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Abstract

Around the world, demographic transitions are reshaping consumption patterns and influencing environmental outcomes. In Colombia, demographic change is expected to alter household spending, reducing demand in sectors such as education and transportation while increasing consumption in healthcare. These shifts have implications for energy demand and CO_2 emissions. This study examines the relationship between demographic change and consumption behavior across age groups, using data from the 2016-2017 National Household Budget Survey and age-specific projections for 2020-2050. We use Seemingly Unrelated Regression models to estimate sectoral consumption shares based on population age and project the sector specific trends to 2050. A regional input-output model is then applied to assess the impact of projected changes in consumption on total CO_2 emissions. Findings suggest a national decline in emissions by 2050, though regional disparities emerge: Bogotá and the Central-East region may see increases, while other regions are projected to experience reductions.

Keywords: Demographic change, Consumption patterns, CO_2 emissions, Population aging, Climate change
JEL classification: Q56, J11, D12, R15

Impacto del cambio demográfico en las emisiones de CO_2: el papel del consumo

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Resumen

En todo el mundo, las transiciones demográficas están transformando los patrones de consumo e influyendo en los resultados medioambientales. En Colombia, se espera que el cambio demográfico altere el gasto de los hogares, reduciendo la demanda en sectores como la educación y el transporte, mientras aumenta el consumo en la sanidad. Estos cambios tienen implicaciones para la demanda energética y las emisiones de CO_2. Este estudio examina la relación entre el cambio demográfico y el comportamiento de consumo en diferentes grupos de edad, utilizando datos de la Encuesta Nacional de Presupuestos de los Hogares 2016-2017 y proyecciones específicas por edad para 2020-2050. Utilizamos modelos de regresión aparentemente no relacionada para estimar la participación sectorial en el consumo basándonos en la edad de la población y proyectamos las tendencias específicas del sector hasta 2050. A continuación, se aplica un modelo regional de insumo-salida para evaluar el impacto de los cambios proyectados en el consumo sobre las emisiones totales de CO_2. Los resultados sugieren un descenso nacional de las emisiones para 2050, aunque surgen disparidades regionales: Bogotá y la región del Centro-Oriente podrían experimentar aumentos, mientras que otras regiones se prevé que experimenten reducciones.

Palabras clave: Cambio demográfico, Patrones de consumo, Emisiones de CO_2, Envejecimiento de la población, Cambio climático
Clasificación JEL: Q56, J11, D12, R15

1. Introduction

Demographic changes represent a structural transformation with profound implications for consumption patterns and the economic dynamics of countries. A growing body of literature documents that population ageing alters household expenditure structures, generating sectoral reallocations that can substantially affect energy demand, greenhouse gas emissions, and climate change outcomes (Carvalho et al., 2021; Santiago et al., 2015; Wang et al., 2019). As societies transition toward older population structures, consumption tends to decline in sectors associated with younger cohorts, such as education, transportation, and housing, while expenditure increases in health-related services, food, and personal services. These shifts modify the energy intensity embedded in household consumption and, consequently, the level and composition of CO_2 emissions.

In developing economies, these dynamics are particularly relevant given the concurrent processes of demographic transition, economic growth, and structural change. While income growth has historically been associated with rising emissions, demographic change introduces an additional layer of complexity by reshaping consumption behavior independently of aggregate demand levels. As highlighted by the literature, population ageing does not necessarily lead to an automatic reduction in emissions but rather induces a redistribution of emissions across sectors, depending on the relative carbon intensity of the goods and services demanded by older households (Carvalho et al., 2021; Wang et al., 2019). Understanding these interactions is therefore essential for evaluating long-term emission trajectories in countries undergoing rapid demographic change.

In this context, Colombia faces a dual and interrelated challenge. On the one hand, it is among the countries most vulnerable to climate change, experiencing recurrent extreme events such as floods and landslides that threaten agricultural production, food security, and regional development (Cardona et al., 2004; Aristizábal, 2008; IDEAM, 2019; Ayala & Ospino, 2023). On the other hand, the country is undergoing a demographic transition characterized by declining fertility and increasing life expectancy, which is expected to substantially alter aggregate consumption patterns across regions and age groups. Despite increasing attention to environmental issues in Colombia, the interaction between population ageing, consumption behavior, and climate change remains largely unexplored in the empirical literature.

Addressing this gap, the purpose of this document is threefold. First, it analyzes how demographic changes affect household consumption behavior across different age groups in Colombia. Second, it estimates the evolution of sectoral consumption patterns associated with population ageing at the departmental and regional levels. Third, it assesses the expected impact of demographic-driven changes in consumption structure on CO_2 emissions. To this end, the analysis combines microdata from the National Household Budget Survey (ENPH, *Encuesta Nacional de Presupuesto de los Hogares,* in Spanish) conducted by DANE for 2016-2017 with age-specific demographic projections by DANE (2018). These data are complemented with sectoral and regional CO_2 emissions from IDEAM's Greenhouse Gas Emissions Inventory (1990-2021).

Methodologically, the analysis proceeds in two stages. In the first stage, Seemingly Unrelated Regression (SUR) models are estimated to quantify the relationship between average population age and the consumption shares of 12 expenditure categories observed in the ENPH. The estimations exploit cross-sectional variation in 38 major cities and 5 regions, yielding 43 observational units. The results reveal statistically significant and heterogeneous effects of ageing across sectors, with declining shares in food, alcoholic beverages and tobacco, clothing, education, and restaurants and hotels, and increasing shares in goods and services, information and communication, recreation and culture, healthcare, and transportation. Based on the estimated coefficients, sectoral consumption shares are projected through 2050.

In the second stage, the projected consumption patterns are incorporated into a regional input-output model for Colombia (Haddad et al., 2023), adjusted to 2023 prices and covering 54 economic sectors across 33 departments. Holding technology and emission intensities constant at their benchmark levels, the model allows for an assessment of how changes in household demand induced by demographic dynamics propagate through the productive system and translate into changes in total CO_2 emissions. This framework makes it possible to isolate the contribution of consumption-structure effects associated with population ageing, independently of technological progress or changes in production efficiency.

The results indicate that, at the national level, total consumption-based CO_2 emissions are projected to decline by 2050 as a consequence of demographic change. However, this aggregate outcome conceals substantial regional heterogeneity. While departments in the Pacific, Caribbean, South Central regions, and the New Departments are projected to experience significant emission reductions, Bogotá and the Central Eastern region are expected to exhibit increases in emissions, reflecting their consumption profiles and productive structures. These findings underscore that demographic transition reshapes not only the level of emissions but also their sectoral and territorial distribution.

Overall, this study contributes to the literature by providing empirical evidence for Colombia on the links between population ageing, consumption behavior, and CO_2 emissions. The results highlight that demographic change acts primarily through a reallocation of household demand rather than through a proportional contraction of consumption, emphasizing the need to integrate demographic dynamics and regional heterogeneity into long-term climate and development policy analysis.

2. Literature review

Demographic changes have the potential to significantly impact consumption patterns (Carvalho et al., 2021; Santiago et al., 2015). As the population shifts from younger to older demographics, a change in consumption patterns is expected, which may affect greenhouse gas emissions and climate change (Wang et al., 2019). Colombia is one of the countries highly vulnerable to climate change, facing recurring phenomena such as floods and landslides (Cardona et al., 2004; Aristizábal, 2008; World Bank Colombia, 2012; Ayala & Ospino, 2023). According to IDEAM (2019), the country's agricultural production and food security are threatened by climate change. Furthermore, it is estimated that climate change could cost Colombia up to 8% of its GDP by 2050 if adequate measures are not taken (World Bank, 2023). These circumstances highlight the need to study how population dynamics interact with climate change. Despite growing attention to environmental issues in Colombia, the specific relationship between demographic transition and climate change remains underexplored.

Several studies agree that economic growth is accompanied by an increase in carbon dioxide emissions. Malik et al. (2016), analyzing global emissions between 1990 and 2010, report a 35% increase, driven by the rapid economic expansion of developing countries such as China and India. This growth was accompanied by the intensification of highly emissive sectors such as industry and transportation. Similarly, Patiño et al. (2020) find empirical evidence for Colombia confirming a positive linear relationship between national per capita GDP, energy consumption, and emissions, leading to the rejection of the environmental Kuznets curve hypothesis, which posits that for some pollutants, emissions increase in the early stages of economic development but tend to decrease after a certain level of per capita income (Bayramli and Karimli, 2024). Complementarily, Suárez et al. (2022) use machine learning models and historical emissions data to predict population growth in Colombia, showing how this growth is directly related to the increase in CO_2 emissions.

However, not all studies fully agree with this perspective. Dietz and Rosa (1997) estimated the effects of population and wealth on CO_2 emissions in 111 countries and argue that the relationship between economic growth and emissions is not always linear. They identify an inverted U-shaped curve, indicating that when per capita wealth reaches levels close to \$10,000, CO_2 emissions stop increasing and tend to fall below strict proportionality, suggesting a possible reduction in carbon intensity as countries move toward more developed stages. They conclude that larger populations are associated with higher CO_2 emissions, with effects that are broadly proportional across most countries. Their findings support the view that population growth is a key driver of environmental impacts and greenhouse gas emissions.

In developed countries, population aging represents a significant challenge, as the age group over 60 years accounts for about one-fifth of the total population in most developed nations (Zheng et al., 2022). Although it might be assumed that an aging population emits less due to lower mobility or productivity, empirical evidence suggests a more complex and often contradictory picture. For example, using an input-output model applied to Germany, Kronenberg (2009) concludes that demographic change does not significantly reduce energy use or emissions and even identifies a relative increase in methane emissions attributable to the consumption patterns of older individuals. Similarly, Zheng et al. (2022) demonstrate that in 32 developed economies, the share of emissions attributed to people over 60 years old grew from 25.2% in 2005 to 32.7% in 2015. In countries like the United States and Australia, this group has the highest per capita carbon footprint due to high demand for energy-intensive services.

Albuquerque and Lopes (2010) point out that some sectors gain importance in an aging society (medical, pharmaceutical, healthcare services, etc.), while others experience relative decline (educational, cultural, recreational, sports services, etc.). In the same vein, Wang et al. (2019) analyzes the case of China and shows that population aging has a nonlinear effect on per capita emissions. In the initial stage, aging may slightly reduce emissions by decreasing aggregate demand; however, as the population continues to age, it shifts consumption toward more energy-intensive sectors, such as residential energy and healthcare services, thereby increasing emissions again. Jung (2021), in a study applied to South Korea, China, and Japan, finds that a population reduction due to aging does not necessarily imply a proportional decrease in emissions. Although GDP declines, emitting sectors retain their share in the economy, maintaining high CO_2 levels.

Other studies offer important nuances. O'Neill et al. (2010), through long-term simulations for various demographic scenarios, find that slower population growth could significantly contribute to reducing future carbon emissions. This does not guarantee automatic reduction but may facilitate the achievement of climate goals, technological innovation, and structural changes in consumption and production. In line with this, Dietz and Rosa (1997) emphasize that environmental impacts do not depend exclusively on population size but on the interaction between population, affluence, and technology.

In this context, it can be stated that the transition to an older population does not necessarily imply an absolute reduction in emissions but rather a redistribution of emissions resulting from changes in consumption patterns. As noted by Carvalho et al. (2021) and Santiago et al. (2015) in the Brazilian case, aging tends to reduce consumption in emission-intensive sectors such as transportation while increasing spending in less emissive sectors such as healthcare and personal services. That is, a sectoral shift occurs that transforms the emissions structure without guaranteeing total reduction.

In the Colombian case, empirical evidence also confirms a link between economic growth, energy consumption, and CO_2 emissions. Based on historical data from 1971 to 2017, studies such as those by Patiño et al. (2020) and Blanco-Camargo et al. (2020) show that emissions continue to rise alongside income, reflecting the country's structural dependence on fossil fuel-based energy sources. This behavior is further observed in a study applied to the city of Ibagué, where Sierra-Ramírez et al. (2022) show that variables such as household size, composition, and socioeconomic stratum explain significant variations in emission levels. Although low-income households have lower individual emissions, their demographic weight makes them the main aggregate emitters, accounting for 41% of the total.

3. Methodology and data

This study is structured in two complementary stages to estimate the impact of demographic change on consumption patterns and, subsequently, on CO_2 emissions in Colombia. In the first stage, we employ Seemingly Unrelated Regression (SUR) models to analyze how the sectoral composition of household consumption varies according to demographic and economic factors. This approach allows for the simultaneous estimation of multiple regression equations, one for each consumption sector, while accounting for potential correlations among the error terms across equations, thereby improving the efficiency of the estimates.

The general specification for each sector j in region i is as follows:

$$s_{ij} = \alpha_j + \beta_j Age_i + e_{ij} \tag{1}$$

Where s_{ij} is the share of sector j in total household consumption in region i, Age_i is the average age of the population in region i, β_j is the coefficient capturing the effect of average age on consumption in sector j, and e_{ij} is the error term. These models are estimated for 12 consumption sectors from the National Household Budget Survey (ENPH, in Spanish) conducted by DANE, using 43 observations corresponding to 38 major cities and 5 regions. Based on the estimated coefficients, we predict the share of each consumption sector up to the year 2050, using age-specific demographic projections (DANE, 2018). The consumption sectors available in the ENPH survey are listed in Table 1, with the respected national average share over total consumption. The highest share is in the Housing, Water, Electricity, Gas, and Other Fuels sector, while the lowest is in the group of Alcoholic Beverages and Tobacco.

Table 1. Consumption by sectors and shares on total consumption, 2016/2017.

Sector	Total Spending (Millions, COP$)	Shares
Housing, Water, Electricity, Gas, and Other Fuels	5.494.908	0,29
Food and Non-Alcoholic Beverages	3.528.381	0,19
Goods and Services	3.126.573	0,16
Transportation	1.754.247	0,09
Restaurants and Hotels	1.574.612	0,08
Clothing and Footwear	786.682	0,04
Furniture, Household Equipment, and Routine Household Maintenance	685.408	0,04
Information and Communication	613.461	0,03
Recreation and Culture	563.353	0,03
Education	399.241	0,02
Healthcare	315.317	0,02
Alcoholic Beverages and Tobacco	157.620	0,01

Source: The authors with data from the National Household Budget Survey.

Once the projected sectoral shares of household consumption are obtained, we proceed to evaluate their economic and environmental implications using an interregional input-output model for Colombia, adapted from Haddad et al. (2023). This model reflects the economic structure of the country in 2015, adjusted to 2023 prices, and includes 54 economic sectors for 33 departments. The input-output model enables us to simulate how changes in final demand, specifically household consumption, propagate through the economy, affecting intersectoral production and, consequently, CO_2 emissions. Emission intensity coefficients by sector are incorporated using data from IDEAM's Greenhouse Gas Emissions Inventory (1990-2021).

In the second stage, we employ the Interregional Input-Output Matrix for Colombia (IIOM-COL) compiled by Haddad et al. (2023). The benchmark year is 2015 and the table covers 33 departments and 54 sectors. In particular, consider a basic interregional input-output system with I sectors and R regions. The solution to the model can be summarized as

$$\mathbf{x} = \mathbf{LYi} \tag{2}$$

where $\mathbf{x}$ is the *IR* vector with the gross output; $\mathbf{L} = (\mathbf{I} - \mathbf{A})^{-1}$ is the *IR x IR* interregional Leontief inverse; $\mathbf{I}$ is the identity matrix; and $\mathbf{A} = \mathbf{Z}(\hat{\mathbf{x}})^{-1}$ is the matrix of input-output coefficients, denoting intermediate inputs ($\mathbf{Z}$) per unit of gross output; $\mathbf{Y}$ is the *IR x C* matrix of final demand, where *C* indexes final demand components (gross fixed capital formation, household consumption, NPISH consumption, government consumption, and foreign export). $\mathbf{i}$ is the *C* column vector of ones. Building on this framework, the total (direct and indirect) greenhouse gas emissions embodied in final demand are given by

$$\mathbf{s} = \hat{\mathbf{e}}\mathbf{LYi} \tag{3}$$

where $\mathbf{s}$ is the *IR* vector representing the total emissions embodied in the final demand. The term $\hat{\mathbf{e}}$ is an *IR x IR* diagonal matrix of emission intensity, which is derived from a vector of emission ($\mathbf{s}$) per unit of output ($\mathbf{x}$), such that $\hat{\mathbf{e}} = \hat{\mathbf{s}}(\hat{\mathbf{x}})^{-1}$.

We focus on emissions required to satisfy household consumption. Let $\mathbf{Y}^{\boldsymbol{H}}$ denote the *IR x R* matrix of household consumption. The emissions embodied in household demand is:

$$\mathbf{S}^{\mathbf{H}} = \hat{\mathbf{e}}\mathbf{LY}^{\mathbf{H}} \tag{4}$$

The *IR x R* matrix $\mathbf{S}^{\mathbf{H}}$ is the emissions embodied in household consumption; where row sums provide the producing sector-region profile of embodied emissions, while column sums yield the total emissions for each consuming region. We built the model to the 2015 Colombian interregional system. For projections, we hold the technology and emission intensity constant by keeping the Leontief inverse ($\mathbf{L}$) and the emission intensity matrix ($\hat{\mathbf{e}}$) fixed at their 2015 levels. We then project changes in the composition of regional household consumption, $\mathbf{Y}_{\mathbf{t}}^{\mathbf{H}}$, for the years $t = 2020, \dots, 2050$, keeping the benchmark levels constant, using data from the National Household Budget Survey for 2016-2017 combined with official demographic projections. Projected consumption-based emissions are

$$\mathbf{S}_{\mathbf{t}}^{\mathbf{H}} = \hat{\mathbf{e}}\mathbf{LY}_{\mathbf{t}}^{\mathbf{H}} \tag{5}$$

This setup allows us to identify the contribution of demographic shifts and consumption-pattern changes to total emissions under a fixed technological and economic structure.

We use Greenhouse gas (GHG) data are sourced from Colombia's National Inventory of Greenhouse Gas Emissions[1] (INGEI, in Spanish), disseminated by the Ministry of Environment and Sustainable Development. INGEI reports emissions in CO2-equivalent (CO_2e) for CO_2, CH4, and N2O over 1990-2021, with 391 emitting-source classifications grouped into major sectors (energy; industrial processes and product use; agriculture, forestry, and land-use change; and waste). The database also provides gross emissions, removals (absorptions), and net emissions. We implement three steps to align emissions with the IIOM-COL framework:

1. Sectoral concordance. We harmonize INGEI's 391 source categories with the IIOM-COL by constructing a correspondence that yields a final set of 40 comparable sectors. This produces national emissions by 40 sectors for the benchmark year 2015. We consider the aggregate of CO_2, CH4, and N2O, converted to CO_2e, as our measure of emissions.

2. Input-output aggregation. The IIOM-COL is aggregated from 54 to the same 40 sectors to ensure consistency between the emissions dataset and the economic accounts.

3. Regionalization. Using a departmental emissions dataset for 2012 (classified into four broad groups, agriculture; trade and transport; manufacturing; and mining and energy), we compute department-specific shares to allocate the 2015 national sectoral totals across the 32 departments and Bogotá. This fixed-share procedure yields net emissions for a 33-department × 40-sector matrix that is compatible with the aggregated IIOM-COL.

4. Results

The empirical results provide consistent evidence that demographic change plays a significant role in shaping household consumption patterns in Colombia and, through these patterns, influences the evolution of CO_2 emissions. Using the Seemingly Unrelated Regression (SUR) framework, the study estimates the relationship between average

[1] Link: https://www.minambiente.gov.co/cambio-climatico-y-gestion-del-riesgo/inventario-nacional-de-emisiones-y-absorciones-de-gases-de-efecto-invernadero-ingei/

population age and the sectoral composition of household consumption across 43 observations corresponding to major cities and regions.

Table 2 shows the results of the SUR model estimated to evaluate the relationship between age and the consumption share for each of the 12 sectors of the 2016-2017 ENPH survey. It shows the coefficient and standard error for the average age of the population, showing the relationship between age and the consumption share of every sector. The base sector is the Transportation spending. The estimation results indicate that population ageing is negatively associated with the consumption share of food and non-alcoholic beverages, alcoholic beverages and tobacco, and clothing and footwear, all of which display negative and statistically significant coefficients (Table 2). In contrast, sectors such as goods and services, information and communication, recreation and culture, and healthcare exhibit positive and significant coefficients, suggesting that older populations allocate a larger proportion of their expenditure to these categories.

Table 2. SUR models for 12 consumption sectors in Colombian departments, 2016/2017.

Sector	Coefficient	Std. Err.	R-squared
Food and Non-Alcoholic Beverages	-0.0053***	(0.0012)	0.3227
Housing, Water, Electricity, Gas, and Other Fuels	0.0004	(0.0015)	0.0009
Alcoholic Beverages and Tobacco	-0.0020***	(0.0004)	0.3714
Goods and Services	0.0028**	(0.0013)	0.0987
Education	-0.0008	(0.0010)	0.0131
Information and Communication	0.0004**	(0.0002)	0.0853
Furniture, Household Equipment, and Routine Household Maintenance	0.0000	(0.0002)	0.0033
Clothing and Footwear	-0.0008*	(0.0004)	0.0809
Recreation and Culture	0.0004*	(0.0002)	0.0701
Restaurants and Hotels	-0.0004	(0.0007)	0.0094
Healthcare	0.0005**	(0.0002)	0.0834
Observations	43		

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The transportation sector is the base sector.

These patterns are consistent with a gradual reallocation of spending away from goods associated with younger households toward services more closely linked to ageing-related needs. Other sectors, including housing, water, electricity, gas, and other fuels, as well as furniture and household maintenance, show coefficients that are not statistically significant, indicating a relatively stable share of expenditure with respect to demographic changes (Table 2). Given that housing-related services already represent the largest share of household consumption, this stability implies that ageing primarily affects the composition of non-housing expenditures rather than altering the dominance of this sector in the consumption basket.

Building on the estimated SUR coefficients, the study projects sectoral consumption shares for the period 2020-2050. Figure 1 illustrates substantial heterogeneity in the evolution of consumption structure over time. The projections show declining shares for food and beverages, alcoholic beverages and tobacco, education, clothing and footwear, and restaurants and hotels. In contrast, consumption shares for housing-related services, goods and services, information and communication, recreation and culture, healthcare, and transportation are projected to increase steadily throughout the period.

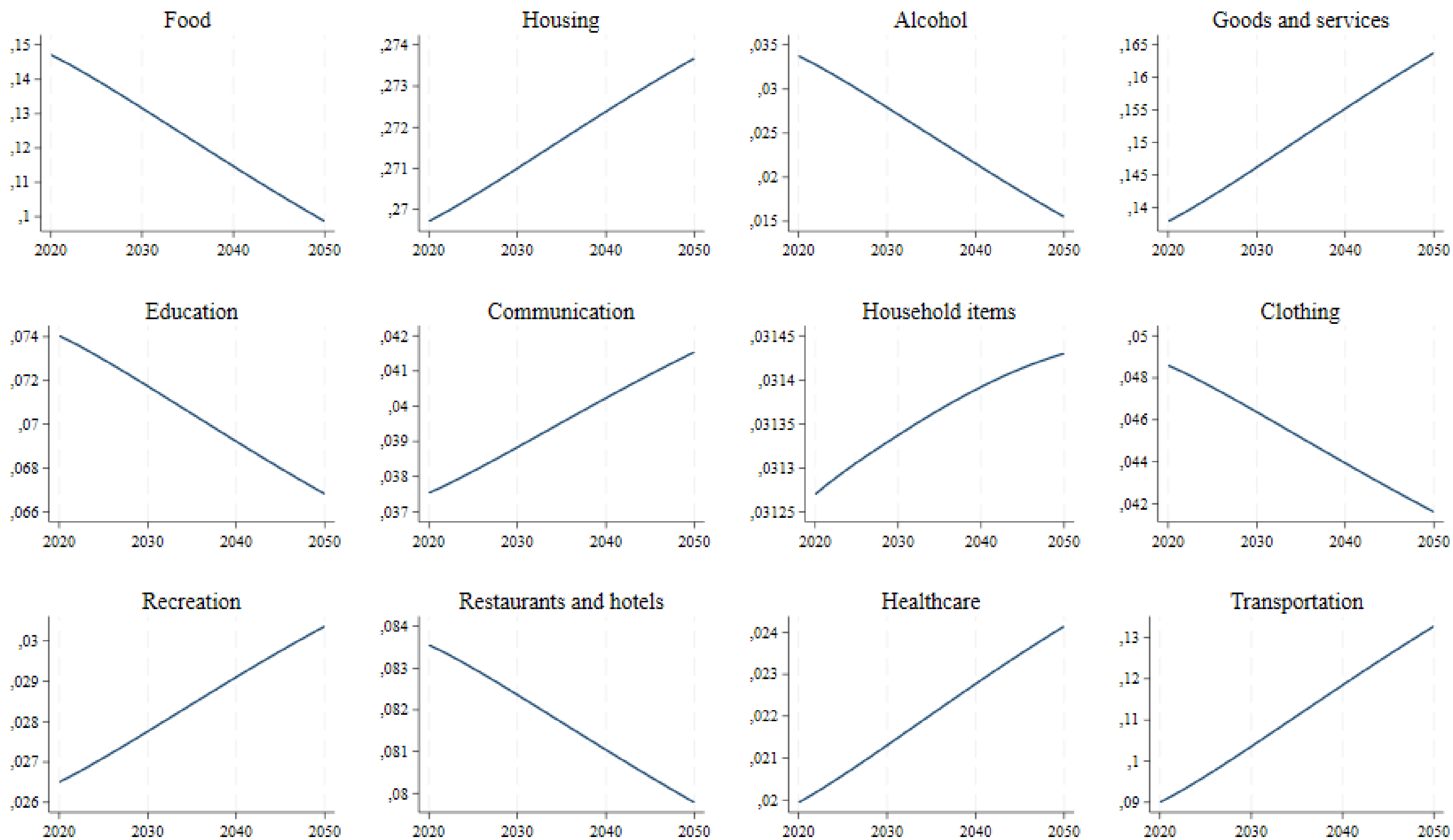
The projected consumption dynamics imply notable changes in the relative importance of sectors within the household budget. While housing remains the dominant expenditure category, goods and services and transportation increase their relative relevance, overtaking food as one of the largest components of consumption by 2050 (Figure 1). Additionally, healthcare moves away from being one of the smallest consumption categories, reflecting the growing importance of ageing-related services, whereas alcoholic beverages and tobacco become the category with the lowest share.

These results are broadly consistent with the international literature (Carvalho et al., 2021; Santiago et al., 2015; Wang et al., 2019), as they indicate that population ageing leads to significant shifts in the composition of household expenditure. However, the Colombian case exhibits some distinctive features. In addition to the expected increase in the expenditure share devoted to healthcare, we also find rising shares in information and communication, recreation and culture, and transportation. This suggests that the consumption preferences of an ageing population in Colombia are not solely driven by greater care-related needs but also reflect more diverse patterns of economic and social participation.

To assess the environmental implications of these consumption shifts, the projected household demand vectors are incorporated into a regional input-output model with fixed technology and emission intensities. The results, summarized in Figure 2, indicate that total consumption-based CO_2 emissions at the national level are projected to decline gradually over the period 2020-2050. This decline reflects the combined effect of reduced demand in relatively emission-intensive consumption categories and increased demand in sectors with lower emission intensities.

Despite the aggregate reduction at the national level, the regional results reveal substantial spatial heterogeneity. Figure 3 shows that Bogotá and the Central Eastern region are projected to experience increases in total CO_2 emissions associated with household consumption. In contrast, the Pacific, Caribbean, South Central regions, and the New Departments are expected to record significant reductions in emissions over the same period. These differences highlight the uneven impact of demographic change across regions with distinct productive structures and consumption profiles.

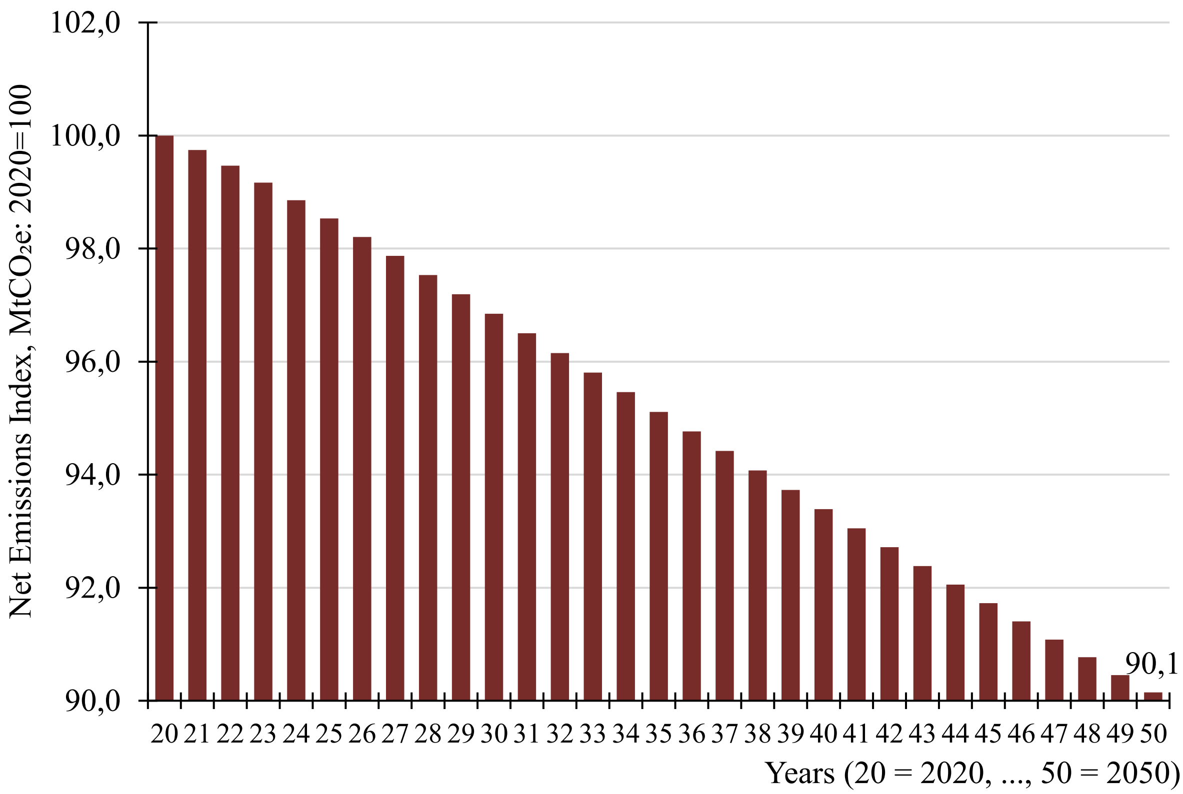
Figure 1. Projection of Consumption Structure by Sector (2020–2050): Shares Across 12 Categories.



Source: the authors with data from the National Department of Statistics, DANE.

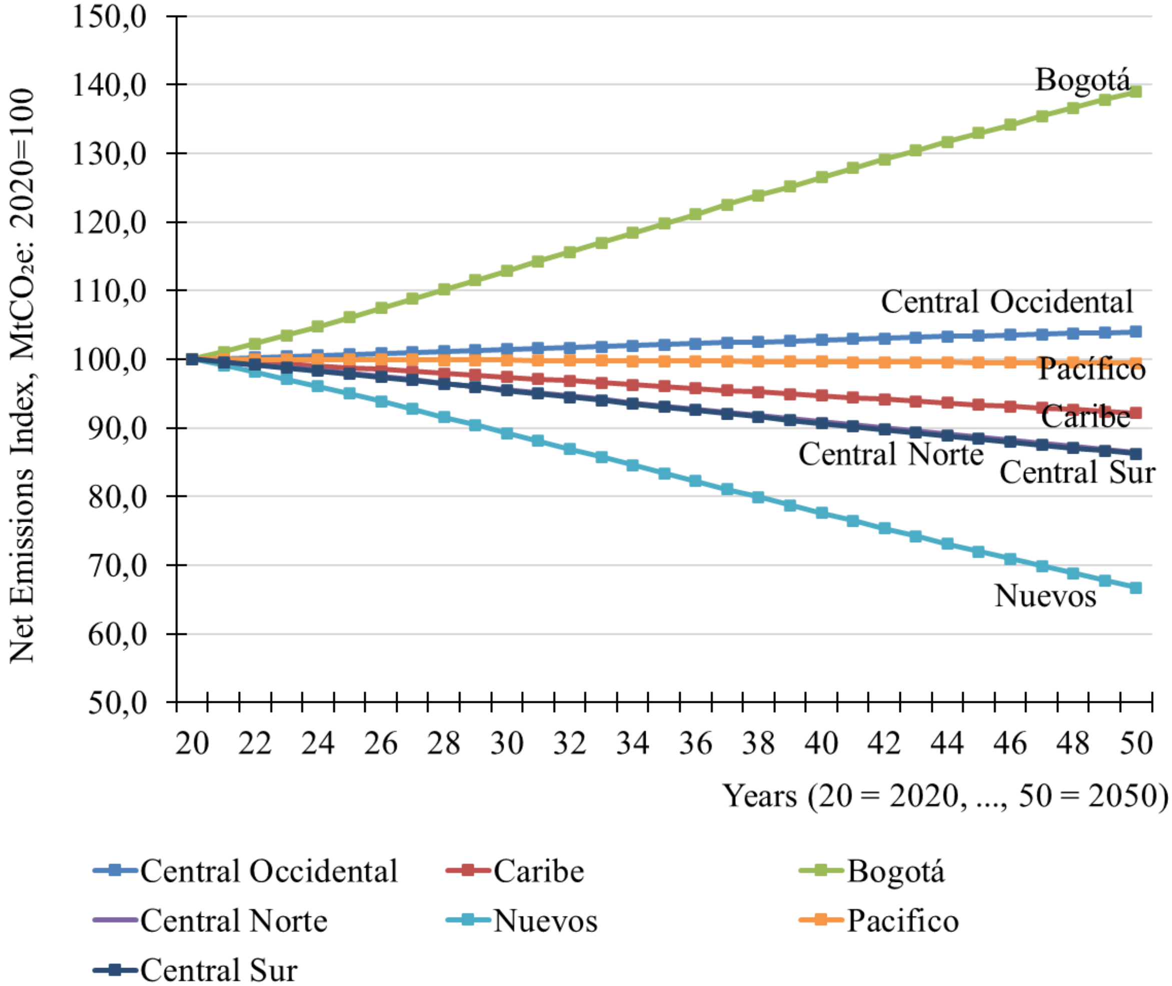
In general, the results demonstrate that demographic change reshapes consumption patterns in ways that have meaningful consequences for CO_2 emissions, but these effects are neither uniform across sectors nor homogeneous across regions. Rather than inducing a proportional decline in emissions, population ageing operates through a reallocation of household demand that modifies the sectoral and regional distribution of emissions. This evidence underscores the importance of accounting for both consumption structure and territorial heterogeneity when evaluating the long-term environmental implications of demographic transitions.

Figure 2. Projected total CO_2 emissions, 2020-2050.



Source: the authors with data from the IDEAM Greenhouse Gas Emissions Inventory and the National Department of Statistics, DANE.

Figure 3. Projected total CO_2 emissions by region, 2020-2050.



Source: the authors with data from the IDEAM Greenhouse Gas Emissions Inventory and the National Department of Statistics, DANE.

5. Conclusion

The findings of this study confirm that demographic change constitutes a relevant structural driver shaping future consumption patterns and, through them, the trajectory of CO_2 emissions in Colombia. Population ageing systematically alters household expenditure composition, reducing the relative importance of traditionally emission-intensive sectors such as transportation, education, and clothing, while increasing demand for housing-related services, healthcare, communication, and other personal services. This process implies a sectoral reallocation of consumption that modifies the emissions structure, even under assumptions of constant technology and emission intensities.

The estimation results from the SUR models reveal statistically significant and heterogeneous effects of population ageing across consumption categories. Increases in average population age are associated with higher expenditure shares in healthcare, goods and services, information and communication, and recreation and culture, while sectors such as food, alcoholic beverages and tobacco, and clothing show declining shares. When projected to 2050, these dynamics indicate a persistent transformation in household consumption baskets, consistent with the demographic transition toward an older population structure.

By integrating projected consumption changes into an interregional input-output framework, the analysis translates demographic-driven shifts in household demand into quantifiable impacts on CO_2 emissions. The results indicate a projected decline in total consumption-based CO_2 emissions at the national level by 2050. However, this aggregate outcome masks substantial regional heterogeneity. While the Caribbean, Pacific, South Central regions, and the New Departments are expected to experience significant reductions in emissions, Bogotá and the Central Eastern region are projected to show increases, reflecting their productive structures, income levels, and consumption patterns that remain more carbon-intensive.

Overall, the results suggest that population ageing does not automatically guarantee a uniform reduction in CO_2 emissions but rather operates through a redistribution of emissions driven by changes in consumption structure. Consequently, climate mitigation and sustainable development policies should explicitly incorporate demographic dynamics and territorial heterogeneity, adopting region-specific strategies that recognize both the mitigation potential arising from shifts in household demand and the risks associated with the expansion of sectors that may sustain or increase environmental pressures. In this sense, understanding the interaction between demographic change, consumption behavior, and production structure is essential for designing long-term policies consistent with Colombia's socioeconomic and environmental trajectories.

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