

EFFECTS OF URBAN HOUSEHOLD CONSUMPTION ON CO2 EMISSIONS

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ABSTRACT

This study examines the effects of urban household consumption on CO2 emissions in 2011. The required information was obtained from the input-output table (IOT) 2001 and the statistical data on the income and expenditure of urban households in 2011. CO2 emissions (direct, indirect, and total) induced by urban household consumption was estimated. Also, the proportion of income deciles of urban households in CO2 emissions was calculated. The results of the study indicated a higher proportion of higher-income households in the consumption of goods and services. On the other hand, CO2 emissions induced by urban household consumption increases in proportion to the increase in consumption expenditure. Therefore, higher-income deciles of urban households have a larger proportion of CO2 emissions. The results also showed the effectiveness of combining the consumption of different rural households on CO2 emissions induced by urban household consumption. The pollution coefficient of each unit of consumption expenditure of urban households, indicating CO2 emissions from each unit of consumption expenditure of income deciles of urban households, showed an incomplete inverse relationship between the coefficient of pollution of consumer goods and household income. This can be due to reasons like the fact that the consumer goods of the lower deciles are highly domestic, leading to relatively higher pollution of the consumer goods of the lower deciles of society.

Keywords: Urban Household Consumption, CO2 Emissions, Input-Output analysis, Iran

INTRODUCTION

Recently, economic and environmental policies are adopted mainly to reduce greenhouse gas emissions and air pollution. CO2 emissions are affected by many factors, such as economic and demographic factors, technological changes, institutional framework, lifestyle, and international trade. Meanwhile, urban household consumption is also considered as one of the factors influencing CO2 emissions, which can play a decisive role in reducing greenhouse gas emissions, especially CO2.

Problem Statement

Nowadays, the consequences of human intervention on the environment have become more apparent than ever before. These interventions have had far-reaching implications for the traditional and common concepts of economic development today. This approach has led many economists and scientists who once believed that natural resources and the environment should be free to change their beliefs fundamentally.

One of the destructive effects of human activities on the living environment is increasing emissions of greenhouse gases, which is considered a severe threat to global warming. The

CO2 emission problem is directly related to energy use. There is a strong correlation between energy consumption used for economic activities and CO2 emissions (Akhbari, 2008).

Meanwhile, all types of energy are consumed through economic activities to meet the needs of households, one of the factors affecting CO2 emissions. Different households have different CO2 emissions depending on their different income levels. This difference can be attributed in part to costs and consumption levels, and some extent, to the type of goods and services consumed and whether they are domestically produced or imported. This study seeks to evaluate the effect of household consumption on CO2 emissions using input-output analysis.

RESEARCH BACKGROUND

Roca and Serrano (2008) examined the effect of different Spanish households on atmospheric pollution in 2000 using an environmentally-extended input-output (EEIO) model and combining information from different databases. The results showed a significant positive relationship between household expenditure level and household consumption-induced emissions. The attraction of wealthy households to the emission of synthetic greenhouse gases and other gases was positive and greater than 1 and positive and smaller than 1, respectively.

Based on field studies and household questionnaires in June 2006, Liu et al. (2010) analyzed the structure of energy supply and consumption in rural households and its effects on environmental, health, and community aspects. The results showed that traditional energy accounted for almost 70% of total energy consumption in rural households, leading to pressing environmental issues, such as deforestation, soil erosion, pasture degradation, and desertification.

In a paper, Wang and Shi (2009) examined the role of CO2 emissions in China based on the input-output model for the period 2004-1995, emphasizing the role of consumption as one of the most critical factors in CO2 emissions. The results indicated an increase in per-capita CO2 emissions from 1995 to 2004.

Using an EEIO analysis, Arvesen et al. (2010) estimated the environmental impacts of urban households in Beijing on different income groups. The results suggested that each Beijing resident consumed, on average, 52 kilojoules of energy in 2007. This amount of energy consumed corresponds to 4.2 tons of CO2, 27 kilograms of sulfur dioxide, 17 kilograms of oxidant nitrogen, released per year, of which only 18-34% can be attributed to direct energy consumption.

In a paper, Feng et al. (2011) used a consumer lifestyle approach in different regions with different income levels in China to analyze the impact of urban and rural household consumption on energy consumption and CO2 emissions. The results implied a faster increase in direct energy consumption and CO2 emissions by urban households than rural households.

In a study, Fitras and Barati (2011) analyzed the role of urban households and their importance in greenhouse gas emissions. The results of CO2 emissions from indirect energy carrier consumption showed that the "electricity supply," "natural gas supply," and "basic metals" sectors had the highest CO2 emissions. On the other hand, the results obtained from direct consumption-induced CO2 emissions showed a high proportion of electricity and natural gas consumption in total CO2 emissions due to direct energy consumption in urban households.



Using the Johansson-Joselius cointegration method, vector error correction (VEC) model, and time-series data for the period 1967-2004, Behboudi et al. (2010) explored the socio-economic factors affecting CO₂ emissions as a criterion for determining environmental pollution. The results of this model indicated the positive effect of GDP per capita, the degree of economic openness, energy intensity, and urban population on CO₂ emissions per capita.

Vasfi (2007) analyzed the effect of a 10% increase in final demand on CO₂ emissions, as an environmental pollutant, and the household share in these emissions. The study found that 119.8 million tons of CO₂ were released nationwide by a 10% increase in final demand or 3.07 tons per capita.

METHODOLOGY

The present research project is an input-output analysis, the spatial range of which is the urban areas of Iran. The time frame of this study is the latest statistics on household consumption in urban areas since 2011. This study used the latest national statistical input-output table (IOT) in 2001 as a statistical basis for calculations. The statistical sources used are the national input-output table (NIOT) 2001 (Statistical Center of Iran, 2006). This table (at producer price) is currently the last complete official and national statistical table. Information on the cost and income of different income deciles of urban households in 2011 was obtained from the Statistical Center of Iran. The coefficients for environmental pollutants were obtained from the United Nations Climate Change Secretariat (located in the Environmental Protection Agency (EPA)). Statistics on the price of fossil fuels were obtained from the 2001 and 2011 Energy Balance Sheets of the Ministry of Energy. The price index of consumer goods and services in 2001 & 2011 was also prepared from the economic statistics of the Central Bank. Given the different levels of income and the combination of consumption of different deciles of urban households, the present study seeks to answer the following questions:

- 1) What is the role of different income deciles in CO₂ emissions?
- 2) Regardless of household income differences, does the combination of household consumption affect CO₂ emissions?

To achieve the objectives of the present study and for easy and precise application of sectoral technology, this research used the commodity-by-commodity IOT assuming sectoral technology. In this study, the energy IOT was prepared using the commodity-by-commodity symmetric IOT (SIOT), obtained from the previous step. To prepare the energy IOT, the values of exchanges of goods and energy carriers were added to the conventional IOT after the value units were converted to physical units. The EEIOT was prepared to calculate CO₂ emissions from the production and consumption of goods and services. For this purpose, CO₂ emissions from energy consumption were initially calculated by multiplying the intensity of this pollutant (i.e., direct CO₂ emission factors) by the total production and added row-by-row to the conventional IOT. Contrary to previous studies in literature, this study did not calculate the total household CO₂ emissions; instead, it was estimated by determining different household consumption expenditure groups. Thus, the effects of different cost levels on CO₂ emissions were studied.

Direct CO₂ emissions from energy carriers, such as electricity, oil, coal, and gasoline, are generated by households. In contrast, indirect emissions come from the consumption of energy carriers when producing household goods and services, such as furniture, clothing, and food.



In the first phase, direct CO₂ emissions from household energy consumption were estimated using a simple energy dissipation model. In the second phase, the total CO₂ emissions were initially estimated using a generalized IO model, followed by the indirect emission determination by deducting the direct emissions from the total emissions.

To calculate direct household CO₂ emissions, household direct energy consumption values, obtained from the final demand vector of household consumption, was initially converted from value units to physical units. Then, direct emission values were calculated by multiplying these values by CO₂ emission factors.

RESEARCH FINDINGS:

Preparation of Tables

Aggregate Tables

The 2001 aggregate table was used to proceed with calculations due to the lack of a separate price index for each commodity, as well as to facilitate calculations. Consequently, the SIOT of 147 commodities was transformed into a smaller table with 37 commodities with the following titles.

Table 1. Goods and services after aggregation

N.	Product Title	N.	Product Title
1	Agricultural products	20	Liquefied gas
2	Horticultural products	21	Other petroleum products and nuclear fuel
3	Live animals and poultry and its products, etc.	22	Chemical industry
4	Forest products and tree felling	23	Non-metallic mineral industries
5	Fish and other fishery products	24	Other industries
6	Coal, lignite, and peat	25	Basic metals industry
7	Crude oil and natural gas	26	Machinery industry
8	Minerals and their concentrates	27	Construction
9	Electricity and related services	28	Trade and hotel management
10	Water and related services	29	Transportation services
11	Distribution of natural gas and related services	30	Post and Telecommunication Services
12	Food industry	31	Bank and insurance services
13	Textile and leather industries	32	Services of residential and non-residential units
14	Wood and wood-based products	33	Business services
15	Paper and paper products	34	Public services
16	Gasoline	35	Training services
17	Kerosene	36	Health services
18	Gasoline	37	Cultural and artistic services
19	Fuel oil		

Energy Input-Output Table

To prepare the energy input-output table, the values of exchanges of goods and energy carriers were added to the conventional IOT after they were converted from value units to physical units.

Environmental Input-Output Table

Table 2 shows CO₂ emissions per unit of energy carriers (e.g., coal, lignite, and peat, electricity and related services, distribution of natural gas and related services, gasoline, kerosene, diesel, fuel oil, liquefied gas) (Intergovernmental Panel on Climate Change (IPCC)):

Table 2. Factors of CO₂ emissions induced by combustion of energy carriers

Fuel	Unit	Co2 Levels
Coal, lignite, and peat	g/ton	2643
Electricity and related services	g/kWh	807
Distribution of natural gas and related services	g/m ³	1897.9
Petrol	g/l	2289.8
Kerosene	g/l	2610.8
Gasoline	g/l	2684.7
Fuel oil	g/l	2978
Liquified gas	g/l	1624.6

The EEIOT was prepared accordingly, in which CO₂ emissions from each commodity were listed in each row.



Data and Information Analysis

The amounts of goods and services consumed by different income deciles in urban households were calculated by referring to the statistical microdata on urban household expenditure (Statistical Center of Iran). For this purpose, the results of the 2011 Questionnaire on the Costs and Income of Urban and Rural Families were used, including the food and non-food household expenditure table. More related expenditures were aggregated. The table of household consumption of different income deciles was obtained as follows.

An overview of the amount and composition of rural household consumption of different income deciles:

The proportion of rural household consumption expenditure in total urban household consumption expenditure

Table 3 shows the income and consumption expenditure (related to energy carriers and other commodities) of the different income deciles of urban households and the proportion of each decile in total urban household consumption expenditure:

Table 3. Income and consumption expenditure of urban households of different income deciles in 2011 (Billion Rials)

Decile	Income	Consumption Expenditure	Percentage
First	21.56	5.68	9.2
Second	55.72	7.93	1.4
Third	76.8	10.4	4.5

Fourth	93.66	12.28	3.6
Fifth	108.67	15.62	1.8
Sixth	126.35	18.09	3.9
Seventh	147.13	21.46	1.11
Eighth	176.41	25.6	2.13
Ninth	226.56	30.73	9.15
Tenth	392.41	46.02	7.23

Source: The Statistical Centre of Iran (SCI)

According to the table above, the tenth and first deciles accounted for 23.7% and 2.9% of total urban household consumption, respectively. The consumption expenditure of the tenth decile is 8.1 times that of the first decile. The consumption expenditure of the top four household income deciles is 3.4 times that of the lower four deciles. This indicates the increased consumption expenditure and income of urban households when moving from lower deciles to higher deciles.

Combination of consumer goods from different deciles

Tables 4 and 5 illustrate the combination of consumer goods and services in the expenditure basket of income deciles of urban households in the country.

Table 4. The proportion of various commodities in the expenditure basket of low-income deciles of rural households nationwide in 2011

Product Title	Deciles (%)				
	First	Second	Third	Fourth	Fifth
Agricultural products	2.18	2.01	1.7	1.44	1.20
Horticultural products	0.74	0.70	0.67	0.64	0.53
Live animals and poultry and its products, etc.	0.63	0.70	0.53	0.44	0.35
Forest products and tree felling	0.0003	0.001	0	0.0007	0.0002
Fish and other fishery products	0.22	0.22	0.19	0.19	0.16
Coal, lignite, and peat	0.00009	0.0001	0	0.0004	0.00003
Crude oil and natural gas	0	0	0	0	0
Minerals and their concentrates	0	0	0	0	0
Electricity and related services	0.45	0.38	0.31	0.30	0.25
Water and related services	0.66	0.77	0.49	0.44	0.36
Distribution of natural gas and related services	0.70	0.64	0.59	0.49	0.43
Food industry	6.70	6.08	5.12	4.36	3.61
Textile and leather industries	4.83	5.33	4.51	3.90	4.10
Wood and wood-based products	0.03	0.02	0.02	0.02	0.01
Paper and paper products	1.39	1.62	1.30	1.32	0.99
Gasoline	0.50	0.64	0.68	0.63	0.61
Kerosene	0.05	0.03	0.03	0.01	0.01
Gasoline	0.001	0.001	0.0004	0.001	0.004

Fuel oil	0	0	0.00004	0	0
Liquefied gas	0.07	0.04	0.02	0.02	0.02
Other petroleum products and nuclear fuel	0.03	0.05	0.04	0.04	0.05
Chemical industry	1.67	1.45	1.15	1.04	0.91
Non-metallic mineral industries	0.50	0.86	0.65	0.53	0.67
Other industries	4.80	4.38	4.12	4.25	4.20
Basic metals industry	0.01	0.02	0.01	0.01	0.01
Machinery industry	19.60	21.35	24.44	23.05	25.64
Construction	0.98	0.78	0.59	0.65	0.49
Trade and hotel management	0.21	0.21	0.25	0.18	0.30
Transportation services	1.24	1.14	0.96	0.79	0.66
Post and Telecommunication Services	3.46	3.59	3.32	2.96	2.69
Bank and insurance services	10.57	14.27	20.71	22.84	25.20
Services of residential and non-residential units	9.23	7.95	7.20	6.94	6.08
Business services	1.89	2.40	2.08	2.18	1.96
Public services	0.49	0.49	0.59	0.38	0.45
Training services	3.96	4.65	4.12	4.82	4.39
Health services	7.49	5.28	4.28	4.24	4.21
Cultural and artistic services	14.70	11.93	9.34	10.89	9.47

Source: The Statistical Centre of Iran (SCI)



Table 5: The proportion of various commodities in the expenditure basket of high-income deciles of rural households nationwide in 2011

Product Title	Deciles (%)				
	Sixth	Seventh	Eighth	Ninth	Tenth
Agricultural products	1.15	1.06	0.97	0.86	0.66
Horticultural products	0.52	0.51	0.48	0.43	0.39
Live animals and poultry and its products, etc.	0.34	0.34	0.29	0.28	0.27
Forest products and tree felling	0.0001	0.0005	0.0002	0.0001	0.0001
Fish and other fishery products	0.18	0.18	0.16	0.15	0.13
Coal, lignite, and peat	0	0.00004	0	0.00001	0.00007
Crude oil and natural gas	0	0	0	0	0
Minerals and their concentrates	0	0	0	0	0
Electricity and related services	0.23	0.21	0.18	0.16	0.13
Water and related services	0.32	0.26	0.23	0.22	0.16
Distribution of natural gas and related services	0.40	0.37	0.32	0.29	0.24
Food industry	3.33	3.07	2.77	2.47	1.88
Textile and leather industries	3.62	3.83	3.42	3.17	3.37
Wood and wood-based products	0.01	0.01	0.01	0.01	0.01
Paper and paper products	1.11	1.05	1.07	1.03	0.93
Gasoline	0.68	0.70	0.62	0.58	0.56
Kerosene	0.01	0.01	0.01	0.004	0.003
Gasoline	0.002	0.003	0.003	0.00	0.004

Fuel oil	0	0	0	0	0
Liquefied gas	0.02	0.02	0.01	0.01	0.01
Other petroleum products and nuclear fuel	0.05	0.06	0.06	0.05	0.06
Chemical industry	0.88	0.77	0.72	0.66	0.55
Non-metallic mineral industries	0.42	0.43	0.40	0.44	0.30
Other industries	4.02	4.60	4.34	4.76	6.19
Basic metals industry	0.01	0.01	0.01	0.01	0.01
Machinery industry	27.10	25.67	29.20	29.32	29.78
Construction	0.45	0.44	0.55	0.38	0.33
Trade and hotel management	0.30	0.27	0.23	0.22	0.27
Transportation services	0.57	0.55	0.53	0.46	0.44
Post and Telecommunication Services	2.48	2.35	2.30	2.11	1.92
Bank and insurance services	27.06	27.78	26.93	26.54	25.67
Services of residential and non-residential units	5.51	4.82	4.33	4.20	3.39
Business services	2.08	2.00	1.81	1.95	1.84
Public services	0.40	0.49	0.41	0.90	0.47
Training services	4.72	5.10	5.55	5.35	4.86
Health services	3.34	3.12	2.53	2.72	2.15
Cultural and artistic services	8.69	9.93	9.58	10.27	13.04

Source: The Statistical Centre of Iran (SCI)

Overall, the machinery industry accounted for the largest proportion of consumption expenditure in all deciles, except for the seventh decile. In contrast, crude oil and natural gas, minerals, and their concentrates (mainly intermediate goods that must be refined and processed for consumption) accounted for zero percent of the consumption expenditure of all rural households.

Analysis of the amount and composition of energy carrier consumption of different income deciles of urban households:

Part of the consumption expenditure of urban households comes from a variety of energy carriers. Energy is indeed a determining factor in specifying household consumption. This section examines and compares consumption expenditure and the expenditure proportion of various types of energy carriers in expenditures of different income deciles of urban households.

To analyze the results as clearly as possible, Figure 1 (consumption expenditure of various types of energy carriers (e.g., natural gas, gasoline, and electricity) of different income deciles of urban households) was used.

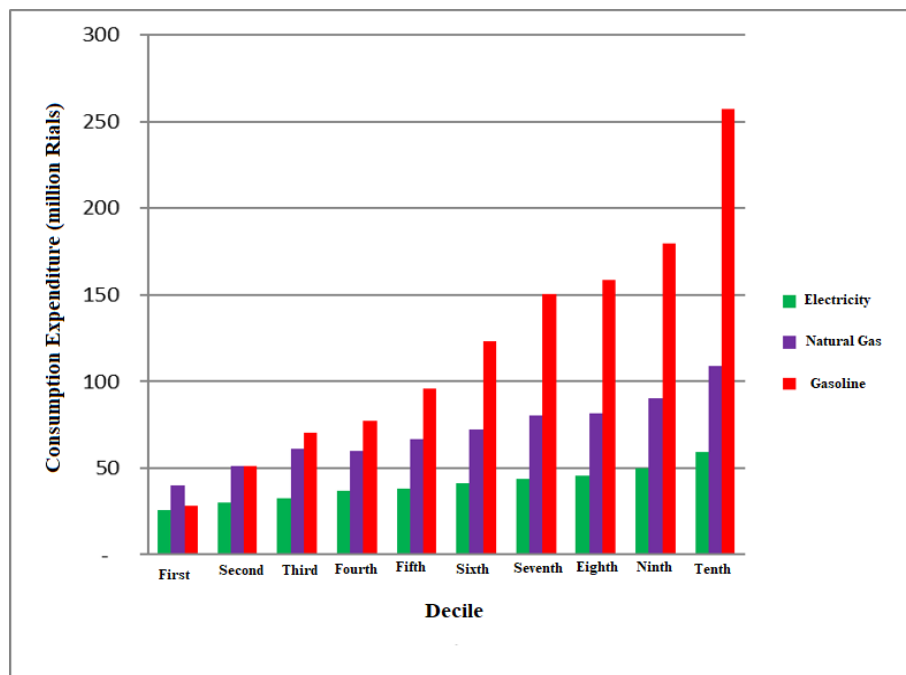


Figure 1: Consumption expenditure of energy carriers (e.g., natural gas, gasoline, and electricity) of different income deciles of urban households

Figure 2 shows the expenditure proportion of various energy carriers in the energy expenditure of urban households of different income deciles.

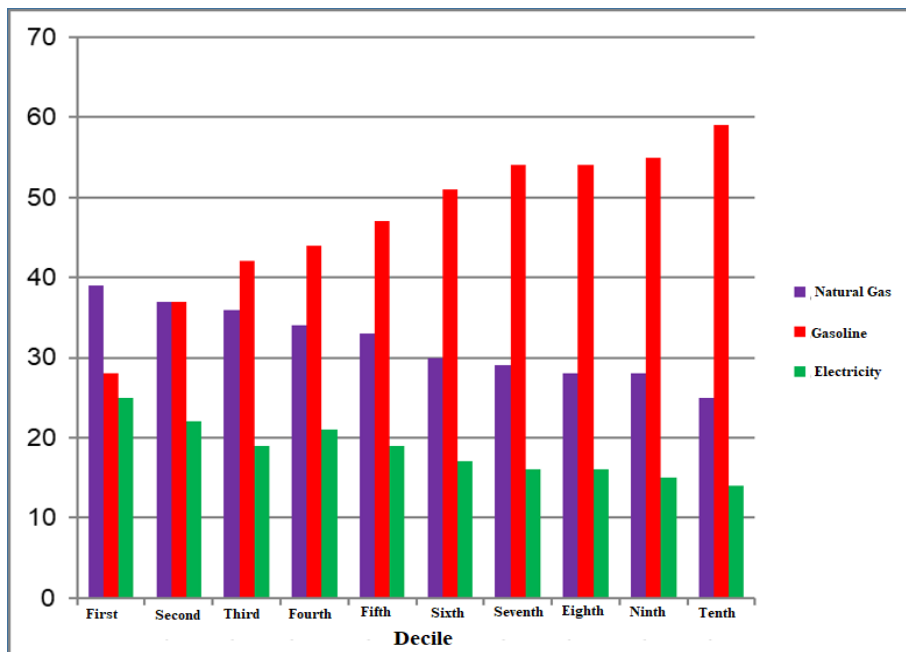


Figure 2: Expenditures proportion of various energy carriers in energy expenditures of income deciles of urban households

The results of Figure 2 show an increasing proportion of the expenditure of gasoline consumed by urban households due to increased income when moving from lower deciles to higher deciles. Nevertheless, the proportion of natural gas and electricity consumed by households plunge due to the increased income of urban households when moving from lower deciles to



higher deciles. This indicates an increase in electricity and natural gas consumption of urban households to a certain extent due to increased income.

CO2 emissions of households in different income deciles in 2011

CO2 emissions from urban household consumption were calculated and analyzed using the SIOT and the statistical data of different income deciles of urban households. Table 6 demonstrates CO2 emissions induced by expenditures of different income deciles in 2011.

Table 6. CO2 emissions induced by households in different income deciles in 2011 (ton)

Decile	Direct Emission	Indirect Emission	Total Emission
First	2014.34	2016.33	4030.67
Second	2477.15	2911.81	5388.96
Third	2864.8	3614.6	6479.39
Fourth	2869.19	4757.74	7626.93
Fifth	3224.36	6061.74	9286.1
Sixth	3599.88	6838.22	10438.09
Seventh	4061.98	8542.35	12604.33
Eighth	4145.25	10771.74	14916.99
Ninth	4595.07	13391.6	17986.67
Tenth	5703.28	22662.11	28365.39

Source: The Statistical Centre of Iran (SCI)

Answering Research Questions

Answering Q1

Table 7 shows the proportion of CO2 emissions of different income deciles in the total CO2 emissions (direct, indirect, and total) engendered by urban household consumption.

Table 7. The proportion of income deciles of urban households in the total CO2 emissions (direct, indirect and total) (percentage)

Decile	Total Emission	Direct Emission	Indirect Emission
First	3.4	5.7	2.5
Second	4.6	7.0	3.6
Third	5.5	8.1	4.4
Fourth	6.5	8.1	5.8
Fifth	7.9	9.1	7.4
Sixth	8.9	10.1	8.4
Seventh	10.8	11.4	10.5
Eighth	12.7	11.7	13.2
Ninth	15.4	12.9	16.4
Tenth	24.2	16.0	27.8

Source: Research Findings

According to the results, the tenth decile accounted for the highest percentage of direct, indirect, and total CO2 emissions by urban households. The amount of pollution was 16%, 27.8%, and 24.2%, respectively. After the tenth decile, lower-income deciles accounted for a

lower percentage of direct, indirect, and total CO₂ emissions, respectively. This indicates a direct relationship between household income levels and CO₂ emissions (direct, indirect, and total) by their consumption. Hence, there is a direct relationship between the proportion of direct, indirect, and total CO₂ emissions of households and their income.

On the other hand, there is a much larger difference between the proportion of different income deciles in indirect CO₂ emissions compared to direct emissions. This suggests that the consumption of some energy items (essential for lighting and heating) increases less than other goods due to increased household income. The raised income has mainly affected the consumption of non-energy goods of urban households, rather than the consumption of energy carriers of households.

To show the exact direction and intensity of this relationship, the correlation coefficient between income levels of income deciles of urban households, and direct/indirect CO₂ emissions by urban household consumption was used. The correlation coefficient between different income deciles of urban households and their direct CO₂ emissions was 0.97, indicating a high and almost complete correlation between income and direct CO₂ emissions. The results of the correlation coefficients suggested an increase in indirect CO₂ emissions (resulting from the production of other consumer goods of urban households) as a result of the raised income of urban households. Contrarily, direct CO₂ emissions (from household energy carriers) increased at a lower rate.

Answering Q2

Since the second question was similar to the second hypothesis, the answer was raised along with the second hypothesis testing to prevent repetition.

Research hypotheses

H1: Consumption of different deciles is proportionately effective in their pollutant emissions.

To test the first hypothesis, the correlation coefficient between the income deciles of urban households and CO₂ emissions (indicating the relationship between the consumption expenditure of urban households and CO₂ emissions resulting from these expenditures) was used.

The correlation coefficient between the consumption expenditure of income deciles of urban households and CO₂ emissions was approximately equal to 1, indicating full alignment between the two. In other words, CO₂ emissions from the consumption of income deciles of urban households increased in proportion to raised consumption expenditure of urban households. Figure 3 compares the proportion of consumption expenditure and the proportion of CO₂ emissions in different rural income households. Here, the direct and proportional relationship between consumption expenditure and CO₂ emissions from each decile of consumption is quite evident. Therefore, H1 was confirmed.



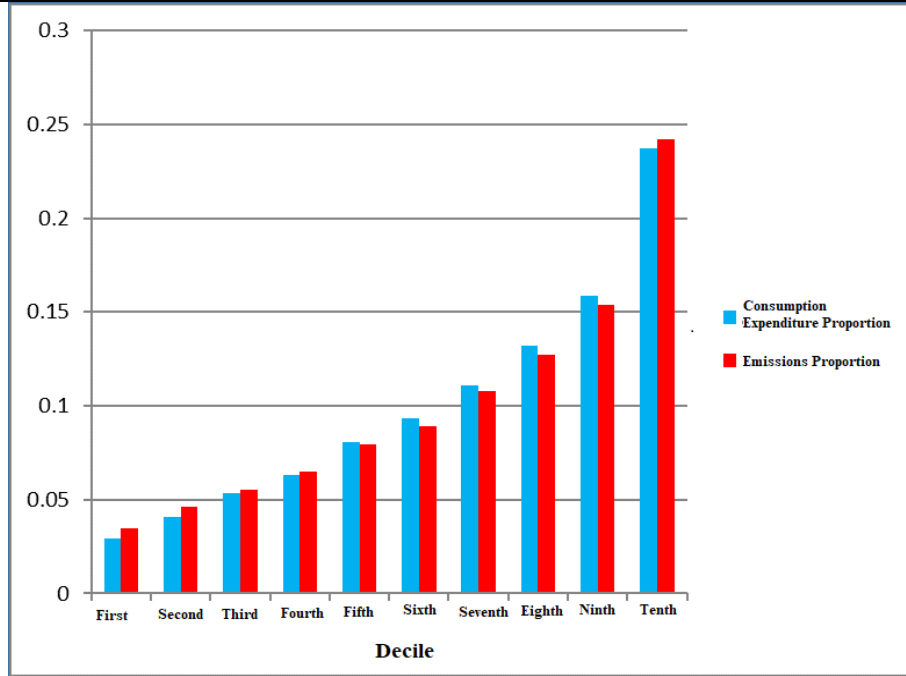


Figure 3: The proportion of consumption expenditure and the proportion of CO2 emissions of different income deciles of urban households

H2: The combination of consumption of different deciles of urban households is effective in their pollutant emissions

To test the second hypothesis, the pollution coefficient of each unit of consumption expenditure of income deciles of urban households was initially calculated by dividing the total CO2 emissions by the deciles by their consumption expenditure. The high pollution rate per unit of consumption expenditure of a decile shows that the consumer goods of that income decile of urban households are more polluting. Table 8 shows the pollution coefficient of each unit of consumption expenditure of income deciles of urban households.

Table 8. Pollution coefficient of consumer goods of income deciles of urban households

Decile	Pollution Coefficient
First	0.71
Second	0.68
Third	0.623
Fourth	0.621
Fifth	0.595
Sixth	0.577
Seventh	0.587
Eighth	0.583
Ninth	0.585
Tenth	0.616

Source: Research Findings

As can be seen in Table 8, 0.71 grams of CO2 are released by each rial of household consumption expenditure in the first decile. Consumer goods of households in the first income

decile of urban households generate more pollution than other groups. The second, third, fourth, tenth, fifth, seventh, ninth, and eighth deciles ranked next, respectively. Finally, consumer goods of households in the sixth decile generate less pollution than other groups.

On the other hand, the correlation coefficient between the total CO₂ emissions induced by the income deciles of urban households and the pollution coefficient of consumer goods of different deciles of urban households was approximately -0.5, indicating an incomplete inverse alignment between the two. Put differently, the combination of consumer goods of lower decile households creates more pollution than higher deciles. This can be attributed in part to the fact that the vast majority of consumer goods of lowest-income classes of society (compared to the higher income classes) are produced domestically; thus, pollution engendered during the production process occurs entirely within the country. Nonetheless, the low correlation coefficient can indicate the effect of other factors on CO₂ emissions induced by household consumption. Therefore, H2 is confirmed.

DISCUSSION AND CONCLUSIONS

The present study examined the effect of urban household consumption on CO₂ emissions in 2011. The results of the estimated CO₂ emissions by household expenditure indicated an increasing trend in CO₂ emissions (direct, indirect, and total) from first to tenth deciles. The lowest and highest CO₂ emissions from the consumption of deciles of urban households were associated with the first and tenth deciles, respectively. However, indirect CO₂ emissions increase more rapidly with a steeper slope compared to direct emissions, with the transition from lower deciles to higher deciles of urban households.

The correlation coefficient between income and indirect CO₂ emissions by income deciles of urban households was approximately equal to 1, while the correlation coefficient between income and direct CO₂ emissions was approximately 0.97. The results of correlation coefficients indicated increased indirect CO₂ emissions (due to the production of consumer goods of urban households) with an increase in the income of urban households. In contrast, direct CO₂ emissions by household energy consumption increased less. This means that CO₂ emissions by urban household consumption increases, resulting in increased consumption expenditure of urban households, confirming H1.

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