B. Sudhakara Reddy · Sergio Ulgiati
Editors

Energy Security and Development

The Global Context and Indian Perspectives

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Chapter 2
The Tertiary Economy: A Threat to the Global Economy

Mark T. Brown and Sergio Ulgiati

2.1 Introduction

Given the continuing crises in the global financial system and the inequalities between individuals, corporations, and nations that seem to compound daily, it seems logical to reflect on the structure of the economy that has precipitated these issues and has proposed changes to the monetary system that might alleviate some of them. The current monetary system fosters the creation of money far in excess of the resources (energy and materials) that support it, producing an illusion of increased wealth. For the most part, this illusionary wealth is concentrated in the hands of a few, while the remaining population has seen their incomes shrink and "cost-of-living" increase due to inflation.

Following Schumacher's (1973) concept of the primary economy (nature providing ecosystem services, energy, and minerals) feeding the secondary economy (agricultural and industrial production), we suggest that there now exists a tertiary economy (the financial system of trade, banking, insurance, and stocks). This economy (also called sector in most economic terminology) is the tail that wags the dog (i.e., economy) of modern nation states. Driven by expectations for continued growth, investments in most nations have been increasingly directed toward the tertiary economy rather than toward the primary and secondary economies. As most of the economic theories are based on growth, the planning and policy recommendations for economic health of nations are also based on growth. Yet, growth cannot continue forever, and in fact, the insistence on continued growth is at the root of the current economic crises.

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In this chapter, we demonstrate using the economies of the USA and India that recent increase in wealth suggested by a growing gross domestic product (GDP) are actually only an illusion of more wealth as the biophysical basis for the economy has not increased in a like manner. The biophysical basis is measured by the emergy concept (the amount of solar emergy needed for resource generation by nature and processing by humans, Odum 1996), a measure of the demand for environmental support by a process or an economy. Emergy (Brown and Ulgiati 2004, 2011) is measured in a common unit (solar equivalent joule, seJ), and is the investment of energy and material resources by linking an economic process to the biophysical basis of a country, a farm, or a city. The increasing concentration of money in the tertiary economy represents paper wealth as there are few, if any, flows of emergy connecting the tertiary with the rest of the economy. We hypothesize that the increasing distance (spread) between the actual increase in wealth (measured by emergy throughput) and the illusion of wealth (measured by GDP) is a sign of serious future shocks or stochastic surprises similar to the boom and bust cycles that have occurred till 2008. With each boom and bust cycle over the past 100 years, the consequences are even more severe.

In reality, it is a good thing that the newly created illusionary wealth remains concentrated in the tertiary economy in the form of stock profits and bank deposits. Should it be released into the "main economy," it would result in hyperinflation as limited resources would not be matched to the large influx of money. In addition to the potential of precipitating future stochastic surprises, paper wealth concentrated in the tertiary economy represents a significant threat to the larger economies by causing hyperinflation if it were to be spent in the economy.

2.2 Resources Are Wealth

The wealth of a nation, as was well recognized in the past by Adam Smith (1776), is the nation's resource base. Smith, in *The Wealth of Nations*, described wealth as "the annual produce of the land and labour of the society." An obvious consequence of this viewpoint should be that the wealth of a nation is its natural, human and physical *assets*, or *capital*. Natural assets include things such as land, forests, fossil fuels, and mineral resources. Human assets include the education and/or skill levels of the population, while physical assets include the manufactured capital (roads, buildings, machines, etc.) (Odum 1996).

In the last 50–100 years, the popular usage of the term "wealth" has defaulted to "the state of controlling or possessing items of economic value, usually in the form of money, real estate, and personal property." The shift has resulted from the general concepts of monetary economics, which provides the framework for money as medium of exchange, store of value, and the unit of accounting.

Unfortunately, the preoccupation with money has translated into measuring the wealth of nations as the monetary value of that which is produced. Viewed in this way, the wealth of nations is the market value of the final goods and services

produced within a country in a given period of time, known as the GDP. Contrary to how most of us view the economy, however, the monetary value of that which is produced is not a real measure of wealth, rather it is a measure of what people are willing to pay for wealth. In other words, the natural, human, and physical capital, and the products generated from that capital are the true wealth, and market price (monetary value) is a way of valuing it from the human perspective.

2.3 Biophysical vs. Monetary Economy

We define the measure of biophysical productivity of an economy by the *gross emergy product* (GEmP), which is the emergy value of all goods and services produced within a country in a given period of time, and by definition is equal to total emergy use in the economy. GEmP is similar to the GDP, which is the economic term, for market value of all final goods and services produced within a country in a given period of time (generally 1 year).

Figure 2.1a is the basic diagram that every student taking a beginners course in economics sees as his/her first glimpse of the economy. In this, the economy is composed of producers and consumers connected by the flow of money, which is explained as the payment for goods and services by consumers to producers and the payment of wages and rent by producers to consumers. It is explained that this

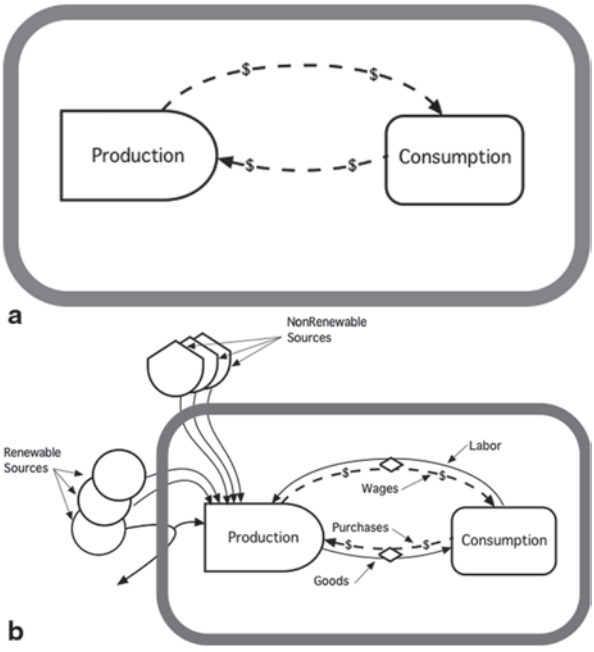

Fig. 2.1 Elementary view of the economy (*top*) showing the cycle of money between the producing and consuming sectors of the economy. A more realistic view of the economy (*bottom*) shows that the economy is driven by the inputs of renewable and nonrenewable resources

represents the economy and if one was to quantify the two flows, it would be a measure of the total productivity of the economy (in the ideal situation the two flows are equal).

The biophysical economic system is composed of flows of matter, energy, and information with counter-current flows of money as shown in Fig. 2.1b. The most striking difference between this depiction of the economy (Fig. 2.1b) and standard text book diagrams of the economic system (Fig. 2.1a) is the driving energies and the environment that are completely ignored when one only looks at the economy as a circulation of money between producers and consumers. From a *biophysical* point of view, energy and other resources drive the circulation of money, and no circulation of money is possible independent of resources. Thus, in Fig. 2.1b, the circular economy is shown being driven by *renewable* sources and *nonrenewable* storages of matter and fossil fuels.

The economy, when viewed from a biophysical perspective, is a hierarchical, interconnected system of resource, and monetary flows driven by available energy and resources. The flow of resources, products, human labor, and information within the economy, each having a counter flow of currency based on the prices paid. From an economic perspective, total productivity of the economy and individual sectors is determined by the monetary value of the goods, services, or information produced. From the emergy perspective, total productivity is computed as the sum of the inputs necessary to produce the goods, services, and information.

2.4 The Emergy Basis of the Economy

The graphs in Fig. 2.2 show the emergy basis for the US and Indian economies as an emergy signature (breakdown of emergy input flows) for the year 2008. The inputs to each economy are expressed in emergy per year, so they represent the total emergy throughput of each economy. Emergy inputs are grouped as renewable, indigenous (which represent nonrenewable resources from within the countries), and imports of nonrenewable resources. The sum of inputs represent the total emergy driving each economy (emergy throughput), which is the basis for the generation of goods and services that are produced. Reflecting back on the diagrams in Fig. 2.1, the emergy inputs to the economy represent the biophysical basis for the circulation of money because each flow of money is accompanied by a transaction (the diamond symbol), which results in the purchase of resources or services.

While the total emergy throughput of the two economies was quite different (the US economy had over four times as much emergy throughput than the Indian economy), the structure of both economies was similar. Both economies are dominated by the use of indigenous resources with imports totaling to about 50 % of the total emergy throughput. The Indian economy seems to be dominated by the use of indigenous minerals and metals, while the US economy is dominated by a combination of indigenous minerals and metals and fossil fuels.

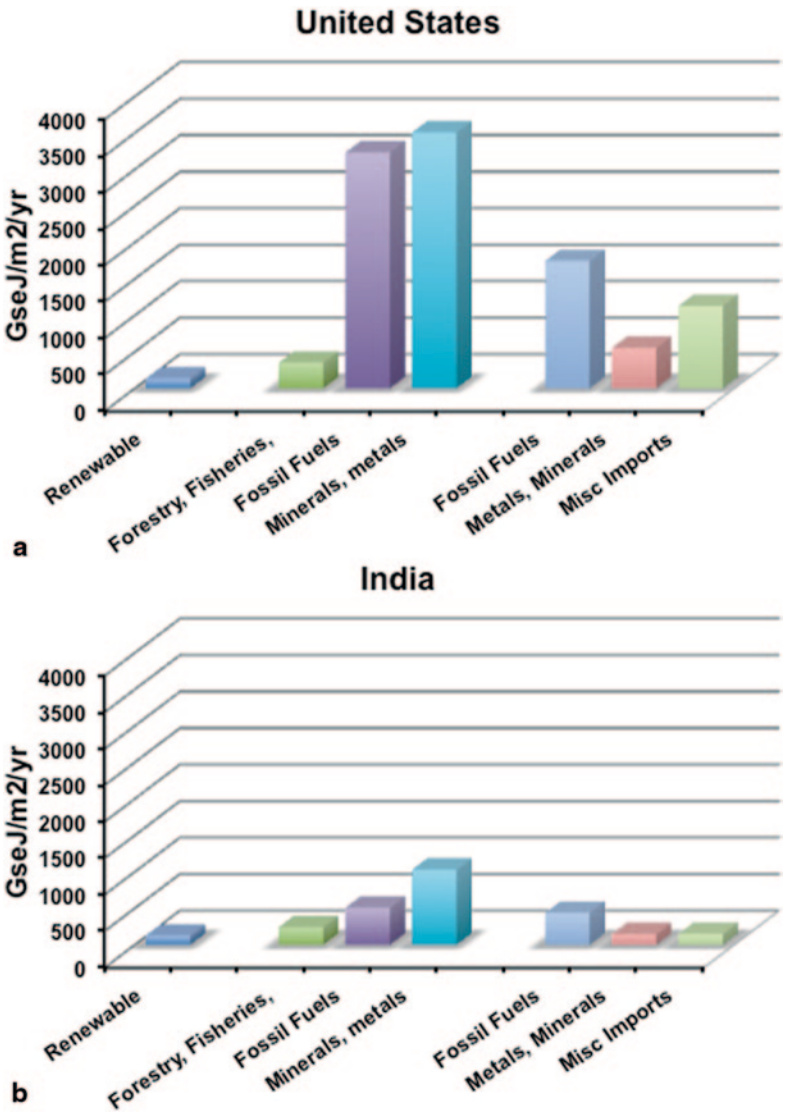

Fig. 2.2 Emergy signatures of the US and Indian economies showing the resource throughput of each economy expressed in Giga-solar emjoules per m^2 per year

2.5 Emergy and Inflation

In economics, inflation is an increase in the prices of goods and services over a period of time. To put it another way, it is an increase in the money required to purchase the same quantity of goods and services. From a biophysical perspective, inflation results when an increase in the circulation of money is not accompanied by an increase in the emergy throughput of the economy. The diagram in Fig. 2.3

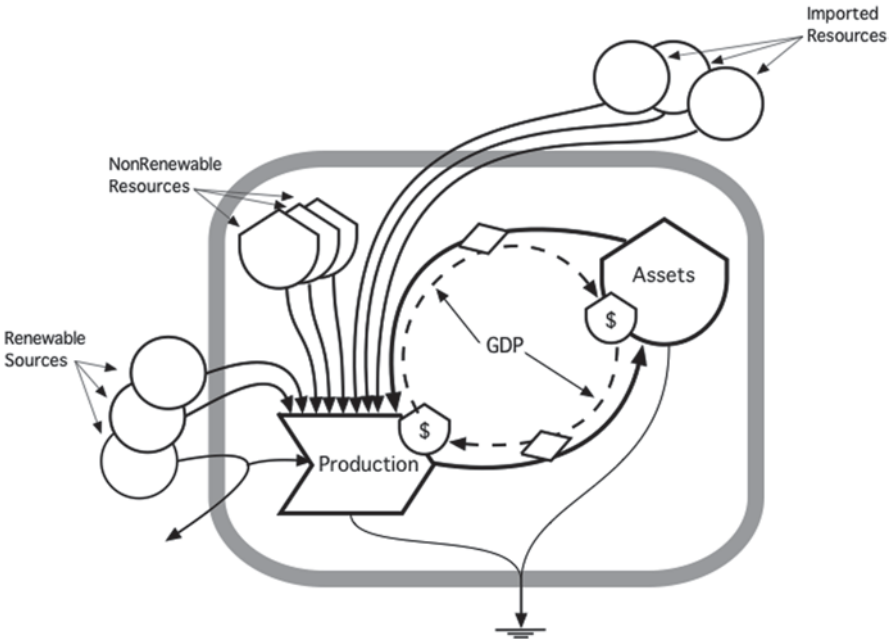

Fig. 2.3 An aggregated diagram of a national economy driven by renewable resources, nonrenewable resources, and imports. Total production flows into a storage of assets, which are used in turn to foster more production, the counter current flow of money is the GDP

illustrates the biophysical perspective. There are three main emergy resource inputs, renewable, nonrenewable, and imported. These resources drive the economy, which is shown as the circular flow of money GDP within the circular flow of resources.

If the circulation of money increases faster than the resource throughput, the result is inflation. Nations use the supply of money to either stimulate or slow down the economy by either increasing or decreasing the supply respectively. With small changes in the money supply, there are corresponding small rates of inflation. In general, when money supplies are increased there is an increase in demand for resources and the economy is stimulated with the additional resource flows. However, if too much stimulus is applied, or if the resource flows are not available, then the increase in money results in inflation (more money circulating for a smaller quantity of resources).

The graph in Fig. 2.4 relates to the total emergy driving the world economy to the Gross World Product (GWP) since 1900, showing that the growth rate of GWP far exceeds the growth rate of the emergy throughput. The difference in growth rates is the inflation rate as shown in the bottom graph in Fig. 2.4. The increase in money represented by the GDP without a corresponding increase in the driving emergy throughput results in more money for purchasing smaller and smaller quantities of resources and services at each transaction.

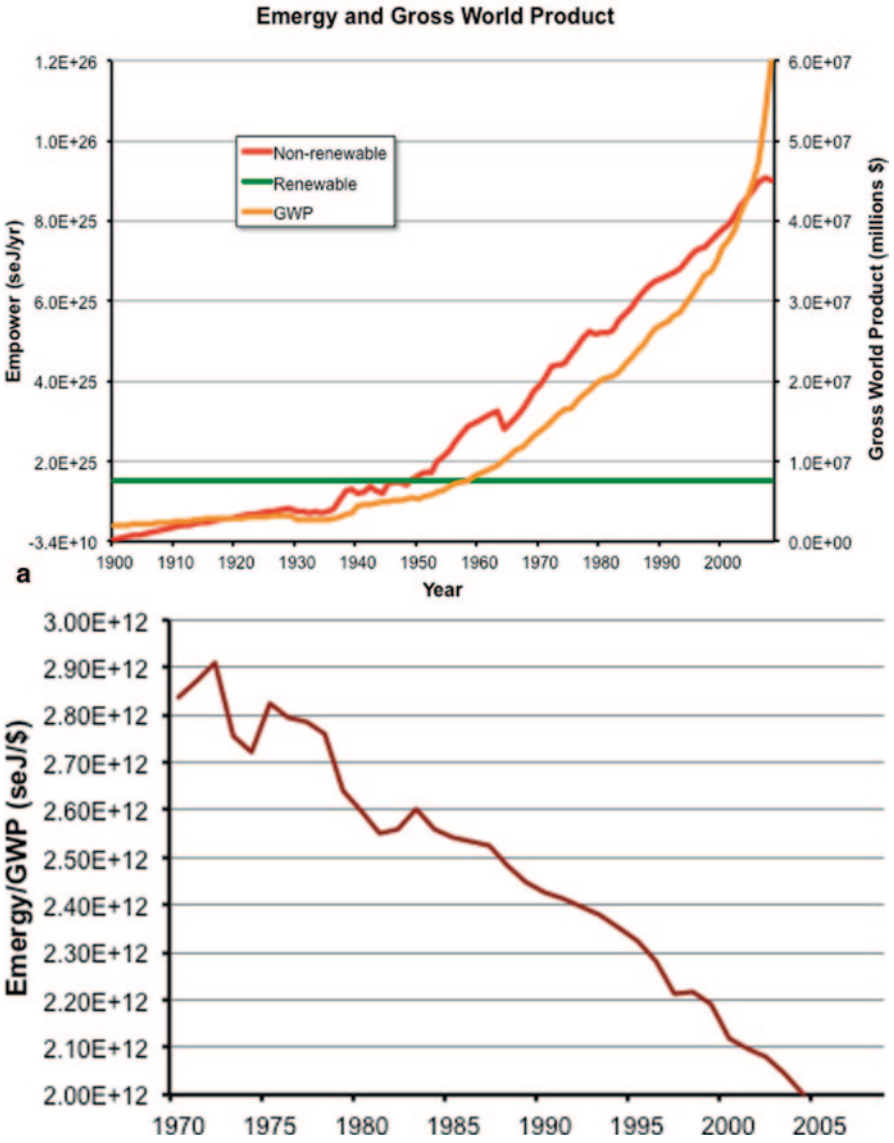

Fig. 2.4 The growth of global nonrenewable emergy use (*red line*) and GWP (*gold line*) since 1900 (*top*). Emergy per dollar of GWP is declining, which indicates the rate of inflation (*bottom*)

2.6 The Tertiary Economy

If we decompose a national economy into sectors, the result is depicted in Fig. 2.5a, which shows the production sector (primary economy), the consumption sector (secondary economy), and the government. To call the secondary economy as "consumption" is a bit of a misnomer because obviously through consumption it

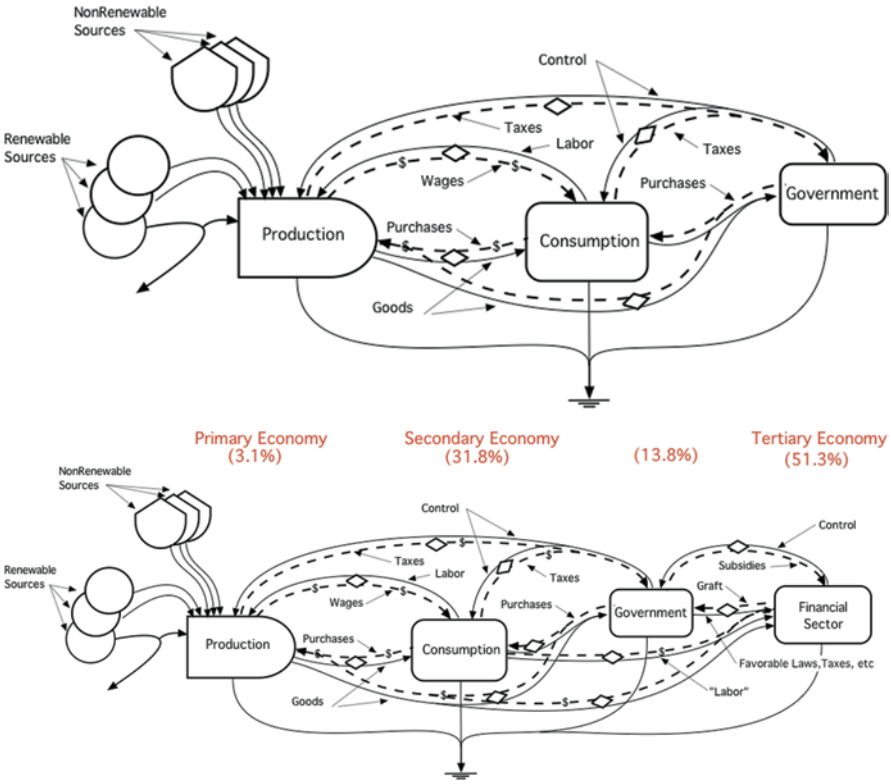

Fig. 2.5 Diagram of a typical economy showing three main sectors production, consumers, and government (*top*). In recent years there has been explosive growth of the financial sector termed the "tertiary economy" (*bottom*). The numbers in parentheses indicate the percentage of the monetary economy

produces (services and labor) just as the primary economy consumes resources to produce products. Government is actually a part of secondary economy, but is shown separately to make the point that it provides needed services and controls to the primary and secondary economies. In the last several decades, many national economies have experienced unprecedented growth of a third sector (Fig. 2.5b) that in the past was too small to be considered as a part of the secondary economy. However, with its increase in size the tertiary economy now controls major monetary flows in the economy. The tertiary economy is composed of the financial sector, which includes banks, investment firms, insurance companies, and real estate. The numbers in parentheses at the top of the diagram show the percentage of the US GDP that is attributable to each sector.

The graphs in Fig. 2.6 show the changes in the percentage of GDP that is derived from each of the three sectors of the US and Indian economies. The tertiary economy is now over 50 % of the US economy and over 35 % of the economy of India. While it would seem that deriving such a large portion of the GDP in one sector is not a bad thing; consider that this sector is capable of increasing a nation's money

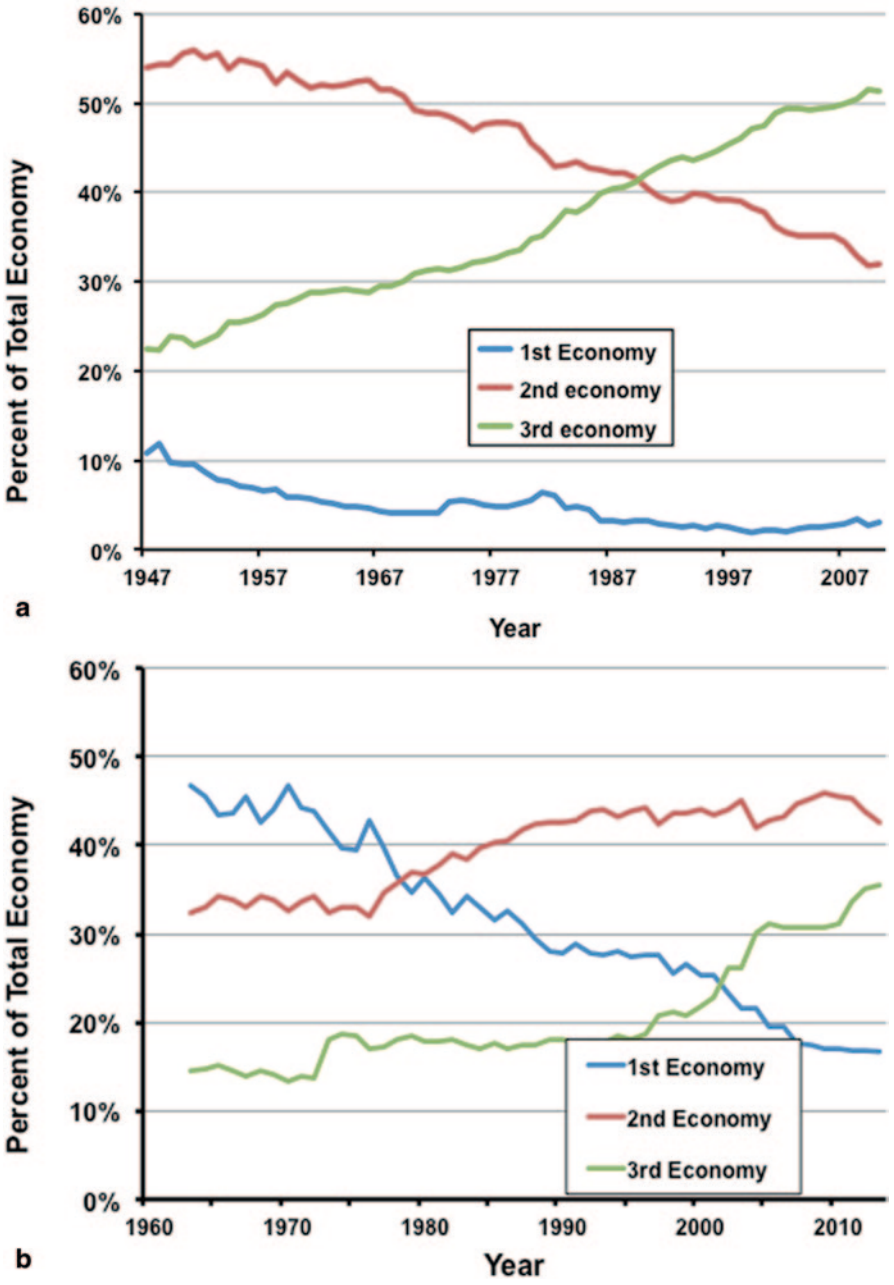

Fig. 2.6 Changes in the three main sectors of the USA (*top*) and Indian (*bottom*) economies. The first economy is comprised of agriculture, forestry, fishing, hunting, mining, utilities, construction, and manufacturing, the second economy is comprised of wholesale and retail trade and transportation. The third economy is composed of information, finance, professional services

Table 2.1 Emergy money ratios for selected countries (2008)

Country	GDP ($/year)	Total emergy use (seJ/year)	Emergy money ratio (seJ/$)
Japan	4.85E+12	9.20E+24	1.90E+12
UK	2.67E+12	5.50E+24	2.06E+12
Italy	2.30E+12	5.10E+24	2.22E+12
USA	*1.43E+13*	*3.60E+25*	*2.52E+12*
Germany	3.60E+12	9.10E+24	2.53E+12
Sweden	4.90E+11	1.40E+24	2.86E+12
Brazil	1.65E+12	5.50E+24	3.33E+12
New Zealand	1.32E+11	5.00E+23	3.79E+12
Australia	1.05E+12	4.40E+24	4.19E+12
Mexico	1.09E+12	5.30E+24	4.86E+12
Russia	1.66E+12	8.70E+24	5.24E+12
Costa Rica	2.98E+10	1.60E+23	5.37E+12
South Korea	9.30E+11	5.60E+24	6.02E+12
India	*1.26E+12*	*8.10E+24*	*6.43E+12*
Panama	2.30E+10	1.62E+23	7.04E+12
South Africa	2.74E+11	2.20E+24	8.03E+12
Botswana	1.36E+10	1.50E+23	1.10E+13
China	4.52E+12	5.10E+25	1.13E+13
Ireland	2.63E+11	6.40E+24	2.43E+13
Mali	2.78E+09	6.90E+22	2.48E+13

supply through the creation and sale of debt. In doing so, the tertiary economy has the power to affect the money supply, and as it increases in size, its potential impact on the economy grows as well. The result of this top heavy national economy is the potential for serious shocks, when the economy readjusts the monetary system to the biophysical system. As it was stated numerous times since the beginning of the world recession in 2008…"too big to fail." The tertiary economy in most developed and developing economies is so large and centralized that it dominates the economy, and indeed could be catastrophic in failure. Governments now would do well to constrain the growth of the tertiary economy and reinvest in growing the secondary economy (within the constraints of available natural capital), which by virtue of its basic diversity is less likely to cause catastrophic failure should the economy experience a downturn.

2.7 The Emergy Money Ratio

Given in Table 2.1 are data for a selected number of national economies showing the total driving emergy and the resulting GDP measured in dollars or other reference currency. Since, as we have already pointed out, emergy drives the economy, we

compute a ratio of emergy to GDP dollars, known as the emergy money ratio (EMR; units are seJ/$). EMR is a measure of the average amount of emergy that is used in the economy for every dollar that circulates. Monetary flows in the economy can be converted to their emergy equivalents by multiplying them by the EMR for that economy. In like manner, emergy flows can be converted to dollars equivalents by dividing emergy by the EMR.

Of note is the fact that developed economies have low EMRs compared to developing and undeveloped economies. At first, this seems counter intuitive as it is always assumed that developed economies are more "energetic" than less developed economies, but what the EMR shows is that the purchasing power of countries like Japan and the USA when compared to less developed economies is much higher. In essence a currency with low EMR (i.e., small emergy use per unit of GDP), when used to purchase goods and services from another economy with higher EMR (i.e., large emergy use per unit of GDP) receives more emergy from that economy than it would if used in its "home economy."

Likewise, the emergy "cost of production" of a good or commodity can be divided into its money value, expressing a measure of value named "emprice" (seJ/$), the amount of emergy "embodied" in a dollar value of that commodity.

2.8 Emergy and Trade

Trade between nations is most often evaluated and balanced based on monetary flows. Country A and Country B are said to have a balance of payments if the money received to the money paid between the two countries is equal. In economic terms, the relative price of a country's exports compared to its imports is called "terms of trade." The terms of trade for a nation are said to be favorable if the relative price of a country's exports is higher than the price of its imports. Thus, the theory reduces the trade problem to one of balancing monetary flows in one's favor to insure a positive balance of payments, and therefore favorable terms of trade. This economic concept ignores the real issue…by assuming that the commodities exported and imported are of equal "value," the only difference between them is their relative price instead of their emergy, which measures their ability to drive production.

A second economic concept, "factor proportions" assumes that countries export those goods whose production is intensive in factors with which they are abundantly endowed. Examples given in economic texts are for two factors, labor and capital. The model suggests that countries that are abundantly endowed with either factor will trade those commodities whose production is more intensive in the more abundant factor. The concept ignores the fact that countries strive to export commodities not because they are labor- or capital-intensive, but often because they have an abundance of the commodity or resource, and require income to purchase resources that are needed but not abundant. Under these circumstances, a country trades a commodity or resources in abundance for resources in short supply to overcome limiting factors to production. In both cases, (under favorable terms of trade,

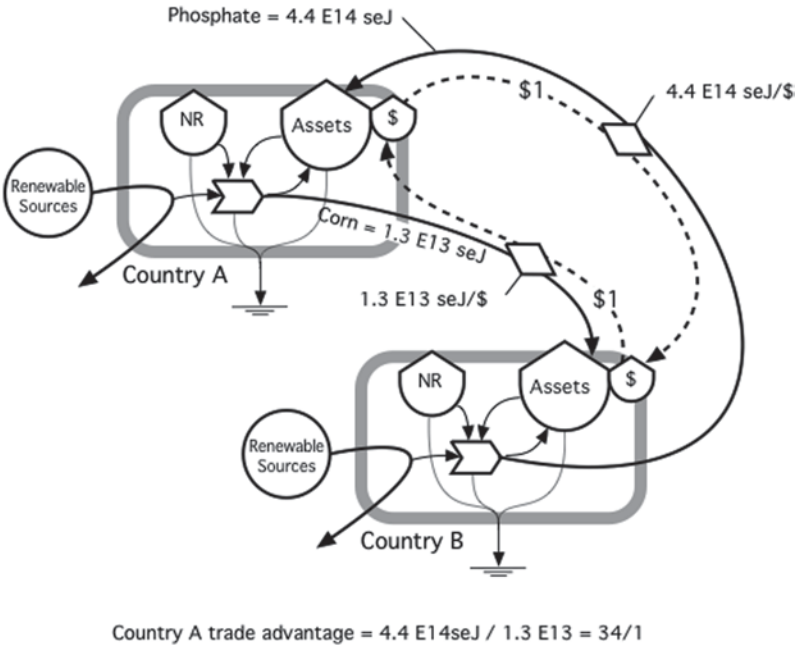

Fig. 2.7 Diagram illustrating the emergy benefit in trade of commodities. While the flow of money between the two countries is equal ($ 1) Country A exports 1.3 E13 seJ to Country B and in turn imports 4.4 E14 seJ, a trade advantage of 34/1

or factor proportions) the true value of the goods traded is ignored, and all trade is reduced to relative monetary values. Instead, trade should be evaluated in emergy terms.

Emergy values of international trade between nations can be evaluated either for individual commodity trades (e.g., phosphate for corn) or for national trade balances in aggregate. In the first case, emergy of each commodity or resource that is traded under the assumption of equal monetary trade is computed and compared. The country that receives a higher emergy has the trade advantage. Trade of corn for phosphate is illustrated in Fig. 2.7, where $ 1 worth of corn is traded for $ 1 worth of phosphate. The emprice (emergy per dollar value) of corn is 1.3 E13 seJ/$ while the emprice of phosphate is 4.4 E14 seJ/$. As a result of the differences in the emprice, Country A enjoys an emergy trade advantage of 34 to 1.0.

Secondly, international trade in the aggregate, is evaluated by comparing the EMR's of both trading partners. If we assume that monetary flows are nearly balanced, then a unit of currency that circulates between two economies can be expressed as emergy and compared similarly to the commodity trade above. The aggregate comparison is termed the Emergy Exchange Ratio (EER) of two economies and is calculated as the ratio of the two trading partners' EMRs. When comparing aggregate trade between two trading partners (Fig. 2.8), the country with a lower EMR has the trading advantage, as it buys more emergy in the other country

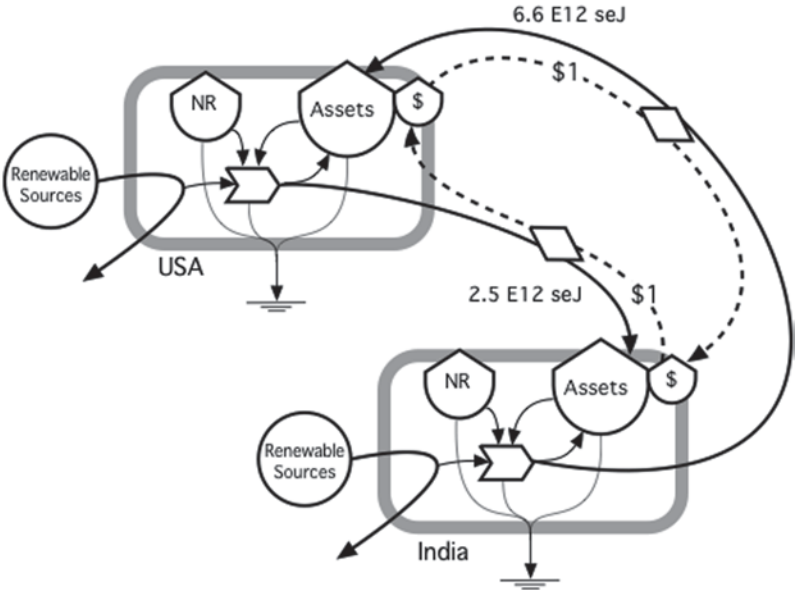

Fig. 2.8 Diagram illustrating aggregate trade between the USA and India. Emergy value of trade is computed from each country's EMR. For each dollar of trade exported to India, valued as 2.5 E12 seJ, the USA imports 6.6 E12 seJ, or a trade advantage of about 2.6/1

than if that same dollar were spent at home. The greater the difference between the two EMRs, the greater is the buying power of the currency of the country compared with the lower EMR. Aggregate trade between the USA and India is shown in Fig. 2.8. The USA has aggregate trade advantage of about 2.6 to 1.0. That is to say, the USA receives 2.6 times as much emergy from India as it exports to India (when aggregate trade is compared).

2.9 Resource Imperialism

Resource imperialism is the act of appropriating resources from other countries with unfair advantage. Under the guise of free trade, nations with strong currencies, because of the differences in the buying power of their currencies, (USA and Western Europe) have an unfair advantage if trade is balanced using monetary flows. If we assume that monetary flows for imports and exports need to have more or less balance, then nations with weak currencies are at a competitive disadvantage. Thus, countries with high EMRs, for instance Mali (Table 2.1) is at a distinct disadvantage on international markets and investments. But even more important is the fact that the currencies of developing countries are undervalued on international monetary markets.

Table 2.2 Relationship between OER and EBER—2008

Country	Currency	Official exchange rate (currency/US$)	GDP (currency/year)	Total emergy use (seJ/year)	Emergy/Money (seJ/currency)	Emergy based exchange rate (currency/US$)	OER/EBER
Japan	Yen	103	5.12E+14	9.20E+24	1.80E+10	139.1	0.74
United Kingdom	Pound	0.54	1.47E+12	5.50E+24	3.74E+12	0.7	0.81
United States	USD	1	1.44E+13	3.60E+25	2.50E+12	1.0	1.00
Italy	Euro	0.78	1.55E+12	5.10E+24	3.29E+12	0.8	1.03
Sweden	Kronor	6.6	3.30E+12	1.40E+24	4.24E+11	5.9	1.12
Germany	Euro	0.78	2.40E+12	9.10E+24	3.79E+12	0.7	1.18
Brazil	Real	1.83	3.00E+12	5.50E+24	1.83E+12	1.4	1.34
New Zealand	NZD	1.42	1.72E+11	5.00E+23	2.91E+12	0.9	1.65
Australia	AusD	1.19	1.25E+12	4.40E+24	3.52E+12	0.7	1.68
Mexico	Peso	11.13	1.20E+13	5.30E+24	4.43E+11	5.6	1.97
Russia	Ruble	24.85	4.01E+13	8.70E+24	2.17E+11	11.5	2.16
South Korea	Won	1,102	1.00E+15	5.60E+24	5.60E+09	446.4	2.47
Costa Rica	Colon	526.2	1.36E+13	1.60E+23	1.18E+10	212.5	2.48
India	Rupee	43.51	5.60E+13	8.10E+24	1.45E+11	17.3	2.52
Panama	USD	1	2.10E+10	1.62E+23	7.73E+12	0.3	3.09
Mali	Af. Franc	447.8	3.77E+12	6.90E+22	1.83E+10	136.6	3.28
South Africa	Rand	8.26	2.19E+12	2.20E+24	1.00E+12	2.5	3.32
Botswana	Pula	6.83	9.18E+10	1.50E+23	1.63E+12	1.5	4.46
China	Yuan	6.95	3.15E+13	5.10E+25	1.62E+12	1.5	4.50
Ireland	Euro	0.78	1.88E+11	6.40E+24	3.40E+13	0.1	10.62

The international exchange of currencies is based on an "official exchange rate" (OER) determined through buying and selling of currencies on international monetary markets. When the OER is compared to the exchange rate computed on an emergy basis, in general, developing economies are negatively affected. Table 2.2 shows data for selected countries that is used to compute an emergy based exchange rate (EBER). The final column in Table 2.2 relates the OER to the EBER. The higher the ratio of OER/EBER, the greater is the negative impact on developing economies. Not only is their EMR higher, placing them at trade disadvantage, but also the OERs further exacerbate the problem. The ratios in the final column of Table 2.2 show how problematic this is. Currencies of developing countries (those lower in the table) are undervalued on the international markets so that countries like Mali or South Africa are undervalued by as much as 3.3/1. This has serious consequences on international finance and the debt that most developing countries have.

2.10 Emergy and International Debt

International or external debt of countries is that portion of the total debt that is owed to creditors outside the country. We illustrate the impact of the OERs under valuing of currencies by studying the economies of several countries of the Sahel region of Africa: Mali, Senegal, Niger, Burkina Faso, and Mauritania (Cohen et al. 2012). Each of them has a substantial international indebtedness (Table 2.3). The complied data in Table 2.3 is for the 30-year-time period between 1970 and 2000. The official debt of each country is shown as a negative number, while the recalculated debt based on each country's EMR is positive. The final column shows the year of repayment.

In order to generate international currency to make their debt payments, every country exports large quantities of local environmental capital, either in the form of mined resources, agricultural commodities, or otherwise raw goods. When debt service is computed based on their respective emergy-based exchange ratios, they not only have repaid their debt (the year given in the last column), but also have become emergy creditors. This is most pronounced for Mauritania and Senegal, who

Table 2.3 Summary of long-term financial debts, emergy indebtedness and year of emergy repayment for five West African nations. (Cohen et al. 2012)

Nation	2000 official debt outstanding balance (World Bank 2005)	2000 debt balance based on EMR	Year of repayment for debt
Burkina Faso	−3.31E+09	1.11E+09	1994
Mali	−6.16E+09	8.22E+09	1986
Mauritania	−4.77E+09	7.65E+10	1971
Niger	−4.10E+09	9.46E+09	1979
Senegal	−8.86E+09	1.83E+10	1975

officially owe $ 4.8 and $ 8.9 billion, respectively, but have over paid by $ 77 and $ 18 billion, respectively, if flows are examined in emergy units.

2.11 Concluding Remarks

In this chapter, we explored a system's perspective of modern economies and the biophysical basis for national productivity. The recent economic downturn in the global economy has highlighted the impact of the growth in influence of the tertiary economy. We suggest that continued concentration of paper wealth in the tertiary economy threatens the security of the nations as it precipitates boom and bust trends and fosters resource imperialism. Much of the inflation over the past 50 years has been driven by the creation of illusionary wealth in the tertiary economy.

The economy is composed of emergy flows that are accompanied by monetary flows. Without continuous inflows of emergy in the form of material, fossil, and renewable energy, the monetary economy would come to a standstill. The monetary economy has increased in size as the industrial revolution and in the last 50 years has come to dominate the biophysical economy. As the emergy and monetary economies are linked, increase in money supply that is not accompanied by real increase in the supply of emergy results in inflation.

On the other hand, considering that emergy resources are not unlimited, a sustainable economy cannot grow without a limit and may need to degrow according to the declining availability of resources. If energy supplies are indeed limited and the overall availability is declining, then attempts by national governments to grow by "stimulating" the economy with increase in the money supply, will only result in an increase in inflation. It may be time to realize the energetic constraints on economic growth and to begin now to reorient economic theory to fully recognize the biophysical realities.

Emergy purchasing power of a country's currency is the quantity of emergy driving the economy divided by GDP (the market value of all final goods and services made within the borders of a country in a year). Dollar-for-dollar trade benefits countries with low emergy per dollar ratios. Balancing trade between nations using money does not lead to equitable trade; on the contrary, it causes disparities where the economies with the highest emergy use per dollar of GDP (developing nations) lose in trading relationships with countries having lower ratios (the developed nations). An interesting approach to create fair trade, and therefore to make it more advantageous for all countries involved, would be to balance trade using emergy. In other words, balance the emergy in exchanges instead of the money. This may not necessarily mean acting on monetary transactions such as increasing the price of traded commodities, or balancing exported resources with other resources or goods. It may instead be an interesting option to balance the emergy of primary resources with the emergy of know-how, technology, and education in support of the less-developed countries. As it now stands, most nations of the global economy stand

to lose on every average trade transaction with the more-developed economies of Europe and North America…no wonder the developed world is pushing free trade.

Many developing and underdeveloped countries (D&U countries) have external monetary debts incurred by their governments that is beyond their ability to repay. Much of the current debt of these nations was acquired as a result of the oil crises in the early 1970s when the price of oil skyrocketed from about $ 3.00 to almost $ 40 per barrel. The impact on many countries—a tenfold increase in the cost of oil over such a short period of time—was to borrow funds from international banks. In addition to the oil impacts of the 1970s, a global recession in 1981–1982 reduced export prices in most D&U countries, which compounded the problems of meeting their monetary debt obligations. Adding to these issues, the unfair monetary exchange rates of currencies, and the result was an escalating monetary debt for most developing countries of the world. For many countries, external debt increased rapidly following the 1973 oil crises, as did the debt service payments. Evaluating the countries of the Sahel region of Africa, Cohen et al. (2012) found that in all cases when repayments were expressed in emergy rather than money by adjusting the monetary repayments by the emergy dollar ratios of the countries, each of these countries has repaid their debt many times over.

Often, the result of increasing international debt is the rapid exploitation of natural resources in order to generate the needed cash for debt repayment. As most resources have relatively low prices (i.e., much emergy per unit of currency), repayment requires large quantities of resources. However, if the true value of these exports were factored into the repayment equation, debts would be paid in short order in most instances. The net result of D&U countries borrowing to finance development projects, is most often a significant increase in the flow of resources that are exported; exactly opposite of good energetic policy, which would favor using resources within an economy rather than exporting them.

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