

ANALYSING THE BIOPHYSICAL PERFORMANCE OF ARGENTINA USING THE MFA METHODOLOGY (1970-2009)

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Summary

This paper studies the biophysical features of Argentinean economy using the approach of social metabolism. A Material Flow Analysis (MFA) of this economy was conducted for the period 1970-2009. We conclude that Argentina follows a resource-intensive and export-oriented development model with a persistent physical trade deficit. We also find that the terms of trade have declined during the studied period. Results are systematically compared with a similar study conducted for Spain. By comparing different metabolic profiles with divergent levels of development and similar levels of population we discuss the differences between developing and developed countries regarding material use.

Keywords: Material flow accounting, extractive economies, societal metabolism, Argentina.

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Introduction

World economy growth and trade liberalization in Latin American countries have generated an explosion of commodity flows between this region and the rest of the world in the last thirty years. Argentina, as one of the major South American economies has importantly increased its participation in international based on a growing mining industry and a stronger agricultural sector. In 2008, it was the 4th gold and 5th copper producer in Latin America (USBM 2011), 3rd producer of soybeans and 5th producer of maize of the world (FAOSTAT 2010). Such economic performances rest on physical conditions and have direct impacts on the environment that might alter present and future conditions for social reproduction.

By using the approach of societal metabolism (Ayres and Simonis, 1994; Fischer-Kowalski, 1998), the biophysical pattern of economies can be quantified. In this sense, the objective of this paper is to presents the biophysical profile of Argentinean economy between 1970 and 2009 by means of the use of the Material Flow Analysis (MFA) methodology. By doing so, we intend to observe the material impact of economic growth policies based on the intensification of natural resource extraction.

This paper is structured in five sections. **Section 2** presents the foundations of social metabolism and MFA methodology as well as the practical issues dealt with in the application of this methodology. **Section 3** presents a summary of the economic history of Argentina in the past four decades analyzing the economic cycles and crises affecting the country as well as structural aspects. **Sections 4** analyze main MFA flows such as Domestic Extraction (DE), physical Imports (M) and Exports (X) and derived indicators. Results are systematically compared with a similar study carried out for the case of Spain. By comparing metabolic profiles of economies with divergent economic development paths and similar levels of population, differences regarding material use between developing and developed countries can be observed.

The question of integration of Latin American countries in the global economy and their difficulties to reach economic development has been an important concern for decades; addressed notably by sociologists and economists belonging to the “theory of dependency” approach. The latter points out a polarization process of the world economy between “centers” and “peripheries”. In this context, **Section 4** also addresses the physical dimension of Argentina’s integration into global economy by means of trade. In addition, comparison with Spain is performed in order to observe differences in terms of external trade integration strategies and trends; and identifying the consequences of specialization patterns in Argentina’s external trade.

Theory, Methods & Sources.

Social Metabolism.

This biophysical analysis of Argentina's economy rests on the framework of Social Metabolism, an approach useful to analyse the physical base of socioeconomic systems; which has been developed in the fields of Ecological Economics and Industrial Ecology since the 1990s. This notion of *Social Metabolism* refers to the overall material and energetic interchanges between a society and its environment in order to sustain itself, to reproduce or to grow (Fischer-Kowalski, 1998).

According to this approach, the economic process is supported by flows of materials and energy provided by the environment, which are processed by the economy and then returned to the environment as material wastes (Goodland, 1990).

MFA as a Physical Accounting Methodology.

Economy-wide Material Flow Analysis (Economy-wide MFA) is defined as “a consistent compilation of the overall material inputs into national economies, the material accumulation within the economic system and the material outputs to other economies or to the environment” (EUROSTAT 2001 p.17), providing a picture in physical terms of an economic system.

Focusing on the input side by taking into account all materials that enter into the national economy —excepting water and air— this article allows to reveal information about the physical dimension of foreign trade and can determine the amount of all inputs transferred from the environment to the economy. The basic flows measured in this analysis are:

The physical indicator used are Domestic extraction (DE), Direct material input (DMI), Domestic material consumption (DMC) and Physical trade balance (PTB).

DE comprises harvested or extracted material for domestic use, DMI accounts for the total input entering into the economic activities. It is obtained by summing up domestic extraction plus imports. DMC sums up all materials directly used in the economic system until released to the environment. It is calculated by subtracting exports to direct material input. This indicator is the closest equivalent to GDP and can be considered as its physical equivalent. PTB, net physical flow through the national borders. It is obtained by subtracting exports from imports (M-X). Contrary to the monetary trade balance (X-M), PTB takes into account the fact that money and goods move in opposite directions in economies.

Trade flows are classified in direct or indirect (hidden) flows. Direct flows account for the material physically transferred during the dealing, hidden flows account for all the material requirement necessary to produce the traded good, and virtually transferred. Indirect and unused flows are not included in this analysis, despite their relevance¹. The main materials categories taken into account are mentioned in Table 1.

Being widely applied to OCDE countries², *Economy-wide* Material Flow Analysis started to be applied to so called southern countries, and in particular to Latin American countries such as Chile, Peru, Mexico, Ecuador, Colombia and Brazil (Giljum, 2004; Russi et. al. 2008; Gonzalez-Martinez and Schandl, 2008; Vallejo, 2010; Vallejo et. al. 2011; Eisenmenger et. al. 2007). These analyses helped to define the metabolic pattern of economies at the periphery of the global economy and to understand the socio-ecological consequences of their trade patterns.

Among Latin America, Argentina has remained as one country whose material throughput has not been studied yet over a long period (1970-2009), despite various specificities, which make this economy a case of interest. Argentina is the third largest Latin American economy (after Brazil and Mexico), having a long history of exploitation of natural resources. In addition, this country experienced several crises and structural changes during the past forty years, which have had effects on the biophysical structure of this economy. Nowadays, despite the international economic turmoil, it is one of the few countries performing an outstanding economic growth.

For comparison purposes, biophysical data on Spain, obtained in Gonzalez-Martinez et al. (forthcoming) is presented along the document. The choice of Spain is motivated by at least two reasons. Firstly, in the past these two countries shared quite the same level of wealth. For instance in 1970 per capita GDP in Argentina was 11.7% higher than per capita GDP in Spain. Nevertheless, since then both followed very different paths of development leading Spain to grow faster whereas Argentina remained far below. In 2009, per capita GDP of Spain was three times higher than per capita GDP in Argentina, although at present Argentina GDP is growing fast while Spain stagnates (after the end of the building boom and a spectacular decline in cement consumption). Secondly, their strategies of integration into the world economy have diverged. Spain is the typical European country net importer of natural resources whereas Argentina is a large net exporter. Besides, their population is similar. In 1970, Spanish population was 33.8 million while Argentinean population were 24.0 million inhabitants. By 2009, Spain had 46.0 million habitants whereas Argentina had 40.1 million people (INDEC 2011, INE 2011).

Data Sources

In this work we applied the standard approach of Economy-wide MFA as defined by EUROSTAT (2001), focusing in the Argentinean economy between 1970 and 2009; a relevant period in which the country experienced major political and economic events. Table 1 summarizes the different sources used in this analysis, subdivided into categories of relevance for our case study. Times series were compiled following a preference for data from national sources, using international databases only when local ones were not available.

Table 1: Domestic extraction categories and sources

	Material categories	Subcategories	Sources and data
Domestic extraction categories	Biomass	Food, fodder, timber and other biomass	Most of the data comes from FAO databases (2011), contrasted with MAGyP's data (2011). Fodder category includes an estimation of grazing apparent demand by livestock.
	Minerals	Metallic ores, industrial minerals, construction minerals	All data comes from SMRA (1993, 2011). For the case of metals, primary ore production was calculated with the help of data from the industry and the USBM (2011). Sand and gravel extraction for construction was estimated using cement production statistics of USBM (2011).
	Fossil fuels	Oil, coal, natural gas, other fossil fuels	All data comes from SMRA (1993, 2011), SERA (2000, 2011) completed by IEA database (2010a).
Physical Trade	Imports and Exports		Data was compiled from UNSD (2011).

Source: author's elaboration, adapted from Gonzalez-Martinez (2008)

Argentina's Economic Overview

Considering GDP evolution in Argentina, four different stages can be observed the behavior during the period of study (figure 1). A turbulent period between 1970-1990 marked by political instability and lack of continuity of growth policies [ISI Policies (1970-1975), neoliberal policies (1976-1982)], democratic transition and hyperinflation (1983-1990)). This climate of political instability generated continuous fluctuations of GDP and per capita GDP, annual average growth rates was 0.82% and -0.7% respectively. A second stage of economic growth covering the period 1991-1998 mainly driven by convertibility policies that favored the opening to foreign markets and promoting the development of industrial, agriculture and mining sectors. During this period; average GDP and per capita GDP growth rates were 6.3% and 5% respectively. A third phase of

economic decline can be observed from 1998 until 2001 when the Argentinean peso suffered a severe devaluation. Finally, a dynamic growth phase has been observed in the last seven years (2003-2009), characterized by the consolidation of export model. During this period average GDP and per capita GDP growth rates were 7.3% and 6.3% respectively.

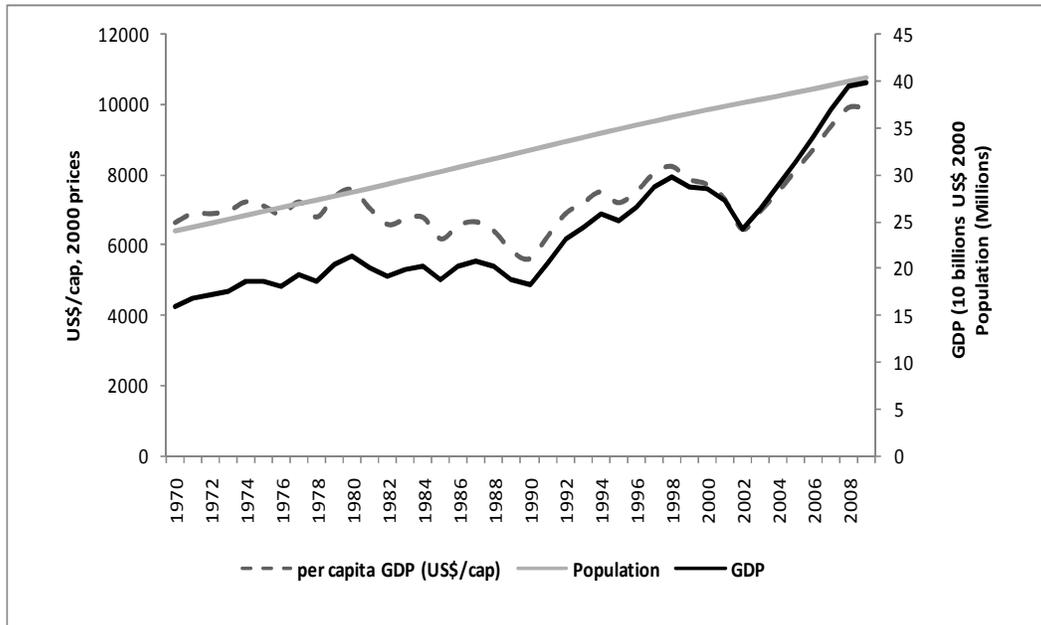


Fig. 1: Argentina population, GDP and GDP per capita (1970—2009). *Note:* GDP is in US\$ constant, base 2000
Source: WB (2010)

The “ISI” Policies

Until 1976, macro-economic policies were based on Import Substitution Industrialization (ISI), characterized by the development of an industry focused mainly on the domestic market. A strong protectionist scheme was developed, based on exchange restrictions and high tariff levels, where the state played a key role through subsidies, loans and provision of services.

Despite ISI policies generated economic growth during the period 1970-1975, they were not totally successful as the structural problem of restriction to capital access persisted, resulting in a domestic industry based on the production of low added-value products. Additionally, after the implementation of ISI, inflation and external imbalance problems appeared as the model in its initial phase required foreign capital and intermediate goods imports. It discouraged the export sector by taxing agricultural exports (*retentions*), generating a persistent imbalance, which ultimately was resolved through inflation, after which the cycle started again. In 1972 inflation rate was 90% and in 1975 a new inflation crisis appeared with an annual rate of 566% (Gorosito et al. 1998).

The Neoliberal Policies

In March of 1976, armed forces took power, implementing neoliberal economic policies, already put in practice by force in Chile and Uruguay, considered at that time successful cases. The main economic measures implemented were abolishment of ISI policies, commercial opening, deregulation of the economy and reduction of state's size. Treber (1987) and Ramos (1986) underline that, despite the fact that neoliberal economic policies put in practice from 1976 to 1983 reduced inflation and boosted exports, were unsuccessful regarding growth. As shown in Figure 1, average GDP growth rate was 0.5 %.

The democratic transition

The military government collapsed in 1982 after the Malvinas War against United Kingdom. Raúl Alfonsín won free elections in 1983, representing democratic transition. His intention was the stabilization of the economy where the import re-substitution emerged again as an alternative after the failure of the economic openness experience (ECLAC 1984). However, economic crisis reappeared in 1989 when inflation reached its peak in July of 1989 (197% monthly rate), generating economic chaos and the new collapse of the closed-economy approach.

The arrival of Menem's presidency in May 1989 and the Convertibility Law took effect on April 1, 1991 showing that curiously, a Peronist government became neoliberal.

The Age of Convertibility.

The "Convertibility Plan" implied a change in the relative prices of the economy. In this context, monetary policy was reduced to a currency board mechanism, where the central bank was unable to print money above the limits determined by the level of dollar reserves (because of the peso-dollar fixed parity), subordinating the economy to monetary policy of the U.S. Federal Reserve. (Giletta, 2005). The strong peso allowed the payment of the dollarized liabilities of the economy where the agricultural sector, heavily indebted, could restore its profitability, overcoming a period characterized by low international prices (Peretti, 1998).

In this context, structural change took place, recreating advantages in natural resource endowments, and driving some innovative activities, especially in the public and private service sector. Thus, trends in specialization of the Argentinean production system prevailing in the 90s were based mainly on the use of "old" (e.g., agriculture³) and 'new' natural advantages (oil, gas and derivatives and large metal mining), the use of markets such as public service sector and the development of consumer-oriented high-income services (property, commercial, financial,

education and health) (Heymann, 2006). The key word was “re-primarization”, that is, emphasis on the extractive industries mainly biomass extraction.

In general, the economy had favorable conditions in the external markets through increases in international prices of exported goods. The supply of exportable goods was expanded due to a significant boost in grain production (between 1997 and 1998 harvest rose 70%). Exports measured in money terms increased more than twice between 1993 and 1998 (Heymann, 2006). Moreover, in 1996 Argentina approved the use of genetically modified soybeans and the expansion of the agricultural frontier towards the north of Argentina.

The Financial Crisis.

In 2001 a financial crisis and shortage of foreign currency known as the “corralito” started up and the economy turned from recession to depression (JEC 2003).

This scenario resulted in devaluation of the national currency in December 2001 caused among other things by the asphyxia of the external financing mechanism of the convertible peso (total external debt rose from US\$ 61,337 million in 1991 to 145,583 million dollars in 2003). Similarly, temporal international prices falling of major export products, appreciation of the dollar against other currencies and the strong devaluation of the Brazilian currency, principal trading partner, generated this outcome, characterized also by social unrest and high unemployment rate (Giletta, 2005).

As shown in Figure 1, GDP at constant prices declined over 8% per year between 1998 and 2001 mainly by domestic demand contraction of -12% average. Contribution of exports to aggregate growth in this period was low (4% of GDP) and imports fell nearly 24% (Bugna and Porta, 2007).

2003-2009, a New Growth Regime

In the context of domestic demand contraction, sectors that initially recovered were those able to increase their exports. The international sustained demand and higher prices for primary commodities favored such development (Giletta, 2005).

The exchange rate policy based on devaluation of national currency boosted the agricultural sector. Soybean crops increased during this period, due to technology and production efficiency achieved in the previous decade (Wainer, 2005).

In this new scenario, Argentina's economy has experienced rapid growth in recent years. Average annual rate between 2003 and 2008 was 8.4%. Despite, the economy grew 0.9% in 2009, affected by the international economic crisis (INDEC 2011); it regained growth in 2010, favoring prospects for re-election of Cristina Fernández who, like her late husband President Kirchner, has been riding the commodity boom.

Material Flow Patterns of the Argentinean Economy

Notions of ‘metabolic profiles’ (Schandl and Schulz, 2000) of the economy and ‘socio-ecological transitions’ (Fischer-Kowalski and Haberl, 2007; Krausmann et al., 2007) are built and analyzed on the base of three material flow indicators: Direct Material Input (DMI), Domestic Material Consumption (DMC) and Physical Trade Balance (PTB). In addition, terms of trade (TOT) describe the position of the country in trade relations with the rest of the world. Biophysical scales and dematerialization trends are compared through material intensities related to income and population figures.

Metabolic profiles are defined by patterns and levels of material use. This term can be useful to analyze “socio-ecological transitions” which understand the social change process as a qualitative transition which transforms the agrarian socio-ecological regime into an industrial regime thereby establishing a distinct and fundamentally new pattern of society–nature interaction and material and energy use (Fischer-Kowalski and Haberl, 1997, 2007; de Vries and Goudsblom, 2002). Metabolic profiles, demographic features, patterns of land use, socioeconomic organization, infrastructure, and technologies are fundamental facts in socio-ecological transitions (Schandl et al., 2009).

Extraction of Materials in Argentina.

With a territory of 3,761,274 km² Argentina is the second largest country in South America, seven times larger than Spain. Due to its fertile soils and favorable climate, the “Pampas” region has become one of the most agro productive regions in the world, gaining the nickname of “barn of the world” (Pengue, 2001).

Figure 2 shows DE from 1970 to 2009 by material component. Due to the ups and downs of Argentina’s economy, DE experienced a modest increase during the period of analysis, going from 445 Mt. in 1970 to 683 Mt. in 2009, largely driven by the agricultural sector. DE average growth rate in the period was 1.04%, below population growth rate (1.33 %) and economic growth rate (2.56%). In per capita terms, DE passed from 18.6 tons in 1970 to 17 in 2009 showing a decreased in per capita extraction unlike other Latin American economies. Nevertheless, Argentina presents

higher values of per capita DE than other economies in the region: 8.3 tons/cap average from 1970 to 2007 for Colombia (Vallejo et al. 2011), 7.4 tons/cap average in the same period for Ecuador (Vallejo, 2010). Even Spain—an economy based on “heavy” building minerals— presented a per capita DE of 12 tons/cap in average for the period 1980-2009 (Gonzalez-Martinez. et al. forthcoming).

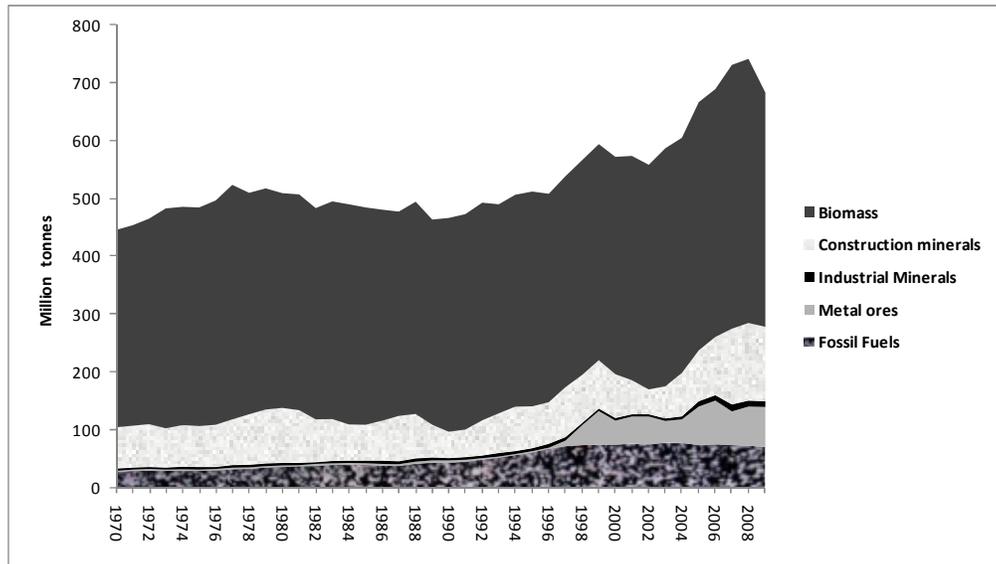


Fig. 2: Domestic extraction of Argentina (1970-2009)
Source: own estimations

Biomass DE represents the most predominant activity (72% of DE share), composed of fodder and grazing, other biomass from fishing and agricultural crops. As for the latter, soybeans has been the most predominant flow: it represented 17% of all agricultural crops in weight between 1970-2009 and 21% of all agricultural crops between 1996-2009, being the main export product.

Biomass from primary crops increased consistently from 50 Mt. in 1970, to 137 Mt. in 2009. According to Pengue (2001), permanent crops for exports have displaced crops for domestic consumption. This is the case of soybeans whose production passed from 26,000 tons in 1970, to 30.9 Mt. in 2009. This growth was driven on the one hand by high international prices of this commodity from the 1990s onwards (because of increased demand) and on the other hand, by higher mechanization of agricultural sector and the introduction of transgenic soybeans and chemical weeding with glyphosate (Teubal, 2006).

This rise in agricultural production requires clearing the land and forest, as well as the displacement of many indigenous and rural communities because of the expansion of agricultural frontier. Harvested area of this soybeans passed from 38,000 Ha in 1970 to 18 million Ha in 2009, being more than half of the total area used for grain production (MAGyP 2011); evidencing

problems like detriment of food security, increasing use of agrochemicals, water, air and soil pollution; and health impacts on the surrounding populations (Binimelis et al. 2009). Material Flows from deforestation have not been subtracted in our accounts due to the lack of reliable annual estimates.

Despite livestock units and land occupied for raising cattle showed only a moderate pattern of growth, it was the most predominant biomass flow (74% of total biomass share). This is related to the importance of the livestock industry in Argentina: 53.4 million cattle heads in average were raised in the national territory during the period under study (FAO 2010).

DE ores and fossil fuels increased—in weight— by a factor of 27 and 3 respectively between 1970-2009. The DE intensification of those categories since mid 1990s was driven primarily by external demand—particularly for ores— and high international prices. In addition, mining was eased by the 1993 Foreign Investment law, under which licenses were released for oil and gas mining.

DE ores passed from 9.6 Mt. in 1997 to 34.4 in 1998, driven by the opening in 1997 of mining projects such as “Bajo la Alumbreira”, “Cerro de la Vanguardia” y “Salar de Hombre Muerto”. As a result, exports value increased from 150 million dollars in 1990 to 1,200 million in 1999 (Prado, 2005).

Extraction of fossil fuels rose importantly due to the approval of the 1993 foreign investment law mentioned above, mainly in natural gas exploitation (ECLAC 1997), which increased by a factor of 6.31 during the period, showing annual growth rates of 9.9% in 1995 and 13.8% in 1996.

In Argentina, annual extraction of construction minerals represents 14% of total DE, unlike Spain where this category represented 68% until the economic crisis of 2008-09. (Gonzalez-Martinez, et. al. forthcoming). The sum of construction minerals and industrial minerals related to construction activities in Argentina just increased by a factor of 1.39, between 1980 to 2009.

Correspondence of building materials extraction and economic growth cycles was found in previous studies (Weisz et al. 2006; Behrens et al. 2007). In Argentina the deepest economic downturns in 1989 and 2001 coincide with the lowest DE of construction minerals. Likewise, economic recovery from 2002 onwards led to an increment in construction activities. However, in contrast to Spain or other Latin-American countries such as Mexico, building materials have not been and they are not the most important flow of this economy.

Material Input

The evolution of per capita DMI of Argentina is depicted in Figure 3. Per capita DMI remained constant in 19 tons from 1970 to 2009. Imports grew especially after 1990 because of the commercial opening resulting from the fixed parity plan. DE of resources has been by far the main source of material inputs, per capita imported materials represented only 2.3% of per capita DMI in 1970 and 3% in 2009. A completely opposite pattern regarding imports is presented by Spain, where per capita imported materials accounted for 23% of the DMI in 1980, increasing to 31% in 2009 (Gonzalez-Martinez, et al. forthcoming).

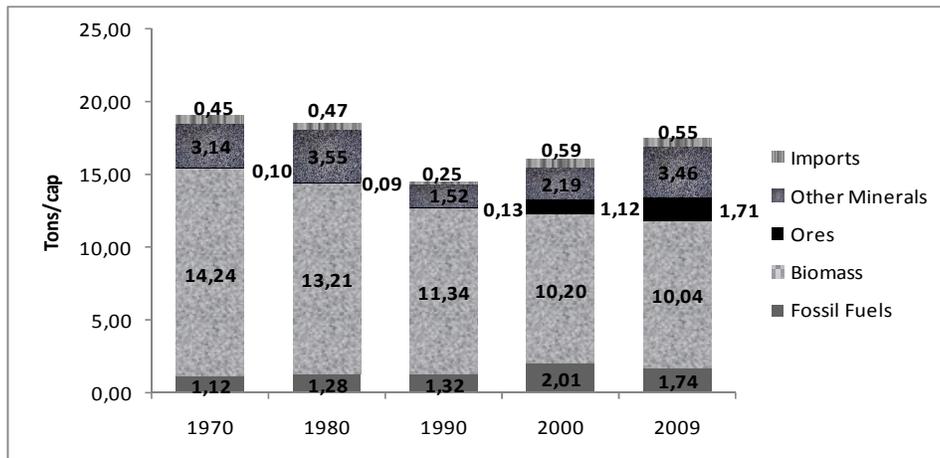


Fig. 3. Argentina per capita DMI (tons/cap.) (1970-2009)
Source: Author's estimations

Domestic Material Consumption

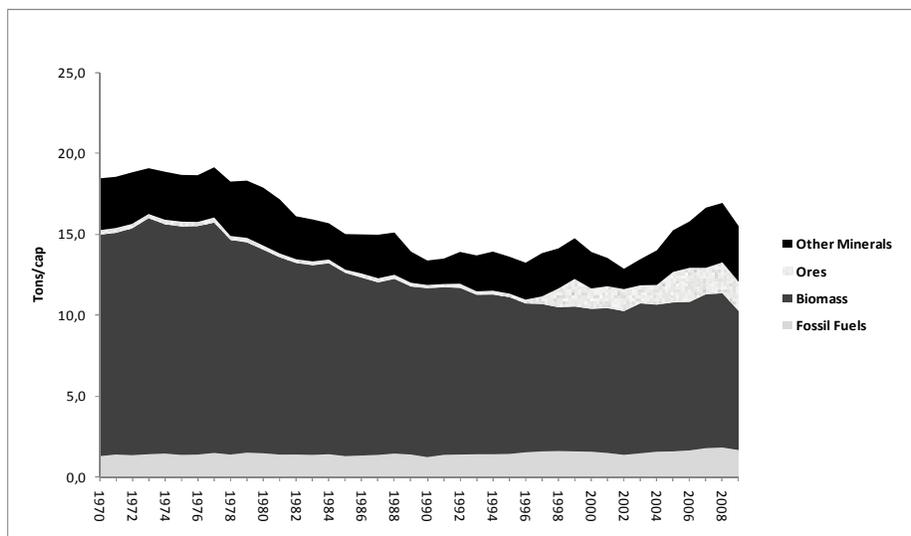


Fig. 4: Per capita Domestic Material Consumption for Argentina (1970-2009)
Source: Author's estimations

DMC stands for a crucial indicator of the material pattern of consumption in the national territory. As shown in Figure 4, Argentina presented some peculiar features for DMC during the period of study.

Biomass represented the major share of DMC per capita, followed by minerals and fossil fuels. Values for biomass were exceptionally high, between 7 and 13 tons per capita between 1980 and 2000 unlike Spain, where values were between 3 and 4 tons per capita during the same period. So far, Argentina has the highest value recorded in Latin America. We observe two trends of the total DMC, a long decline from 1970 to 1990; and then three cycles of growth and degrowth. The first must be understood as corresponding to the economic stagnation, and the deterioration of per capita GDP experienced during this period. The second corresponds to the economic revival vitiated by the 2001 recession and 2008 financial crisis.

According to Krausmann et al. (2008), societies can present “different sociometabolic regimes, each characterized by a specific metabolic profile that corresponds to a set of impacts on the environment”. In this framework, the dynamics of these metabolic profiles constitute "sociometabolic transitions". Krausmann et al. recognize two main metabolic regimes, namely agrarian and industrial which can be identified by a set of indicators. Table 2 presents the more relevant indicators for Argentina and Spain for the years 1970, 1990 and 2008. In previous studies for Latin-American countries, a slow transition from agrarian to industrial regime was observed for Brazil and Venezuela (Eisenmenger et al. 2007), Ecuador (Vallejo, 2010) and Colombia (Vallejo et al. 2011). In Argentina, the transition towards industrial regime has some contradictory signals. The transition seems to be slow between 1970 and 1990 where DMC per capita declines, contrary to other indicators. As a result, DMC per capita in 2008 was below the level observed in 1970. However, the share of agricultural population —a major indicator— argues strongly in favor of an industrial regime.

The typology proposed by Krausmann et al. is too general to fit the features and trends of economies like Argentina, which is at the same time an advanced agriculture exporting country and also highly urbanized.

Table 2: Metabolic profile of Argentina compared to agrarian and industrial socio-ecological regimes

Indicators	Units	Agrarian regime (*)	Industrial regime (*)	Argentina				Spain				Sources
				1970	1980	1990	2008	1970	1980	1990	2008	
Per capita energy use	GJ/cap	40–70	150–400	58 (#)	62	59	80	47	75	97	127	(a)
Per capita DMC	t/cap	3–6	15–25	18.4	17.8	13.3	16.9	na	10.3	12.4	17.7	(b)
Population density	cap/km ²	<50	<400	8.8	10.3	11.9	14.7	67.6	74.9	77.8	91.3	(c)
Agricultural population	%	>80	<10	21	17	13	8	34	27	25	23	(c)
Energy use per area	GJ/ha	<30	<600	5 (#)	6	7	12	31	56	75	115	(a)
DMC per area	T/ha	<2	<50	1.6	1.8	1.6	2.4	na	7.6	9.5	15.8	(b)

Sources: table adapted from Vallejo (2009); (*) Kraussmann et. al. (2008) (a) IEA (2010) (b) own calculation (c) WB (2010) (#) 1971 value

Rather, Argentina has followed a resource use patterns similar to those of these countries such as Canada and Australia, although its GDP per capita is still far below. Australia's per capita GDP increased 13 times from 1970 to 2009 while in Canada ten folded in the same period. Argentina's per capita GDP only 6 folded, it passed from \$1,317 to \$ 7,665 in 2009. Current levels of per capita GDP in Australia and Canada are \$ 42,131 and \$ 39,599 respectively (2009).

The Debate on Dematerialization

One of the objectives of a MFA analysis is to provide evidence on dematerialization: economies are dematerializing if there is a downshifting in the amount of extracted material and emitted waste that sustains them. Authors distinguish strong and weak dematerialization, the first concerning the absolute reduction of extraction and consumption pattern, the second observing the same feature per unit of economic value (Cleveland and Ruth, 1999).

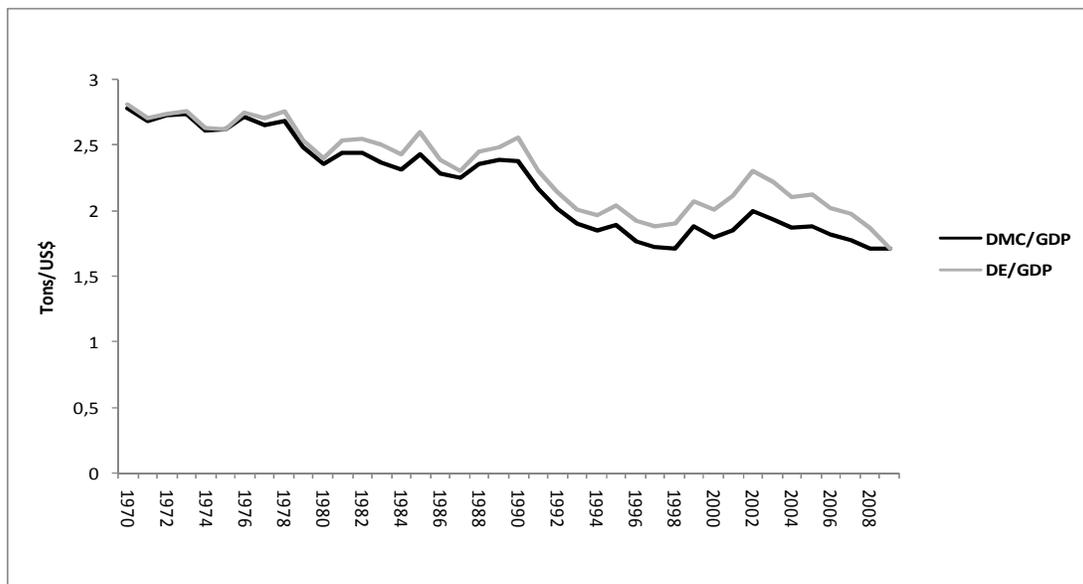


Fig. 5: Indicators of relative dematerialization. Material intensity (DMC/GDP). *Note: GDP is in US\$ constant, base 2000. Source: Author's estimations*

Regarding strong dematerialization, it can be observed that during the period of study it did not take place in Argentina. Absolute DMC increased from 441 Mt. in 1970 to 682 Mt. in 2009, registering an average growth of 1% during this period.

As far as weak dematerialization is concerned, Figure 5 shows a clear trend of decline of material intensity by unit of GDP in the time. It passed from 2.8 to 1.6 ton/US\$ (constant base 2000) in the 40 years of the study.

Observed improvements in material intensity efficiency may be caused by structural change. The economic structure of Argentinean has been increasingly dominated by service activities. In 1970, services contributed with 55% to GDP, 62% in 1980 and 67% in 1990 and 2000. By 2009, services sector share went up to 68% of GDP. However, the results obtained for Argentina confirm that little evidence on dematerialization in regard to overall material and energy use, do not led to a decrease in total throughput (Weisz et al. 2006). There's a lot of literature about the issue of whether or not material efficiency gains lead to environmental improvements. Efficiency gains, by themselves, have necessarily resulted in an overall decrease of environmental pressures. On the contrary, they are likely to contribute to increased pressure due to the "rebound" effect, also known as "take-back" or Jevons paradox (Schipper 2000; Huesemann 2003; Polimeni and Polimeni 2006; Herring 2006; Homer-Dixon 2006).

Physical Trade Pattern

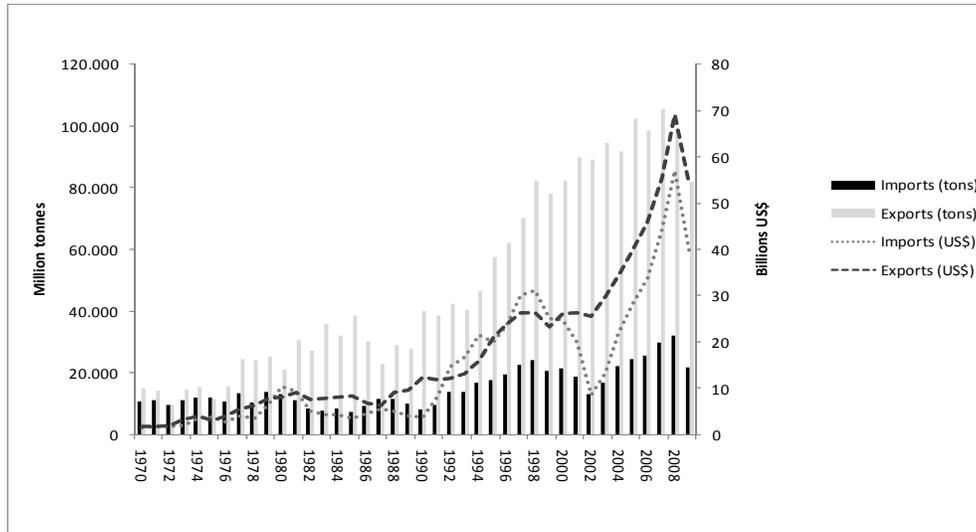


Fig. 6: physical and monetary flows from trade of Argentina (1970-2009)
Source: Author's estimations

Figure 6 presents the evolution of exports and imports in physical terms and their monetary equivalents. Since 1970, growth of physical exports took place particularly since the mid-1990s, driven by external demand. Between 1970 and 2008 exports more than six folded. Concerning imports, these remained constant due to import substitution during the 1970s while in the 1980s they physically stagnated due to the economic downturn. Exports grew in the 1990s but fell drastically during the crisis and devaluation of 2001, to grow again rapidly until 2008, be 3 times higher than in 1970.

There is a tight link between trade and monetary policies practiced in that period and the physical response of the economic system. Prior to 1976, trade was characterized by stable features both in term of weight and value, which ended with the first neoliberal policy package, implemented by the military government once in power in 1976. Afterwards there was liberation of trade initiated by the lowering of tariffs, which went hand-in-hand with ISI policies.

Figure 7 and 8 presents exports' and imports' composition, expressed in tones, which have been divided into different categories in reference to their main material basis.

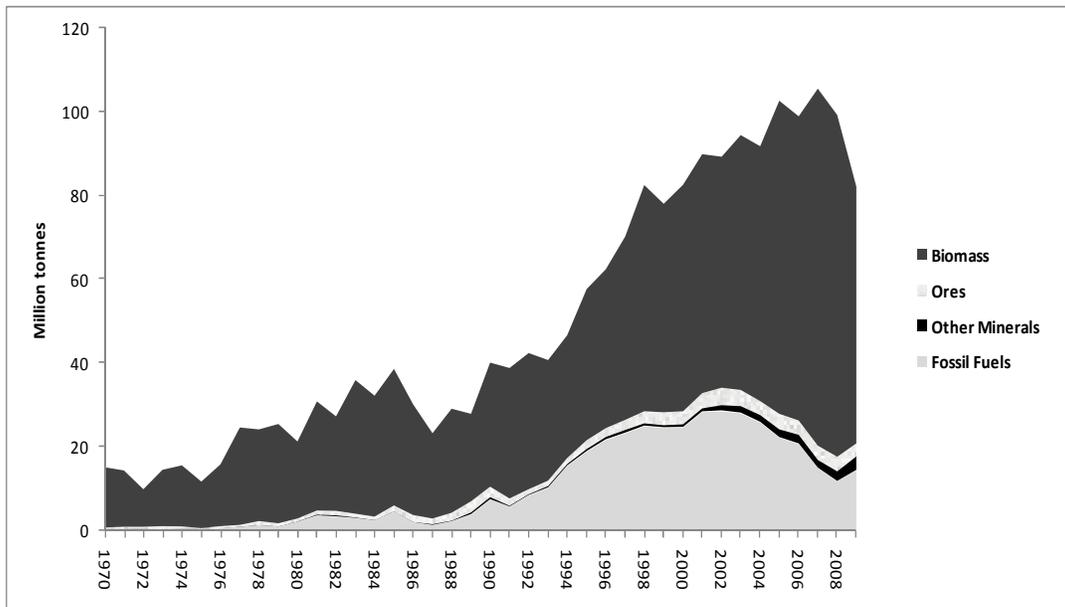


Fig.7: physical exports of Argentina (1970-2009)
Source: Author's estimations

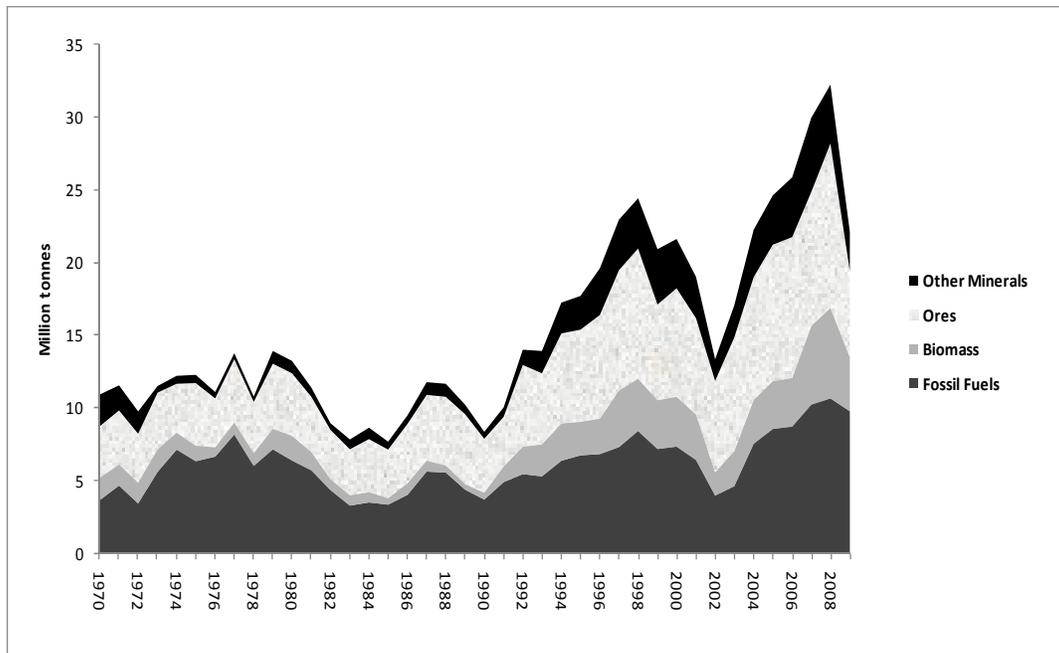


Fig. 8: physical imports of Argentina (1970-2009)
Source: Author's estimations

As shown in Figure 7, biomass based products were the main exported commodities during the period. The most significant part was Food and Feed, which represented 94.1% of total exports in 1970 and 82.1% in 2008. Cereals contributed significantly to total exports, 46% in 1970 whereas they represented almost 26.8% in 2007.

From 1993 to 2009, the so-called soy complex (beans, oil, flour and pellets), comprised in average 41% of total exports, while manufactures of agricultural products represented an important

component of this group, reached 35% of total exports (by weight) in the same period. It is important to mention that these products have a low added value (e.g. vegetable oils) (Giletta, 2005).

Since the early 1990s, petroleum started to be another major exported commodity, consequence of the reform of the whole energy industry in Argentina. The government privatized the national petroleum company and liberalized the market, authorizing oil imports and exports in 1989, until then prohibited (Kozulj, 2002). Fossil fuels based products represented about 30% of exports in weight during the 1994-2004 decade. They are now in relative decline due to the fact that Argentina reached intermediary peak oil in 1998. It could be that further investment will produce additional substantial reserves (Araoz et al. 2008).

Concerning imports (Figure 8), fossil fuels and ores/industrial minerals have been the most predominant flows. Argentina has been very dependent on foreign iron and steel which represented 30% of cumulative physical imports during 1970-2009, despite an attempt from the government to reduce iron dependency opening an iron mine in 1978 (USBM 2011).

As shown in Figure 7 and figure 8, oil exports steadily increased during that period of study. This is because since the early 90s, the refining capacity in Argentina has not been enough to meet the increasing domestic demand largely driven by the industrial sector (Araoz et al. 2008). The remarkable increase in fossil fuels extraction generated a considerable decline in country oil and gas reserves as new reserves weren't added at the rate they were consumed. By year 2008, Argentina became a net importer of oil and its derivatives.

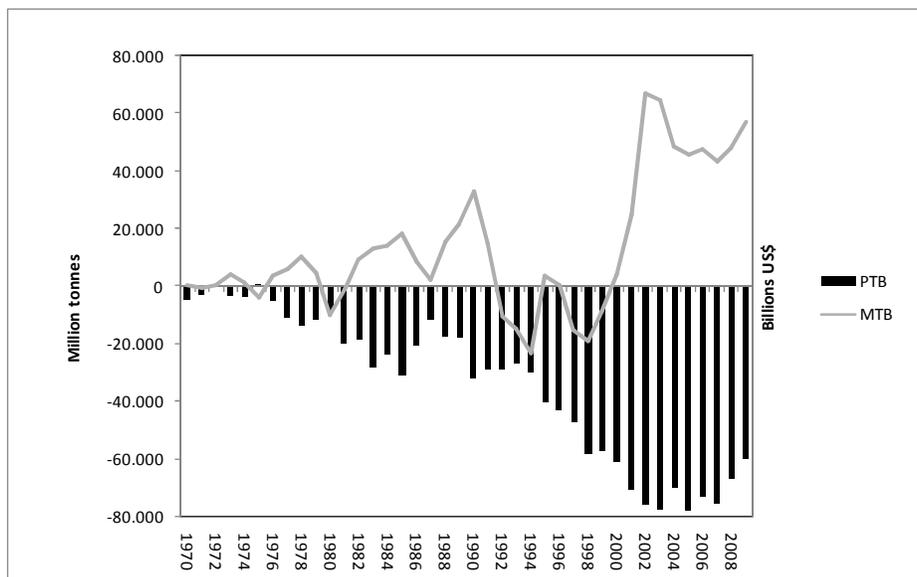


Fig. 9: Physical and monetary trade balance of Argentina (1970-2009)
Source: Author's estimations

Due to the import and export patterns described before, Argentina has been a net exporter in terms of weight during the whole period. An increasing negative trade balance is observed (PTB deficit of 4.4Mt in 1970 and 67Mt in 2008) during the period under study, excepting 1975 (see Figure 9). PTB deficit in Argentina is one of the highest observed in Latin America: for instance, in 2000 physical deficit reached 1.65 ton/capita in Argentina, higher than in Ecuador's and Colombia's which both were 1.3 ton/capita (Vallejo, 2010; Vallejo et. al. 2011).

A physical trade deficit does not necessarily imply a positive monetary balance. Despite the fact that export prices have improved significantly from 1990 to 2009, Argentina continues exporting relatively cheap commodities under a primary exports model. We will see in terms of trade section, that such are unfavorable for Argentina through a comparison of the relative prices of imports and exports.

Recently, trade in Argentina suffered the effect of the recent global economic crisis as both, imports and exports decreased 32% and 20% respectively in 2009 due to the contraction of internal and external demand. Besides, the agricultural sector was affected by a serious drought that affected yield of major exported cultures like wheat, maize, soybeans, whose harvests reduced respectively by 49%, 40% and 33% in physical terms (FAOSTAT 2011). However, harvest increased again in 2010 except wheat (although with a large rate of inflation, the statistics of which are subject to political debate, so that there are doubts on the real rate of economic growth). It is estimated that harvest of maize show a higher level again more than 20 Mt, in addition, it is expected that soybean production will reach its highest level ever more than 52 Mt (ECLAC 2009, 2010)

Terms of Trade and integration in global economy

About six decades ago, the Latin American "structuralist school"-concerned about the obstacles preventing Latin America to develop- introduced a theory about the causes of underdevelopment. One such cause was the trend towards deterioration of terms of trade (TOT) of primary export products. This approach notably defended by Prebisch rests on the recognition of centre-periphery polarization of the economic space. According to this approach, the economic growing area is the centre and the less developed area is the periphery that supplied cheap raw materials in competitive markets.

Prebisch (1950) observed that peripheral countries are specialized in exporting primary goods whereas central countries export industrial goods. He made the hypothesis that due to this pattern of specialization, the terms of trade for peripheral countries tend to deteriorate because in industrial countries salaries increased in line with productivity.

First, if we look at prices of imports and prices of exports, comparing Argentina and Spain, we can see the average value per ton of imports that can be purchased through the sale of one ton of exports. In Figure 10 for instance the value of 0.6 means that one ton of exports buys only 0.6 tons of imports.

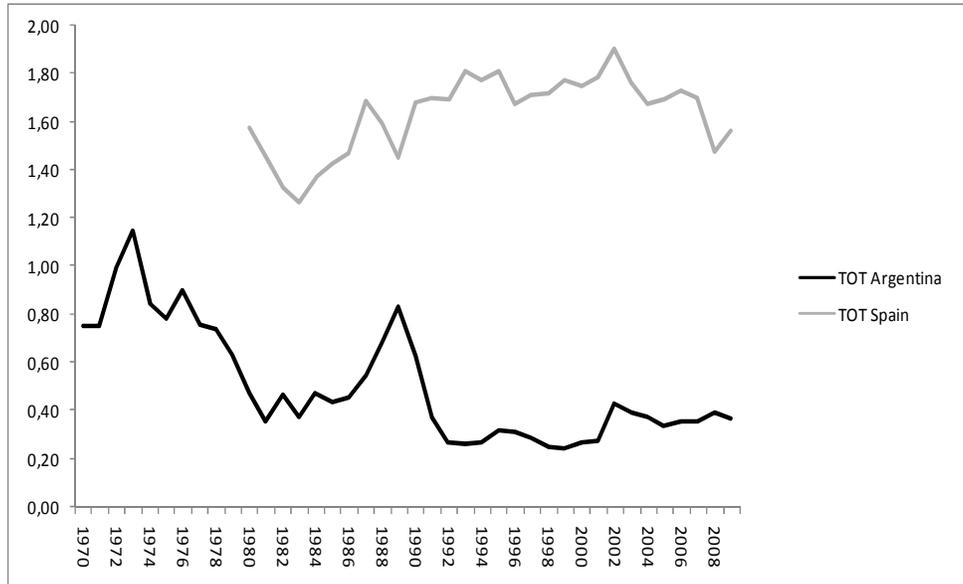


Fig. 10: Argentina terms of trade (TOT) (1970-2009) and Spain terms of trade (TOT) (1980-2009)
Source: Author's estimations, Gonzalez-Martinez., et al., forthcoming

TOT are said to deteriorate if the index decreases, i.e. if the price of exported products tends to decrease compared with imported products. TOT for Argentina exhibits a downward trend during the period of study, passing from 0.75 to 0.37. In this sense, TOT for Argentina are four times lower than those for Spain.

This is because a large part of technological change in manufactured goods tends to reduce the cost of raw materials, reducing their prices in international markets. This does not mean however that the demand for raw materials decreases in general, because of rebound effects. While technical innovation and increased productivity deliver benefits through higher profits and wages in the case of manufactured goods; technical progress translates into lower prices and lower wages for primary products because these are competitive markets dominated by international corporations (Prebisch, 1950). One exception is the OPEC cartel. But yet, there is no copper cartel or soybean cartel or even a gas cartel.

Asymmetries in the value of imports and exports can be extended to international ecological issues. Empirical findings suggest that while exports are indeed shifting, trade relations remain extremely unbalanced and unfair because poorer nations export large quantities of under-priced

products whose value does not include the environmental —and social— costs of their extraction, processing, or shipping (Jorgenson, 2009; Rice, 2007).

In this sense, an ecologically unequal exchange (Hornborg, 1998, Giljum and Eisenmenger, 2004; Muradian and Martinez-Alier, 2001) can be observed in the intensification of natural resource exploitation in order to acquire the same amounts of imported goods, while environmental liabilities and social costs are not incorporated into the final prices of export goods (Roberts and Parks, 2009). As Hornborg wrote in 1998, world metropolitan areas rely structurally on relatively cheap imports of energy and materials which they dissipate or use in large quantities. In this context, the international division between the center and the periphery relates to the physical trade in which many Southern countries provide the material and energy for Northern countries to increase or maintain their socioeconomic metabolism. The North today includes parts of China.

In this line of thought, Bunker (1985, 2007) suggested a structural asymmetry between “extractive economies” in the periphery and “productive economies” in the core. Eisenmenger and Giljum (2006) called “*extractive economies*” all those economies specialized in extracting resources for exporting rather than for domestic use. In this sense, we note that Argentina, as a country specialized in primary export products, behaves as an “extractive economy”.

Since Argentina follows a resource-intensive and export-oriented developed model, it had a persistent physical trade deficit. Not only lost natural resources, but also gained little economic profit; TOT declined during these forty years. Despite the fact that export prices have increased in the last ten years (see Figure 11), Argentina has to pay a large and increasing price for imports in terms of exports which carry heavy ecological costs. This supports the concept of ecologically unequal exchange implied by the world-system.

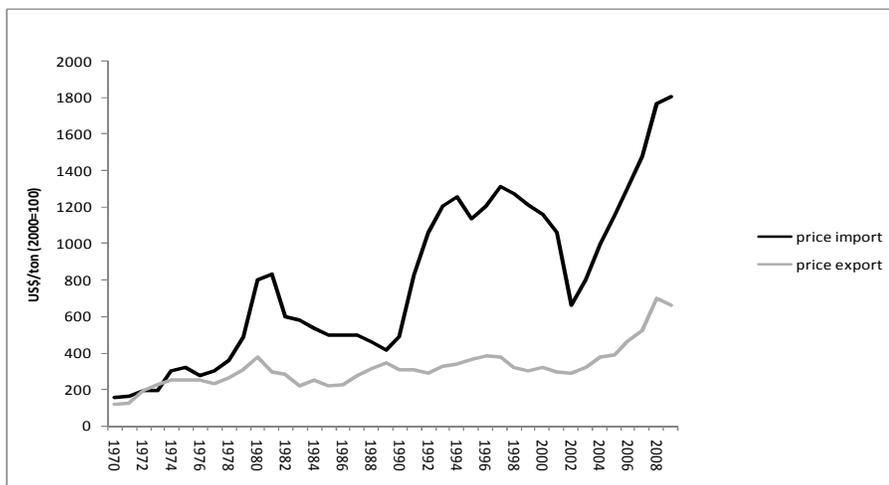


Fig. 11. Unit values of trade of Argentina (1970-2009)

Source: Author's estimations

Trends of unit values of trade of Argentina (US\$ per ton of imported and exported materials) are presented in Figure 11. Unit values of exported and imported products are expressed at constant prices (base year 2000). During this period, import prices have been higher than export prices reaching a factor of 2.73 in 2009 in Argentina while an opposite trend is the case of Spain where the export prices are higher than import prices. Even the industrialization of agricultural exports, the registered high commodity prices in the 2000s and the fact that Argentina is positioned as a net exporter of fossil fuels since 1990 have not achieved a significantly reduction of this gap. Trade policy in Argentina has not improved terms of trade for this country but it has intensified the use of exhaustible resources and intensive agricultural activities, implying both important environmental damages.

Conclusions

This study presents information about biophysical aspects of the Argentinean economy using MFA methodology and comparing such results to those of another study on Spanish economy (Gonzalez-Martinez., et. al. forthcoming). The quantity of materials domestically extracted and consumed in Argentina has grown by 77% and 77.2% respectively during the forty years period of study, due to growth of biomass and ores extraction.

Over the last four decades, external demand was the main driving force for the increasing use of natural resources in Argentina. The growth of exports since 1970 was mainly based on biomass products. From the late 1990s onwards this pattern changed as metals ores gained importance. MFA indicators show the degree of *commoditization* of the Argentina's foreign trade. Mining projects only consider the production of concentrates and products without refining, so the added value in the extraction of minerals is low. Additionally, despite the fact that manufactures of agricultural origin have increased, the added value remains low in total Argentinean exports.

Therefore, the Argentinean economy presents the same pattern as other Latin American economies. Its dependence on exports of bulk commodities in the monetary and physical trade balance increased during the period analyzed, which places it as an "extractive economy". Additionally, it is an economy based on intensive agricultural activities that go hand-by-hand with deforestation, loss of biodiversity, and intensive use of agrochemicals. Likewise, open cast mining of coal or other minerals is also a source of hazardous wastes, which threaten human health and the environment. In addition, deterioration of TOT was observed in the case of Argentina during the period of study, evidence that seems to reinforce the ecological Prebisch's thesis.

The typology proposed to analyze sociometabolic transitions (Krausmann et al.) is too general to fit the features and trends of economies like Argentina. Whether Argentina has gone through a transition from an agrarian regime to an industrial economy, as it was observed in other empirical studies in Latin American economies, it is difficult to conclude. Argentina is characterized by high levels of biomass production as if it was an agrarian society but it is highly urbanized and with a relatively high level of energy consumption per capita. Its current per capita GDP of \$ 7.665 (current US\$ in 2009) (WB 2011) is one of the largest in Latin America but its industrial economy is still based on low added value products.

Rather, we might conclude that Argentina presents a resource use pattern similar to those countries with an abundance of natural resources, large territories and low population densities such as Australia or Canada. Nevertheless, per capita income in Argentina is still far below these two countries.

Finally, despite extraction and material consumption in Argentina increased, improvements in material intensity efficiency were observed. These gains in material efficiency may have been the result of an increasingly dominance of the service sector in the economy.

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Notes

1. Despite the fact that indirect flows increase the accuracy of the analysis, their inclusion can generate arbitrariness since they are calculated by multiplying direct flows by standard coefficients which do not take into account available technology and the specific natural and economic conditions of each country.
2. See Bringezu et. al. 2003 for a review of the MFA application in developed economies.
3. Pampa's agricultural sector was transformed by means of introducing technological and organizational innovations, encouraged by the new structure of relative prices. This fact summed up to the natural fertility of the land in exploitation boosted yields and productivity.

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