Integrated Assessment of the Recent Economic History of Ecuador

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This paper presents an application of the Multiple-Scale Integrated Assessment of Societal Metabolism to the recent economic history of Ecuador. The most relevant phases are: (1) a "single commodity" export oriented economy; (2) an import-substituting industrialization triggered by the oil-boom; (3) the current critical situation. This study centers on the crucial changes that took place in 1970s in relation to the oil boom. Changes are described using economic variables and biophysical variables (both extensive and intensive referring to different hierarchical levels). These two parallel readings are combined at the end in the discussion section.

KEY WORDS: Ecuador; Economic Labor Productivity; Exosomatic Metabolic Rate.

PHASES OF RECENT ECONOMIC HISTORY OF ECUADOR

Like many others less developed countries in Latin America, Ecuador pursued an outward-oriented model of growth (Larrea, 1992, p. 98). This pattern prevailed from the second half of the nineteenth century to the mid-1960s when import-substituting industrialization began to be pursued. A moderate economic diversification and domestic market expansion took place in the following decades.

Three product-related periods can be distinguished in the historical evolution of the external sector (Larrea, 1992). The first of these was the *cacao period* which can be divided into an upswing phase from about

1860 to 1920, a subsequent crisis until World War II, and then a period of senescence in which it became progressively less important. The second period dominated by a single export commodity was the *bananas period* which experienced a boom during 1948–1965, followed by a period of stagnation. The third commodity-driven period was linked to the exploitation of oil resources in the country. The *petroleum period* began with a boom phase from 1972 to 1982, followed in the 1980s by a crisis from which the country has partially recovered in the 1990s.

This study focuses on the changes that took place in the 1970s in relation to the oil boom. The country suddenly had a surplus of energy that was the trigger for the sudden economic growth in the 1970s. However, in order to take advantage of this opportunity, Ecuador had to face a huge demand for investments.

Two important side-effects took place after the oil boom: (1) A debt crisis in 1982 linked to the decline of the import-substituting industrialization and external shocks; (2) a boost in population growth. The combined result of these two side-effects was a period characterized by the recession and impoverishment in the 1980s. After that, at the beginning of the 1990s, the relatively favorable condition of the international financial system and the boom of exports (especially flowers, and tropical fruits) generated an improvement in terms of stabilization and poverty. However, this period of relative prosperity ended with a new depression occasioned by the recent financial crisis (Páez, 2000).

In the following I will discuss possible explanations and links between events described in this section using the framework of integrated assessment of societal metabolism.

LOOKING AT THE HISTORIC PHASES USING AN ECONOMIC VIEW

Country Level—Combining Extensive and Intensive Variables

Changes in GDP Per Year. In 1970 the GDP at market prices (constant 1995 US$) of Ecuador was 5.2×10^9 and it was 19×10^9 (1995 US$) in 1998 (World Bank, 2000). The average growth rate of constant GDP between 1970 and 1998 was 3.9%. This increase reflects changes in an intensive variable, "economic output per person," and an extensive variable, "population size."

Intensive Variable: Economic Output Per Person. The GNP per person was 870 (constant 1995 US$) in 1970, and 1,524 (constant 1995 US$) in 1998. Per capita real GNP has risen at an average rate of 1.2% per year between 1970 and 1998. In spite of this increase, this value of GNP per person is still more than twenty times smaller than in developed countries such in Japan or United States. It is also substantially lower than the Latin America and Caribbean mean, which was 3,883 (constant 1995 US$) in 1998 (World Bank, 2000).

Extensive Variable: Population (THA). The Ecuadorian population doubled between 1970 to 1998, from 6 million inhabitants to 12.2 million inhabitants. The population has risen, over this period, at an average rate of 2.6% per year.

Combining the Effect of Intensive and Extensive Variables. Figure 1 indicates, between 1970 and 1998, the rate of growth of population (2.6% per year) has been more than double the rate of growth of economic output per person (1.2% per year). The phases described in the narrative are indicated in Figure 1. They are: (1) the pre-oil boom, before 1972; (2) the oil-related boom, between 1972 and 1982; and (3) the crisis following the oil-boom, after 1982.
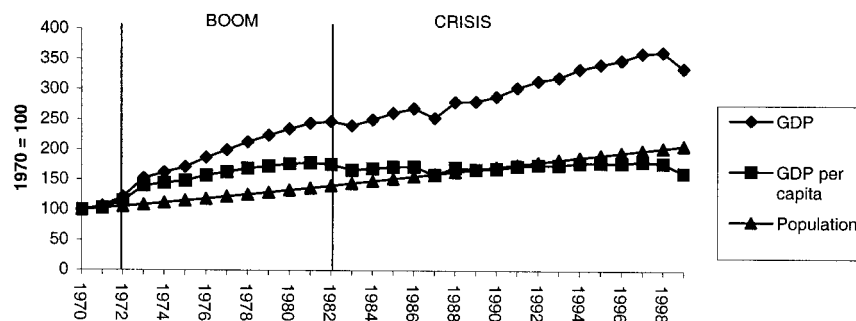

FIGURE 1. Index of components of economic growth: GDP, GDP per capita and population.

Sources: Banco Central del Ecuador (1996, 2000), SIISE (1999).

POPULATION AND ENVIRONMENT

Changes in Economic Labor Productivity per year (ELP$_{AS}$). The Economic Labor Productivity—defined as the average value for a society (ELP$_{AS}$)—is the value of a country's final output of goods and services in a year, assessed in terms of overall added value, divided by the work hours delivered by its economically active population (EAP). ELP$_{AS}$ assesses the average productivity of a country's workers, reflecting the availability of capital, technology, natural resources, and "know how."

To calculate values of ELP$_{AS}$ one has to have data on GDP (presented in the previous section) and data on labor supply. Labor supply is proportional to: (1) size of the Economically Active Population (EAP = able-bodied people in their working years); (2) unemployment; and (3) yearly work load of the labor force.

The Ecuadorian labor force has increased from 1.9 million adults in 1970 to 4.6 million in 1998 (World Bank, 2000), an average growth rate of 3.2% per year during this period. The unemployment rate was 11.5% of total EAP in 1998, and 6.1% in 1990. Data on unemployment are not available between 1970 and 1986, so I use a flat rate of 5% in that years. The "work load per year" was calculated using a flat value of 1,800 hours/year per worker for all economic sectors. (For a discussion of this assumption see the first paper of Giampietro and Mayumi, this issue.)

TABLE 1

Changes in the Work Supply

	1970	1980	1990	1998
Total Population. 10^6	6.0	8.0	10.3	12.2
Labor force. total. 10^6	1.9	2.5	3.6	4.6
Labor force in agriculture. 10^6	1.0	1.0	1.2	1.3
Unemployment total (% total labor force)	5%	5%	6.1%	11.5%
Labor force employed	1.8	2.4	3.4	4.1
Human Time Allocation				
Total Human Time. 10^9 Hours	52.5	69.7	89.9	106.7
Supply of working time. 10^9 Hours	3.3	4.4	6.1	7.4
Non working time. 10^9 Hours	49.2	65.4	83.8	99.3
Supply of working time (%)	6%	6%	7%	7%
Non working time (%)	94%	94%	93%	93%

Notes: The annual series of labor force of non-agriculture sectors for 1991 and 1998 have been obtained by extrapolating the past trends. For the rest of assumptions, please see the text.
Sources: Instituto Nacional de Estad,sticas y Censos (INEC), Ministerio de Trabajo e Instituto Nacional de Empleo (INEM), World Bank/IBRD 2000.

The resulting changes in ELP_{AS} can be described as follows: In 1970 ELP_{AS} was 1.6 (constant 1995) US$/hour, rising in 1980, to 2.8 (constant 1995) US$/hour, then lowering in 1998, to 2.6 (constant 1995) US$/hour. That is, Ecuador experienced an annual average growth rate of ELP_{AS} (assessed in constant 1995 US$), which is positive over the whole period 1970 and 1998 (+0.9%). However, this positive trend reflects the robust economic expansion of the 1970s. When analyzed over the last 18 years, ELP_{AS} shows a negative trend reflecting the economic crisis.

Sector Level—Combining Extensive and Intensive Variables

HH Sector: Changes in Household Typologies Data from the national census indicate a process of rapid urbanization since the 1970s. Urban population was 40% of total population in 1970. It increased from 47% of the total population in 1980 to 63% in 1998 (World Bank, 2000). The annual growth rate of the urban population was 4.4% during the intercensal period 1974–1982, and 3.1% during the intercensal period 1982–1990 (SIISE, Version 1.0, 1999). In both periods, it was superior to the annual growth rate of population of the country indicating a clear trend of rural exodus. The growth of Guayaquil, the most crowded city of Ecuador, in 1970–1980 was 4.6%, higher than Sao Paulo (4.4%), and Mexico City (4.2%) (ECLAC, 1999).

Turning now to the age structure of households, in 1990 the countryside's fecundity rate (expected number of children) was 5.4, much higher than the fecundity rate of the urban population (3.2). However, urban births rate (number of births by 1000 habitants), due to the migratory flow, was 29/1000, a value higher than the birth rate of the rural population (24/1000). In 1990 urban life expectancy was 69 years, higher than the life expectancy of rural population (64 years) (SIISE, Version 1.0, 1999).

Sectors Producing "Added Value": Changes in PS and SG

Changes in GDP by Sector. Table 2 shows that the relative importance of the industrial sector has steadily risen at the expense of agriculture. In 1970, the agricultural sector was 25% of GDP in real terms (sucres of 1975). This dropped to 17% in 1998 (Banco Central del Ecuador, 2000). The service sector also decreased in relative importance over the past 28 years, from 49% to 45%. The industrial sector, on the other hand, has increased sharply. In 1970, the participation of industrial sector in the GDP was 21%, rising at 33% in 1998.

Table 3 shows that the per capita output of the manufacturing, con-

TABLE 2

Structure of the GDP by Economic Sector 1 as % of Total GDP (constant 1975 sucres)

Sector/Year	1970	1980	1990	1998
Agriculture, livestock and fishing	25.0%	14.4%	17.7%	17.3%
Industrial	20.5%	33.8%	31.7%	33.0%
Services	49.1%	47.1%	46.7%	44.9%
Others elements of GDP	5.4%	4.8%	3.9%	4.9%
Total GDP 10^6 constant 1975 sucres	62.912	147.622	181.531	227.678

Source: Banco Central del Ecuador. SIISE. Version 1.0 (1999).
[1]To define economic sectors, I use the Industrial International Classification Uniform of United Nations. According to this classification, the economy has three main sectors: (1) Agriculture, livestock and fishing sector; (2) Industrial sector (oil and mining, manufacturing, electricity, gas, water and construction); (3) Services sector.

TABLE 3

Output Per Capita by Economic Sectors and by Periods: 1970–1998 Annual Growth Rates

Sector/Periods	1970–1980	1980–1990	1990–1998	1970–1998
Total agriculture (1)	−0.1%	1.8%	0.4%	0.9%
Domestic agriculture (2)	−0.9%	1.3%	0.5%	0.4%
Export agriculture (3)	1.6%	2.8%	0.3%	1.9%
Manufacturing	7.1%	−2.6%	0.9%	1.0%
Construction	2.7%	−4.7%	−1.2%	−2.5%
Commercial & Transport	6.3%	−0.5%	1.1%	1.8%
Services	5.5%	−1.1%	−0.3%	1.0%
GDP	5.9%	−0.6%	0.7%	1.4%

Notes: The annual growth rates were calculated using exponential regressions. Per capita sector output is the monetary value of a country's final output of goods and services in a year (real sucres of 1975), divided by the population.
(1) Includes agriculture, livestock, fishing, logging and hunting.
(2) Includes inward oriented agriculture and livestock only.
(3) Includes banana, coffee, cacao, fishing, logging and hunting.
Source: Banco Central del Ecuador.

struction and services sectors had a robust growth during the oil boom. On the other hand, per capita domestic agricultural output remained stagnant. During the crisis, export agriculture grew at a relatively high rate (2.8% per year). After that, between 1990 and 1998, the annual growth rates of the output per capita of almost all economic sectors were low or negative.

Extensive Variable: Changes in Work Supply over Economic Sectors. The profile of allocation of EAP over different economic sectors has changed considerably between 1970 and 1990. Data on the relative importance of agriculture in the total EAP show a steadily decline since the 1970s. In 1970, agriculture was 50.6% of total EAP while providing only 25% of the GDP. This dropped to 38.6% of total EAP in 1980 and to 32.7% in 1990 (ECLAC, 1999). Again this 32.7% of the work force generate only 17% of the GDP. On the contrary, the services sector, as percentage of total EAP, increased from 28.9% to 48.3% between 1970 and 1990. The participation of the industrial sector in the total EAP was almost the same: 20.5% in 1970 and 19% in 1990. However, this 19% of the work supply generated, in 1990, 32% of the GDP.

Intensive Variable: Changes by Sector in Economic Labor Productivity. Figure 2 shows that ELP sector growth has been negative in non-agriculture sectors and positive in the agriculture sector between 1970 and 1998. Agriculture productivity increased at 2.4% per year between 1970 and 1998. However, this can be easily explained by its very low initial value. Actually, ELP of agriculture remained well below the values of ELP reached by the other economic sectors — around 1 constant 1995 US$ in 1998 . As expected, the ELP of the industrial sector is the highest. However, as will be discussed later on, this is the sector which requires also the highest level of capitalization per worker.

TABLE 4

Structure of the EAP by Economic Sector as % of Total EAP

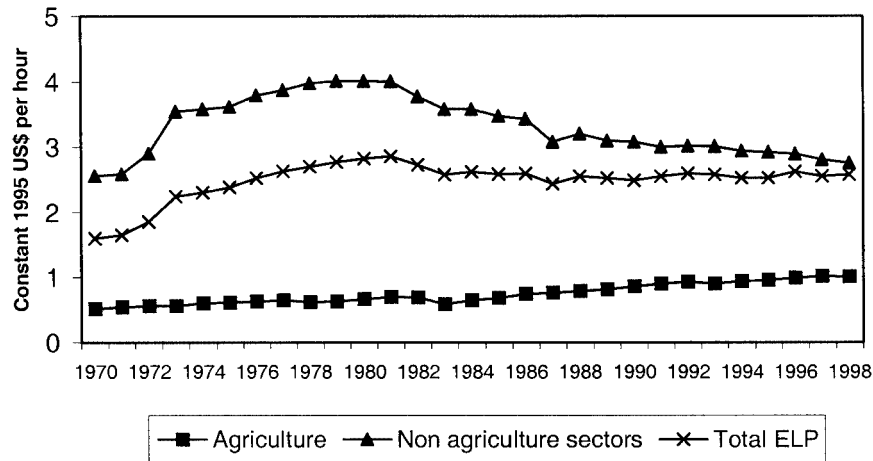| Sector/Year	Agriculture	Industry	Services	Total
1970	50.6	20.5	28.9	100
1980	38.6	19.8	41.6	100
1990	32.7	19.0	48.3	100

Source: ECLAC. 1999.

FIGURE 2. Economic Labor Productivity by sectors.

(*A) Assuming a work load of 1,800 hours.
Sources: Banco Central del Ecuador (1996, 2000), INE, Censos de Población (1974, 1982 and 1990), World Bank/IBRD 2000.

LOOKING AT THE HISTORIC PHASES USING THE BIOPHYSICAL VIEW

Country Level—Combining Extensive and Intensive Variables

    Changes in Exosomatic Energy Consumption per Year. Total exosomatic energy consumption (or Total Exosomatic Throughput) in 1970 was

TABLE 5

Economic Labour Productivity by Sectors in Constant 1995 US$ per Hour

Year/Sector	Agriculture Sector	Non Agriculture Sectors	Total
1970	0.5	2.6	1.6
1980	0.7	4.0	2.8
1990	0.9	3.1	2.5
1998	1.0	2.8	2.6

Sources: Banco Central del Ecuador, Ministerio de Trabajo and Instituto Nacional de Empleo (INEM), World Bank/IBRD 2000.

88 PJ (1 PetaJoule = 10^{15} Joules). In 1998 this rose to 274 PJ. Energy consumption grew substantially over most of the 1970s, but then it declined over the 1980s, reflecting the economic crisis. In the 1990s, on the other hand, energy consumption has grown again rapidly and consistently. Over the period 1970 to 1998, energy consumption has grown an average rate of 4.1% per year.

Extensive Variable: Population (THA). Population growth data are the same as described previously in the economic view. The relevant figure here is that population increased at an average rate of 2.6% per year from 1970 to 1998.

Intensive Variable: Exosomatic Energy Consumption Per Capita. Ecuador's exosomatic energy use was 22.5 GJ per head in 1998, compared with 14.8 GJ per person in 1970 (OLADE-SIEE, 1999). Even though total energy use has increased greatly in Ecuador, rapid population increases have kept per capita energy use very low compared with that in the developed world (in the order of hundreds GJ per capita).

Combining the Effect of Intensive and Extensive Variables. Figure 3 indicates that between 1970 and 1998 the rate of population growth (2.6% per year) has been greater than the rate of growth of energy consumption per capita (1.5% per year). The phases described in the narrative are indicated in Figure 3. They are: (1) pre-oil boom, before 1972; (2) oil-
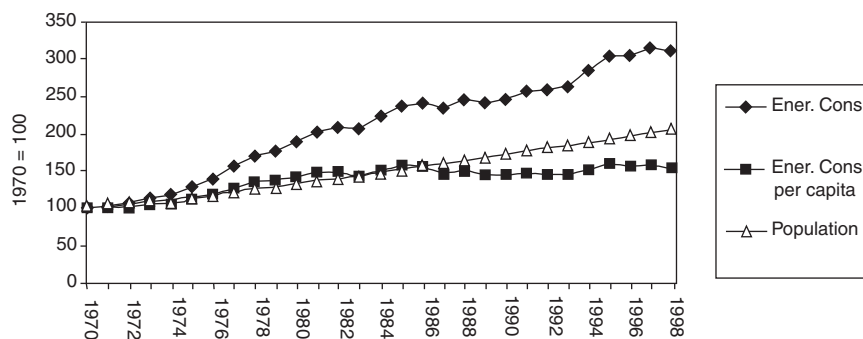

FIGURE 3. Index of components of energy consumption growth TET, TET per capita, and population.

Sourced: OLADE-SIEE, (1999).

related boom, between 1972 and 1982; and (3) crisis following the oil-boom, after 1982.

Sector Level—Combining Extensive and Intensive Variables

Sectors Producing "Added Value": Changes in productive sectors (PS) and services and government (SG). The profile of investments of exosomatic energy in the various sectors is given in Table 6. Transportation consumed 40% of all exosomatic energy in 1998, compared with 26% in 1970. The energy consumption of residential sector (households) has decreased from 56% in 1970 to 27% in 1998. Industry consumed 20% of all energy in 1998, contrasted with 14% in 1970. Energy consumption in construction has increased from 0.3% to 3.7% in the same period. The 5.4% of the total energy consumption was consumed by the agriculture, fishing and mining sector in 1998, compared with 4% in 1970. Unfortunately OLADE's data do not provide more disaggregation of the data on energy consumption. However, the *Energy Balance of Ecuador* published by the Energy Ministry tabulates the energy consumption of agriculture and the fishing sector separately. According to this source, in 1998 60% of the total energy consumption (14.6 PJ) went to fishing and 40% was from agriculture.

Extensive Variable: Exosomatic Energy Throughput (ET_{PS} and ET_{SG}) by Sector. Consumption of commercial fossil energy by agriculture, fishing and mining increased from 3.6 PJ (10^{15} joules) in 1970 to 14.6 PJ in

TABLE 6

Structure of the Energy Consumption by Sector and Energy Consumption Per Capita as % of Total Consumption and GJ per Person

Year/Sector	Agriculture Fishing, Mining	Industrial	Services	Households	Consumption p.c. GJ per person
1970	4.0%	14.5%	25.6%	55.9%	14.8
1980	3.3%	26.8%	40.1%	29.8%	21.1
1990	4.5%	21.4%	46.2%	28.0%	21.1
1998	5.4%	20.0%	47.1%	27.4%	22.6

Source: OLADE-SIEE, 1999.

1998 (OLADE-SIEE, 1999). In relative terms, the consumption of commercial fossil energy in this sector has increased from 0.6 GJ (10^9 joules) per worker in 1970 to 1.2 GJ per worker in 1998.

Reflecting the trends found when analyzing economic performance, the manufacturing, construction and service sectors had strong growth during the oil boom. The commercial sector had a robust growth in the 1980s (9.1% per year), while the construction sector decreased (by 4.2% per year). With the exception of construction, energy consumption of all the sectors grew in the 1990s. Regarding agriculture, from 1970 to 1980, energy consumption grew at an average rate of 5.3% per year. Annual energy consumption growth was 6.2% between 1980 and 1990, despite the economic recession of these years. The growth in energy consumption of the agricultural sector increased again between 1990 and 1998 at an average rate of 5.8% per year.

Intensive Variable: Sectorial Exosomatic Metabolic Rate. The Exosomatic Metabolic Rate of Paid Work (EMR_{PW}) has increased from 27 MJ hr^{-1} in 1970 to 37 MJ hr^{-1} in 1998. Exosomatic Metabolic Rate (EMR) is the energy of a country's final consumption, in a year, referring to the activities included in a given sector, divided by the hours of human activity spent, in the same year, in the same sector. When dealing with Paid Work the exosomatic final consumption of this sector has to be divided by the labor force, discounting unemployment. To arrive to an assessment per hour I assume a flat value of 1,800 hours/year per worker.

Ecuador had a positive annual average growth rate of EMR_{PW} over the whole period 1970 and 1998 [+ 1%]. Again, this upward trend reflects the robust economic expansion of the 1970s. However, between 1970 and 1998, EMR grew positively in agriculture and negatively in non-agricultural sectors. The values taken by EMR_i in the set of considered sectors is given in Table 7. The change of the various EMR_i over the period is shown in Fig. 4.

In particular, we can observe the following tendencies:
• EMR_{AG} (energy consumption of the agriculture sector per hour) increased at 4.8% per year between 1970 and 1980. This corroborates the fact that agriculture experienced a process of capitalization over the 1970s. The average growth rate of EMR_{AG} over the decade of the 1980s and the 1990s was 4.4% and 5.2%, respectively.
• EMR in non-agricultural sectors increased at 2% per year in the 1970s. As indicated above, the economy went into a recession in 1982,

TABLE 7

Exosomatic Metabolic Rate by Sectors MJ per Hour

Year/Sector	Agriculture Sector	Non Agriculture Sectors	Total
1970	2.0	50.0	27.1
1980	3.0	58.7	38.5
1990	4.4	48.0	35.7
1998	6.4	42.8	37.2

Sources: Ministerio de Trabajo and Instituto Nacional de Empleo (INEM), OLADE-SIEE (1999), World Bank/IBRD 2000.

and the EMR in non-agricultural sectors experienced a negative annual growth throughout the 1980s of −2.1%. During the 1990s the same tendency was apparent (−0.9% annual growth rate).

In spite of these contrasting trends, the absolute value of EMR_{PS} (manufacturing and construction) always remained much higher than EMR_{AG}.
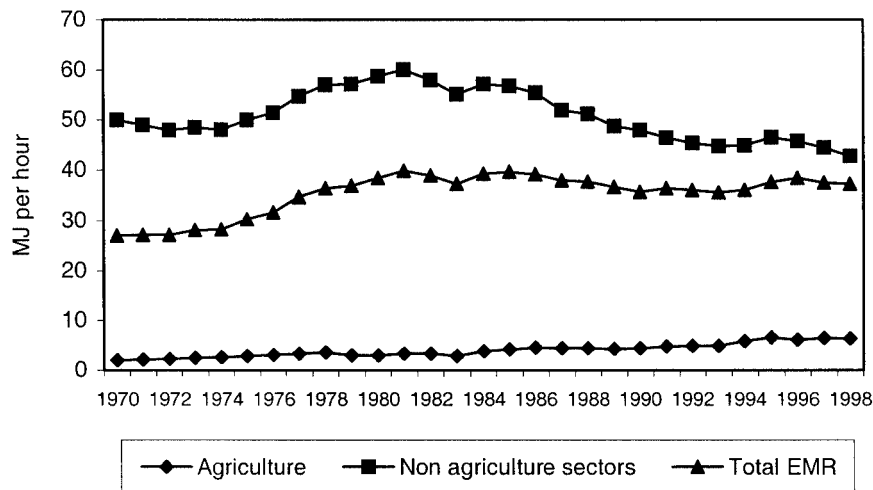

FIGURE 4. Exosomatic Metabolic Rate by sectors.

Sources: INFC, Censos de Población (1974, 1982 and 1990), OLADE-SIEE (1999).

Household (HH) Sector

Changes in Household Typologies. Over the past three decades, the sources of the energy consumed in the household sector have changed dramatically. The percentage of energy provided by gas increased from 1% of all energy consumed in 1970 to 37% in 1997. On the other hand, the energy provided by firewood decreased from 85% in 1970 to 47% in 1997. (Some housing units use either firewood or kerosene; other use both.) The percentage of energy provided by electricity increased from 4% to 13%. Finally, the percentage of energy provided by other fuels (gasoline and kerosene) decreased from 10% to 3% over the same period. As discussed below, these differences can be related to gradients in income and/or geographic location.

Extensive Variable: Sectorial Exosomatic Energy Throughput (ET_{HH}). The total amount of energy consumed by households in 1998 was 73.7 PJ, rising from 49 PJ in 1970. Over this 28-year period, the total annual consumption first increased by 0.4% percent over the 1970–1980 period, then increased by 1.5% over the 1980–1990 period, and finally increased by 3.1% over the 1990–1998 period.

Intensive Variable: Exosomatic Metabolic Rate (EMR_{HH}). However, when considering intensive variables, we get a totally different picture of the trend of energy consumption in the HH sector. Per capita residential consumption was 6.1 GJ in 1998, compared with 8.2 GJ per capita in 1970. EMR_{HH} (energy consumption of households per hour of non-working population) decreased by 1% per year since 1970. In 1970 EMR_{HH} averaged 1 MJ hr^{-1}, but this value declined to an average value of 0.74 MJ hr^{-1} in 1998.

Combining Extensive and Intensive Variables. As indicated in Figure 5, this de-capitalization of the Household Sector was the result of the lower rate of expansion of the flow of exosomatic energy consumed by households (rate of growth ET_{HH}) in relation to the rate of increase of Human Activity invested in the non-working compartment (the rate of growth of HA_{HH}). The values of these parameters over the considered period are shown in Table 8. I will elaborate further in the final section of this paper on the implications of these data.
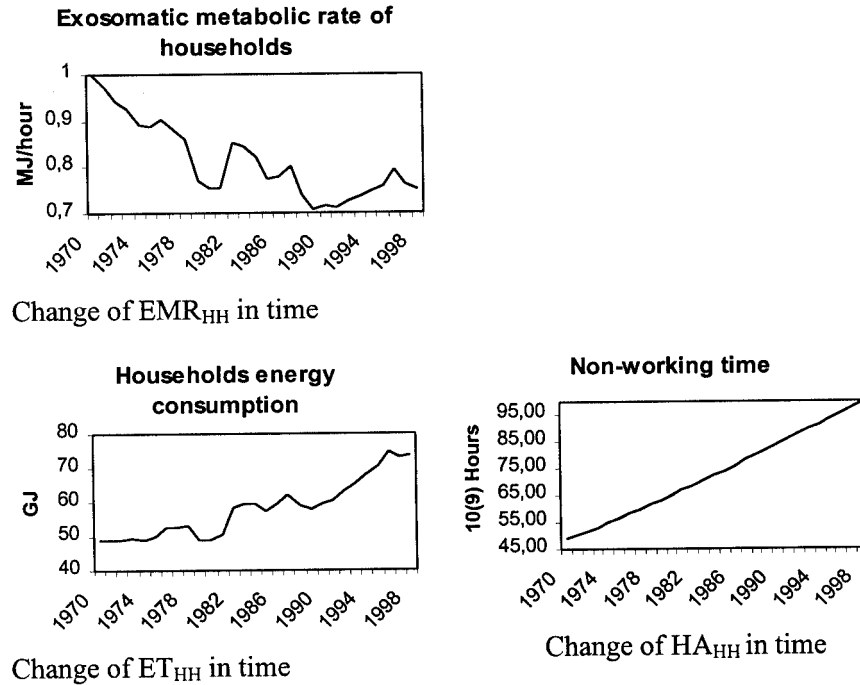
Exosomatic metabolic rate of households

Change of EMR_{HH} in time

Households energy consumption

Change of ET_{HH} in time

Non-working time

Change of HA_{HH} in time

FIGURE 5. Extensive and intensive variables describing changes in the HH sector.

TABLE 8

Annual Growth Rates of EMR_{HH}, ET_{HH}, and HA_{HH} by Periods

Periods	EMR_{HH}	ET_{HH}	HA Non-working	HA working
1970–1980	−2.5%	0.4%	2.9%	2.9%
1980–1990	−1.1%	1.5%	2.5%	2.6%
1990–1998	1.0%	3.1%	2.1%	2.6%
1970–1998	−1.0%	1.5%	2.5%	2.8%

Source: OLADE-SIEE (1999). World Bank/IBRD (2000).

FANDER FALCONÍ-BENÍTEZ

LOOKING AT THE HISTORIC PHASES USING AN INTEGRATED DESCRIPTION

At the Country Level—The Link Between Capitalization of Paid Work and Economic Labor Productivity: The Negative Spiral Leading to the Crisis

Previous energetic analyses of the economic process (Cleveland et al., 1984; Hall et al., 1986; Gever et al., 1991; Kaufman, 1992) have indicated a clear link between the following: (1) the amount of exosomatic energy used in economic activities per hour of work (termed here the level of capitalization of the compartment in which human activity takes place, see Giampietro and Mayumi—second paper of this issue); (2) the amount of added value generated by economic activities per each hour of work (called here economic labor productivity). According to this hypothesis, if we graph changes of ELP and EMR over the same compartment (e.g., within PW) during the same time window, we should find curves that look very similar. This is what was found by Cleveland et al. (1984) in a seminal paper analyzing the USA and confirmed by successive studies of the US economy (see list of references provided above).

The relation between the index of ELP_{AS} (1970 = 100) and the index of EMR_{PW} for Ecuador over the considered period is shown in Fig. 6. The figure confirms the link suggested by previous authors. The curves of ELP and EMR for the PW sector of Ecuador look very similar. Ramos-Martin (this issue) in his historical analysis of Spain obtains the same result.

What are the implications of the link between EMR_{PW} and ELP_{PW}? In a country such as Ecuador this implies that in order to have economic growth, the value taken by the parameter ET_{PW} has to grow faster than the value taken by the parameter HA_{PW}.

Put another way, the condition for economic growth can be expressed as:

$$d(ET_{PW})/dt > dt \qquad\qquad \text{Relation 1}$$

However, as anticipated in Section 2, in the case of Ecuador two facts prevented that this condition was matched:

A. The Burden of Debt Servicing Since the 80s. The debt crisis exploded in 1982 when the economy suffered a series of adverse shocks, worsened by periods of declining world oil prices. This was particularly damaging due to the heavy dependence on the export of oil to its economy. Today Ecuador still has one of the largest per capita external debt levels in
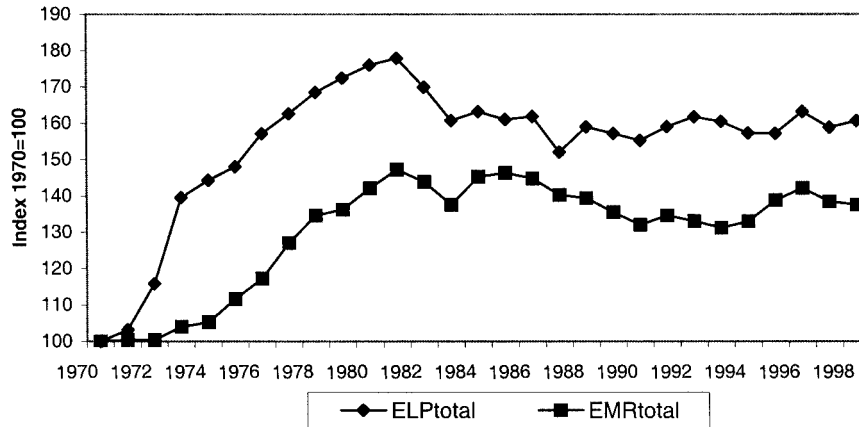
FIGURE 6. Index of ELP_{PW} and EMR_{PW}.

Latin America. At the end of 1999 its debt stood at $13.8 billion (100 per-cent of GDP) (Banco Central, 2000). Figure 7 shows two self-explanatory indicators: (a) debt service (as % of GDP) and (b) debt service per capita.

The cost of "buying capital" in the 1970s to take advantage of the opportunity given by oil (to be able to increase the levels of EMR) translated into the existence of a large debt in the 1980s. This in turn prevented (and it is still preventing) Ecuador from using its disposable added value to further capitalize its economic sectors. The flow of disposable added value is used for servicing the debt rather than for keeping $d(ET_{PW})/dt$ high. In this way the sectors providing well paid jobs, which are the ones requiring also the highest level of capitalization, are the most affected by the crunch. (Recall here the negative annual growth of EMR_{PS} in the 1980 discussed before).
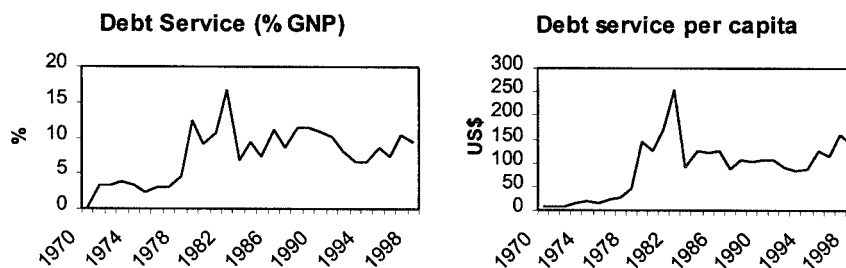

FIGURE 7. Parameters characterizing debt servicing.

B. The Baby-Boom of the 1970s Implied the Arrival of the First Youngsters into the Work Force in the Mid-1980s. The rapid population growth triggered by the oil boom in the 1970s implied a growth in $d(HA_{PW})/dt$ in the 1980s which would have required the creation of a adequate number of job opportunities. As noted earlier, this would have required a massive capitalization of ET_{PW}. However, due to the shortage of capital to expand job opportunities in the PS sector and the location of the households that experienced the largest demographic growth (largely resident in rural areas), it was unavoidable that the vast majority of this new work force entered the agricultural sector. However, the agricultural sector had the lowest level of economic labor productivity of any economic sector. The already difficult process of urbanization (requiring the fast building of infrastructures for which capital is not available) does not indicate an easy way out of present situation, at least in the short term.

At the Household Sector Level: The Implications for Standards of Living and Equity

When reading the effects of the crisis experienced in the last years from the perspective of the households we can characterize the situation in two main points:

• *Job opportunities:* The majority of the households have only two options: either to accept to work on jobs providing a very low income (at the time just providing bare subsistence) or remaining unemployed while looking for better opportunities (migrating to the cities).

• *Inequity and poverty:* There is rising inequality due to the fact that the generation of surplus has been insufficient to result in economic growth, in terms of average values, at the country level and by other structural reasons. Economic growth is occurring only in special spots related to social and geographic niches.

In the rest of this section, I will illustrate how the general indicators used to describe changes in the economic performance of Ecuador can be related to the social dimension. To do that, it is necessary to use descriptive tools related to the perspective of the household.

How the 1995 Crisis Boosted Social Stress. In 1995 Ecuador there was a great deal of inequality in the distribution of land. An indicator of inequality is the Gini Coefficient of land distribution. (This indicator, which varies between 0 and 1, is a statistical measure of the inequality in the access for households to this productive resource. The higher the inequality, the more the index approximates to 1. The index corresponds to 0 in

TABLE 9

Land Distribution, 1995, Gini Coefficient

Geographical Regions	Gini Coefficient
Coast	0.872
Andes	0.907
Amazon	0.586
Ecuador	0.885

Source: SIISE (Survey of Life Conditions 1995), Version 1.0, 1999.

the hypothetical case of a totally fair distribution.) In 1995 The Gini Coefficient of the distribution of land in Ecuador was 0.89—a remarkable high value for this index. Results shown in Table 9 indicate that among the three eco-regions of Ecuador (Coast, Andes and Amazon), the Andes have the highest inequality in the distribution of land.

Similarly, the richest 20% of households control 91% of the available land, while the poorest 20% of households had less than 1% of the available land (Survey of Life Conditions for 1995; SIISE, Version 1.0, 1999). These data are shown in Table 10.

The number of people living in poverty, expressed as a percentage of total population, is higher in the countryside than in the city. In the Andes countryside 78% of total population was living in poverty in 1995 (SIISE, Version 1.0, 1999). These data are shown in Table 11.

The pattern of energy consumption at the household level can be used to investigate the differences between household typologies in relation to

TABLE 10

Distribution of Land by Quintile, 1995

Quintile of Population	% of Total Land
Quintile 1 (poorest)	0.1
Quintile 2	1
Quintile 3	2
Quintile 4	6
Quintile 5 (richest)	91

Source: SIISE (Survey of Life Conditions 1995), Version 1.0, 1999.

TABLE 11

Poverty Impact, 1995

Geographical Region	%	Poor People	Total Population
Coast	54%	3,135,575	5,811,569
City	43%	1,600,483	3,763,253
Countryside	75%	1,535,092	2,048,316
Andes	58%	2,636,698	4,552,613
City	42%	1,068,566	2,532,726
Countryside	78%	1,568,132	2,019,887
Amazon	65%	251,783	384,568
City	47%	34,537	73,238
Countryside	70%	217,246	311,330
Total	56%	6,024,056	10,748,750

Source: SIISE (Survey of Life Conditions 1995), Version 1.0, 1999.

differences in income and geographic location. As indicated in Table 12, household consumption of fuels changes according the distribution of income. In 1995, firewood was used by 30.4% of poorest households, while only 4.3% of the richest households used firewood. In the same year, 68% and 77.3% of poorest households consumed gas and electricity, respectively while 91.3% and 96.2% of the richest households consumed gas and electricity, respectively.

TABLE 12

Percentage of Households that Consume Electricity, Gas, or Firewood by Quintile of Population, 1995

Quintile of Population	Electricity	Gas	Firewood
Quintile 1 (poorest)	77.31%	68.04%	30.38%
Quintile 2	89.50%	81.28%	16.81%
Quintile 3	90.99%	89.96%	9.06%
Quintile 4	95.82%	94.10%	4.62%
Quintile 5 (richest)	96.19%	91.32%	4.33%
Country average	89.96%	84.94%	13.04%

Sources: SIISE (Survey of Life Conditions 1995), INEC and World Bank.

Differences in energy consumption in relation to income can also be analyzed over quintile of population. The poorest quintile of households consumed 61.3 Kilowatt-hour (Kwh) per month in 1995, compared with 221 Kwh of the richest quintile. Gas consumption per household of the richest quintile was 1.29 cylinder per month in 1995. (Each cylinder has 15 kilograms of gas.) On the other hand, the poorest quintile of households consumed only 1.05 cylinder per month in 1995. These data are presented in Table 13.

Looking at economic expenditures of candles, electricity and fuel gas as a percentage of the total expenditure of households, poor households allocated a great proportion of their expenditure to energy and fuels compared to non-poor persons. These data are presented inTable 14.

CONCLUSIONS

In this paper I presented an application of a Multiple-Scale Integrated Assessment of Societal Metabolism to the analysis of recent economic history of Ecuador. This was done with the goal of providing a complementary analysis to be used in addition to other analytical tools already available (historical analysis, social analysis, institutional analysis, classic economic analysis etc.).

The major advantage of this integrated method of analysis is not that of providing totally "new" or "original" explanations of events. Rather it

TABLE 13

Electricity Consumption and Number of Gas Cylinder by Quintile of Population, 1995

Quintile of Population	Kilowatt-Hour per Month in 1995	Number of Gas Cylinder
Quintile 1 (poorest)	61.33	1.05
Quintile 2	85.31	1.18
Quintile 3	118.06	1.30
Quintile 4	145.26	1.38
Quintile 5 (richest)	221.33	1.29
Country average	126.26	1.24

Source: SIISE (Survey of Life Conditions 1995), INEC and The World Bank.

TABLE 14

Energy and Fuel Expenditures According to Social Conditions by Region and Residence Area as % of Total Households Expenditure, 1995

Region	Area	Poor levels			
		Indigents %	Poor Persons %	Non-poor Persons %	Total %
Country	Countryside	2.09	1.44	1.16	1.47
	City	2.85	1.96	1.65	1.80
	Total	2.32	1.71	1.54	1.68
Coast	Countryside	2.30	1.55	1.39	1.61
	City	2.27	1.98	1.70	1.81
	Total	2.29	1.79	1.64	1.74
Andes	Countryside	1.99	1.34	0.94	1.37
	City	3.21	1.94	1.60	1.80
	Total	2.37	1.63	1.44	1.63
Amazon	Countryside	1.72	1.25	0.93	1.17
	City	2.91	1.92	1.36	1.64
	Total	1.89	1.36	1.06	1.27

Source: SIISE (Survey of Life Conditions 1995), INEC and The World Bank.

makes possible the integration of the various insights provided by different disciplines, making possible synergism among them.

In relation to the recent economic history of Ecuador this integrated analysis pointed at a set of quite obvious facts (when considered one at the time):

(1) The possibility of increasing EMR_{PW} and therefore ELP_{PW} in time—a condition required to be able to increase the EMR_{HH}—is linked to the feasibility of investing in these sectors. That is, the capitalization of the various compartments of the socio-economic system—either in production or in consumption—requires previous investments in the sectors generating added value.

(2) In the case of Ecuador, economic surpluses generated by economic growth were mainly used to either: (a) increase the capitalization of the economic sectors, thereby producing added value (increases in EMR_{PW}); (b) service the external debt; (c) increase internal consumption (i.e., increase EMR_{HH}); this can be obtained only by increasing the capitalization of the HH sector.

(3) The combined effect of servicing of the external debt, among other external shocks, and population growth played a crucial role in determining that the economic growth of Ecuador went into a negative feedback loop. In fact, to have economic growth (= an increase in either EMR_{PW} or EMR_{HH} or both at the same time) a socio-economic system has to fulfil the following condition: The rate at which both ET_{PW} and ET_{HH} grow (dET_{PW}/dt and dET_{HH}/dt) must be higher than the rate at which both HA_{PW} and HA_{HH} grow (dHA_{PW}/dt and dHA_{HH}/dt).

(4) In the case of Ecaudor, new population (new HA) was added because of the fertility of the resident population. It was not due to immigration. Therefore this new HA entered into the HH compartment, remained there for 10–15 years as the children approached adulthood, and then it moved mainly into the agricultural sector since this was the only sector accessible to the majority of new workers. Unfortunately, agriculture was also the sector with the lowest ELP and EMR among the productive economic sectors. It should be noted that, according to this analysis, emigration has a double positive effect on the economy of Ecuador. Not only does it generates a flow of money entering the country, without requiring economic investments in PW, but also it reduces the rate of increase of dHA_{PW}/dt.

The crisis experienced by Ecuador following the oil boom can therefore be seen as generated by two factors: (1) the necessity of a rapid capitalization of the economy (both in the productive sectors and in building infrastructures) in that decade; (2) the side-effect on demographic trends generated by better economic conditions or, better, by a widespread expectation for better economic conditions. As a consequence of this fact, the servicing of the debt reduced the speed at which the country could capitalize its economic sector (dET_{PW}/dt), at the very same moment in which the rate of dHA_{PW}/dt was peaking. As result of this, the rate of growth of HA_{PW} was higher than the rate of growth of ET_{PW}.

The implications for the HH sectors were as follows: (1) The rate of capitalization of the PW sector was not able to absorb all the new work force in well-paid jobs. This hampered the capacity to reduce the fraction of rural population engaged in low-input agriculture, and implied the creation of low-paid jobs in the service sectors—the fractions of HA_{PW} that are keeping the aggregate economic indicators around very low values; (2) The fraction of TET that was available for consumption at the HH level was too low to even maintain the status quo (to keep stable in time the original value of EMR_{HH}), when facing the high rate of demographic growth.

This explanation, however, is not the centerpiece of this approach. Using different terms and different concepts, other scientists coming from

different disciplines, could have also described the phases of the recent economic history of Ecuador in a useful way. That is, they could have used other theoretical frameworks to explain the various phases considered in the narrative. Two additional features make the Multiple-Scale Integrated Assessment of Societal Metabolism (MSIASM) particularly useful:

(1) MSIASM can be interfaced with other scientific disciplinary readings, without problems, including participatory integrated assessment. (2) MSIASM can be interfaced with an analysis of landscape use. It therefore makes it possible to link indicators of socio-economic performance to indicators of environmental impact. Actually, a parallel study of changes in landscape uses in Ecuador, is available. This study includes indicators referring to ecological impact and is linked to the analysis provided in this paper (Falconi, forthcoming). A more exhaustive discussion and examples on the possible combined use of socio-economic and environmental impact indicators is provided in the paper of Gomiero and Giampietro (this issue).

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