

ECONOMICS

Scarcity and Environmental Disaster: Why Hotelling's Price Theory Doesn't Apply

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Economists' Perspective on the Future

Despite the obvious importance of natural resources, economists have typically paid little attention to the subject. For example, the term scarcity appears in an article title only 27 times on JSTOR, a multidisciplinary database of scholarly journals that includes full archives up until July 2002 of 97 business and economics journals. Some of these journals have been publishing for more than a century.

More often than not, the message about scarcity in these few papers reflects capitalist dogma that concern over conservation is unwarranted, because markets are effective in managing resources. Consider the opening sentences of Harold Hotelling's classic article, "The Economics of Exhaustible Resources":

Contemplation of the world's disappearing supplies of minerals, forests, and other exhaustible assets had led to demands for regulation of their exploitation. The feeling that these products are now too cheap for the good of future generations, that they are being selfishly exploited at a too rapid rate, and that in consequence of their excessive cheapness they are being produced and consumed wastefully has given rise to the conservation movement.

Though Hotelling's words described the concerns that gave rise to the conservation movement, he didn't share them. Putting his faith in the system of private enterprise, he went so far as to suggest that the existence of monopoly could perhaps dramatically slow the depletion of resources.

Taking a broader perspective, Harold J. Barnett and Chandler Morse, authors of what many economists consider the bible of resource economics, declared: "Nature imposes particular scarcities, but not an inescapable general scarcity." In other words, we may experience a shortage of some particular resource, but such shortages do not present an obstacle to further growth, because new technology will allow us to create plenty of substitute technologies. Barnett and Morse based their optimistic conclusion on economic indicators rather than material conditions. For example, if looming petroleum scarcity were a real problem, as petroleum critics have long claimed, then prices should be trending upward. And though we've seen increases in the last couple of years, the cost of oil, corrected for inflation, is still lower than it was during the late 1970s.

And indeed, new technology has made a major impact in the oil sector. Richard Norgaard, a resource economist from the University of California, Berkeley estimated that in the absence of such new technology, extraction costs would have risen 70 percent between 1939 and 1968.

Ironically, although economists display a nonchalance regarding future natural resource scarcity, they often display a touching sensitivity concerning the future when analyzing programs for

citizens provided by the public sector. They have developed a whole new subdiscipline named intergenerational accounting, which claims that the present population is paying insufficient attention to the burdens that it is bequeathing future generations. They invoke this concept to spread the (false) alarm that Social Security, the U.S. government program that gives retirement income to senior citizens, is facing bankruptcy, thus current policies threaten to saddle future generations of Americans with excessive taxes.

Substitutability

The substitution of one resource for another undergirds economists' optimism that scarcity can be overcome. A favorite example economists use to dismiss concerns about scarcity is the 19th century warnings about the looming shortages of whale oil. Walter Wriston, former Chief Executive Officer of Citicorp, provided a typical description:

The tragedy of our Civil War disrupted whale oil production, and its price shot up to \$2.55 a gallon, almost double what it had been in 1859. Naturally, there were cries of profiteering and demands for Congress to "do something about it" Meanwhile, men with vision and capital began to develop kerosene, other petroleum substitutes, and innovations based on technology.

Economists take particular delight in this story, because it supposedly exposes the naiveté of the environmentalists who presumably would have predicted the end to indoor lighting due to shortages of whales. The moral of this story is that nobody has to worry about scarcity. The market will take care of everything.

This logic has also been applied to the soil. Thus, there have been claims that if the soil eroded, farmers could happily find the necessary nutrients in guano. Once the guano deposits became exhausted, farmers could conveniently turn to manufactured fertilizers, a procedure which, since it requires heavy consumption of fossil fuels, contributes to another form of scarcity.

But the manufacture of synthetic fertilizers also created other dangers. Chemists soon learned that the same process for producing nitrogen fertilizers could also yield powerful explosives, which could then be used by military forces to fight over access to oil and other resources. Similarly, as fossil fuels become more scarce, many observers expect that atomic energy will become more acceptable, which dramatically increases the likelihood of further proliferation of nuclear weapons.

Ultimately though, the idea of scarcity becomes impossible for economists, because they maintain that everything always has a substitute. Just as money can purchase any type of commodity, the thinking goes, industry can always find some replacement for any seeming scarcity. Economists believe that before some potential scarcity might cripple a vital technological process, some new technology—in economics jargon, a "backstop technology"—will successfully replace the supposedly endangered one. Not only will the backstop technology substitute for the older one, economic theory holds that it will also prove to be a superior technology.

This faith in the possibility of successful substitution suggests an interconnectedness in the economic environment, comparable in some ways to the interconnectedness that environmentalists see. Economists see this interconnectedness extend to technology as well. And indeed, there are numerous examples of scientific discoveries intended for a relatively narrow purpose in one industry that unexpectedly spilled over into other industries, often with extraordinary results.

However, economists seem blind to another sort of interconnectedness: the detrimental effects of pollution that individual industries spew out upon one another and society as a whole. Rather than acknowledge pollution as a negative but common byproduct of modern industrial production, economists decouple it from its cause by classifying it as an “externality,” since the price system does not reflect these effects.

Although substitutability is real in many cases—for example, metal, plastic, and glass can all serve as construction materials—substitutability has limits. For instance, new technology can minimize water requirements, which suggests a degree of substitutability. But ultimately water remains a necessity for life, and for that purpose, no substitute is possible.

In addition, converting to substitute materials can require time. In the 17th century, the British feared a looming shortage of timber for making ships. Today, steel is the primary material for constructing vessels, but the British could not suddenly turn to metal ships at the time, since the creation of the technical infrastructure needed for the conversion to metal required years.

In an even larger sense, ultimate substitutability is impossible. Yes, we can conserve energy, water, or any other resource, but literally everything we do creates entropy. Considering a recent example, over the last ten years, the nuclear power industry and its supporters have made a heroic effort to repackage nuclear energy as an economic and even environmentally friendly energy source. And if nuclear power could be safe and economical—which it isn’t—producers could tap a huge reservoir of potential energy, dramatically pushing back the boundaries imposed by the Second Law of Thermodynamics, though those boundaries would still exist. For instance, nobody has yet discovered a way to economically dismantle a nuclear plant once it shuts down, a process known as “decommissioning.” Nor has anyone figured out how to safely store nuclear waste products, which remain deadly for tens if not hundreds of thousands of years. Even where commercial nuclear power plants exist, they do so only because of the benefit of enormous subsidies for virtually every aspect of nuclear production. Taking just one example, nobody in their right mind would ever dream of building, owning or operating a nuclear power plant if they had to face full exposure from the liability of major accidents. In the United States, the Price-Anderson Act protects the nuclear industry from all but a tiny portion of the potential liability of a major accident.

Hotelling, Prices, and Substitutability

The underlying concept behind the faith in substitutability comes from economists’ certainty that the price system will somehow provide the correct signals to induce entrepreneurs to take appropriate action. In particular, Hotelling attempted to prove that under ideal conditions, nonrenewable resource prices should or would rise at a rate equal to the real rate of interest. These rising prices will supposedly warn of the need for conservation, leading people to adopt technologies and consumption patterns that increasingly economize on resources as they become more scarce. Consequently, markets purportedly have the capacity to efficiently ration scarce goods.

But there are two problems with the theory of substitutability. While substitutability sounds wonderful in theory, in practice, people in authority rarely display much confidence in the concept. Consider the words of Winston Churchill, writing in a January 1914 cabinet note two years after he, as First Lord of the Admiralty, made the fateful decision that oil rather than coal would thereafter fuel the ships of the Royal Navy. This decision had far-reaching consequences, because it meant a

dependence on foreign oil supplies rather than Welsh coal. Once Churchill had made that momentous commitment to oil, the future Prime Minister was brutally frank about England's dependence upon imported resources, warning:

We are not a young people with an innocent record and a scanty inheritance. We have engrossed to ourselves an altogether disproportionate share of the wealth and traffic of the world. We have got all we want in territory, and our claim to be left in the unmolested enjoyment of vast and splendid possessions, mainly acquired by violence, largely maintained by force, often seems less reasonable to others than to us.

Nor was the importance of colonial resources lost on other people in power. Consider how often the United States has intervened in the affairs of countries upon which it relies for oil. If substitutability seemed practical, such activities would have little purpose.

In addition, efforts to devise more efficient use of a resource can be self-defeating. As Jevons had already observed in his *Coal Question*, efficiencies, which are expected to conserve a resource, can actually make even more intensive use of those resources attractive.

Denying Scarcity

Although those who had the responsibility for maintaining the empire displayed a keen awareness of the threat of scarcity, economists tended to deride anyone—even an economist of Jevons' stature—who would dare to raise the question.

While almost unanimously praised for his efforts in pioneering the “scientific” value theory that most economists still accept today, the questions Jevons raised in *The Coal Question* subjected him to more than a century of ridicule by the same mainstream economists. Ordinary intellectuals uninformed by rigorous training in economics could safely warn about the dangers posed by looming scarcity, but that a leading economist could do so was unthinkable. I never had a class that mentioned Jevons without some snide remark about his “foolish” book on scarcity.

John Maynard Keynes launched the most famous attack on Jevons' *Coal Question*. While praising much of his economic work, Keynes mocked Jevons' concern about resource scarcity. Keynes attributed Jevons' book to personal eccentricities that exhibited themselves in compulsive behavior, such as hoarding paper. Keynes dismissed Jevons' mistaken belief in “the approaching scarcity of paper as a result of the vastness of the demand in relation to the supplies of suitable material,” noting that “here again he omitted to make adequate allowance for the progress of technical methods.” Keynes concluded that, for this and other reasons, “there is not much in Jevons's scare which can survive cool criticism.”

But, of course, from Keynes' vantage point, scarcity was the farthest thing from his mind. Writing in the midst of the Great Depression, he was concerned that the wealth-creating capacity of the economy was bound to outstrip the capacity to consume in a purely market-driven economy. He expected that in the near future, modern market economies would “have built all the houses, roads and town halls and electric grids and water supplies and so forth which the stationary population of the future can be expected to require.”

Of course, Jevons was far more realistic than Keynes, at least insofar as the question of resources was concerned. Both wanted to see the build-up of productive capacity, but Jevons realized that to do so would eventually lead to serious problems that ultimately could not be resolved.

Jevons, however, was swimming against a current that he himself was instrumental in creating. While *The Coal Question* was written for popular consumption, Jevons' theoretical works were highly influential in turning economics away from a concern about scarcity. His pioneering approach to economics shifted its perspective away from a dynamic analysis of the forces that determine the cost of production. Instead of beginning with production, Jevons called upon economics to concentrate on a theory of consumption. In effect, this new style of economics focused on how consumers' choices rather than production drive the economy.

Economists do not deny that individuals face conditions of scarcity. After all, though we are awash in a seemingly endless variety of commodities, poverty still weighs upon a large portion of society, and even the affluent would like to consume more. Yet more than a half century after Jevons pioneered this new economics—now known as neoclassical economics—most economists still downplay the importance of scarcity.

In general, economists view scarcity as an obstacle to be overcome. In fact, economists typically define their discipline as the science of allocating scarce resources. However, the overarching scarcity that economists study is the general scarcity of *capital*—i.e., complex conditions collapsed down to a single monetary measure. And this sort of scarcity does not represent an ultimate barrier to the economy. As long as there is an appropriate degree of saving and investment, economists envision a process of capital accumulation that can always promise to continue to build up enough stock of plant and equipment to continually produce more and more goods and services.

However, economists can neither give a satisfactory definition of what capital is nor measure it. For example, plant and equipment depreciate over time, but economists have no satisfactory method of measuring this depreciation—only a few rough rules of thumb with no basis in theory. Furthermore, each school of thought has its own interpretation of capital, and none are consistent with each other. Finally, what economists define as “capital” changes. For example, economists often include “human capital,” as part of the capital stock.

Labor: The Partial Arrival of Eldorado

Keynes ignored the roles of both resources and the colonies, presuming that the world was on the verge of achieving what he called, “Eldorado,” his term for economic utopia in reference to the mythical kingdom of riches. And in terms of labor, the developed market economies have indeed transcended the traditional limitations that scarcity supposedly imposes, a condition that represents a dramatic break with traditional economic relations.

In the early years of capitalism, the key to economic development was mobilizing as many workers as possible. In 18th century British political economy, for example, most of the major figures were obsessively searching for new ways to increase the supply of available labor. Joseph Townsend, the self-declared “Well-Wisher to Mankind,” proposed that after farm workers labored a full day in the fields threshing or plowing, in the evenings “they might card, they might spin, or they might knit.” Others went even further. William Temple called for the addition of poor, four-year-old

children to the labor force. Anticipating modern Skinnerian psychology, Temple speculated, “for by these means, we hope that the rising generation will be so habituated to constant employment that it would at length prove agreeable and entertaining to them.” Not to be outdone, John Locke, often seen as a philosopher of liberty, called for the commencement of work at the ripe age of three.

By the time that Keynes was coming into his own as an economist in the 1920s, rapidly advancing technology had changed the picture dramatically. Despite the fact that the production of goods was expanding, total labor requirements were falling fast. Employers no longer had to worry about how to find enough workers. The problem at hand was to find new sources of demand for products to keep unemployment from soaring.

Prior to this modern state of affairs, the traditional rationale for keeping wages in check was to free up productive capacity. With fewer productive resources going to meet the demands of the working class, more efforts could be directed into creating the capital goods that would pave the way for future growth. In other words, it was a transfer of resources from the workers to the capital goods, which were sold and returned increasing profits to the employers. But once the economy reached this partial Eldorado, this logic made no sense whatsoever, since the world would already have enough productive capacity to satisfy its needs.

Resources still posed potential limits to production. For example, between 1920 and 1969, energy inputs increased more than three times as rapidly as the number of man-hours employed. In addition, in the modern economy, workers with particular occupational skills might be in short supply, but labor in general is not particularly scarce.

The main reason to keep wages in check is to increase potential profits. However, to realize these potential profits, business had to find alternative sources of demand. The only alternative justification for keeping wages low that I’ve ever seen reverts back to the traditional theory that pervasive scarcity requires marketplace rationing. In other words, restricting wages is necessary to ration the scarce supply of goods.

Keynes correctly set out to refute this archaic mindset, but he never did so in a systematic way. As a result, his successors managed to neutralize the most challenging aspects of his work and then integrate Keynes into conventional economics.

The Perverse Incentives of Markets

Although the depletion of stocks of inanimate resources such as oil might seem to be a natural and necessary consequence of economic activity, market forces place demands on renewable sources faster than natural processes can replenish them. One of the first hints that market forces are inimical to environmental sustainability came from a British surveyor named John Richards in 1730. Richards estimated the annual yield from allowing a 50-year-old oak tree to survive an additional 50 years to maturity. Comparing the timber yield from the 50-year-old and 100-year-old tree, Richards calculated an increase equivalent to a little more than 3 percent per year. Since the prevailing interest rate at the time was almost double that, economic logic suggested that harvesting the tree at 50 years was preferable to allowing it to survive to maturity. So, while good forestry practices call for a longer harvest period, market incentives impose a conflicting requirement.

Colin Clark addressed an even more intractable problem: the harvesting of whales. He estimated that blue whales had a maximum per annum reproductive potential of perhaps 4 to 5 percent. Given a much higher expected return on capital, he revealed that under neoclassical economic logic, protecting the whale from extinction made no economic sense:

The standard economic argument for the overexploitation of resources (based on the logic of the Tragedy of the Commons) neatly lay[s] the blame on open competition, particularly among the impoverished and powerless. Yet the most spectacular and threatening developments of today, such as the reduction of the whale stocks and the demersal fisheries on the Grand Banks, can by no means be attributed to impoverished and local fishermen. On the contrary, it is large, high-powered ships and the factory fleets of the wealthiest nation's that are now the real danger.

In other words, profit maximization demands that the most profitable strategy for harvesting whales is to hunt them quickly. Specific whale populations have already disappeared. By 1828, for example, whale hunters had already almost extinguished the bowhead whales remaining in the waters off Greenland's east coast. Today there are none.

In strictly economic terms, preservation of the species makes no sense, because even the stingiest savings account produces interest income faster than whales reproduce themselves. Reviewing the standard economic theory of the rational exploitation of fisheries in a market economy, Vernon Smith, in his classic article on the subject, concluded: "This theory ... is not able to handle the situation in which a species may be depleted to the point of extinction This is perhaps one of the more serious deficiencies of the received doctrine."

But rather than admit that the decline of the whale stocks confirms the fact that markets threaten sustainability, economists commonly trumpet the substitution of oil for whales as evidence of the triumph of the market. By the same logic, mainstream economists maintain that concern about looming shortages of fossil fuel must be ill-founded, since some new technology will once again provide an economical alternative.

A Practical Application of Hotelling Prices

Soil fertility is a precious gift. Technology can replace the soil, for example through hydroponics, but a hydroponically produced diet would be extraordinarily expensive (as well as nutritionally questionable). Yet modern agriculture typically puts little value on fertility.

American farmers' abuse of land has appalled many observers—both foreign and domestic—for centuries. For example, writing in the early 20th century, Harvard economist, Thomas Nixon Carver observed:

Where land is cheap and labor dear, there will always be wasteful and extensive farming, and it is useless to preach against it.

In spite of the marvelous growth of American agriculture and its apparent prosperity it is doubtful if it has ever been self-supporting in any strict sense before the present period. The average farmer had never counted the partial exhaustion of the soil as part of a crop. Taking the country over it is probable that if the farmers had been compelled to buy fertilizers to maintain the fertility of their soil without depletion, the whole industry would have become bankrupt.

The agricultural sector avoided such a bankruptcy by moving on to new lands after it exhausted the fertility of the older lands. In his classic study of agriculture in the Southern United States, Lewis Gray said: “Planters bought land as they might buy a wagon—with the expectation of wearing it out.” James F.W. Johnston, a noted Scottish agronomist explained to his readers:

...there is as yet in New England and New York scarcely any such thing as local attachment—the love of place, because it is a man’s own—because he has hewed it out of the wilderness, and made it what it is; or because his father did so, and he and his family have been born and brought up, and spent their happy youthful days upon it. Speaking generally, every farm from Eastport in Maine, to Buffalo on Lake Erie, is for sale. The owner has already fixed a price in his mind for which he would be willing, and even hopes to sell, believing that, with the same money, he could do better for himself and his family by going still further west.

Despite the enormous environmental damage done by early agriculture, some economists still applaud those questionable farming practices. For example, writing a half century after Carver, Warren Scoville, attempted to refute the widely accepted environmental complaints about the destruction of the soil in early North America:

The generally held opinion that the so-called “land butchery” practices by the American farmer during colonial and pre-Civil War days was “wasteful” of our land and timber resources falls, I believe, into this category of misconceptions. It seems a sounder view that “land butchery” was not necessarily wasteful either from the viewpoint of contemporaries or from the viewpoint of citizens living today.

In a follow-up article, Scoville defended the primacy of economic logic:

I, for one, would be most loath to defer to the judgment of agronomists and statisticians as to whether our natural resources (or any capital goods, for that matter) should be conserved or in some degree used up. If they can supply economists with the essential data on all possible production and cost functions, this would be highly desirable. But let us hope that our most competent economists would be charged with the responsibility of interpreting the data and of recommending desirable public policy regarding conservation.

In other words, the future economic costs of the environmental damage were small relative to the immediate benefits. Scoville never explained how to calculate such costs; that task supposedly was the responsibility of the critics. Lacking such evidence, he concluded that the land butchery must have been rational, because market forces made such practices profitable.

The rationality of exhausting the fertility of the land depended upon two different possibilities offered to American farmers. First of all, farmers could move to new land after they depleted the fertility of their farms. And as the British agronomist, Johnston, previously observed, they often did move to new land. Some of the farmers of North America took the other option. They followed the example of their English counterparts and replenished the fertility of their land with imported guano. In the 1830s, the price of guano was approximately \$30 a ton, according to *American Farmer*, “making it, as may be perceived, a very profitable business” for both purveyors and users.

Alas, supplies of guano were also limited. As John Bellamy Foster tells the tale:

So desperate was the condition of capitalist agriculture in this period that the mid-nineteenth century saw a frantic search for guano throughout the world and the rise of a period of guano imperialism. The first great overseas colonial expansion of the United States was a direct outgrowth of this crisis of the conditions of production in agriculture. Under the authority of the Guano Island Act, passed by Congress in 1856, U.S. capitalists seized 94

islands, rocks, and keys around the globe between 1856 and 1903, 66 of which were officially recognized by the U.S. Department of State as U.S. appurtenances. Nine of these guano islands remain U.S. possessions today.

After the guano deposits gave out, farmers turned to another substitute for soil fertility: commercial nitrogen fertilizer. Nitrogen, the most important component of commercial fertilizers, seemed to defy industrialization because, unlike other nutrients, it volatilizes. Capturing nitrogen from the air seemed virtually impossible until German chemists discovered how they could harness free nitrogen into a form that farmers could apply to the land. This process was not magic. It required large quantities of fossil fuel. One student of the subject declared that this synthesis of ammonia was the most important invention of the 20th century because, he claimed, without it millions of people would starve.

So, in practical terms, Scoville's perspective prevailed over that of the more skeptical Thomas Nixon Carver. After all, massive soil erosion continues to this day. In 1989, for example, the United States Department of Agriculture reported that 2.7 billion tons of eroded sediments are transported to small streams each year. To put this quantity into perspective, each year about 10 tons of soil erodes for every person in the United States. To put this magnitude of soil erosion into context, compare it with food consumption. If the average person were to consume five pounds of food per day, over the course of a year, that weight would represent less than a ton. Considering that soil is relatively dry and food contains considerable water, soil losses are even greater compared to the agricultural output.

Of course, agriculture is not responsible for all soil erosion, though a great deal of the erosion occurs on the farms. While soil can erode relatively quickly, a single inch of topsoil can literally take centuries to accumulate.

With a rising population and a shrinking agricultural area, according to Hotelling's price theory, the price of soil fertility should be increasing. Prices for land have indeed risen over time, but there is little evidence that this pricing mechanism reflects an allowance for fertility. Instead, farmland prices seem to be determined by their potential for commercial or residential development—which, ironically, locks up the soil's productive capacity for good.

Despite increasing agricultural yields, a rising population and shrinking agricultural area along with a rapid increase in meat consumption should have caused a rapid increase in the price of soil fertility. Hotelling's theory notwithstanding, that has not been the case. Furthermore, until very recently, a rapid increase in meat consumption imposed additional demands on the land. While yields have increased, they have not kept pace with these other factors.

One factor preventing a Hotelling-like price increase that reflects declines in land fertility is that food imports compensate for shrinking agricultural lands in the United States. Without a clear international market for land based on concerns about diminishing soil quality, the issue remains invisible, because the assumption that there is always enough fertile land somewhere still holds.

Passenger Pigeons

No case better illustrates how markets conflict with sustainability than the fate of the passenger pigeon. In this vein, Gardner Brown, an economist from the University of Washington, once wrote:

“The passenger pigeon is a marvelous case study for the economist.” How right he was! Certainly, the fate of the once abundant but now extinct creature stands as a stark warning about the inadequacy of the price system. Jennifer Price offered a glimpse into the world of the passenger pigeon before its demise:

They say that when a flock of passenger pigeons flew across the countryside, the sky grew dark. The air rumbled and turned cold. Bird dung fell like hail. Horses stopped and trembled in their tracks, and chickens went in to roost. “I was suddenly struck with astonishment at a loud rushing roar, succeeded by instant darkness,” the ornithologist Alexander Wilson wrote after he encountered a pigeon flock along the Ohio River in the early 1800s: “I took [it] for a tornado, about to overwhelm the house and everything around in destruction.” Wilson sat down to watch the flock pass over, and after five hours, he estimated that it had been 240 miles long and numbered over two billion birds.

Price continued:

A typical wild-pigeon roost blanketed hundreds of square miles of forest. The underbrush died, the trees were entirely denuded of their leaves, dung piled up inches deep, and century-old trees keeled over under the cumulative weight of the nine-ounce birds.

This unfortunate creature was doubly cursed by both instinct and market forces. At the sound of gunshots, the frightened birds would flock together, making them an easy target for hunters. Worse yet for the bird’s reproductive potential, each female would produce only one egg per year.

Widespread commercial hunting did not begin until about 1840, although early New England settlers already hunted passenger pigeons. Within a decade, the creature was in serious decline in New England:

The last significant nesting in New England happened in 1851, near the town of Lunenburg, Massachusetts. The following year, Henry David Thoreau wrote: “Saw pigeons in the woods, with their inquisitive necks and long tails, but few representatives of the great flocks that once broke down our forests.”

By the 1860s, hunts of grand proportions became common in the Middle West. Consider just how grand these proportions were. James Tober, a student of Gardner Brown’s, wrote:

From Hartford, Michigan in 1869, 3 carloads per day were shipped to market for forty days, which yielded a total of 11,880,000 pigeons. Another Michigan town was reported to have shipped some 15,840,000 birds over a two-year period. From the Michigan nesting of 1874, a single railroad station is reported to have shipped 80 barrels per day, each containing from 30 to 50 dozen birds, for the length of the nesting season. Two reports from the Shelby, Michigan nesting of 1876 suggest that 350,000 and 398,000 birds were shipped per week.

The last major nesting occurred near Petoskey, Michigan, in the spring and summer of 1878, with an estimated total shipment of 1,500,000 dead birds and 80,352 live from Petoskey station alone. This massive slaughter soon took its toll. According to Stephen Gould:

By 1870, birds were reproducing only in the Great Lakes region. Hunters used the newly invented telegraph to inform others about the location of dwindling populations. Perhaps the last large wild flock, some 250,000 birds, was sighted in 1896. A gaggle of hunters, alerted by telegraph, converged upon them; fewer than 10,000 birds flew away.

People comforted themselves by regarding the collapse of the population as a temporary phenomenon. In 1897, *Western Field and Stream* wrote that the birds were “as liable to return at any time as unexpectedly as they went.” In 1899, *Forest and Stream* supposed that the species would “live long in the land, but never again as a bird found in enormous numbers.”

Soon thereafter the passenger pigeon disappeared from the planet. The last member of the species, named Martha, died in the Cincinnati Zoo on September 1, 1914, at the approximate age of 29 years. For the next couple of decades, purported sightings of passenger pigeons (like those of Elvis) trickled in, but none were verified.

The tragic combination of market forces and instinct sealed this creature’s fate. Recall that, following Hotelling, economic theory teaches that the price of the bird should have risen as its numbers dwindled, signaling to all concerned that they should respond to the looming scarcity by economizing on the resource. But that didn’t happen with this unfortunate creature. According to Gardner Brown and Barry Field, “The passenger pigeon became extinct with hardly a ripple in its commercial price.” Later Brown added: “Since price did not rise to signal growing scarcity, there was no economic force inducing entrepreneurs to attempt to save the pigeon.”

According to economists who dismiss the threat of scarcity, a combination of new technology and substitution provides alternatives to scarce resources. In the case of the passenger pigeon, these forces actually contributed to the extinction of the bird. Insofar as substitution is concerned, people regarded the bird as a close substitute for chicken. According to Brown:

The market price of passenger pigeons did not rise, because chicken was regarded as a close market substitute and the price of chicken remained stable during the passenger pigeon’s demise. Since price did not rise to signal growing scarcity, there was no economic force inducing entrepreneurs to attempt to save the pigeon, because there was no evident economic scarcity rent to be earned.

Even though the price did not increase, hunting the birds was so easy that the enterprise remained profitable despite their dwindling numbers. Here technology *contributed* to the problem. The rapid spread of the railroad at the time meant that sellers could ship the birds on ice over a longer distance, thereby hastening the demise of the bird. In addition, the telegraph made the slaughter more “efficient.”

Although Hotelling’s elegant theory may give comfort to those who advocate market-based management of the environment, evidence that the price system will work in the way that he proposed is lacking—certainly in the case of the passenger pigeon. Neither substitution nor technology helped to prevent the extinction. The supply of chicken held prices down, preventing the market from signaling an impending shortage, while the railroad expanded the demand for the bird.

Looking at this case from a purely economic perspective, however, a cynic could assert that the scarcity problem was non-existent. After all, because consumers could substitute chicken for passenger pigeons, the extinction caused them no hardship at all. Of course, resources have value over and above their capacity to serve an immediate economic need. They may have a potential that is presently unknown, as was the case with helium.

Thus, the case of the passenger pigeon indicates that the warnings, which Hotelling theorized would signal a growing scarcity, do not always occur. Frequently, the price system fails to give even a hint

of an impending disaster. The extinction of the passenger pigeon offers a particularly sad illustration of how markets fail to promote conservation.

Market Solutions

If the passenger pigeon had not been a common property would its fate have been different? Here the answer may—or may not—come from black stuff in the ground rather than black birds in the air. Oil is obviously becoming more scarce, but up until the last couple of years, its price has not even hinted of its growing scarcity. Instead, the improvement in technology has camouflaged the problem by keeping prices in check, even though the rate of depletion of the oil supply is increasing.

As Geogescu-Roegen has repeatedly emphasized, prices in general depend on cost flows, leaving considerations of stocks out of view. The oil market is now an exception to this rule, since the flow of new oil onto the market largely determines the price. Matters become more complex, since nobody knows how large the stocks of oil are, a fact which is also true of many other resources.

New flows of oil supplies send the wrong signal, because people tend to assume that large supplies loom in the background—just as they did in the case of the passenger pigeon. Within this environment, the oil industry is worried about overcapacity, not depletion.

The day will certainly come when the scarcity of oil will cause prices to increase to a level that truly reflects the amount of available supply. But as long as the current economic paradigm reigns, that will only happen after the current cost of production in low-cost wells begins to rise. Unfortunately, the transition to a non-petroleum energy system will necessarily be a long process. Judging by current trends, the inevitable price spike will come too late to give people a chance to make an orderly transition a new energy regime. And once again, neoclassical economic formulations will have failed us.