

Ecological macroeconomics: a critical review

Based on the thermodynamic framework, ecological economics recognizes that the economy is embedded within the ecosystem, implying physical limits to economic growth. From this perspective, the transformations of material and energy are subject to the laws of thermodynamics. Analyzing the economic activity under these laws, specially the second one – the entropy law –, we can observe that production essentially means irreversible transformation of low entropy matter and energy in high entropy waste (Georgescu-Roegen, 1971). Therefore, besides implying irrevocable growing disorder of isolated systems, the entropy law denies the idea that growing physical product is the ultimate end of economy. To society matters only the welfare that results from physical production and, indeed, after a certain level of income, there isn't a positive correlation between income and happiness (Easterlin, 1974).

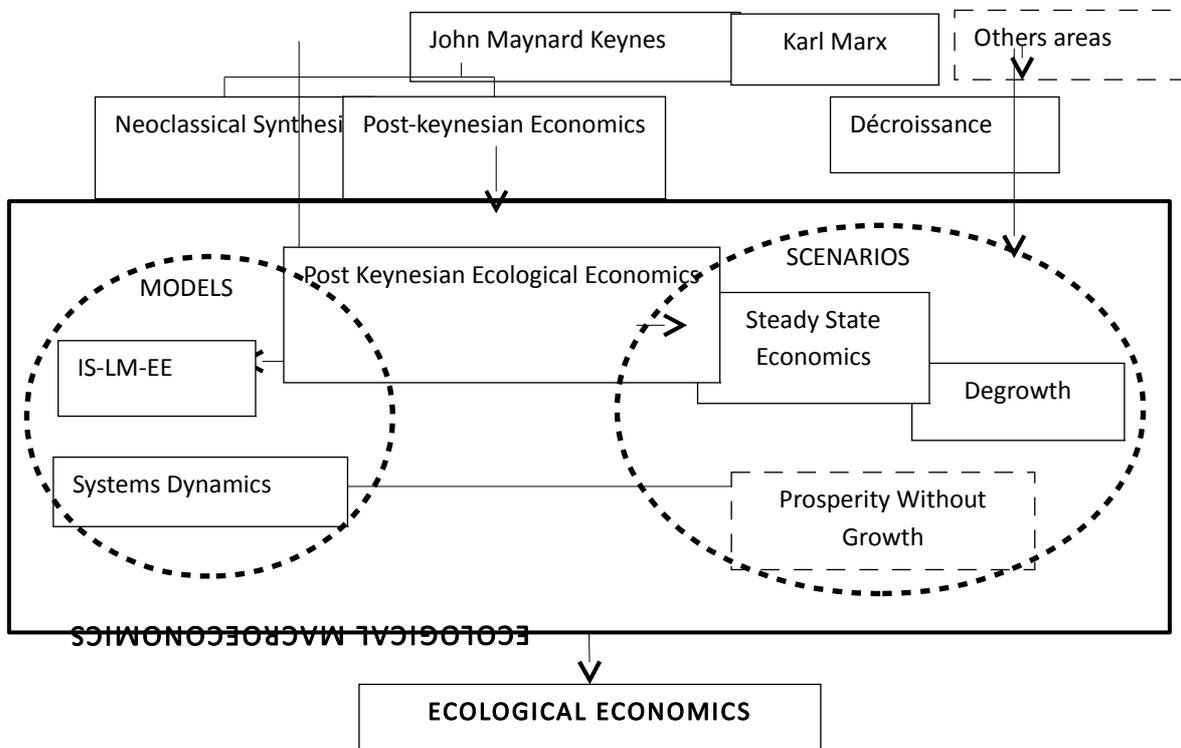
The thermodynamic understanding of economic process raises radical critics to mainstream macroeconomics. Under this approach, the economy is an isolated system that doesn't exchange energy or material with the ecosystem and economic growth always brings welfare, never costs. Even though, ecological economics don't have an alternative to analyze and propose macroeconomic policies. Also, there isn't a consensus on how achieve or transit to a successful economy capable of satisfying human needs without depending on continuous unsustainable growth. In the beginnings of 1990s, Herman Daly (1991) stated this gap in *Towards an Environmental Macroeconomics*. However, until recently there were few and isolated advances in the area. The scenario only changed after 2008, when ecological economists saw in the crisis the opportunity to discuss further alternatives. This paper describes the most relevant ecological macroeconomics alternatives; identify their bases in economic approaches and the main policies and measures suggestions.

The main initiatives are indicated in the figure below, in which we attempted to identify the economics approaches that base ecological macroeconomics. Common to all initiatives is the role of ecological economics that places mainly the scale problem, assuring a common ground to ecological macroeconomics. However, the others approaches behind it are not only numerous, but also quite different between them. Despite the advantages of a pluralistic view advocated by ecological economics, these great divergences certainly hinder the dialogue between researches and the influence on

policy making. Thus, we believe that one first step to strengthen the field is discussing and classifying these divergences and their effect in policy formulation.

We divide the initiatives in two major groups – models and scenarios. The first comprises the IS-LM-EE model, a didactical adaptation of conventional IS-LM model with an environmental restriction – “environmental equilibrium-EE” (Heyes, 2000; Lawn, 2003), and the Systems Dynamics models, capable of analyzing complex and dynamical relations between variables in different systems (Victor, 2008; Rezzai et al., 2012; NEF, 2012; Jackson and Victor, 2013). On the other hand, there are three main scenarios of ecological macroeconomics: Degrowth (Martinez-Alier et al., 2010; Kallis, 2012; Kallis et al., 2012), based on the French *décroissance*; Steady State Economics (Daly, 2008; Lawn, 2010), developed initially in the 1970s by Daly (1977); and the new perspective called “prosperity without growth” (Jackson, 2009), which hasn’t yet consolidated a particular perspective, supporting the previous two. Finally, the initial contributions to formulate a post-Keynesian ecological economics attempts to combine both approaches that already consider economic and ecological processes as complexes and uncertain (Holt et al., 2009).

Economics approaches behind ecological macroeconomics



The IS-LM-EE model represents the economy embedded within the ecosystem, yet working with static equilibrium that ignores the relationships between variables over time. Even in more developed versions of the model (see Lawn, 2003), in which technological progress shifts the curve EE, the static equilibrium occult the time lag between monetary and fiscal policies and long-term changes in technology state. This deficiency is solved by the Dynamical System models, including the well-known LowGrow (Victor, 2008). This study was received with optimism among ecological economists because it showed that a non-growing economy in Canada would not necessarily produce a social catastrophe. The LowGrow model to the Canadian economy worked with economic, social and environmental variables in different systems and explored their complex and dynamical relation in time. While IS-LM-EE model focuses primarily on the pricing mechanism, LowGrow analyze different types of policies (table below) that are also discussed in ecological macroeconomics scenarios.

Policies and measures based on ecological macroeconomics

	Scenarios		Models	
	Steady State	Degrowth	IS-LM-EE	LowGrow
Scale	Resources and CO2 caps Cap-auction-trade Cap-and-share		Fiscal and monetary policies, cap-and-trade and environmental regulation.	Taxes on emissions of greenhouse gases, ecological tax reform.
Employment	Reducing working hours, Job Guarantee.		Fiscal and monetary policies.	Reducing working hours.
Financial system	Zero interest rates, high reserve requirements for banks.		-	-
Distribution and poverty	Redistributive taxation, basic income, income caps, new social security guarantees.		-	Direct and indirect programs.
Technology	Environmental and consumption taxes, green investments.		Cap-and-trade.	Research incentive to promote preventive technologies.
Demography	Direct and indirect policies for stabilizing population.	-	-	Immigration policies with humanitarian nature.
International trade	WTO reform to reduce free trade.	Regional currencies, commercial free zones, support models of “local living”	-	Trade and tax policies to strengthen the local economy.

On the other hand, the initiatives not based on conventional macroeconomics didn't develop economic formal models – excluding GEMMA, still under development (Jackson and Victor, 2013). Even though, ecological macroeconomics scenarios present important insights and policies suggestions to achieve the transition to economies non-dependent on growth. Accordingly to Daly (2008), in a Steady State Economics the capital stock is constant and is maintained by a throughput flow compatible with the regeneration capacity of resources and ecosystem services. Thus, the main emphasis is on the biophysical limits, but to respect this limit it is required a significant set of environmental and redistributive policies (table above). Although, this set of policies would demand a really strong State willing to implement radical changes.

The limits of radical changes driven by State are addressed by Degrowth, which discusses the political nature of transition. In this perspective, the State is not independent of capitalist system dynamics. Thus, although Steady State and Degrowth policies and measures are very similar, the direction of change is the opposite, since Degrowth emphasizes the role of social and political actors (Kallis et al., 2012). Instead of policymakers and governments technicians, bottom-up processes can drive changes. Finally, this perspective converges with post-normal science – highly relevant to ecological economics – that asserts that in contexts of high uncertainty and conflicting interests the science should enter the political arena.

The implicit economic approaches in ecological macroeconomics initiatives can be quite divergent, generating very different analyzes and proposals. Static models based on conventional macroeconomics have major limitations to analyze deep and complex transitions. Systems Dynamic models address these limitations, although sometimes from similar economic assumptions. Moreover, the differences between Degrowth and Steady State, notably the bottom-up *versus* top-down perspective, also reflect divergences in their underlying economic approaches. In Keynesian viewpoint, the State drives the policies that guarantee wellbeing. From the perspective of French *décroissance*, strongly influenced by Marxism, social transformations result from social conflicts. Further discussion of these differences is an indispensable step for additional advances in the field. In this sense, besides analyzing the suggestions for policy making, it is important to identify assumptions and implicit approaches in each initiative, opening them for discussions.

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