourism in mind.

The rural villages such as Podbablje, Primorski Dolac, and Proložac found in the Dalmatian hinterland are a desired unit of consideration in the statistical sample: They are not developed in any meaningful way, have relatively few tourist overnight stays during summer, and none during winter. Their contribution to the estimation of MSW generation of the local population is crucial as they provide quantitative minima for the Croatian rural population in absence of tourists. These villages generate about 0.63 kg of MSW per person per day. There is no clear-cut border between the first and second group of municipalities giving space for error in their classification. Some of the rural municipalities are mainly tourism-oriented (such as, for example, the municipalities in Istria), and some coastal municipalities do not have a strong tourist specialization.

In the middle, we have a mainstream of coastal municipalities with a MSW of around 0.98 kg of MSW per person per day. According to data from Table 9, the per capita MSW of the local population falls steadily.

On the other side of the spectrum, we have extremely wealthy tourist destinations. The Croatian Institute of Public Finance [50] publishes a comprehensive list of Croatian municipalities' incomes. The 22 wealthiest municipalities, either in terms of municipal budget income or income per capita of its citizens, are found in coastal Croatia, and their main source of income is tourism. They are in alphabetical order: Baška, Brtonigla, Dubrovnik, Fažana, Funtana, Hvar, Jelsa, Kršan, Konavle, Kostrena, Medulin, Motovun, Nin, Novalja, Novigrad (Istria), Opatija, Rovinj, Sutivan, Tar, Umag, Vrsar, and Vir. The Istrian municipality of Medulin, numbering no more than 7000 inhabitants, is the richest Croatian municipality. It had almost a million tourist overnight stays in August 2019, and did not surpass the average Croatian MSW of 1 kg per person per day in total; and according to their data, the MSW per local inhabitant was around 1.3 kg per day. Most of the MSW consists of packaging, and the share of recycled MSW is around 40%. Whatever is recycled does not end up in the municipal landfill. A similar case can also be made for other extremely wealthy municipalities. Thus, if we make a case-by-case analysis of municipalities, we come to the conclusion that municipalities specialized in tourism cannot afford environmental degradation, thus, their opportunity costs of environment dictates strong local environmental policies devoted to a larger share of recycled MSW. Revenues from tourism enable them to endorse such policies.

6. Conclusions

The primary goal of the paper was to try to separate the MSW generated by the domestic population from the MSW generated by the tourists in the Croatian coastal region. This information is not only useful for future scientific purposes, but also for the practitioners in the field, solving the problem of MSW management. It was not our intention to address the problem of MSW management itself. We think the parameters received from the OLS, EGLS, and GMM FD regressions could be of much help for some future analysis of the MSW generation problem, and also for future comprehensive coastal area management.

We performed a Panel Estimated Generalized Least Squares (EGLS) cross-section Fixed Effects (FE) with Panel weights Panel-Corrected Standard Errors (PCSE) analysis on tourist overnight stays and domestic population overnight stays as independent variables, and metric tons of waste at 160 Croatian municipalities in coastal counties. We used the above mentioned method to achieve better results with higher significance, and lower Standard Errors (S.E.) than comparable methods. We used PCSE to preserve the weighting of observations for autocorrelation. Due to differences in population and tourist capacities in Croatian coastal municipalities, the municipalities with low tourist overnight stays served well as a placebo group in the EGLS regression for the purpose of separating the tourists' impact on waste disposal from the one of the local inhabitants'. After performing the Hausman test on a Panel EGLS cross-section random effects equation, we showed that the data was not suitable for a Random Effects analysis due to large differences in municipality sizes and, consequently, their constants' coefficients.

What we found in the case of Croatian coastal municipalities is that parameter values for total MSW, of about 1 kg per person per day, have a standard deviation of about 0.6 kg of MSW per person per day, meaning they diverge across municipalities due to idiosyncrasies. By looking at individual municipalities, we found that higher average MSW generation numbers are found across larger municipal agglomerations, and smaller average MSW generation numbers are found across rural municipalities with lower GDP per capita. Marginal analysis tells us that potentially wealthier municipalities create absolutely more waste, but with a decreasing marginal slope ending with lower average MSW generation in the case of wealthy municipalities with well-defined recycling policies.

Our main question was: By how much does the number of inhabitants and their overnight stays, as well as the overnight stays from tourists, correlate with the size of the disposed waste, taking into account the unobserved heterogeneity of the municipalities in the panel? This question could only be answered by dynamic statistical tests such as GMM FD, eliminating such idiosyncrasies.

We conclude that tourism impact on solid waste generation is at least 22% greater than the impact of the local population when not taking into account influences represented by the constant, i.e., cross-section independent influences such as local industries. However, when we introduce the constant—representing the local industrial capacity to create solid waste, spreading the difference between local population and industry—the difference between local population and tourists rises to 55% in favor of tourist overnight stays which contradicts other research of Mediterranean tourist destinations [47,48]. This number is actually exacerbated by the fact that the greatest part of the local industry is functionally integrated with tourism. Moreover, the difference is probably caused by the effect known as the Environmental Kuznets Curve. According to this hypothesis, higher per capita GDPs correlate with higher MSW generation up to a point, and then slow down to a halt or even decrease. The difference in size of the MSW per capita generation of Croatian tourists compared to the tourists on the Balearic Islands is not as large as the difference in MSW per capita generation of the Croatian local population compared to the local Spanish population on the Balearic Islands. These differences are commensurate to their differences in GDP per capita. The same can be said for the differences in MSW and GDP between Croatian communities. Additionally, we also took a closer look at the 22 wealthiest Croatian municipalities in terms of per capita income and local government revenues. We conclude that there is evidence of Environmental Kuznets Curve behavior, as higher municipal revenues enable better recycling policies, resulting in less MSW per capita, not only in the case of local inhabitants, but also tourists. The behavior of tourists and the local population regarding waste generation is different, but tends to amalgamate in different environments due to institutional and cultural reasons, but primarily due to municipal disposal and recycling policies.

We conclude that waste disposal conjectured to be caused by tourism is the major contributor to MSW generation in coastal Croatia, but also, as tourism is the greatest creator of wealth in the coastal municipalities, it could be the engine of future MSW reduction. For further, more detailed analysis, we would need a much more detailed dataset comprising additional variables.

In this study, we analyzed the data gained from the first year of its collection. We have encountered many methodological difficulties during our research: from data inaccuracies resulting from incommensurate locations that generate MSW, with municipalities that do not have a landfill, or do not collect statistical data on MSW. Nevertheless, we were able to encompass a large majority of Croatian coastal municipalities in the research and we hope to be able to continue this research in the future.

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