HOW CONSUMPTION CARBON EMISSION INTENSITY VARIES ACROSS SPANISH HOUSEHOLDS

2023

BANCO DE ESPAÑA
Eurosistema

Documentos Ocasionales
N.º 2309

Henrique S. Basso, Ourania Dimakou
and Myroslav Pidkuyko

HOW CONSUMPTION CARBON EMISSION INTENSITY VARIES ACROSS SPANISH HOUSEHOLDS

HOW CONSUMPTION CARBON EMISSION INTENSITY VARIES ACROSS SPANISH HOUSEHOLDS (*)

Henrique S. Basso (**)

BANCO DE ESPAÑA

Ourania Dimakou (***)

URJC

Myroslav Pidkuyko (****)

BANCO DE ESPAÑA

(*) The views expressed in this paper are those of the authors and do not necessarily represent the views of the Banco de España or the Eurosystem. We thank Olympia Bover, Laura Hospido, Carlos Thomas, Javier Vallés and Ernesto Villanueva for comments.
(**) Email: henrique.basso@bde.es.
(***) Email: ourania.dimakou@urjc.es.
(****) Email: myroslav.pidkuyko@bde.es.

https://doi.org/10.53479/29855

Documentos Ocasionales. N.º 2309

April 2023

The Occasional Paper Series seeks to disseminate work conducted at the Banco de España, in the performance of its functions, that may be of general interest.

The opinions and analyses in the Occasional Paper Series are the responsibility of the authors and, therefore, do not necessarily coincide with those of the Banco de España or the Eurosystem.

The Banco de España disseminates its main reports and most of its publications via the Internet on its website at: http://www.bde.es.

ISSN: 1696-2230 (on-line edition)

Abstract

The prominence of emission mitigation policies calls for an understanding of their potential distributional impact. To assess the distributional heterogeneity, we quantify and analyse the consumption emission intensity, defined as carbon emissions per unit of consumption, across households in Spain. With the exception of the poorest households, emission intensity decreases with income and peaks for households whose head is middle-aged (40 years old). Moreover, households whose main earner is less educated and male emit more per unit of expenditure. Thus, emission mitigation policies may disproportionately impact middle-aged households whose income is around €1,000, and whose head is male and less educated.

Keywords: carbon taxes, carbon caps, emission allowances, household expenditure, CO_2 emission intensity.

JEL classification: E21, E31, D12.

Resumen

La prominencia de las políticas de mitigación de emisiones exige una comprensión de su impacto distributivo potencial. Para evaluar la heterogeneidad distributiva, cuantificamos y analizamos la intensidad de emisión del consumo, definida como las emisiones de carbono por unidad de consumo, en los hogares de España. A excepción de los hogares más pobres, la intensidad de las emisiones disminuye con los ingresos y alcanza su punto máximo para los hogares cuya persona de referencia es de mediana edad (40 años). Además, los hogares cuya persona de referencia tiene menos educación y es hombre emiten más por unidad de gasto. Por lo tanto, las políticas de mitigación de emisiones pueden afectar de manera desproporcionada a los hogares de mediana edad cuyos ingresos rondan los 1.000 euros y cuyo cabeza de familia es hombre y tiene menos educación.

Palabras clave: impuestos al carbono, tope y asignaciones, gastos de los hogares, intensidad de las emisiones de CO_2.

Códigos JEL: E21, E31, D12.

Content

1 Introduction

Most economies face the challenge of curbing emissions in the next decades, if not now. The key tools to achieve this are the introduction of carbon emission taxes and/or caps or allowances. As of now, and following the example of Finland, 19 European countries have implemented a carbon tax policy, although the intensity and coverage of each policy differ remarkably. The establishment of the EU Emissions Trading System, establishing emission allowances, and the explicit intent of many countries to introduce or expand their emission mitigating policies are clear indicators of the relevance of measures that could increase the relative price of carbon emissions. Relative price changes lead to adjustments in the behaviour of firms and consumers, as well as the possibility of distributional impacts. Such policies might face strong public opposition, and understanding how their incidence varies across groups of households could be crucial to a better design, implementation, and the scaling up of such policies, increasing the chance they are introduced successfully (Carattini et al. (2018)).

The effect of changes in relative prices due to emission mitigating policies across households depends on how much emission each household creates through their consumption or their consumption carbon emission intensity, defined as the emission per unit of consumption. Note that the consumption emission embeds the emissions incurred while producing the goods that are finally consumed by the household at hand. The purpose of this work is twofold. First, we evidence and analyse the heterogeneity of emission intensity from consumption across households using Spanish data. In particular, leveraging data on consumption expenditure of goods and services across households provided in the Spanish Household Budget Survey (Encuesta de Presupuestos Familiares, EPF henceforth), the emission and output by industry, and the production network described by the Input-Output tables from National Accounts, we measure the household-specific consumption emission intensity from 2006 to 2021 and analyse how it varies according to households' known characteristics. Second, we investigate how emission intensity has varied in the last 15 years and whether the relationship between emission intensity and household characteristics is stable.

We find that, in general, emission intensity decreases with income and peaks for households whose head is middle-aged (around 40 years old). Moreover, we show that households whose main earner is relatively less educated and male also emit more per unit of consumption expenditure. Emission intensities are heterogeneous across households, driven by different compositions of goods in consumers' baskets, warranting the attention of policymakers and other stakeholders making decisions on how to implement emission mitigating policies. Although emission intensity has fallen significantly in the past decade, due to improvements in emission efficiency in production, the pattern of heterogeneity across households we highlight remained stable from 2006 to 2021.

Merging the emission and output by industry and the Input-Output tables, we generate a measure of emission intensity at the industry level, defined as the emission associated with producing one euro of gross output, taking into account the emission embedded in all inputs used in the production of the goods in each industry. The Spanish EPF collects information on household expenditure across different categories of goods. We then assign each category of consumption goods in the EPF (COICOP classification) to each industry and calculate the share of household consumption expenditure in each industry. Household-specific emission intensity is then obtained by combining emission intensity by industry with the share of household expenditure in each industry. Under the assumption that variation in expenditure shares across households reflects variation in emissions - rather than, say, changes in prices - we can assign an emission intensity per unit spent to each household. The EPF survey also provides information on a set of characteristics for each household and its members. We analyse whether these characteristics are systematically correlated to higher or lower levels of household-specific emission intensity to get a better understanding of how a carbon policy that alters relative prices would impact each household and why.

Emission intensity is found to vary with the level of income. During 2006 - 2021, households at the lower to middle end of the income distribution (more precisely from the first decile upwards to the middle) emit more for each unit of consumption than high income (above the 50th percentile of the distribution) households and thus would have higher carbon tax incidence. In particular, given the average emission intensity in 2021, households whose income is at the bottom decile emit almost 5% more per thousand euros of consumption expenditure than households whose income is at the top decile.[1] The key driver of this result is that poorer households spend a greater share of their consumption on energy. Despite the recent growth in renewable energy, the energy sector as a whole is still the most emission intensive sector in the Spanish economy. We also observe that the relationship between income and emission intensity is not linear. For households whose income is higher than the 10th percentile, we uncover a monotonic negative relationship between income and emission per unit of consumption. In contrast, for households whose income is below the 10th percentile (which corresponds to less than 750 euros monthly - the base year 2015) emission intensity increases with income. That is so because although energy expenditure decreases with income, expenditure in transport increases sharply as income increases from such low levels, driving emission intensity up. Our core results are for CO2 emission. We also show these correlation patterns are unchanged when we use a more general measure of Greenhouse Gas (GHG) emissions.

[1] In this paper, we focus on emission intensity, i.e. the total emission per 1000 EUR spent. If we look instead at total emissions, as rich consume more overall, they also emit more, but at a decreasing rate for each unit of consumption increase. This is consistent with Starr et al. (2023).

Emission intensity also varies with age, peaking for households whose head is middle-aged. Given the average emission intensity in 2021, households whose head is 40 years old emit almost 10% more per thousand euros of consumption expenditure than households whose head age is 70 years old. Confirming the results in Basso et al. (2022), the age and emission intensity relationship remains largely unchanged when cohort effects are controlled for. We also find that households headed by a female, whose main occupation is managerial or white collar type of job, whose level of education is higher all emit less by unit of consumption. Finally, households who rent their main residence, households living in smaller cities, and households with more members have higher consumption emission intensity.

The core of our analysis focuses on the heterogeneity in emission intensity coming from households' different patterns of consumption, keeping industry emissions constant. Incorporating variation in industry emission allows us to highlight the evolution of average yearly emission intensity stemming from the production side and to investigate the contribution of each in total emission intensity. We find that average emission intensity decreased by fifty percent in the last fifteen years. The main underlying source of this fall has been improvements in production processes that have reduced the emission per unit of output across all industries in Spain. Furthermore, as the gains in emission efficiency have been widespread across all sectors, the heterogeneity in emission patterns across households identified in the baseline results is unchanged when we allow for time variation in industry emission.

This work relates to other studies that leverage household-level data to build measures of consumption carbon emission intensities, merging expenditure shares with emission, output, and production network linkages. Fremstad and Paul (2019), Levinson and O'Brien (2019) and Sager (2019) build measures for the US looking particularly at the link between income and emission. Basso et al. (2022) look at the link between demographics and age, employing both household-level data and US state and country-level data. In line with this literature, we analyse how emission intensity varies with income, age, and other household characteristics in Spain. Relative to the results for the US, we find that emission intensity is also negatively associated with income but to a lesser extent, while we also highlight that for the poorest (first decile) emission increases with income. We find that the relationship between age and emission intensity is hump-shaped in Spain as it is in the US, although it peaks at an earlier age in Spain (40 years old) than in the US (60 years old). Finally, we confirm that looking at a more general measure of total greenhouse emissions does not alter the correlation patterns identified between emissions and household characteristics. The main caveat to the conclusions from this literature is that the introduction of carbon taxes may induce households to alter their consumption baskets and some households may have better conditions to do so than others. Complementing the results here with an analysis of household demand responses to price increases in energy and transport would improve the understanding of the overall impact of carbon taxes across different households.

2 Data and Methodology

We build a panel of emission intensity, real income, and known demographic characteristics across households in Spain, leveraging micro data from the Household Budget Survey (EPF) from 2006 to 2021, as well as sectoral data from the industry production and the input-output tables of the Annual Spanish National Accounts, from 2006 to 2019, and the industry-by-industry carbon emissions from the Environmental and Air Emission Accounts, from 2008 to 2020. All datasets are from the Spanish National Statistical Institute (INE by it's Spanish abbreviation). As in Levinson and O'Brien (2019), Sager (2019) and Basso et al. (2022), combining the input-output table and carbon emissions, we obtain the total emission in tons of CO2 of producing 1 euro of output for each industry k, denoted e_k. That combines both direct and indirect, through the production network linkages, emission to produce a final good in each industry.[2]

For the baseline estimations, we hold emission intensity by industry constant using data for 2008, focusing exclusively on the heterogeneity of consumption baskets. In Section 4 we allow emission by industry to change with time and decompose the source in the evolution of annual emission.

We use consumption data from 2006 to 2021. From 2006 to 2015, the EPF provided household-level expenditure at the 4-digit good category level based on the COICOP classification. From 2015 onwards, the EPF provides expenditure on good categories based on the ECOICOP classification. Assigning each EPF consumption category (COICOP or ECOICOP) to each industry (k), we calculate the share of consumption of household i ($S_{i,k,t}$) for each industry.[3] The emission intensity of consumption for household i living in Spain in the region (Comunidad Autonoma) s is then defined as

$$e_{i,s,t} \equiv 1000 \sum_{k \in K} e_{k,2008} S_{i,s,k,t}, \tag{1}$$

in tons of CO2 per thousand euros of consumption, and K denotes the set of industries (CNAE 2009, 2 digits).[4]

When calculating emission intensity for a particular set of industries (for example, transport), we only aggregate goods within the industries in question:

[2]If additional emissions -beyond production and distribution- result from the usage/ consumption of the product or service in hand, these may not be included in our measure.

[3]Here, we focus on total expenditure rather than physical units consumed. The reason being that EPF provides data on physical units only on a subset of COICOP/ECOICOP categories and households.

[4]Emissions from consumption could also be calculated using the emissions generated from the entire life-cycle of products/goods (Life-cycle assessment, LCA). Castellani et al. (2019) show that for CO2 emissions both methodologies deliver similar results.

$$e_{i,s,t}^{K_1} = \sum_{k \in K_1} e_{k,2008} S_{i,s,k,t} \tag{2}$$

where $K_1 \subset K$.

Real income is defined as the household total income divided by the appropriate GDP deflator. The key household characteristics used are age, gender, education level, occupation, and type of contract of the household's head (as an indication of the permanent level of income of the household). We also include other demographic characteristics of the households, family size, housing tenure status and city size to control for potentially different spending patterns. Appendix A provides the details of all the variables used.

3 Household Characteristics and Emission Intensity

We start the analysis by investigating how the emission intensity of household's consumption i during the period of 2006 to 2021, denoted $e_{i,s,t}$, varies with a set of household characteristics after we control for time (α_t) and region (γ_s, s denotes the autonomous community each household resides in). The explanatory variables included are the age and age squared of the household's head (age_{it} and age_{it}^2), total household real income (y_{it}) and $\mathbf{X}_{i,t}$, a set of dummy variables that include the sex, education, occupation, type of contract of the household head, whether the household rents or owns a house and whether the household lives in cities of different sizes (different scales from greater than 100,000 to less than 10,000 habitants). See Appendix A for a detailed description of the data. Formally, the baseline econometric model is

$$e_{i,s,t} = \beta_0 + \alpha_t + \gamma_s + \beta_a age_{it} + \beta_{a2} age_{it}^2 + \beta_y y_{it} + \beta_x \mathbf{X}_{i,t} + \epsilon_{i,s,t} \tag{3}$$

Standard errors are clustered on both time and region (Comunidad Autonoma).

As in our baseline, we kept emission and production data constant, the key driver of heterogeneity is the consumption baskets of distinct households. We find that poorer households emit more for every thousand euros in expenditure and obtain a hump-shaped relationship between age and emission intensity, confirming the results in Basso et al. (2022) who use US data. Given the parameter estimates for age_{it} and age_{it}^2, while keeping all other variables constant, emission intensity is at its maximum when the household head is around 40 years old. Moreover, emission intensity tends to be higher for households with more members and lower for households whose head is female and has completed a college degree. Households that live in larger cities and households whose head's occupation is classified as managerial or white collar emit less for each unit of expenditure. Finally, emission intensity is higher for households whose main residence is rented. Results are displayed in the first column of Table 1.

The next three columns of Table 1 offer a similar analysis of decomposing emission intensity by sector. After accounting for the production network linkages across sectors, the highest emission intensity sectors in the Spanish economy are: Mining and quarrying (05-09), five Manufacturing subsectors[5] (paper (17), petroleum products (19), chemicals (20), non-metallic (23) and basic metals (24)), transport-related sectors (Land (49), Water(50) and Air transport(51)) and the Electricity, gas, steam and air conditioning supply (35) sector.

First, we sum the emission intensity coming from consuming goods produced by these sectors, to obtain $e_{i,s,t}^{High}$. Results in the second column of Table 1 verify the correlation of the high emitting sectors with households characteristics. This indicates that the driver of emission intensity across households is due to their expenditure on goods in these key sectors.

Table 1: Emission Intensity and Household Characteristics

	(1)	(2)	(3)	(4)
	Total	*High Emission*	*Transport*	*Energy*
Age	2.68***	1.71***	2.14***	-0.54**
	(0.23)	(0.24)	(0.17)	(0.23)
Age Squared	-0.036***	-0.023***	-0.037***	0.014***
	(2.1e-03)	(2.2e-03)	(1.5e-03)	(2.0e-03)
Real Income	-0.012***	-0.015***	0.0078***	-0.022***
	(6.3e-04)	(6.2e-04)	(3.3e-04)	(5.6e-04)
Household Size	22.8***	13.9***	13.8***	-0.90**
	(0.55)	(0.54)	(0.37)	(0.41)
Female	-14.9***	-8.35***	-24.7***	16.1***
	(0.97)	(1.03)	(0.65)	(0.93)
College	-23.5***	-17.5***	-0.95	-15.3***
	(1.16)	(1.19)	(0.83)	(1.00)
Manager	-17.0***	-10.6***	-1.04	-8.06***
	(1.18)	(1.31)	(0.78)	(1.12)
Fixed-term contract	1.35	7.12***	-0.83	7.50***
	(1.34)	(1.35)	(0.98)	(1.13)
City Size	19.0***	16.5***	16.7***	-0.67
	(0.60)	(0.60)	(0.52)	(0.48)
Renters	62.7***	46.1***	2.41*	40.1***
	(2.25)	(2.11)	(1.23)	(2.04)
Observations	261975	261975	261975	261975

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: Description of variables: Age - Age of Head of the Household, Age Squared - Square of Age of Head of the Household, Income - Real Income, Household size - Number of members in the household, Female - Head of household is Female, College - Head of household obtained a college degree, Manager - Occupation of the Head of the household classified as managerial or white collar, Fixed-term contract - Head of the household works under a fixed-term contract, City size - Takes values of 1 to 5, 1 denoting cities with more than 100000 habitants, increasing for smaller cities until 5 denoting cities with less than 10000 habitants and Renter - The main residence of the household is rented. Using the sectors codes from CNAE 2009, *High Emission* sectors include: 05-09, 17, 19, 20, 23, 24, 35, 49, 50, 51. *Transport* includes sectors 19, 49, 50, 51, and Energy includes sector 35.

[5]The manufacturing sectors are: Manufacture of paper and paper products (17), Manufacture of coke and refined petroleum products (19), Manufacture of chemicals and chemical products (20), Manufacture of other non-metallic mineral products (23), Manufacture of basic metals (24)

Within the most emitting sectors, *Transport*, defined as the sum of sectors 19, 49, 50 and 51 (Petroleum products (fuel) and Transport in Land, Water and Air) and *Energy*, including only sector 35, usually account for greater shares in consumption expenditure on average. We thus focus on the emission intensity coming from these expenditure items in the third and fourth column of Table 1. As expected, we observe that emission intensity from *Energy* expenditure decreases with income, driving the negative relationship we find at the aggregate level. However, this is not the case for *Transport*. The direction of the overall relationship between emission intensity and the size of the household, whether the head of the household is female or male or whether it lives in a small or large city seems to be related to their expenditure on *Transport*. Whereas households whose heads are college educated and whose occupation is managerial or white collar emit less by euros spent on *Energy*, driving the conditional correlation on total emission intensity. Finally, renters' overall emission intensity is higher due to their higher expenditure share on *Energy*, although emission intensity on *Transport* is also slightly higher for these groups of households. Note that our core results are for CO2 emission. Nonetheless, the estimation results are unchanged when we use a more general measure of Greenhouse Gas (GHG) emissions, in tonnes of carbon dioxide equivalent (results are in the Appendix B).

3.1 Emission Intensity and Income

Next, we scrutinise further the relationship between income and emission intensity. We start by splitting the sample into three groups, one with households whose income is at the bottom decile and corresponds to less than 755 euros per month for 2015 constant prices, one with households whose income is between the bottom decile and the median and the third with the household whose income is higher than the median or more than 1,735 euros per month.[6] As shown in Table 2, we estimate the baseline empirical model for each income group separately, while column 1 replicates the results for all households.

First, we observe that the relationship between income and emission intensity is not linear. In particular, an additional unit of income is related to more emission intensity for households whose income is in the first decile. In comparison, it is related to less emission intensity for households whose incomes are in all higher deciles.[7] We highlight this non-

[6]We compute the deciles for real income using the pooled sample for the whole time period. We verify that the households in the bottom decile are not overrepresented in the years of recession or at the beginning of the sample period. The base year for the calculations is 2015.

[7]The other relationship between emission and other household characteristic that changes significantly across different income groups is for female and male headed households. For the entire sample and within richer households, female headed households emit less for each euro spent than male headed households. Within poorer households that is not the case, emission intensity is relatively higher for female headed households.

linearity by regressing emission on age, age squared, and other characteristics $\mathbf{X}_{i,t}$, but instead of assuming an affine relationship between income and emission intensity we search for the best-fitting (deviance difference) fractional polynomial of dimension two, $f(y_{it}) = \beta_{y,1}((y_{it}+a)/b)^{Y_1} + \beta_{y,2}((y_{it}+a)/b)^{Y_2}$, where a and b are the scaling factors and Y_1 and $Y_2 \in \{-2,-1,-0.5,0,0.5,1,2\}$, and if $Y_1 = 0$, $((y_{it}+a)/b)^{Y_1} = ln((y_{it}+a)/b)$ and if $Y_1 = Y_2$, $((y_{it}+a)/b)^{Y_2} = ln((y_{it}+a)/b)((y_{it}+a)/b)^{Y_2}$. The empirical model therefore is $e_{i,s,t} = \beta_0 + \alpha_t + \gamma_s + \beta_a age_{it} + \beta_{a2} age_{it}^2 + f(y_{it}) + \beta_x \mathbf{X}_{i,t} + \epsilon_{i,s,t}$. Estimation details are shown in the appendix. We observe that β_0, β_a, β_{a2} and β_x are not significantly changed if instead of an affine structure for income we use this more flexible specification. We plot how the predicted value $\hat{e}_{i,s,t} = \hat{\beta}_0 + \widehat{f(y_{it})}$ varies with y_{it}, see Figure 1 (a). The relationship between income and emission is positive for a household with income within the first decile,

Table 2: Emission Intensity and Household Income

	All Households	Households Income < p10	Households p10 < Income < p50	Households Income > p50
Age	2.68***	6.44***	3.04***	1.38***
	(0.23)	(0.81)	(0.31)	(0.31)
Age Squared	-0.036***	-0.058***	-0.039***	-0.025***
	(2.1e-03)	(6.9e-03)	(2.7e-03)	(2.9e-03)
Real Income	-0.012***	0.030***	-0.0074***	-0.012***
	(6.3e-04)	(1.1e-02)	(2.6e-03)	(6.9e-04)
Household Size	22.8***	39.8***	27.0***	13.4***
	(0.55)	(1.96)	(0.72)	(0.56)
Female	-14.9***	10.4***	-19.0***	-9.21***
	(0.97)	(3.55)	(1.52)	(1.32)
College	-23.5***	-29.6***	-16.8***	-24.5***
	(1.16)	(6.76)	(2.13)	(1.32)
Manager	-17.0***	12.0*	-7.86***	-27.7***
	(1.18)	(6.64)	(1.92)	(1.24)
Fixed-term contract	1.35	4.09	1.48	13.1***
	(1.34)	(4.27)	(1.81)	(1.94)
City Size	19.0***	14.1***	19.1***	20.5***
	(0.60)	(1.57)	(0.74)	(0.60)
Renters	62.7***	165.4***	59.7***	25.2***
	(2.25)	(5.82)	(2.59)	(2.31)
Observations	261975	26231	104849	130881

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: Description of variables: Age - Age of Head of the Household, Age Squared - Square of Age of Head of the Household, Income - Real Income, Household size - Number of members in the household, Female - Head of household is Female, College - Head of household obtained college degree, Manager - Occupation of the Head of the household classified as managerial or white collar, Fixed-term Contract - Head of the household works under a temporary contract, City size - Takes values of 1 to 5, 1 denoting cities with more than 100,000 habitants, increasing for smaller cities until 5 denoting cities with less than 10,000 habitants and Renter - The main residence of the household is rented.

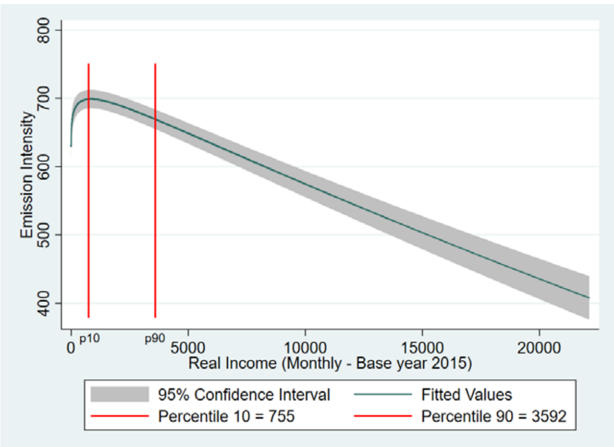
and negative for households whose income are greater than percentile 10 (or more than 755 € per month).[8]

To pinpoint the driver of the reversal of the relationship between income and emission intensity for the poorest households, we depict the emission intensity from *Highest Emission* sectors and within that the intensity for *Transport* and *Energy* sectors. As already indicated in the regressions including all households in table 1, on the one hand, the emission intensity from *Energy* decreases with income; the poorest spend a greater share of consumption on energy expenses. On the other hand, the emission intensity from *Transport* increases with income. The emission intensity from *Transport* is fairly small for the poorest decile and increases substantially for the next deciles (p10 to p50) who in fact emit roughly the same amount of kilos per 1000 € in *Transport* as the richer households whose income is above the median. Thus, the positive relationship between income and emission intensity for the poorest households is due to the increase in *Transport* expenditure that offsets the drop in emission intensity from *Energy*, while the negative relationship observed for households whose income is within the second to the tenth decile is largely due to the decreasing shares of expenditure in *Energy*, as for these income groups *Transport* expenditure only mildly increases (see figure 1 (b)).

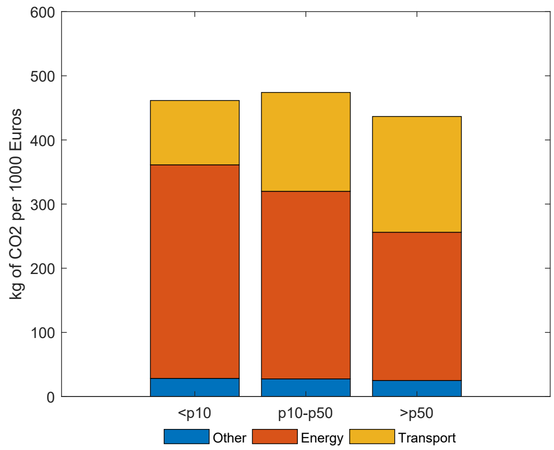
Finally, we observe that the relationship between the other household characteristics and emission intensity is fairly stable across the three income groups (Income $<$ p10, p10

Figure 1: Emission Intensity and Real Income

(a) Emission Intensity and Income



(b) Emission Intensity - High Emission Sectors



Note: Figure (a) depicts the fitted emission intensity level as a function of best-fitting fractional polynomial of dimension 2 on real income, its 95% confidence interval and the vertical lines depicting the level of income of percentiles 10 and 90 of the income distribution in Euros, 2015 constant prices and figure (b) depicts the average emission intensity for the high emission sectors for households within different income groups from 2006 to 2021.

[8] We also run a regression model that allows the linear relationship between income and emission intensity to be different for households with income below and above 755 Euros (10th percentile), further corroborating the nonlinearity between income and emission intensity (see the appendix B for details).

$<$ Income $<$ p50 and Income $>$ p50), with the only exception of the parameter estimates for the dummies for Female headed households, which change sign, and Renters, which become significantly stronger (see Table 2). In order to verify whether these households characteristics are influencing the reversal between the relationship between income and emission intensity, we test whether the reversal occurs for each group separately, showing that it does in all cases (so for instance, that relationship is negative for female headed households whose income is greater than the 10th percentile but positive for female headed households whose income is smaller than the 10th percentile). Results are displayed in the Appendix. Also notable is the fact that the relationship between age and emission intensity (see Table 2) changes depending on the income level. The higher the household income, the less pronounced the hump-shaped profile of emission intensity is. Basso et al. (2022) find similar results for the US, using individual consumption data, but also at the aggregate level, exploring the link between demographic structure and emission intensity across US states.

3.2 Emission Intensity and Age

In the baseline model specification, we introduced age and age squared to capture the relationship between age and emission intensity. To analyse the robustness of our results with regards to the relationship between age and emission intensity, we estimate an additional model where we exclude age, age squared and include instead four dummy variables, for households whose head has age below 25, from 26 to 40, from 40 to 55, and from 55 to 70 (the reference group, therefore, are the households whose head is above 70 years old). Furthermore, we add controls to capture cohort effects, including dummy variables for households whose head was born after 1977, between 1963 and 1976, between 1949 and 1962, and between 1935 - 1948 (the reference group therefore are the households whose head was born between 1918 - 1934) to verify whether the age relationship we uncover is, in fact, proxying for differences in the behaviour of different cohorts. Results are shown in Table 3. We confirm the hump-shaped relationship obtained under the baseline estimation and find that introducing cohort effects do not alter the qualitative implications of our results.

Identifying cohorts and age effects when time fixed effects are used is problematic due to the collinearity of regressors (*Age = Period - Year of birth*). In the specification above, we make additional restrictions, assuming the age and cohort effects are the same for 15-year age and cohort groups, given the limited time series dimension of our dataset. The main drawback is that age and cohort effects are generally not robust to changing the additional restrictions (see Lagakos et al. (2018)). Using a longer dataset for the US, Basso et al. (2022) estimate age, cohort, and time effects of emission intensity using the intrinsic estimator (Yang et al. (2008)), which identifies age and cohort effects that are invariant to the restriction imposed, and find a similar hump-shape relationship between emission intensity and age than

Table 3: Emission Intensity and Age

	Emission Intensity			
Age	2.68***		1.35***	
	(0.23)		(0.38)	
Age Squared	-0.036***		-0.020***	
	(2.1e-03)		(3.5e-03)	
Age $\leqslant$ 25		22.6***		-18.7***
		(5.05)		(6.15)
Age 26 - 40		66.5***		27.4***
		(1.92)		(3.33)
Age 41 - 55		50.5***		14.7***
		(1.63)		(2.82)
Age 56 - 70		43.5***		17.0***
		(1.51)		(2.07)
Real Income	-0.012***	-0.012***	-0.012***	-0.012***
	(6.3e-04)	(6.3e-04)	(6.3e-04)	(6.2e-04)
Household Size	22.8***	24.1***	23.3***	23.8***
	(0.55)	(0.56)	(0.55)	(0.56)
Female	-14.9***	-14.6***	-14.4***	-14.1***
	(0.97)	(0.98)	(0.97)	(0.98)
College	-23.5***	-22.4***	-22.6***	-22.5***
	(1.16)	(1.18)	(1.16)	(1.17)
Manager	-17.0***	-16.7***	-17.1***	-17.1***
	(1.18)	(1.19)	(1.19)	(1.19)
Fixed-term contract	1.35	2.38*	1.10	1.61
	(1.34)	(1.33)	(1.34)	(1.33)
City Size	19.0***	19.0***	19.0***	19.0***
	(0.60)	(0.60)	(0.60)	(0.60)
Renters	62.7***	63.3***	62.4***	63.2***
	(2.25)	(2.27)	(2.24)	(2.25)
Year of Birth $\geqslant$ 1977			33.5***	55.4***
			(5.61)	(4.19)
Year of Birth 1963 - 1976			27.8***	51.6***
			(4.95)	(3.64)
Year of Birth 1949 - 1962			32.6***	49.8***
			(4.23)	(3.15)
Year of Birth 1935 - 1948			18.4***	26.6***
			(2.84)	(2.37)
Observations	261975	261975	261975	261975

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

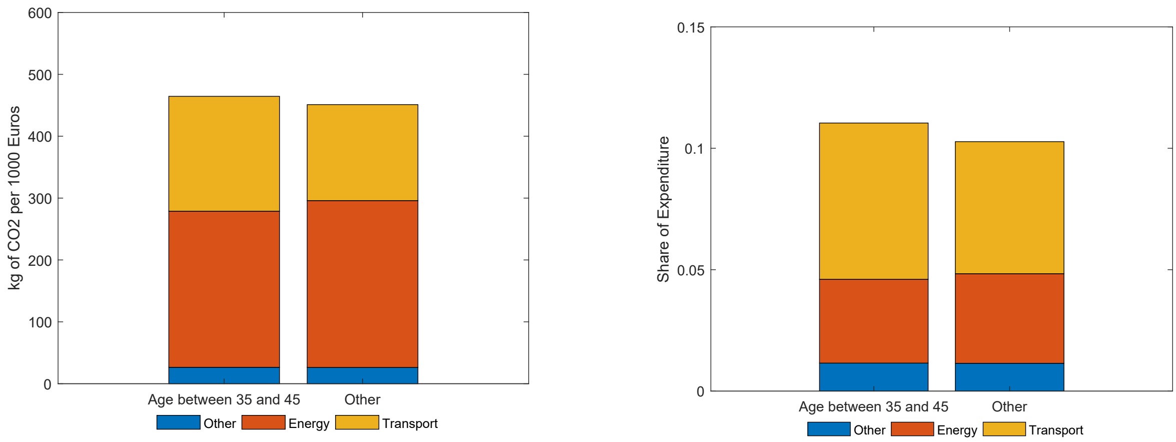
Note: Description of variables: Age dummies (Take value one if Age within the range specified, reference group - Age ¿ 70), Year of Birth dummies (Take value one if Year of Birth within the range specified, reference group - year of birth ¡ 35), Income - Real Income, Household size - Number of members in the household, Female - Head of household is Female, College - Head of household obtained college degree, Manager - Occupation of the Head of the household classified as managerial or white collar, Fixed-term Contract - Head of the household works under a temporary contract, City size - Takes values of 1 to 5, 1 denoting cities with more than 100000 habitants, increasing for smaller cities until 5 denoting cities with less than 10000 habitants and Renter - The main residence of the household is rented.

the one obtained from a simple empirical model using age and age squared as regressors, indicating that cohort effects are not driving this result.

To illustrate the link between age and emission intensity, we show the average emission intensity and the average share of expenditure for *Highest Emission* sectors and within that, the intensity for *Transport* and *Energy* sectors, for different age groups in Figure 2. The key component driving the higher emission intensity for household whose head is middle-aged is the expenditure on *Transport*. *Energy* expenditure and thus the emission intensity from Energy consumption is greater, particularly for households whose head is older.

Figure 2: Emission Intensity and Expenditure Shares Across Age groups

(a) Emission Intensity for High Emission Sectors (b) Share of Expenditure for High Emission Sectors



Note: Figure (a) depicts the average emission intensity for the high emission sectors for households whose head's age is within 25 and 45 and for the other households whose head's age are greater than 45 or smaller than 25. Figures (b) depicts the average share of expenditure on these sectors for the same household groups from 2006 to 2021.

4 The Evolution of Emission Intensity from Consumption

So far, we have considered emission intensity, keeping industry emissions fixed at their 2008 level, thus concentrating on the heterogeneity coming from households' different patterns of consumption. In this section, we now calculate emission intensity updating industry emission, which implies that our measure of emission intensity is given by[9]

$$e^{tv}_{i,s,t} \equiv \sum_{k \in K} e_{k,t} S_{i,s,k,t}, \tag{4}$$

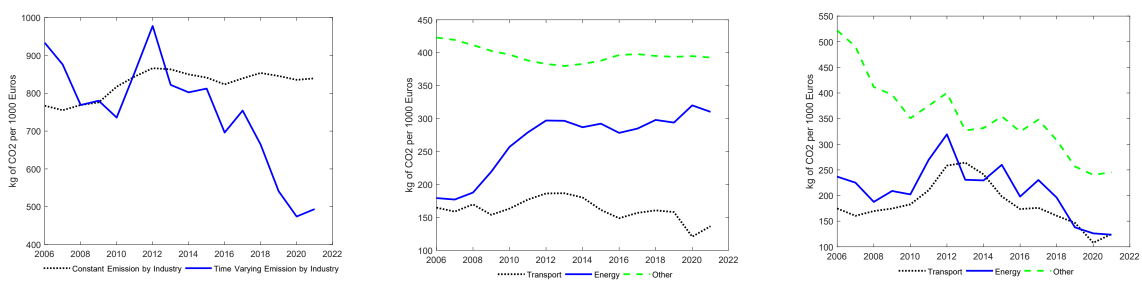
[9]Due to data availability, for 2006 and 2007, we use emissions data from 2008, and for 2021 we use emissions data from 2020.

Our interest in Section 4 is twofold. First, by depicting the evolution of average yearly emission intensity under first fixed and then changing industry emissions, we can separate, from the aggregate movement in emission intensity, the contribution of changes in the basket of goods and the contribution from changes in efficiency in production. In other words, we can untangle whether households are switching towards greener consumption and or whether production processes are becoming greener in Spain. Second, we can verify whether the heterogeneity in household emission patterns is stable as industry emission varies. That is, are the efficiency gains in production affecting some households more than others? Both sets of questions are vital in terms of the policy implications of carbon taxes.

We start by looking at the yearly average emission intensity across households, both with constant industry emission ($e_{i,s,t}$) and with time-varying industry emissions ($e^{tv}_{i,s,t}$). Results are displayed in Figure 3 (a), (b) and (c). Constant industry emission numbers highlight the effect of changes in household consumption patterns only. From the period 2008 to 2021 households switched towards *less* greener goods; holding industry emissions constant, household total emission intensity increased during this period (see Figure 3 (a)). When we look at the decomposition of across household emission intensity with constant industrial emission by sectors (*Transport*, *Energy* and *Other*, denoting the emission of goods from the remaining sectors) we see that the increase in emission intensity is largely due to the increase in the share of households' expenditure on energy from 2008 to 2012 (see Figure 3 (b)). Comparing constant versus time-varying industry emissions numbers highlight the effect of the efficiency gain in production on household emission intensity. When efficiency gains are considered household total emission intensity falls by almost 50% in the last 15 years see Figure 3 (a)). These gains are particularly noticeable after 2012 during the time in which household consumption patterns have been fairly stable.[10] In Figure 3 (c) we depict

Figure 3: Evolution of Average Emission Intensity across Households

(a) Constant versus Time Varying Industrial Emissions (b) Constant Industrial - Household Emission Intensity by Sector (c) Time Varying Industrial - Household Emission Intensity by Sector



Note: Figure (a) depicts the evolution of consumption emission intensity from 2006 to 2021 under constant and varying industry emission. Figures (b) depicts the evolution of consumption emission intensity from different goods with constant industry emission. Figures (c) depicts the evolution of consumption emission intensity from different goods with varying industry emission.

[10] From 2008 to 2012 households increased their share of expenditure on *Energy*, offsetting the industry efficiency gains.

the evolution of yearly average of the household emission intensity by sectors under time-varying industrial emission. The key conclusion that can be drawn is that the fall in emission intensity during the last decade is fairly general, efficiency gains have not been concentrated in any specific sector, indicating that gains have affected households more or less equally.

To confirm that the efficiency gains are not affecting some households more than others, altering the conditional correlations between household characteristics and emission intensity, we re-run regression (3) using $e^{tv}_{i,s,t}$ as the dependent variable instead. Results are displayed in Table 4. Parameter estimates are largely unchanged, confirming that the efficiency gains (steaming from less emitting production processes) affect all households uniformly and thus are being captured by the time fixed effects when the time-varying emission intensity ($e^{tv}_{i,s,t}$) is used in the regressions.

Table 4: Emission Intensity - Constant versus Time Varying Industrial Emissions

	$e_{i,s,t}$	$e^{tv}_{i,s,t}$
Age	2.68***	2.87***
	(0.23)	(0.23)
Age Squared	-0.036***	-0.042***
	(2.1e-03)	(2.1e-03)
Real Income	-0.012***	-0.0076***
	(6.3e-04)	(5.2e-04)
Household Size	22.8***	24.5***
	(0.55)	(0.63)
Female	-14.9***	-21.7***
	(0.97)	(0.92)
College	-23.5***	-20.5***
	(1.16)	(1.14)
Manager	-17.0***	-15.3***
	(1.18)	(1.17)
Fixed-term contract	1.35	0.52
	(1.34)	(1.33)
City Size	19.0***	22.3***
	(0.60)	(0.71)
Renters	62.7***	48.7***
	(2.25)	(2.23)
Observations	261975	261975

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: Description of variables: Age - Age of Head of the Household, Age Squared - Square of Age of Head of the Household, Income - Real Income, Household size - Number of members in the household, Female - Head of household is Female, College - Head of household obtained a college degree, Manager - Occupation of the Head of the household classified as managerial or white collar, Fixed-term contract - Head of the household works under a fixed-term contract, City size - Takes values of 1 to 5, 1 denoting cities with more than 100,000 habitants, increasing for smaller cities until 5 denoting cities with less than 10000 habitants and Renter - The main residence of the household is rented.

5 Conclusion

This work offers an empirical investigation of emission intensity for Spanish households, covering the period 2006-2021. This is achieved by combining and elaborating household-level consumption data from the EPF with sectoral-level data on production from the input-output table of the Spanish National Accounts and the industry-by-industry carbon emissions database from the Environmental and Air Emission Accounts. Understanding the distributional picture of emission intensity and relating this to a set of household characteristics is very relevant for eminent climate crisis mitigation policies, including carbon taxes. Our analysis indicates a non-linear relation between household real income and emission intensity. For households whose income is higher than the first decile, we uncover a monotonic negative relationship between income and emission per unit of consumption; emission intensity decreases with income. In contrast, for households whose income is below the first decile (which corresponds to less than 750 euros monthly) emission intensity increases with income. The underlying factor for this is the composition of households' consumption expenditure and changes therein at different levels of income. In particular, within the lowest decile, although energy expenditure decreases with income, expenditure in transport increases sharply as income increases from very low levels, driving emission intensity up. Emission intensity also varies with age, peaking for households whose head is middle-aged. We also find that households headed by a female, whose main occupation is managerial or white collar type of job, whose level of education is higher all emit less by unit of consumption. Finally, households who rent their main residence, households living in smaller cities, and households with more members have higher consumption emission intensity. These characteristics should be considered when designing a reduction emissions policy frame.

Our baseline analysis focuses on the divergences in emission intensity coming exclusively from households' different patterns of consumption, keeping industry emissions constant. Incorporating variation in industry emission allow us to highlight the evolution of average yearly emission intensity stemming from the production side and to investigate the contribution of production and consumption in total emission intensity. We find that the average emission intensity decreased by fifty percent in the last fifteen years for Spain, with a sharp decrease from 2012 onwards. The main underlying source of this fall has been improvements in production processes that have reduced the emission per unit of output across all industries, more or less uniformly. Before 2012, the share of expenditure on Energy increased. As the Energy sector, despite the recent growth in renewable energy, is the most emission intensive sector of the economy, that offset some of the gains in production emission efficiency. As consumption patterns stabilize from 2012 onwards, efficiency gains drove household emission intensity down. Furthermore, as the gains in emission efficiency have been widespread across all sectors, the heterogeneity in emission patterns across households identified in the baseline results is unchanged when we allow for time variation in industry emission.

References

Basso, Henrique S., Richard Jaimes and Omar Rachedi. (2022). "Demographics and Emissions: The Life Cycle of Consumption Carbon Intensity", Vniversitas Económica 020566, Universidad Javeriana - Bogotá. https://drive.google.com/file/d/1va7lMQXe9u-8YlwNosVhv3sctUmcNqBL/view

Carattini, Stefano, Maria Carvalho and Sam Fankhauser. (2018). "Overcoming public resistance to carbon taxes". *Wiley Interdisciplinary Reviews: Climate Change,* 9(5). https://doi.org/10.1002/wcc.531.

Castellani, Valentina, Antoine Beylot and Serenella Sala. (2019). "Environmental impacts of household consumption in Europe: Comparing process-based LCA and environmentally extended input-output analysis". *Journal of Cleaner Production,* 240, p. 117966. https://doi.org/10.1016/j.jclepro.2019.117966.

Fremstad, Anders, and Mark Paul. (2019). "The Impact of a Carbon Tax on Inequality". *Ecological Economics,* 163(C), pp. 88-97. https://doi.org/10.1016/j.ecolecon.2019.04.016.

Lagakos, David, Benjamin Moll, Tommaso Porzio, Nancy Qian and Todd Schoellman. (2018). "Life Cycle Wage Growth across Countries". *Journal of Political Economy,* 126(2), pp. 797-849. https://doi.org/10.1086/696225.

Levinson, Arik, and James O'Brien. (2019). "Environmental Engel Curves: Indirect Emissions of Common Air Pollutants". *The Review of Economics and Statistics,* 101(1), pp. 121-133. https://doi.org/10.1162/rest_a_00736.

Sager, Lutz. (2019). "Income inequality and carbon consumption: Evidence from Environmental Engel curves". *Energy Economics,* 84(S1). https://doi.org/10.1016/j.eneco.2019.104507.

Starr, Jared, Craig Nicolson, Michael Ash, Ezra M. Markowitz and Daniel Moran. (2023). "Assessing US consumers' carbon footprints reveals outsized impact of the top 1%". *Ecological Economics,* 205, p. 107698. https://doi.org/10.1016/j.ecolecon.2022.107698.

Yang, Yang, Sam Schulhofer-Wohl, Wenjiang J. Fu and Kenneth C. Land. (2008). "The intrinsic estimator for age-period-cohort analysis: What it is and how to use it". *American Journal of Sociology,* 113(6), pp. 1697-1736. https://doi.org/10.1086/587154.

A Data

In this section, we give more details on the data used in the analysis.

Our household-level data is the 2006 - 2021 waves of the Household Budget Survey in Spain (Encuesta de Presupestos Familiares, EPF). We use the 4-digit household-level expenditures based on the COICOP (between 2006 and 2014) and eCOICOP (from 2015 onwards) classification. We use the correspondence between two classifications provided by the Spanish Statistical Office (Instituto Nacional de Estadistica, INE). We define age as the age of the head of the household. Income is defined as total real household income. As the EPF reports nominal household income, we deflate household income by the GDP deflator available from FRED. Household size is measured as the number of members in the household. Female indicates if the head of household is female. Variable College is an indicator variable that takes a value 1 if the head of household obtained a college degree. Variable Manager indicates if the occupation of the head of the household is classified as managerial or while collar. Fixed-term contract indicates if the head of the household works under a temporary contract. City size takes values of 1 to 5, 1 denoting cities with more than 100000 habitants, 2 for cities with 50000 to 100000 habitants, 3 for cities with 20000 to 50000 habitants, 4 for cities with 10000 to 20000 habitants and 5 denoting cities with less than 10000 habitants. Finally, Renter takes a value of 1 if the tenure status of the household is renters.

The input-ouput tables are provided by INE and is available for 2016 only. Data on industry-level production is available from INE between 2006 and 2020, and is available at 2-digit level of National Classification of Economic Activities (NACE). Data on emissions is available from Environmental and Air Emission Accounts and is available from INE at the 2-digit level of NACE. In our baseline analysis we use the total level of CO2 emissions, expressed in tones. In Appendix B we also use the total Greenhouse Gas emissions, available as tones of CO2 equivalent. Emissions data is available between 2008 and 2021.

B Additional Results

In this section we first report the estimation results assuming a more flexible relationship between income and emission intensity and one in which we allow the linear relantionship between income and emission intensity to be different for household whose income is below the 10th percentile. After that we report the main results from Section 3 replacing the total CO2 emissions with total Greenhouse Gas emissions (expressed in tones of CO2 equivalent).

Table 5: Emission Intensity and Income - Nonlinear

	Emission Intensity		
Age	2.68***	2.75***	2.79***
	(0.23)	(0.23)	(0.23)
Age Squared	-0.036***	-0.037***	-0.037***
	(2.1e-03)	(2.1e-03)	(2.1e-03)
Income	-0.012***		-0.014***
	(6.3e-04)		(6.6e-04)
Income(term 1)		-55.9***	
		(6.83)	
Income(term 2)		-118.1***	
		(7.10)	
Income*DummyLow			0.048***
			(0.01)
Household Size	22.8***	22.3***	22.3***
	(0.55)	(0.55)	(0.55)
Female	-14.9***	-13.8***	-12.9***
	(0.97)	(0.98)	(0.98)
College	-23.5***	-23.5***	-23.3***
	(1.16)	(1.16)	(1.16)
Manager	-17.0***	-17.6***	-17.6***
	(1.18)	(1.21)	(1.18)
Fixed-term contract	1.35	4.25***	4.38***
	(1.34)	(1.32)	(1.33)
City Size	19.0***	19.0***	19.1***
	(0.60)	(0.60)	(0.60)
Renters	62.7***	63.7***	63.7***
	(2.25)	(2.24)	(2.25)
Observations	261975	261975	261975

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: Description of variables: Age - Age of Head of the Household, Age Squared - Square of Age of Head of the Household, Income - Real Income, Income (term 1) denotes the first term of the fractional polynomial $f(y_{it})$ which in the best specification is equal to $((y_{it}+6e-05)/10000)^{0.5}$, Income (term 2) denotes the second term of the fractional polynomial $f(y_{it})$ which in the best specification is equal to $ln((y_{it}+6e-05)/10000)((y_{it}+6e-05)/10000)^{0.5}$, Income*DummyLow denotes the interaction term income multiplied by dummy variable that takes the value one if income is below the 10th percentile, Household size - Number of members in the household, Female - Head of household is Female, College - Head of household obtained a college degree, Manager - Occupation of the Head of the household classified as managerial or white collar, Fixed-term contract - Head of the household works under a fixed-term contract, City size - Takes values of 1 to 5, 1 denoting cities with more than 100,000 habitants, increasing for smaller cities until 5 denoting cities with less than 10000 habitants and Renter - The main residence of the household is rented.

Table 6: Emission Intensity and Income - Nolinearity, Renter vs Owners, Female vs Male

	Emission Intensity				
	All	Renters	Home Owners	Female	Male
Age	2.79***	1.70***	1.49***	3.36***	2.56***
	(0.23)	(0.60)	(0.24)	(0.38)	(0.29)
Age Squared	-0.037***	-0.010*	-0.028***	-0.042***	-0.035***
	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)
Real Income	-0.014***	-0.022***	-0.013***	-0.012***	-0.014***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Income*DummyLow	0.048***	-0.058**	0.11***	0.038***	0.051***
	(0.01)	(0.03)	(0.01)	(0.01)	(0.02)
Household Size	22.3***	18.3***	22.3***	25.9***	20.5***
	(0.55)	(1.03)	(0.55)	(0.89)	(0.57)
Female	-12.9***	-10.5***	-13.1***	0	0
	(0.98)	(2.64)	(1.07)	(.)	(.)
College	-23.3***	-28.1***	-23.0***	-20.1***	-24.7***
	(1.16)	(3.79)	(1.11)	(2.26)	(1.26)
Manager	-17.6***	-21.5***	-17.9***	-16.5***	-18.0***
	(1.18)	(3.60)	(1.22)	(2.50)	(1.28)
Fixed-term contract	4.38***	6.98**	5.54***	3.96**	5.63***
	(1.33)	(2.87)	(1.44)	(1.98)	(1.63)
City Size	19.1***	21.7***	19.0***	20.6***	18.3***
	(0.60)	(1.52)	(0.57)	(0.88)	(0.57)
Renters	63.7***	0	0	77.3***	55.9***
	(2.25)	(.)	(.)	(3.22)	(2.33)
Observations	261975	35517	226458	83052	178923

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: Description of variables: Age - Age of Head of the Household, Age Squared - Square of Age of Head of the Household, Income - Real Income, Income*DummyLow denotes the interaction term income multiplied by dummy variable that takes the value one if income is below the 10th percentile, Household size - Number of members in the household, Female - Head of household is Female, College - Head of household obtained a college degree, Manager - Occupation of the Head of the household classified as managerial or white collar, Fixed-term contract - Head of the household works under a fixed-term contract, City size - Takes values of 1 to 5, 1 denoting cities with more than 100,000 habitants, increasing for smaller cities until 5 denoting cities with less than 10000 habitants and Renter - The main residence of the household is rented. Columns 3 to 6, regressions including only Renters, Home Owners, Female Headed Households and Male Headed Households respectively

Table 7: Greenhouse Gas Emission Intensity and Household Characteristics

	(1) Total	(2) *High Emission*	(3) *Transport*	(4) *Energy*
Age	4.11***	1.86***	2.27***	-0.56**
	(0.26)	(0.25)	(0.18)	(0.23)
Age Squared	-0.046***	-0.025***	-0.039***	0.015***
	(2.3e-03)	(2.3e-03)	(1.6e-03)	(2.1e-03)
Real Income	-0.016***	-0.015***	0.0083***	-0.022***
	(6.9e-04)	(6.5e-04)	(3.5e-04)	(5.7e-04)
Household Size	29.3***	15.0***	14.6***	-0.93**
	(0.60)	(0.57)	(0.39)	(0.42)
Female	-18.6***	-9.47***	-26.4***	16.6***
	(1.04)	(1.07)	(0.69)	(0.96)
College	-30.0***	-18.5***	-1.11	-15.8***
	(1.29)	(1.24)	(0.88)	(1.03)
Manager	-23.9***	-11.3***	-1.14	-8.29***
	(1.25)	(1.37)	(0.83)	(1.15)
Fixed-term contract	3.08**	7.35***	-0.93	7.72***
	(1.52)	(1.42)	(1.04)	(1.16)
City Size	21.6***	17.7***	17.8***	-0.69
	(0.66)	(0.64)	(0.55)	(0.50)
Renters	77.1***	47.7***	2.10	41.3***
	(2.60)	(2.19)	(1.30)	(2.10)
Observations	261975	261975	261975	261975

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: Description of variables: Age - Age of Head of the Household, Age Squared - Square of Age of Head of the Household, Income - Real Income, Household size - Number of members in the household, Female - Head of household is Female, College - Head of household obtained a college degree, Manager - Occupation of the Head of the household classified as managerial or white collar, Fixed-term contract - Head of the household works under a fixed-term contract, City size - Takes values of 1 to 5, 1 denoting cities with more than 100,000 habitants, increasing for smaller cities until 5 denoting cities with less than 10000 habitants and Renter - The main residence of the household is rented. Using the sectors codes from CNAE 2009, *High Emission* sectors include: 05-09, 17, 19, 20, 23, 24, 35, 49, 50, 51. *Transport* includes sectors 19, 49, 50, 51, and Energy includes sector 35.

BANCO DE ESPAÑA PUBLICATIONS

OCCASIONAL PAPERS

2120 MATÍAS PACCE, ISABEL SÁNCHEZ and MARTA SUÁREZ-VARELA: Recent developments in Spanish retail electricity prices: the role played by the cost of CO_2 emission allowances and higher gas prices. (There is a Spanish version of this edition with the same number).

2121 MARIO ALLOZA, JAVIER ANDRÉS, PABLO BURRIEL, IVÁN KATARYNIUK, JAVIER J. PÉREZ and JUAN LUIS VEGA: The reform of the European Union's fiscal governance framework in a new macroeconomic environment. (There is a Spanish version of this edition with the same number).

2122 MARIO ALLOZA, VÍCTOR GONZÁLEZ-DÍEZ, ENRIQUE MORAL-BENITO and PATROCINIO TELLO-CASAS: Access to services in rural Spain. (There is a Spanish version of this edition with the same number).

2123 CARLOS GONZÁLEZ PEDRAZ and ADRIAN VAN RIXTEL: The role of derivatives in market strains during the COVID-19 crisis. (There is a Spanish version of this edition with the same number).

2124 IVÁN KATARYNIUK, JAVIER PÉREZ and FRANCESCA VIANI: (De-)Globalisation of trade and regionalisation: a survey of the facts and arguments.

2125 BANCO DE ESPAÑA STRATEGIC PLAN 2024: RISK IDENTIFICATION FOR THE FINANCIAL AND MACROECONOMIC STABILITY: How do central banks identify risks? A survey of indicators.

2126 CLARA I. GONZÁLEZ and SOLEDAD NÚÑEZ: Markets, financial institutions and central banks in the face of climate change: challenges and opportunities.

2127 ISABEL GARRIDO: The International Monetary Fund's view of social equity throughout its 75 years of existence. (There is a Spanish version of this edition with the same number).

2128 JORGE ESCOLAR and JOSÉ RAMÓN YRIBARREN: European Central Bank and Banco de España measures against the effects of COVID-19 on the monetary policy collateral framework, and their impact on Spanish counterparties. (There is a Spanish version of this edition with the same number).

2129 BRINDUSA ANGHEL, AITOR LACUESTA and FEDERICO TAGLIATI: 2021 Survey of Small Enterprises' Financial Literacy: Main Results. (There is a Spanish version of this edition with the same number).

2130 PABLO HERNÁNDEZ DE COS: Testimony before the Congress of Deputies Budget Committee on 25 October 2021 and before the Senate Budget Committee on 30 November 2021 in relation to the Draft State Budget for 2022. (There is a Spanish version of this edition with the same number).

2131 LAURA AURIA, MARKUS BINGMER, CARLOS MATEO CAICEDO GRACIANO, CLÉMENCE CHARAVEL, SERGIO GAVILÁ, ALESSANDRA IANNAMORELLI, AVIRAM LEVY, ALFREDO MALDONADO, FLORIAN RESCH, ANNA MARIA ROSSI and STEPHAN SAUER: Overview of central banks' in-house credit assessment systems in the euro area.

2132 JORGE E. GALÁN: CREWS: a CAMELS-based early warning system of systemic risk in the banking sector.

2133 ALEJANDRO FERNÁNDEZ CEREZO and JOSÉ MANUEL MONTERO: A sectoral analysis of the future challenges facing the Spanish economy. (There is a Spanish version of this edition with the same number).

2201 MANUEL A. PÉREZ ÁLVAREZ: New allocation of special drawing rights. (There is a Spanish version of this edition with the same number).

2202 PILUCA ALVARGONZÁLEZ, MARINA GÓMEZ, CARMEN MARTÍNEZ-CARRASCAL, MYROSLAV PIDKUYKO and ERNESTO VILLANUEVA: Analysis of labor flows and consumption in Spain during COVID-19.

2203 MATÍAS LAMAS and SARA ROMANIEGA: Designing a price index for the Spanish commercial real estate market. (There is a Spanish version of this edition with the same number).

2204 ÁNGEL IVÁN MORENO BERNAL and TERESA CAMINERO GARCÍA: Analysis of ESG disclosures in Pillar 3 reports. A text mining approach.

2205 OLYMPIA BOVER, LAURA CRESPO and SANDRA GARCÍA-URIBE: Household indebtedness according to the Spanish Survey of Household Finances and the Central Credit Register: a comparative analysis. (There is a Spanish version of this edition with the same number).

2206 EDUARDO GUTIÉRREZ, ENRIQUE MORAL-BENITO and ROBERTO RAMOS: Population dynamics during the COVID-19 pandemic. (There is a Spanish version of this edition with the same number).

2207 JULIO GÁLVEZ: Measuring the equity risk premium with dividend discount models.

2208 PILAR CUADRADO, MARIO IZQUIERDO, JOSÉ MANUEL MONTERO, ENRIQUE MORAL-BENITO and JAVIER QUINTANA: The potential growth of the Spanish economy after the pandemic. (There is a Spanish version of this edition with the same number).

2209 PANA ALVES, SERGIO MAYORDOMO and MANUEL RUIZ-GARCÍA: Corporate financing in fixed-income markets: the contribution of monetary policy to lowering the size barrier. (There is a Spanish version of this edition with the same number).

2210 PABLO BURRIEL, IVÁN KATARYNIUK and JAVIER J. PÉREZ: Computing the EU's SURE interest savings using an extended debt sustainability assessment tool.

2211 LAURA ÁLVAREZ, ALBERTO FUERTES, LUIS MOLINA and EMILIO MUÑOZ DE LA PEÑA: Fund raising in the international capital markets in 2021. (There is a Spanish version of this edition with the same number).

2212 CARLOS SANZ: El peso del sector público en la economía: resumen de la literatura y aplicación al caso español.

2213 LEONOR DORMIDO, ISABEL GARRIDO, PILAR L'HOTELLERIE-FALLOIS and JAVIER SANTILLÁN: Climate change and sustainable growth: international initiatives and European policies. (There is a Spanish version of this edition with the same number).

2214 CARMEN SÁNCHEZ and JARA QUINTANERO: Las empresas *fintech:* panorama, retos e iniciativas.

2215 MARÍA ALONSO, EDUARDO GUTIÉRREZ, ENRIQUE MORAL-BENITO, DIANA POSADA, PATROCINIO TELLO-CASAS and CARLOS TRUCHARTE: In-person access to banking services in Spain: a comparison with other countries and other types of services. (There is a Spanish version of this edition with the same number).

2216 BEATRIZ GONZÁLEZ, ENRIQUE MORAL-BENITO and ISABEL SOLER: Schumpeter Meets Goldilocks: the Scarring Effects of Firm Destruction.

2217 MARIO ALLOZA, JÚLIA BRUNET, VICTOR FORTE-CAMPOS, ENRIQUE MORAL-BENITO and JAVIER J. PÉREZ: Government spending in spain from a european perspective. (There is a Spanish version of this edition with the same number).

2218 PABLO AGUILAR, BEATRIZ GONZÁLEZ and SAMUEL HURTADO: Carbon tax sectoral (CATS) model: a sectoral model for energy transition stress test scenarios.

2219 ALEJANDRO MUÑOZ-JULVE and ROBERTO RAMOS: Estimation of the impact of changes in the period used to calculate the regulatory base on new retirement pension amounts. (There is a Spanish version of this edition with the same number).

2220 LUIS ÁNGEL MAZA: An estimation of the carbon footprint in Spanish credit institutions' business lending portfolio. (There is a Spanish version of this edition with the same number).

2221 SUSANA MORENO SÁNCHEZ: The EU-UK relationship: regulatory divergence and the level playing field.

2222 ANDRÉS ALONSO-ROBISCO and JOSÉ MANUEL CARBÓ: Inteligencia artificial y finanzas: una alianza estratégica.

2223 LUIS FERNÁNDEZ LAFUERZA, MATÍAS LAMAS, JAVIER MENCÍA, IRENE PABLOS and RAQUEL VEGAS: Analysis of the usability of capital buffers during the crisis precipitated by COVID-19. (There is a Spanish version of this edition with the same number).

2224 SONSOLES GALLEGO, ISABEL GARRIDO and IGNACIO HERNANDO: IMF precautionary facilities and their use in Latin America. (There is a Spanish version of this edition with the same number).

2301 LAURA HOSPIDO, CARLOS SANZ and ERNESTO VILLANUEVA: Air pollution: a review of its economic effects and policies to mitigate them.

2302 IRENE MONASTEROLO, MARÍA J. NIETO and EDO SCHETS: The good, the bad and the hot house world: conceptual underpinnings of the NGFS scenarios and suggestions for improvement.

2303 ADRIÁN LÓPEZ GONZÁLEZ: Inteligencia artificial aplicada al control de calidad en la producción de billetes.

2304 BELÉN AROCA MOYA: Conceptos, fundamentos y herramientas de neurociencia, y su aplicación al billete.

2305 MARÍA ALONSO, EDUARDO GUTIÉRREZ, ENRIQUE MORAL-BENITO, DIANA POSADA and PATROCINIO TELLO-CASAS: Un repaso de las diversas iniciativas desplegadas a nivel nacional e internacional para hacer frente a los riesgos de exclusión financiera.

2306 JOSÉ LUIS ROMERO UGARTE, ABEL SÁNCHEZ MARTÍN and CARLOS MARTÍN RODRÍGUEZ: Alternativas a la evolución de la operativa bancaria mayorista en el Eurosistema.

2307 HENRIQUE S. BASSO, OURANIA DIMAKOU and MYROSLAV PIDKUYKO: How inflation varies across Spanish households.

2308 LAURA CRESPO, NAJIBA EL AMRANI, CARLOS GENTO and ERNESTO VILLANUEVA: Heterogeneidad en el uso de los medios de pago y la banca *online:* un análisis a partir de la Encuesta Financiera de las Familias (2002-2020).

2309 HENRIQUE S. BASSO, OURANIA DIMAKOU and MYROSLAV PIDKUYKO: How consumption carbon emission intensity varies across Spanish households.