The Economics of Needs and Limits

A theory for sustainable well-being

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Preface

Economics is the study of humankind's production, consumption, and related matters. Today the word is used primarily in reference to standard or mainstream economics, which addresses these topics from the capitalist perspective. As discussed in my book *Youth Ecological Revolution*, capitalism must be urgently superseded if the young are to have any chance of surviving the ecological crisis. This shift can succeed only if a sustainable economic theory is available to guide the transition. My proposal for this new theory, the Economics of Needs and Limits (ENL), is the subject of this book.

My initial motivation for developing ENL was an incident at Simon Fraser University, where I studied economics in the early 1990s based on my environmental concerns. At the time I was still a progressive, and one day I was challenged by a conservative professor to support my classroom assertions with a progressive economic theory. This didn't exist, so I was unable to respond. Deeply humiliated, I resolved to fill this massive gap. The initial result was called Progressive Economics. After a few years this was changed to Human Economics, and about a decade later I settled on ENL.

My first book on ENL was self-published in 2007. Five editions were self-published subsequently, making this the seventh. However, my work has been almost completely ignored, so I am treating past versions as personal struggles to produce the final version presented here. In that sense, this is the book's first edition.

The main change to ENL over the years has been to rid the framework of its progressive bias. Standard economics is deeply compromised because it smuggles capitalism's ecocidal logic into its analysis. ENL was at first similarly tainted because it smuggled progressive values into its principles. This is a fatal error because it alienates conservatives who reject these values, but whose participation will be required to achieve a sustainable world.

The reader will likely find the text to be succinct and even terse. This is intentional: the absence of superfluous details focuses attention on the facts presented and the logic applied. In my experience authors frequently use verbosity to mask logical incoherence. Even if this is not the case, such elaborations make it difficult to follow the author's precise train of thought.

The full development of an economic theory is beyond the capacity of one person. This book is therefore intended as the starting point for a robust and comprehensive theory for sustainable well-being. My hope is that I have taken the first steps in the right economic direction, and that strong analysts will soon correct, extend, and deepen my preliminary ideas.

Frank Rotering
Gabriola, Canada
September, 2021
ecologicalsurvival.org

Introduction

A. THE URGENT NEED FOR A SUSTAINABLE ECONOMICS

As stated in the preface, my initial motivation for developing ENL was the absence of a progressive economic theory. However, its primary purpose at this point is to help the young survive the ecological crisis. Considered more broadly, ENL's main goal is to help prevent ecological collapse in the hope of preserving humankind's civilized existence on this fragile planet.

Humankind has so far done exactly what all biological species do: increase its consumption, population, and global range to the maximum possible extent. Because of our unique intelligence and thus our capacity for continued expansion, it was inevitable that we would one day violate the Earth's natural limits. This in fact occurred in the 1950s when greenhouse gas concentrations exceeded their long-term maximum levels and ecosystems began their rapid decline. To prevent the collapse of societies and the untold misery that would result, humankind must rapidly shift from its expansionary past to a contractionary and then stable future.

Standard economics cannot serve this purpose because it reflects the growth-based logic of capitalism - the system that now dominates the global economy. Although the standard discipline is useful for analyzing markets and economic behavior, it lacks the concepts and analytical tools required for sustainability. The same is true for ecological economics, which arose in the late 1980s as a response to the environmental ignorance of mainstream thinkers. The field correctly locates the economy within the natural world, but it clings to mainstream assumptions and cannot achieve the optimal economic scale it purportedly seeks.

Given this theoretical landscape, a new economic theory is now an existential necessity. Valid economic ideas from our expansionary past must be retained, but novel ideas and methods for our post-expansionary future must be quickly introduced. These considerations have guided ENL's conceptual development.

B. ENL'S CORE FEATURES

Although the fact has long gone unrecognized, a complete economic theory must include two distinct conceptual frameworks. One is required to establish the economy's rational objectives given its stated goal, and another is needed to analyze its operations as these objectives are being pursued. I call the first a *guiding framework* and the second a *functional framework*. ENL is a guiding framework with the goal of sustainable well-being. A functional framework to analyze ENL-based economies will also be required, but this important work - which will presumably be based on mainstream concepts - must be left to others. I briefly discuss its development in chapter 10.

The ENL framework is *independent* in that it is based on the core attributes of humankind and nature. It therefore has no connection to capitalism or any other economic system. If the need for such a framework had been recognized a thousand years ago, it could have been developed at that time. In this respect ENL differs sharply from ecological economics, which is a modification of the standard theory and is thus linked to capitalism in numerous ways.

ENL is *socially neutral*. This is the result of my protracted effort to dissociate the framework from its progressive origins so as to gain support from across the political spectrum. Social neutrality means that the conservative view of society, which values individual freedom over social solidarity, is treated with the same respect as the progressive view, which values solidarity over freedom. As one important consequence, ENL does not define well-being, but instead provides the concepts required for socially-specific definitions. This approach avoids the imposition of values and norms that could disastrously alienate one side or the other.

The ENL framework also adheres to the principle of *technological neutrality*. This means that economic progress refers exclusively to increases in sustainable well-being. Factors such as economic growth, greater scientific knowledge, and rising technical sophistication are thus seen as irrelevant in this regard. For this reason, ENL's terms, concepts, and analytical tools make no implicit judgments about a society's level of scientific or technological development. Instead, a society's technologies are factually characterized as varying from a low to a high level of complexity.

ENL is also intended to be rigorous and coherent so that it can serve as a solid foundation for future development. The book thus defines new and unfamiliar terms as they arise, carefully adheres to these definitions throughout, and includes a detailed glossary.

C. REBUILDING AFTER ECOLOGICAL COLLAPSE

As emphasized above, ENL's primary aim is to help the young survive the ecological crisis by preventing environmental and social collapse. However, as this is being written in the summer of 2021, it is increasingly evident that environmental collapse has already begun. Widespread floods, droughts, storms, and unprecedented heat are now destroying the infrastructure that undergirds civilized life. It is therefore necessary to consider ENL's potential role in rebuilding societies on a sustainable basis if the destruction continues. Two points must be made in this connection.

First, the militant struggle for youth survival, as described in *Youth Ecological Revolution*, remains critically important even under these rapidly deteriorating conditions. If ecological collapse cannot be halted, it can be minimized. If civilization cannot be maintained, some form of organized human life can perhaps be salvaged. To achieve even these modest aims it will be necessary to replace capitalism's growth-obsessed leaders and demand the rapid implementation of the rational crisis response.

The second point is that some aspects of ENL were developed from the rebuilding perspective. At various points I imagined how the resources of a newly-discovered island might be sustainably exploited as its population grew and its economic activities expanded. This was done for conceptual clarity rather than social restructuring, but the analytical results are the same. I conclude that, if organized human life can be maintained or restored, a mature form of ENL could play a central role in restoring the global environment to a sustainable state.

This is a brief summary of the book's contents:

In chapter one I describe capitalism's ecocidal goals and assumptions, and how these are modified in ENL. Chapter two then explains how the framework is structured to implement the ENL perspective. The seven chapters that follow cover the framework's technical concepts and analytical methods. The last chapter discusses some residual topics and includes suggestions for ENL's improvement. The book's two appendixes are a proposed public statement by concerned economic thinkers and a glossary that defines key terms.

Chapter 1:
Economic Logic

The essence of any economic system is its *economic logic*. This term refers to the economy's goal and its assumptions about humankind and nature, which together determine its broad operations. An economic logic is thus the set of factors that drive an economy's allocation decisions, its production activities, and the distribution and consumption of its outputs. In this opening chapter I first describe the expansionary logic of capitalism. I then explain how this was modified to produce ENL's sustainable version.

A. CAPITALISM'S ECONOMIC LOGIC

An economic logic does not appear by historical accident, but is instead rooted in the motivations of specific social actors. For capitalism these were the medieval business owners who were materially dissatisfied with the restricted production of the feudal economy. A useful guide to the economic and social developments during this period is A History of Business in Medieval Europe, 1200-1550. According to the authors,

> "... medieval business was driven from beginning to end by the continuous demands of the elite. ... The initial thrust [to business and trade] came from the elite's dietary preferences ... and from their insatiable desire for luxuries of food, clothing, and ornamentation." (p. 2f)

The authors also note that these merchants quickly converted their increasing wealth into political power as they became "the towns' capitalists." (p. 55)

Briefly stated, the medieval elite wanted more, and transformed the low-output feudal economy into a high-output capitalist economy to get it. Capitalism's economic logic thus expresses the deep-seated desire by elites for the expanded availability of luxury goods and services, and more generally for rapid economic growth. This does not imply that the rest of society was excluded from the material gains, but rather that the system was established primarily to serve the consumption appetites of powerful merchants and other social leaders.

These factors underpin capitalism's economic logic, which is depicted in figure 1-1.

Figure 1-1. Capitalism's economic logic

There are six factors in all. The most important of these are the closely related goals of maximum profits and rapid economic growth. Supporting these goals are two ecological factors: the assumptions of infinite natural sources and infinite natural sinks. According to the first, the resources provided by nature (soil, water, timber, fish, minerals, etc.) are either unlimited or can be replaced indefinitely by available substitutes. According to the second, the environment has an unlimited capacity to safely absorb the economy's wastes (greenhouse gases, industrial effluents, plastics, etc.).

Three social factors also support the system's goal. As shown at bottom left, capitalist logic treats workers exclusively as labor inputs, not as human beings who provide labor. Similarly, as shown at bottom right, the populace is treated exclusively as consumers, not as human beings who consume. Finally, the economy's output mix (the types and quantities of outputs produced) is determined by affordable desire: consumption desires that are backed by the purchasing power of money.

Let me briefly evaluate this logic, starting with the ecological factors.

Capitalism began to replace feudalism during the 16th century. At that time nature's sources were still abundant, and its sinks remained largely intact. Thus, from the environmental perspective, the economic logic adopted by the early capitalists was not an unreasonable choice. Unfortunately this situation changed dramatically over time: centuries of rampant growth depleted many sources, and critical sinks filled up and then overflowed. Capitalism's economic logic was thus environmentally rational at its inception, but became disastrously irrational as the system's expansion severely damaged the natural world.

The significance of the logic's three social factors is that they degrade the populace's quality of life. Treating workers exclusively as labor inputs ignores the effects of labor on their health and life enjoyment. Examples are automation that robs them of skills and creativity, and work intensification that leaves them exhausted and accident-prone. Treating the populace exclusively as consumers neglects the effects of consumption on their bodies and minds. Some consumption enhances well-being and provides enjoyment, but dangerous products can cause substantial harm. Finally, determining an economy's output mix through affordable desire means that production will be heavily skewed towards the consumption desires of the affluent. As environmental conditions deteriorate and consumption declines, this could result in severe social instability that could hamper efforts to create a sustainable world.

B. ENL'S ECONOMIC LOGIC

As noted above, capitalism's economic logic is rooted in the drive for luxury consumption by social elites during the medieval period. This logic guided the establishment of a highly productive economy that was biased towards the rich and eventually became a massive ecological threat. The task is therefore to develop a replacement logic that is both sustainable and takes a broader view of workers and consumers. My proposal for this new logic is shown in figure 1-2.

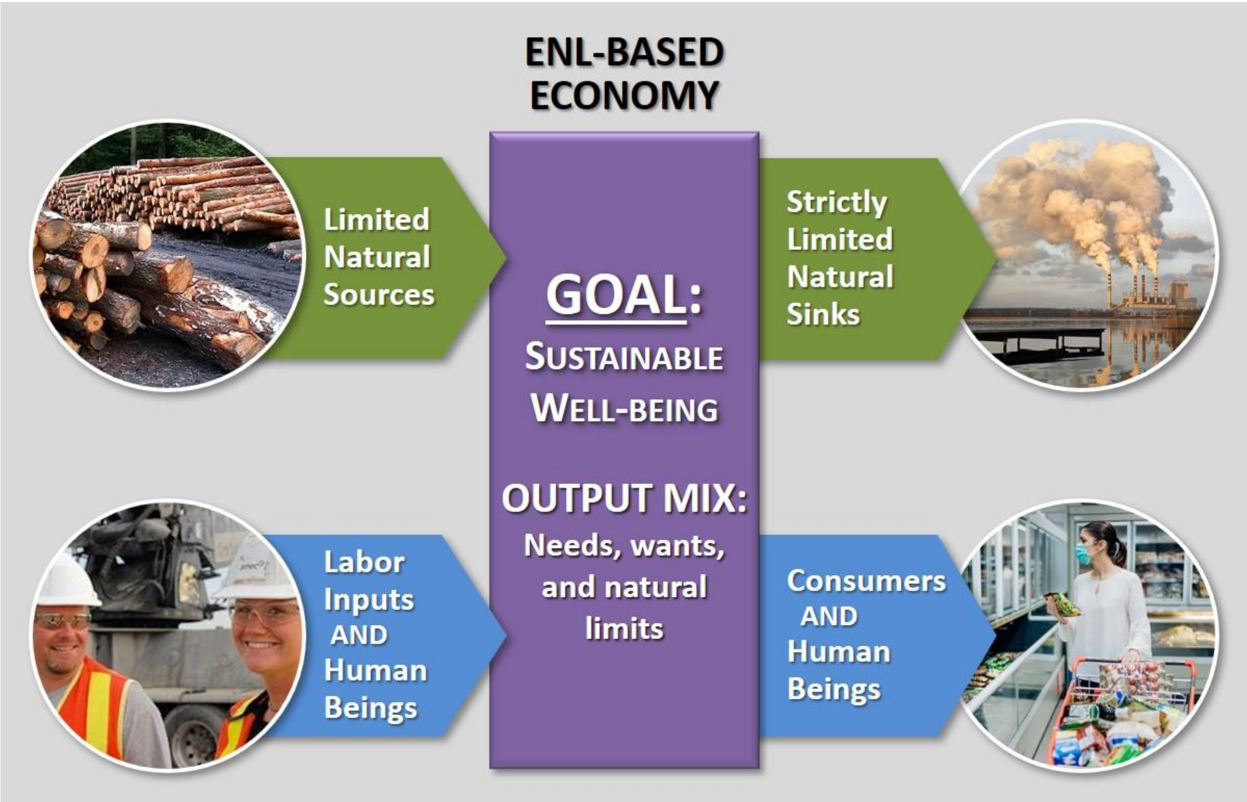


Figure 1-2. ENL's economic logic

The same model is used, so the six factors can be directly compared. Note that this is an overview - many topics will be further discussed in future chapters.

1. **ECONOMIC GOAL:** The logic's goal is sustainable well-being. "Sustainable" is the standard term, indicating that the economy operates within environmental boundaries. "Well-being", however, has a unique meaning within ENL. This term refers to the socially-specified combination of physical health, which is an objective factor, and life enjoyment, which is a subjective factor. ***The goal of an ENL-based economy is therefore to maximize humankind's physical health and life enjoyment under the constraints of limited natural sources and sinks.***

2. **OUTPUT MIX:** The types and quantities of outputs produced by an economy are driven by consumption, and consumption under ENL's logic is determined by needs, wants, and natural limits. These factors are consistent with the above goal: satisfying needs serves physical health, satisfying wants serves life enjoyment, and respecting natural limits protects sources and sinks.

3. **NATURAL SOURCES:** Capitalism's assumption of infinite natural sources is environmentally dangerous because it drives capitalists to destroy ecosystems as they extract increasingly scarce resources and their substitutes. ENL's logic therefore treats sources as limited and requiring careful allocation to sustainably maximize the resulting economic benefits.

4. **NATURAL SINKS:** This is the critical environmental factor. As is now painfully obvious, Earth systems are acutely sensitive to increases in greenhouse gas concentrations, which result in global warming and ocean acidification. To a lesser degree, this sensitivity also applies to chemical toxins, microplastics, and other wastes. ENL's logic thus sees natural sinks as tightly constrained and strictly subject to rational allocation.

5. **WORKERS:** ENL's logic treats workers as both labor inputs and human beings. As labor inputs they are commodities in a labor market, as under capitalism. As human beings, however, their well-being must be taken into account. Thus, when a new machine is being considered to increase productivity, an ENL analyst would examine not just the increased output rate, but also the effects of the modified labor process on the affected workers. If the overall results are negative, the machine would be economically irrational and would thus be rejected.

6. **POPULACE:** The populace is treated in a similar fashion: they are both consumers and human beings. As consumers they are markets for the economy's outputs, as under capitalism. As human beings their well-being must again be considered. This means that economic decisions must take into account the impacts of consumption on both their health and life enjoyment.

Given ENL's principle of social neutrality, the economic treatment of human beings is largely a social choice. However, as consumption declines in the transition to a sustainable society, a minimum level of equity will be required for social stability. Unless workers and the populace are treated fairly, this stability will be severely threatened. It is thus likely that, whether a society is progressive, liberal, or conservative, capitalism's narrow assumptions about workers and consumers will have to be substantially modified.

C. SUMMARY

Figure 1-3 provides a summary of the logic comparison above. The four factors relating to sustainability are in colored fonts: red for the ecocidal aspects of capitalism's logic and green for the sustainable aspects of ENL's logic.

	CAPITALISM	ENL
GOAL	Maximum profits and growth	Sustainable well-being
OUTPUT MIX	Affordable desire	Needs, wants, natural limits
NATURAL SOURCES	Unlimited	Limited
NATURAL SINKS	Unlimited	Strictly limited
WORKERS	Labor inputs only	Labor inputs <u>and</u> human beings
POPULACE	Consumers only	Consumers <u>and</u> human beings

Figure 1-3. Economic logic comparison: capitalism and ENL

The above discussion would be incomplete without acknowledging a troubling but indisputable fact: capitalist logic is consistent with humankind's biological nature, but ENL's logic is not. As biological beings we strive to increase our consumption, swell our numbers, and expand our territories. These impulses are precisely what capitalist logic supports. ENL's logic, by contrast, compels us to severely restrain all these drives. Its implementation in a post-capitalist economy will therefore make unprecedented ethical and lifestyle demands of our species. Humankind's ecological survival largely depends on our capacity and willingness to meet these non-biological imperatives.

Chapter 2:
The ENL Framework

In chapter one I presented ENL's economic logic, which specifies the framework's goal and its assumptions about humankind and nature. In this chapter I describe the basic attributes of this framework, which is the formal expression of the logic. I have already said that ENL strives for social neutrality to avoid progressive bias, and that it is technologically neutral to restrict the idea of progress to increased sustainable well-being. Below I discuss its other key features: the scope of its analysis, the economic abstraction it employs, its broad perception of the economic process, and its analytical tools.

Because ENL is a new mode of economic thought, it unavoidably introduces a large number of technical terms. When a new or unfamiliar term is first defined, it is printed in ***bold italics***. If you forget a definition as you proceed, please consult the book's glossary in appendix B.

A. ANALYTICAL SCOPE

Analytical scope refers to the boundaries of ENL's subject matter, thus identifying the range of topics for which the framework takes analytical responsibility. As previously stated, ENL is not intended to replace economic thought as a whole. Instead, it is exclusively a ***guiding framework***. This means that it provides concepts and analytical tools to establish rational economic objectives, but it does not address an economy's detailed operations. Another kind of economic theory, called a ***functional framework***, must be employed for this purpose.

A strong temptation that must be avoided in developing a guiding framework is to cast the net too wide by inviting non-economic issues into an economic theory. ENL avoids this trap by adopting a narrow analytical scope. This focuses attention on the economic logic itself and avoids diluting it with non-economic considerations.

The framework's analytical boundaries are established by first noting that an economy's ultimate purpose is consumption: the assimilation and utilization of outputs to satisfy human consumption desires. For consumption to occur, outputs must be assigned to consumers, a social act called distribution. Consumption and distribution in turn require that outputs are produced, and production means that inputs must be allocated to the desired outputs. ENL's analytical scope is this chain of core economic activities: humankind's distribution and consumption, the allocation and production these entail, plus any directly related topics.

B. GEOGRAPHICAL SCOPE

In standard economics the geographical unit of analysis is typically the country. Statistics such as gross domestic product (GDP) and trade deficits refer to specific countries, and most economic policies are developed on a national basis. In ENL the country is seen as a purely political entity, without special economic significance. The framework treats the geographical unit of analysis as either a region or the world as a whole. If the unit is a region, this can be an area within a country, a country, or a collection of territories up to but not including the entire world. Geographical scope in ENL is thus either regional or global. When the term "economy" is used in this book, it refers to the chosen geographical unit.

ENL gives analysts a choice of geographical scope because this provides analytical flexibility. Political borders can be respected or ignored depending on the nature of the analytical project. Global scope can be used if the world is usefully perceived as a unified economic community. Regional scope can be employed if this unity is absent, or if a more restricted area must be directly addressed for other reasons.

C. ECONOMIC ABSTRACTION

Systematic thought about any complex reality demands that we ignore minor details and focus on its most significant features. This distinction sets the stage for all subsequent development and is thus of central importance. When combined with ENL's analytical and geographical scope, the economic abstraction fully defines the range of its conceptual universe. The abstraction is shown in figure 2-1. Its components are briefly described here and will be treated more fully in the coming chapters.

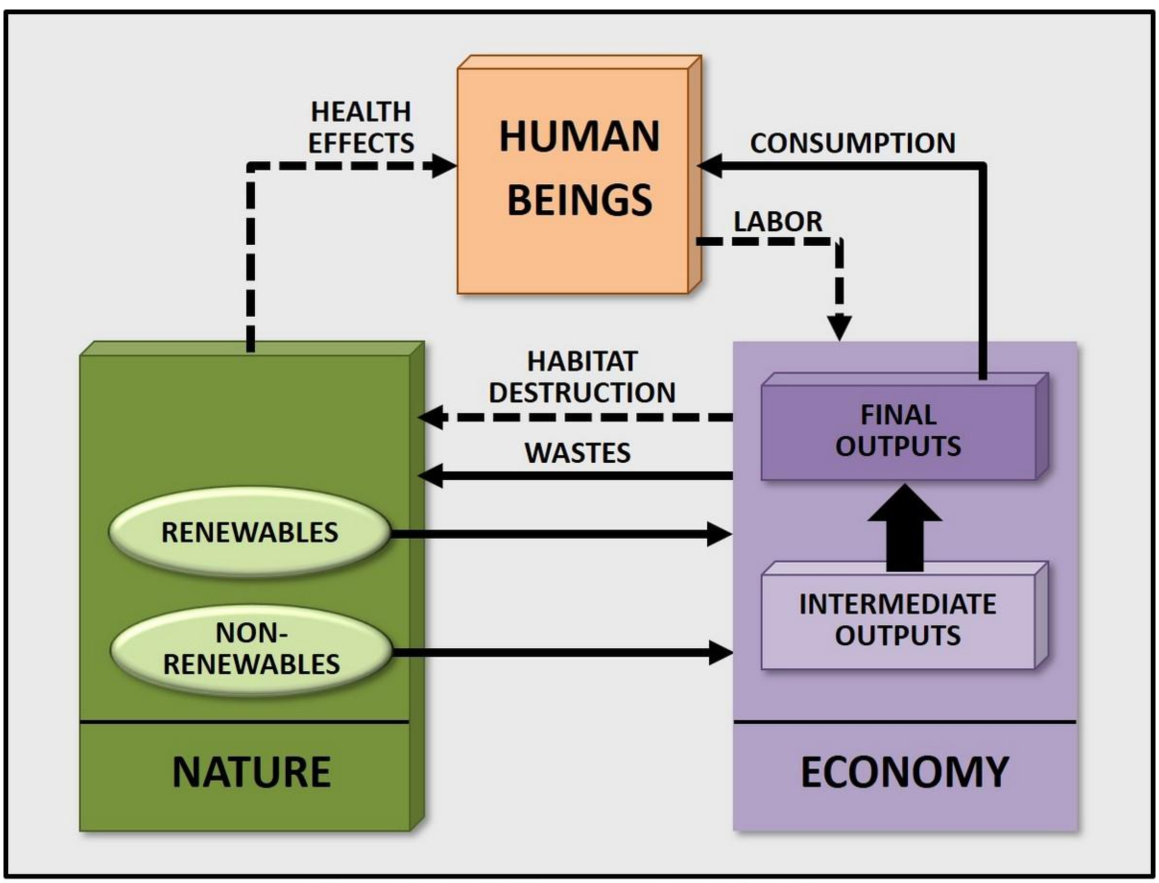


Figure 2-1. ENL's economic abstraction

This diagram uses solid lines to depict flows that are predominantly physical, and dashed lines for flows that are mostly non-physical. It divides the economic world into three major components: human beings, nature, and the economy itself.

Human beings are at the heart of ENL's economic concerns, and are therefore placed at the top of the abstraction diagram. As can be seen from the arrows, people interact with the economy in three ways: through the consumption of final outputs, the provision of labor, and the health effects from the environmental consequences of production.

The box marked "economy" contains final and intermediate outputs. A ***final output*** is one that is directly consumed, such as a house, a book, a donut, and a manicure. By contrast, an ***intermediate output*** is not directly consumed, but is instead used in the production or consumption of other outputs. Some outputs can be both, depending on their application: a train can be used for leisure travel or to deliver cargo; a computer can be used to play games or to write business reports. Because many final outputs are physical objects, consumption is shown as a solid line. Labor is not a physical flow and is therefore shown as a dashed line.

The distinction between final and intermediate outputs is significant because our consumption desires are met exclusively by final outputs. Producing intermediate outputs may be good for business, but from ENL's perspective they are simply a means to an end: the production of final outputs that can enhance human well-being.

Inside the box marked "nature" are renewable and nonrenewable resources, which flow from nature into the economy. Nature also has the capacity to absorb the economy's wastes, and it is subject to habitat destruction. These are represented by arrows going the other way - from the economy to nature.

Renewables are mostly resources associated with the sun's radiation: the organic components of the biosphere plus the hydrological and atmospheric phenomena resulting from solar energy. Although independent of the sun, the geothermal energy from the earth's interior is also included in this category. ***Nonrenewables*** are materials found at or near the Earth's surface that are not regenerated over time periods that are meaningful to humankind. Examples include minerals, fossil fuels, topsoil for agriculture, and water. Such natural assets are stored, in finite amounts, in accumulations called stocks.

Habitat destruction refers to the degradation of living conditions for non-human species as a consequence of humankind's economic activities. This can result in the weakening of species through population declines, and also in their extinction. ***Wastes*** are the material residues of economic activities. Included in this category are greenhouse gases, other pollution, materials discarded during production, and outputs that are thrown away at the end of their useful lives.

The four main interactions between nature and the economy - habitat destruction, wastes, renewables, and nonrenewables - are called ***natural flows***. The first three have a biological basis and are therefore called ***biological flows***. Such flows, which are associated with ecological degradation and threshold effects, are used in ENL to help set production limits. The fourth flow type, ***nonrenewables***, does not have a biological basis. These resources are subject to depletion, but not to degradation or thresholds, and are therefore ignored when production limits are set.

D. OUTPUT LIFE CYCLE

As just indicated, an output can be considered from two different perspectives: as a discrete commercial product, or as part of a chain of activities that ends in consumption. Standard economics generally takes the first view, which is aligned with business realities and sees all outputs as profit-making opportunities. In this perspective, for example, the extraction of raw materials for bus components, the manufacture of these components, the construction of the bus itself, and the recycling or disposal of the disused bus are all treated separately.

The second view might be called the social perspective. This sees all bus-related activities as a unified process that results in bus transportation services. ENL adopts the latter view, and refers to the unified process as the ***output life cycle***. See figure 2-2.

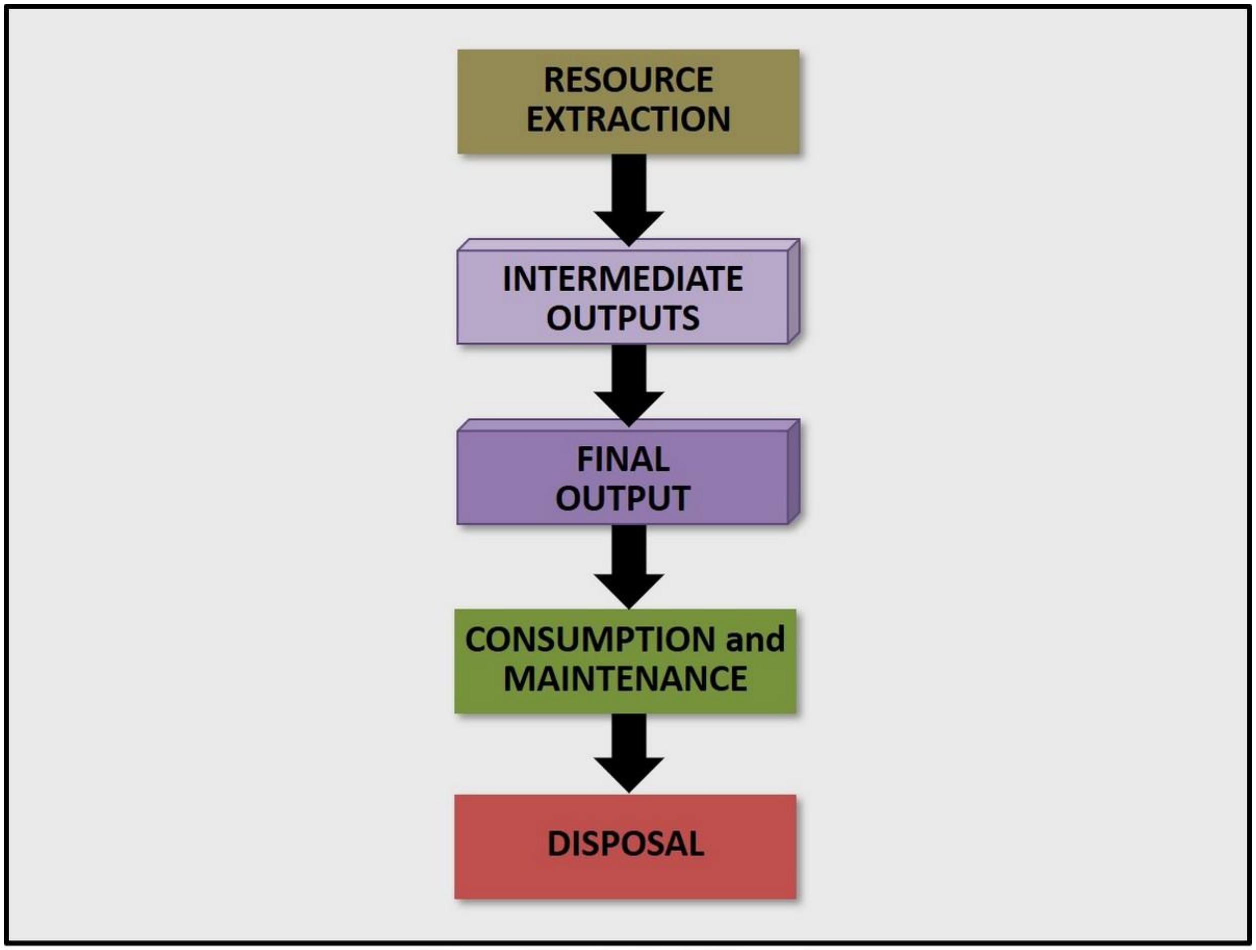


Figure 2-2. Output life cycle

For durable outputs like houses, ships, furniture, and buildings, all five stages apply. For non-durable outputs like food there is no maintenance stage, but disposal does apply. This is the vexing problem of dealing with human wastes in a sanitary manner to prevent disease and return nutrients to the soil.

ENL uses the life-cycle approach because one of its central tasks is to help a society determine if, and in what quantity, an output should be produced. This can be rationally established only if values and costs associated with the entire economic chain are estimated and compared. To illustrate, the production of tires can be analyzed separately for business purposes, but their human desirability cannot be considered in isolation. Tires on their own cannot be consumed and therefore have no value to offset against the cost of their production. For ENL the life-cycle perspective is therefore unavoidable.

E. MARGINAL ANALYSIS

Although standard economics is frequently criticized in this book, the field deserves praise for its formalization of marginal analysis. This is a method that emphasizes incremental changes in quantities rather than the totals we tend to emphasize in daily life. For example, if a quantity increases from seven to nine, the marginal view will highlight the difference between them - plus two - rather than the original and final figures.

Marginal quantities are central to economic thought because they allow analysts to establish an activity's optimum level, which maximizes its resulting benefits. Because ENL is deeply concerned with such maximizations, it is strongly committed to both optimization and marginal analysis.

For those unfamiliar with the marginal approach, an example will make the method more concrete. Imagine you are stranded on a tropical island. In order to stay alive you must gain enough energy from the island's food sources to fuel your internal fires. It takes energy to gather food, so you must balance your energy gains against your losses. What is the best strategy for obtaining your sustenance? It turns out that you will maximize your survival chances if you continue hunting, fishing, and picking berries until the next unit of food - the marginal unit - requires more energy to obtain than the energy you would gain from its consumption. If you gather less food than this, you are not gaining as much net energy as you could from your surroundings. If you gather more, your overexertion will result in lost net energy. In either case you could perish in a difficult environment.

F. GRAPHS AND QUANTIFICATION

Before proceeding to ENL's concepts and analytical tools I must address the graphs I will use as well as the underlying issue of quantification.

When employed in the physical or social sciences, graphs fall into two categories: those that express known quantitative relationships through *empirical curves*, and those that express general conceptual relationships through *notional curves*. Each category is indispensable in its proper sphere. Let me illustrate this with two examples from scientific sources.

A physics text I own shows a graph that relates the force on a car as a function of time during a crash impact. Force is on the vertical axis, in Newtons. Time is on the horizontal axis, in seconds. The curve, which traces the destruction of a Mercedes-Benz over 120 milliseconds in a test environment, is based on actual measurements and is therefore empirical.

A completely different situation exists for scientists who are studying the prevalence of life in the universe. Controlled conditions do not exist in this sphere, so direct measurements are impossible. Nevertheless, the book Rare Earth shows a graph that relates species diversity to mass extinction events. (p. 172) Diversity is on the vertical axis, without units. Mass extinction events are on the horizontal axis, also without units. There are two curves, depicting two possible relationships between the variables. Although these curves are entirely notional, they accurately express the authors' exploratory ideas.

Aside from their conceptual significance, such curves are important because they provide investigators with both the guidance and incentive to transform them into empirical curves. Once a curve is drawn, economists can examine statistical data and try to substantiate the relationship being depicted. Where such information is lacking, they can initiate efforts to collect it.

In brief: So long as the underlying ideas are sound, notional curves can accurately depict general relationships, permitting the analyst to draw broad conclusions. Such curves are frequently indispensable in the early stages of theoretical development. Because ENL is in its infancy, all the graphs in this book express broad conceptual relationships using notional curves.

Chapter 3:
Consumption and Value

Value and cost are the central concepts in economic thought. As such they have been subjected to various ideological distortions over the centuries. If the reader is unaware of these developments it will be difficult to understand the modifications made in ENL. This chapter and the next therefore include brief histories of these ideas before describing their ENL counterparts. To begin, however, let me present an overview of the economic process in order to place the value concept in its broad economic context.

A. DISTRIBUTION AND CONSUMPTION

Economies vary widely due to differences in technology, culture, type of economic system, and many other factors, but they share a set of core activities. When these are combined, they form the generic economic process shown in figure 3-1.

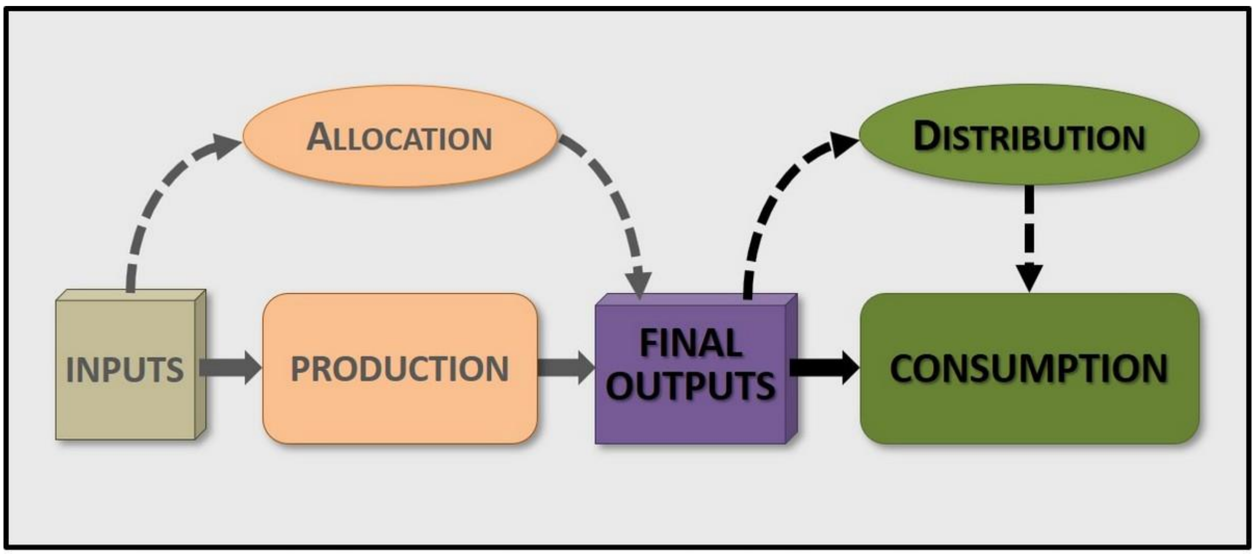


Figure 3-1. The economic process - distribution and consumption

The predominantly physical aspects of the process are indicated by solid arrows. For example, inputs such as natural resources and machines are converted by production into final outputs, and these outputs are then consumed. The exclusively social aspects - allocation and distribution - are indicated by the dashed arrows.

Allocation refers to decisions that determine which inputs will be used to produce which outputs. This is a critical stage because it is the starting point for all subsequent activities. The other social aspect of the economic process is ***distribution***, which determines by whom, and in what quantities, outputs are consumed. (ENL in fact broadens the distribution concept to include labor and wastes. For simplicity this is ignored in the diagram.)

I begin with the components at the right side of the diagram - distribution and consumption - because consumption is the economy's end, whereas allocation and production are the means used to achieve this end.

B. A BRIEF HISTORY OF VALUE

In economics, value is what human beings desire in an object or service. Water has value because it supports life, a bicycle because it provides transportation, and music because it gives us pleasure. In a simple economy without money-based exchange, this meaning is the only one that applies. In an exchange-based economy such as capitalism, it is necessary to distinguish between use-value and exchange-value.

Use-value is the direct usefulness of an object or service to human beings, as indicated by the above examples. ***Exchange-value*** refers to indirect usefulness - the capacity of one commodity to be exchanged for another. For example, if four units of commodity A are normally exchanged for one unit of commodity B, then the exchange-value of B is four units of A.

Something can have use-value without having exchange-value. Rocks can be useful, and air certainly is, but because these things are readily available under normal circumstances they cannot be exchanged for anything else. The converse is not true: something cannot have exchange-value without having use-value. Even if something was produced with great expenditures of time, labor, and natural resources, it cannot be exchanged for another output unless someone besides the producer finds it useful.

Standard economics today uses the term "utility" instead of "use-value", but there is no real difference between the two, so use-value as a concept still exists in mainstream thought. This is not the case for exchange-value. As the result of a bitter ideological struggle, this concept has largely disappeared from view. Let me briefly tell this important story.

Adam Smith proposed early in The Wealth of Nations (1776) that labor time should serve as the measure of exchange-value:

> "Labor alone, therefore, never varying in its own value, is alone the ultimate and real standard by which the value of all commodities can at all times and places be estimated and compared. It is their real price; money is their nominal price only." (p. 63)

However, Smith felt that this was true only in the early stages of a society's economic development, and that the principle does not apply to a modern economy. Despite Smith's ambivalence about the role of labor in exchange-value, his idea was picked up by two other economic thinkers: David Ricardo and Karl Marx. In Marx's version, labor time is capitalism's estimate of the social resources required to produce a commodity, and as such plays a central role in the system's functioning.

Marx used his labor theory of exchange-value as the main conceptual tool for explaining capitalism's internal dynamics and systemic tendencies, especially in his major work, Capital. Given his revolutionary commitments, however, his interpretation was unacceptable to standard thinkers. They initially responded by rejecting his theory as a valid explanation of exchange-value, and then expunged the term from economics entirely. If you examine the index or glossary of an economics text today it will almost certainly be absent, and even "value" by itself is becoming rare. Standard economists today have little interest in capitalism's systemic features. They have shifted their attention almost entirely to market phenomena that can be analyzed with the less nettlesome concepts of utility and price.

Exchange-value and price are indispensable in a functional framework because they help explain the operations of a market-based economy. However, the concepts are not useful in setting broad economic objectives, and therefore play no role in a guiding framework. ENL thus defines only use-value, which is how "value" by itself will be used in the remainder of this book. Despite the universal interpretation of use-value as subjective in functional frameworks, there is nothing illogical about treating it as objective for guiding purposes. As will be seen, this is the approach taken by ENL.

C. VALUE AND COST ARE *HUMAN* MEASURES

Over the past several decades, as environmental concerns have grown, the concepts of value and cost have increasingly been applied to ecosystems and natural resources. The motivation for doing so is obvious: if the environment has monetary value, and if its destruction incurs a financial cost, then the natural world will be taken into account when economic decisions are made.

It is true that the application of value and cost to nature can be effective as a short-term response to environmental degradation. This approach uses capitalism’s own measurement standard of money to modify the system’s operations and decrease its ecological impact. However, ENL is intended to be part of a transformative shift that replaces capitalist logic for guiding purposes and results in a post-capitalist economy. In this deeper context, value and cost cannot be extended to nature. Let me briefly explain why this is so.

Although human beings are integrated with the natural world in many ways, from the economic perspective the two are in distinct categories. Human beings are the economy's end, whereas nature provides its resources and establishes its constraints. People can make autonomous choices, but much of nature cannot. People can share experiences with their fellow human beings, but we cannot readily do so with nature. Because of these fundamental differences, it is impossible to apply the concepts of value and cost to both humankind and nature in a conceptually coherent manner.

This problem relates to an extremely important concept in economic thought: *commensurability*. This is the idea that entities can be measured by the same yardstick, and thus quantitatively compared, only if they are qualitatively the same or sufficiently similar. Considered economically, people and nature are qualitatively different, and trying to apply the same economic yardstick to both creates insurmountable conceptual problems.

Let me now move beyond these preliminaries to consider a measurement standard for value and cost that is consistent with ENL's economic logic and is suited to its analytical aims.

D. ENL'S MEASUREMENT STANDARD

Developing such a standard is challenging because of the pervasive influence of standard economics. The discipline has convinced virtually all economic thinkers that the only valid way to assess value is through subjective desires, and that these must be measured by the money people are prepared to pay.

It should be noted at the outset that, once a standard of value is established, the cost standard must be its opposite or negation. For example, if ENL were to choose increased happiness as its standard of value, then decreased happiness would have to be its standard of cost. The reason for this close relationship is that the framework must offset cost against value to determine the net effects of economic activities on human beings. Unless the two are commensurable, as explained above, this is logically impossible. Let me now return to the search for a standard of value.

ENL's goal for the economy is sustainable well-being. "Sustainable" means that natural limits are not violated. The term "well-being" is defined in chapter four, but for now I will use the dictionary meaning: satisfactory conditions for existence. Because an analyst can choose global geographical scope, ENL's goal must apply to the world's entire population, irrespective of cultural or social differences. The framework's value concept must therefore capture our normal understanding of well-being, and it must permit well-being to be achieved in a sustainable manner on a global scale. In addition, because ENL strives to be as rigorous as its subject matter permits, the concept must allow for quantification and thus empirical development.

Another critical consideration is that the measurement standard cannot be subjective. Using the strength of individual desires as the measure of value would contradict ENL's goals in two ways.

First, desire is not directly measurable, and thus cannot be used to ensure that well-being has been achieved. The strength of subjective desire can be gauged only by an external representative such as money. This allows the rich to express their consumption desires much more effectively than the poor, thereby focusing production on the luxuries of the few rather than the necessities of the many.

The second reason is that subjective desire does not necessarily express genuine well-being. Under capitalism, desires are incessantly manipulated by social influences such as advertising, media images, and peer pressures. Many consumption desires are nothing more than the deeply implanted urges of corporate marketing campaigns. Such influences result in both the quantitative expansion and the qualitative distortion of our consumption demands.

If ENL's standard of measurement for value and cost cannot be subjective, it must be objective - that is, it must be based on the publicly observable state of the external world rather than the private experiences of the individual's internal world. This was acknowledged several decades ago by ecological economist Herman Daly, who stated that value should reflect, "... the objective needs of human beings or other species considered as biological entities ... ″ (Steady-State Economics, p. 213)

To summarize, we are looking for an objective factor in the human realm that captures our normal understanding of well-being, permits quantification, and applies on a global basis. I have found only one factor meets all these criteria: humankind's physical health.

Physical health is objective in that it relates to our externally observable state: it can be quantified through strength, flexibility, freedom from disease and injury, and many other readily accessible attributes. It puts rich and poor on roughly the same plane and can be applied, with only minor adjustments, to all societies and cultures. It restricts consumption based on the physical limitations of the human body. Numerous studies have shown that physical health is strongly impacted by our emotional states and stress conditions; it therefore serves as a proxy for general health. General health, in turn, is for most people the central aspect of happiness and well-being.

Based on the above reasoning, ENL's assessment of a final output's value is the degree to which it increases the physical health of human beings through consumption. Conversely, its assessment of a final output's cost is the degree to which it decreases physical health through production. These broad statements are refined in what follows. For brevity, I will in most cases shorten "physical health" to "health".

E. POTENTIAL VALUE

ENL includes not one but two use-value concepts: potential value and effectual value. Both derive from the work of John Ruskin, a 19th century social thinker who wrote several books on economics. (See chapter 10 for more on Ruskin). Although Unto This Last (1860) is better known, the value concepts were formally introduced in a later work, Munera Pulveris (1862). Ruskin actually referred to "intrinsic value" instead of "potential value", and this was initially true for ENL as well. I have shifted to the latter term to avoid confusion with several current usages of "intrinsic value".

Potential value, when it is positive, is the maximum capacity of a final output, over the duration of its useful existence, to increase health. If an output has the opposite effect - if it decreases health - its potential value is negative. Based on the assumption that a consumer can always be found to extract an output's maximum health benefits, potential value is the same at all output quantities. Potential value is used in ENL to judge the quality of outputs resulting from production.

A highly significant word in the above definition is "capacity." An apple has the capacity to increase health, but it can also be thrown away or allowed to spoil. Its health benefits constitute only a potential, which may or may not be realized. The apple must be eaten, while reasonably fresh, by someone who can assimilate its nutrients. Only then will its potential health be fully transformed into actual health.

Recall that final outputs are objects and services that are directly consumed, such as food, furniture, and haircuts. This is the only type of output that has potential value. While intermediate outputs are required for most economic activities, they are not consumed as end products and do not contribute directly to health. They therefore fall outside the term's definition.

As stated, potential value is a constant quantity, and is therefore plotted on a graph as a straight horizontal line. This line can be in the positive or negative range, or it can be zero. See figure 3-2.

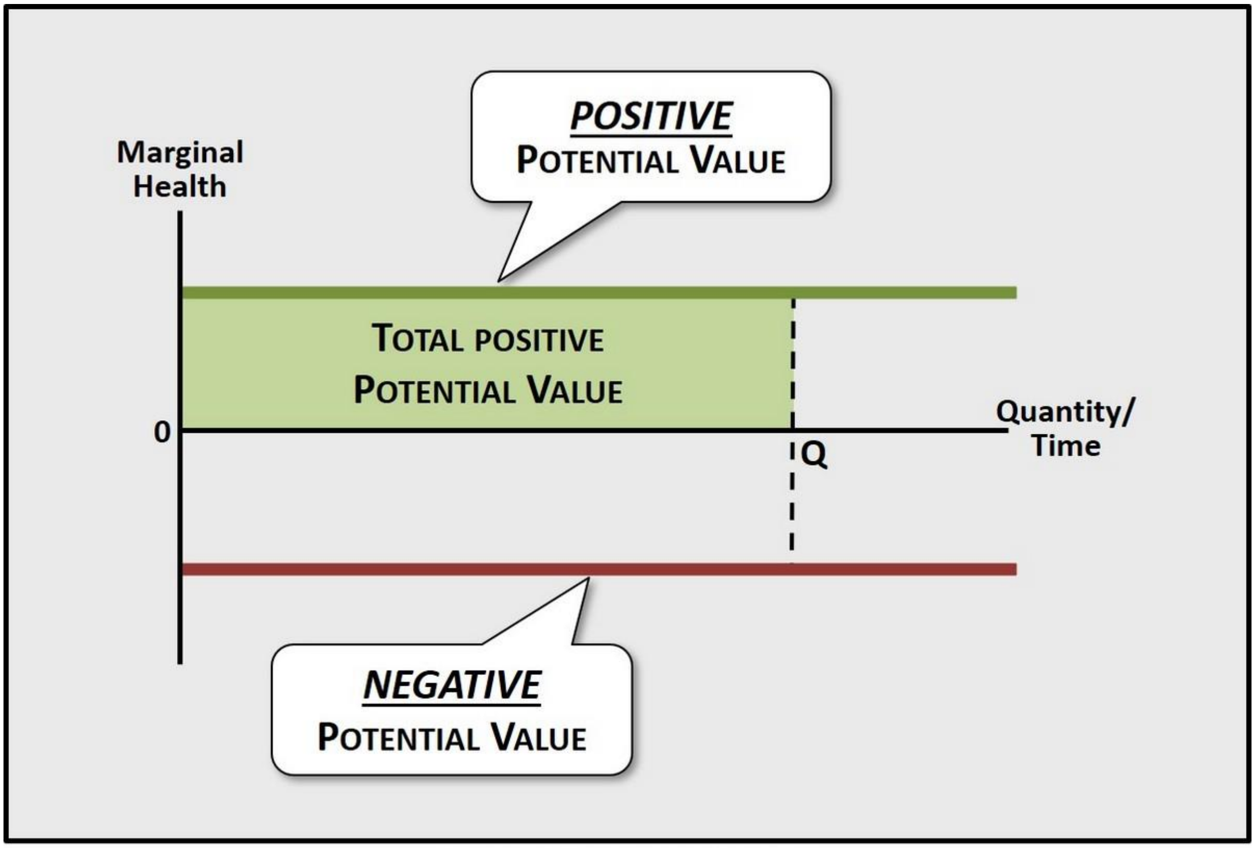


Figure 3-2. Potential value

The quantity of the output being produced per unit of time, or output rate, is on the horizontal axis. Marginal health is on the vertical axis. The letter "Q" (quantity) is used in all ENL graphs to represent the current output rate. The output's total potential value is the area under the positive potential health line, from quantities 0 to Q. This is the shaded area in the above diagram.

Although the potential value of an output is fixed at any particular time, it is not necessarily fixed over time. Food provides a particularly worrisome example of declining potential value. According to US and Canadian government statistics, there has been a marked drop in the nutritional value of many foods since 1963. The calcium content of tomatoes has decreased by about 60%, the vitamin C content of broccoli by 45%, and the vitamin A content of chicken by 50%. Such decreases would be represented by the downward shift of the positive potential value line from one time period to another.

Cigarettes, harmful drugs, and poisonous substances have negative potential value and are depicted by a negative horizontal line. Changes in potential value are possible here as well. For example, if e-cigarettes are less destructive to health than standard cigarettes, their potential value will be higher (less negative), thereby shifting the potential value line upward.

Potential value is readily understood with respect to food because this is ingested and assimilated - the intuitive meaning of "consumption". The situation is similar for cigarettes and drugs. But what about an output like a car (automobile), which is utilized rather than ingested? In the rich countries, cars are for many people a practical necessity. However, there is no essential relationship between practical necessity and potential value. Something is necessary if it is required under prevailing conditions; it has positive potential value if it has the capacity to increase health. This example is worth pursuing to clarify the meaning of this fundamental concept.

If we exclude a car's various amenities and focus on the vehicle itself, what do we have? An enclosed space with windows that can move when it is mechanically sound and supplied with fuel. Movement can provide exhilaration, possibly augmenting health to a small degree, but it can also cause accidents, thereby decreasing health or causing death. On the other hand, a non-moving, enclosed space can serve as a residence, which will likely increase the occupants' health relative to living outdoors. A car's potential value is the sum of factors such as those cited: exhilaration, accidents, and living space. Many others could also be mentioned, such as the inhalation of fumes from surrounding traffic and the obesity resulting from inactivity while the driver is behind the wheel.

The issue requires formal study, but it appears likely that a car's overall potential value is negative. The fact that a car nevertheless has high subjective use-value for many people, and therefore commands a high market price, does not alter this conclusion. The subjective perception arises from factors such as the long distances from home to essential destinations and the hassles involved with public transportation. While overcoming these may satisfy subjective desires, objective health is not significantly increased.

It is important to recognize the underlying principle here: *whatever is necessary for production, but does not directly increase health, is a component of cost rather than value*. In a rational economy such factors will be minimized and if possible eliminated.

F. EFFECTUAL VALUE

Whereas potential value is the capacity of a final output to increase health, ***effectual value*** is the actual health gained from the output's consumption. Effectual value is used in ENL to judge the distribution and consumption of final outputs. Like potential value, it can initially be positive, negative, or zero. Unlike potential value, it tends to decrease at the margin. Thus, effectual value that is initially positive may become negative as consumption proceeds. A typical effectual value curve is shown in figure 3-3.

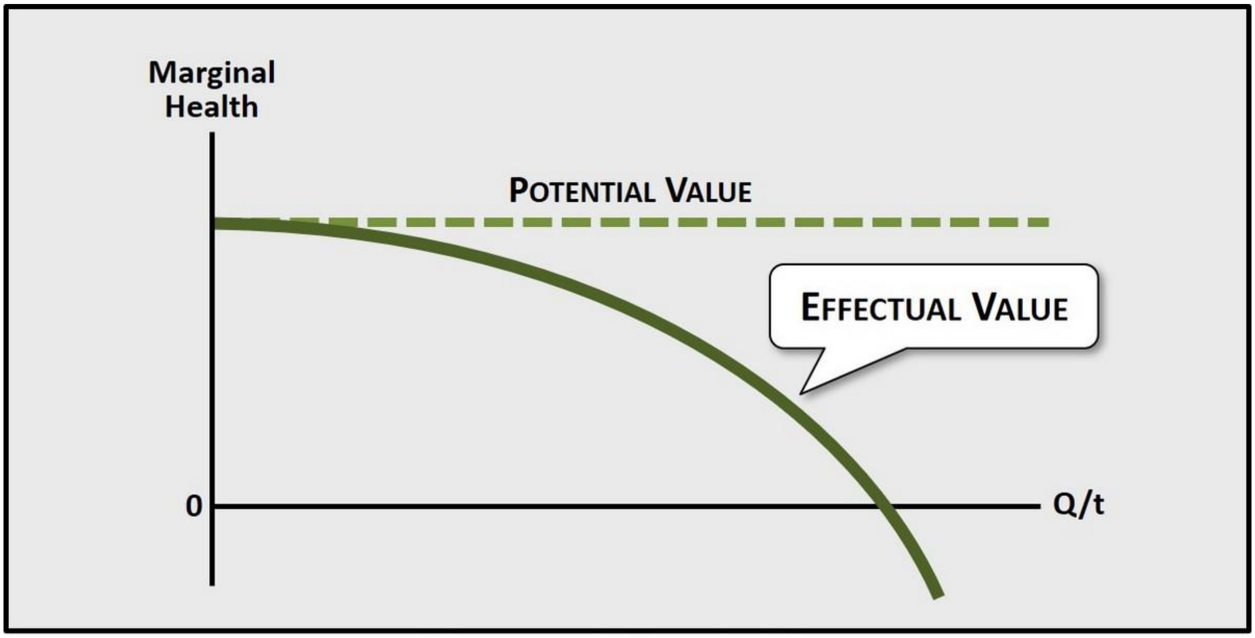


Figure 3-3. Effectual value

Economic activist Michael Albert displays a strong intuitive grasp of this concept in the following passage: "The United States has 3 million people without homes to sleep in, though it has roughly 50,000 hotels that are generally only about half full and are able to house 15 million people. So, the United States has 3 million homeless people with 7.5 million empty rooms that they could, but can't, occupy." (The Trajectory of Change, p. 31) This example cuts to the heart of effectual value: outputs exist that have the potential to increase health, but that under current conditions fail to achieve this result.

Let me now turn to one of the main factors that cause effectual value to decline at the margin: satiation.

G. SATIATION

Satiation refers to the decrease in an output's beneficial health effects as greater quantities are consumed over a specified period of time. Assume, for example, that you drink several glasses of tomato juice over the course of an hour. It is likely that the first few will increase your health by roughly the same amount. However, at some point the beneficial health effects of each glass will start to diminish. Eventually these effects will become zero, and if you continue quaffing your health could well suffer. Figure 3-4 depicts the broad effect.

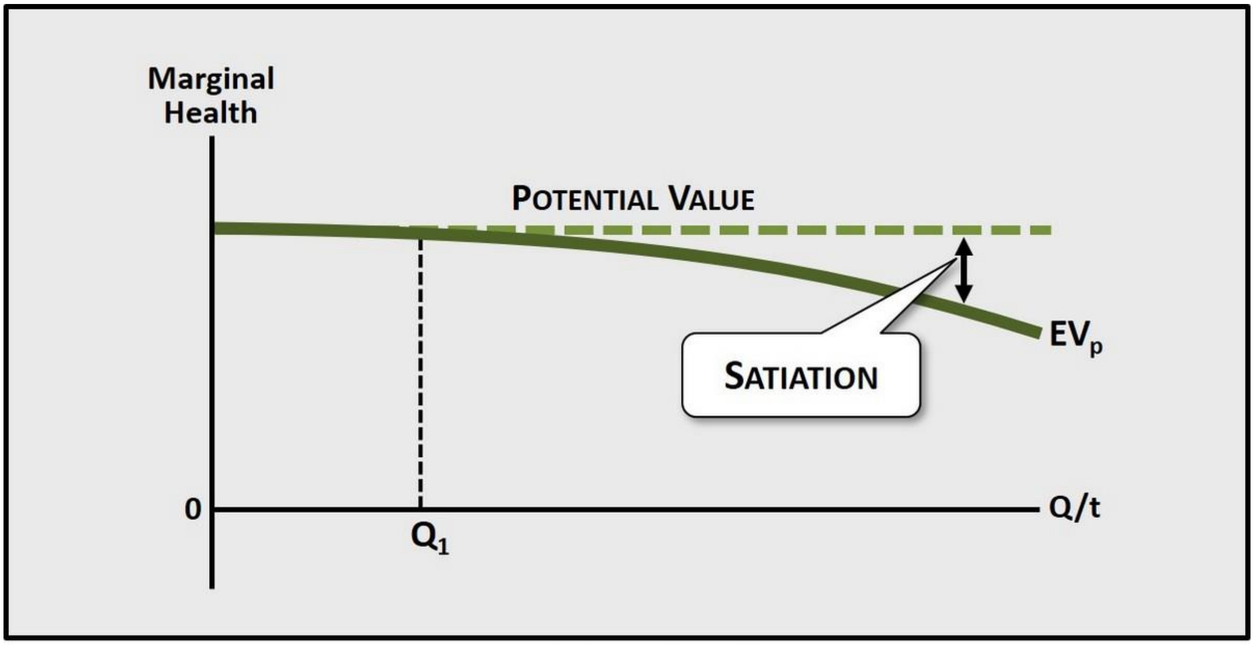


Figure 3-4. Satiation

In this graph effectual value is abbreviated to "EV", and the subscript "p" signifies that distribution is perfect. This means that the decline in effectual value is the result of satiation alone, without the added effect of maldistribution - a topic that is addressed below.

Satiation is the result of the human body's inherent limits in absorbing positive health effects through consumption. The point where satiation begins will vary with the output and the consumer, but the effect itself is biologically inexorable and places a universal limit on our capacity for health-increasing consumption.

ENL's treatment of satiation differs significantly from the non-satiation assumption of standard economics. Although the discipline acknowledges that a consumer can be satiated with respect to a specific output based on declining subjective desire, it insists that satiation is impossible for outputs as a whole. This position is in fact the starting point for standard thought. A typical expression is that, "The problems of economics arise out of the use of scarce resources to satisfy *unlimited human wants*." (*Economics*, 4th edn, Richard Lipsey et al., p. 6, emphasis added.) Heterodox economist Joan Robinson succinctly noted that this assumption is tied to business needs: "Satiation of material wants is bad for profits." (Economic Philosophy, p. 135)

ENL categorically rejects the standard position and acknowledges satiation with respect to both individual outputs and all outputs collectively. Desires may be infinite - or can be manipulated to appear so - but health is strictly circumscribed by the physical constitution of our bodies, and satiation is thus an unavoidable economic effect.

H. MALDISTRIBUTION OF FINAL OUTPUTS

Satiation on its own will cause effectual value to decline, but this decline can be sharply accentuated by maldistribution. Recall that distribution refers to the assignment of outputs to the individuals who will consume them. This is a social act that should not be confused with the physical act of transportation. Distribution should also be kept separate from allocation, which is the social act of assigning inputs to the production of intermediate and final outputs.

An output is perfectly distributed when each unit is consumed by the person who can convert its potential value into the highest attainable effectual value. Any distribution that fails to satisfy this criterion is called ***output maldistribution***. Figure 3-5 depicts its economic effect.

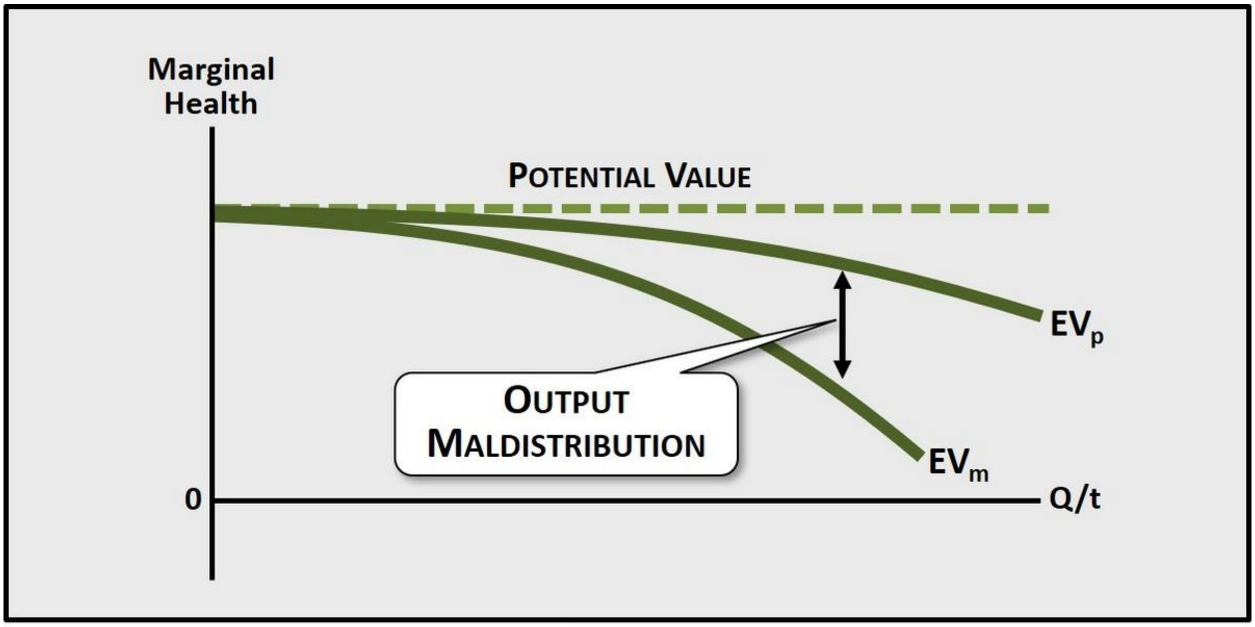


Figure 3-5. Output maldistribution

As noted above, the effectual value curve labeled EVp depicts the result of perfect distribution. This curve declines at a relatively gradual pace because each output is going to the consumer who can extract the greatest health from it. Satiation is thus the only negative force at play. Now examine the lower curve labeled EVm, which depicts the results of maldistribution.

Maldistribution means that outputs are not being consumed by those who can extract the maximum effectual value from them, thus decreasing the aggregate health achieved. An example will help clarify this.

Assume that consumers are divided into three income grades: poor, middle, and rich. The EVp curve reflects consumption by all three income grades. Now imagine that the output is no longer distributed to the poor. As a result, they can no longer convert its potential value into effectual value. Even if the outputs are fully consumed by those in the middle and rich income grades, their capacity to generate effectual value has been reduced by their prior consumption - that is, by their level of satiation. Briefly stated, maldistribution can severely accentuate satiation by drastically reducing an output's effectual value and thus its aggregate health benefits.

I. DEATHS FROM CONSUMPTION

Human deaths resulting from consumption constitute a distinct category that requires special treatment. Although ethical issues obviously apply, these are beyond ENL's scope. The pertinent question is this: how should the framework estimate the purely economic losses associated with consumption-related deaths?

Fortunately such issues have been addressed by various governments and global organizations. For example, the provincial government of British Columbia, Canada publishes statistics on the "potential years of life lost" (PYLL) from different types of accidents, diseases, etc. This measure gives added weight to the causes of death for younger people. For example, PYLL is higher for car accident deaths than for prostate cancer deaths because teenagers tend to die in cars, whereas older men tend to die of prostate cancer. In this sense, a death in the average fatal car accident is worse than the average prostate cancer death.

This health-loss approach has been adopted by ENL. If a 50-year-old dies from a drug overdose, and if this person was expected to live to age 80, then the health that would have been gained by this person over those 30 years is negated. In ENL this is called called ***lost potential health***. Such losses decrease an output's potential value. For a dangerous drug, the resulting overdose deaths would contribute to its negative potential value. Similarly for cigarettes: some of this output's negative potential value is due to the severe health degradation caused by smoking. For the most part, however, it is due to the stunning mortality, and thus the massive lost potential health, associated with this addiction.

J. NEEDS AND WANTS

ENL's value concepts are based on physical health, but there is clearly more to well-being than this. Some consumption is desired not because it maintains our bodies, but because it is enjoyable. Both health and enjoyment are valid criteria when making production decisions, and ENL thus requires terms to analyze both.

To accommodate this duality, a ***need*** is defined as a consumption desire that increases health when it is satisfied, whereas a ***want*** is a consumption desire that does not have this effect. The satisfaction of needs serves life and health, whereas the satisfaction of wants increases life enjoyment.

Wants are deeply problematic because they are potentially infinite and their full satisfaction would risk environmental damage. They must therefore be split into two categories. An ***authorized want*** is one that society has decided to satisfy, whereas an ***unauthorized want*** is one that society has decided to reject. In chapter six, after environmental limits have been considered, I will discuss the factors that bear on these decisions.

Figure 3-6 illustrates the above terminology, and indicates that an ENL-based economy strives to produce those outputs - and only those outputs - that satisfy needs and authorized wants.

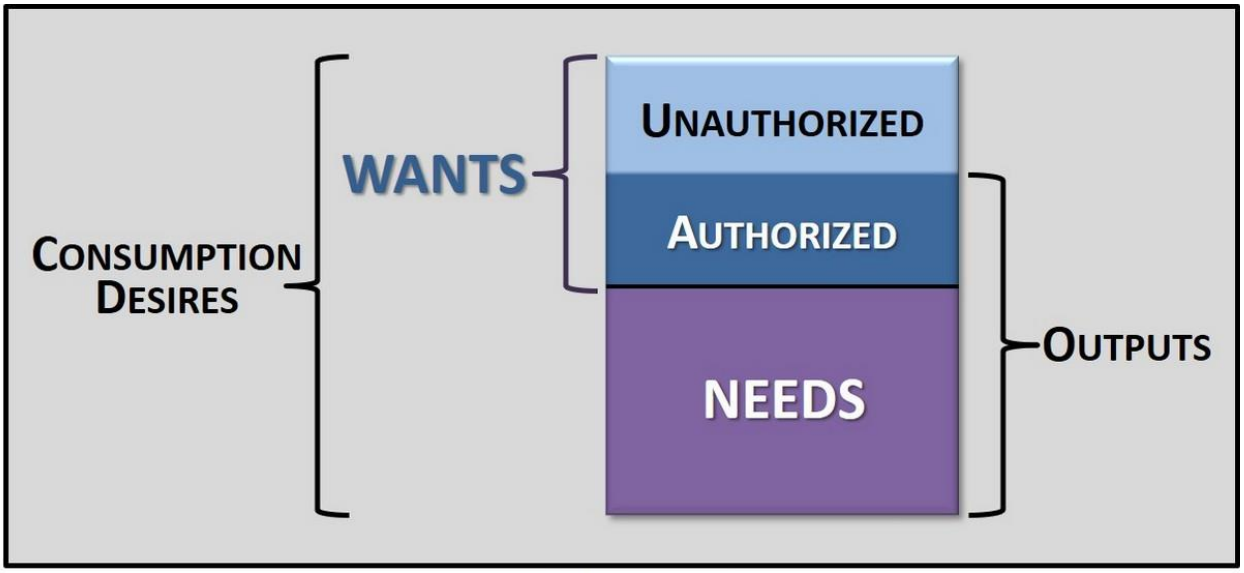


Figure 3-6. Needs and wants

It must be remembered that needs and wants refer to consumption desires, not to the outputs that satisfy those desires. This is most obvious when an output increases health at low quantities but decreases it at higher quantities - as in the tomato juice example above. At low quantities such an output increases health and thus satisfies a need, but at higher quantities its health improvement ceases and it thus satisfies a want instead.

Standard economics, which reflects capitalist realities, refuses to make the above distinctions. The discipline acknowledges consumption desires through the concept of utility, but it fails to separate these into needs and wants. It therefore ignores the fact that some desires have an objective, physical basis, but others do not. As well, because the standard discipline does not recognize wants in the ENL sense, it cannot acknowledge that some wants must be unauthorized for environmental reasons. These refusals are among the reasons why standard thought must now be superseded for guiding purposes.

Chapter 4:
Production and Cost

In this chapter the focus shifts from consumption and its associated value concepts to production and its associated cost concepts. Recall that value and cost are closely related: value is the degree to which an output increases health through its consumption, whereas cost is the degree to which health is decreased through its production. As with value in chapter three, I offer a condensed history of cost to give the reader some perspective on this crucial concept.

A. ALLOCATION AND PRODUCTION

Figure 4-1 repeats figure 3-1, but this time highlighting the initial stages of the economic process: allocation and production.

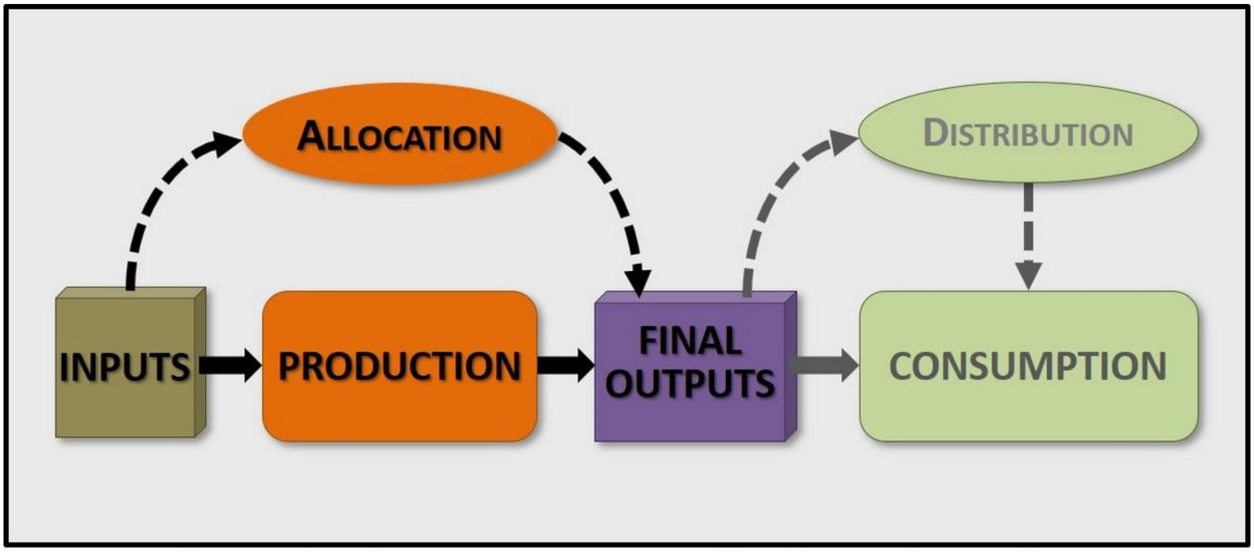


Figure 4-1. The economic process – allocation and production

Because allocation assigns inputs to specific outputs, it precedes production in time. Prior to the start of any production activity, economic decision-makers must determine the outputs to which workers, natural resources, buildings, land, and machines will be directed. One of the most significant differences among economies is which social actors make these decisions, and what criteria they use in making them.

Because ENL's criterion for economic success is sustainable well-being, allocation must serve this end. Ignoring wants for now, this means that those who make allocation choices must be aware of the prospective health consequences of their decisions. They must therefore consider effectual value, which implies that their vision must extend beyond production to distribution and consumption. Allocation is therefore a critical economic activity not only because of its far-reaching consequences, but also because it makes the heaviest demands on our information sources, our intellects, and our social judgments.

Production is a somewhat narrower topic. Allocation decisions have already been made, so producers know which outputs should be produced and at what quantities. The challenges at this stage are to maximize output quality and quantity, minimize the inputs used, and minimize damage to workers and the environment. The concepts introduced in this chapter are intended to help an economy meet these challenges.

B. A BRIEF HISTORY OF COST

Compared to value, cost has a much quieter history, at least on the surface. Smith defined it as the amount of money a capitalist must spend to produce a commodity. Marx had very little to say on the subject, although his interpretation was similar to Smith's - cost is the capitalist's financial outlay in production. However, a very different interpretation of cost was occasionally employed by economic thinkers. Marx used the terms "real cost" and "social cost" when he discussed the pain, toil, disease, and pollution experienced by workers and society at large, although he did not formalize the idea. Alfred Marshall similarly referred to the pain or disutility of work as a cost.

The troubling disparity between these two interpretations of cost was resolved for standard thinkers with the concept of ***opportunity cost.*** This is defined as the use-value of the best forgone alternative action. In the context of production, opportunity cost means the following: if a set of inputs is used to produce commodity A when it could have been used to produce best alternative commodity B, the opportunity cost of producing A is the use-value of B. In other words, opportunity cost measures the relative merits of allocating inputs to various production possibilities through the utilities that are expected to result.

Note carefully what is happening here: *opportunity cost avoids the outlay-pain confusion by dissociating cost from the production process and attaching it to allocation decisions*. In the words of pioneering economic thinker Frank Knight:

> "If costs are stated in terms of alternative commodities and all reference either to 'sacrifice' or 'outlays' simply omitted, we retain the scientific content of cost of production theory while side-tracking the sources of a century and a half of controversy." (*Journal of Political Economy*, 1928)

In standard economics today, two concepts of cost are generally recognized. The first is opportunity cost, which reigns supreme as a broad explanatory principle. The second is "accounting cost." This is the outlay idea above, which is normally used when the nitty-gritty of market behavior is addressed. One of my economics texts includes both terms in its glossary, but uses "cost" by itself to mean accounting cost. The definition provided is, "Total payment made by a firm for the services of factors of production." (Michael Parkin, *Economics*)

It is worth nothing that, of the three cost concepts that have arisen in the history of standard thought, opportunity cost and outlay survive, but pain is gone. That is, the two concepts that pertain to capitalist sacrifices are still with us, but the one that pertains to worker and social sacrifices has been abandoned.

C. OPPORTUNITY COST: THE GREAT DECEPTION

Opportunity cost is singled out for further treatment here because of its far-reaching human and ecological significance, and because it appears to have an intoxicating effect on thinkers, both inside and outside the economics profession.

An example of someone outside the field who fits this description is the progressive scholar for whom I did book research at university. When opportunity cost came up at one of our meetings he nearly swooned at the concept's subtlety and incisiveness. Although he was deeply suspicious of standard economics as a whole, he was convinced that at least this idea was solid, and could therefore be the foundation for a new mode of economic thought. Among specialists in the field the situation is, if anything, even more extreme: the ideological origins of opportunity cost are ignored and the concept is considered inviolable.

The truth about opportunity cost should be evident from the above historical sketch: *it is not cost*. As stated, it is a forgone consumption benefit arising from allocation, not a loss incurred in production. *It is what we could have gained, not what we did in fact lose.* As will be explained further below, a forgone benefit and an actual loss are both sacrifices, but in entirely different senses that must be kept strictly separate.

Once opportunity cost became the predominant cost concept in the early 20th century, standard economists bypassed "true cost" - the damage to people and nature in production - and fixed their attention on a related but different subject: allocation. Hence, despite its lavish press, opportunity cost is a cheap bit of conceptual legerdemain that has been astonishingly successful in diverting attention away from the injuries, deaths, and ecological destruction that accompany many production activities.

The success of the opportunity cost concept cries out for an explanation, so let me provide one. The concept is generally introduced to university students as follows: Assume you have a free hour in your busy day at school, and you're deciding how to spend it. Your two best options are studying in the library and attending a documentary film in the theater. If you choose to study, you forgo the film. Watching the film is therefore the opportunity cost of studying. Conversely, if you attend the film, you forgo the study option. Studying is therefore the opportunity cost of attending the film. Another version of this lesson is to use money rather than time. You have a hundred dollars to spend. Your best options are ... and so forth.

Many students nod their heads vigorously at stories like these because they make perfect sense. Students have long understood that choices must be made with respect to time and money, and that making such choices entails the sacrifice of alternative possibilities. Now they are informed that their intuitive understanding is formally recognized, and is a linchpin in the subject they're studying. For those who continue in economics this experience is often the first step in a lifelong commitment to opportunity cost as one of the field's most fundamental and unchallengeable ideas.

Note what such stories achieve. First, they equate the world of personal experience with the economic world of allocation and production, although there is little similarity between the two. Second, they apply the word "cost" to a forgone alternative - a crucial but highly misleading association. Third, they establish the idea that all resources are essentially the same as time and money - that is, they are capable only of being spent. The last two of these points, along with the true nature of cost, can be explained more fully with reference to figure 4-2.

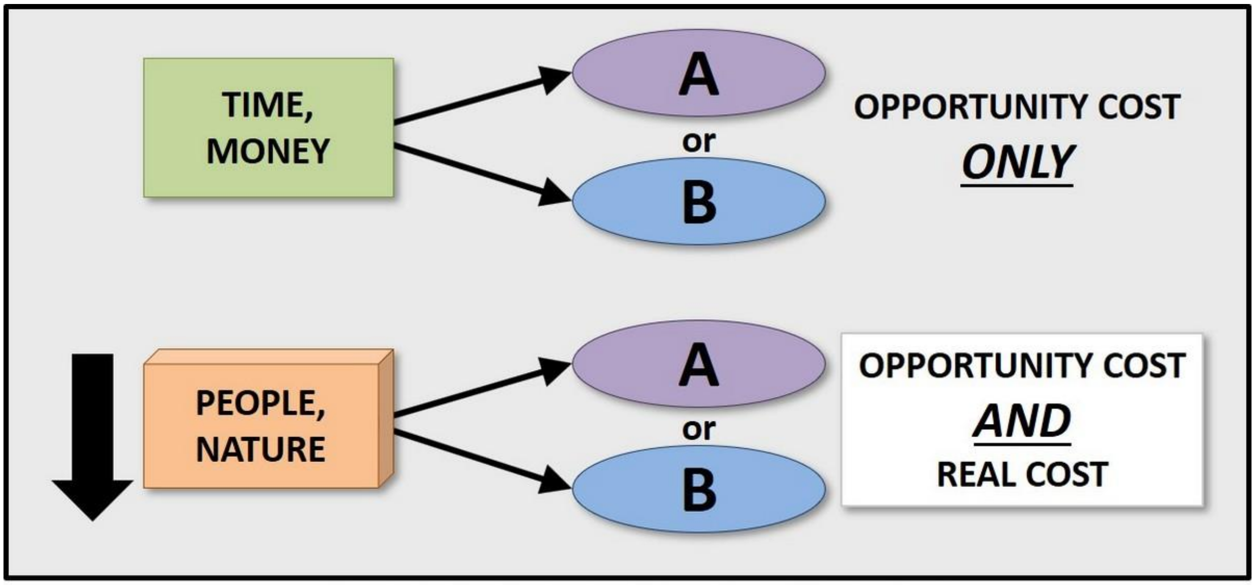


Figure 4-2. Opportunity cost and real cost

At left are four types of resources used in production, divided into two categories. In the first are time and money, which are non-material and therefore not subject to wear and tear in production. They can be spent, but not damaged or degraded, and can thus be called *non-degradable resources*. In the second category are people and nature. Even if ethical issues are ignored, these are fundamentally different in that they are material, and therefore subject to wear and tear in production. Like non-degradable resources they can be "spent", but they can also be damaged or destroyed. They can thus be called *degradable resources*. This distinction is critical for the protection of humankind and the environment, but it is one that standard economics categorically refuses to make.

When a non-degradable resource is allocated to alternative A rather than B, the only sacrifice incurred is the benefit associated with alternative output B. The diagram therefore shows that it entails only opportunity cost. By contrast, when a degradable resource is allocated to alternative A rather than B, two distinct sacrifices are made. The first is the benefit associated with B, as before. In addition, however, we must count the concrete results of the production process: the damage to people, such as injuries, diseases, and deaths, and the degradation of nature, such as habitat destruction and pollution. In the diagram, these negative effects are indicated by the downward-pointing arrow. As shown, these two cases entail both opportunity cost and "real cost".

I should emphasize that ENL does not reject opportunity cost. However, the framework recognizes the concept's limitations and refuses to apply it beyond these boundaries. As has been emphasized, ENL fully acknowledges that allocation is a critical economic task. It therefore accepts opportunity cost as a valid concept with respect to allocation, and incorporates it as such into the framework - albeit under a name that expunges the deceptive word "cost". But in addition to this, ENL recognizes "real cost" as the damage to degradable resources. These two sacrifices are discussed later in this chapter.

D. FORGONE HEALTH AND INPUT COST

The sacrifice made in the allocation of inputs to a specific output is the possibility of using these inputs in other production to gain alternative benefits. This is the sacrifice that standard economics calls opportunity cost. For inputs that are used up in production, such as wood, steel, chemicals, and fuels, this statement is true as it stands. For other inputs, such as workers, tools, and buildings, the statement refers to concurrent production activities. It is impossible to use a set of workers to build a bridge and a dam simultaneously, but they could build both structures at different times.

Although an allocation sacrifice refers to a potential rather than an actual loss, it is highly significant. Inputs that are misallocated will result in fewer benefits than could have been achieved from alternative production, resulting in degraded lives or deaths. This means that the concept of opportunity cost, in this limited application, accurately reflects the sacrifice made in allocation. ENL refers to this sacrifice as ***forgone health***. As explained above, the word "cost" is avoided because the framework does not recognize an allocation sacrifice as a true cost.

Although forgone health is similar to opportunity cost, it may be useful to explain the concept again, this time using ENL terms exclusively.

Assume that a set of inputs can be employed to produce one of three outputs: A, B, and C. Based on analysis and experience, it is estimated that the health gains from these outputs will be 20 units, 15 units, and 10 units respectively. If we choose to produce B, the best alternative is A, which results in 20 units of sacrificed health. The same is true if we choose C. However, if we choose A, the best alternative is B, resulting in 15 units of sacrificed health. Choosing A thus minimizes forgone health, which is ENL's criterion for rational allocation.

The second sacrifice to be considered relates to the health impact on human beings from production, and in this context the word "cost" fully applies. A worker's death is a cost. So is a work-related disability from injury or disease. Less obviously, the impact on human health from greenhouse gas emissions and other production wastes is a cost. In general, any direct or indirect health damage to humankind resulting from production activities is a cost that must be set against the health achieved from consuming the associated final outputs.

This second type of sacrifice, informally called "real cost" above, is referred to as ***input cost*** in ENL. Like potential and effectual value, input cost is objective. It has two components, reflecting the direct and indirect effects of production on health. The direct effects are predominantly experienced by workers themselves: excessive fatigue, debilitating stress, injuries, diseases, deaths, etc. These are collectively called *labor cost*. The indirect effects, through the environmental changes resulting from production, are experienced by both workers and the population at large. These are collectively called *natural cost*.

E. LABOR COST

Labor is the human input to production. It includes all activities, such as transportation to and from the work site, that are immediately necessary for workers to engage in production. It excludes education, training, and other preparatory activities that are not part of production per se.

The two determining factors in labor cost are quality and quantity. Labor quality refers to such factors as the intensity of work, the presence of hazardous materials and dangerous machinery, and stressful relationships. It also refers to work that is conducted at night. The International Agency for Research on Cancer has ruled that overnight shifts likely increase the risk of developing cancer. The Danish government has compensated women who developed breast cancer after working night shifts for a long period. Although some night work - police, janitors, medical staff, etc. - is necessary for most societies, this should not obscure the fact that these activities incur a relatively high labor cost.

High labor quality is characterized by conditions such as a clean working environment, tolerable noise levels, and manageable stress. Particularly important is labor intensity. When this is low or moderate, workers can avoid exhaustion, take frequent breaks, and have time to observe safety standards and thus minimize injuries. For those doing work that requires fine motor skills - factory assembly, sewing, typing, etc. - eyestrain and repetitive strain injuries can be avoided. For those in stressful personal situations, frequent breaks provide opportunities to relax and vent.

Labor quantity simply refers to hours of labor. This is represented indirectly on most ENL graphs by the output quantity produced over a unit of time, on the assumption that labor productivity remains constant.

Labor cost tends to rise with increased labor quantity, for two reasons. The first is that the negative aspects of labor quality - stress, exhaustion, noise, toxins, etc. - increasingly damage workers as the work-day expands. Such effects frequently accumulate in the body, much like environmental contaminants accumulate in nature. The risk of threshold effects is also present. A human being who is pushed to the limit of stress or noise can suffer a devastating nervous collapse, and injuries will likely escalate sharply among time-harried workers.

The second reason why labor cost increases with labor quantity is that more hours at work means fewer hours available for other life activities, such as leisure and sleep. Human beings need adequate time to recover from intense work activities, and like other complex organisms they need adequate sleep to keep their bodies fully functional.

A related issue is that, for many people such as the working poor, the most destructive aspect of work is often not the labor itself, but rather the excessive number of hours they spend getting to their jobs and returning home. Especially if they have small children or other time-consuming responsibilities, they will be deprived of sufficient sleep and leisure, and their bodies will suffer as a result.

Figure 4-3 depicts labor cost of low, average, and high labor quality. As noted above, labor productivity is assumed to be constant, so labor quantity increases at a constant rate with output quantity.

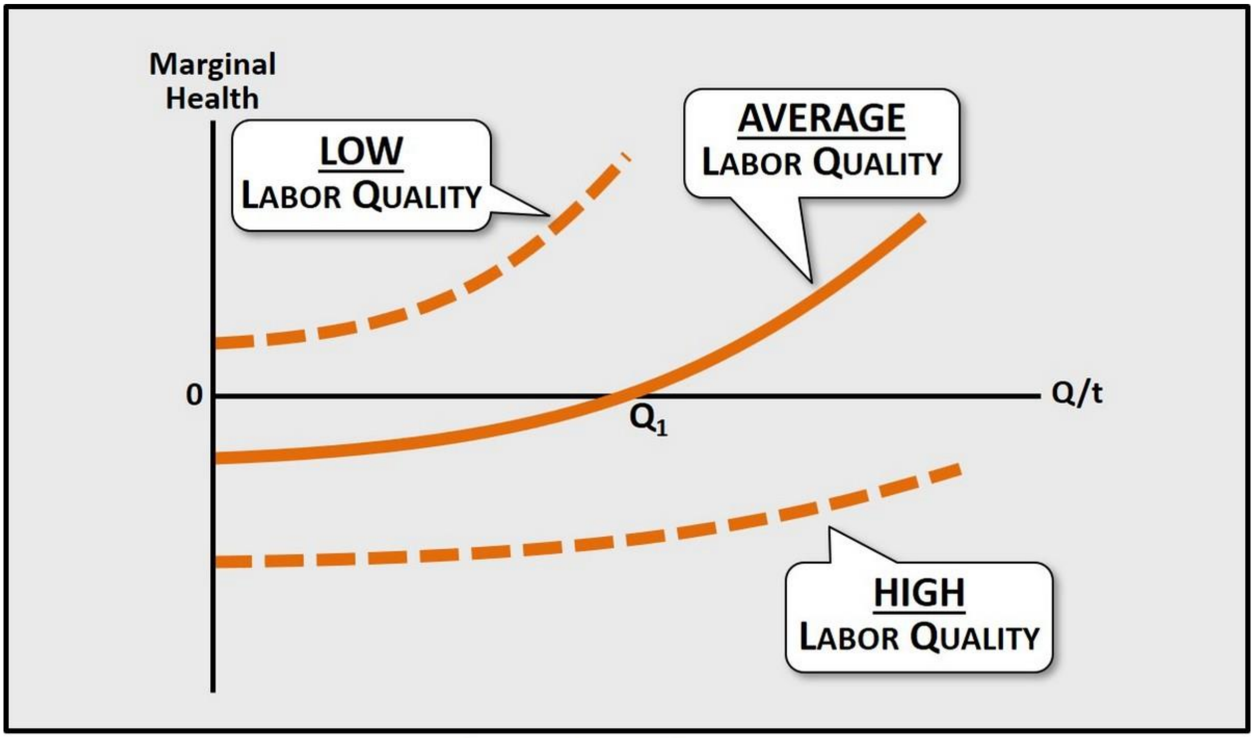


Figure 4-3. Labor cost

If the "high" and "low" in the graph confuse you, remember that cost is the converse of value. Whereas positive value increases health, positive cost decreases it. Similarly, negative value decreases health, while negative cost increases it. The middle curve, which represents average labor quality, begins in the negative range, which means that the health effects of this labor are initially positive. The curve rises as labor quantity increases, and at output quantity Q1 cost becomes positive, indicating that the health effects have become negative.

If labor is of high quality, the cost curve will start below the average curve and may never become positive as labor quantity increases. If labor is of low quality, the curve will start above the average curve and will move rapidly upward. Workers in a coal or uranium mine could be engaged in such labor, which may be destroying their health even when output quantity, and thus labor quantity, is relatively low.

F. EMPLOYMENT LEVEL

A striking fact about social thinkers is their sharp divergence regarding the desirable level of employment. For some, work is an abomination that should be suffered by no-one, while for others it is a wondrous opportunity that should be shared by all. Murray Bookchin is in the first category. In Post-Scarcity Anarchism he praised the Dadaists - “those magnificent madmen” - for demanding “unemployment for everybody”. (p. 131) E. F. Schumacher held precisely the opposite view. In Small is Beautiful he summarized the Buddhist perspective on work and then commented that, "... work and leisure are complementary parts of the same living process and cannot be separated without destroying the joy of work and the bliss of leisure.” (p. 58)

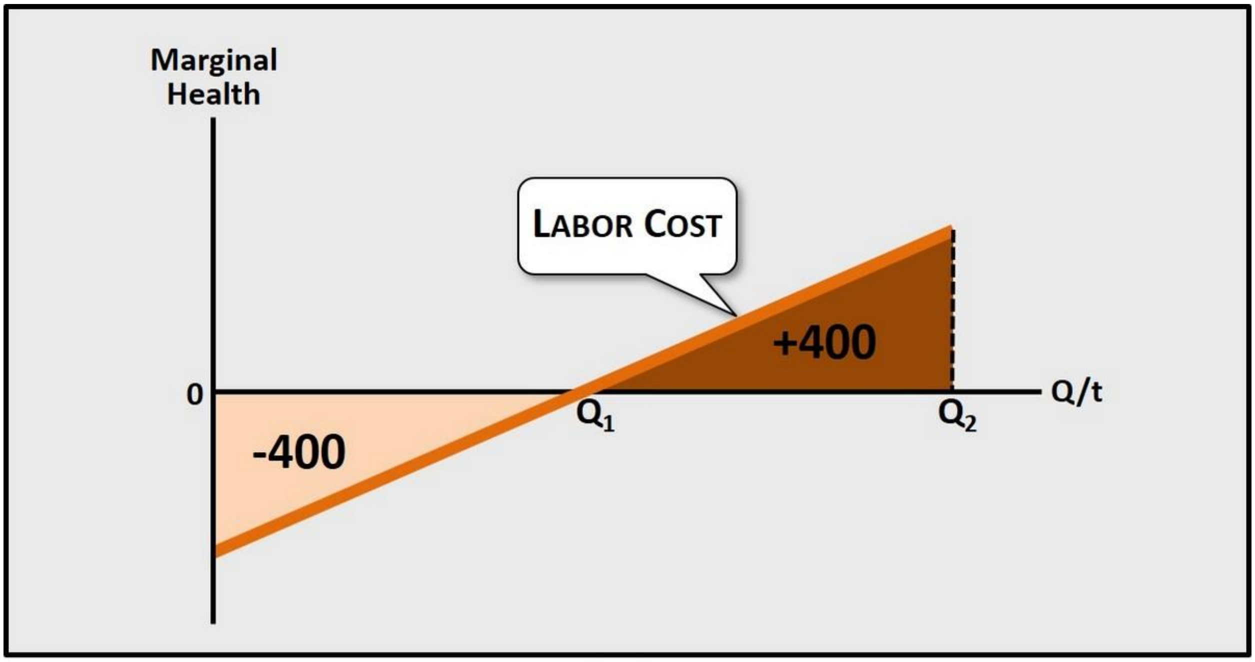


Figure 4-4. Labor cost and employment level

For ENL the question must be settled according to its principles. We must therefore ask: what employment level will maximize aggregate health? The answer to this question follows from the shape of the labor cost curve. As described above, this tends to slope upward, reflecting the increasing levels of stress, fatigue, injuries, deaths, etc. that accompany a longer work-day. With a rising cost curve, a higher number of workers will result in higher aggregate health when output quantity is kept constant. This can be illustrated with reference to figure 4-4, where labor cost is depicted as a straight line for simplicity.

Assume that twenty workers are currently employed, and that each produces quantity Q2, with a work-day of corresponding length. Each worker thus incurs a labor cost of -400 + 400 = 0, for a total labor cost of zero among the work force. Now assume that twenty more workers are allocated to the production of the same total quantity. Each worker thus produces a quantity of Q1, which corresponds to a work-day that is half the initial length, with a labor cost of -400. In this situation, positive labor cost is not incurred by any worker. The total labor cost among the work force is now 40 * -400 = -16,000. A minus cost is a health gain, so this represents a substantial increase in total health. This total continues to increase as more workers are allocated to the same production task because their labor is shifted even further down the labor-cost curve.

This leads to the above general conclusion: aggregate health from labor is maximized when the employment level is maximized for a given quantity of work. In the expressive language of folk wisdom: "Many hands make light work." There are of course practical limits to the number of workers who can be fruitfully engaged in a production process based on technical requirements, space considerations, etc., but within these limits we should strive to employ as many workers as possible.

G. MALDISTRIBUTION OF LABOR

ENL applies the concept of distribution not only to final outputs, but also to labor and wastes. The reason for this broader treatment is that all three can be socially assigned to individuals in ways that significantly decrease their health. That is, they are all subject to maldistribution. In the previous chapter maldistribution was discussed in relation to final outputs. Here it is extended to labor, and in a later section to economic wastes.

As stated in chapter three, an output is perfectly distributed when each unit is consumed by the person who can convert its potential value into the highest possible effectual value. The analogous statement here is that labor is perfectly distributed when each unit of labor time is assigned to the worker who will incur the lowest labor cost. If labor cost is negative, this points to the worker who will gain the most health from working this unit. If labor cost is positive, it points to the worker who will lose the least health. Any distribution that does not satisfy this criterion is called ***labor maldistribution***. See figure 4-5.

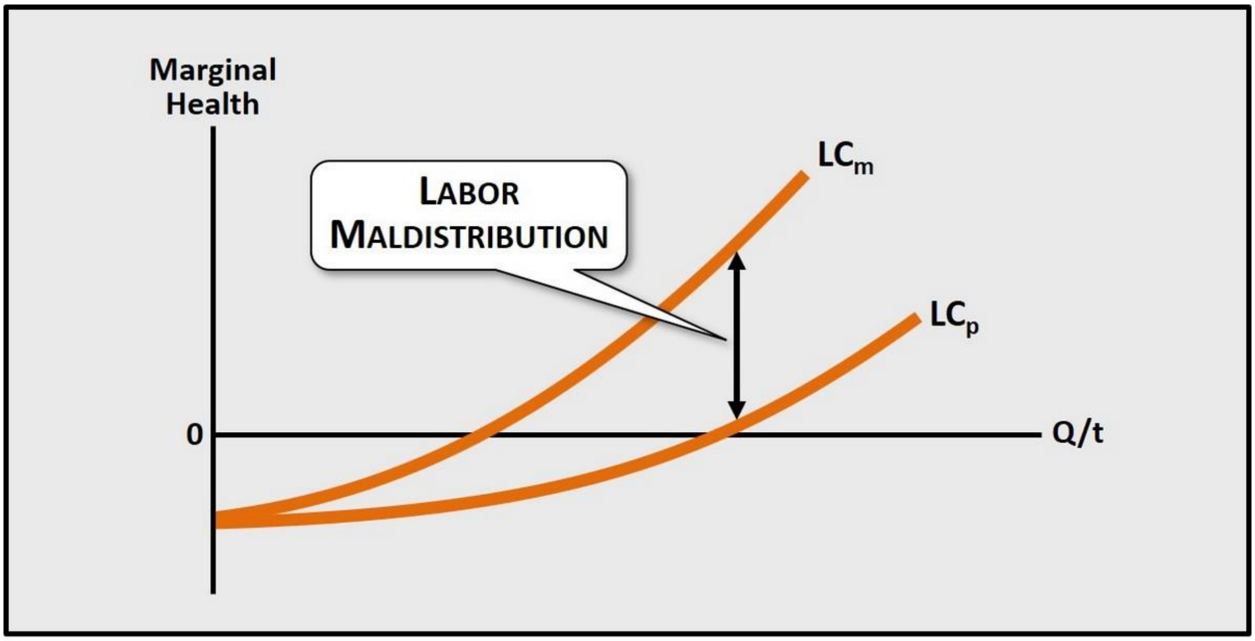


Figure 4-5. Labor maldistribution

The bottom curve, labeled LCp, represents perfect labor distribution in that each labor unit is performed by the worker who can best absorb its health effects. The top curve, labeled LCm, reflects the maldistribution of labor. Similar to output maldistribution (figure 3-6), this results in decreased aggregate health, although in this case the curve rotates up rather than down.

H. NATURAL COST

In chapter three I said that value and cost pertain to humankind alone. It follows that ***natural cost*** does not refer to environmental damage itself, but rather to the human health effects associated with such damage. It is thus an indirect effect of production. ENL of course addresses environmental damage, but it does so by treating the environment as a set of limits rather than a set of costs. These limits are addressed in chapter six.

Like labor cost, natural cost can initially be positive or negative, and it tends to increase at the margin. It is positive when production degrades the environment so that human health is adversely affected. It is negative when production results in a cleaner or more habitable environment, thereby increasing health. Because input cost is the sum of labor cost and natural cost, natural cost is graphically depicted as the difference between the input cost and labor cost curves. See figure 4-6.

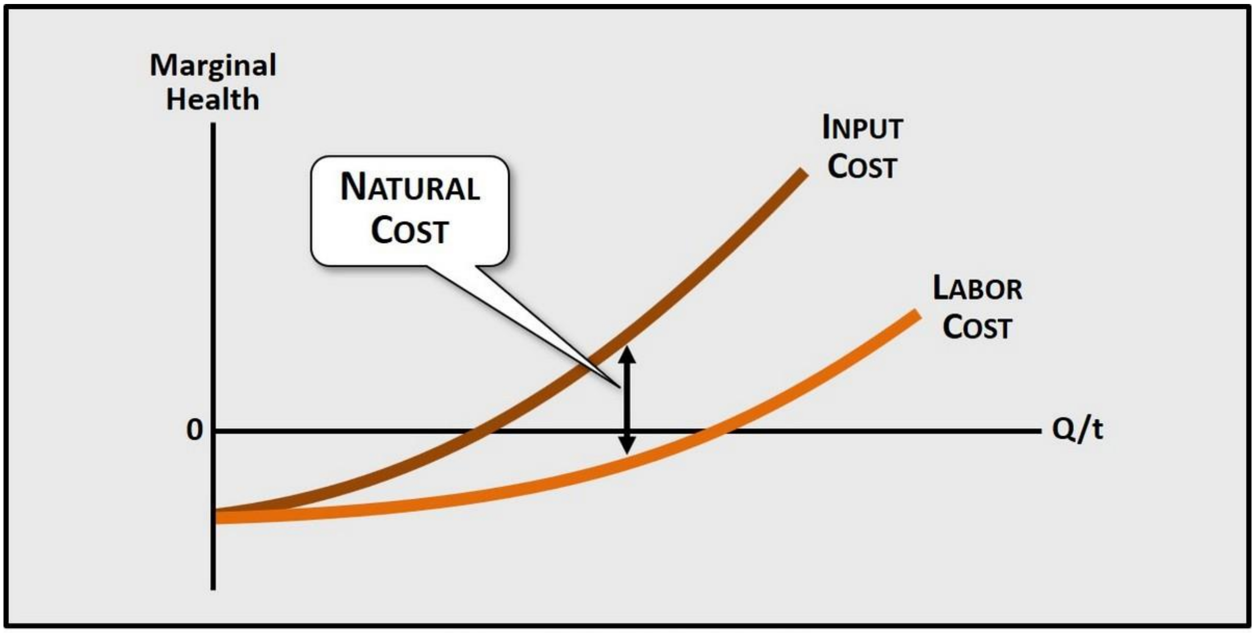


Figure 4-6. Natural cost

Natural cost tends to increase at the margin because wastes typically accumulate in the environment, as does the impact of habitat destruction on non-human species. This will cause an escalating effect on humankind, as depicted by the growing distance between the two curves.

The decision to represent labor cost as the bottom curve and natural cost as the difference between the curves was made for two reasons. First, labor cost is the direct effect of production, whereas natural cost is the indirect effect. It seems more appropriate to explicitly depict the direct factor. Second, natural cost is more likely to be positive across the entire range of an output’s quantity. This prevents the two curves from crossing and makes such graphs easier to interpret.

Note that, even if the analyst chooses regional geographical scope, the natural cost of production is always considered on a global basis. When greenhouse gases escape from a region, or when its agricultural phosphates invade an international waterway, the worldwide health impacts of these environmental effects are counted as a natural cost for the region that initiated the damage. In other words, there are no environmental "externalities" in ENL.

I. MALDISTRIBUTION OF WASTES

Recall from chapter two that wastes are the material residues of economic activities: pollution, discarded production materials, junked outputs, etc. Because these residues can be harmful to human health, their distribution among countries, regions, neighborhoods, and individuals is a critical issue for an economy's health maximization.

Analogous to labor cost, aggregate natural cost is minimized when each unit of waste is assigned to those who will incur the lowest possible natural cost. Any distribution that does not meet this criterion is called ***waste maldistribution***. See figure 4-7.

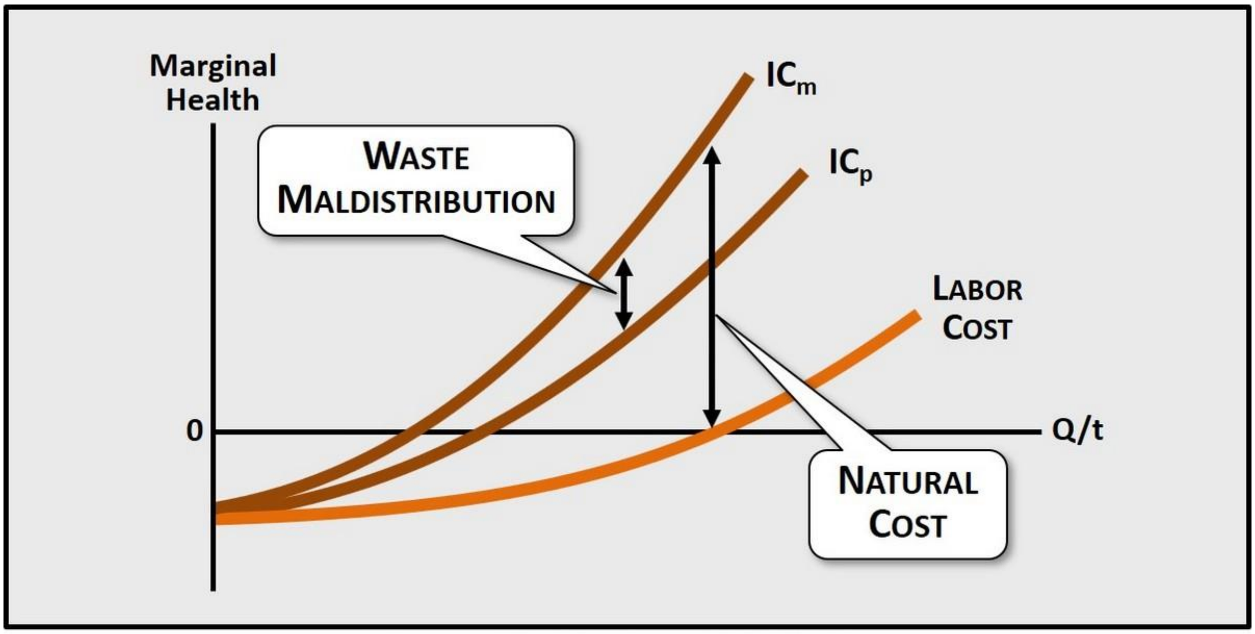


Figure 4-7. Waste maldistribution

As explained in the previous section, natural cost is the difference, or vertical distance, between the labor cost and input cost curves. In this graph "input cost" has been replaced by "ICp" to indicate that perfect distribution of wastes was assumed in figure 4-6. When waste maldistribution occurs, natural cost rises. This causes input cost to rise, as indicated by the curve marked ICm.

A good example of waste maldistribution appeared in a 2006 New York Times article:

> "The South Bronx is home to miles of expressways, more than a dozen waste-transfer stations, a sewage-treatment plant and truck traffic from some of the busiest wholesale produce, meat and fish markets in the world. It is also home to some of the highest asthma hospitalization rates for children in the city. The N.Y.U. study found that the students were exposed to high levels of air pollutants in their neighborhoods, and that children in the South Bronx were twice as likely to attend a school near a highway as were children in other parts of the city."

Concentrating all these pollution sources in one area of the city means that its residents will absorb far more economic wastes than their bodies can tolerate, which means their health will suffer. If these sources were distributed more widely among New York's five boroughs, more people would be exposed, but possibly at levels that cause far less damage to aggregate health.

J. DEATHS FROM PRODUCTION

In chapter three I discussed ENL's method for quantifying the health effects of consumption-related deaths. To recap: Various organizations have developed measures, such as PYLL (potential years of life lost), to account for the fact that a young person's death is more serious than that of an older person. ENL has adopted this approach, and quantifies the loss through *lost potential health*. In the context of consumption, this means decreased potential value. In the context of production, it means increased labor cost or natural cost.

Consider a 30-year-old steelworker who dies while constructing a building. If this worker was expected to live to age 80, they will lose the health that would have been gained from ages 30 to 80. This cost must be added to the overall labor cost of constructing the building. Similarly, if 10,000 people around the world have shortened lives because of air pollution caused by local production, the lost potential health due to their early deaths must be added to the natural costs of the associated outputs.

K. VALUE, COST, AND THE OUTPUT LIFE CYCLE

Figure 4-8 repeats the output life-cycle diagram from chapter two, but adds the value and cost concepts discussed in this and preceding chapters.

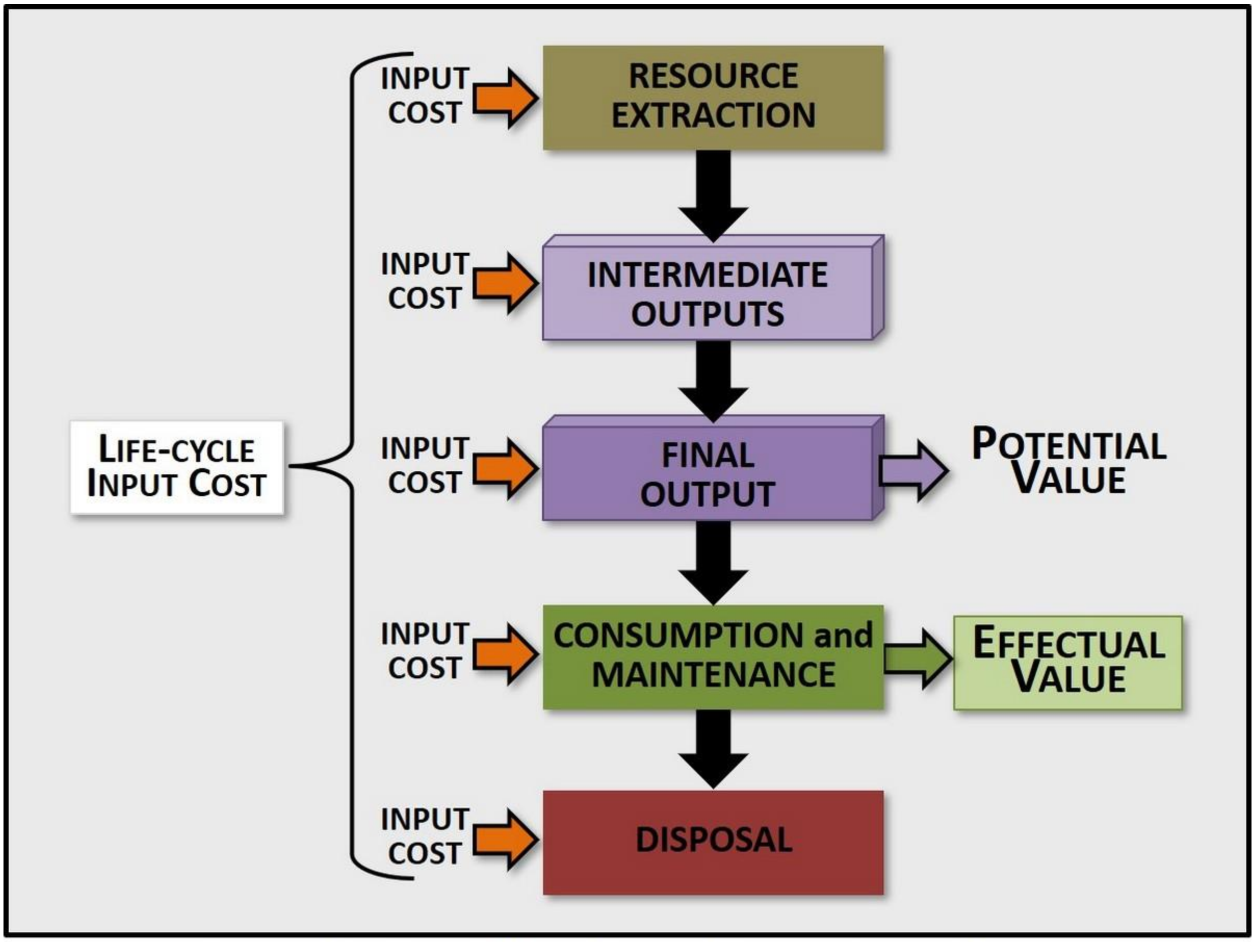


Figure 4-8. Output life cycle in relation to value and cost

Note that potential value applies only to the final output, and that effectual value applies only to the output's consumption. Input cost, however, applies to all stages of the output's life cycle because production - which includes transportation - is typically required at each stage.

The above diagram is important because it captures the essence of ENL's approach to the gains from economic activities - a topic that is discussed in chapter five. In this approach, effectual value is compared to life-cycle input cost. If effectual value is greater than this cost, people within the geographical scope of analysis will gain health from this output at the current quantity. If effectual value is less, health will be lost instead.

L. DEFINING WELL-BEING

To this point "well-being" has been used informally, with the conventional meaning of satisfactory conditions for human existence. Now that ENL's core concepts have been introduced, the term can be formally defined. First, however, two difficulties must be acknowledged.

The first is that, to fully capture human experience, well-being must refer to the combination of health satisfaction and want satisfaction. Unfortunately this runs into the problem of incommensurability. Health is objective and directly measurable, whereas want satisfaction is subjective and must be measured indirectly.

The second difficulty is that well-being is subject to social neutrality, which implies that ENL cannot dictate how the health and want satisfactions are combined. One society may decide that well-being means adequate health plus extensive want satisfaction, whereas another may choose maximum health plus modest want satisfaction.

Taking these two difficulties into account, ENL defines ***well-being*** as the socially-specified combination of an individual's need satisfaction (as measured by effectual value) and want satisfaction, net of any input cost incurred. This is how the term will be used in the rest of this book, and what it means in ENL's goal of sustainable well-being.

Because well-being includes two incommensurable factors, ENL generally avoids the concept where quantification is required. The only exception is the framework's treatment of population. As explained in chapter seven, average well-being is the measure applied there.

Chapter 5:
Maximizing Gains

This chapter marks a shift from ENL's basic concepts to its core analytical tools. These tools address the maximization of health gains, environmental limits, and the population level. The first topic is addressed here. The last two are discussed in the next two chapters.

When dealing with the economy as a whole, health maximization refers to a society's aggregate health gains. Aggregation means that all members of a society are treated equally for analytical purposes. The gains achieved by some members will therefore be offset by the losses incurred by others. This reflects ENL's social perspective: the goal is maximized well-being for society as a whole. Remember, however, that ENL observes the principle of social neutrality: the framework identifies the components of well-being, but does not dictate how these components are combined in the term's definition.

Because there are strong interactions among gains, the environment, and population, a systematic approach is necessary to avoid errors and confusion. With this in mind, the present chapter deals with gains in isolation from the environment, and assumes that the population level is fixed. Its conclusions are therefore tentative. Chapter six modifies these conclusions by taking the environment into account, but it retains the assumption of a fixed population. Chapter seven finalizes the conclusions by considering the effects of population changes.

One last note: The maximization of human gains from economic activities is a broad topic that includes two specialized areas - labor productivity and trade. Because these require fairly extensive treatments, they are deferred until the core components have been presented. I therefore return to labor productivity in chapter eight, and to trade in chapter nine.

Gains maximization is heavily dependent on optimization. I therefore begin with this concept.

A. OPTIMIZATION

In general, to "optimize" means to achieve the most desirable outcome, given a stated objective and any relevant constraints. In standard economics a typical optimization involves the maximization of utility within the constraint of a financial budget. In ENL the term refers to the extraction of the greatest possible health from an economic activity, without regard to environmental limits.

More specifically, ENL's optimization answers the following question: for a given final output, what quantity should be produced over a specified period so as to maximize overall health gains? This question is considered first with respect to the short run, during which the value and cost curves are fixed. It is then considered with respect to the long run, where underlying economic conditions can change and the curves can be modified.

The distinction between the short and long run is important, so let me clarify it before proceeding. The ***short run*** is characterized by changes that are predominantly behavioral rather than physical. At least in principle, a society could one day decide that it is drastically over-consuming and immediately lower its consumption level. This would quickly reduce the economy's natural flows, which include today's perilous greenhouse gas emissions. Output quantities and natural flow rates can thus change in the short run. This is also true for allocation and distribution, which are driven by social decisions that could rapidly shift.

Population change is clearly in a different category. Reducing a society's population would entail not just behavioral modifications, but also the physical realities of births and deaths. Similarly, changes in potential value and input cost typically require physical modifications to production methods, as well as technological changes that depend on the physical processes of experimenting, prototyping, testing, etc. This means that population, potential value, input cost, and technology are in the ***long-run*** category. Let me now return to optimization.

Technically speaking, optimization applies only to final outputs. This is because the method deals with gains, which - as will be seen in the definition below - require the availability of both effectual value and input cost. Because an intermediate output is not directly consumed it does not result in effectual value, which means that its optimum quantity cannot be directly defined. However, I find it convenient to relax the terminology here and to apply the word "optimum" to intermediate outputs as well.

Optimization requires the consideration of life-cycle input cost. Recall from the last chapter that this is the inclusive interpretation: the sum of all five stages of the output life-cycle, from resource extraction to disposal. This is how "input cost" is used in this chapter.

B. COMBINING THE VALUE AND COST CURVES

The value and cost curves introduced in the last two chapters can be combined in a single graph, as shown in figure 5-1.

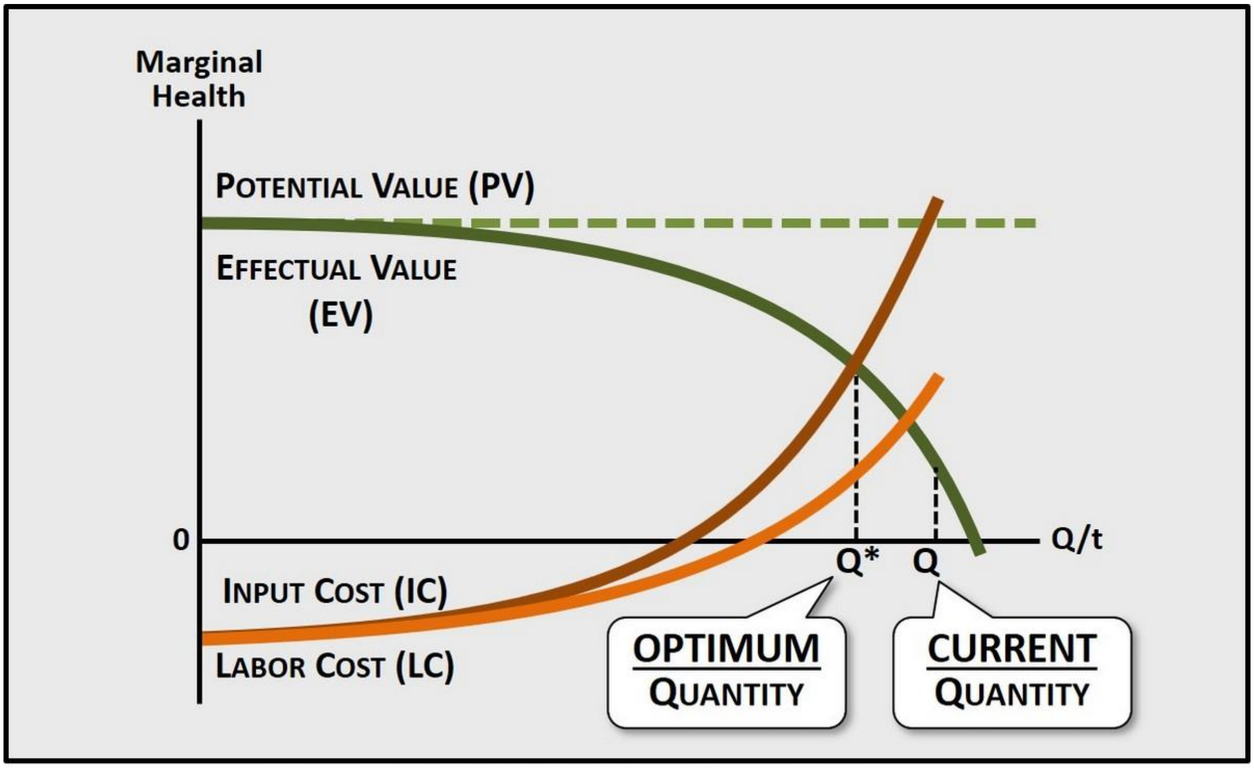


Figure 5-1. Combining the value and cost curves

Following a convention used in standard economics, the symbol "Q*" (pronounced "Q-star") indicates the optimum quantity, which in ENL's case means the health-maximizing output quantity. As previously noted, the letter "Q" by itself denotes the current quantity - that is, the quantity actually produced during the specified time period. In figure 5-1, the current output quantity is higher than the optimum output quantity.

The above graph includes four curves, which explicitly depict the two types of value and two of the three types of cost. Natural cost is also present, but as an implicit quantity - the difference between the input cost and labor cost curves. For many analytical purposes only the health effects are relevant, and in such cases this graph is unnecessarily complex. Potential value refers to possible rather than realized health, and labor cost is just one component of input cost. Thus, when analysis requires only the consideration of actual health effects, both of these curves can be omitted.

In the descriptions below I repeat some of the principles that were introduced in the previous two chapters. This is intended to help the reader come to grips with ideas that are presumably unfamiliar. As well, in several of the explanations I avoid the term "marginal" in order to simplify the text.

C. HOW MUCH BREAD?
OPTIMUM QUANTITY FOR A FINAL OUTPUT

If we are trying to maximize health gains, the most basic task is to determine the optimum quantity for a single final output such as bread.

Imagine that we are members of a small, self-contained economy. There is no trade, so all values and costs are experienced by the members themselves. Our task is to decide how many loaves our economy should produce so as to maximize aggregate health. What method should we use in making our decision? The correct approach is to use marginal analysis to determine the optimum number based on the current value and cost curves for this output.

The optimization rule is straightforward: *increase the output's quantity until its cost has risen to equal its value*. The first type of value to consider in implementing this rule is potential value: the maximum capacity of a loaf of bread to increase our health. Let's assume that this capacity is 100 health units.

Although potential value is the necessary starting point, it is only a potential - considered by itself, it has no effect on health. The realization of this potential, which will determine the actual health our society gains from bread consumption, depends on the attainment of effectual value. This will depend on three factors: the loss of bread through degradation or destruction after it is produced, the satiation experienced during consumption, and maldistribution.

Because we are imagining a more or less ideal situation, let's assume that bread loss is low, and that distribution is perfect. A few loaves are destroyed in production, a few others are crushed during delivery, and some are left on the shelf too long and get moldy. However, most of the loaves survive, and they are consumed by people who can extract the maximum amount of effectual value from them.

Let's therefore assume that, under these conditions, the effectual value of the loaves starts at 95 health units. If the pattern of distribution remains unchanged as more loaves are produced, and if satiation does not occur, 95 units will be a constant quantity, and we should continue to produce loaves until their cost rises to this level. However, satiation will inevitably occur - this is an unavoidable consequence of all such consumption. Thus, even with perfect distribution, the effectual value resulting from our bread consumption will decline, although the rate at which this occurs is entirely an empirical issue.

Now let's consider the cost side. The only "true cost” in ENL is input cost. The opportunity cost of standard economics, which in ENL is called forgone health, addresses allocation rather than production. Here we are dealing with production, after allocation decisions have already been made.

The input cost to be considered refers to the bread's entire life cycle. Producing bread involves much more than putting dough in ovens: it entails a whole string of prior activities, including the production and transportation of flour, yeast, salt, sugar, additives, and packaging. After the bread is consumed, the packaging must be recycled or discarded. The facility that produces the bread must initially be constructed, then serviced and maintained, and eventually torn down. The labor cost and natural cost for all these steps must be included when estimating the bread's input cost.

Let's assume that the labor required to produce small quantities of bread consists of healthy activities, but that there is some natural cost associated with this production. The input cost of the initial loaves is therefore low - let's say 10 health units.

As explained in the last chapter, input cost tends to rise as output quantity goes up. As bread production increases, it might turn out that, when production reaches 10,000 loaves, the effectual value from a loaf of bread has decreased from 95 to 55 units, and its input cost has increased from 10 to 55 units. This means that, for the next batch of loaves to come out of our ovens, input cost will be greater than effectual value. Thus, if we bake more than 10,000 loaves, our society will lose more health from producing the next batch than will be gained from its consumption. This is clearly irrational given the aim of aggregate health maximization, so production should cease at this number.

What we have just done, using informal terms and fictitious numbers, is to establish the optimum level of bread production for our society. Although many issues must be addressed before such an estimate can be made in a realistic situation, this is the heart of the rationality we should strive to achieve.

This procedure is not new with ENL. Standard economics has for many years used it to optimize a firm's output level in order to maximize its profits by equating its marginal cost to its marginal revenue. What is new here is that this well-established technique has been applied to the basic human realities of health gains and losses so as to reach a preliminary conclusion about a final output's rational quantity.

The graph in figure 5-2 depicts the situation just described - specifically the case where production goes beyond the optimum output of 10,000 loaves. As explained above, the potential value and labor cost curves are omitted. As well, abbreviations are used for "effectual value" and "input cost". This will also be done in future graphs to minimize clutter.

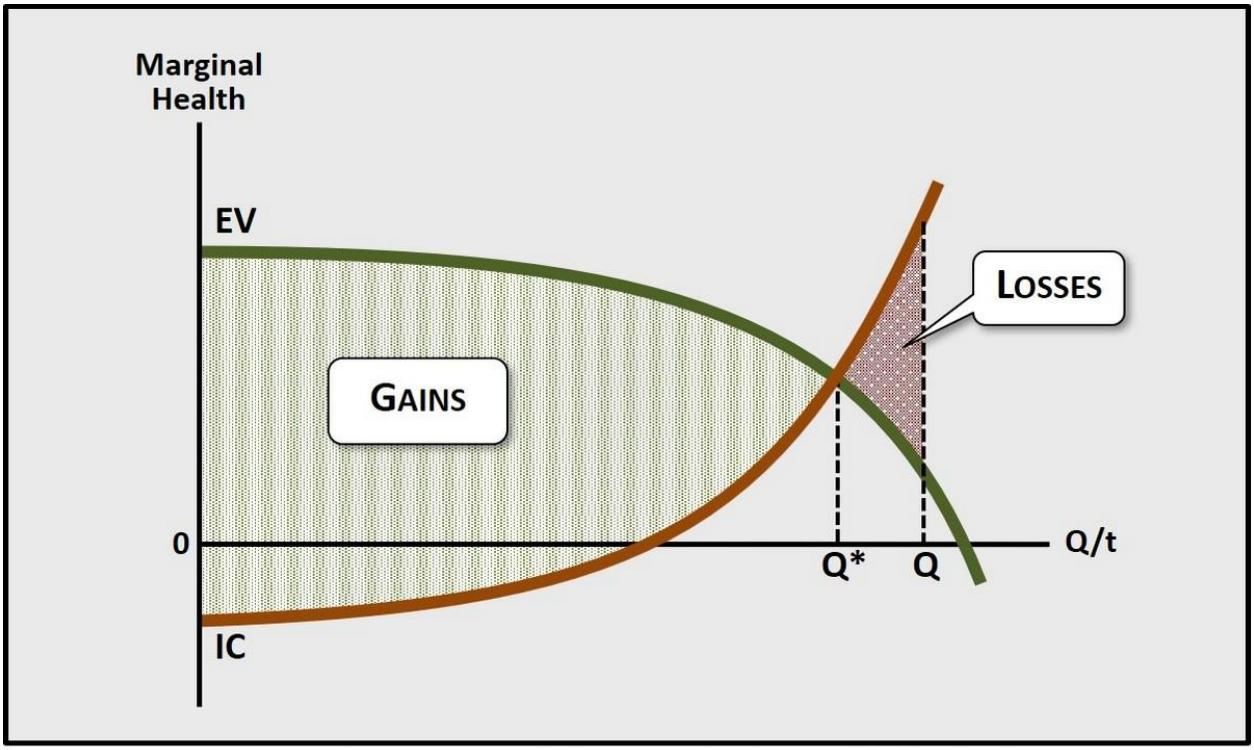


Figure 5-2. Overproduction - output quantity too high

In ENL, ***gains*** is a formal term. They arise when the effectual value from consuming an output is greater than its input cost, and a health increase is therefore achieved. Here this is true for the quantities between 0 and Q*. The gains are thus represented by the lightly shaded area at left. ***Losses*** are incurred when the situation is reversed - when input cost is greater than effectual value and a health decrease results. This is true for quantities between Q* and Q. Losses are thus represented by the heavily shaded area at right.

To determine the overall health effects in this situation, we must calculate the ***net gains*:** the difference between gains and losses. For example, if the gains area at left represents 50 health units and the losses area at right represents 7 units, the net gains are 50 – 7 = 43 units.

Losses are incurred whenever an output is overproduced - that is, whenever the current quantity is greater than the optimum quantity, as in figure 5-2. Whether such losses result in net gains or net losses depends on the numbers involved, so no general statement can be made. In this case net gains arise because the gains (50) are greater than the losses (7). If the output quantity were to increase so that losses exceeded 50, the result would instead be ***net losses***.

The losses shown above can be reduced by decreasing the output quantity. However, if this goes too far, the error of overproduction becomes the error of underproduction. This is depicted in figure 5-3.

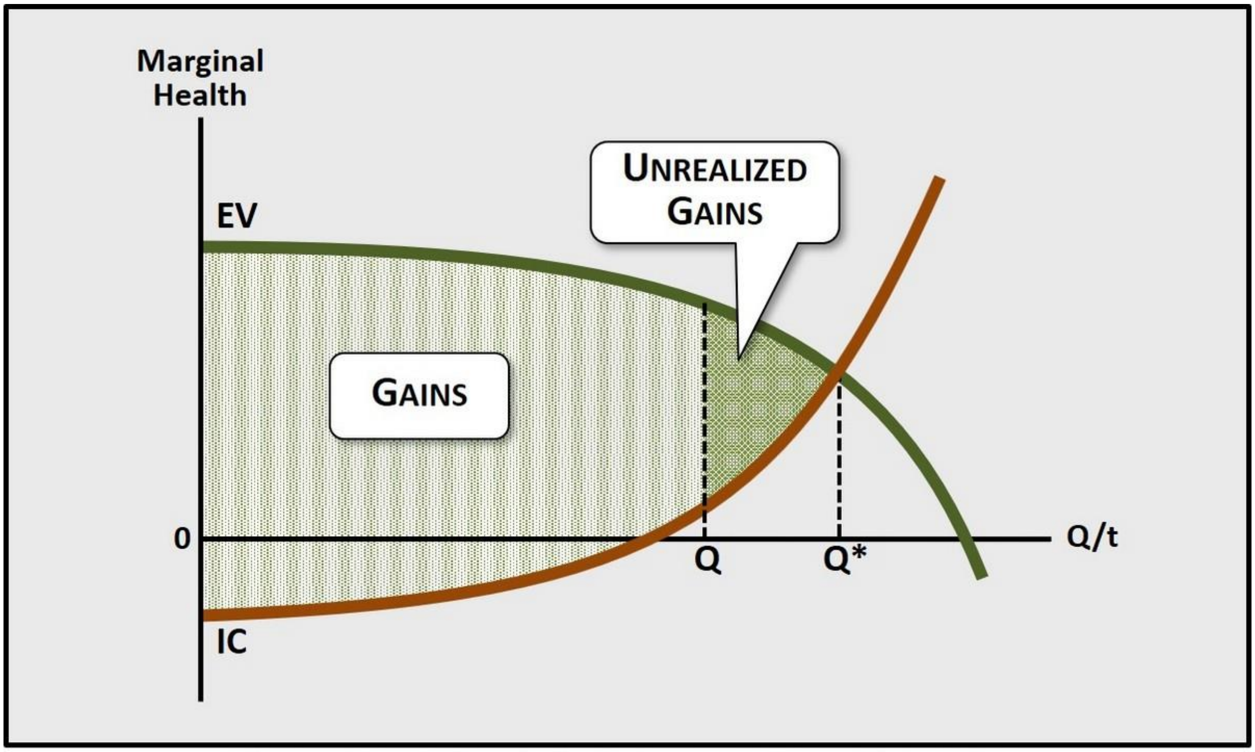


Figure 5-3. Underproduction - output quantity too low

Here the current quantity is less than the optimum quantity, resulting in too little output, or underproduction. Outright losses are avoided, but some achievable gains are not realized. These are represented by the heavily shaded area at right. If we assume that this area represents 7 units of health, output quantity Q results in the same net gains as in the previous situation: 43 units.

Although this demonstration is by no means rigorous, it should be apparent that health is maximized, and output quantity is therefore optimized, when the current quantity is Q* - the output level where marginal input cost equals marginal effectual value. This is shown in figure 5-4.

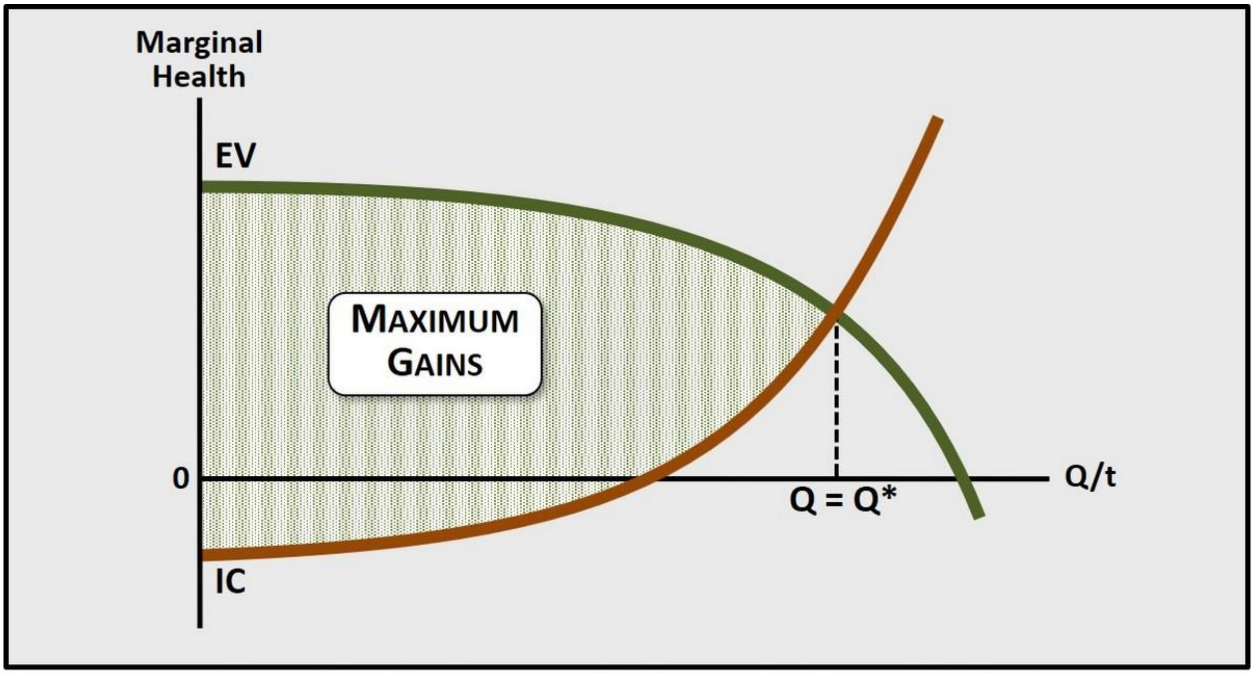


Figure 5-4. Optimum production - output quantity ideal

Here all achievable gains are realized and no outright losses are incurred. The net gains of 50 health units are the maximum possible given the effectual value and input cost curves shown. In the short run, therefore, this is the optimum quantity for this final output. Unless the curves are modified in the long run, health from this output is maximized by producing it at this ideal quantity.

D. HOW MANY CIGARETTES?
OPTIMUM QUANTITY FOR A HARMFUL OUTPUT

Some outputs, such as cigarettes, result in sharply negative effectual value because of the severe health problems they cause. Even if such outputs are produced under healthy working conditions, the effectual value derived from their consumption will likely be lower than their input cost at all output rates. Based on ENL's criteria, such outputs should not be produced at all and are therefore called ***irrational outputs***. The optimum quantity for such outputs is zero, which means that production at any level would constitute overproduction. Figure 5-5 depicts two examples.

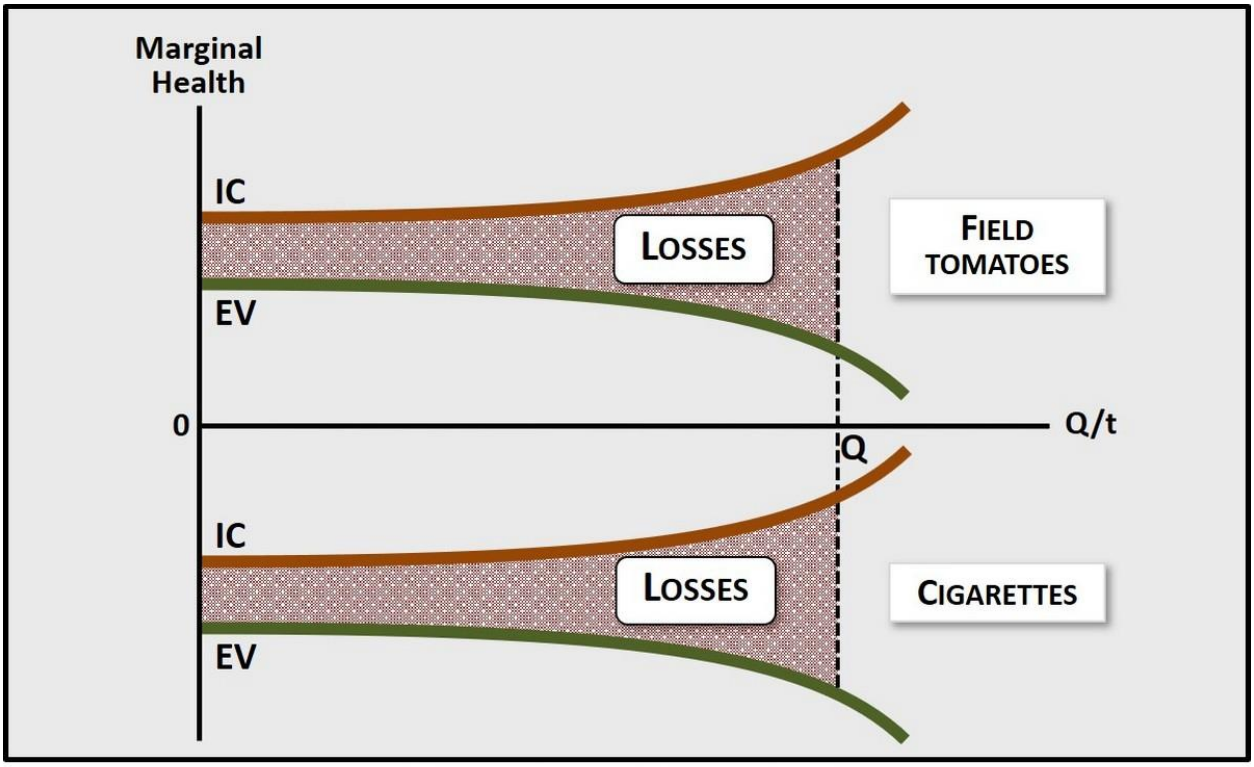


Figure 5-5. Irrational outputs

For cigarettes, input cost is assumed to be negative across the entire output range. Because negative cost means positive health, health is achieved in the production process. However, the effectual value from consumption is so low that this prospective gain is more than cancelled out. Losses are incurred at even the lowest quantities, so any production of this output is economically unjustified.

Unlike cigarettes, field tomatoes generate positive effectual value across their entire range, indicating that health would be gained from their consumption. Here, however, the input cost is so high that this prospective gain is wiped out. Production of this output is therefore irrational as well. This situation could arise if the tomatoes are grown under conditions of intense heat and exhaustion, thereby incurring high labor cost. In addition, fields are typically sprayed with toxic chemicals, and tomatoes are frequently transported long distances to their markets, thereby incurring considerable natural costs. The sum of these costs, which is the input cost of their production, could in some cases exceed their effectual value even at low quantities.

E. HOW MANY TRANSPORT TRUCKS?
OPTIMUM QUANTITY FOR AN INTERMEDIATE OUTPUT

A transport truck is an example of an intermediate output. Recall that such outputs are not consumed as end products, but are instead used in the production, physical distribution, and consumption of other outputs. Because an intermediate output cannot directly affect health in consumption, it lacks potential value and cannot achieve effectual value. As emphasized in chapter three, anything that is necessary for production, but has no value itself, is a cost. Transport trucks and other intermediate outputs are therefore part of the life-cycle input costs of the final outputs with which they are associated.

As we have seen, the optimization procedure for final outputs requires both effectual value and input cost. The fact that an intermediate output cannot achieve effectual value means that its optimum quantity must be indirectly determined. Because such an output is part of the input cost for each of its associated final outputs, its ***optimum quantity*** is the quantity that will minimize these costs. In most cases this means the minimum quantity required for the current production process.

For example, if we are currently using transport trucks to move the optimum quantity of bread from a central bakery to various stores, and transportation costs are minimized when eight transport trucks are used, this is the optimum number of such trucks our society should have on the road. However, the optimizing principle should be more broadly construed: we are not really seeking the optimum number of trucks, but rather the means of bread transportation with the lowest input cost. Thus, if this cost is lower for trains than for trucks, we should switch to trains. Still more broadly, we should consider decentralizing bread production to further reduce the input cost of its transportation.

F. HOW MANY CONCERTS?
OPTIMUM QUANTITY FOR A WANT-SATISFYING OUTPUT

In many cases, especially in the rich countries, an economy will produce outputs that are non-essential in that they satisfy wants instead of needs. Such outputs either generate no positive health effects when they are consumed, or the health effects are so minor that they can't realistically be quantified. Some examples are concerts, movies, and electronic gadgets.

Whether or not such wants should be authorized depends on the strength of society's overall consumption desire, the input cost of the output's production, and the economy's available ecological space. This topic must therefore be deferred until chapter six, after environmental factors have been considered and ecological limits can be included in the discussion.

G. WHAT LEVEL OF TOTAL OUTPUTS?
OPTIMUM SCALE FOR THE ECONOMY

Analytically addressing an economy's cumulative outputs, or scale, is a vexed issue because it is difficult to measure, or even to coherently define, the total quantity of non-homogeneous outputs. Standard economics aptly calls this the aggregation problem.

There is no difficulty in quantifying changes to a specific output mix. If an economy produces 5 bicycles and 100 pomegranates, and this mix increases to 10 bicycles and 200 pomegranates, the economy's size has clearly doubled. But what can be said if the output proportions change, and the new mix includes 10 bicycles and 150 pomegranates? Worse, what if the mix itself changes, and the economy now produces 8 bicycles, 75 pomegranates, and 50 pounds of carrots? In such cases it is impossible to quantify the changes in the economy's scale unless we have a unit of measurement that is common to all outputs.

Standard economics solves this problem by expressing all outputs in monetary terms. This allows its practitioners to talk about increases and decreases in an economy's output level by citing changes in its GDP. Although the reduction of concrete outputs to abstract money removes all distinctions about output quality - their objective effects on humankind and nature - this does not deter the standard discipline. Numerous commentators have decried the absurdity of this approach, but the business world and its economists continue to speak with reverence about GDP fluctuations.

Because ENL is deeply concerned about an economy's effects on people and planet, it cannot solve the aggregation problem in such a facile manner. However, its rejection of the monetary abstraction also means that it rejects a universal measurement unit. The result is that, when ENL talks about an increase or decrease in the economy's scale, it must assume that the output mix remains substantially unchanged. Under this assumption, the economy reaches optimum scale when the total marginal input cost of its outputs equals their total marginal effectual value. The graphs in figures 5-2, 5-3, and 5-4 could then be used for analytical purposes.

H. LONG-RUN OPTIMIZATION

The optimization of output quantities has to this point assumed that value and cost remain unchanged, which means that their curves are fixed. However, an economy's health results can be significantly increased by modifying the underlying value and cost conditions, which would be expressed by shifting and rotating the associated curves.

The following are some examples of beneficial changes in economic conditions:

- *Potential value* rises due to improvements in food nutrition, toy safety, and output durability;
- *Effectual value* increases based on lower output spoilage and more equitable distribution;
- *Labor cost* decreases because excessive stress and fatigue are avoided in the workplace, thereby reducing worker injuries, diseases, and deaths;
- *Natural cost* decreases due to reductions in the toxins released from production processes.

Such improvements in cost and value are depicted in figure 5-6.

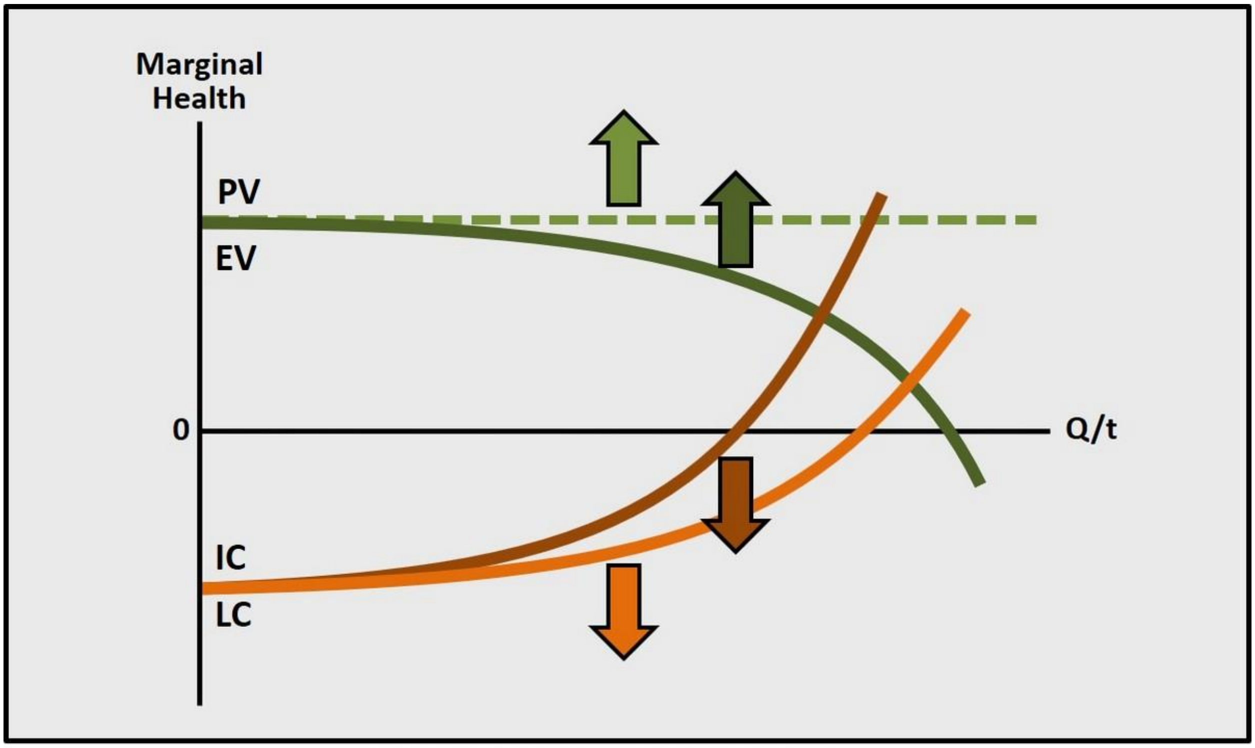


Figure 5-6. Long-run optimization

An important effect of shifting the value and cost curves in this manner is that the optimum output quantity will increase. This will result in unrealized gains due to underproduction, as shown in figure 5-3. The output quantity should therefore rise to the new optimum level, which will further increase health gains.

Chapter 6:
Environmental Limits

Marginal analysis was used in the last chapter to determine an output's optimum quantity, but without taking environmental limits into account. It is now time to consider these constraints using non-marginal methods to establish an output's ecological limit. This will allow us to modify our preliminary conclusions about its rational quantity.

To comprehensively consider environmental limits, three natural flows must be taken into account: habitat destruction, renewable resources, and wastes. As described in chapter two, these are called *biological flows* because they can directly harm the natural world, leading to ecosystem degradation and possible collapse. Such effects are scientifically detectable as they develop, thereby providing humankind with clear signs that damage is being done and that thresholds and points of no return are being approached.

ENL's treatment of ecological constraints has two distinct aspects. The first is the widely accepted idea that our economic activities must not violate natural limits. The second is less familiar: these restrictions should be imposed so as to maximize human health. The involvement of health in setting environmental limits means that the analytical tools developed in this chapter must be integrated with those previously discussed.

A. ENVIRONMENTAL BUDGETS

A typical family has a financial budget for what it can spend each month. This budget depends largely on its income, and is usually divided into expenditure categories: so much for mortgage or rent, so much for food, so much for entertainment, etc. An economy is analogous - it has an environmental budget for each biological flow used in its activities. Just as a family budget specifies how much can be spent without risking financial ruin, an environmental budget specifies how much of a biological flow the economy can exploit without risking ecological ruin. Because only the physical sciences can determine when such points are reached, establishing environmental budgets is a scientific rather than an economic task.

A broad consensus exists among environmental thinkers with respect to sustainable limits for two of the three biological flows - renewables and wastes. A typical formulation is the following by ecological economist Herman Daly, as quoted by the authors of Limits to Growth: The 30-Year Update:

> "For a renewable resource - soil, water, forest, fish - the sustainable rate of use can be no greater than the rate of regeneration of its source. ... For a pollutant [i.e., a waste] the sustainable rate of emission can be no greater than the rate at which that pollutant can be recycled, absorbed, or rendered harmless in its sink." (p. 54)

These limits have firm biological foundations and have therefore been adopted by ENL.

Daly does not offer a guideline for the maximum rate of habitat destruction, so the authors provide their own. They reject species extinction because the number of species is unknown and the extinction rate is extremely difficult to pin down. Instead their suggested method is one developed by the World Wide Fund for Nature (WWF). Instead of tracking extinctions, the organization tracks the population sizes of a large number of different species. These trends are then used to determine the health of their habitats.

The above restrictions on biological flows have a common element: the effects of economic activities are not permitted to accumulate in the environment to cause escalating effects. If a renewable resource is harvested at or below its regeneration rate, the resource will remain at a more or less stable level, and humankind's impact on the resource will not accrue over time. If expelled wastes are safely absorbed by the environment, they will not build to concentrations that are dangerous to life. Finally, keeping habitat destruction below a level that causes species decline will allow them to thrive until they are weakened or eliminated through natural processes. This non-growing, non-accumulating human impact on nature is the essence of ENL's interpretation of sustainability.

Consistent with its budgetary approach to ecological limits, ENL refers to an economy's biological flows as environmental expenditures. Thus, the framework's interpretation of an informal expression like "high environmental cost" is that the economic activity entails significant expenditures of the economy's environmental budgets.

B. BUDGET SHARES AND SHARE LIMITS

Once an economy's budget for a biological flow has been scientifically established, the flow must be allotted to the final outputs that require it in their life cycles. Each such allotment is called a ***budget share***. The question is: how should these shares be determined?

To frame this question using a simple example, consider the case where the budget is 100 units of a particular pollutant, and four outputs unavoidably expel this pollutant in their life cycles. What is a rational basis for establishing their budget shares? The simplest choice is to divide the budget evenly by allotting 25 units to each. However, this makes little sense from the ENL perspective. One output may achieve a great deal of health, while another may achieve very little. If our objective is to maximize a society's overall health, an environmental budget must be divided on the basis of an output's health-generating potential.

ENL's method is therefore to allot the next unit of a biological flow to the output that will achieve the greatest marginal health benefit. To illustrate, consider four outputs called A, B, C, and D. The output quantity for each is currently zero. When the first unit of A is eventually consumed, it is expected to achieve the highest marginal gains of the four outputs. The first unit of B is expected to achieve the second-highest marginal gains, etc.

Clearly, the initial unit of the pollutant should be allotted to output A. In fact, the pollutant should continue to be allotted to A until its projected marginal gains have decreased to those of B. At this point the pollutant should be allotted to A and B equally, up to the point where their joint marginal gains have decreased to those of C. Then the pollutant should be allotted to A, B, and C equally, until their joint marginal gains have decreased to those of D. At this point the pollutant should be allotted to all four outputs equally until the budget of 100 pollutant units is exhausted. This method of equalizing marginal effects, which is well-known in standard economics, ensures that the greatest health gains will be squeezed from the waste in question.

ENL's approach to environmental budgets and the allotment of budget shares is summarized in figure 6-1.

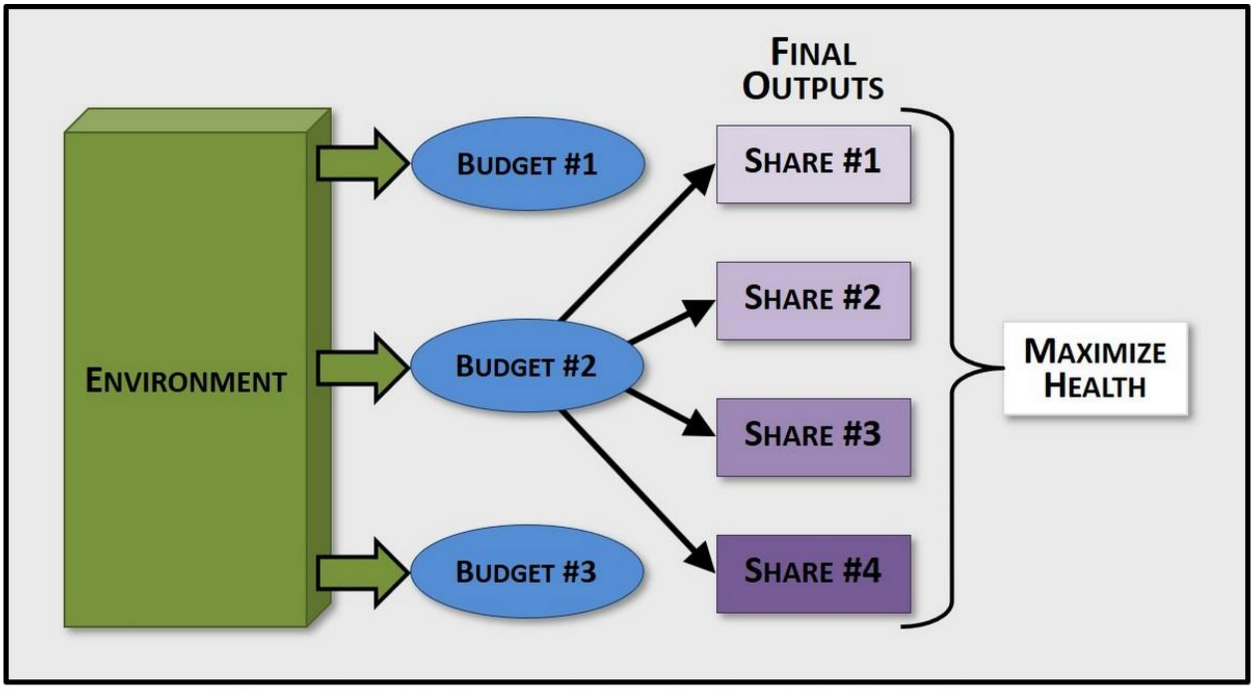


Figure 6-1. Environmental budgets and budget shares

In this diagram the economy requires three biological flows, and therefore has three environmental budgets. The budget for the second flow will serve as an example. This is divided into four budget shares, corresponding to the four outputs that require the flow. As explained above, the division of these shares is based on comparative marginal health benefits. This allotment method results in the maximum health that the economy can achieve from utilizing this flow at its budgeted rate.

We must now shift our attention from a specific flow to a specific output. Recall that our task is to determine an output's ecological limit. The practical consequence of assigning a budget share to an output is that this indirectly sets its maximum production level. Once an output has exhausted its budget share by using its entire allotted flow, it has reached its ***share limit*** for this flow. To safeguard the environment, production must stop at this output quantity.

However, this is obviously not the whole story. Each output will typically have not one but many biological flows associated with it. Imagine any output - a cup, a book, a set of skis - and consider the numerous natural impacts each has during its life cycle, from resource extraction to disposal. A typical output thus has multiple associated share limits. The next question is therefore: what is the relationship among these share limits in setting the ecological limit for an output's production?

C. ECOLOGICAL LIMIT – SINGLE OUTPUT

Based on ENL's commitment to sustainability, an economy must respect all of its environmental budgets, without exception. This means that an output cannot contribute to the violation of any budget. This in turn implies that, once an output has exhausted its first budget share as its production rate increases, any further increase in output quantity is prohibited. That is, the ***ecological limit*** for a final output is the lowest of its share limits. See figure 6-2.

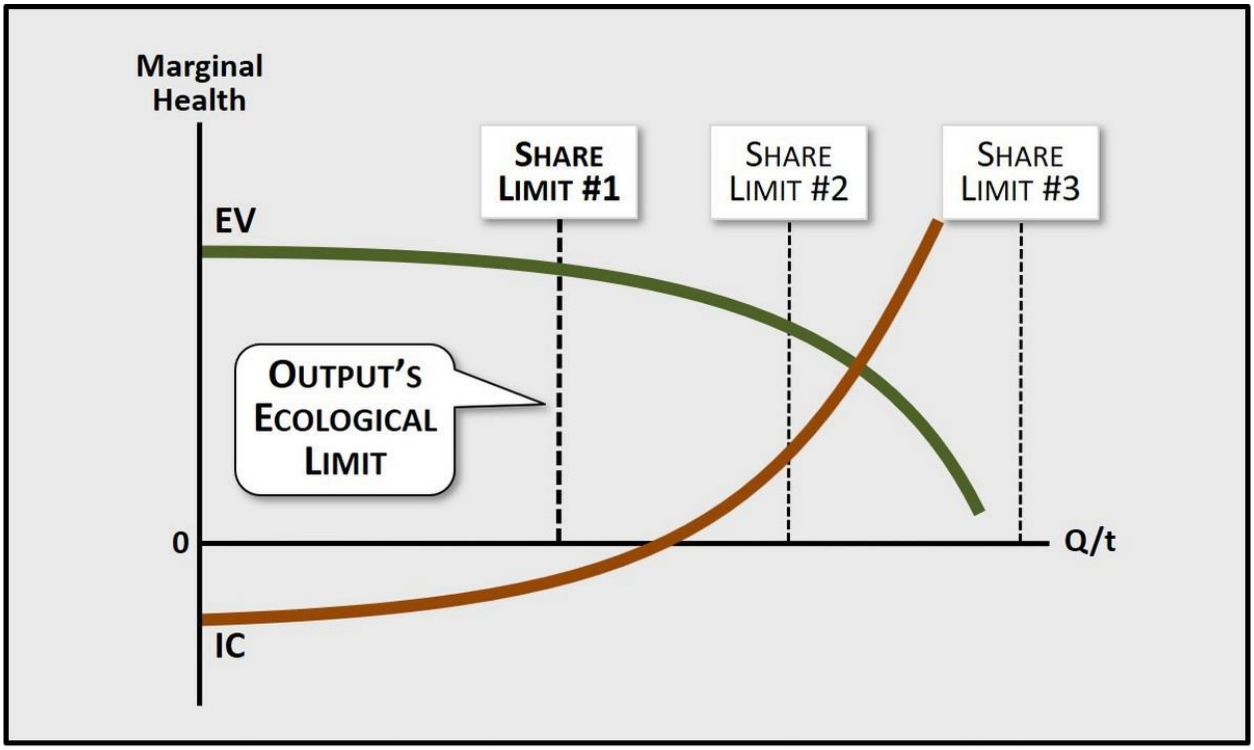


Figure 6-2. Share limits and an output's ecological limit

The output depicted requires three biological flows, and therefore has three budget shares. Based on the economic conditions associated with the output's life cycle, these shares are exhausted at the share limits shown. The lowest of these - share limit #1 - is the output's ecological limit. Unless economic conditions change, the output's production must not exceed this quantity. If conditions anywhere in the output's life cycle do change and flow #1 is sharply reduced or is no longer required, share limit #2 will become the new ecological limit and thus the new maximum allowable output quantity. This applies to each share limit in turn, until the last biological flow required by the output has been considered.

In brief: because of the potentially disastrous consequences of overexploiting a biological flow, ENL takes the precautionary stance of choosing the lowest share limit to set the maximum quantity for an output's production. This share limit is also the output's ecological limit.

D. ECOLOGICAL LIMIT - ECONOMY

Ecological constraints apply to an economy's total outputs in much the same way as for a single output. The only difference is that the constraints are based on the environmental budgets themselves instead of individual budget shares.

When an economy's scale increases, it will eventually exhaust an environmental budget. Its scale at this point is called the economy's ***budget limit*** with respect to this flow. Because an economy requires numerous biological flows, it will have numerous budgets and budget limits. Given the sustainability goal, the limit associated with the lowest economic scale establishes the economy's maximum allowable scale, and is therefore the economy's ecological limit. See figure 6-3.

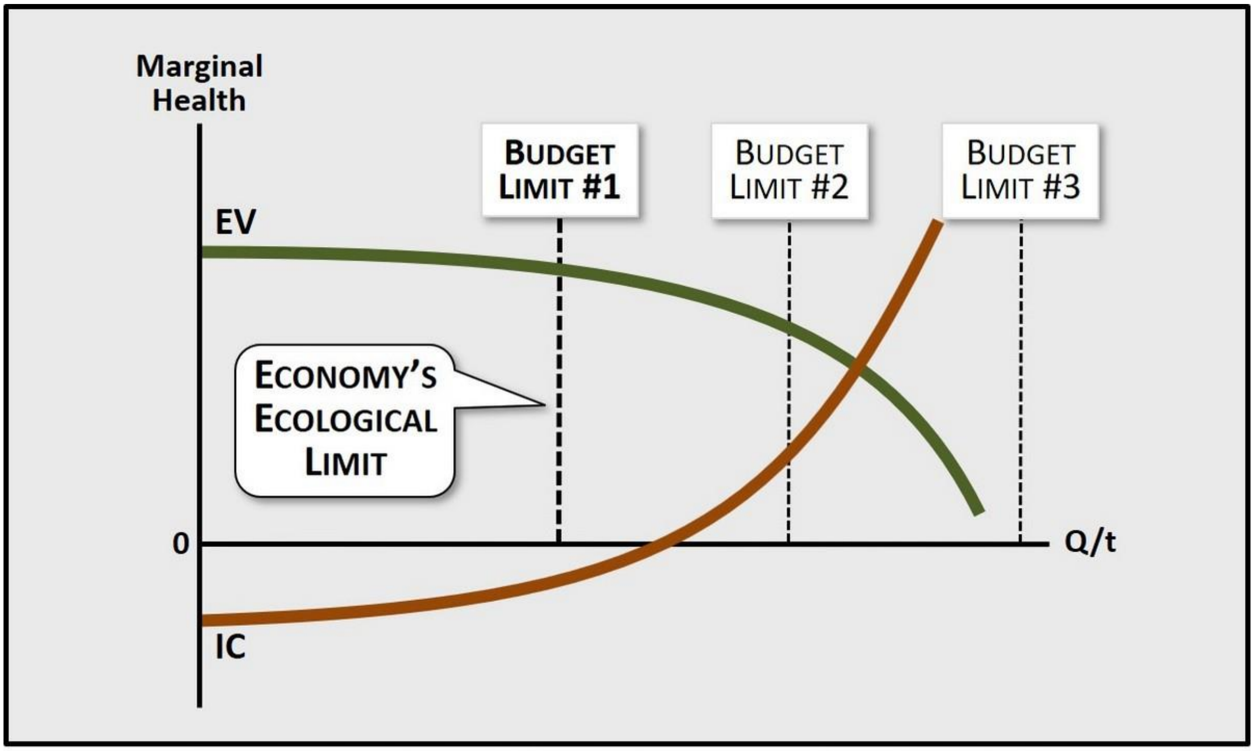


Figure 6-3. Budget limits and the economy's ecological limit

It should be noted that the violation of an economy's ecological limit is the local version of global ecological overshoot. The latter has occurred because numerous rich countries have heedlessly applied capitalism's expansionary logic, thereby causing their economies to drastically overstep their ecological limits.

E. TARGET OUTPUT QUANTITY

I have previously used the informal term "rational quantity" to refer to the output quantity that meets ENL's human and natural criteria. This quantity is established as follows:

1. If the output's ecological limit is lower than its optimum quantity, the ecological limit is chosen because a higher output level is unsustainable;
2. If the output's optimum quantity is lower than its ecological limit, the optimum quantity is chosen because a higher output level would result in health losses.

The term used in ENL to designate the lower of these two limits is ***target quantity***. This output level is rational in that it helps achieve sustainable well-being by maximizing aggregate health while fully respecting ecological constraints. It thus identifies the unique quantity that an economy should strive to produce for each output in its output mix.

Figure 6-4 depicts the case where the ecological limit is the lower of the two limits.

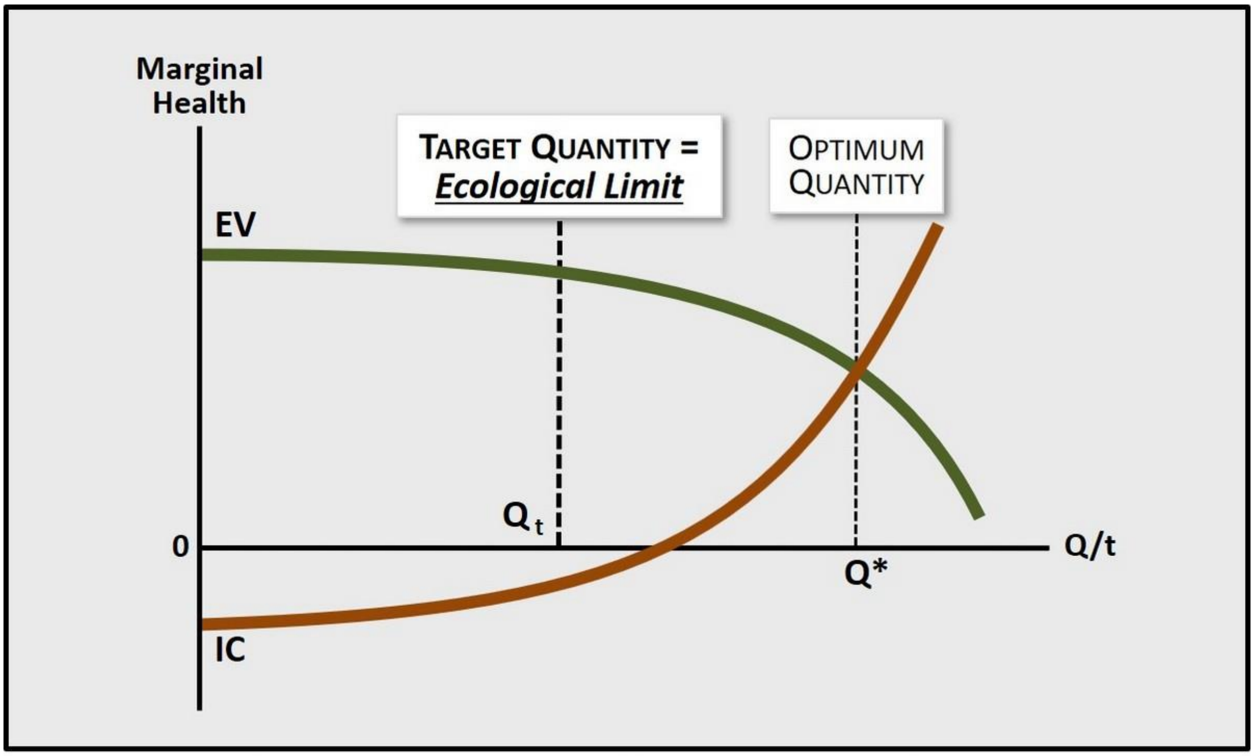


Figure 6-4. Target quantity is the ecological limit

In this situation output quantity should increase to, but not beyond, its ecological limit. This is designated as Qt in the diagram. If production is lower than this, some sustainable health will not be realized. If production is higher, environmental degradation could occur.

The second possibility is that the optimum quantity is lower than the ecological limit. This is shown in figure 6-5.

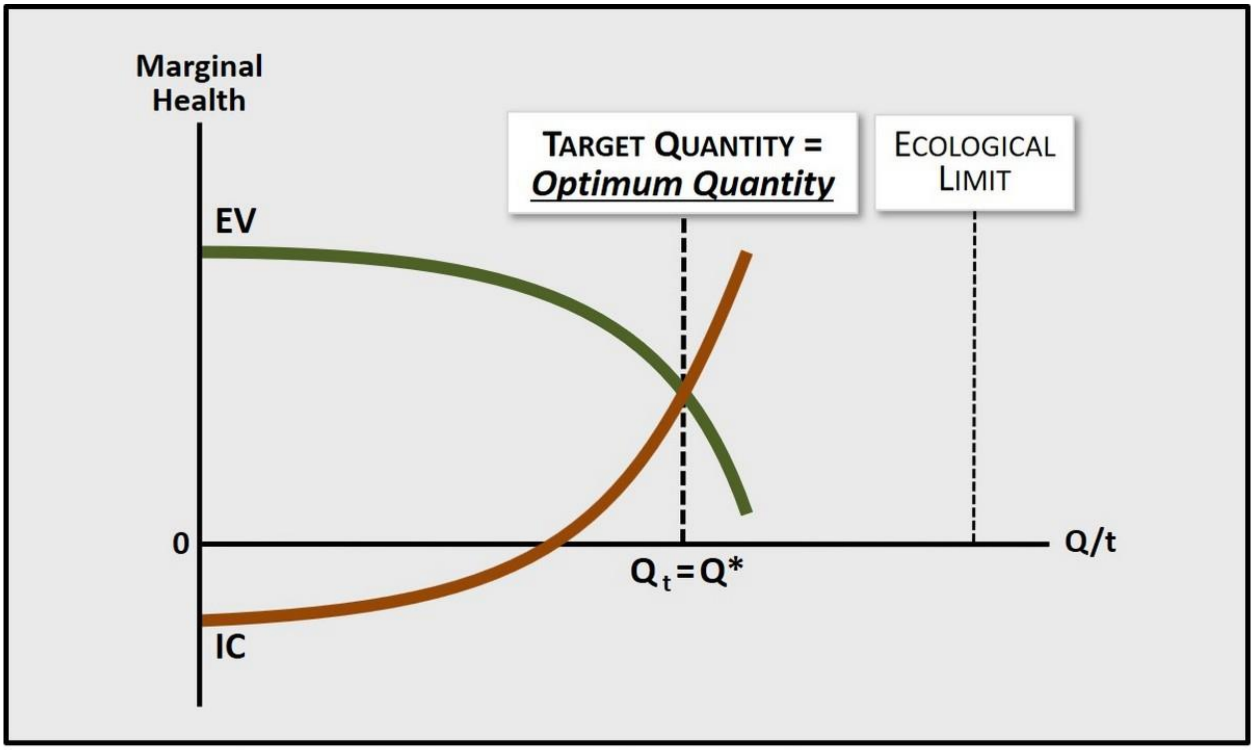


Figure 6-5. Target quantity is the optimum quantity

In this case production should increase to, but not beyond, the output's optimum quantity. If production is lower than this, aggregate health will not be maximized. If production is higher, we will initially incur losses, and we will eventually risk environmental damage. The output's target quantity in this situation is therefore its optimum quantity. The same reasoning can be applied to an economy's total outputs, thus giving us the economy's ***target scale***.

Now that the target quantity for a final output has been established, the concept can be extended to intermediate outputs. Recall from chapter five that the optimum quantity for such an output is the minimum required for the optimum quantities of all associated final outputs. Similarly, the ***target quantity*** for an intermediate output is the minimum required for the target quantities of all associated final outputs.

F. ECOLOGICAL EFFICIENCY

Ecological efficiency measures an economy's success in minimizing a natural flow in production. The concept is introduced here because changes in these efficiencies can shift budget limits and share limits, and thus ecological limits and target quantities. Note that, although these limits are based on biological flows, ecological efficiency applies to all natural flows, and is thus a valid measure for nonrenewables as well.

Ecological efficiency (EE) is the relationship between a natural flow and its associated output, and is expressed as a ratio - output quantity divided by flow rate:

EE = Q/flow

If an output incorporates multiple natural flows, it will have multiple ecological efficiencies associated with it.

Because ecological efficiency excludes any consideration of health or well-being, it is relevant to economic activities in general, and can therefore be applied to any stage of the output life cycle. For instance, even though a printing press is an intermediate output that lacks potential value, we can calculate the ecological efficiencies for the natural flows used in its production. The same is true for the fuel consumption of a commercial airplane or a transport truck.

Note that ecological efficiency is a ratio of mixed dimensions. The numerator is an output quantity and the denominator is a natural flow. The following are three examples of such ratios:

- One house/Board feet of lumber
- One kilogram of carrots/Liters of water
- 1,000 hours of consulting services/Kilograms of greenhouse gases

The mixed nature of this ratio means that ecological efficiencies are commensurable only if the outputs and natural flows are the same or sufficiently similar. For example, it is possible to compare the ecological efficiencies of two house-building methods by citing how many board feet of lumber each requires for a standard-size house. However, it is not possible to compare such efficiencies with those for the construction of a commercial building that uses steel and concrete components.

The effects of changes in ecological efficiencies on share limits (for a single final output) and budget limits (for the economy as a whole) are depicted in figure 6-6.

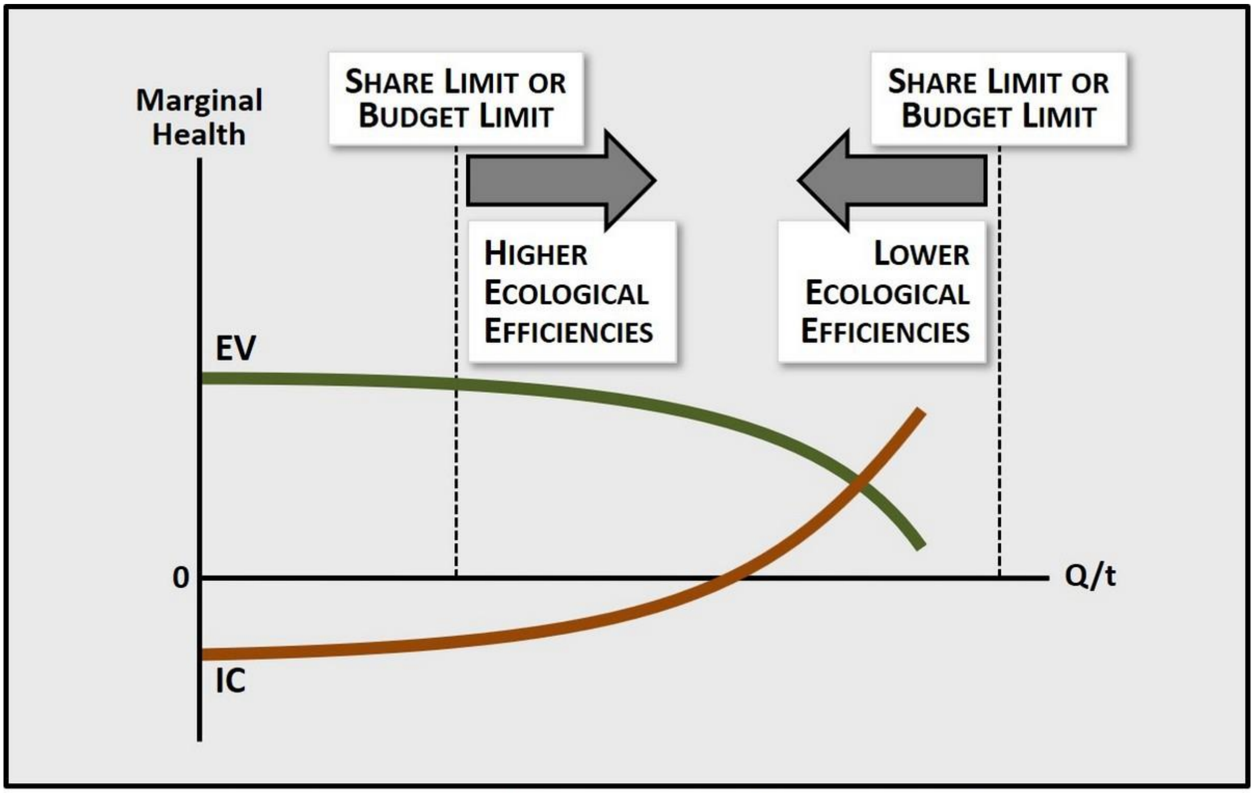


Figure 6-6. Ecological efficiencies and budget/share limits

Consider a single output first. If ecological efficiency rises for a biological flow, less of the flow is required per unit of output, which means that more of the output can be produced within its budget share. The output's share limit thus increases - that is, it shifts to the right. If this share limit is also the ecological limit, the ecological limit increases. If the ecological limit is also the target quantity, the target quantity increases as well. The reverse sequence applies if ecological efficiency falls.

For an economy's total outputs, a rise in ecological efficiency means that the associated budget limit shifts to the right. If ecological efficiency falls, the budget limit shifts to the left. The impacts on the ecological limit and target scale are similar to those for a single output.

G. AUTHORIZATION OF WANTS

In chapter three I said that wants - consumption desires that do not significantly increase health when they are satisfied - would be addressed after environmental limits were covered. This has now been done, so the time has come to explore this topic.

As previously stated, want satisfaction is potentially dangerous for the environment. Need satisfaction is limited by the physical constitution of the human body, but want satisfaction is limited only by desires and imagination. A sustainable economy must therefore keep want satisfaction within environmental bounds while maximizing this subjective component of well-being. It thus requires criteria for authorizing some wants while rejecting others. These criteria are my primary topic here.

Two preliminary points must be made before I proceed. First, want satisfaction refers to the increase in well-being achieved when an *unmanipulated* want is satisfied. Wants must arise from genuine consumption desires and not from deceptive advertising, intense peer pressures, and the like. Second, ENL makes no moral judgments about the kinds of outputs desired. If people want pizzas and movies, they should get pizzas and movies. The health criterion applies only to needs. Which wants should be satisfied is entirely a social matter, and the analytical method below is only a suggestion.

The distinguishing feature of a want-satisfying output is that its potential value is zero, which means that the effectual value resulting from its consumption is zero as well. These two forms of value are therefore excluded from the present discussion. The three relevant factors are:

1. The degree of social want satisfaction (WS) the output potentially achieves;
2. The input cost incurred in its production;
3. The economy's ecological limit.

The broad idea is that, once a society decides that its needs have been adequately met, a want-satisfying output should be produced if it achieves a high degree of social satisfaction, its input cost is low, and the economy has not yet reached its ecological limit. One way to formalize this idea is to combine the first two factors into a *satisfaction score*: the ratio between the output's want satisfaction and its input cost (WS/IC). Figure 6-7 shows how this ratio can be applied.

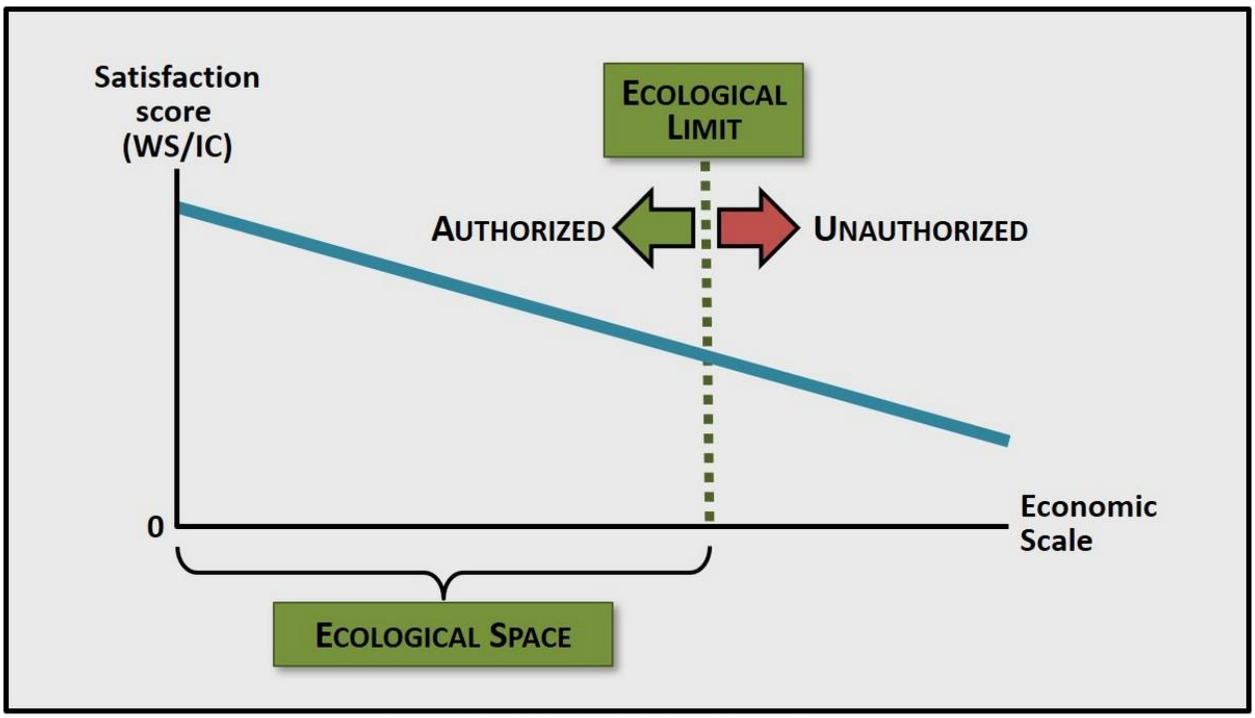


Figure 6-7. Want authorization

To decide which outputs should be authorized, the satisfaction score for each want-satisfying output is estimated. The outputs are then ranked from highest to lowest, as shown by the downward-sloping line. Only those outputs that are within the economy's ecological limit can be authorized, while the rest must be rejected as environmentally dangerous production. If this procedure is followed, want satisfaction will be sustainably maximized while health losses due to labor cost and natural cost are minimized.

Let me underscore that want authorization is possible only if the economy has not yet reached its ecological limit - that is, if ecological space exists for want-satisfying production. Today, in the rich countries, this restriction is blatantly ignored. The ecological crisis largely stems from the fact that these economies all "authorize" radically unsustainable production to satisfy massively manipulated wants.

The most challenging aspect of the above method - or of any method that addresses wants - is to reliably determine the levels of want satisfaction within a society. Unlike health increases, which can be objectively assessed, want satisfaction is subjective. Given the differences among cultures and people, every society must decide, based on its own standards, tastes, and perceptions, how this determination will be done. The following are some indicators that could be used for this purpose:

- **Market behavior.** This is the standard approach, and it has merit. If people are willing to spend hard-earned cash for an output, they clearly desire it. Although ENL downplays market behavior because people differ widely in their capacity to pay, including it as one of several indicators of want satisfaction seems reasonable.
- **Surveys.** Especially for those with meager financial resources, simply ask them which outputs would satisfy their genuine wants.
- **Historical behavior.** If human beings at different times and places have shown a clear propensity to consume certain types of outputs (alcohol, meat, entertainment, etc.), these wants are probably deep-seated and apply here and now as well.
- **Experimental economics.** Test consumer responses in a formal experimental setting to determine which outputs are genuinely desired, and to what degree.
- **Neuroscience.** This is somewhat extreme, but it might be possible to monitor the neurological responses of experimental subjects to various types of existing and prospective outputs. This would provide an objective basis for judging subjective reactions and might help circumvent the manipulations that distort wants.

Chapter 7:
Population

Chapter five discussed the maximization of gains without considering environmental limits or allowing population to vary. Chapter six took the environment into account, but the assumption of a fixed population was retained. This assumption is now dropped in order to examine the relationships between the population level and sustainable well-being. Before proceeding, two issues must be addressed.

First, recall that ENL defines well-being as the socially-specified combination of an individual's need and want satisfaction, net of input cost incurred. Because this combination includes incommensurable elements and could vary among societies, the framework does not use well-being as a general measurement standard. However, the population issue entails broad social objectives that I believe are adequately captured by this concept. ENL thus uses well-being rather than physical health as the criterion for determining a society's optimum and target population levels.

The second issue is that aggregation is inapplicable to population. At a given level of average well-being, a society's aggregate well-being would double if its population doubled. However, individuals would be no better off. The measurement standard for determining optimum and target population levels is thus average rather than aggregate well-being.

A. OPTIMUM POPULATION LEVEL

Try this thought experiment: You and a thousand fellow adventurers have decided to establish a new society on an unpopulated island. The island is large and unspoiled, so environmental limits are not an immediate concern. If your objective is to maximize the average well-being of this society's members, at what point will you stop its population growth? That is, what would you consider to be the optimum population for your new domain?

Although a rigorous definition of "optimal population" is difficult to formulate, it is reasonable to state that a population is too low if a society does not have sufficient opportunities for cooperation, specialization, and exchange to permit average well-being to reach its maximum attainable level. Conversely, population is too high if these opportunities have been largely exhausted and average well-being has stabilized and possibly declined.

Many standard economists have adopted a similar perspective. The following explanation by Robert Solow is typical:

> "We all know the bad consequences of too large a population: crowding, congestion, excessive pollution, the disappearance of open space - that is why the curve of average well-being eventually turns down at large population sizes. Why does the curve ever climb to a peak in the first place? The generic reason is what economists call *economies of scale,* because it takes a population of a certain size and density to support an efficient chemical industry, or publishing industry, or

symphony orchestra, or engineering university, or airline, or computer hardware and software industry ... ." (Is the End of the World at Hand?, 1973)

ENL calls such factors ***scale effects***. A society's ***optimum population*** is defined as the level where these effects have been exhausted and average well-being has thus reached its peak. Scale effects arise because they improve the social conditions for individual well-being. A rising population level can, through specialization and exchange, result in higher potential value and effectual value, as well as lower input costs. The value and cost curves will therefore shift outward, as in the long-run optimization depicted in figure 5-6.

However, this is not the entire story. As a standard thinker attuned to capitalist realities, Solow assumed that a society must be technologically complex, and will therefore require a chemical industry and an engineering university. ENL has instead adopted technological neutrality, and in this context technological complexity is a social choice.

In the island example, people must first determine what kind of society they are trying to establish. Do they want one that is simple and close to nature, or one that is highly technical and less integrated with the natural world? If the group decides on technological simplicity, a relatively low population will provide adequate opportunities for cooperation and specialization. If it decides on technological complexity, a relatively high population will be required for these purposes. Figure 7-1 depicts the difference.

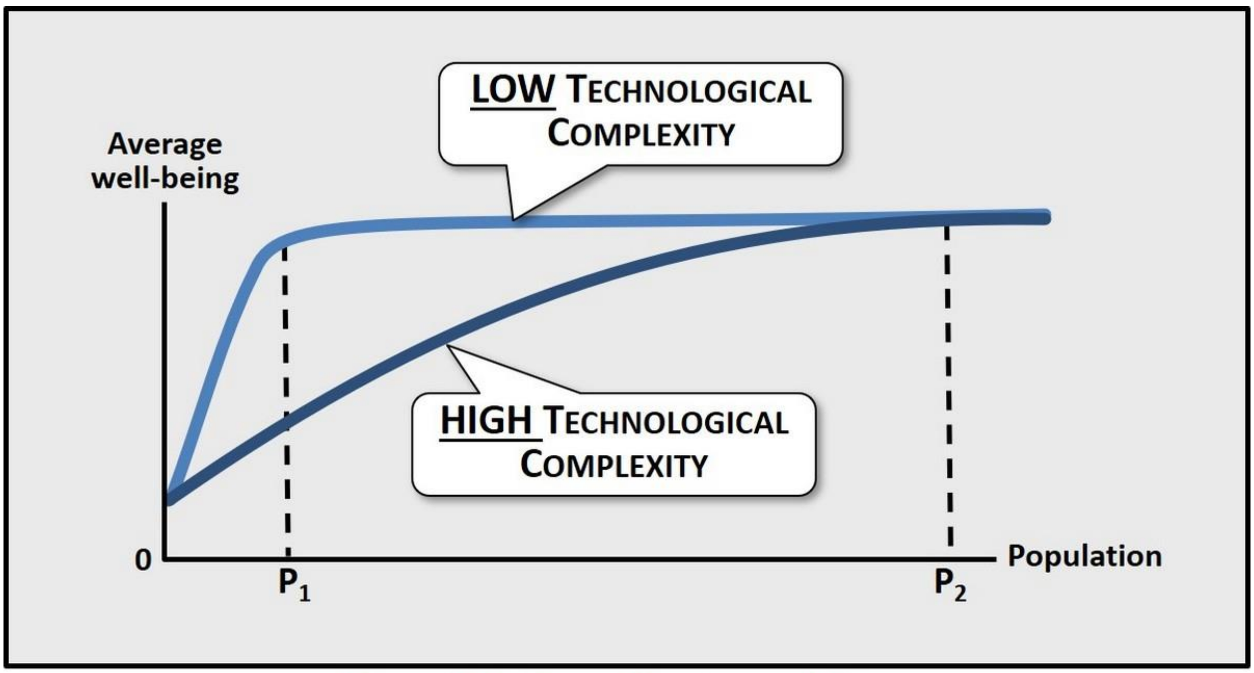


Figure 7-1. Two optimum populations

In this graph the horizontal axis represents population, and the vertical axis represents average well-being. The graph thus tracks changes in average well-being from scale effects as population increases.

The rate at which the curve rises depends on the society's chosen level of technological complexity. A technologically simple society will reach its optimum population level quickly, at a point such as P1, because relatively few people are required to develop and operate such an economy. A technologically complex society will reach its optimum population level far more slowly, at a point such as P2, because of the factors mentioned above. Its curve will therefore rise more gradually to its maximum and thus optimum level.

The crucial point is this: aside from higher average well-being, there is no reason within ENL's analytical scope for a population to increase. There can of course be compelling political, military, or other reasons, but these are not relevant economic factors. Based on the ENL framework, a society's population should never exceed its optimum level.

B. ECOLOGICAL LIMIT FOR POPULATION

Because a society's population is supported by its economy, the economy's ecological limit establishes the population's ecological limit. In other words, population cannot expand beyond the point where the economy has exhausted its lowest environmental budget. This statement can be clarified with the help of figure 7-2.

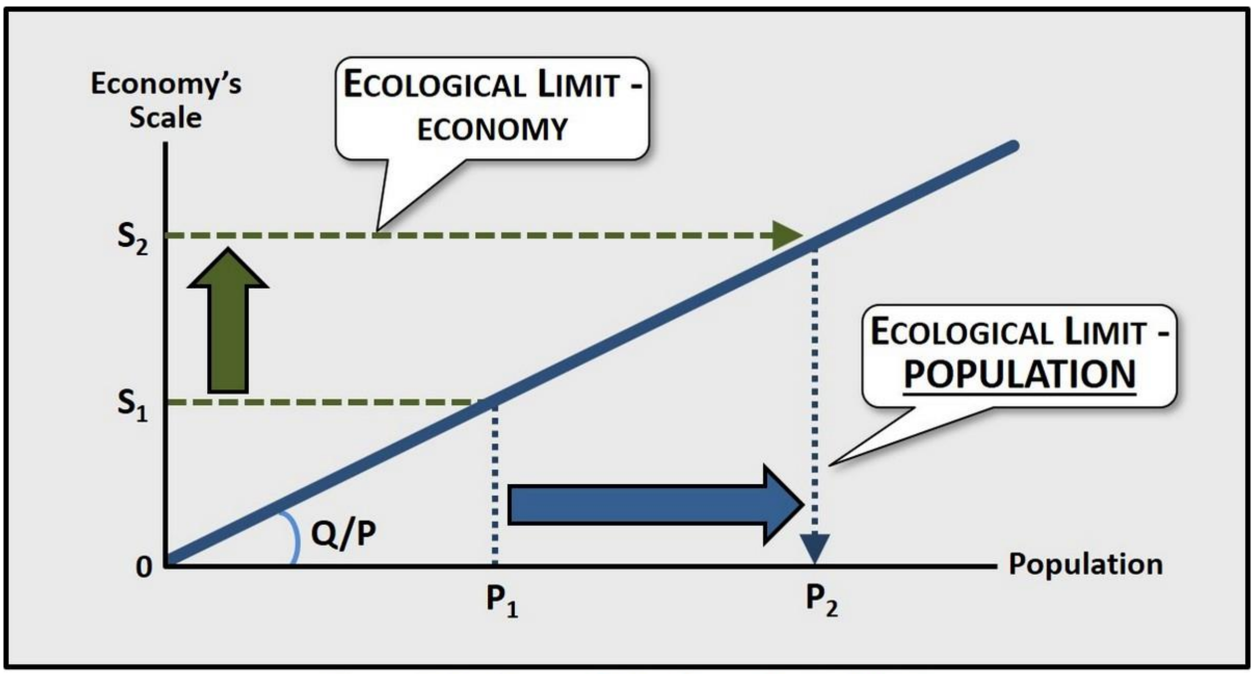


Figure 7-2. A population's ecological limit

In this graph the economy's scale - its total output production per unit of time - is on the vertical axis. The angle of the sloping line indicates average per capita consumption, and is therefore marked Q/P: total output quantity divided by population. Increasing this angle means that average consumption goes up; decreasing it means that average consumption goes down. The line thus relates a specific population level such as P1 to a specific economic scale such as S1.

As population increases from P1, the economy's scale increases from S1, as shown by the two arrows. When the economy's scale reaches its ecological limit at S2, the population has reached its ecological limit at P2. Population cannot rise further because the economy would violate its lowest environmental budget and thus contribute to global overshoot.

This model is important because it permits analysts to graphically experiment with various combinations of increased ecological efficiencies, reduced consumption, and reduced population in returning an over-expanded economy to a sustainable scale. I discuss these possibilities in section D below.

C. TARGET POPULATION LEVEL

The method for determining a society's target population level is similar to the one used for target output quantities. It is the lower of the two population constraints just discussed: the optimum level and the ecological limit. If the optimum level is reached first, average well-being has been maximized, and it makes no economic sense to increase population further. Conversely, if the ecological limit is reached first, further increases would be unsustainable. Figure 7-3 depicts the first case, where the target population is the optimum level.

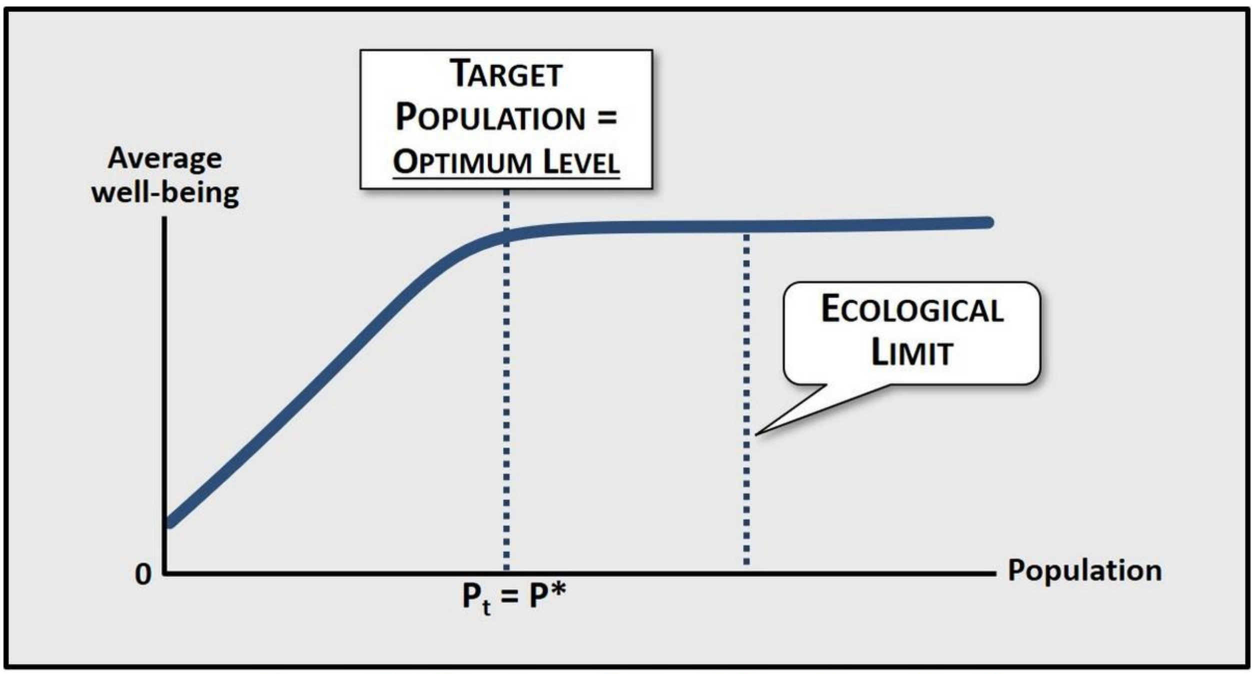


Figure 7-3. Target population is the optimum level

This is the ideal situation: the population's ecological limit is higher than its optimum level, so population can rise to achieve maximum average well-being without endangering the environment. As previously stated, there is no economic reason to increase population further.

The second possibility is that the population's ecological limit is lower than its optimum level, in which case the target population is the ecological limit. The reader can easily envisage this situation, so I have omitted the relevant graph.

D. POPULATION AND THE IPAT FACTORS

In chapter three of *Youth Ecological Revolution* I use the IPAT formula to formulate the rational response to the ecological crisis. As stated there, the formula is a mathematical identity (two equivalent expressions) that disaggregates impact (I) into three components: population (P), affluence (A) and technology (T). Affluence in this context refers to average per-capita consumption, and technology to ecological efficiencies.

As mentioned in section B, the model for determining a population's ecological limit (figure 7-2) is a key tool for analyzing sustainability issues. In this section I use this tool to show how changes to the three IPAT factors relate to an economy's sustainable scale. For the sake of clarity I repeat the graph to illustrate each case. I apologize for this graphical profusion, but feel it is warranted by the existential significance of the population issue.

Figure 7-4 depicts the broad challenge. The current economic scale is higher than the sustainable scale, so this gap must be closed. To achieve this we can increase the sustainable scale to the current scale (left arrow), decrease the current scale to the sustainable scale (right arrow), or combine the two. In the graphs below I initially ignore the combinations in order to explain the individual IPAT solutions.

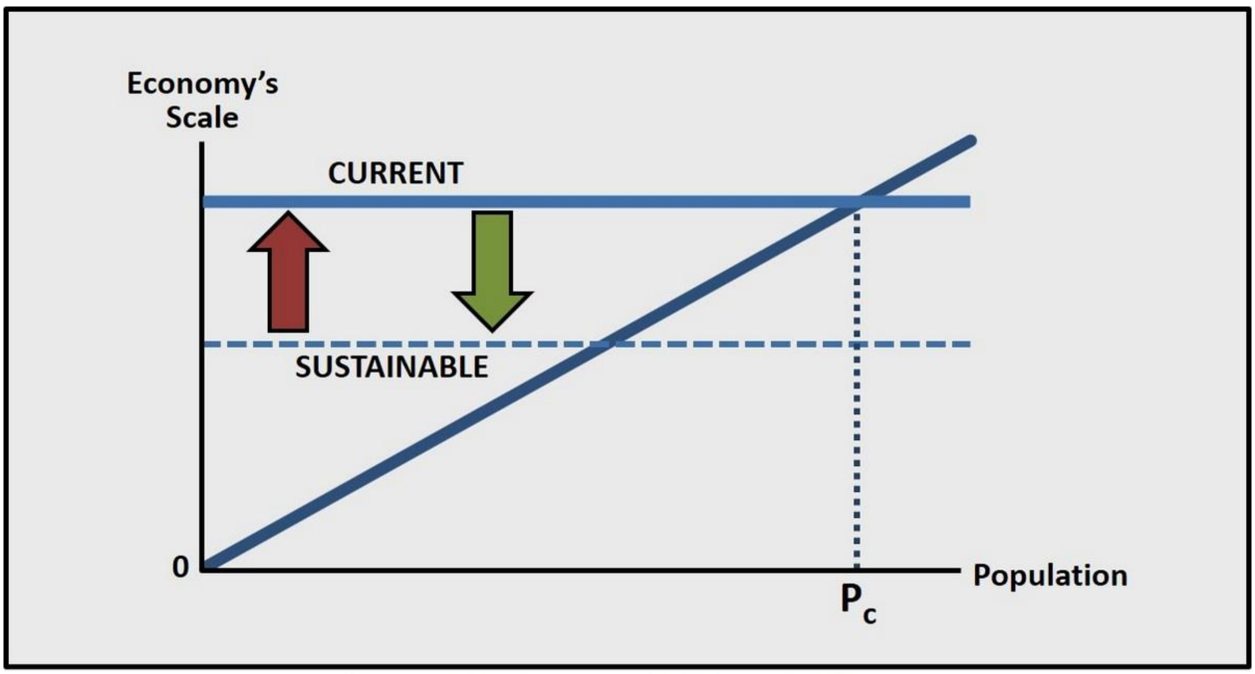


Figure 7-4. The sustainability challenge and solution #1: higher efficiencies

Because figure 7-4 also depicts the effect of increased ecological efficiencies, I begin with this solution. Note that Pc indicates the current population level.

Higher efficiencies permit higher output quantities for a given environmental impact, so their effect will be to increase the economy's sustainable scale. If the improvements go far enough, this scale will increase to the current scale, thereby closing the gap as required. Achieving sustainability through improved efficiencies is therefore depicted by the left arrow above.

The second solution is to decrease per-capita consumption, which is depicted in figure 7-5.

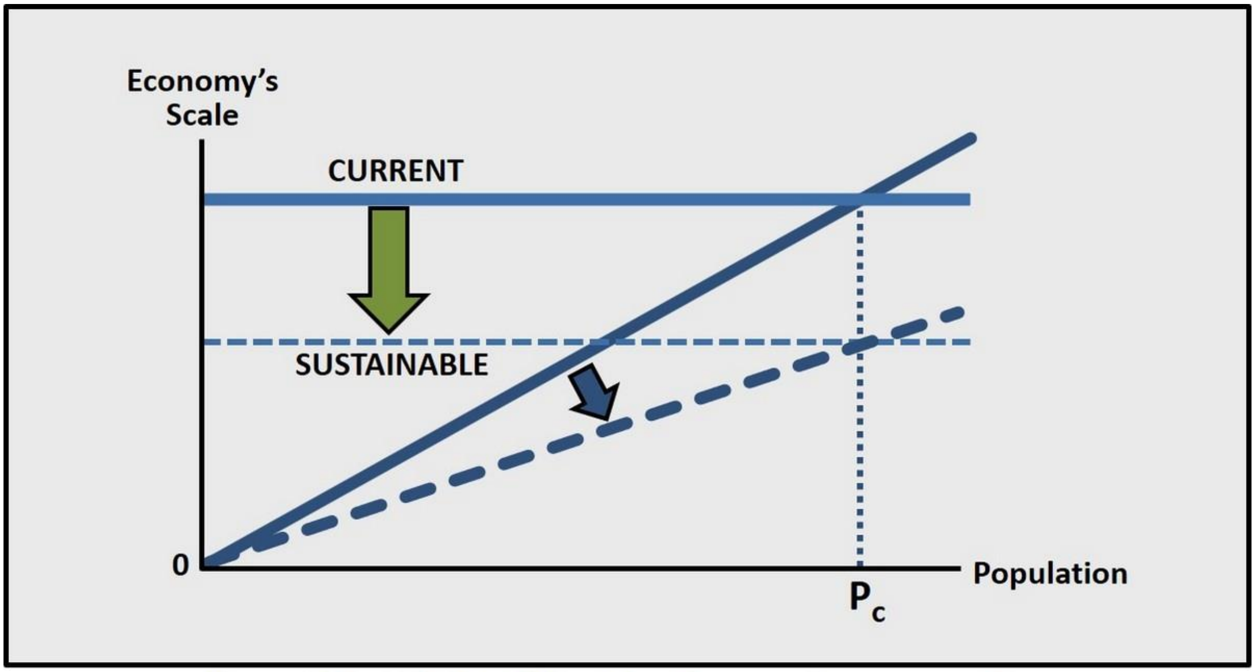


Figure 7-5. Solution #2: reduced per-capita consumption

Recall that this factor is represented by the angle of the consumption line, so a decrease in consumption will reduce this angle by rotating the line down. As shown, this will also decrease the economy's current scale to its sustainable scale.

The last IPAT-based solution is to reduce population. See figure 7-6.

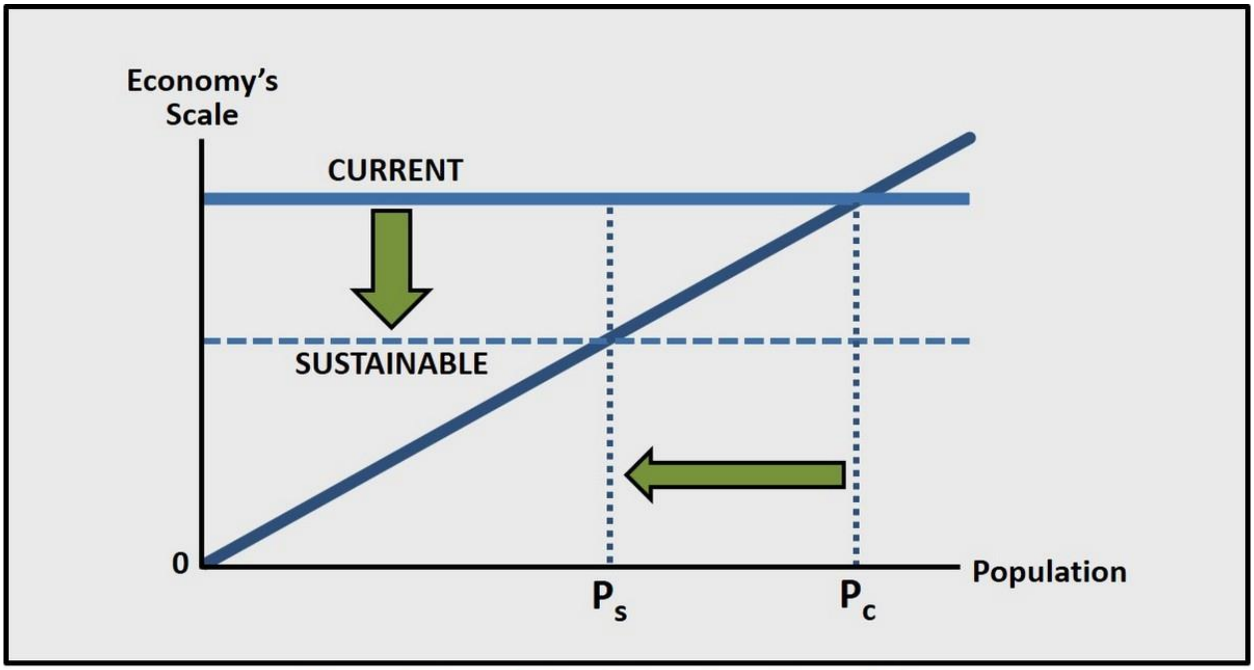


Figure 7-6. Solution #3: reduced population

In this case ecological efficiencies and average consumption remain stable, but the population is reduced from Pc to Ps. As with lower consumption, this will decrease the economy's current scale to its sustainable scale.

To summarize, there are four approaches that can modify an economy to achieve sustainable scale:

1. Increase ecological efficiencies while leaving per-capita consumption and population unchanged. This will increase the economy's sustainable scale to its current scale.
2. Decrease per-capita consumption while leaving ecological efficiencies and population unchanged. This will decrease the economy's current scale to its sustainable scale.
3. Decrease population while leaving ecological efficiencies and consumption unchanged. This also will decrease the economy's current scale to its sustainable scale.
4. Combine increased ecological efficiencies, decreased per-capita consumption, and decreased population so that their total effect is sustainable scale.

Today the only solution being seriously implemented is increased ecological efficiencies. The reason is obvious: reduced consumption and population are inconsistent with capitalism, economic growth, and rich-world lifestyles. These two approaches are therefore rarely considered as either full or partial solutions.

E. REDUCING POPULATION

A society that decides to reduce population to help achieve sustainable economic scale must decide which methods it will use. Among the possibilities cited by social thinkers are better education for women, greater contraceptive availability for all, and laws that permit death with dignity for those who are ready to take this step. In the ENL context, a reduction in technological complexity will mean that the optimum population will decline due to changes in scale effects, as shown in figure 7-1. This is therefore a promising option for societies seeking to return to a nature-oriented mode of life.

Another approach is to increase the ratio of parents to children. China attempted to control its population by reducing the ratio of children to parents (the one-child policy), but this was strongly resisted by the populace. Legally permitting and socially encouraging families to take forms such as seven adults and two children, or ten adults and three children, could satisfy the human drive to procreate and nurture, spread the heavy burdens of the baby stage, allow for siblings, broaden the range of adult influences, and reduce financial pressures on individual parents.

The graph in figure 7-7 could be used to analyze this possibility.

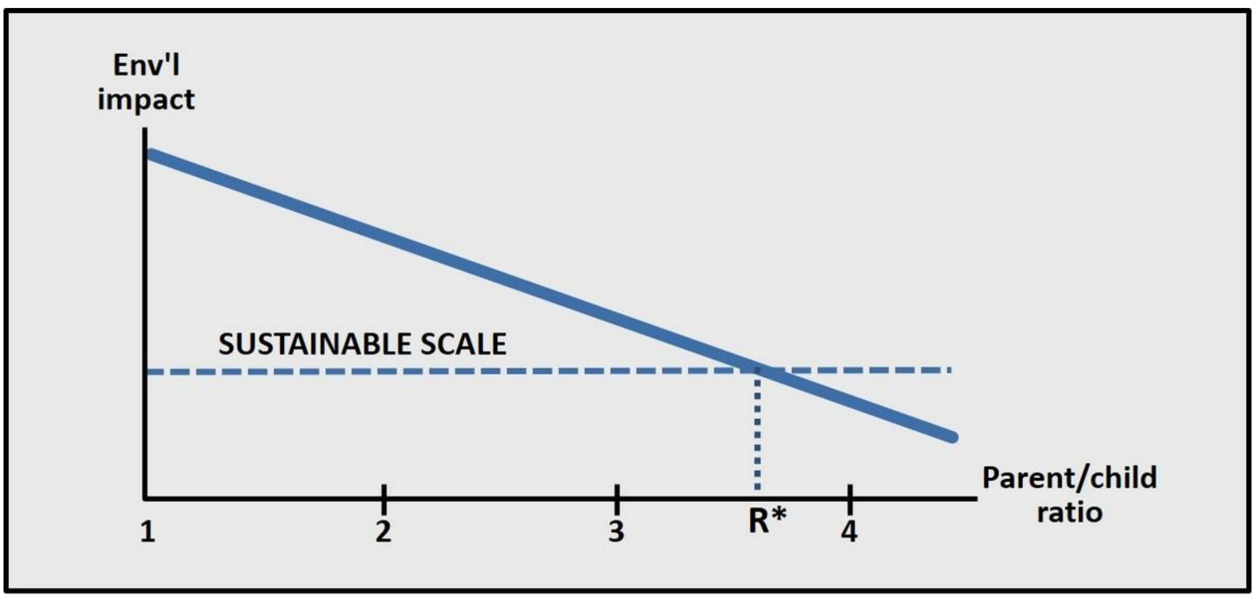


Figure 7-7. The sustainable parent/child ratio

Today, in rich countries like the US and the UK, there are approximately two children per household. Thus, if each household has two parents, the current ratio is approximately one child per parent. The graph shows that the environmental impact of this ratio, given its associated population level, is beyond the economy's sustainable scale. However, this goal can be reached by increasing the ratio to around 3.6. Although this figure is speculative, it could be close to the empirical truth.

It may well turn out that no society, at any point, will be receptive to this approach for reducing population. However, in a world hurtling towards ecological catastrophe, even the highly unusual should be seriously considered.

For a thoughtful analysis of population issues and further suggestions for reducing population, see The Overpopulation Project.

Chapter 8:
Labor Productivity

Labor productivity is logically part of production, which was discussed in chapter four. As noted there, this topic was deferred because it is a specialized area that requires detailed treatment. Now that ENL's core components have been covered, it can be addressed.

Recall that the sphere of production cannot assume responsibility for consumption, so the present chapter refers to potential value rather than effectual value. For brevity, I will use "productivity" instead of "labor productivity".

Productivity is significant for several reasons. First, increasing this factor will raise output quantities while altering the working conditions that underlie labor cost. Productivity also has a strong bearing on the division of labor, and it is closely associated with a society's choice of technological complexity. In addition, the topic is ideologically significant. Standard economics repeatedly goes beyond its proper sphere of functional analysis by encouraging society to raise its productivity levels. ENL must therefore distinguish between situations where this measure increases health and is therefore justified, and those where it does not.

Although several factors have been cited in the economics literature to account for higher productivity, the most straightforward and generally accepted explanation is technological change. In ENL this is assumed to be the dominant factor.

A. DEFINITION

ENL uses the standard definition of productivity: the quantity of an intermediate or final output produced per unit of labor time. It is therefore calculated by dividing output quantity by time, where the latter is generally expressed in hours:

LP = Q/t

For example, if it takes 100 hours to produce 200,000 loaves of bread, labor productivity for this final output is 2,000 loaves per hour. Because the definition makes no reference to potential value, a similar statement can be made for an intermediate output such as transport trucks: if it takes 10,000 hours to produce two trucks, labor productivity is one truck per 5,000 hours.

In what follows I deal with final outputs first because these are assessed on the basis of both potential value and input cost. I then consider intermediate outputs, which must be assessed on the basis of input cost alone.

B. TECHNOLOGICAL INTENSITY

As explained in the introduction, technological neutrality refers to ENL's stance that technological complexity is a social choice, and is therefore irrelevant for judging economic performance or progress. In this chapter we are concerned with specific labor processes, and in this narrower context the term ***technological intensity*** is used instead. This refers to the degree to which machines, and technology generally, substitute for autonomous human action in production tasks.

Technological intensity is significant because the technology used in labor processes frequently curtails human autonomy, which can significantly impact worker health. ENL thus treats this factor as a contributor to input cost, much like the toxins and stressful noise that may be present in a work environment.

An important aspect of technological intensity is that its increase can initially relieve painful drudgery. For tasks that are physically arduous, machines can reduce both the toil and the dangers that are frequently associated with strenuous labor, thereby decreasing labor cost. At one point in my life I worked as a construction laborer, and I can attest that a wheelbarrow greatly reduces the toil associated with moving gravel and sand. A backhoe reduces this toil considerably further. The challenging issue is to determine what happens to the worker's health after drudgery has been eliminated and the worker's skills and personal involvement are eroded by the continued increase in technological intensity.

It has long been evident to economic thinkers that workers are seriously impacted by the skill levels required for labor tasks. French economist Jean-Baptiste Say was aware in 1803 that workers are degraded when the division of labor forces them to focus too narrowly on one simple task:

> "A [person], whose whole life is devoted to the execution of a single operation, will most assuredly acquire the faculty of executing it better and quicker than others; but [they] will, at the same time, be rendered less fit for every other occupation, corporeal or intellectual; [their] other faculties will be gradually blunted or extinguished; and the [person], as an individual, will degenerate in consequence."

What is exceptional about Say's understanding is that it went beyond the physical realm to include intellectual labor. He added: "... [people], whose professional duties call into play the finest faculties of the mind, are subject to similar degradation." (A Treatise on Political Economy, p. 98)

In the 1950s the relationship between automation and skill level was rigorously examined by James R. Bright of the Harvard Business School. His study is extensively cited by Harry Braverman in his book, Labor and Monopoly Capital. Bright's task was to assist management in choosing workers who were best suited to the machines then being deployed. Based on empirical studies, he found that skill requirements increased sharply during the initial phase of automation, but soon peaked and then rapidly declined.

The explanation he offered was that machines at first amplify human capabilities and give greater scope to creativity and imagination, but beyond a threshold they usurp human dexterity, mental involvement, and control, eventually turning workers into the machine's appendages. The extent to which this occurs depends on concrete circumstances, but it is incorporated into ENL as a broad reflection of industrial reality.

According to studies cited by biologist Robert Sapolsky, the less control a worker has during the labor process, the greater the health risk: "Numbing assembly-line work and an occupational lifetime spent taking orders erode workers' sense of control. ... the less autonomy one has at work, the worse one's cardiovascular health.” (*Scientific American*, December, 2005, p. 96f) There are also links between boredom and decreased worker health. Boredom likely plays a role in depression, which is a risk factor in heart disease. It is also conducive to anger suppression, which can raise blood pressure and decrease the body's natural immunity. As well, bored people tend to eat and drink more, and to focus their appetites on unhealthy products.

The general conclusion is this: If the required skill levels are high, worker health will likely benefit. As skill levels decline with increased worker specialization and machine sophistication, worker health will likely suffer. The combination of these factors, plus the initial reduction of drudgery, constitutes the overall effect of increasing technological intensity on workers. As shown in figure 8-1 below, this will first cause labor cost to decrease, then stabilize, and finally rise.

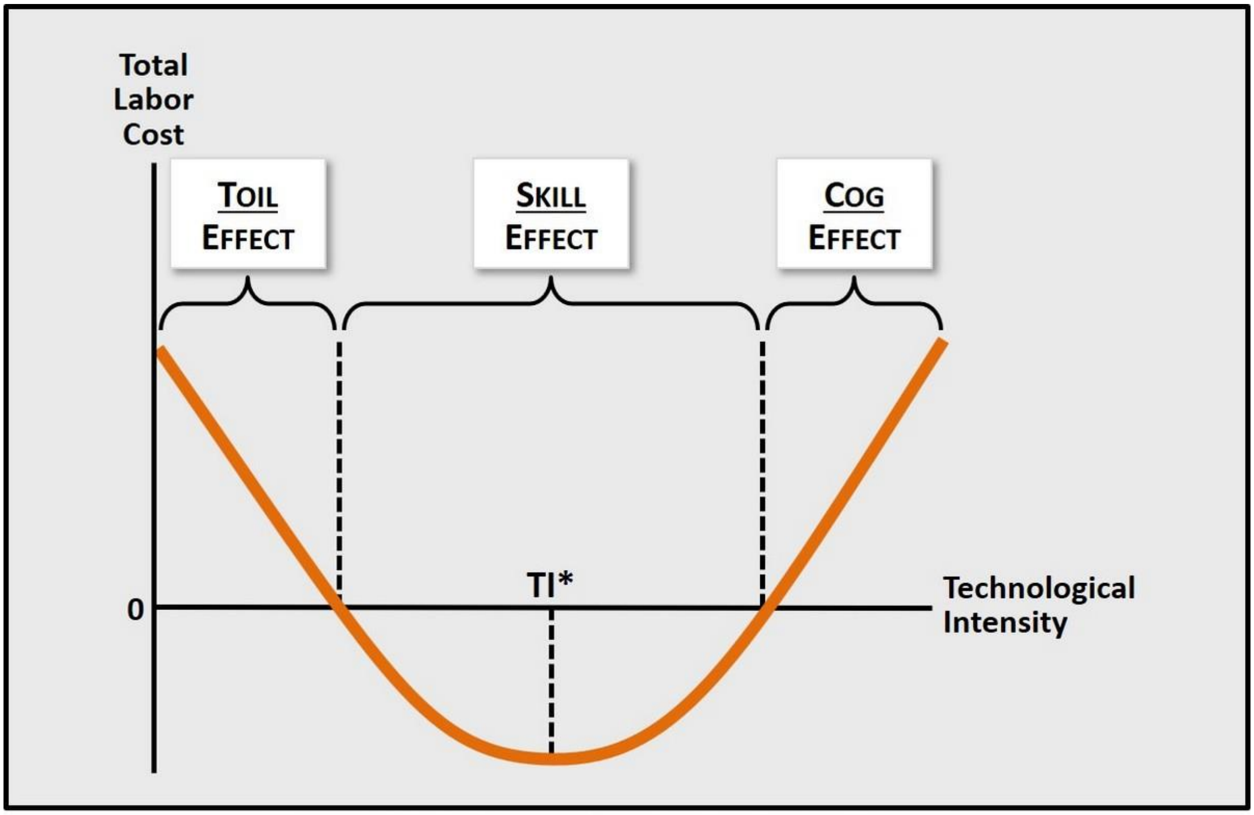


Figure 8-1. Labor cost vs. technological intensity

In this graph labor cost is expressed in total rather than marginal health units. The curve thus traces the actual labor cost as technological intensity increases.

The sharp initial decline in labor cost based on the negation of drudgery is called the ***toil effect***. This stage continues until labor cost is reduced to zero. The next stage, where labor cost is negative and health therefore improves, is called the ***skill effect***. This improvement increases, stabilizes, and then decreases until labor cost is again zero. The last stage, where labor cost becomes positive, is called the ***cog effect***. The optimum technological intensity (TI*) is the point where labor cost is minimized due to the skill effect - that is, at the lowest point on the graph.

C. TWO PERSPECTIVES: CAPITALISM AND ENL

Before proceeding I must present the standard perspective on labor productivity. This will serve two purposes: it will underscore the need for ENL to take an independent stance on this issue, and it will introduce the elements that must be taken into account in the framework's treatment of labor productivity.

Assume that, for the current labor process in a production facility, one unit of labor results in two output units over a specified time period. The labor process is then technologically modified, causing productivity to increase by 50%. One labor unit will thus produce three output units instead of two over the same period. For standard economics, which reflects capitalism's economic logic, this situation would be perceived as shown in figure 8-2.

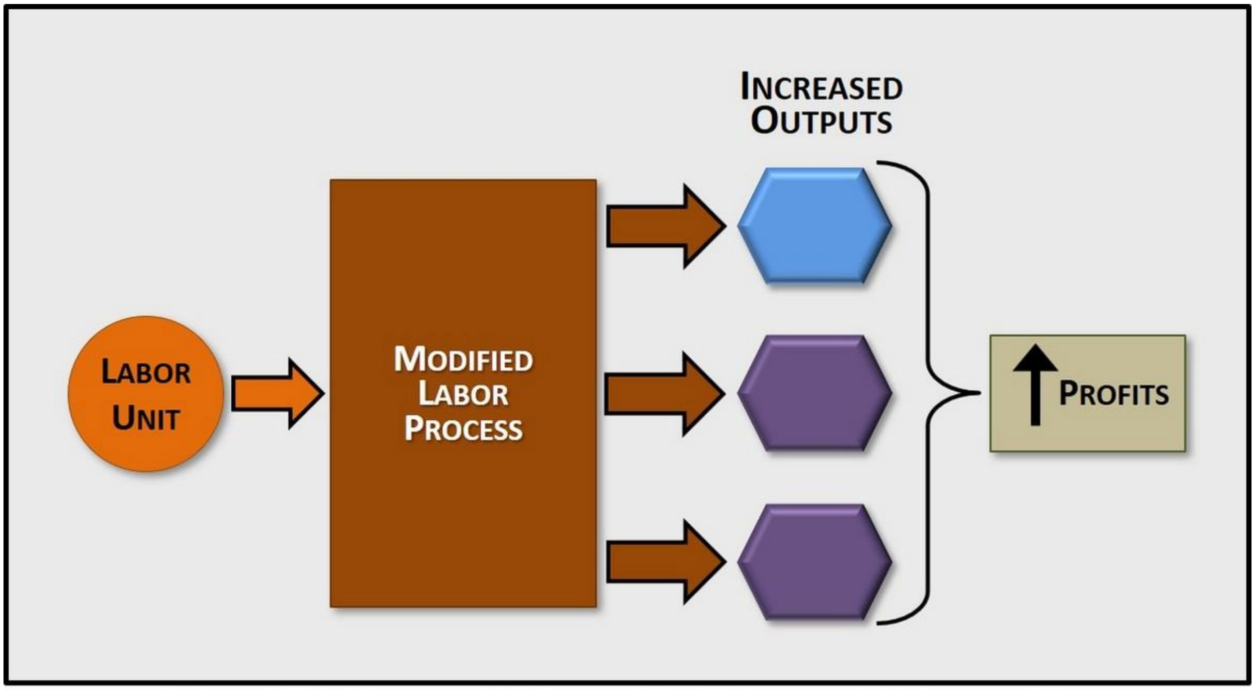


Figure 8-2. Increased labor productivity - standard economics

Let me make three points about this simplistic conception.

First, the standard discipline sees workers exclusively as a means - that is, an input to production. Except for issues that are legally addressed or may impact the bottom line, the effects of technical modifications on the workers themselves are ignored. The reader may recall from the discussion of opportunity cost in chapter four that standard thought treats people and nature the same way it treats time and money. That is, people and nature are not acknowledged to be degradable resources that can be materially damaged in production. This is a major factor in the standard perspective on productivity.

The second point about the standard conception is that the health consequences of incremental environmental damage from the new labor process are ignored. In the coy language of standard economics, such damage is "externalized".

Third, the criterion used to decide if labor productivity should be increased is whether or not this will increase profits. If it is more profitable to raise output quantity by increasing labor quantity instead of labor productivity, then either additional workers will be hired or existing workers will work longer or more intense hours.

Let me now turn to ENL's view of increased productivity. See figure 8-3.

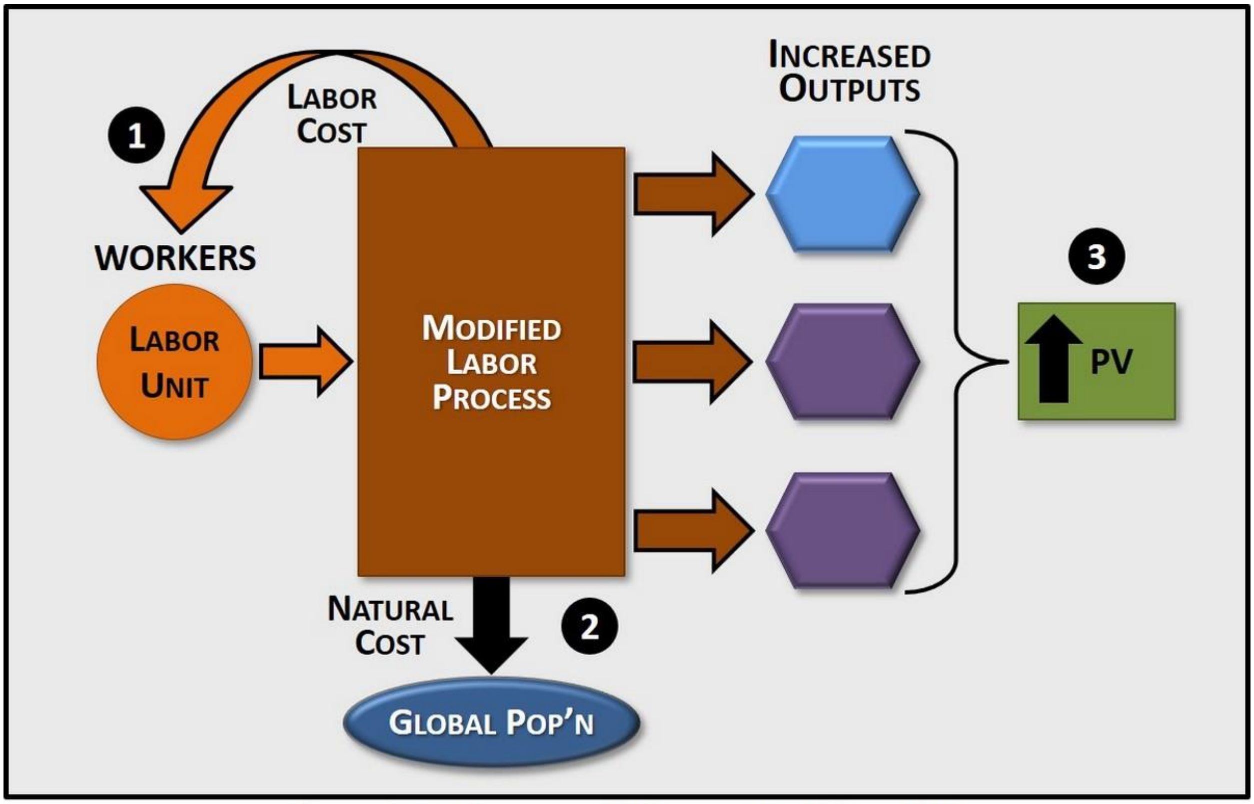


Figure 8-3. Increased labor productivity - ENL

There are three important differences between the two views. First, ENL sees workers as both a means and an end. As a means they are an input to production, as in standard economics, but as an end they are human beings. We must therefore determine how the modified labor process will affect their health. In ENL this is done through the concept of labor cost, which now includes the effects of increased technological intensity.

A second difference is that the public health consequences of incremental environmental damage are fully considered through natural cost rather than being dismissed as externalities.

The last difference is that the criterion for deciding if productivity should be increased is not just profit, but also society's overall health consequences, which take into account labor cost, natural cost, and the rise in potential value from increased production.

D. DIVISION OF LABOR

This term refers to the reduction in the number of economic tasks assigned to individual workers - that is, to the specialization and fragmentation of labor. Much has been written on this subject, and I don't want to add unduly to the pile. However, a few words that explain how ENL's concepts apply to this issue are in order.

Division of labor is strongly related to a society's choice of technological complexity. High complexity implies high technological intensity, which entails the need for specialized skills and knowledge. During humankind's lengthy hunter-gatherer phase labor was to some degree divided between the sexes, but for the most part it was highly integrated. Much of this integration dissolved as humankind moved to farming and civilization, and it virtually vanished as we moved to increasingly complex modes of civilization, culminating in today's capitalist version.

Many of the negative effects of subdividing labor are captured through ENL's concepts of labor cost and labor maldistribution. Excessive specialization will result in reduced skill levels and boredom (the cog effect), thus lowering the quality of labor and increasing labor cost. These negative effects will be severely intensified by labor maldistribution.

Probably the most significant aspects of the division of labor under capitalism are its roles in social control and increased profits. Regarding social control, labor fragmentation allows many tasks to be radically deskilled, thereby degrading workers and largely removing them as a systemic threat. This is not speculation on my part. Chemist Andrew Ure, a key capitalist ally during the system's manufacturing period, had this to say on the subject:

> "By the infirmity of human nature, it happens that the more skillful the [worker], the more self-willed and intractable [they are] apt to become, and of course the less fit a component of a mechanical system in which ... [they] may do great damage to the whole." (Quoted by Karl Marx in *Capital* vol. 1, p. 346f)

Regarding profits, the comment sometimes made about the American political system - "designed by geniuses so it can be run by idiots" - also applies to a capitalist economy. If the total money paid to a few well-compensated "geniuses" and many poorly-compensated "idiots" is less than modest compensation for all, the capitalists will pocket the difference. This is a powerful incentive to shape such an economy in precisely this manner.

The assumption underlying ENL is that the framework will replace capitalist logic for the purpose of economic guidance. If this transition occurs, capitalist motivations will no longer apply, and the destructive division of labor that now prevails should weaken and eventually disappear.

E. LUDDISM RECONSIDERED

Luddism was a 19th-century British working class movement whose members occasionally destroyed automated looms and other machines. Their main grievances were that the machines deprived them of income and destroyed a traditional and independent mode of life that was highly valued. To be called a "Luddite" today means that one rejects the latest technological advances, especially with regard to personal electronic devices.

Marx was careful to distinguish between machines themselves and the manner in which they are employed under capitalism. In *Capital*, after pointing out that the Luddite movement gave conservative forces a useful pretext for violent measures against workers, he said,

> "It took both time and experience before the workpeople learned to distinguish between machinery and its employment by capital, and to direct their attacks, not against the material instruments of production, but against the mode in which they are used." (*Capital Vol. 1*, p. 404)

This perspective is partly correct. As noted above, technology under capitalism is used not to advance human well-being but to increase profits. This topic was addressed earlier in *Capital*:

> "John Stuart Mill says in his *Principles of Political Economy*: 'It is questionable if all the mechanical inventions yet made have lightened the day's toil of any human being.' That is, however, by no means the aim of the capitalistic application of machinery. Like every other increase in the productiveness of labor, machinery is intended to cheapen commodities and, by shortening that portion of the working-day in which the laborer works for himself, to lengthen the other portion that he gives, without an equivalent, to the capitalist. In short, it is a means for producing surplus-value." (*Capital Vol. 1*, p. 351)

Marxists believe that this exploitive use of technology will be transcended once capitalists no longer control the economy and workers can relate to each other as "freely associated producers".

To summarize, there have been two main viewpoints regarding the application of technology to production. The standard, capitalist view is that this is invariably a good thing because it improves a society's standard of living. The Marxist view is that it will invariably be a good thing once workers have organized the labor process in accordance with their interests. Both perspectives reject the idea that the application of technology itself might be harmful to workers.

However, ENL's treatment of productivity indicates that neither view is entirely correct. When the toil and skill effects have been exhausted and the cog effect kicks in, technology applied to productivity will be detrimental to worker health, irrespective of the social relations that govern the labor process. At this point the machine itself becomes the workers' enemy, and must therefore be "destroyed". In this narrow sense, a modern form of Luddism would be justified.

This means, for example, that the threat of robots stealing satisfying jobs from workers would not appear in an ENL-guided economy. If the introduction of such technology would cause worker health to decrease, it would be economically irrational to proceed. Advanced automation such as workplace robots are a threat only in an economy that fails to treat workers as human beings, and thus to distinguish between efficiency maximization and productivity optimization.

Does this mean that technological innovation in production should cease once the health-increasing potential of productivity has been exhausted? Not at all. On the assumption that higher technological complexity has been socially accepted, technological change can generate a continuous increase in ecological efficiencies. Recall that efficiencies are increased by decreasing the natural flow rate. Technological improvements can continue this decrease without practical limit, thereby reducing environmental impact indefinitely for the benefit of both humankind and nature.

Chapter 9:
Trade

Like labor productivity, trade is logically part of production, which was addressed in chapter four. Its presentation has been deferred for the same reason: it is a specialized area that requires fairly detailed treatment.

Recall that ENL makes no assumption about the geographical scope of analysis. The analyst can treat the entire world as a single unit, in which case only internal exchange is possible. Alternatively, geographical scope can be a region such as a set of countries, an individual country, or a defined area that ignores national boundaries. In these cases, trade can occur between the chosen geographical unit and the rest of the world.

The term "region" refers to any geographical unit below the global level. Trade occurs when a final or intermediate output is produced in one region and then transported to another for consumption or use. The region that is being analyzed is called the local region; all others are called remote regions. An *export* is an output that is produced locally and transported to a remote region. An *import* is one that is produced remotely and transported to the local region.

A. TRADE FUNDAMENTALS

An isolated region that avoids trade is called a *closed economy*. Given its available inputs, climate, and other conditions, such an economy can produce a specific range of final outputs, incurring specific local input costs. This is shown in highly simplified form in figure 9-1.

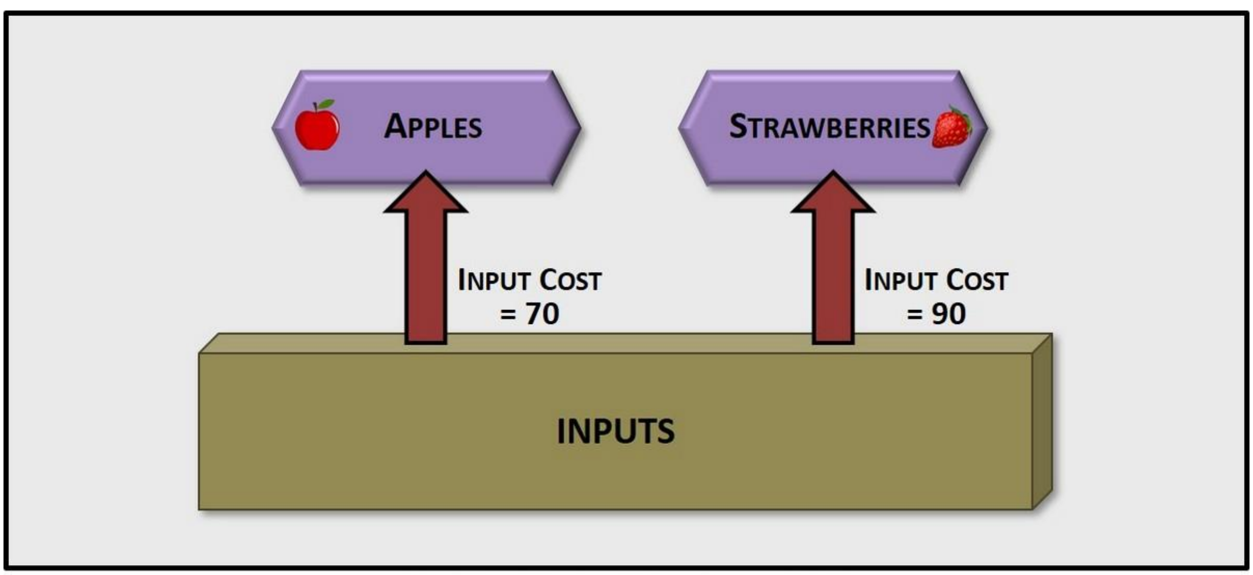


Figure 9-1. A closed economy

This economy is capable of producing apples and strawberries. For apples, the input cost of local production is 70 health units, while for strawberries it is 90 units. The effectual values for the two outputs are omitted because these are irrelevant to the initial part of this discussion. When we open this economy by permitting trade, two major changes are possible, as shown in figure 9-2.

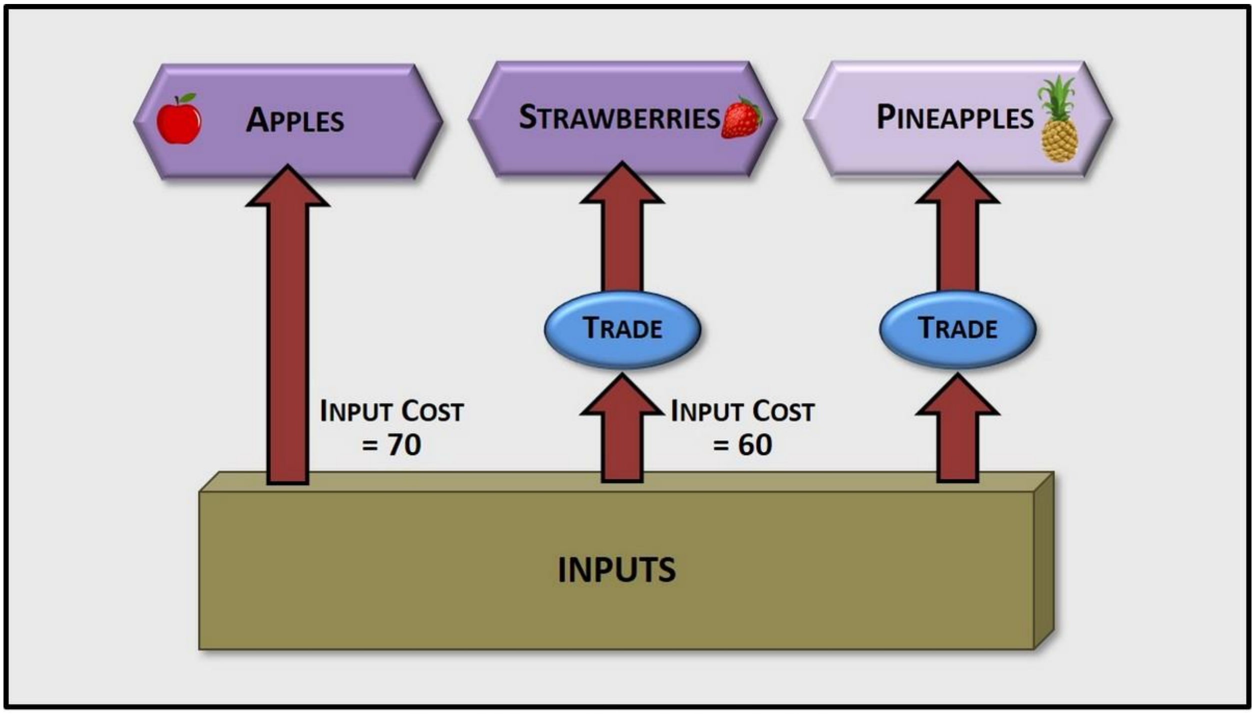


Figure 9-2. An open economy

The first change is that imported pineapples have been added to the output list. The second is that the input cost of strawberries has decreased from 90 units to 60 units. This example points to the main differences that trade can make to a closed economy: it can expand the range of its final outputs, and it can reduce the input cost of its locally-produced outputs. Let me briefly explain these two effects.

There are two reasons why trade can expand an economy's range of outputs. The first is that a remote region, given its inputs and conditions, is able to produce something that cannot be produced in the local region. In the above example the local region has the climate necessary to grow apples and strawberries, but not pineapples. Trade would therefore give the country access to an output it would otherwise lack.

The second reason for the expanded output range is that an economy may not have the necessary intermediate outputs. The local region may have the right climate for growing pineapples, but not the machinery to harvest and process them. In that case, importing these machines will permit the country to add pineapples to its domestic output list.

There are also two reasons why trade can decrease the input cost of a final output. First, the economy may be able to import this output in exchange for an output with a lower input cost. It could then replace the locally-produced output with the "cheaper" import. Second, the economy may be able to import an intermediate output at a lower input cost. Substituting this imported intermediate output will again lower the input cost of production.

To summarize, trade can expand the range of an economy's final outputs by importing those it cannot produce itself, and it can decrease the input cost of its final outputs either by replacing them with cheaper imports or by producing them with cheaper intermediate outputs.

B. TRADE IS AN ALLOCATION ISSUE

As explained in chapter three, allocation refers to social decisions that assign an economy's inputs to the production of specific outputs. The basis for these decisions is *gains*: the difference between an output's effectual value (EV) and its input cost (IC). Allocation is rational when inputs are assigned to the output that will achieve the highest possible gains.

Because trade can expand an economy's output range and reduce its input costs, it can significantly influence allocation decisions. ENL therefore analyzes trade from the allocation perspective. This implies that trade is rational when it results in the highest possible gains currently available to the economy.

To explore this further it will be useful to divide production into three categories and note the gains associated with each.

1. **Domestic production.** This excludes trade. Final outputs and their associated intermediate outputs are produced locally, and the final outputs are consumed locally. Using the subscript "d" to mean "domestic", the gains from consuming such outputs are: **EVd - ICd**.
2. **Domestic production with imported intermediate outputs.** Final outputs are produced locally, but their associated intermediate outputs are imported in exchange for locally produced exports. Using the subscript "x" to mean "export", the gains from consuming such outputs are: **EVd - ICx**.
3. **Remote production.** This is normal trade for imports. Final outputs are produced remotely in exchange for locally produced exports. Using the subscript "m" to mean "import", the gains from consuming such outputs are: **EVm - ICx**.

In the purely domestic production of a closed economy (#1 above), rational allocation is achieved by estimating gains for all local outputs and choosing the highest among them. This limited range of output choices restricts the total health the economy can achieve.

When the economy is opened by permitting trade, the gains in #2 and #3 can be considered as well. For domestic production with imported intermediate outputs (#2 above), input cost is lowered, which means that gains will be higher than domestic production. For remote production (#3 above), gains are higher in those cases where the remote region has superior production conditions. This expanded range of choices gives analysts a wider scope in making health-maximizing allocation decisions.

Briefly stated, trade in ENL is an allocation issue, and allocation is rational when inputs are assigned to the output that maximizes gains (EV - IC), irrespective of its production category.

C. EXAMPLE: TRADING LUMBER FOR AVOCADOS

Let me make the above more concrete by using a fairly realistic example. The Canadian province of British Columbia (BC), where I live, is heavily forested and thus a good place to grow trees for lumber. Costa Rica is a lush tropical country and is therefore a great spot for growing avocados. Treating BC as the local region, what gains might we achieve by exporting our lumber to Costa Rica and importing their avocados in exchange?

Let's assume that BC has reached its target quantities for all final outputs that require lumber in their production. This means we cannot gain health by using additional wood ourselves. The environmental budget for our wood extraction has not yet been exhausted, so we have ecological space to extract more wood. With these facts in mind, we get in touch with the Costa Ricans to talk trade, and discover that they are willing to exchange 5,000 kilograms of their avocados for 1,000 board-feet of our lumber. If this is the best deal we can get from them, should we proceed? Let's run through the allocation logic and see.

Avocados are final outputs and therefore have potential value. When they arrive in BC's stores they will reach consumers, who will convert this potential value into effectual value. BC incurs negligible input cost in this process, so our health gains from importing the avocados will be the effectual value associated with their local consumption.

Now consider the lumber we must ship to Costa Rica in return. Extracting logs from our forests and transforming them into lumber will incur both natural cost and labor cost. We will also have to ship the lumber to Costa Rica, which will incur transportation costs. The total of all these costs is the input cost of the exported lumber.

What we gain from this trade is the difference between the effectual value (EV) from consuming the imported avocados and the input cost (IC) from producing the exported lumber. We are thus considering case #3 above:

Gains = EVm – ICx

If there are no gains because input cost is equal to or greater than effectual value, the trade obviously makes no sense. Assuming they are positive, however, should we start shipping lumber to Costa Rica and look forward to the avocados we will get in return? Not quite yet - our aim is not just to increase our society's health, which we know this trade will accomplish, but to maximize it. We therefore have to go one step further to justify the trade relationship.

The resources we would expend for this trade are the inputs required for lumber production - labor, machines, buildings, oil, and so forth. So the question is: will our trade with the Costa Ricans maximize the health we could potentially achieve from these inputs, considering all alternative production (including other trade) possibilities? The situation that confronts us is summarized in figure 9-3.

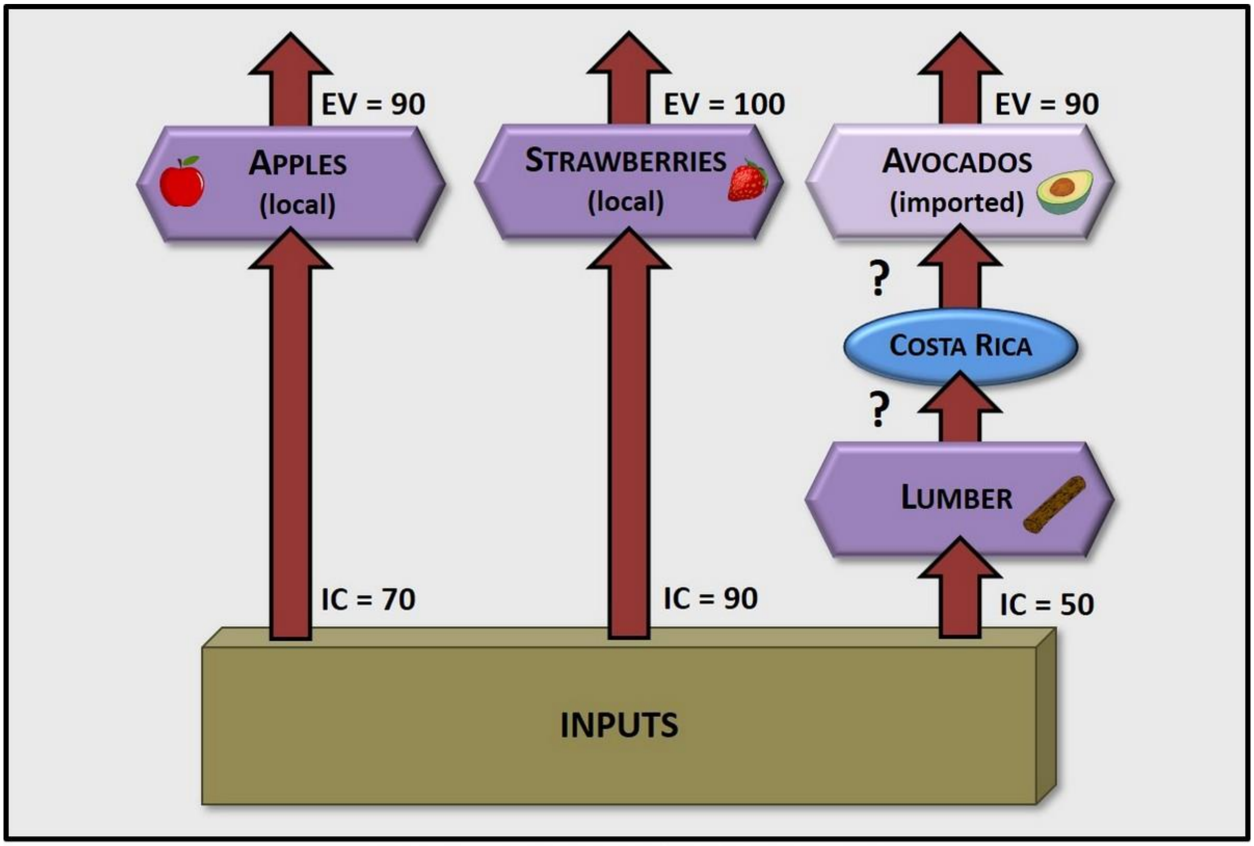


Figure 9-3. The rationale for trade

At the bottom of this diagram is a set of inputs we are seeking to allocate. At the top are three output options: locally-grown apples, locally-grown strawberries, and imported avocados. For each output our economy incurs the indicated input cost and achieves the indicated effectual value. The basis for the allocation decision is straightforward: when we put these inputs to work we should maximize the resulting gains. These gains are:

Local apples:	**EVd – ICd =**	**90 - 70 = 20**
Local strawberries:	**EVd – ICd =**	**100 - 90 = 10**
Imported avocados:	**EVm – ICx =**	**90 - 50 = 40**

The imported avocados are the clear winners here, so we should proceed with this trade. The inputs should therefore be allocated to the production of the lumber we intend to export. In this situation, the addition of this import will give BC residents the opportunity to increase their aggregate health relative to exclusively local production. It should be noted that, in making the gains comparison during allocation, it was irrelevant that the avocados will be imported instead of being produced at home.

Let's examine the trade with Costa Rica a little more closely. We have full knowledge about the input cost of the exported lumber because we incur this cost ourselves. Similarly, we have full knowledge of the effectual value of the imported avocados because our population experiences this benefit directly. However, we probably know nothing about the effectual value of the final outputs for which the lumber is destined. Similarly, we are likely to be ignorant about the input cost of the avocados produced in Costa Rica.

There is in fact no need for us to know about these two factors. This is why the arrows relating to Costa Rica's interactions are labeled with question marks. Also unknown to us, but not shown in the diagram, are the environmental expenditures incurred by the Costa Ricans in producing the avocados, and thus whether they are violating any environmental budgets in their production. Finally, we know nothing about the depletion of nonrenewable resources that might be involved in Costa Rica's avocado production.

All these unknowns are the result of our choosing regional rather than global geographical scope. In restricting ourselves to regional scope we are consciously isolating our economy from the rest of the world and ignoring the global implications of our actions. If we decide that such ignorance is unacceptable, we have no choice but to adopt global scope. Trade between regions will then disappear, and we will assume full responsibility for determining all values, costs, and environmental impacts before making allocation decisions in our global ENL economy.

To summarize this chapter: The reason for considering trade is that this modifies the local economy's allocation options, first by expanding the range of outputs that can be obtained with its inputs, and second by effectively reducing the input cost of locally-produced outputs. The rationale for proceeding with trade is that it achieves the highest health gains among the allocation options for a set of local inputs.

Chapter 10: Concluding Topics

A. DEVELOPING AND IMPROVING ENL

My development of ENL has been a long and arduous process in part because I have been unable to convince other economic thinkers to join my project. This has compelled me to develop ENL in almost complete isolation. I therefore suspect that, despite my best efforts, the framework contains errors. This should not be surprising: even the brilliant John Maynard Keynes found solitary work daunting. In the preface to his General Theory he admitted that, "It is astonishing what foolish things one can temporarily believe if one thinks too long alone, particularly in economics …" (p. vii) The first task for those who see ENL as a useful starting point is thus to carefully scrutinize the framework for unfounded assumptions, logical missteps, conceptual inconsistencies, unwarranted conclusions, and the like.

Beyond this initial project there are numerous areas where improvements can be made. The following strike me as the most urgent:

- **Health measurement.** In earlier versions of this book I proposed a physical health index to empirically establish value and cost. However, I have no expertise in this area, and the index was intended solely as a proof of concept. Professionals in the health field should be consulted to determine how physical health should be objectively measured for ENL purposes.
- **Empirical graphs.** Currently all of ENL's graphs are notional in that they are conceptual instead of being derived from observed data. To be useful in concrete situations, they must be converted into empirical graphs. For example, various labor processes should be examined to determine how labor cost varies with time, stressful working conditions, increasing technological intensity, etc. Other research should address the potential value of outputs, the effectual value resulting from their consumption, the natural cost of their production, etc.
- **Want satisfaction.** In chapter six I proposed several methods for assessing want satisfaction. This is a critical area because wants are both environmentally dangerous and psychologically powerful. ENL developers should thus consider versions of potential and effectual value that apply to wants. Outputs will likely fail to realize their want-satisfying potential for reasons that are similar to those for need-satisfying outputs - particularly through satiation. Another concept that will prove useful is *forgone want satisfaction* - the analogue to forgone health. This will help rationalize the allocation of inputs to want-satisfying production. Because ENL considers trade to be an allocation issue, this concept will also extend and deepen the framework's trade logic.
- **Additional efficiencies.** Chapter six introduced ecological efficiency, which measures the economy's success in minimizing natural flows in production. This

> should likely be broadened to include consumption activities. An example is the amount of jet fuel consumed per passenger mile. A new efficiency might be *consumption efficiency*: the ratio of effectual value to potential value. This would measure the economy's success in maximizing the health gains from consumption by minimizing satiation and maldistribution. Another option is *production efficiency*: the ratio of potential health gains (potential value minus input cost) to input quantities. This would measure the economy's success in squeezing the greatest potential health from its scarce inputs.

B. DEVELOPING A FUNCTIONAL FRAMEWORK

Recall that a complete economic theory must include two conceptual elements: a guiding framework to establish the economy's rational objectives given its stated goal, and a functional framework to analyze its detailed operations as these objectives are being pursued. ENL is intended to evolve into the guiding framework. Mainstream economics, which includes sophisticated tools for probing an economy's operations, will presumably underpin the functional framework.

The mainstream discipline is fortunately not homogeneous, and its internal differences can be exploited to speed theoretical progress. Although most schools of thought address capitalism and thus treat value as subjective, their perspectives vary widely. The core mainstream discipline is standard economics, and its principles can with some modifications be applied in selected areas. The non-standard modes of mainstream thought, which are collectively called *heterodox economics*, will be useful in extending and refining what the standard discipline offers.

One heterodox offshoot is ecological economics. This field has extensive experience in analyzing resource and waste flows, and in formulating policies that are conducive to their minimization. It also understands the need to rapidly increase ecological efficiencies, and it has done considerable work in placing monetary values on natural assets. These tools and policy guidelines could make positive contributions to the framework's development.

Heterodox thinkers could also assist in moving functional thought beyond a crucial standard assumption: *methodological individualism*. This is the idea that economic behavior is based entirely on individual motivations, and that group interactions are therefore irrelevant. One heterodox thinker who has challenged this assumption is Paul Ormerod. His Butterfly Economics states:

> "In orthodox economics, individuals are not permitted to affect each other's behavior directly, and in circumstances where this is a good approximation to reality, this offers a powerful explanation of what goes on. But such circumstances are rather limited, and it is more usually the case that people or companies are influenced directly by what others do. This leads to a much more complex world, but one which offers a better description of reality." (p. vii)

In developing a theoretical description of this more complex world Ormerod adopts a model that permits individuals to modify their behavior based on the actions of others. Such ideas hold great promise for understanding both collective economic behavior and seemingly unpredictable events like financial crises and stock market collapses. They are thus likely candidates for inclusion in the functional framework.

C. JOHN RUSKIN'S VALUE CONCEPTS

ENL is conceptually rooted in the economics of John Ruskin, the ecological limits of environmentalism, and the marginal analysis of standard economics. Because marginal analysis is part of mainstream thought and ecological limits are now widely recognized, the framework's only unorthodox feature is Ruskin's economics. I will therefore conclude this book by expanding on the key concepts I have taken from this British social thinker.

As mentioned in chapter three, Ruskin introduced the concepts of intrinsic value and effectual value in his book, *Munera Pulveris* (1862). He defined intrinsic value as, "the absolute power of anything to support life". He elaborated as follows: "A sheaf of wheat of given quality and weight has in it a measurable power of sustaining the substance of the body; a cubic foot of pure air, a fixed power of sustaining its warmth; and a cluster of flowers of given beauty a fixed power of enlivening or animating the senses and the heart." (p. 170)

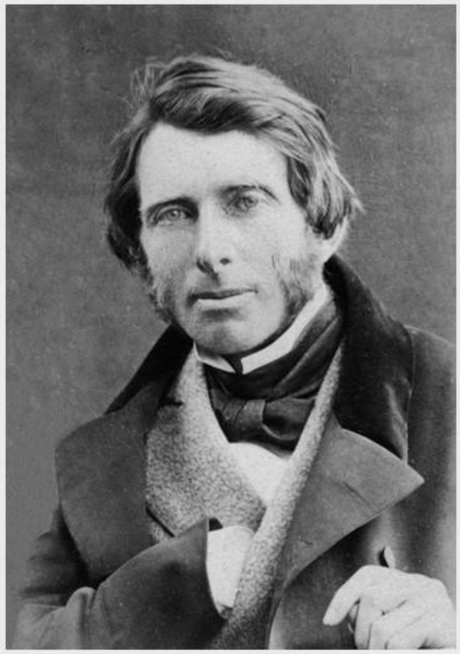
What I have done in ENL is to rename intrinsic value to potential value in order to avoid confusion with current usages. I have also restricted the concept to physical health, for two reasons. First, health is objective and quantifiable, whereas the psychological impacts of floral beauty are not. Second, ENL recognizes want satisfaction as well as need satisfaction. The positive effects of flowers on the senses and heart can reasonably be placed in this second category.

Ruskin underscored that intrinsic value is *objective*: "It does not in the least affect the intrinsic value of the wheat, the air, or the flowers, that [people] refuse or despise them. Used or not, their own power is in them ...". (p. 170f)

Having defined intrinsic value, he noted that, "... in order that this value ... become effectual, a certain state is necessary in the recipient of it. The digesting, breathing, and perceiving functions must be perfect in the human creature before the food, air, or flowers can [achieve their full value]." (p. 171) He therefore distinguished between the life-enhancing potential of intrinsic value and its realization in effectual value. In ENL I make the same distinction with respect to health.

Ruskin summarized the two forms of use-value as follows: "The production of effectual value ... always involves two needs: first, the production of a thing essentially useful; then the production of the capacity to use it. Where the intrinsic value and acceptant capacity come together there is effectual value ... where there is either no intrinsic value, or no acceptant capacity, there is no effectual value ...". (p. 171)

I am deeply indebted to Ruskin for these seminal ideas. They are indispensable in a guiding framework, and they triggered the development of ENL many years ago. Unfortunately I have found nothing else in Ruskin's work that could contribute to ENL under current conditions. Intellectually he lived in a pre-capitalist world, and he greatly valued the personal relations and paternalism of feudal times. We must remember, however, that feudalism was a steady-state economy, and that humankind must soon return to the steady-state condition. Thus, if we survive capitalism's environmental onslaught, we may one day read Ruskin from a radically different perspective and for the first time appreciate the depth, wisdom, and morality of his heartfelt counsel.



John Ruskin, 1863

Appendix A:
Public statement by concerned economic thinkers

NOTE: This is my proposal for a public statement by concerned economic thinkers who understand the urgent need to develop a sustainable economic theory.

The undersigned are economic thinkers who are deeply concerned about the ecological crisis. Our shared view is that a new economic theory must be quickly developed, for two reasons: to guide present humankind to a sustainable future if catastrophic collapse can be averted, and to help surviving humankind reconstruct societies on a sustainable basis if such a collapse occurs. Although mainstream or standard economics has many useful features, it cannot achieve these critical ends.

The fundamental problem with mainstream thought - which includes both standard and heterodox theories - is that it reflects capitalism's economic logic. This logic strives for maximum profits and growth, and it treats natural sources and sinks as unlimited. Given the environment's catastrophic decline, we categorically reject these premises. In our view the new theory must be based on the following principles:

1. **The economy's goal is sustainable well-being.** An economy cannot violate environmental limits, and it must maximize human well-being as this is socially defined.
2. **Use-value is objective, not subjective.** Mainstream economics values outputs based on the strength of consumption desires by those with the capacity to pay. A sustainable theory would value outputs based on an objective factor such as physical health.
3. **Needs are distinguished from wants.** The mainstream places all final outputs in the same category: commodities to be consumed. A sustainable theory would distinguish between final outputs that satisfy needs by improving health, and those that satisfy wants by enhancing life enjoyment.
4. **Natural sources and sinks are sustainably allocated.** Formal methods must be developed to utilize natural sources and sinks so that environmental limits are fully respected while well-being is maximized.

The theory we propose has a restricted role: to help analysts establish rational economic objectives based on the goal of sustainable well-being. It must therefore be supplemented by a modified form of mainstream economics that addresses the economy's operations. We emphasize that our opposition is not to mainstream thought as a whole, but rather to the extension of its role beyond functional analysis into the guiding realm.

Similar considerations apply to capitalism. Although we reject the system's ecocidal logic, we broadly support many of its institutions. Capitalism's markets, monetary systems, regulatory methods, legal infrastructure, etc. are not necessarily damaging to the environment, and should be selectively retained in suitable forms. Society's familiarity with these institutions will likely facilitate the transition to a sustainable economy.

We plead with concerned economic thinkers to immediately begin work on a sustainable economic theory, and to modify mainstream economics as indicated. Given the severe time constraints, we strongly recommend that an existing proposal, the Economics of Needs and Limits (ENL), be used as the starting point for the sustainable theory's development.

(Signatories)

Appendix B:
Glossary

Allocation: The social act of assigning an input, or a set of inputs, to the production of an intermediate or final output. The output can either be consumed in the local region or be exported.

Analytical scope: The range of economic topics for which ENL takes analytical responsibility. These are humankind's allocation, production, distribution, consumption, and any directly related matters.

Biological flow: One of the three natural flows that have direct biological effects: habitat destruction, the utilization of renewables, and the expulsion of wastes.

Budget limit: The economy's maximum scale within the constraints of a specified environmental budget.

Budget share: The portion of an environmental budget that is allotted to a specific final output. This allotment is based on the output's marginal health gains relative to the other final outputs that utilize the flow.

Cog effect: One of the three effects of increasing technological intensity on labor cost. This occurs when the skill effect is exhausted, the worker loses control of the production process, and health consequently declines. See also "skill effect" and "toil effect".

Consumption: The assimilation or utilization of final outputs to satisfy consumption desires.

Consumption desires: Needs and wants, collectively.

Distribution: The social act of assigning final outputs, labor, or wastes to individuals. This term should not be confused with the physical transportation of inputs and outputs.

Ecological efficiency: The measure of an economy's success in minimizing a natural flow in production. This is a ratio: output quantity divided by flow rate.

Ecological limit (economy): The economy's lowest budget limit. That is, the economy's maximum scale within the constraints of its most restrictive environmental budget.

Ecological limit (output): A final output's lowest share limit. That is, the output's maximum quantity within the constraints of its most restrictive budget share.

Ecological limit (population): The maximum population that can be supported, at a specified level of average per-capita consumption, by an economy at its ecological limit.

Ecological space: The increase in an economy's scale that is possible before its ecological limit is reached. Ecological space is a requirement for want authorization.

Economic scale: An economy's overall rate of output production.

Effectual value: The realization of potential value. That is, the actual health gained from the consumption of a final output. Effectual value can initially be positive, negative, or zero, and tends to decrease at the margin due to satiation and maldistribution.

Environmental budget: For the economy as a whole, the maximum rate of a biological flow that does not cause environmental harm.

Final output: An output that is assimilated or utilized to satisfy consumption desires. Compare: "intermediate output".

Forgone health: The sacrifice made in allocation for a need-satisfying output. Thus, the health that would have been achieved by producing the best alternative output from a set of inputs. Forgone health is ENL's version of *opportunity cost* in standard economics.

Functional framework: A conceptual framework used to analyze an economy's detailed operations. Compare: "guiding framework".

Gain: A health increase that considers either consumption or production, but not both. Thus, positive effectual value or negative input cost. Compare: “loss”.

Gains: A health increase that results from consumption and production, taken together. Gains are equal to effectual value minus input cost when effectual value is higher. Compare: "losses".

Geographical scope: The geographical area, either global or regional, to which ENL-based analysis is applied.

Guiding framework: A conceptual framework such as ENL that is used to establish an economy's rational objectives based on a stated goal. Compare: "functional framework".

Intermediate output: An output that does not satisfy consumption desires, but is instead used in the production or consumption of other outputs. Compare: "final output".

Input: A resource used in production, such as labor, natural materials, productive assets like machines and buildings, and services (accounting, legal, janitorial, etc.).

Input cost: The direct and indirect effects of production on health. The direct effects are called labor cost; the indirect effects are called natural cost.

Irrational output: An output whose input cost is greater than its effectual value at all quantities. The target quantity for such outputs is zero.

Labor: The human input to production.

Labor cost: The health effects of the labor process on workers and the public. Labor cost is positive when labor decreases health; it is negative when labor increases health.

Labor productivity: The quantity of a final or intermediate output produced per unit of labor time. This is a ratio: output quantity divided by labor time.

Long run: The relatively long-term future, during which physical as well as behavioral changes are possible in an economy. Compare: “short run”.

Loss: A health decrease that considers either consumption or production, but not both. Thus, negative effectual value or positive input cost. Compare: “gain”.

Losses: A health decrease that results from consumption and production, taken together. Losses are equal to input cost minus effectual value when input cost is higher. Compare: "gains".

Lost potential health: The health that is unrealized when an individual dies as a result of production or consumption. The lost health is calculated from the date of death to the expected date of death.

Maldistribution: Any distribution of outputs, labor, or wastes that fails to achieve maximum health. For outputs this means the failure to maximize effectual value; for labor, the failure to minimize labor cost; and for wastes, the failure to minimize natural cost.

Natural cost: The global health effects of the environmental changes resulting from production. Natural cost is positive when these effects decrease health; it is negative when they increase health.

Natural flow: A physical interaction between nature and the economy. ENL recognizes four categories: habitat destruction, utilization of renewables, expulsion of wastes, and utilization of nonrenewables. The first three are called biological flows.

Need: A consumption desire that increases health when it is satisfied. Compare: “want”.

Net gains: Gains minus losses when gains are higher.

Net losses: Gains minus losses when losses are higher.

Optimum scale: The economy's scale when the marginal input cost of its collective outputs equals their marginal effectual value.

Optimum population: The population level that maximizes a society's average well-being based on scale effects.

Optimum quantity: The output rate of a final output where its marginal input cost equals its marginal effectual value.

Output: A good or service resulting from economic production. The term can refer to either a final or an intermediate output.

Output life cycle: All stages of a final output's economic existence, including the extraction of natural resources, the production of intermediate outputs, the production of the final output itself, its consumption and maintenance, and its eventual recycling or disposal.

Potential value: The maximum health that can be gained from the consumption of a final output. Potential value can be positive, negative, or zero, and is a constant quantity.

Production: The economic process of converting inputs into outputs.

Sacrifice: What is given up when inputs are allocated to and then used in production. ENL recognizes two types of sacrifice: forgone health, which relates to the allocation of inputs to production, and input cost, which relates to the production process itself.

Satiation: The exhaustion of an individual’s physical or mental capacity to fully convert an output's potential value into effectual value as more is consumed.

Satisfaction score: The ratio between the strength of a society's unmanipulated desire for a want-satisfying output and the input cost of its production.

Scale effects: The opportunities for increased cooperation, specialization, exchange, and trade that can initially accompany an increase in population.

Share limit: The quantity of a final output that exhausts a budget share.

Short run: The relatively near-term future, during which behavioral but not physical changes are possible in the economy. Compare: "long run".

Skill effect: One of the three effects of increasing technological intensity on labor cost. This results in negative labor cost as a worker's skills are applied to production technology. See also "cog effect" and "toil effect".

Social neutrality: ENL's impartial stance with respect to the progressive and conservative views of society.

Sustainable well-being: ENL's economic goal: the achievement of both natural sustainability and human well-being.

Target population: The lower of a population's optimum level and its ecological limit.

Target quantity (final output): The lower of an output's optimum quantity and its ecological limit.

Target quantity (intermediate output): The minimum quantity required for the target quantities of all associated final outputs.

Target scale: The lower of an economy's optimum scale and ecological limit.

Technological intensity: The degree to which technology replaces autonomous human action in a labor process.

Technological neutrality: ENL's principle that an economy's technological complexity is a social choice, and is therefore irrelevant for judging its performance or progress.

Toil effect: One of the three effects of increasing technological intensity on labor cost. This occurs when technology is first introduced and labor cost declines due to the reduction in physical or mental toil. See also "cog effect" and "skill effect".

Trade: The transfer of an output from the region where it is produced (export) to another region where it is consumed or utilized (import). Trade can arise only when the analyst chooses regional geographical scope.

Want: An unmanipulated consumption desire that does not increase health when it is satisfied. Wants are divided into two categories: those that are *authorized* (socially approved) and those that are *unauthorized* (socially rejected). Compare: "need".

Wastes: The material residues of economic activities, including greenhouse gases, pollution, materials discarded during production and consumption, and disused outputs.

Well-being: The socially-specified combination of an individual's need satisfaction (as measured by effectual value), want satisfaction (socially determined), and input cost.