**Financial crisis and consumption patterns effects on carbon and material footprint**

López, Luis Antonio; Morenate, Manuel; Zafrilla, Jorge Enrique and Arce, Guadalupe

Luis.LSantiago@uclm.es; Manuel.Morenate@alu.uclm.es; Jorge.Zafrilla@uclm.es; Guadalupe.Arce@alu.uclm.es

Faculty of Economics and Business, University of Castilla-La Mancha

Plaza de la Universidad, 1, 02071, Albacete, Spain

**Abstract**

This paper develops a Multi-Regional Input-Output (MRIO) model to assess the impact of the economic and financial crisis on Spanish households’ carbon and material footprint. The deep economic standstill and the subsequent strong jobs destruction experienced by the Spanish economy between 2009 and 2013 not only have reduced households’ consumption levels, but have also changed the consumption patterns according to different income levels. Thus, energy, material and environmental pressure of this consumption has changed, bringing new paths of growth and production more sustainable in terms of use of natural resources and equivalent CO2 emissions. The MRIO model developed takes into account international trade between Spain and the rest of the World aggregated in six major regions, using data provided by the World Input-Output Database (WIOD). By doing so, we can evaluate which part of Spanish households’ carbon and material footprint leaks to other countries through internationally traded imports of final and intermediate goods. Information about Spanish households’ consumption made public by the Spanish National Statistics Institute’s Family Budget Survey, combined with data published by WIOD, allow us to calculate households’ consumption patterns depending on the socio-economic context (rural or urban) and on different income levels (low, mid and high incomes).

**1. Introduction**

This paper addresses a concise question: Does an unequal rich world imply a progressively natural resources exhausted and polluted planet?

The economic degrowth in rich countries after the 2008 financial economic crisis has not been accompanied of a shared prosperity, supported by Tim Jackson and wished by everybody, since it has supposed an unemployment increase and a reinforce of the economic inequalities. In terms of Greenhouse Gases (GHG) emissions, the economic crisis implied a soft moderation, however, GHG emissions recover the trends since 2009 fed by the strong economic growth of developing countries ([Peters et al., 2012b](#_ENREF_15)). In this context, the alternative in terms of economic and social sustainability should be based on an economic growth which allows a redistribution of wealth ([Weinzettel et al., 2013](#_ENREF_20)). This requires, to be environmentally sustainable, the incorporation of new technologies to the most CO2 intensive sectors ([Liu et al., 2013](#_ENREF_11)) and the use of natural resources which allow a relative decoupling, and especially absolute, with economic growth ([Wiedmann et al., 2013](#_ENREF_22)). Nevertheless, the redistribution of the income is another alternative to try to restrain the human being footprint of the planet and as a way to mitigate the increasingly income inequality derived from the economic crisis in developed countries.

In this paper we develop a Multi-Regional Input-Output (MRIO) model to assess the economic and financial crisis impact in the distribution of the income of Spanish households on the carbon and material footprint. Carbon, water and materials footprint are adequate instruments to evaluate the economic pressure over the environment since include of the wastes and resources required to satisfy the final demand, under the consumer perspective ([Steen-Olsen et al. (2012)](#_ENREF_16), [Wiedmann et al. (2013)](#_ENREF_22)). The MRIO framework has the advantage to evaluate suitably the factor content integrated in the international trade ([Wiedmann et al., 2009](#_ENREF_21)). Carbon footprint papers are focus in the international trade impact and derived responsibilities transfers between countries ([Peters et al. (2012a)](#_ENREF_14), [Steen-Olsen et al. (2012)](#_ENREF_16), [Cadarso et al. (2012)](#_ENREF_4)) or in the structural decomposition analysis to evaluate the impact of the trade ([Xu and Dietzenbacher, 2014](#_ENREF_23)). Other papers have shown the displacement in terms of deforestation ([Karstensen et al., 2013](#_ENREF_9)) and the loss of biodiversity linked to international trade ([Lenzen et al., 2012](#_ENREF_10)).

Affluence or per capita income of develop countries drives the displacement of land use from developing and emerging countries ([Weinzettel et al., 2013](#_ENREF_20)), the global materials embodied in international trade with the density of population ([Bruckner et al., 2012](#_ENREF_3)) and the growth of GHG emissions ([Arto and Dietzenbacher, 2014](#_ENREF_2)). Therefore, focus the attention in the household’s consumption, separated from investment, public expenditures and exports decisions, allows us to isolate the role of the families in the environmental sustainability of the planet and the effects over the inequality. The impact will depend on the different propensities to consume of the families ([Kalecki, 1971](#_ENREF_7)) and on different consumption patterns. The literature has evaluated the possibility of reducing those footprints through the identification and strengthen of more sustainable patterns. Some examples are the papers of [Weber and Matthews (2008)](#_ENREF_19) about food miles, and [Cazcarro et al. (2013)](#_ENREF_5) or [Vanham et al. (2013)](#_ENREF_18) about water footprint. The voluntary reduction of families consumption levels or the increasing collaborative consumption, regulated by the European Union ([EESC, 2014](#_ENREF_6)), could be examples of voluntary changes in the consumption patterns towards a more responsible consumption. However, our paper is referred to forced changes in the consumption due to family´s income reduction and to changes in the income distribution generated by the economic crisis.

**2. Methodology.**

The matrix of total factor content, direct and indirect, in an MRIO context is obtained from the expression 1 ([Miller and Blair, 2009](#_ENREF_13)):

 [1]

Where refers to the diagonalized direct emissions coefficient or factor content (CO2 emissions, materials, added value, employment, …) per unit of sector output, is the matrix of total (domestic and imported) technical coefficients, is the Leontief inverse and the amount of direct and indirect inputs per unit of output produced that satisfies final demand, is the diagonal matrix of final demand, is the diagonal matrix of domestic final goods (consumption, investment and public expenditure) and is the diagonal matrix of exported final goods. By columns, the matrix [1] for the region *r* quantifies the factor content footprint of the region ([Wiedmann et al. (2009)](#_ENREF_21), [Peters et al. (2012a)](#_ENREF_14)). In this paper, we considered as factor content, CO2 emissions and materials, and we talk about carbon footprint and materials footprint of a region.

The parceling of the Leontief inverse and final demand is useful to isolate the domestic and imported factor content demand (). For this purpose, the domestic multiplier is defined () as a matrix with the values in *rr* and zeros in other elements *rs* and the exports multiplier () is defined too as a matrix of zeros in the main diagonal *rr* and with the values in the rest of *rs* values.

 [2]

The expression [2.1] shows the domestic footprint of the different regions *r* (Yu et al., 2011) and the others three expressions shows the footprint embodied in imports from the other regions considered, that could decomposed into trade in final goods between different regions [2.2], last round of production [2.3] or other rounds [2.4] ([López et al., 2013](#_ENREF_12)). By rows, the sum of the expressions [2.2], [2.3] and [2.4], e.g. for region *r*, shows the virtual factor content embodied in final and intermediate exports from country *r* that are required to satisfy the final demand of the others countries *s*. This virtual factor content is generated within the country *r* but in response to the final demand of the country *s*, where consumption of intermediate inputs becomes endogenous ([Kanemoto et al., 2012](#_ENREF_8)), and the significance of the transferred virtual factor content is based on the presence of country *r* in the successive domestic and international supply chains. In practice, this involves a reorganization of emissions sectoral responsibility from the manufacturing industry *i* of the country *r* to the final demand for industry *j* of country *s*.

***2.1. Household footprint of a region.***

Our proposal in this paper is to assess the significance of carbon and materials footprint associated with the consumption of the householders of a region *r* (in this case, Spain). To do this, is required information about household consumption () according to different *i* characteristics (income levels, residence, etc.), which is decomposed into the diagonalized vector of domestic household consumption with the different *i* characteristics of the region *r* () and the diagonalied vector of imported goods from region *s* of the same households (). The expression that assesses the household footprint of the region householders *i* of the region *r* is:

 [3]

Where the expression [3.1] shows the footprint of the households *i* of the region *r* linked to the products purchased by households in region *r* and the expression [3.1] shows the households footprint of the region r associated with the products that imports from other regions. In both cases, intermediate goods of the different regions become endogenous and can be split into domestic and imported if the Leontief inverse is partitioned. The expression is:

 [4]

The sum of the expressions [4.1] and [4.3] shows the domestic footprint associated with the households *i* consumption of goods intended to final demand in the region r, in the first case, and consumption of households by the other regions *s*, in the second case. The imported footprint of the households *i* is the sum of the expressions [4.2] and [4.4], for the purchase of final goods provided by companies in the region *r* or provided by the rest of regions *s* respectively.

***2.2. Databases used.***

The WIOD Database ([Timmer, 2012](#_ENREF_17)) is used in this paper for the years 2006 and 2009, using the original sectoral aggregation to 35 sectors, but aggregate into 7 regions: Spain, rest of European Union, NAFTA, China, East Asia, BRIIAT and the rest of the world[[1]](#footnote-1). Environmental information was obtained from the Environmental Accounts that also provides WIOD, in which one can find total CO2 emissions for 40 countries and the Rest of the World (RoW), also aggregated in 35 industries and the materials use by type and sector.

The spending of the Spanish families’ patterns is provided by Household Budget Survey (in Spanish *Encuesta de Presupuestos Familiares, EPF*) published by the Spanish National Institute of Statistics (INE, various years). The economic variable used is “Average annual expenditure per household by expenditure group”, which presents disaggregating data according to various socio-economic factors such as the size of the town of residence, educational level, etc. In this paper we differentiate the final consumption expenditure based on the level of monthly income of the household aggregates to 5 sections (up to 999 €; from 1,000€ to 1,499€; from 1,500€ to 1,999€; from 2,000€ to 2,499€ and from 2,500€), so each section has a similar weight (about 20%) of the total Spanish households. These data have been processed for its presentation at basic prices and have been deflated[[2]](#footnote-2).

On one hand, the *EPF* provides data on household expenditure with a sectoral aggregation to 48 industries according to COICOP classification (Classification of individual consumption by purpose), while on the other hand, WIOD data is presented according to NACE rev. 1 classification (*Nomenclature generale des Activités économiques dans les Communauté Européenne*), therefore, a conversion matrix of two databases have been constructed.

Finally, the *EPF* does not distinguish between domestic consumption and imported consumption, this information is obtained by distributing proportionally the consumption using the information provided by the WIOD input-output framework and assuming that this distribution is independent of household characteristics.

**3. Main results**

The rhythm of growth reached by the economy since the last years of the past century suddenly stopped in 2008 because of the burst of the financial and economic crisis. The great job destruction suffered, around 4 million jobs were lost, led to a significant 23.7% average decrease in household consumption between 2006 and 2009, reduction underwent by almost all of the five income tiers considered, except households with an income below 1000 euros per month (Graph 1).

Graph 1. Average household final consumption spending, by income tier (euros at constant prices).

Source: Instituto Nacional de Estadística (INE).

A big part of this household’s spending goes in 2009 to Real Estate Activities, followed in importance by spending in Hotels and Restaurants, Retail and Wholesale Trade, energy and Food (Graph 2). Average consumption per household in Spain reached 36.236,50 euros in 2006. The economic crisis sank the income of the families which, nevertheless, had to face several fixed costs in terms of rental expenses and/or necessary electricity and water supply, increasing the importance on these fixed costs, in absolute and relative terms, in the consumer basket of households (from 31.25% in 2006 to 26.92% in 2009). As a result, spending in consumption goods is reduced (19.26% in 2006, 22.80% in 2009). Meanwhile, spending in other services doesn’t change too much (from 13.40% in 2006 to 13.86% in 2009), although some of these services experienced an increase, like Post and Telecommunications (4%) and Air Transport (5%).

Graph 2. Average consumption spending per household (euros).

Source: own estimations using INE data.

The distribution of consumption among the different spending groups, according to each income level, reveals interesting relationships (Graph 3). In relation to income category, we find a clear downtrend in the share of household’s rental expenses and mortgage payments in total spending as income increases. While households with less incomes dedicated in 2006 a 31.03% of their total spending to this category (31.87% in 2009), high income households dedicated just a 16.58% of their total spending in the same year (20.39% in 2009). We observe that, while there is an inverse relationship between income level and the share of food, energy and water spending in total consumption, the relationship is direct for transport, post and telecommunications and goods and services consumption spending.

Graph 3. Households’ consumption patterns by major sectors and income level in 2009 (% over total spending)

Source: own estimations using INE and WIOD data.

These trends observed in 2006 occur in the same way in 2009, but with fewer variations. Spending in Hotels and Restaurants does not show big changes neither between 2006 and 2009, neither between income tiers, but it is true that the spending of the middle income households in this category is slightly higher than in the rest of household types. Economic crisis hasn’t changed Food consumption of the families; on the contrary, it has changed the values of consumption spending in Transport and Communications and Energy. Energy spending has reduced around a 9% for all income levels, except for those households with less incomes than 1000 euros per month, where spending in this necessary services has increased a 15.18%.

There are some sectors where almost all households’ consumption is domestic; as Energy, Trade sectors, Hotels and Restaurants, Real Estate sector, Health and Education. Final domestic consumption is also high in the rest of sector related with the rest of services. In the other hand, those sectors with a greater share of imports in final consumption are Textile, Electrical and Optical Equipment, Leather and Footwear, Chemicals and Plastics.

Carbon Footprint linked to household consumption reaches 163.931,12 kt of CO2 in 2006, and 130.780,38 kt of CO2 in 2009, a 20.22% less. In relative terms, consumption related Carbon Footprint represents around 55% over the total Spanish Carbon Footprint. The distribution of this CF by household type depends on the number of households in each group and on the spending that these afford. Although between 2006 and 2009 the CF has been reduced for all household type, the reductions are quite different according to these types and they oscillate between the 6.58% reduction for households with incomes above 2500 euros per month and the 33% reduction for those with incomes between 1500 and 1999 euros (Graph 4).

Graph 4. Relative carbon footprint (ktCO2 per Euro spent) and by type of household

Source: own estimations using INE and WIOD data.

**4. Households ‘materials footprint**

The households´ materials footprint presents a different distribution between domestic and imported for biomass and for the rest of the materials (Graph 5). The most of the biomass comes from the use of domestic resources (43%), with a noted presence of Rest of European Union imports (14%). However, the imported material footprint is the predominant for the rest of the materials and varies in 2009 between 96% for fuels, 99% for Metal ores and 88% for materials construction. The most of the materials imports come from emerging or developing countries with lower level of per capita income than the Spanish one and with abundant natural resources.

Graph 5. Domestic and imported Materials Footprint for all Households in 2009 (Kt).

Source: own estimations using WIOD data.

Economic crisis drives a significant reduction of the households´ materials footprint for all income levels (Graph 6) which oscillates between 25% of biomass footprint of households with an income lower than 999 Euros, to the reduction of a 51% in the construction materials footprint of families with a 2000 and 2499 Euros income level. In the first fourth income levels, the decrease of the materials footprint is increasing while income increases. However, in the case of families with an income higher than 2005 Euros, the reduction, in relative terms, of its materials footprint is lower than the rest of the groups. The lowest decrease is produced between families with the lowest income, 999 Euros, as they have to maintain that consumption to keep their living standards.

Graph 6. Domestic and imported materials footprint by income levels of each household, 2006 and 2009 (Kt).

Source: own estimations using WIOD data.

*Note: Y1 to Y5 is referred to the five income levels considered.*

The materials footprint of households per Euro spent on each level of income informs about the most materials intensive consumption pattern. Discrepancies in the materials footprint respecting to the average are small for Biomass (6% lower for income level 5, and a 5 and 6% higher than the average for groups 1 and 2, the lowest income levels) and for income level 3 in the materials construction (15% lower than the average), discrepancies for Fuels and Metal ores are lower than 2%. A more disaggregated information would be required for a better evaluation.

However, changes along the time in the households´ materials footprint per Euro spent are very important between 2006 and 2009. A reduction of 35% for Biomass, 31% for Construction materials and 40% for Metal ores (Graph 7). This results reflect a combined effect of a technical and/or environmental improvement, changes in the consumption patterns or even a change of suppliers. In this sense, a more adjusted design by firms which allows reducing primary materials outputs used by industries, would allow to reduce impacts in terms of materials and carbon footprints ([Allwood et al., 2010](#_ENREF_1)), transferring responsibilities from households to firms.

Graph 7. Materials footprint per Euro spent, 2006 and 2009 (Kt).

Source: own estimations using WIOD data.

The IPAT model has been applied to decompose the evolution of the materials footprint (Graph 8) in: population (households), affluence (consumption per householder) and technology (material footprint per unit of consumption). El increase of Spanish households between 2006 and 2009 had produced a 7.6% increase of all material footprints, in contrast the economic crisis reduced the consumption which implies a 6.8% reduction of the materials footprint. This reduction oscillates between a reduction of 25.4% of Biomass and -40% of metals ore.

Graph 8. IPAT model to decompose the materials footprint.

Source: own estimations.

**5. Conclusions**

The Spanish households´ carbon footprint has a scale effect on the level of income, showing a direct relationship between the average of CO2 emissions and the level of household income. However, this relationship reverses if one considers the scale effect in consumption patterns by calculating emissions per euro spent or the environmental efficiency in each income range. Both in 2006 and 2009 families who earn less than 1,000 euros, has the most polluting consumption pattern, because energy costs and water transport and have a higher weight on their consumption. Financial crisis leads decrease the carbon footprint of Spanish households, in absolute and relative terms. As consumption is reduced, it changes its composition and improving environmental efficiency of global value chains. Still, in a context where are increasing the imports from China, that has the most polluting mix of the regions considered.

Spanish materials footprint has only some similarities with the carbon footprint: both have a direct relation with the income level and both were reduced when households´ incomes decreased after the economic crisis. With the exception of the biomass, more than 80% of the rest of natural resources are part of the imported materials footprint from low income countries. There is an increasingly internationalization of the production systems. A huge part of the final consumption is spent on Services sectors, provided domestically but with a big dependency on imports from other regions.

The limitation of 5 different levels of income and the limited variability of the materials footprint for each income level restrict the impact of significant changes on income distribution could have over the Spanish households´ materials footprint. A more disaggregated study is needed to evaluate the main advantages, in terms of economic, social and environmental sustainability, of redistribution policies. In any case, the reduction of the materials footprint per Euro spent shown between 2006 and 2009 allow us to identify an intensive decoupling en those years and which follows the decoupling found for the world economy before the economic crisis ([Wiedmann et al., 2013](#_ENREF_22)).

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1. The region referred as ‘Rest of EU’ incorporates all European countries that provides WIOD except Spain; NAFTA refers to the *North American Free Trade Agreement* countries (Canada, Mexico and United States); East Asia is represented by Japan, North Korea and Taiwan; and Brasil, Russia, Indonesia, India, Australia and Turkey are the BRIIAT. [↑](#footnote-ref-1)
2. These data exclude indirect taxes on consumption, that have been removed based on the data of the weighted average VAT rate for each year, published by the Spanish Tax Agency (Agencia Tributaria). The data have been deflated based on the Consumer Price Index for the corresponding year published by the Spanish National Statistics Institute. [↑](#footnote-ref-2)