Material Flow Accounting of Spain (1980-2004)

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ABSTRACT

Material Flow Accounting (MFA) has been developed by several countries, as a method to measure the metabolism or physical dimensions of a society's consumption. It has been taken as an indirect and approximate indicator of sustainability. MFA can be used to test the dematerialisation hypothesis: that technological progress causes a decrease in total material used (strong dematerialisation) or material used per monetary unit of output (weak dematerialisation). Moreover, it is also a useful tool to obtain key indicators about a nation's economy that could be used for both public discussion and policy making.

Spain´s Material flow accounting revealed that, far from dematerialization, this county keeps using large amounts of material: more than 100% increment in minerals extraction from 1994 to 2004, and also a 100% increment in mineral imports in the same period. On the other hand, from 1993 to 2004 fossil fuel extraction has been decreasing in Spain, although this has been replaced by larger fossil fuel imports. Imports and exports of all categories keep increasing during the period, although imports are growing at a higher rate than exports, and even doubles the amount of exports.

1. Introduction

There is burgeoning literature on the topic of environmental Kuznets curve, a hypothesis based on the idea that economic and technological development allows for the reduction of environmental impact of societies (Rothman, 1998). If verified, this hypothesis would lead to important political consequences, in the sense that following the present development path will lead to a more sustainable economic system. This would mean that environmental measures are not necessary, and that instead, the environment would benefit from policies that aim at stimulating the economic growth.

An interesting way to test this hypothesis is to analyse the amount of material used by a country in physical terms. The material used cannot be taken as a direct measure of sustainability: many materials, used in small quantities, such as mercury, can have highly negative effects on the environment. Nevertheless, the total amount of material used by an economy can give insights into its 'social metabolism1'(Fischer-Kowalski, 1998a; 1998b) and can be applied as an indirect measure of the environmental impact. In fact, materials must be extracted and processed in order to produce goods that are then transported, exchanged, used and finally, discharged. All these activities have environmental impacts.

Material flow accounting can be used to test the dematerialisation hypothesis (Bruyn and Opschoor, 1997). According to this theory, countries tend to use less material in absolute terms (*strong dematerialisation*) or at least per unit of service produced (*weak dematerialisation* or *decoupling*) due to technological progress, which is in turn made possible by economic growth. The dematerialisation hypothesis can be seen as a different formulation of the environmental Kuznets curve. In addition, information about a country's level of dependence on materials coming from other economic systems can be of use. Much research has already been carried out in this direction on international (Fischer-Kowalski and Amann, 2001; Bringezu and Schütz, 2001) and national scale (Carpintero, 2002; Alonso and Bailón, 2003).

This paper analyses material flows associated to the Spanish economy between 1980 and 2004. The Eurostat methodology (EUROSTAT, 2001) has been followed in order to ensure comparability with other similar analyses conducted for different countries in Europe (Bringezu and Schütz, 2001), as well as for other countries such as the USA, Japan (Adriaanse *et al.*, 1997) and Brazil (Matthews *et al.*, 2000). The Eurostat methodology produces quite adequate and easy-obtained indicators, providing a first overview on the physical dimensions of a country.

In this framework, a complete balance of an economy can be carried out (Figure 1) by taking into account what crosses the system's boundaries. However, this methodology does not specifically analyse the different sectors of the economy. In other words, the system is regarded as a 'black box.' The basis of the methodology is the first law of thermodynamics which states that – with the exception of nuclear reactions – matter is neither created nor destroyed. Thus the net accumulation of materials in a system can be calculated as the difference between what enters (*inputs*) the system and what goes out (*outputs*).

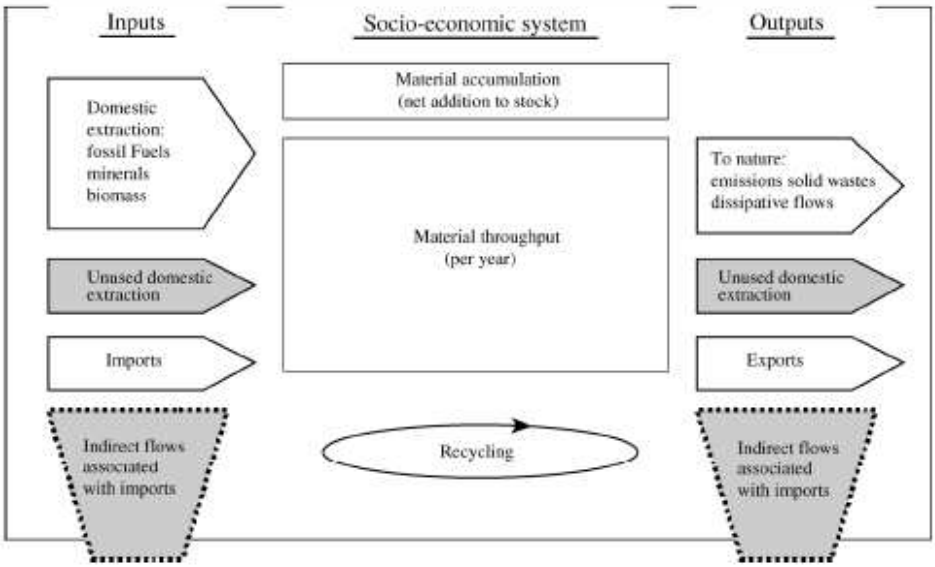

Figure 1. Economy-wide material balance (excluding air and water)

According to the Eurostat classification, material flows can be *domestic*, if extracted from the system, or *ROW*, if coming from the *R*est *O*f the *W*orld. ROW material flows can be *direct* or *indirect*. The former enter directly into the system while the latter – the so-called ecological rucksack – are linked to the production of goods, even if these resources are later not exchanged in the market. In addition, both direct domestic and ROW material flows can be *used* and *unused*. The latter represent materials extracted or discarded during the production of a good, i.e. mining overburden, while the term *used* refers to an input for use in the economy.

This paper focuses on direct material inputs, due to the fact that even though indirect flows increase the comprehensiveness of the analysis, they also increase its arbitrariness. This is because indirect flows are calculated by multiplying direct flows by standard coefficients. However, in reality they vary considerably depending on many factors, such as the state of technology and the economic conditions of a country. Moreover, if indirect flows are accounted for, comparisons between countries may imply double-counting internationally traded goods since indirect flows are accounted for twice – in both the exporting and the importing country. It should also be noted that water and air are excluded (although the water and air content present in materials are included), as they represent nearly 95% of the entire metabolism of an industrial society (Schandl, Weisz and Petrovic, 2000).

In the Eurostat methodological guide (EUROSTAT, 2001) material flows are classified into three main material groups (*minerals*, *energy* and *biomass)* and into three main categories (*imports*, *exports* and *domestic extraction*), which are used to structure the indicators calculated in this study:

- *Domestic extraction*: Materials extracted in the national territory per year.
- *Direct material input (DMI)*: Domestic extraction (DE) plus direct material imports (I) (DMI = DE + I).
- *Domestic material consumption (DMC)*: DMI minus direct material exports (E) (DMC = DMI – E = DE + I – E).

2. Is Spain dematerialising?

The Spanish economy has experienced a strong growth in the last twentyfour years in a path of convergence in income per capita with the older members of the European Union. This period includes:

- cycles of recession, stagnation and recuperation
- structural change (due to an increasing predominance of the service sector in terms of employment and economic added value)
- an increasing use of natural resources, this section analyses the impact of this economic performance on material use.

Firstly, strong dematerialisation did not take place since the use of materials steadily increased over this period. For instance, the material moved by the economy, expressed by the direct material input (DMI), increased by more than 100% between 1980 and 2004. As can be observed in Figure 2, domestic extraction (DE), domestic material input (DMI) and domestic material consumption (DMC) followed a similar path. Material consumed in Spain (DMC) increased also more then 100%

This tendency has also been observed in the long term. Carpintero (2002) gave figures for the total material requirement (TMR)[2] of the Spanish economy showing that it was 4.5 times larger in the 1990s than it was in the 1950s. Specially fast growth can be observed after 1995, incremented even more after year 2001.

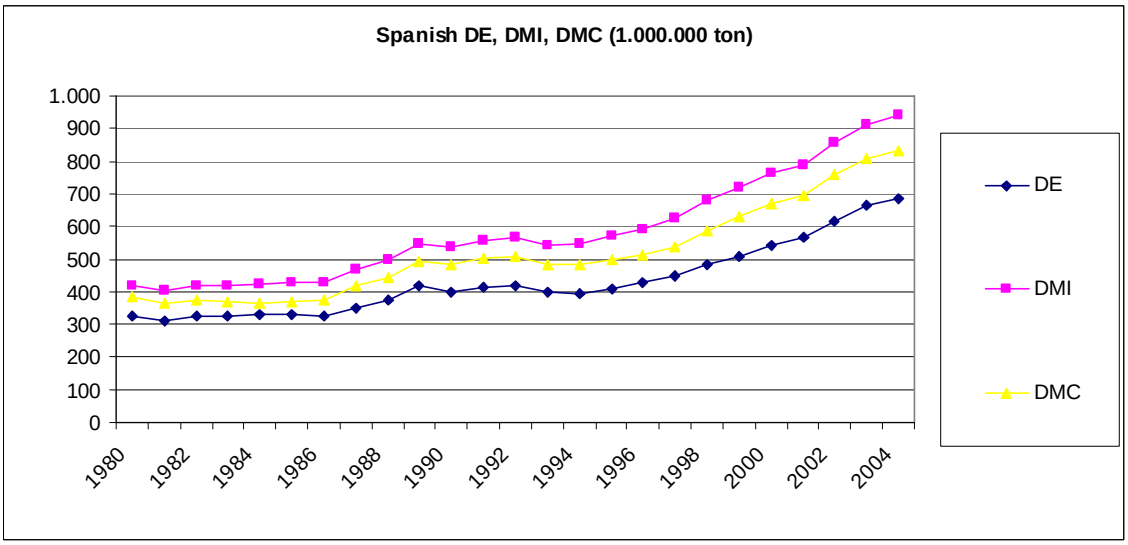

Figure 2. Spanish DE, DMI and DMC (1980–2004)

DMC measured in per capita terms increased from 10.28 ton/person in 1980 to almost 15 ton/person in 1998 and near 20 ton/person in 2004, while population remained almost stable during this period. The population was 37,5 and 42,3 in 2004. So, in the last six years, DMC increased almost the same quantity as the previous 18 years, showing no symptoms of strong dematerialisation at all.

Secondly, weak dematerialisation did not take place in Spain either. While GDP increased by 104%, DMI increased by 123%. As can be observed, DE, DMC and DMI followed the country's economic cycles: stagnation in the early eighties, followed by a cyclic expansion from 1985 to 1990, a halt from 1992 to 1995, after which a new period of expansion began again. In other words, there are no signs of material consumption detaching from

the economic evolution. Figure 3 shows that direct material input (DMC) in relation to GDP increased by approximately 7%.

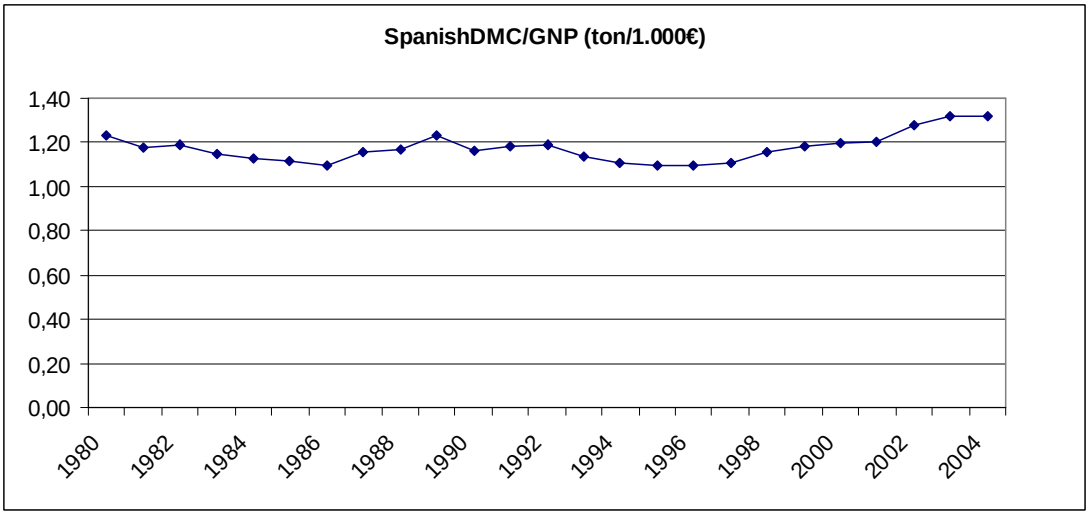

Figure 3. DMI/GDP in Spain (1980–2004)

In this sense, this trend does not follow the performance of other industrialized countries. In fact, previous analyses have proven that in some industrialized countries a decoupling between GDP and material use took place notwithstanding an increase in material flows in absolute terms (Adriaanse *et al.*, 1997).

Regard to type of material extracted, the one caring the main load are minerals (figure 4), while fossil fuels shows a diminishing. This does not represent a less use in energy, but more imports, and more use of other kind of energy.

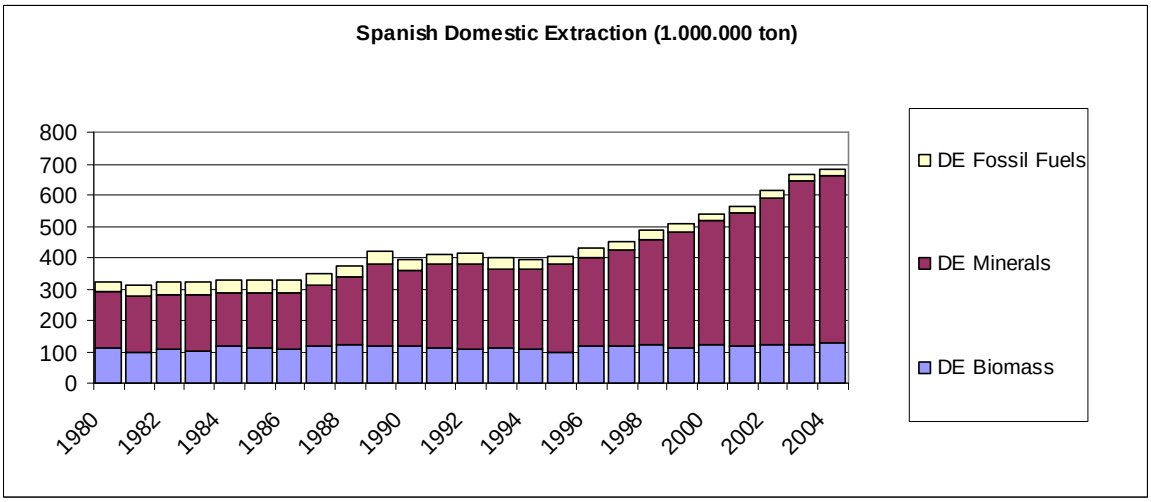

Figure 4. Spanish Domestic Extraction (1980-2004)

As regards the material flows between Spain and the rest of the world (fig. 5), exports grew faster than imports throughout the whole period. As a matter of fact, they increased by 190% whereas imports increased by 160%. However, since imports weighed more than twice the exports, net imports increased by 150%. This underlines the fact that the Spanish economy has become more dependent on international trade. The analysis of these figures suggests that Spain is importing a large amount of primary natural resources, which are characterized by high weight, low price and low added value.

These types of imports might also imply high levels of pollution and environmental degradation in the countries from which these materials are extracted (Muradian, O'Connor and Martínez-Alier, 2002). These hypotheses are to be confirmed on further analyses.

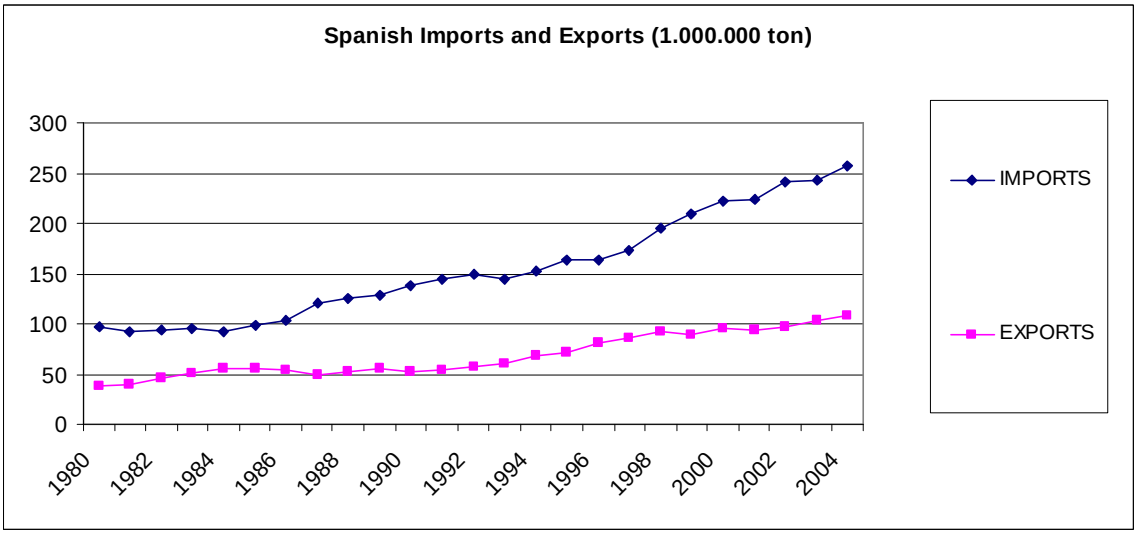

Figure 5 Spanish trade (1980–2004)

3 Conclusions

A number of conclusions concerning the relationship between the Spanish economy and its surrounding environment can be drawn from this analysis. Firstly, the Spanish economy has shown no signs of dematerialization in absolute terms. In contrast, the total mass of material moved by the Spanish economy (i.e. DMI = domestic extraction plus direct material imports) increased by 123% from 1980 to 2004, whereas GDP increased by 104%. Thus, Spain's trend towards convergence of income per capita within the European Union is matched by its 'race to the top' in terms of materials.

Secondly, domestic extraction (DE), consumption (DMC) and material input (DMI) in the economy has evolved in line with the economic cycles. Therefore, there is no evidence of a decoupling trend between economic growth and material use dematerialization in relative terms.

Thirdly, the Spanish economy has become increasingly dependent on international trade. Imports are twice as much as exports in terms of weight. In other words, Spain is using more and more natural resources from other economic systems to increase its welfare-displacing environmental loads to poorer countries. The dependence on energy imports has been a key characteristic of the Spanish economy. Also, metals that used to be domestically produced are now imported.

Our finding that Spain has not reached a stage of 'weak dematerialization' in 2004 should not be construed as agreement on our part to the use of environmental indicators based on intensive variables such as energy intensity or carbon emissions intensity or volume of transport relative to GNP or indeed material intensity (material per unit of GNP). The environment, so to speak, does not care about GNP.

Efforts should be made to communicate MFA results (system knowledge) to policy makers and to the public. MFA indicators can put simply and clearly in few figures complex issues such as construction patterns in Spain. MFA results provide a better understanding of the economic system that could be very useful to support decision makers and to add elements to the public debate.

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