A New Perspective on Ethics, Ecology, and Economics

Donald L. Adolphson

ABSTRACT. This paper introduces the important concept of a biophysical perspective on economics into the business ethics literature. The biophysical perspective recognizes that ecological processes determine what can be done in an economy and how best to do it. A biophysical perspective places the economic system into a larger context of the ecologic system. This changes the perception of ethical issues by identifying a larger scope of management decisions. The paper examines the changing ethical landscape in such issues as biotechnology, planned obsolescence, productivity, and international trade. The paper also examines the shift in mindset associated with the shift in economic framework. It draws on the literature on cognitive structures and moral imagination to show this new perspective can actually raise the bar for ethical decision-making and behavior. The pattern is that the ethical behavior associated with a biophysical economic framework has a greater scope of responsibility with the benefit that the required ethical behavior leads to better long-term decision making.

KEY WORDS: Ecology, economics, natural capital, mental models, moral imagination

Donald L. Adolphson is currently a full professor in the Romney Institute of Public Management at Brigham Young University. He has a B.A. in Mathematics from the University of California, Berkeley (1966) and a PhD in Computer Science and Applied Mathematics from the University of Wisconsin, Madison (1973). His primary teaching responsibilities are teach Decision Analysis Courses to graduate students in MPA and MBA programs, at the University of Washington (1970-1981) and at Brigham Young University (1981 – Present). He has won numerous teaching awards and has published extensively in Applied Mathematics and Operations Research Journals. He developed and taught a course in Creativity in Business and is currently teaching Business Ethics courses. Current research interests are in applied Excel-based decision analysis, the interface of economics and ecology, and building a learning framework to develop visionary managers and leaders.

Introduction

This paper presents an alternate perspective on economics that highlights the interaction between the economic and ecologic systems and the ethical issues and provides a link between environmental and business ethics. Both fields are broad and large which provides some justification for keeping them separate. However, by keeping them separate, we miss important ethical issues that arise from the interaction between the environment and the economy.

Werhane and Freeman list environmental sustainability as one of the four most important topics in contemporary business ethics (Werhane and Freeman, 1999). Freeman suggests that much of the past dialogue about business and ethics has taken place along the lines of what he calls the Separation theory. A succinct statement of the separation thesis is that a business decision has no moral content a moral decision has business content (Freeman, 1994). Freeman suggests this separation is self-serving for both business practitioners and ethics academics, but that it is ultimately a bankrupt discourse, failing to get to the heart of important issues in business ethics. This paper is a step in reintegrating ethics and business by integrating economics and ecology.

This paper is stimulated by the development of a new framework for economic thinking, which can be described as a biophysical approach (Cleveland et al., 1984; Hall et al., 2001). This approach recognizes that "natural processes put limits on what we can do and how we do it" (Jacobs, 2000, pp. 96–97). From this perspective, value is grounded in the biophysical realities of energy and matter including the basic laws of thermodynamics. In contrast, conventional thinking about economics emphasizes the exchange of goods according to subjective human preferences.

The purpose of this paper is to examine the different ways in which business ethical issues are

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framed when one shifts from the willingness-to-pay perspective to a biophysical perspective. Section 2 of this paper will compare and contrast the biophysical approach to economics with the neoclassic approach to economics. Section 3 reviews important optimizing principles in business and in ecology that guide strategic decisions. The section also describes a generalized optimization principle that can serve as a decision-making guide for the interaction of economic and ecologic systems. Section 4 links the biophysical approach to the literature on cognitive structure such as mental models and to the literature on moral imagination to show how the new framework can translate into improved ethical decision-making and subsequent behavior. Section 5 outlines future work growing out of the work in this paper.

A biophysical perspective on economics

Embeddedness of economic systems

The foundation of a biophysical economics is that all economic activity originates in the material world and is subject to basic laws of energy transformations, especially the first and second laws of thermodynamics. These two laws are identified by Ehrlich et al. (Daly and Twonsend, 1993) as the foundation of a set of principles ''governing the bookkeeping by which one keeps track of energy as it moves through [various] transformations'''.

From this perspective, energy replaces money as the primary form of currency in measuring and tracking wealth. According to systems ecologist H.T. Odum, ''Everything which we regard as being of real value has to be produced and maintained by work processes from the [physical] environment, sometimes helped by people and sometimes not''. Odum's statement recognizes that all work that contributes to human well-being involves transformation of energy, whether or not humans are involved in the process. The work done for the benefit of humans which does involve humans is therefore a proper subset of all work; in other words, work involving humans is embedded in the larger system of all work done for the benefit of humans.

World Bank economist Herman Daly also argues that the economic system is embedded in an ecologic system. Daly's argument is that the ecologic system is both the source and sink of all economic activity and must be included in valuations of economic activity, if one is to avoid severe distortions.

Farmer and essayist, Wendell Berry articulates the same perspective in his essay on the ''Two Economies'' (Berry, 1987). Berry refers to industrial economy as the ''Little Economy'' to emphasize its dependence on nature's economy, which he calls the ''Great Economy''. He characterizes the little industrial economy as one which is (1) not comprehensive enough and (2) which tends to destroy that which it does not comprehend, and (3) depends on the things which it does not comprehend.

The biophysical approach to economics also supports the notion that an economic system is embedded in a social system. The biophysical approach considers the complete scope of work done for the economic well being of humans and recognizes that some of that work takes place in nature's economy, independent of human interaction. However, if we consider only the work done with human interaction, there are two distinct categories: that which takes place with the exchange of money and that which does involve an exchange of money. The human work without money takes place in the social systems and is based on familial and community relationships and norms. The human work done with an exchange of money takes place in the economic system of producers and consumers based on market prices and voluntary exchange.

From a biophysical perspective, work done for humans is the set of interest. The proper subset of work done for humans, but involving human interaction constitutes a proper subset of interest. Of the work done for humans, with interaction of humans, a proper subset of this work occurs with the exchange of money.

Types of work

The difference between conventional thinking about economics and the less familiar biophysical perspective can best be summarized by considering the types of work recognized by each framework. A biophysical perspective on economics recognizes that there are three types of work that contribute to human economic well being:

A. Work performed by humans accompanied by an exchange of money.
B. Work performed by humans without a direct exchange of money.
C. Work performed by nature independent of human interaction.

Examples of the first type are abundant and obvious – we see the first type of work whenever we buy a car, get a haircut, or buy stocks. The second type of work is equally abundant, even if the economic benefit is not always recognized; examples include a parent helping a child with homework, a family planting a garden, a neighbour visiting the sick, or any type of volunteer work in a community.

The third type of work is also abundant but is even more subtle since it takes place without any human interaction and is a frequently unrecognized, unless these processes are interrupted. The most basic type of ecological service is photosynthesis – the transformation by green plants of solar energy into chemical energy. Other types of ecological service include silent soil building processes, nature's water filtration through wetlands, or air filtration through trees. All of these ecological services provide economic benefit to humans, but without human interaction.

Types of capital

According to Lovins et al. ''The traditional definition of capital is accumulated wealth in the form of investments, factories, and equipment''. (Lovins and Hawken, 1999). This definition leads to the idea that capital can be thought of as the capacity for work – the more wealth you have accumulated, the more work you can get done. The traditional definition of capital has been expanded to each include non-financial forms of capital (Lovins and Hawken, 1999; Prugh, 1999). Thinking of capital as capacity for work, we can associate each type of work with a type of capital:

A. Capacity for human work with money: Financial Capital.
B. Capacity for human work without money: Human Capital.
C. Capacity for nature's work: Natural Capital.

We should note that our definition of human capital is broader than that used in the economics literature (see Lucas, 1988). The typical economics definition is restricted to individuals rather then communities or cultures, and focuses on education and training. Even this limited view broadens one's perspective of traditional forms of capital. According to Lucas, ''The idea of human capital seemed ethereal when it was first introduced … but after two decades of research applications of human capital theory we have learned to ''see'' it in a wide variety of phenomena … for me the development of the theory of human capital has very much altered the way I think about physical capital'' (Lucas, 1988, p. 35).

The term ''social capital'' is used in the sociology literature to refer to work accomplished through social norms and institutions, that impacts the economy, but without direct economic incentives (Coleman, 1988). The paper by Coleman, notes the over-emphasis on the individual in the economics literature and the over emphasis on social norms in the sociology literature. His paper is an attempt to integrate the two perspectives into a single framework.

The work by Lucas and Coleman and others is important in expanding the scope of a framework for thinking about economics, but both leave out the role of nature's processes that has an economic value, even without any interaction with humans. Several authors have recognized the need to include this type of work to develop a realistic framework for thinking about economics and wealth. These authors

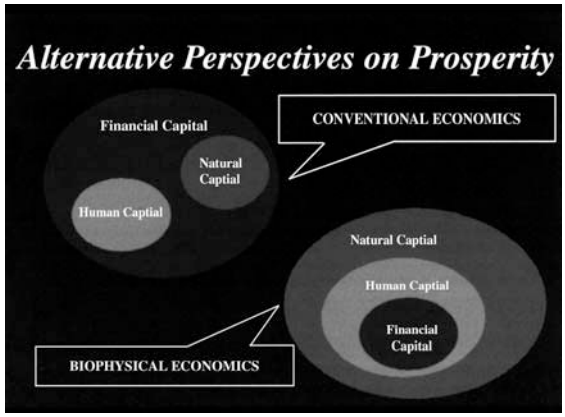

Figure 1. Two views on embeddedness of the economic system.

include Odum (1996), Hall (1995), Daly (Daly and Townsend, 1993), and Georgescu-Roegen (in Daly and Townsend, 1993).

Figure 1 shows the relationship among these types of capital from conventional and biophysical frameworks for economics. In the conventional framework financial capital becomes the focus because it is the most tangible ana readily measured. It is dominated by the concept of financial capital, while human and natural capital are defined narrowly to fit within this framework. Human capital is virtually equivalent to labor and natural capital is usually synonymous with natural resources in this framework. From a biophysical perspective, natural capital is the foundation for all wealth, including all sources of energy as the primary focus. Human capital in the form of labor and intelligence and community and culture is added to the natural capital. Financial capital is important, but is ultimately built upon a solid foundation of natural and human capital. According to a valued colleague, ''natural and human capital form the invisible arm that drives the invisible hand'' (S. Peck, personal communication).

Optimizing principles

The contrast between the two perspectives on economics can be highlighted by the operational principles to turn these perspectives into strategy and policy and action. Both perspectives have optimizing principles that translate concept into action.

Maximum profit principle

A guiding principle of neoclassic economics is to create and implement strategies that maximize profits. The principle was most forcibly stated by Friedman, who said that ''there is one and only one social responsibility of business – to use its resources and engage in activities designed to increase profits so long as it stays within the rules of the game, which is to say, engages in open and free competition without deception or fraud'' (Novak 2002, pp. 140-141) The moral justification for the principle is twofold. First it fulfills a commitment to investors who are expecting the firm to do everything it can to maximize its return. Second, according to economic theory, if each individual firm acts in a way that maximizes profits, the result is the best overall allocation of resources within the larger community.

Basic maximum power principle

Friedman has identified a principle that applies to work done within the formal economy. Decades before Freidman stated the maximum profit principle, the biologist, Alfred Lotka, formulated a guiding principle called the maximum power principle (Hall, 1995, p. xiii), that applied to all natural systems but included only work done by nature, independent of human interaction:

> Natural systems adapt in a way that captures and uses all sources of energy as effectively as possible.

The evidence of the maximum power principle is ubiquitous. The maximum power principle dictates the height and structure of a tree, the shape of a leaf, or the configuration of a bird. It is the principle which drives evolution and living systems that fail to use resources in conformance with the maximum power principle, must either adapt or die. Similarly, a business that is not using its resources in a way to maximize profits must either adapt or die.

To summarize, Freidman proposed a normative optimizing principle that applies only to work done by humans for pay, while Lotka proposed a discriptive optimizing principle that applies to work done by nature for free. What is missing is a normative optimizing principle that applies to the interaction between the economy and the environment.

Extended maximum power principle

The missing link has been supplied by systems ecologist, Odum, who spent a lifetime (1924–2002) studying the interaction of economic and ecologic systems. Odum recognized the value of all three types of work described in the previous section and sought to develop a guiding optimizing principle that applies to the combination of all types of work.

Odum recognized that money cannot serve as a common denominator for all types of work since nature performs work without the exchange of money. Energy, however, can serve as a common denominator since all work, whether done by humans or nature, must be accompanied by an expenditure, or more accurately, a transformation of energy (energy is never really expended, only transformed into useless energy, known as entropy). Since Lotka's optimizing principle for living systems is energy based, Odum's approach was to extend the maximum power principle to include work done by humans as well as work done by nature:

> Those human–nature partnerships that capture and use all sources of energy as effectively as possible will be the ones that will be economically viable, in the long run.

Human partnerships with nature

The extension of the maximum power principle takes into account an important distinction between nature's work and human work: choice. Nature, at least from a human perspective, responds to inviolable natural laws, while humans exercise agency and conscious choice. According to Odum, the best strategy for organizing human economic systems is to "Let nature work for you … that's the key. Wherever you are in the world, you find out what the natural cycle is and how you fit into it, developing a partnership with nature". (Hall, 1995, p. 99). Humans are free to organize our economic activities in ways that are or are not consistent with the maximum power principle. However, those system designs that are more in alignment with the extended maximum power principle will be the ones that will prevail in the long run.

In addition to identifying basic principles, Odum has also designed an energy based accounting system that provides tools for optimizing the effect of human and nature's work (Odum, 1996). This accounting methodology is grounded in the laws of thermodynamics which provide the underlying principles for keeping track of energy as it moves through various transformations.

Odum's partnership ideas have been implemented for several decades in his own state of Florida. One such project deals with the massive amount sewage generated at Walt Disney World. That sewage is now treated by ecological engineering ideas derived by Odum to optimize the effectiveness of the partnership between humans and nature. The human/nature partnerships are in the form of wetland restoration to filter water for human use. The human work in such projects is to increase to capacity of natural capital to do its work. The result is better improved habitat at lower costs to complete the task. Projects such as this eliminate ethical issues of tradeoffs between the economy and the ecology by creating win–win solutions by simultaneously strengthening economic and ecologic systems (Brown, 1999).

Humans are free to choose wisely to partner with nature in mutually effective ways, but we are also free to ignore or even interfere or destroy the work of nature. However, humans are not free to choose the consequences of our actions. The penalties for violating natural laws are real and irrevocable and we, as a culture will surely bear the consequences. Odum's student and disciple, Charles Hall, points to many failed civilizations and offers the observation that "… any civilization that believes it can assign value independently of the laws of nature and the dictates of resources can do so only in the short term" (Hall, 1995, p. 205).

Odum's ideas form the foundation of a biophysical perspective on economics that alters the ethical landscape by including human work without pay (Type B) and work done by nature without human intervention (Type C). The new ethical landscape requires a greater sense of responsibility from market participants, consumers as well as producers. The reward for assuming the additional ethical responsibility is that choices made are more consistent with long-term well-being.

Conflicts between maximum profits and maximum power

The biophysical perspective on economics highlights certain features that are not emphasized in a neoclassic approach to economics. As a result, in certain settings, ethical components of some management decisions that may be muted from a neoclassic perspective are highlighted by a biophysical approach. We offer two short examples.

Terminator technology: Destruction of natural capital. ''Terminator Technology'' is the name given to genetically modified plants designed so that the seeds become sterile after the first year (Shiva, 2000, pp. 82–86). This strategy is an ultimate form of planned obsolescence, requiring customers to purchase seeds year after year, rather than to save nature's free seeds from 1 year to use the next. The potential negative impact on impoverished societies received much attention, which forced developer Monsanto to withdraw the technology after intense protests by activist groups. However, continued research in this technology has been approved by the USDA and may still reach the marketplace (Shiva, 2000, p. 84).

The terminator technology is an extreme example of the misuse of natural capital: beyond blindness to the benefits provided by natural capital, beyond waste of natural capital, the terminator technology deliberately creates shortages to increase demand and price by interfering with nature's processes that others are depending on for sustenance and survival.

Much of the traditional business press, operating from the paradigm of conventional economics, has focused on legal issues surrounding patent rights, but a biophysical perspective highlights the cost borne by those whose base of livelihood is being destroyed for the purpose of private gain for the corporations owning the technology and the stakeholders of these corporations.

Single use cameras: strategic waste of natural capital. Large photography firms such as Fuji and Kodak have created a product line of convenient, disposable, or single-use, cameras. The single use is more a marketing strategy than a technological issue. In fact, several companies have refurbished so-called single-use cameras, and have resold them at prices considerably lower then those of first use disposable cameras. John Benun, founder of JazzPhoto Corporation, boasts that he can squeeze as many as eight uses out of a single-use cameras (Bandler, 2002). The big companies such as Fuji and Kodak have succeeded in driving most of the recyclers out of business through violation of copyright laws, but JazzPhoto remains a thorn in the side of the larger companies. Fuji argues, ''single-use cameras were never intended to be fixed'' (Bandler, 2002).

A biophysical perspective highlights that strategies that create short-term value by artificially limiting effective use of natural resources inevitably result in the waste of natural capital. It also highlights the fact that, as a species, we live on a finite energy budget and that natural capital that is purposefully wasted now will not be available to provide sustenance for current and future generations. Purposeful waste of public natural resources does the same harm as purposeful destruction to future beneficiaries or these resources.

Writing from a thermo-dynamics biophysical perspective, Georgescu-Roegen states:

> Every time we produce a Cadillac, we irrevocably destroy an amount of low entropy [or, available energy] that could otherwise be used for producing a plow of a spade … Economic development through industrial abundance may be a blessing for us now … but it is definitely against the interest of the human species as a whole, if its interest is to have a lifespan as is compatible with its dowry of low entropy [or, available energy] (Daly and Townsend, 1993, p. 85).

Changing behavior

Cognitive structures

We argue in this section that augmenting the conventional view of economic behavior with a biophysical approach will lead to better ethical practice. We base our argument on the literature that links mental models and other cognitive structures to ethical behavior and show how new mental models, consistent with a biophysical approach to economics, help decision makers to more fully understand the impact of their decisions, before decisions are made.

First we must establish the context for this argument. The essential context is that we do not experience reality directly and objectively, but only through our own conceptual schemes and mental representations of our experiences. These ideas are based on the work on sensemaking by Weick (1995) and others and the work on mental models by Senge (1991) and others.

Sensemaking can be defined as ''placing stimuli into frameworks … that make sense of stimuli'' (Starbuck and Milliken, 1988, p. 51). Mental models are the mental representations that we carry around

Figure 2. Relationship between sensemaking and mental models.

in our minds of our experiences. Thus, the response to a given stimulus is determined not just from the nature of the stimulus but by the way that the stimulus interacts with our mental models. This relationship is shown in Figure 2 and accounts for differences in responses from those receiving the same stimulus.

Two short examples illustrate this point. A short piece appeared on the front page in the Wall Street Journal on January 31, 1995 (WSJ, 1995), under the headline ''Drug Companies Suffer a Case of the Sniffles''. The piece notes the bad news that revenues were lower than expected for drug companies because of a light flu season. The piece concluded with the hopeful observation that there were still 6 weeks in the flu season and that it might still be a good flu season. The unstated question was whether or not it is good for more people to catch the flu so that drug sales will be higher.

A similar example occurred in December 2003 as the first case of mad cow disease in the United States was announced (Sappenfield, 2003). Response by the media and public statements has been mixed. The most frequently expressed concern is about the financial risk to the beef industry rather than to the public health risk to the nation. Because of this focus, discussions of responses to the problem are more focused on what to do to maintain consumer confidence in the beef industry than on what to do to insure a safe supply of beef.

In both cases, one concern is for the financial well being of the relevant industry, while the other concern is for public health and safety. While mental models are not subject to direct observation, one can infer something about a mental model by observing the stimuli and corresponding responses. In this case, the revenue concerns expressed for the drug and cattle industry are consistent with the neoclassic embeddedness relationship of the social and ecologic systems being subsystems of the economic system. On the other hand, the public health responses in both cases are consistent with the biophysical embeddedness relationship of the economic system being subsystem of both the social and ecological systems.

Gioia (1992) offers further insights into the effect that cognitive structures have on ethical behavior, coming from the unique perspective of one who was involved in a highly publicized ethical dilemma, the recall of the Ford Pinto in the 1970s, and also has had the opportunity to pursue an academic career that has provided time to reflect on the dilemma. As Gioia teaches the Pinto case that he has written, he cringes as some students offer the simple explanation that he was guilty of moral failure. This is clearly one viable explanation for any ethical misdeed, but it does not offer much help for those looking to help people having strong grounding to avoid acting counter to those beliefs.

Gioia offers an alternate explanation based on the power of invisible cognitive structures to influence decision-making. From the opportunity to reflect on his experience on the front line of recall decision-making, Gioia now understands the power of prevailing, but invisible, cognitive structures to influence behavior. Gioia defines a *schema* as a cognitive framework that people use to impose structure upon information, situations, and expectations to facilitate understanding. This is essentially equivalent to a mental model. He identifies a *script* as a special type of schema that retains knowledge of actions appropriate for specific situations and contexts. Gioia emphasized that scripts not only provide a cognitive framework for understanding information, but also serve as a guide to behavior in particular situations and contexts.

Gioia's central thesis to explain his behavior as the recall director was that his own scnematized knowledge unconsciously influenced him to perceive recall issues in terms of the prevailing decision environment. When the issues are perceived in these terms, features that do not fit the existing script can

easily get overlooked. Although the outcomes of the case carried ethical overtones that were obvious in retrospect, the schemas driving his perceptions and actions precluded considerations of the issues in ethical terms because the scripts did not include ethical dimensions.

Gioia identifies the most damaging part of the prevailing script that hampered his ability to see the moral dimension of the recall decision process was the part that said in effect: ''No emotions allowed in the decision-making arena''. This part of the script muted Gioia's attempts to argue for recall from photos of burned up Pinto cars.

Gioia acknowledges the necessity of organizing decision information into schemas, for without the schema, the sheer volume of incoming information would overwhelm the decision maker. Given the necessity of cognitive schema to organize information, the challenge then is to develop within manager's an ability to recognize the mental models that are operating in their decision making processes, and to evaluate and alter or even replace existing mental models to fit the particulars of the current decision.

Systemic mental models

Within this context, we can now make the case that a biophysical perspective will lead to better ethical behavior. The work of management consultant Peter Singe is relevant to our discussion here. Senge has recognized the need for modern organizations to take a more systemic approach to management decision-making. He has identified five key attributes that managers must develop in they are to be successful in the dynamic and complex business environment that exists today. One of these key attributes is the ability to recognize the mental models that they are operating in and, when necessary to create new mental models that will allow them to be more effective managers. Through much experience in training managers to recognize the mental models that are operative in their decision-making, he notes that:

> The impact on managers' understanding is profound – most report that they see for the first time in their life that all we ever have are assumptions never 'truths' that we always see the world through our mental models and that mental models are always incomplete, and especially in Western culture, chronically nonsystemic (Senge, 1990, p. 185).

Assumptions easily get mistaken for truth when the assumptions operate below the level of awareness. For example, if one knows a single language, questions about that language are likely to surface, but questions about language itself are not so likely to surface. If the language is English, one may note that the language contains nouns and adjectives and that adjectives precede nouns. One may assume that all human languages contain nouns and adjectives and that adjectives always precede the noun they modify. This assumption may be below the level of awareness in which case questions about the sequencing of nouns and adjective would never surface. But, when one is introduced to a new language such as Spanish, it becomes apparent that nouns and adjectives still exist but the sequencing is altered. It is at this point that the person becomes aware of their assumption that adjectives always precede nouns. This is the kind of experience that Senge's managers experience, when for the first time in their lives they begin to recognize how many of their decisions are made on automatic pilot without any real visions of other opportunities.

Another critical insight gained by Senge managers is that their decision-making frameworks are chronically non-systemic. This means that their frameworks focus on strict causal relationships among the parts of a system. The appeal of such models is that they are neat and clean and easy to understand. The drawback is that they fail to represent much of what is happening in the real system. The model assumes simple causal relationships, but in reality we have intricate webs of interacting variables. The model assumes and independent system, but in reality we have nesting set of subsystems at multiple levels, with interaction between the subsystems.

A biophysical perspective on economics is in a real sense a second language for describing economic activity. It is an energy-based language rather than a money-based language. Furthermore it is systemic because it recognizes that economics can best be understand by considering the systems of which it is a subsystem and because it recognizes that economic activity involves a web of interacting forces. Being a

distinct second language from the conventional neoclassic approach, important questions surface in this context that would not otherwise arise.

Mad cow disease provides a vivid example of the contrast between systemic and non-systemic decision frameworks. The disease is caused by feeding practices that were instituted as a cost cutting measure (Sappenfield, 2003). From a non-systemic perspective, the cost cutting looks good because it appears that it will increase margins and profits and allow the industry and firms in it to prosper. From a systemic approach, the health risks to the cattle and to the potential customers of the beef industry are considered as a key part of the model. If the cattle all die, or if enough customers stop eating beef to avoid serious illness, then the short-term gains from cost cutting feeding practices mean little. A systemic approach to decision making on feeding practices may have avoided the whole disaster with the British beef market, with both producers and consumers better off.

Senge's process of raising awareness of mental models and their characteristics is designed to promote more effective decision-making, but there is no explicit moral component in his awareness raising process. Systems thinking and systemic decision models may improve ethical behavior, but there is no causal link between increasing awareness of mental models improved ethical behavior. For example, if one augmented an existing amoral mental model with another amoral model, ethical behavior would not necessarily improve. However, if one augments an existing amoral mental model with one that has a clear moral dimension, then ethical behavior is likely to improve.

Moral imagination

Werhane recognizes that systems thinking alone will not improve ethical behavior, therefore she argues that systemic models must be augmented with moral imagination to create a methodology that injects a moral dimension into ordinary business decision-making (Werhane, 2002). She defines moral imagination as the ability to "perceive that a web of competing economic relationships is, at the same time, a web of moral relationships" (Werhane, 1999, p. 5).

Werhane also notes that the moral aspect of moral imagination includes "searching out places where people are likely to be hurt by decision-making or behavior of managers" (Werhane, 1999, p. 5). It is this moral aspect or proactively searching for those who would be harmed by our decisions that links moral imagination to a biophysical perspective of economics. Essayist Berry (1987) also notes this link when he describes how seeing the smaller industrial economy in the context of the larger economy of nature, helps us to see that industrial wastes and losses are not just "trade-offs" or "necessary risks" but they are "costs that, like all costs, are chargeable to somebody sometime" (Berry, 1987, p. 71). Biophysical economic analysis does precisely what Berry speaks about: it identifies what the real costs are and who will bear those costs. A mental model that highlights such features of a problem cannot guarantee better ethical decision making, but it at least provides that type of information that a moral decision maker would want to have.

To summarize the argument to this point, Senge shows that as manager's become more aware of mental models and their properties, they become more systemic in their thinking, which prepares them better to see moral dimensions in economic decisions. Gaining an awareness of mental models is like preparing the soil for good ethical behavior, but in order for the soil to bear fruit in terms of improved ethical behavior, an ethical seed must be planted. Werhane identifies the development of moral imagination as the moral seed to be planted in the soil prepared by a systemic view of the situation. She identifies one important attribute of moral imagination as the ability and the will to search out the places where people are likely to be hurt by managerial decision making. Berry shows that recognizing that the formal economy is embedded in nature's economy, makes clear consequences of our decisions are not just side effects, or what economists euphemistically call external costs, but they are real costs borne by someone, somewhere. Finally, a biophysical perspective on economics with accompanying energy accounting tools provide the tools for carrying out the search out and identify those who bear the externalized costs of management decisions.

Summarizing in the opposite direction, biophysical economics provides tools to search for the bearers of externalized costs, which makes these costs more real in the mind of decision makers. The ability to identify such costs is an important element in developing moral imagination, which is a necessary step in the

integration of moral elements into the management decision process. The integration of moral elements requires the development of new mental models and associated behavioral scripts. The changing of the scripts associated with new mental models is the bottom line connecting a biophysical approach to economics with improved ethical decision making.

Foresight and ethics

The previous examples show that a biophysical perspective on economics requires a broader sense of responsibility than that required from the conventional economics framework. Robert Greenleaf, founder of the Servant Leadership Institute and lifetime observer of management and ethics, sets a standard consistent with the bio-physical perspective:

> The failure (or refusal) of a leader to foresee may be viewed as an ethical failure, because a serious ethical compromise today (when the usual judgment on ethical adequacy is made) is sometimes the result of a failure to make the effort at an earlier date to foresee today's events and take right actions when there was freedom for initiative to act. The action which society labels 'unethical' in the present moment is often really one of no choice. By this standard, a lot of guilty people are walking around with an air of innocence that they would not have if society were able to pin the label 'unethical' on the failure to foresee and the consequent failure to act constructively when there was free to act. (Greenleaf, 1998, p. 130).

Greenleaf's observations about foresight show that foresight is a form of moral imagination - seeing the unseen moral dimensions of decisions made now so that we do not get caught in a lose–lose situation later. It raises the ethical accountability from what is known to what is knowable. This is a standard compatible with a biophysical standard.

The implications of not following the higher ethical standard set by the biophysical perspective can be illustrated by the case of the cod fishing industry along the Atlantic shores of Canada. The Grand Banks area of the North Atlantic off Newfoundland has provided food and employment for local communities for over three centuries. The cod seemed inexhaustible until the late 1960s, when the quantity and average fish size began to decline. Fishery scientists, ecologists, and even some of smaller fishermen recommended a strategy that included a period of reduced fishing to allow the replenishment of the fish populations and to heal damage done to habitat. Unfortunately, market signals were distorted by government subsidies and the fish harvests kept increasing until the whole industry completely collapsed in 1992. The result was disastrous in terms of financial, human, and natural capital (Jacobs, 2000, pp. 96–97).

This example is subtler than the previous examples. There was no intent to destroy or require waste of natural capital. The strategies pursued by producers and consumers were consistent with market signals that failed to reflect the pending disaster. Government official were acting in according with well established policies for supporting a local industry. However, the pending disaster was foreseeable, even if not foreseen. The costs of fishing were badly distorted by government subsidies, which in turn kept market prices artificially low, which led to demand exceeding the supply of fish.

The question then is whether or not the market participants, consumers as well as producers, were acting in an ethical manner. From a conventional economics framework, consumers and producers were merely acting in their self-interest according to the market signals easily available to them. If the prices were distorted by the government subsidies, then one could argue that the fiasco was the government's fault, not the market participants'. This rationale has some credibility since the government clearly bears at least a portion of the accountability.

Since our primary intent here is on business decision-making, we will focus our attention on the producers in the cod fishing industry, but this in no way is meant to absolve either the government or the consumers from their accountability in the disaster. Producers were operating within a free market mental model. A part of this mental model the maximum profit principle which is that the only social responsibility of a business is to maximize profits, provided that it play by the rules of the game, which involves open and free competition without deception or fraud. Once government subsidies are in place, they become, in this mental model, parts of the rules of the game. Given these rules, the profit maximizing strategies for many of the larger fishing companies was to invest in new equipment to allow them to capture more fish more quickly.

In generalizing from his experience as a Ford recall coordinator, Dennis Gioia, notes that scripted decision-making is necessary to deal with the amount of information in most organizations. He observes that scripted decision-making is efficient from the perspective of time needed to make a decision, but there is no guarantee that the quickest decision is the best decision (Gioia, 1992, p. 386). Scripted decision-making tends to perceive those features of a particular problem that fit the script, but tends to dismiss anomalous information. He concludes, ''Scripts offer a viable explanation for why experienced decision makers (perhaps, especially experienced decision-makers) tend to overlook what others would construe as obvious factors in making a decision''. (Gioia, 1992, p. 386).

Returning to the cod-fishing example, it would be obvious to most that catching more fish is not a proper response to ecologic signals that both the quantity and size of fish caught were declining. This information was available to corporate decision-makers, but was not a part of management decision-making models and associated scripts of the cod fishing industry. What was part of the corporate decision-making models and associated scripts is that moving to larger scale would spread fixed costs over more units, this reducing average cost per unit. Signals consistent with this script were perceived and acted upon, while signals that did not fit this script were not perceived and therefore not acted upon.

Giving the benefit of the doubt to the corporate decision makers involved in the decision to fish faster in the face of declining catch, we assume that the decision making scripts blinded the decision makers from seeing the full consequences of their decisions. The blindness would either be in the form of not noting who might be hurt or of being blinded to short run tangible benefits to optimistically estimate negligible probabilities of industry collapse. In either case, the decision did not qualify as moral imagination in the sense referred to by Werhane because they did not include a willingness to search out those places where people would be hurt by their decisions, or if they did, they included a willingness to ignore the harm done to others.

The most damaging part of the prevailing script in issues at the interface of economics and ecology is not the existence of the neoclassic approach, but rather the part of the script that indicates that *nothing but* a neoclassic approach is needed to make wise and moral management decisions. The neoclassic approach clearly adds value and insight to economic decision-making, but when one accepts the notion that nothing but this approach is needed to bring ethical issues to the surface, then important ethical dimensions are missed. The added value of a biophysical perspective on economics is that it puts the economic activities into a larger context, which brings ethical issues to the forefront that would not be highlighted without the biophysical perspective.

The issue looks different from a biophysical perspective and the compatible ethical standard set by Greenleaf. The ecological analysis of the cod fishing industry reflected the biophysical realities that the supply of fish could not keep up with demand and recommended reduced fishing for a period to allow the fish supply to regenerate. This information was knowable, even if unknown. However, the highly relevant ecological information never filtered down into the minds of consumers, and therefore, the market signals sent by consumers indicated a continued high demand. And with incomplete and inaccurate information, the values reflected by consumers in this market failed to incorporate the biophysical realities. The market was able in the short run to ignore the biophysical realties, but not in the long run.

This example reinforces an important lesson. Behavior deemed ethical by a biophysical perspective leads to long-term well-being. In contrast, if one acts ethically from an economic perspective while being blind to biophysical realities, the actions can lead to sudden and unpleasant consequences for individuals and even whole communities.

International trade

A key tenet of conventional economic theory is a faith in unfettered international trade as a key to prosperity. The moral justification for trade is that trade is mutually beneficial, giving the more developed nation access to less expensive labor while raising the standard of living in the less developed nation. This rationale is used to justify policies that may harm the developing nation in the short run, with a promise of higher standards of living in the short run.

The logic of trade, from a conventional economics perspective, is that if voluntary trade takes

place, it must be mutually beneficial. However the logic only holds if both parties understand the value of what they are trading. Biophysical analyses reveal that conventional economics underestimates the value of all products and services being traded since it fails to account for the free work of nature that is invested in a good or service.

Biophysical analyses of international trade (Hall, 1995; Odum, 1996) reveal a built-in bias against the less developed trading partner. This is true because the less developed partner is usually more dependent on nature and therefore, has a greater proportion of nature's free work invested in their products. If the value of nature's free work is ignored, the trade appears to be fair, but when it is included, the less developed nation is trading more value than is received. With this bias in place, a trade that appears to be mutually beneficial will often be unfair to the less developed nation.

We will expand on the general principle above by considering a retrospective biophysical analysis of Ecuador's Shrimp Mariculture industry undertaken by Odum at the request of Stephen Olsen, a resource manager at the Coastal Resources Center at the University of Rhode Island (Hall, 1995, pp. 207–215). Olsen recognized that one could not model a system of interest (Ecuadorian Shrimp Mariculture) without modeling the system that contains it (Ecuador).

The analysis of Ecuador revealed that Ecuador is rich in natural resources with a high potential for generating wealth for human societies. Population density is relatively low and population growth is high. Oil was discovered in the 1970s fueling rapid growth of export income. The GNP was $1.1B in 1965 and grew at an annual rate of about 11% to $11.5B in 1985. From the perspective of traditional economics, this is a respectable growth rate and should be reflected in a higher quality of life for the citizens of Ecuador.

However, rising GNP and rising quality of life do not always go together. It is possible for a set of policies and practices to appear to be generating prosperity, as measured by an increase in financial capital in the formal economy but result in larger losses of human and natural capital. Odum's biophysical analysis of Ecuador shows that this is precisely what has happened with the development of the Shrimp Mariculture Industry along the coasts of Ecuador. According to Olsen, the cost of basic necessities for the poor has escalated; residents of Guayaquil no longer have access to inexpensive, shrimp, mangrove oysters, or crabs. Fish that were large and abundant 20 years earlier are now small and scarce. Mangrove poles used to build houses are also scarce now where they were abundant.

A biophysical framework for economics highlights the important truth that wealth always comes in the form of energy; even money does not represent wealth unless it can be exchanged for real wealth in the form of energy. Therefore, to be able to meet ones needs and to generate a surplus to move beyond subsistence one must have access to energy in the form of food, air, water, fertile soil, shelter, etc. For the poor, much of this accessible energy is outside the formal economy. What this means is that management decisions made on the basis of conventional economics which only measure the amount of economic activity in the formal economy, may well increase the activity in the formal economy, but with a greater decrease in the economic activity taking place in the informal human economy and in nature's economy. This is precisely what was happening, at least on a local level, with the development of the Shrimp Mariculture Industry.

The ethical questions surrounding international trade would change radically in circumstances where the practice of free trade is shown to be harmful to the less developed nation. In these cases, what looks like fair trade to the benefit of both really is exploitation of the weaker nation. In such cases, either the trade arrangements need to be altered or the moral justification needs to be re-examined.

It is beyond the scope of this paper to sort out these complex economic and ethical issues surrounding international trade. The purpose of this example is merely to show how the ethical landscape looks much different from a biophysical perspective than from a neoclassic economics perspective and to stimulate dialogue about the fairness of the exchange in international trade.

Conclusion

This paper has introduced the concept of biophysical economics as a new way of thinking about issues at

the interface of economics and ecology and has shown how this perspective alters the ethical landscape. It does this by showing that the scope of management decision is broader than may have been expected and that harm done to specific people can be traced more effectively than before. This leads to a broader sense of responsibility to match the broader scope of business decision-making.

In many ways, this paper has just touched the tip of the iceberg in terms of re-examining the ethical issues that arise at the interface of economics and ecology. The final example that touches on new insights into the fairness of international trade has extremely important consequences and future research should address these issues in greater detail than was given here.

There is much more to be studied about how the way we frame economic activity affects the way that we think about ethical issues in business. For example, Nelson and Winter have given a thoughtful critique of the neoclassic framework and have proposed and alternate evolutionary theory of economic change (Nelson and Winter, 1982). The evolutionary theory may complement nicely the biophysical approach. The whole area of socially responsible investing has not even been touched on in this paper, but insights from a biophysical perspective may offer important insights and guide to practice in this arena.

In conclusion, a biophysical perspective on economics broadens the scope of business decision-making and the ethical issues associated with such decisions. It defines a fruitful area for further research to examine business ethics issues that occur more and more frequently at the interface between economics and ecology.

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Romney Institute of Public Management,
Brigham Young University,
Provo, UT 84602
U.S.A.
E-mail: donald_adolphson@byu.edu