Emergy perspectives on the Argentine economy during the 20th century: a tale of natural resources, exports and external debt

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Abstract: Numerous approaches seek to incorporate the environmental dimension to macroeconomic indicators. In this study Emergy Accounting (EA), a methodology grounded in systems ecology and ecological economics, was used to assess changes in the ecological sustainability of the Argentine economy during the 20th century. Throughout the century, the proportion of Argentina's economy supported by renewable energy decreased from 67% to 55%. An exporter of commodities, Argentina provided buyers more emergy than it received in exchange. Argentina's international debt is still a burden, but in emergy terms, we calculated that the country has already paid its external obligations by 1985. The unfair emergy terms of trade for many developing countries are at the heart of the external debt issue. EA, integrating the economic and ecological values of commodities, may offer useful insights on how to achieve environmental justice for Argentina and other developing countries trading in the global economy.

Keywords: Emergy Accounting; ecological economics; sustainability; international trade; external debt; environmental justice; developing countries; Argentina; Latin America.

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1 Introduction

Governments around the world assess their countries' economic performance using macroeconomic indicators, such as gross domestic product or GDP. GDP is a measure of the value of final goods and services produced by labour and other resources located within a particular country (Kearl, 1993). During the last few decades there has been increasing concerns regarding the use of GDP measurements for economic evaluation and policy decision-making at both national and international levels (Brouwer and Leipert, 1999; Daly and Cobb, 1989; Darmstadter, 2000; Hecht, 1999; Lange, 2003). One of the main issues is that GDP overestimates total production since it includes activities dealing with unwanted side effects of production, such as environmental protection and remediation (Brouwer and Leipert, 1999; Daly and Cobb, 1989). Another problem is that natural capital consumption is assimilated as income (Folke et al., 1994; Lange, 2003). Finally, environmental goods and services consumed directly without exchange in economic markets are not included in standard systems of national accounts (Darmstadter, 2000; Hecht, 1999).

Emergy Accounting (EA), an evaluation system that incorporates both environmental and economic values in a single measure, has been proposed as a valuable alternative for more holistic assessments of countries and states (Abel, 2004; Brown and Ulgiati, 1999; Cuadra, 2005; Lagerberg et al., 1999; Odum, 1996). Emergy represents all the direct and indirect energies consumed in the production of goods and services, including not only fossil fuel inputs and human services but also the work of nature (Odum, 1996). In this study, we used EA to assess changes in the ecological sustainability of the Argentine economy during the 20th century, including the ecological implications of structural adjustment and international trade. The relative position of Argentina with regard to its external debt in emergy terms was also analysed. The ultimate goal is to add to ongoing discussions regarding the ecological dimension of sustainable development in Argentina and the developing world, as well as to contribute to more integrated evaluations of national and international policies and strategies in that direction.

2 Perspectives on environmental accounting for countries and states

Numerous approaches have been proposed to improve GDP within the realm of environmental economic theory and methods; or to replace it with other macro indicators that bring to the table the philosophical underpinnings, theories and techniques of various disciplines from both the natural and the social sciences (Abel, 2004; Cobb and Cobb, 1994; Daly and Cobb, 1989; Darmstadter, 2000; Hecht, 1999; Lange, 2003; Peskin and De Los Angeles, 2001). Among the former, progress have been made in the development of adjusted, 'greener' GDP measurements that can incorporate variations in stocks of natural capital as well as environmental services' contributions to national economies (Brouwer and Leipert, 1999; Hecht, 2000). In a seminal work, Repetto et al. (1989) adjusted Indonesia's GDP by including the net depletion of some of the country's stocks of natural resources, such as petroleum, timber and soils and estimated an annual Net Domestic Product (NDP) for the 1971–1984 period almost 40% less than the GDP. Following this line of thought, the UN Statistics Division proposed in 1993 its first version of the System of Integrated Environment and Economic Accounting (SEAA), intended for global application and aiming to address all aspects of environmental accounting while maintaining the utmost possible consistency with the 1993 System of National Accounts or SNA (Harrison, 1997). The SNA is a comprehensive conceptual macroeconomic framework based on internationally agreed concepts, definitions, classifications and accounting rules for the measurement of the market economy (UN, 2001). SEEA built on SNA by expanding environment-related stocks and flows already accounted for in this system (Bartelmus, 1997; Brouwer and Leipert, 1999). Critics of SEEA highlighted its limitations because of the narrow focus on natural resource depletion and on commercial uses for asset valuation (Lange, 2003; Peskin and De Los Angeles, 2001). Although other methodological approaches have been developed to address the controversial issue of environmental services' valuation and natural capital depreciation, consensus regarding the design and implementation of an 'expanded' and 'greener' standard system of national accounts for application across developed and developing countries is yet to be achieved (Bartelmus, 1997; Brouwer and Leipert, 1999; Darmstadter, 2000; Hecht, 2005; Lange, 2003; Peskin and De Los Angeles, 2001).

Progress has also been made outside the disciplinary boundaries of environmental economics, providing alternative indicators framed within the context of different philosophical, theoretical and methodological foundations (Bartelmus, 2000; Folke et al., 1994; Hecht, 2005;Paterson and Jollands, 2004; PCE, 2002). This is the case of EA, a methodology grounded in the fields of systems ecology and ecological economics that conceptualises economic systems as embedded in the set of biospheric flows, cycles, processes and structures on which the ecological sustainability of these systems ultimately depends (Abel, 2004; King, 2004). Developed by Odum (1996), EA provides a biocentric, 'donor' system of value[1] for the valuation of natural capital and environmental services traditionally ignored in economic transactions (Brown and Ulgiati, 1999; Cuadra, 2005; Odum and Odum, 2000). As a general rule, EA expresses all inputs contributing to a production process (energy, services and materials) in units of the same form of energy required for their generation. Most frequently they are expressed in solar emergy and units are solar emjoules (abbreviated sej). By allowing the evaluation of human and natural capital on the common basis of solar emergy, EA offers a significant contribution towards the integrated assessment of sustainable development for countries and states. EA theoretical principles, critiques and

applications, from specific economic activities to regional, national and global processes, have been described in greater detail elsewhere (Björklund, 1999; Brown and Hall, 2004; Brown and Ulgiati, 1999; Brown et al., 2003; Moberg, 1999; Odum, 1994, 1996). Emergy evaluations of countries and states include, among other studies, developed economies such as Italy (Ulgiati et al., 1994), the USA (Odum, 1996), Sweden (Lagerberg et al., 1999) and Denmark (Haden, 2003), developing economies such as China (Lan and Odum, 1994), Thailand (Brown and McClanahan, 1996), Brazil (Safonov et al., 1998) and Nicaragua (Cuadra, 2005), as well as the Common Market of the South or MERCOSUR (Brown et al., 2003). These studies have shown the intricate relationships and interdependencies among human societies and the biosphere, highlighting the energetic constraints for sustainable development in a biogeophysical world (Abel, 2004).

3 Case study: Argentina

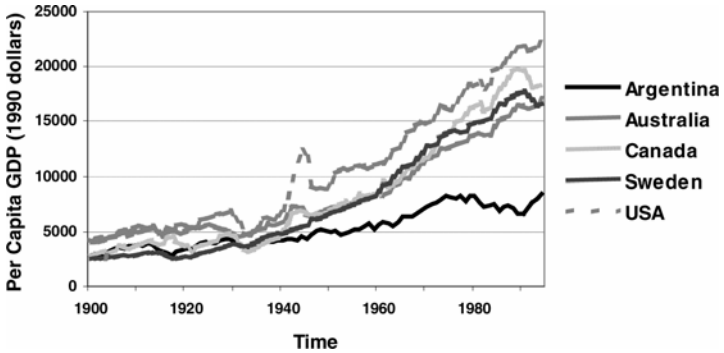
3.1 Overview

Argentina constitutes an interesting case of study for ecologists, economists and sociologists as well (Figure 1). Located in South America, the poor economic performance of Argentina during the second part of the 20th century has been considered something of a paradox (Vitelli, 1999). This perception is reinforced when considering that the beginning of that century found Argentina's economic development equal to that of some developed economies (Figure 2). To a great extent, the causes for this stagnation have been explained in terms of the economic policies undertaken during that period (Kydland and Zarazaga, 2001; Veganzones and Winograd, 1997). The preponderant role of changes in the world economy for the Argentine development has also been highlighted (Ferrer, 1967). Other approaches towards the interpretation of the complexities of the Argentine economic puzzle focuses on non-economic factors (Baer et al., 2002; Bambaci et al., 2002; Ollier, 2003). As clearly highlighted by Diaz Alejandro (1970, p.xiii), "even to an economist untrained in other social sciences, the influence of political, social, and psychological factors on the Argentine economy is striking".

Argentina's economic history cannot be separated from its natural resource base. A nation abundant in resources and land, Argentina started the century as a leader in agricultural exports (Giberti, 1988; Veganzones and Winograd, 1997). The country still benefits from the exceptional Pampean Region, a fertile agricultural plain of almost 55 million hectares and temperate climate that constitutes an important source of state revenue through substantial export retentions (Busnelli, 1992; Ferrazzino et al., 2004; Longoni, 2005). Argentina is also rich in energy reserves, including oil and natural gas, which are growing in importance as exports (EIA, 2000). The trade balance tends to be favourable to Argentina when world demand for food is high. MERCOSUR, the regional customs union of the Southern Cone that includes Argentina, Brazil, Paraguay and Uruguay, has proven to be very important for the country's trade (Connolly and Gunther, 1999). However, there has been escalating stress after the Brazilian devaluation in 1999 (ADFAT, 1999).

Figure 1 Political map of Argentina. Courtesy of the University of Texas Libraries, The University of Texas at Austin

Figure 2 Comparison of Per Capita GDP levels expressed in 1990 Geary-Khamis Dollars



Source: Maddison (1995, Appendix D).

The current state of Argentina's natural capital is rather disappointing (PNUMA and SAyDS, 2004). Soil erosion, biodiversity loss and water contamination are some of the consequences of a development style that chose not to – or was not able to – conserve the quality and quantity of its vast natural resources (MECON, 2000). Environmental degradation in Argentina has been a matter of analysis in numerous studies (Brailovsky and Foguelman, 1991; Ferreyra, forthcoming; Jergentz et al., 2004; Moscatelli and Pazos, 2000; PROCISUR, 1997; SAGyP, 1995; SRNyAH, 1992; Vila and Bertonatti, 1993; World Bank, 1995). A national environmental assessment conducted by PNUMA and SAyDS in 2004 highlighted the economic rationality that guided the use of natural resources in Argentina throughout the 20th century, almost to the exclusion of any other considerations.

3.2 Methods

Using EA five stages of the Argentine economic development during the 20th century were analysed, following the model proposed by Veganzones and Winograd (1997):

1 *1900–1929*: The Golden Age of Argentine Growth.

2 *1930–1943*: The World Depression and Destabilisation of the Argentine Model.

3 *1944–1975*: Import Substitution and Increasing Economic and Political instability.

4 *1976–1989*: The Attempt to Liberalise the Economy, the Debt Crisis and Extreme Macroeconomic Volatility.

5 *1990–1995*: Hyperinflation and Change in the System. Return of Sustainable Growth?

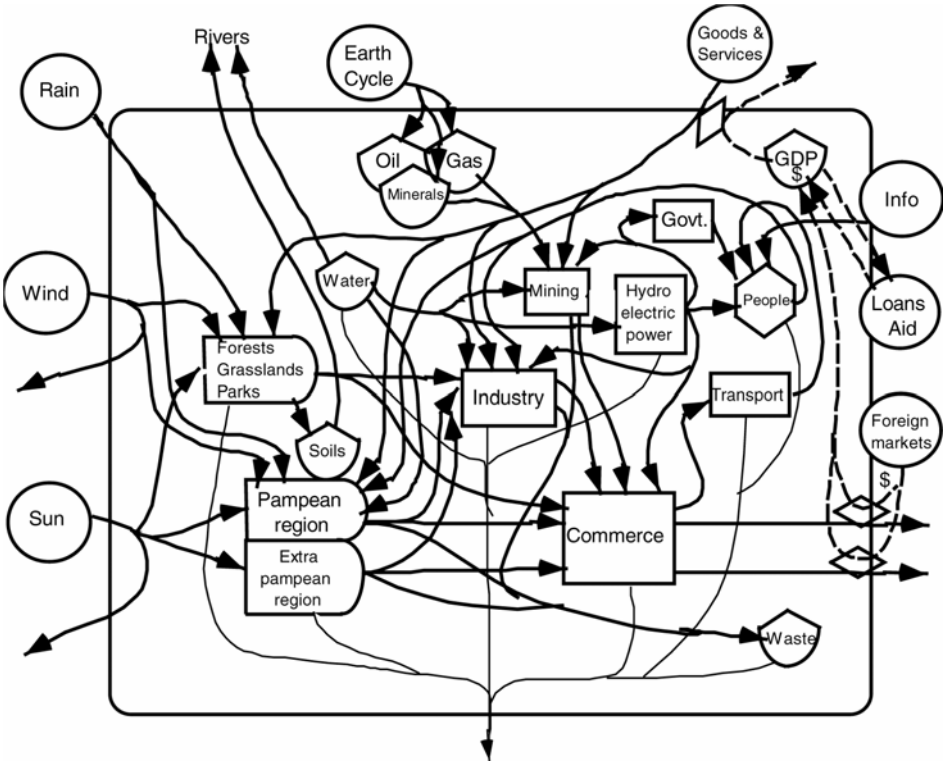
The reliance on economic interpretation for the selection of the study periods acknowledged the interdependence of natural capital and economic development. Moreover, the selection was made with the purpose of attaining an alternative perspective to that of economic history, incorporating the point of view of EA. A detailed description of each of the five periods can be found by Veganzones and Winograd (1997). A synthesis of the work of these authors follows.

> The rapid growth that had begun in the early 1880s continued in the 1900-29 period…. This growth was closely linked to rising exports and investment … agriculture was the most important sector…. State intervention in the economy was limited…. The country was heavily dependent on the free flow of merchandise and capital (p.24)….The 1930s crisis revealed the fragility of the development model chosen by Argentina.… Awareness of this fragility led the country's leaders in 1943 to adopt an import-substitution policy…. Against a background of chronic and accelerating inflation, economic and political instability arising primarily from existing policies, led to loss of control of the economy by the early 1970s (p.33)…. The 1975 breakdown marked the definitive limit of the import-substitution regime…. By 1981 the military government's mishandling of its stabilization programmes and economic liberalisation policy had plunge the country into a serious crisis of unprecedented length…liberalisation was gradually reintroduced by the Radical Government elected in 1983…. The high degree of instability and demonetisation of the economy resulted in two bouts of hyperinflation: one in 1989, under the Radicals; and another in 1990, during the Peronist government

> (p.38).… In this short period from 1990 to 1995, economic performance was exceptional compared to the two preceding decades…. Profound economic reforms were undertaken that set in motion a change in growth strategy. Liberalisation of the economy was completed and stabilization was achieved. It may be too soon to announce the complete success of the reforms; the slow recovery of financial intermediation and the financial crisis of 1995 are signs that the economy is still fragile (p.40).

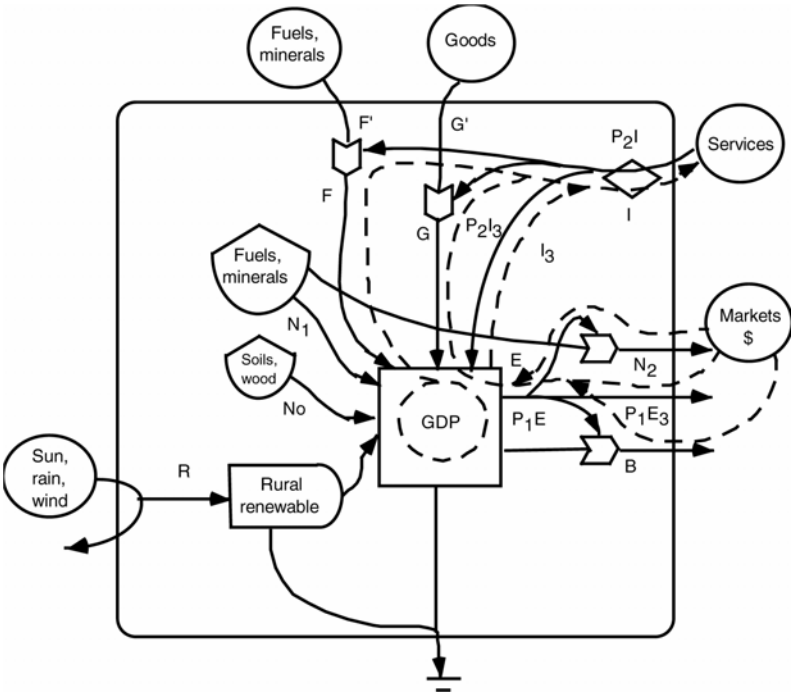
Emergy driving the Argentine economy comes from three main sources (Figure 3): renewable inputs of biospheric emergy (outside sources), imported, non-renewable sources (purchased goods, fuels, services) and indigenous non-renewable energy sources (soils, wood, fuels harvested from within the country). A summary of aggregated flows is presented in Figure 4, including the circulation of money. Using this figure as a guide, the following inputs and exports were evaluated for the time periods described above, using mean data for each time period.

Figure 3 Emergy diagram of Argentina



Renewable inputs (R) include sunlight, wind, waves, tidal influence, rain and geologic contributions of the land. All renewable inputs were evaluated, but only the largest (rainfall chemical potential) was used in the national evaluations and calculation of indices to avoid double counting, following the method of Odum (1996). The contribution of renewable resources was considered to remain constant throughout the century.

Figure 4 Pathways for evaluating the overall emergy use of a nation



Source: Adapted from Odum (1997).

Non-renewable resources that originated within the country's boundaries were comprised of:

1 N_0, rural resources used faster than their regeneration rate (e.g. soils and wood)

2 N_1, the reserves of fuels and minerals and

3 N_2, resources passing through the country economy without appreciable transformation (emergy of these commodities is not considered as an emergy contribution to the national economy).

Imports included flows of energy (F), goods that have emergy in addition to services involved (G) and total imported services (P_2I). In general, the emergy of imported services was estimated using the monetary value and the emergy/money ratio of the country of origin. Exports, comprised of resources (N_2), goods (B) and services (P_1E), were also evaluated. The emergy exported as services (P_1E_3) was estimated using the monetary value of exports and the emergy/money ratio of Argentina for the corresponding period of evaluation.

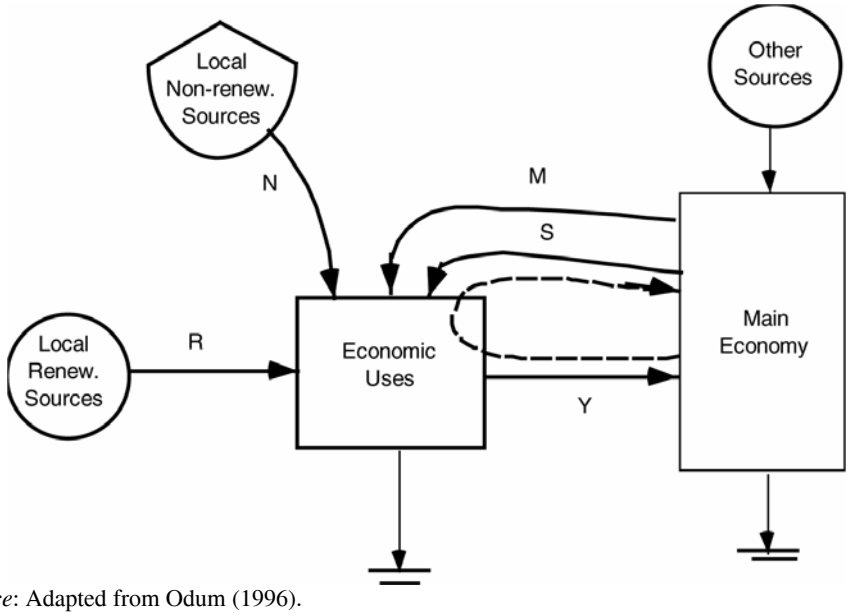
A summary of national parameters based on the main emergy inflows and outflows of Argentina is given in Table 1. Further aggregation of main flows (Figure 5) in indigenous sources ($I = R$ + N), purchased inputs ($F = M + S$), along with the flow of yields (Y), allowed the calculation of the percent of the economy that was derived from renewable sources and other emergy-based sustainability ratios (Table 1). The ratio of emergy in imports to emergy in exports was also calculated as a means of evaluating emergy balance of payments as opposed to monetary balance of payments.

Table 1 Indices and ratios based on emergy analysis

Name of index	*Expression (all expressed in emergy)*
I. National indices	
Total emergy used, U	$N_0 + N_1 + R + F + G + P_2I_3$
Use per unit area	U/area
Use per capita	U/population
Emergy/money ratio (ratio of use to GDP)	F_1 = U/GDP
Fuel use per capita	Fuel/population
Ratio of imports to exports	$(F + G + P_2I_3)/(N_2 + B + P_1I_3)$
II. Emergy-based sustainability ratios	
Percent Renewable (% Renew)	$R/(R + N + M + S)$
Emergy Yield Ratio (EYR)	$Y/(M + S)$
Environmental Loading Ratio (ELR)	$(N + M + S)/R$

Source: Odum (1996) and Brown (1998).

Figure 5 Aggregated diagram of emergy flows, where R: flow of renewable energy, N: non-renewable resource flow, M: purchased goods, S: purchased services, Y: yield



Source: Adapted from Odum (1996).

To evaluate the relative position of Argentina with regard to its international debt, monetary values of debt stocks and services for the period 1980–1996 were converted to solar emergy. The monetary value of total debt stocks was converted to emergy using the emergy/money ratio of the world economy corresponding to each year, following the method of Brown and Ulgiati (1999). The emergy value of Argentina's debt services was calculated using an emergy/money ratio of 2.95×10^{12} sej/USD. This ratio is a weighted

average between the emergy/money ratio of general goods produced in Argentina, the emergy per dollar of agroindustrial products (1.75×10^{12} sej/USD) and the emergy per dollar of crude oil (1.13×10^{13} sej/USD). Exports during the period 1980–1996 varied somewhat but were considered constant as follows (Mercosur, 1998): agroindustrial (65%), energy (10%) and industrial (25%).

4 Results

National emergy indices for the Argentine economy during the 20th century that were derived from the various time period analyses are presented in Table 2 (Ferreyra, 2001). For comparative purposes, the 2000 emergy flows and indices for the USA (Sweeney, 2001) and the 1995 values for the Brazilian economy are also included (Portella, 1997). The total emergy budget of Argentina increased almost 25% throughout the century, but there was a decreasing trend in the ratio of emergy use to the GDP (86%), a consequence of increasing participation of human activities in the emergy flows of the country. Fuel use per person exhibited the most significant increase, growing about 400% as the country developed its oil resources. The emergy use per person decreased approximately 70%, suggesting a continuous trend of lower standards of living in recent periods in emergy terms.

Table 2 Comparison of solar emergy indices of Argentina during the 20th century, including 2000 indices for USA (Sweeney, 2001) and 1995 indices for Brazil (Portella, 1997)

Period	*Total emergy used (10^{23} sej/yr)*	*Emergy/ dollar ratio (10^{12} sej/$)*	*Emergy use per unit area (10^{11} sej/m^2)*	*Emergy use per person (10^{16} sej/p)*	*Fuel use per person (10^{14} sej/p)*
1900–1929	4.0	14.1	1.4	5.1	7.9
1930–1943	3.9	7.3	1.4	2.9	10.0
1944–1975	4.3	3.5	1.6	2.1	22.8
1976–1989	4.8	2.2	1.7	1.7	26.6
1990–1995	4.9	1.9	1.8	1.5	33.2
Brazil	27.4	4.6	3.2	1.8	12.0
USA	108.0	0.9	11.5	4.0	124.0

Emergy-based indices of ecological sustainability for Argentina during the last century are presented in Figure 6. The percent of the Argentine economy that was derived from renewable sources declined from about 67% to about 55% during this century. The Emergy Yield Ratio (EYR), which measures the productivity of the economy per unit of imported emergy, doubled during the century. The Environmental Loading Ratio (ELR), which relates non-renewable emergy use to renewable use and is a relative measure of the load on the environment due to economic activity also doubled. Regarding the evolution of the emergy balance of payments, the country started the century with a positive balance, reaching a ratio of imports to exports of over 2.0 to 1 at mid century (Figure 7). However, the increasing trend changed thereafter, declining to a ratio of almost 0.5 to 1 by the end of the century.

Figure 6 Emergy sustainability indices for the Argentine economy during the 20th century, including 2000 indices for USA (Stachetti and Brown, 2002) and 1995 indices for Brazil (Portella, 1997). EYR: Emergy Yied Ratio, ELR: Emergy Loading Ratio

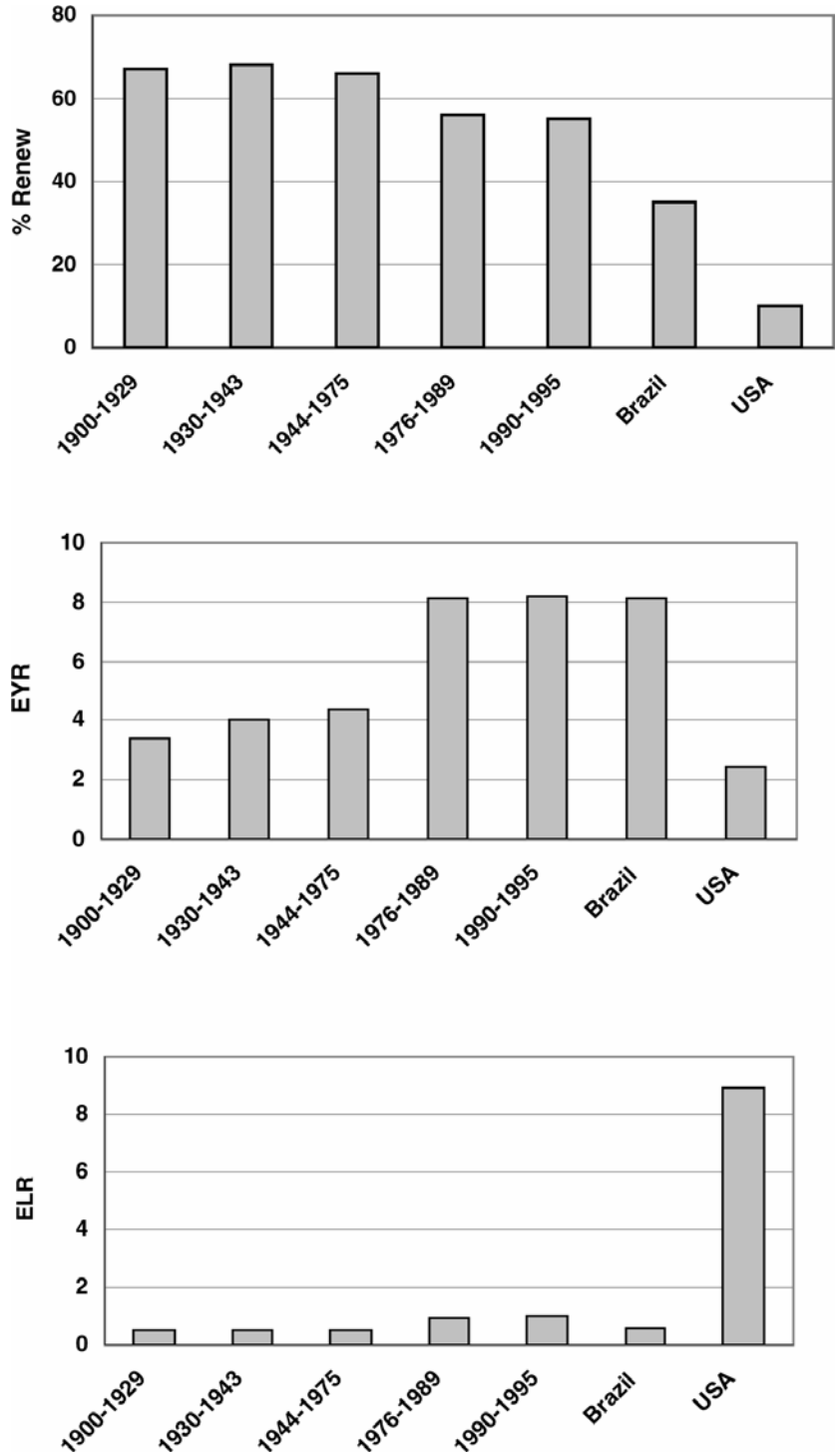


Figure 7 Emergy imports to exports ratio for the Argentine economy during the 20th century, including 2000 indices for USA (Stachetti and Brown, 2002) and 1995 indices for Brazil (Portella, 1997)

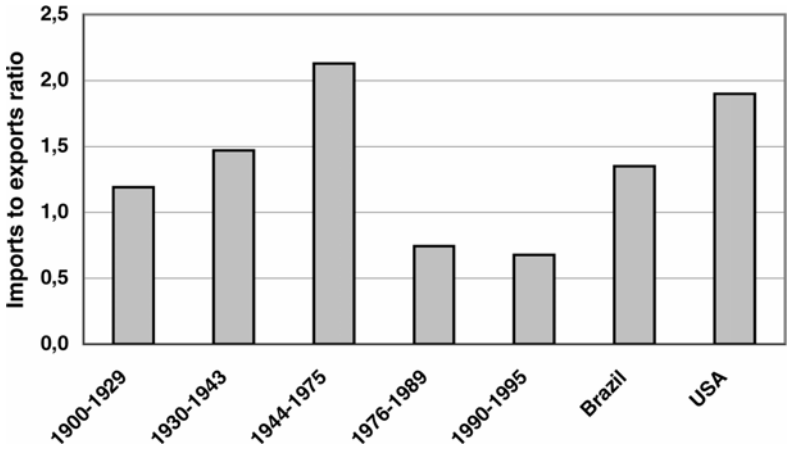
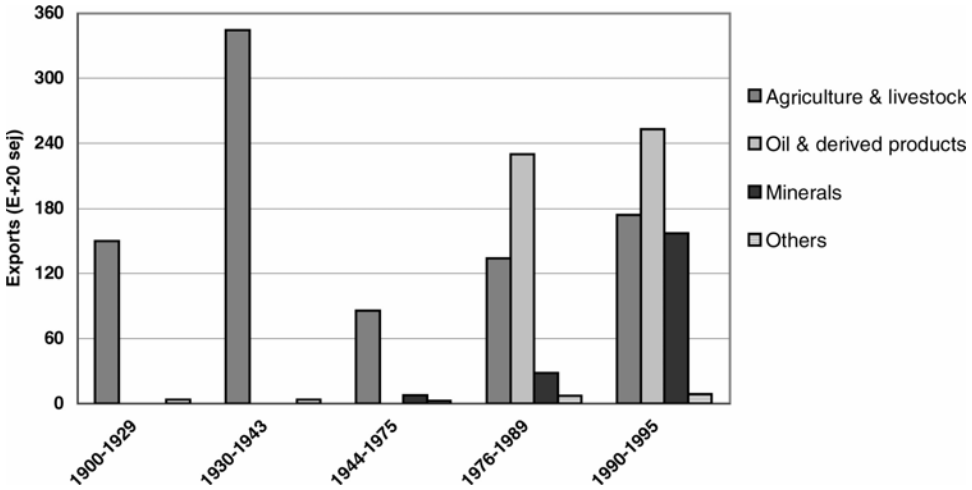


Figure 8 shows the overwhelming dominance of the agricultural sector in the makeup of exports. The emergy in exported agricultural products accounted for nearly 100% of all exports for the first three quarters of the century and has only recently been eclipsed by oil and mineral exports. In 1996, crude oil dominated exports from the energy sector, followed by gasoline, gas oil and liquid gas (Consejo Técnico de Inversiones, 1996). Exported emergy per dollar of crude oil in Argentina was approximately 6.5 times larger than the exported emergy per dollar of soybean during that year. Although the increment in trade after the liberalisation of the economy in 1990 is considered positive for the recovery of the economy, an export strategy based on the exploitation of non-renewable resources should not be evaluated only in economic terms. As was shown in Figure 7, Argentina has had a negative emergy balance of payments (an import to export ration less than one) that has existed for the last 25 years.

Figure 8 Main emergy export flows of Argentina during the 20th century



At the end of the 20th century doubts again were raised regarding the capability of Argentina to pay off its external obligations. According to Janada (1999), "although the ratio of exports that Argentina should use to honour its external debt is not that large, the country is not generating enough foreign currency (or alternatively, it is consuming much more foreign currency than it should)". The emergy analysis of the debt shows, however, the opposite situation. Several indicators of Argentina's external debt are presented in Table 3. Total Debt Stocks and Total Debt Services are given in US dollars and solar emjoules of emergy. The final column in Table 3 is the emergy of Accumulated Total Debt Services, which results from the sum of solar emjoules of annual debt service payments. In emergy terms the country had already paid its total debt stock by 1985, the year when the Accumulated Total Debt Service exceeded the Total Debt Stock. And while Total Debt Stocks have continued to increase since 1985 in both monetary and emergy terms, Accumulated Total Debt Services have increased faster, such that by 1996 the emergy value of Accumulated Total Debt Service represented almost three times the emergy of the Total Debt Stock.

Table 3 External debt of Argentina during the 1980–1996 period

Year	*Total debt stock*		*Total debt service*		*Accumulated TDS*
	10^6 USD	*10^{18} sej*	*10^6 USD[a]*	*10^{18} sej*	*10^{18} sej*
1980	27157	40736	4182	12337	
1983	45920	63370	6805	20075	32412
1984	48857	65468	5197	15331	47743
1985	*50945*	*66229*	*6089*	*17963*	*65705*
1986	52450	67136	7323	21603	87308
1987	58458	74242	6244	18420	105728
1988	58741	74014	5023	14818	120546
1989	65257	81571	4357	12853	133399
1990	62233	77169	6161	18175	151574
1991	65403	81100	5545	16358	167932
1992	68345	83381	5003	14759	182691
1993	70576	83985	6556	19340	202031
1994	77434	89049	6693	19744	221775
1995	83536	91890	9692	28591	250367
1996	93841	100410	14021	41362	291728

Source: European Parliament (1999).

Emergy values of total debt service might be overestimated in this analysis, since Argentina has been using not only higher-emergy export revenues but also lower-emergy external refinancing to repay debt interests and principal. However, the implications of the results still add to the discussion and reflect the need to incorporate environmental considerations in the Argentine external debt issue. As long as external trade is balanced only in economic terms, developing countries will continue the transfer of their natural resources to the developed economies in order to cancel an external debt that has already been paid. EA, which reflects the real value of commodities and raw materials to drive economic productivity, can become a key methodology to achieve environmental justice in international trade.

5 Discussion

5.1 Emergy indicators of sustainability

Evaluation of emergy flows and indices provides insight into the ecological sustainability of Argentina's economy during the 20th century. Total emergy use increased 22% from 1900 to 1995 and therefore emergy per unit area increased a like amount. Fuel use per capita increased 320% rising from 7.9×10^{14} sej/person to 33.2×10^{14} sej/person. More telling is the fact that the ratio of emergy to money decreased 87%, translating into an 87% decrease in emergy buying power of the currency. Likewise, emergy per person decreased over 71%, which means 71% erosion in the standard of living of Argentina's population.

Throughout the century, the proportion of Argentina's economy that was supported by a renewable energy base has decreased from about 67% to about 55%. Contrast this with the USA, which has only about 10% of its economy supported by renewable emergy and Argentina seems to be in a better position. On a global scale, about 33% of the total world economy is driven by non-renewables (Brown and Ulgiati, 1999).

The ELR for Argentina doubled during this century, but in comparison to industrialised economies like the USA it is still relatively low. The ratio is about 1/1, which is reflected by the fact that about 50% of the emergy base of the economy comes from non-renewable sources. ELR is a relative measure of environmental loading and so all we can say is that the load placed on Argentina's environment is about 1/9th that of the USA.

An important aspect of ecological sustainability is the depletion of internal natural resources. Resources that are depleted to build infrastructure and to power the national production contribute to the economy. However, resources that are exported without being upgraded within the economy represent a complete loss. The loss is offset somewhat if currency earned from the export is used to purchase imports. Therefore the ratio of imports to exports (evaluated in emergy) gives the net effect of emergy trade balance on ecological sustainability. Argentina started the century with a positive trend for this ratio, but it has been decreasing since 1976 and presently is about 0.5 to 1.

5.2 Sustainability of international trade

Historically and continuing today, Argentina's economic policies have been dominated by strategies that favoured exports as a way of earning foreign exchange. In the early years of this century agriculture eclipsed all other exports, but beginning in the 1980's the export of oil and oil derived products combined with mineral exports have exceed agricultural exports by a 2 to 1 margin. Economic policies that favour the export of resources in exchange for foreign currency may work against long-term sustainability. Resources drive economies and if more resources are exported than imported, the long-term net effect is a lowering of economic well-being. When evaluated in emergy terms, exports exceeded imports during the last third of the 20th century. The growth in trade deficit, expressed as emergy, beginning in 1976 and ending in 1995 was 68%. In recent years the emergy trade deficit has been about 1.5 to 1. In other words, Argentina exports about 1.5 times as much emergy in resources and agricultural products than it imports in other products. Contrast this with the USA (which exports only half as

much emergy as it imports) and most industrialised economies where their emergy balance of payments is positive to get a better picture why Argentina will never get ahead.

5.3 Emergy evaluation of international debt

There is no question that Argentina's international debt has become a burden. The debt requires that Argentina earn foreign currency in order to make its annual payments. To do so requires that resources are exported and sold and instead of purchasing imports with the earnings, the money is used to pay the debt. Our emergy evaluation of Argentina's debt and accumulated payments showed that the debt was paid in 1985 and the accumulated payments exceeded total debt by a margin of 2.9 to 1 in 1996 (Table 3). In other words, in emergy terms Argentina had paid back 2.9 times its accumulated debt.

Behind trade deficits and crippling external debt is the fact that currency valuing on international markets does not reflect biophysical realities. The emergy currency ratio of developed countries like the USA is around 1.0×10^{12} sej/USD, while for developing economies like Argentina the ratio is more like 3.0×10^{12} sej/USD (and in some cases even higher). What this means is that a US dollar spent in the USA economy buys 1.0×10^{12} sej on the average, while it buys three times that much emergy in Argentina. So with every even dollar trade between a developed economy and Argentina results in a 3/1 loss for Argentina. When money is borrowed from the IMF and used to purchase goods from the global economy and then earned income is used to pay back the loan, Argentina pays three times more than it borrowed.

6 Conclusions

For the century that has just started, Argentina has not only the opportunity but also the responsibility to pursue an economic development scheme that includes the conservation of its vast resource base. As an exporter of emergy rich materials, the country should seek out the recognition of environmental value in international commerce. The unfair terms of trade that are revealed when emergy is used to evaluate the flows of commodities, materials and energy, are at the heart of the external debt issue for Argentina and many developing countries. Changing accounting procedures to reflect the true value of resources and energy, especially as globalisation and world trade increase, should be the base for a realistic strategy towards solving this issue. EA, a methodological tool that attempts to balance society and environment, can offer a timely contribution towards addressing this challenge.

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Note

[1]An opposite view to utility-based systems of value that advances the view that, in biospheric terms, the more energy, time and resources that are 'invested' in something, the greater its value (Brown and Ulgiati, 1999).