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# CORPORATE AFTERSHOCK

The Public Policy Lessons from the Collapse  
of Enron and Other Major Corporations

Edited by Christopher L. Culp and William A. Niskanen

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# 1

## EMPIRE OF THE SUN

*A Neo-Austrian Economic Interpretation of  
Enron's Energy Business*

CHRISTOPHER L. CULP AND STEVE H. HANKE

**B**y the time the Enron Corporation filed for Chapter 11 bankruptcy protection on December 2, 2001, virtually everyone with a television set knew that things were not as they had once seemed in Houston. How could a company go from a market capitalization of almost \$100 billion and the number seven ranking in the *Fortune 500* to bust within two years? How could a stock that had seen highs of nearly \$90 per share become a penny stock in record time? How could the six-time consecutive winner (1996 to 2001) of *Fortune's* "most innovative company in the United States" have engineered its own financial destruction? *What can we do to make sure this never happens again?*

We must be careful when we define *this* in the phrase "make sure this never happens again." Not everything Enron did, after all, was illegal, unethical, or even questionable. What actually caused Enron to fail is still subject to contentious debate. As Part Two of this volume describes, Enron did *not* fail because it was engaged in commercial and merchant commodity businesses. Nor did a "rogue trader" or Enron's use of creative and sometimes-complex financial contracts bring Enron to its knees. And, as the chapters in Part Three explain, Enron's corrupt financial activities—concealing its true indebtedness, lining the pockets of select senior managers at the expense of shareholders, hiding major losses, and so on—are also not what caused Enron to fail. Enron's financial deception undoubtedly allowed it to remain in business for longer than an otherwise similar firm engaged in accurate financial disclosures, but this is a question of timing alone and not causality.

We argue in this chapter that Enron's ultimate financial failure most likely occurred for the same reason that WorldCom, Global Crossing, and many other firms periodically have run into trouble. In short, these firms all lacked the ability to identify their true *comparative advantage*. In some cases, this meant overinvesting in new markets and technologies that never took off. In other cases, the firms simply overestimated the value that they could add. But is *this* something that new policies and regulations should strive to ensure "never happens again"? Or, as we argue here, is this aspect of Enron's failure nothing more than a testimonial to the fact that competitive markets are effective judges of success and failure?

We begin this chapter with an overview of Enron. In doing so, we stress that it was first and foremost an energy business that employed an innovative *asset lite strategy* that accounted for many of Enron's genuinely successful years. We then briefly discuss those businesses in which Enron failed because it departed from the successful asset lite strategy employed in the energy business. The next section formally frames Enron's asset lite strategy in the context of competitive economic theory. We argue that the standard "neoclassical" economic models do not explain firms such as Enron and that a more "disequilibrium-oriented" or "neo-Austrian" approach is required. A concluding section considers whether Enron's failure *as a business* either offers lessons for other firms or provides a proscriptive case for greater regulation.

Apart from providing an analysis of Enron's business strategy through the lens of economic theory, our chapter also illustrates the limitations of the traditional neoclassical theory of the price system for explaining *entrepreneurship* and *innovation*—terms we feel that, despite Enron's illegal and fraudulent activities in some areas, nevertheless, do describe this company in other areas. From a neoclassical perspective, markets are viewed as being in a stationary state in which the relevant knowledge about demand and supply is known and market prices are static, or given, data to be taken and used by individuals and firms. In this world without change, we need not ask how this state of affairs came about. This knowledge simply falls into the category of irrelevant bygones.

Neoclassical economics also deals with change. It does so by employing comparative statics. For example, we can conceive of a quasi-stationary state in which changes in the relevant knowledge in a market are few and far between, and the analysis of the full repercussions are dealt with by evaluating and comparing the stationary states before and after the changes in relevant knowledge occur. In the neoclassical world, prices act as signposts, guiding consumers to substitute goods for one another and producers to learn which lines of production to abandon or

which to turn toward. In this neoclassical conception, the price system acts as a network of communication in which relevant knowledge is transmitted at once throughout markets that jump from one stationary state to the next.

In the neo-Austrian or disequilibrium-oriented context, by contrast, the market is viewed as a process that is in a constant state of flux.<sup>1</sup> As a consequence, there are no stationary or quasi-stationary states. Indeed, expectations about the current and future state of affairs are always changing because the state of relevant knowledge is always changing. With those changing expectations, market prices are also changing. The price system is functioning as a network for communicating relevant knowledge. It is also a discovery process that is in continuous motion, working toward creating a unity and coherence in the economic system. The speed of adjustment and the dissemination of knowledge in the price system depend on the scope and scale of the markets, however.

As it relates to our discussion here, the full force of market integration is realized when both spot and forward markets exist. Indeed, one important function of forward or derivatives markets is to spread relevant knowledge about what market participants think the future will be. Forward markets connect and integrate those expectations about the future with the present in a consistent manner. Although the future will always remain uncertain, it is possible for individuals to acquire information and knowledge about the expected future and adjust their plans accordingly. In addition, they can—via forward markets—express their views about the future by either buying or selling forward. Forward markets, then, bring expectations about the future into consistency with each other and also bring forward prices into consistency with spot prices, with the difference being turned into “the basis.”

In a neo-Austrian world, the state of relevant knowledge and expectations is in a constant state of flux. And not surprisingly, spot and forward prices, as well as their difference (the basis), are constantly changing, too. Ever-changing expectations, therefore, keep the market process in motion. In consequence, disequilibrium is a hallmark of the neo-Austrian orientation. While the neo-Austrian market process is in a constant state of flux, it is working toward integrating and making consistent prices, both spot and forward.<sup>2</sup>

As the analysis in this chapter demonstrates, the explicit incorporation of neo-Austrian variables such as time, knowledge, and market process into the traditional price theoretical framework for microeconomic analysis is fundamental to understanding fully the financial and commercial market strategies of a company such as Enron.

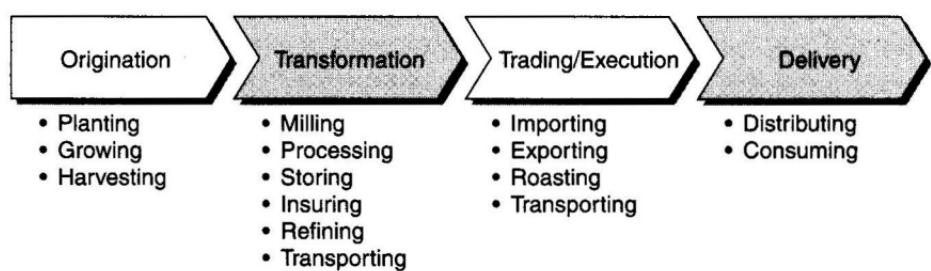
## ENRON'S ENERGY BUSINESS

To understand Enron's business model for its core activities requires a brief explanation of how *commodity markets* function. The usefulness of many physical commodities to producers (e.g., wheat that can be milled into flour) and consumers (e.g., bread) depends on the *supply chain* through which the commodity is transformed from its raw, natural state into something of practical use. Figure 1.1 shows a typical supply chain for a variety of commodities.

When a commodity moves from one part of the supply chain to the next, transportation, distribution, and delivery services are almost always involved. These services are the glue that keeps the supply chain linked. To put it simply, Enron specialized in these transportation, distribution, and transformation services—often called *intermediate supply chain* or *midstream* services. Accordingly, Enron acted as a wholesale merchant. It acquired the latest information about alternative sources of supply and set prices for goods in a process that would maximize Enron's turnover. Enron was an ideal vehicle for the discovery and transmission of relevant knowledge.

In its 2000 annual report, Enron described itself as “a firm that manages efficient, flexible networks to reliably deliver physical products at predictable prices” (Enron, 2001, cover).<sup>3</sup> This involved four core business areas for the firm: wholesale services, energy services, broadband services, and transportation services.

Enron Wholesale Services was the corporation's largest—and generally the most profitable—operation. The bulk of that business was the transportation/transmission and distribution of natural gas and electricity. On a volume basis, Enron accounted for more than twice the amount of gas and power delivery in the United States of its next-largest competitor (Enron, 2001, p. 9). In addition, Enron maintained an active (and, in several cases, growing) market presence in the supply chains



**FIGURE 1.1** The Supply Chain

for other commodities, including coal, crude oil, liquefied natural gas (LNG), metals, steel, and pulp/paper. Enron Wholesale Service's customers were generally other large producers and industrial firms.

Enron Energy Services dealt mainly with the retail end of the energy market supply chains. Enron Wholesale Services might deliver electrical power to a utility, for example, whereas Enron Energy Services might contract with a large grocery store chain to supply their power directly.

Enron Broadband Services was focused on the nonenergy business of broadband, or the use of fiber optics to transmit audio and video. Capacity on fiber-optic cables is known as *bandwidth*. Enron Broadband Services had three business goals. The first was to deploy the largest open global broadband network in the world, called the *Enron Intelligent Network*, consisting of 18,000 miles of fiber-optic cable. The second commercial objective was for Enron to dominate the market for buying and selling bandwidth. Finally, Enron sought to become a dominant provider of premium content, mainly through streaming audio and video over the Internet.

Enron's fourth operating division was Enron Transportation Services, formerly the Gas Pipeline Group. Long a core competency of Enron, Transportation Services concentrated on operating interstate pipelines for the transportation of natural gas. Albeit highly specialized and narrowly focused, gas transportation was perhaps the core brick on which the Enron Corporation foundation was laid.

The Houston Natural Gas Production Company was founded in 1953 as a subsidiary of Houston Natural Gas (HNG) to explore for, drill, and transport gas. From 1953 to 1985, the firm underwent a slow but steady expansion, respectably keeping pace with the gradual development of the gas market.

Natural gas was deregulated throughout the late 1980s and early 1990s. During this time, supplies increased substantially, and prices fell by more than 50 percent from 1985 to 1991 alone. As competition increased, the number of new entrants into various parts of the natural gas supply chain grew dramatically, and many existing firms restructured.

One such restructuring was the acquisition in 1985 of HNG by InterNorth, Inc. The takeover of HNG was largely the brainchild of Kenneth Lay, who had joined HNG as its CEO in 1984. Working closely with Michael Milken, Lay helped structure the InterNorth purchase of HNG as a leveraged buy-out relying heavily on junk-bond finance.<sup>4</sup> Lay wrested the position of CEO of the merged firm from InterNorth CEO Samuel Segnar in 1985.

In 1986, InterNorth changed its name to Enron Corporation and incorporated Enron Oil & Gas Company (EOG), reflecting its expansion

into oil markets to supplement its gas market presence. By then, most firms active in oil markets were also involved in gas—and conversely—given complementarities in exploration, drilling, pumping, distribution, and the like. With the exception of a brief hiatus toward the end, Lay remained CEO of Enron Corporation until the firm failed.<sup>5</sup>

In 1985, the Federal Energy Regulatory Commission (FERC) allowed open access to gas pipelines for the first time. As a consequence, Enron was able to charge other firms for using Enron pipelines to transport gas, and, similarly, Enron was also able to transport gas through other companies' pipelines.

Around this time, Jeffrey Skilling, then a consultant for McKinsey, began working with Enron. He was charged with developing a creative strategy to help Enron—recall, it had just been created through the InterNorth/HNG merger—leverage its presence in the emerging gas market. Skilling argued that the benefits of open access might be more than offset by the declining revenues associated with the general drop in prices and margins that greater competition would bring. Add to that Enron's mountain of debt, and Skilling maintained that Enron would not last very long unless a creative solution was identified.

Skilling argued, in particular, that natural gas would never be a serious source of revenues for the firm as long as natural gas was traded exclusively in a "spot" physical market for immediate delivery. Instead, he argued that a key success driver in the coming era of postderegulation price volatility would be the development of a *natural gas derivatives market* in which Enron would provide its customers with various price risk management solutions—forward contracts in which consumers could control their price risk by purchasing gas today at a fixed price for future delivery and option contracts that allowed customers the right, but not the obligation, to purchase or sell gas at a fixed price in the future.

Viewed from a neo-Austrian perspective, Skilling was functioning as a classic entrepreneur. Once FERC changed the rules of the game and natural gas became deregulated, Skilling spotted an entrepreneurial opportunity to develop new markets. By introducing forward markets, individuals could acquire information and knowledge about the future and express their own expectations by either buying or selling forward. Moreover, with both spot and futures prices revealed, the basis—the difference between spot and futures prices—could be revealed and a more unified and coherent natural gas "market" could be created. While such a new setup would not eliminate risk and uncertainty, it promised to allow much more relevant knowledge to be discovered and disseminated, allowing firms to adjust their expectations and plans accordingly and to manage their risk more effectively (Lachmann, 1978).

To create this market in natural gas derivatives, Skilling urged that Enron set up a “gasbank”—called GasBank. Much as traditional banks intermediated funds, Enron’s GasBank intermediated gas purchases, sales, and deliveries by entering into long-term, fixed-price delivery and price risk management contracts with customers. Soon thereafter, other natural gas firms began to offer clients similar risk management solutions. And those producers, in turn, also came to Enron for their risk management needs.

Enron acted as a classic *market maker*, standing ready to enter into natural gas derivatives on both sides of the market—that is, both buying and selling gas (or, equivalently, buying at both fixed/floating prices or swapping one for the other). Enron thus became the primary supplier of liquidity to the market, earning the spread between bid and offer prices as a fee for providing the market with liquidity. In addition and in a broader sense, Enron was functioning to spread knowledge about what market participants expected prices to be.

Did this mean Enron was exposed to *all* of the price risks that its trading counter parties were attempting to avoid? No, because many of the contracts into which Enron entered naturally offset one another. True, a consumer seeking to lock in its future energy purchase price with Enron would create risk exposure for Enron. If prices rose above the fixed price at which Enron agreed to sell energy to a consumer, Enron could lose big money. But that might be offset by a risk exposure to *falling* prices that Enron would assume by agreeing to *buy* that same asset from a producer at a fixed price, thus allowing the producer to hedge its exposure to price increases. (See Chapters 4, 5, and 9 for more discussion of these different types of contracts.) Enron was left with only the *residual* risk across all its customer positions in its GasBank, which, in turn, Enron could manage by using derivatives with other emerging market makers, generally known as *swap dealers*, or on organized futures exchanges.<sup>6</sup>

For a long time, Enron was not merely *a* market maker for natural gas derivatives—it was *the* market maker, having virtually *created* the market. This meant wider spreads, higher margins, and more revenues for Enron as the sole real liquidity supplier to the market. But this also meant few counter parties existed with which Enron could trade to hedge its own residual risks.

Here is where Enron’s *physical* market presence comes back into the picture. In addition to allowing Enron to discover and reveal a great deal of “local” knowledge, Enron’s presence in the physical market meant that it could control some of the residual price risks from its market-making operations. This could be accomplished because of *offsetting positions in its physical pipeline and gas operations*. Consider, for example, a firm that is

buying natural gas in Tulsa, Oklahoma, from a pipeline with a supply source in San Angelo, Texas. If that firm seeks to lock in its future purchase price for gas to protect against unexpected price spikes, it might enter into a forward purchase agreement with Enron, thus leaving Enron to bear the risk of a price increase. But if Enron also *owns the pipeline* and charges a price for distribution proportional to the spot price of gas, the *net effect* will be roughly offsetting.

Operating this kind of gasbank also gave Enron valuable information about the gas market itself. Knowing from its pipeline operations that congestion was likely to occur at Point A, for example, Enron could anticipate price spikes at delivery points beyond Point A arising from the squeeze in available pipeline capacity. And Enron could very successfully “trade around” such congestion points. Conversely, when prices in derivatives markets signaled surplus or deficit pipeline capacity in the financial market, Enron could stand ready to exploit that information in the physical market.

Gradually, thanks to Enron’s role as market maker, the natural gas derivatives market became increasingly standardized and liquid. Accordingly, relevant knowledge was spread more rapidly and the natural gas market became more integrated and coherent. Enron still offered customized solutions to certain consumers and producers, but much of the volume of the market shifted to exchanges such as the New York Mercantile Exchange (NYMEX), which began to provide standardized gas futures. Nevertheless, Enron’s role as dominant market maker left the GasBank well situated to profit from supplying liquidity to *those* standardized markets, as well as retaining much of the custom over-the-counter (OTC) derivatives dealing business.

The Enron GasBank division eventually became Enron Gas Services (EGS) and later Enron Capital and Trade Resources (EC&TR). In 1990, Skilling left McKinsey to become a full-time Enron employee, and Skilling later became CEO of both EGS and EC&TR. In 2001, Skilling ultimately replaced Lay as CEO for the whole firm, marking the only time in the history of Enron that Lay was not at the helm.

When Skilling joined Enron formally in 1990, he maintained that the future success of the firm would come from repeating the GasBank experience in other markets. To accomplish this, Skilling developed a business concept known as *asset lite*, in which Enron would combine small investments in capital-intensive commodity markets with a derivatives trading and market-making “overlay” for that market. The purpose was to begin with a relatively small capital expenditure that was used to acquire portions of assets and establish a presence in the physical market. This allowed

Enron to learn the operational features of the market and to collect information about factors that might affect market price dynamics. Then, Enron would create a new financial market overlaid on that underlying physical market presence—a market in which Enron would act as market maker and liquidity supplier to meet other firms' risk management needs. As Skilling described it, “[Enron] is a company that makes markets. We create the market, and once it's created, we make the market” (Kurtzman and Rifkin, 2001, p. 47). Needless to say, this encapsulates the essence of one of the central roles of a neo-Austrian entrepreneur.

One reason for the appeal of asset lite was that it enabled Enron to exploit some presence in the physical market without incurring huge capital expenditures on bulk fixed investments. Enron quickly discovered that this was best accomplished by focusing on investing in *intermediate* assets in commodity supply chains. In natural gas, this meant that Enron could get the biggest bang for its buck in midstream activities such as transportation, pipeline compression, storage, and distribution. Enron's Transwestern Pipeline Company eventually became the first U.S. pipeline that was *exclusively* for transportation, neither pumping gas at the wellhead *nor* selling it to customers (Clayton, Scroggins, and Westley, 2002).

Other markets in which Enron applied its asset lite business expansion strategy with a large degree of success included coal, fossil fuels, pulp, and paper. But after its successful experience with gas, Enron remained much more interested in markets that were being deregulated. Electricity thus became a major focus of the firm in the mid-1990s and was a key success driver for Enron, as Neves explains in Chapter 4.

## OIL AND WATER DO NOT MIX

Throughout its history, Enron's consistent financial and market successes occurred only in the energy sector. This was not for lack of effort, however. On more than one occasion, Enron tried to expand its business outside the energy area, albeit rarely with any success.

### *Asset Heavy at Enron International*

When it became clear that Lay was preparing to turn over the reins in the latter half of the 1990s, an extremely contentious struggle for the leadership of Enron ensued (Fusaro and Miller, 2002). In no small part, this occurred because of the success of Enron GasBank and the power marketing operations of EC&TR. When the dust settled, Lay named EC&TR CEO and asset lite inventor Skilling as the new CEO of Enron Corporation in

February 2001. That Skilling would rise to this level, however, was not at all a foregone conclusion. Right up to the announcement date, debates about whose shoulder Lay would tap were popular coffee shop banter. Skilling's chief competitor was Rebecca Mark.

In 1993, Mark prevailed on Lay to establish Enron International (EI), of which she became the first president. Mark did *not* adhere to an asset lite strategy. Instead, she pursued an *asset heavy* strategy of attempting to acquire or develop large capital-intensive projects *for their own sake*. In other words, there was no financial trading activity overlay component for most of her initiatives, nor was there intended to be. She tried instead to identify projects whose revenues promised to be sizable purely based on the capital investment component with no need for a market-maker component. Unlike asset lite, this did not prove to be an area in which Enron Corporation had much comparative advantage.

### ***Water Trading Rights***

The EI operations delved into the asset-heavy water supply industry. At least here, there was some pretense of eventually developing a "water rights trading market," but it was so far down the road that the firm's water investments had to be regarded as largely self-contained capital projects, the largest of which was Azurix and its Wessex Water initiative.

In 1998, Enron spun off the water company Azurix. Enron retained a major interest in the firm, which focused its efforts on water markets in a single purchase—the British firm Wessex Water, for which Enron paid about \$1.9 billion. But in this case, deregulation did not help Enron. There was no market-making function and no trading overlay—there was only a British water company serving a market with plummeting prices. (This experience also underscores the fundamentally correct view that Skilling advanced when he was still at McKinsey—namely, expanding in a deregulating market makes little sense if you are limited to selling a spot commodity, whose price is falling out of bed.)

At the same time that the falling prices of deregulation in Britain were eating away Wessex's margins, Azurix itself was hit with staggering losses on several of its other operations, mainly in Argentina. In the wake of this failed venture, as well as the spectacular failure of EI's Dhabhol, India, power plant project, which may have cost Enron as much as \$4 billion, Mark resigned as CEO in the summer of 2000. Enron eventually sold Wessex in 2002, just about three years after financing its acquisition by Azurix to a Malaysian firm for \$777 million, or \$1.1 billion less than it paid for the firm (Fusaro and Miller, 2002).

### ***The Broadband Black Hole***

Like its forays into the water industry, Enron's broadband efforts were plagued with problems from the start. In gas and power markets, Enron acquired its physical market presence by investing in assets sold mainly by would-be competing energy companies. It then used those investments to help create and develop a financial market, the growth of which, in turn, helped *increase* the value of Enron's physical investments. But that increase did not come at the expense of Enron's competitors, which in turn were benefiting from the new price-risk management market. In broadband technologies, by contrast, Enron's asset lite effort required the firm to acquire assets not just from competitors, but from the *inventors* of the technology. Even then, Enron was paying for a technology that was essentially untested with no guarantee that the emerging bandwidth market would bolster asset values. As such, Enron had to pay dearly to acquire a market presence from firms that viewed Enron's effort not as a constructive market-making move, but as essentially intrusive.

Several other drags on Enron's broadband expansion efforts contributed to its ultimate failure. One was the simple lack of demand for the technology to materialize as expected. Enron is also alleged to have been using the bandwidth market to mislead investors—and possibly certain senior managers and directors—about its losses on underlying broadband technologies. On the one hand, Enron touted optimism about the eventual success of the broadband strategy in part by pointing at significant trading in the bandwidth market. On the other hand, few other market participants were observing any appreciable trading activity, and Enron was openly disclosing millions of dollars of losses on its quarterly and annual reports on its broadband efforts. Much of that market activity now seems to have come from Enron's "wash" or "round-trip trades" or transactions in which Enron is essentially trading with itself.<sup>7</sup> To take a simple example, a purchase and sale of the same contract within a one- or two-minute period of time in which prices have not changed shows up as "volume," but the transactions wash out and amount to no real bottom-line profits.

Apart from using wash trades to exaggerate the state of the market's development, Enron was also alleged to have used some of its bandwidth derivatives for "manufacturing" exaggeratedly high valuations for its technological assets. Enron and Qwest are under investigation for engaging in transactions with each other that are alleged to have been designed specifically to create artificial mark-to-market valuations. Enron and Qwest engaged in a \$500 million bandwidth swap negotiated just before the end of the 2001 third-quarter financial reporting period. Many would argue that Enron and Qwest were swapping one worthless thing for another worthless

thing, given the lack of a market for bandwidth and the lack of *interest* in bandwidth. Nevertheless, both firms apparently used the swaps to justify having acquired a much more valuable asset than they were getting rid of. With essentially no market, no market prices were available to evaluate the validity of those claims at the time.

## THE ECONOMICS OF ASSET LITE AND BASIS TRADING

Through its investments in the underlying commodity supply chains, the trading room overlay on the physical markets allowed Enron to generate substantial revenues as a market maker. But this was not the only source of profits associated with the asset lite strategy of combining physical and financial market positions. Specifically, Enron engaged in significant *basis trading*. Understanding what this is and when a company might be able to do it profitably is essential for recognizing the differences between businesses on which Enron made money and those on which it did not.

### *Synthetic Storage with Derivatives*

To understand the economics of spread/basis trading, you must first recognize the important finance proposition that commodity derivatives—contracts for the purchase or sale of a commodity in the future—are economic substitutes for physical market operations.<sup>8</sup> Buying a forward oil purchase contract, for example, is economically equivalent to buying and storing oil (Culp, 2003; Williams, 1986). In a competitive equilibrium of the physical and derivatives markets, the forward purchase price—denoted  $F(t, T)$  and defined as the fixed price negotiated on date  $t$  for the purchase of a commodity to be delivered on later date  $T$ —can be expressed using the famed *cost-of-carry model* as<sup>9</sup>

$$F(t, T) = S(t)[1 + b(t, T)]$$

where

$$b(t, T) \equiv r(t, T) + w(t, T) - d(t, T)$$

and

$S(t)$  = Time  $t$  spot price of the commodity to be delivered at  $T$

$r(t, T)$  = Interest rate prevailing from  $t$  to  $T$

$w(t, T)$  = Cost of physical storage of the commodity from  $t$  to  $T$

$d(t, T)$  = Benefit of holding the commodity from  $t$  to  $T$

such that  $w$  and  $d$  are expressed as a proportion of  $S(t)$  and are denominated in time  $T$  dollars.

The term  $b(t, T)$  is often called the *basis* or the *net cost-of-carry* to reflect the fact that its three components together comprise the cost of “carrying” the commodity across time and space to the delivery location on future date  $T$ . The term  $d(t, T)$  that reflects the benefit of physical storage is called the *convenience yield*, a concept developed by Keynes (1930), Kaldor (1939), Working (1948, 1949), Brennan (1958), and Telser (1958). The convenience yield is driven mainly by what Working (1962) calls the “precautionary demand for storage,” or concerns by firms that unanticipated shocks to demand or supply could precipitate a costly inventory depletion or stock-out. Airlines store fuel at different airports, for example, to avoid the huge costs of grounding their local fleets in the case of a jet fuel outage. Gas pipeline owners store fuel to help ensure there is always an adequate supply of gas in the lines to maintain the flow and avoid a shutdown.

Keynes (1930), Working (1949), Williams (1986), and others have observed how the *supply of storage* (i.e., the amount of a commodity in physical storage) is related to the convenience yield and, by extension, to the *term structure of futures prices*. More important, this relation defines the economic linkage among derivatives, physical asset markets, and the allocation of physical supplies across time (Culp, 2003). Specifically, the supply of storage is directly related to the premium placed on selling inventory *in the future* relative to selling spot *today*. When inventories are high, the *relative* premium that a commodity commands in the future vis-à-vis the present is reasonably small; plenty of the commodity is on hand today to assure producers and intermediaries that a stock-out will not occur, leading to a very low convenience yield. As current inventories get smaller, however, the convenience yield rises (at an increasing rate) and the spot price rises relative to the futures price to induce producers to take physical product *out of* inventory and sell it in the current spot market. A high spot price *alone* would not do that. But a high spot price *relative to* the futures price signals the market that inventories are tight *today* relative to the future.

We can now see more meaningfully where cost-of-carry pricing comes from. Namely, it is the condition that must maintain equilibrium to make market participants indifferent between physical storage and “synthetic storage” using forwards or other derivatives. Here’s how it works. Suppose a firm borrows  $S(t)$  in funds at time  $t$  and uses the proceeds to buy a commodity worth  $S(t)$ . At time  $T$ , the firm is holding an asset then worth  $S(T)$  and repays the money loan. In the interim, the firm incurs physical storage costs  $w$  but earns the convenience yield  $d$ . Table 1.1 shows the net effect of this physical storage operation.

**Table 1.1 Physical Commodity Storage**

<i>Time:</i>	<i>t</i>	<i>T</i>
<i>Money Loan:</i>		
Borrow dollars	$S(t)$	—
Repay dollars and interest	—	$-S(t)(1+r(t,T))$
<i>Buy and Store the Asset:</i>		
Buy commodity	$-S(t)$	—
Pay storage costs	—	$-S(t)w(t,T)$
Earn convenience yield	—	$S(t)d(t,T)$
Still own the commodity	—	$S(T)$
NET	0	$S(T) - S(t)(1 + r(t,T) + w(t,T) - d(t,T))$

Because not every firm has the same convenience yield or storage costs, commodity forward prices are driven to the cost-of-carry expression by the dynamics of a competitive equilibrium.<sup>10</sup> To see how it works, suppose the forward purchase price is

$$F^\circ = S(t)(1 + b^\circ(t, T))$$

where  $b^\circ(t, T)$  denotes any arbitrary net cost-of-carry. All firms for which  $S(t)(1 + b(t, T)) < F^\circ$  can earn positive economic profits by going short the forward and simultaneously buying and storing the commodity. They continue to do this until the forward price falls and  $S(t)(1 + b(t, T)) = F^\circ$ . As long as *any* firm can make positive profits from this operation, the selling continues, until  $S(t)(1 + b(t, T)) = F^*$  where

$$F^* = S(t)(1 + b^*(t, T))$$

where  $b^*(t, T)$  denotes the *marginal* net cost-of-carry for the *marginal storers* from *t* to *T*. This marginal entrant earns exactly zero economic profits because its own net cost-of-carry is equal to  $b^*$ .

Things work in the other direction for any firms where  $S(t)(1 + b(t, T)) > F^\circ$ . Those firms will go long the forward and then engage in a commodity repurchase agreement (i.e., lending the commodity at time *t* and repurchasing it at time *T*).<sup>11</sup> Again, entry occurs until  $F^\circ$  exactly equals  $F^*$  and reflects the marginal basis of the marginal storers.

In the short run, the basis  $b^*$  thus reflects the marginal cost of carrying an incremental unit of the commodity over time. In the long run,  $b^*$

also corresponds to the minimum point on a traditional U-shaped long-run average cost curve.<sup>12</sup> Suppose all firms have  $b^*$  below this minimum long-run average cost. In this case, at least one firm will expand output until marginal cost rises to minimum average cost and equals the marginal price of the cost-of-carry and the new  $b^*$  is also reflected in the forward price.

The process by which commodity derivatives and the underlying asset market simultaneously grope toward a competitive equilibrium helps illustrate an important point. Namely, the *relation* between forward and spot prices—the *basis*—is really a *third market* implied by the prices of the two explicit ones (Williams, 1986). In the previous example, the two explicit markets are the spot and forward markets, and the relation between the two implicitly defines *the price of physical storage*. Such third markets are also called *basis* relations. The implicit market for storage over time is called the *calendar basis*, the implicit market for transportation is called the *transportation basis*, and so on.

Firms can also use derivatives *based on different assets* to conduct “spread” trades to synthesize a third market. Going short crude oil and simultaneously long heating oil and gasoline, for example, is called trading the *crack spread* and is economically equivalent in equilibrium to synthetic refining. Short soybeans and long bean oil and meal is likewise *synthetic crushing*. Trading the *spark spread* through a short position in natural gas and a long position in electricity is called *synthetic generation* because the derivatives positions replicate the economic exposure of a gas-fired electric turbine.

### **A Neo-Austrian Explanation for Basis Trading**

Armed with an understanding of how commodity derivatives are priced *in equilibrium*, we now consider the economic rationale for why Enron and firms like it sometimes dedicate substantial resources to basis trading. More important, we now want to recognize what can happen *out of equilibrium*—a state of affairs that typically prevails. Indeed, expectations and relevant knowledge (data) are in a constant state of flux. Accordingly, a neoclassical stationary state—one that treats the data as constant—is of limited use in explaining the market process.<sup>13</sup>

We have seen how equilibrium emerges from the interactions of numerous firms competing to drive prices to their marginal cost. Specifically, suppose  $b^*$  is the marginal net cost-of-carry reflected in the prevailing natural gas forward price. This is the price of transportation and delivery *in equilibrium*. The net cost-of-carry  $b^*$  may conform only to the *actual* physical and capital costs-of-carry less the convenience yield for

one firm—the marginal entrant into the gas transportation market. Or  $b^*$  may be shared by all firms in the short run, but aggregate output may need to adjust in the long run if  $b^*$  does not also reflect the minimum average long-run cost-of-carry. The point is: The cost-of-carry reflected in the forward price may or may not be the optimal cost-of-carry for any given firm at any given time. As is standard in neoclassical microeconomic theory, the price that “clears the market” in the long run equals short-run marginal cost for any given firm only by pure coincidence.

Suppose we begin in a situation where  $b^*$  is the cost-of-carry reflected in the forward price and that  $b^*$  is equal to the short-run marginal costs of all market participants at their production optima. Now consider a new entrant into the market, and suppose that new entrant is Enron with its large number of pipelines and strong economies of scale that lead to cost of distributing and transporting natural gas at some point in time of  $b^e < b^*$ . In this case, Enron can *physically* move gas across time and space at a lower cost than gas can be moved “synthetically” using derivatives.

By going short or selling gas for future delivery using forwards or futures, Enron is selling gas at an implied net cost-of-carry of  $b^*$ . But its *own* net cost-of-carry—a cost that is relevant in Enron’s ability to move the gas across time and space to honor its own future sale obligation created by the forward contract—is less. Accordingly, *in disequilibrium*—or, more properly, on the way to equilibrium—Enron can make a profit equal to the difference between its own net cost of storage and the cost reflected in the market.

The reason that this is a short-run profit inconsistent with a long-run equilibrium is that Enron’s sale of the forward contract drives the  $b^*$  reflected in forward prices closer to  $b^e$ . If Enron is the lowest cost producer and other firms can replicate its production techniques (i.e., Enron owns no unique resources), ultimately  $b^*$  becomes  $b^e$ , which also eventually approaches the long-run minimum average cost-of-carry. Enron’s capacity to earn supranormal profits will vanish in this new equilibrium—in fact, zero economic profits earned by every producer is basically the very meaning of a long-run equilibrium.

Because markets are constantly adjusting to new information, new trading activity, and new entrants, however, it is hard to determine when a market actually is in some kind of final equilibrium resting state, as opposed to when it is adjusting from one state to another. The inevitability of a long-run competitive equilibrium in which profits are *not* possible thus must be considered relative to the inability of market participants to identify slippery concepts such as *long run* and *in equilibrium*. Strictly speaking, a market is in equilibrium as long as supply equals demand. But we use the term here in a more subtle fashion, where *equilibrium* refers

to the steady state in which firms earn zero supranormal economic profits in the long run. Firms may engage in basis trading to try to exploit the differences in prices reflected in derivatives and their own ability to conduct physical market "pseudo-arbitrage" operations that are economically equivalent to those derivatives transactions.<sup>14</sup>

Now consider a situation when the market is *always* adjusting and *never* reaches a long-run competitive equilibrium.<sup>15</sup> In this situation, the tendency is still toward the archetypical neoclassical long-run competitive equilibrium, but we never quite get there. Why not? Certainly economic agents are responding in the manner we have described, and this behavior should ultimately lead to a steady-state long-run equilibrium. The only reason it does not is that too much is happening at any given moment for us to make the leap from short run to long run.

In this situation, all firms are always inframarginal in some sense of the term. The kind of pseudo-arbitrage between physical and synthetic storage that we described previously thus can be expected to occur *regularly*. And at least some firms will earn supranormal profits regularly. More important, these profits are not riskless, but at least some firms are sure to be right at least some of the time.

Does this mean that physical and synthetic storage are not really equivalent? Technically, it does. But we never said otherwise. We claimed only that the two are equivalent *in equilibrium*. When a market is in disequilibrium, what you actually pay to store a commodity physically may differ from what you actually pay to store it synthetically. But this is not important.

What is important is that, even if new information and other market activities drive a wedge between  $b^o$  and  $b^*$ , maximizing decisions by firms *always* leads *toward* the convergence of the two prices of storage. Conversely, the price mechanism *never* sends a signal that will lead maximizing firms to engage in physical or derivatives transactions that drive  $b^o$  and  $b^*$  further apart. The very fact that maximizing firms are constantly seeking to exploit differences between  $b^o$  and  $b^*$  is what gives the theory meaning. That the two might never end up exactly equal is really not very relevant because, as we now explain, information changes before the long-run equilibrium is ever reached.

### *Asymmetric Information*

Now suppose that the net cost of storage is a random variable about which some firms are better informed than others—for example, the impact of supply or demand shocks on particular locational prices, the impact of pipeline congestion on the transportation basis, and the like. Suppose

further that we assume a competitive long-run equilibrium *does* hold. Because of the information asymmetry, a rational expectations equilibrium (REE) results in which *expected* supranormal profits are zero in the long run. But *expected* by whom?

In this case, firms such as Enron may engage in basis or spread trading in an effort to exploit their perceived comparative informational advantage. If a firm owns physical pipelines, for example, it may have a superior capability for forecasting congestion or regional supply and demand shocks. This creates a situation similar to a market that is out of, or on the way to, equilibrium—that is, the net cost-of-carry that the *firm* observes may be *different from* the net cost-of-carry market participants expect, given the different information on which the two numbers are based. Just as in the disequilibrium case, firms may engage in basis trading to exploit these differences.

In a traditional rational expectations equilibrium, this type of behavior is akin to inframarginal firms attempting to exploit their storage cost advantage relative to the marginal price of storage reflected in forwards. And, as noted, this cannot go on for very long because the trading actions of the lower cost firm eventually lead them to *become* the marginal entrant, thus driving  $b^*$  to  $b^\circ$  for that firm. The same is true in a REE, where trading *itself* is informative. Every time a well-informed trader attempts to exploit its superior information through a transaction, it reveals that superior information to the market. So, the paradox for the firm with better information is that the firm must either *not trade* based on that information to preserve its informational advantage or must *give away* its informational advantage while simultaneously trying to exploit it in the short run through trading.

Culp and Miller (1995b) argue, however, that this sort of classic equilibrium assumes that the trading activities of the better-informed firm are, indeed, informative. But what if other market participants cannot *see* all the firm's trades? And what if the trades are occurring in highly opaque, bilateral markets rather than on an exchange? In this case, better informed firms *can* profit from their superior information without necessarily imparting all of their valuable information into the new marginal price. Anecdotal evidence certainly seems to support this in the case of Enron, given how heavily the firm focused on less liquid and less transparent markets.

### ***Why Not Speculate Outright?***

Trading to exploit disequilibrium, market imperfections, or asymmetric information is hardly riskless. On the contrary, it can be *very* risky. This

helps explain why many firms engaged in such trading do so with *relative* or *spread* positions in third markets rather than taking outright positions in one of the two explicit markets. Suppose, for example, that a firm perceives the "true" net cost of storage of gas to be  $b^*$  (which is equal to the firm's own net cost-of-carry) but that the current net cost-of-carry reflected in listed gas futures prices is  $b' > b^*$ . It is a good bet that  $b'$  will fall toward  $b^*$ . As such, an outright short position in forward contracts would make sense. But this is *extremely risky*.

A position that exploits the same information asymmetry *without* the high degree of risk is to go short futures *and simultaneously* buy and hold gas. In this manner, the firm is protected from wild short-term price swings and, instead, is expressing a view solely on the *relative* prices of storage as reflected in the futures market and storage by the firm itself.

In essence, asset lite is a basis trading or third-market trading strategy in which physical assets are traded vis-à-vis derivatives positions. A physical market combined with the *residual risk* of a market-making function is essentially one big spread trade.

### ***Putting Enron in Context***

Reading the marketing and business materials of Enron's energy business lines is eerily similar to reading an example of a firm putting all the theories of basis trading just discussed into practice. And, in this sense, Enron was hardly the first firm to leverage its physical market presence into financial and basis trading opportunities. Perhaps the best-known example of a firm engaged in the same practice is Cargill (see, e.g., Broehs, 1992). Cargill is the largest private company in the world, with \$50 billion in annual sales and 97,000 employees deployed in 59 countries. For 137 years, Cargill has employed an asset lite strategy that has allowed it to basis trade and manage risks for a wide variety of agricultural commodities, among other things. For the commodities it deals in, Cargill is involved in every link of the supply chains. As a result of its commodity trading, processing, freight shipping, and futures businesses, Cargill has been able to develop an effective intelligence network that generates valuable information. Indeed, via its people on the ground, Cargill knows where every ship and rail car hauling commodities are in real time and what that implies about prospective prices over time and space. By being able to ferret out valuable local information, Cargill has been able to obtain an edge, one that accounts for much of its success. (See, e.g., Weinberg and Capple, 2002.)

Basis trading can make economic sense to a firm *ex ante* without making profits *ex post*. The key driver underlying most basis traders' behavior is the *perception* that they have some comparative informational advantage

about some basis relation. But perception need not be reality. Markets are, after all, relatively efficient. Indeed, most of the inefficiencies that give rise to profitable trading opportunities can be linked to taxes, regulations, and other institutional frictions that essentially prevent markets from reflecting all available information of all traders at all times.

Enron did indeed attempt to focus its efforts on markets riddled with inefficiencies, often created by overregulation, ill-specified property rights, or a slow deregulation process. But this did not mean Enron had a comparative informational advantage in all of those markets.

Structural inefficiencies that prevent prices from fully reflecting all available information is only *part* of what it takes to run a successful basis trading operation. The other requisite component is for a firm to perceive itself as (and, hopefully, actually to be) *better informed*. In oil and power, Enron achieved this informational superiority like many other firms do in their own industries—by dominating the financial market. This allowed Enron to develop informationally rich customer relationships that, in turn, could be extrapolated into superior knowledge of firm-specific supply and demand considerations, congestion points along the supply chain, and the like.

Now consider, by contrast, a market such as broadband in which Enron was *not* the primary inventor of the technology, not the primary buyer or seller of the supply chain infrastructure, and not a regular player in the consumer telecommunications arena. The mere existence of market frictions in broadband attracted Enron, but without the requisite information, Enron could not achieve the market dominance required to make asset lite profitable.

## BUYING TIME AND THE END OF ENRON

As Culp and Miller (1995a, 1995b, 1999) explain, firms best suited to the asset lite kind of strategy that Enron pursued typically require fairly significant amounts of capital—not invested capital assets necessarily, but rather *equity capital* in a financial market sense. Equity capital is a necessary component to successful basis trading and the asset lite strategy for several reasons. First, equity is required to absorb the occasional loss inevitably arising from the volatility that basis trading can bring to cash flows. Second, maintaining a strong market making and financial market presence requires at least the perception by other participants of financial integrity and creditworthiness. Especially in long-dated, credit-sensitive OTC derivatives, financial capital is essential to support the credit requirements that other OTC derivatives users and dealers demand (see Chapters 7 and 11).

Unfortunately, Enron's cash management skills were no match for its apparent trading savvy. Despite being asset lite, Enron's expenditures on intermediate supply chain assets were still not cheap. Add to this EI's asset-heavy investment programs and a corporate culture under Skilling and Lay that emphasized high and stable *earnings*, often at the expense of high and stable *cash flows* (Bassett and Storrie issue warnings about this in Chapter 2), and the net result was financial trouble for the firm.<sup>16</sup>

### ***Enron's Deceptions***

Much of the public controversy about Enron—and much of the remainder of this book—focuses on how Enron abused accounting and disclosure policies. In short, Enron's abuses in these areas included the following:

- Using inappropriate or aggressive accounting and disclosure policies to conceal assets owned and debt incurred by Enron through special purpose entities (SPEs)—see Chapters 2, 8, and 10.
- Using inadequately capitalized subsidiaries and SPEs for “hedges” that reduced Enron’s earnings volatility on paper, despite, in many cases, being dysfunctional or nonperforming in practice—see Chapters 2 and 8.
- Allegedly engaging in wash trades with undisclosed subsidiaries designed to increase trading revenues or mark-to-market valuations artificially—see Chapters 2, 4, 5, 6, 8, and 10.

At first, Enron's abuses of these structures seem to have been driven more by a desire to manage earnings than anything else. But as time evolved, Enron used aggressive accounting and disclosure policies to buy time for itself. Especially as Enron moved into new markets in which its comparative advantage was more questionable (e.g., broadband) or in which Enron's success depended strongly on the rate of government deregulation (e.g., water), Enron's financial shenanigans amounted to robbing Peter to pay Paul. In other words, as Enron's cash balances got lower and lower, concealing its true financial condition was the only way that Enron could sustain itself long enough to hope that its next big investment program paid off. That might have worked had Enron stuck to markets in which its success with asset lite had been more assured. Unfortunately, as we have argued, the firm's end became inevitable once it decided to start moving into areas that deviated from its core business strategy.

There is also the question of whom Enron was actually deceiving with its accounting and disclosure policies. Over the course of many years, you could argue that Enron seduced investors, monitors (e.g., rating agencies

and accounting firms), creditors, and even its own employees into believing that the firm was stronger financially than it actually was through a mixture of aggressive marketing, cultural arrogance, and, in some cases, outright deception. But especially as the end of Enron neared, many institutions had begun to view the company with deepening suspicion (see Chapter 2). By the time Enron failed, a surprisingly large number of firms dealing with Enron commercially had come to fear that the worst for Enron might lie ahead (see Chapter 11). In the end, those who seem to have been the most deceived—and for the longest time—were perhaps Enron's own employees, who, unlike other firms dealing with Enron, had more cause to be inherently optimistic and were doubtless taken almost completely off guard.

## CONCLUSION

Enron's main business was asset lite—exploiting the synergies between a small physical market presence, a market-making function on derivatives, and a basis trading operation to “arbitrage” the foregoing. Many have questioned the wisdom of Enron's asset lite strategy. Most of these criticisms are hard to address without getting into the details of Enron's financial situation. In short, people argue that although asset lite did not require much capital expenditure and investment in fixed capital, the strategy *did* require Enron to have a fairly large chunk of equity capital—enough to convince its numerous financial counter parties that it was creditworthy. If indeed Enron was camouflaging its capital structure to hide a massive amount of debt, Enron probably *was* undercapitalized to exploit asset lite effectively. But this is not a criticism of asset lite—it is a criticism of *Enron*.

Asset lite has become a very common practice for many firms engaged in energy market activities, especially at intermediate points along the various physical supply chains—transmission and distribution in power, midstream transportation and distribution in oil and gas, and the like. One firm that has been consistently successful at playing the asset lite game, for example, is Kinder Morgan, founded by Enron's former president, Richard Kinder, when he left Enron in 1996. Kinder Morgan was started in part by Kinder's successful acquisition from Enron of Enron Gas Liquids, for which he outbid six other firms, including Mobil Oil (Fusaro and Miller, 2002).

In nonenergy markets, firms such as Cargill and André have also long practiced their version of asset lite, often going the way of Enron in electricity and becoming asset heavy over time. The key common denominators are twofold: the use of a physical market presence to acquire specific

information about the underlying market and the use of a financial trading operation to make markets and engage in basis trading to leverage off that underlying asset infrastructure.

Unfortunately, there is no exact answer to the question of when asset lite and basis trading might work for a firm versus when it might fail dismally. The comparative informational advantage that allows some firms to earn positive economic profits is exceedingly hard to analyze or identify except through trial and error. This process of trial and error is what Schumpeter meant by the “creative destruction” of capitalism, and great economists such as Knight and Keynes went on to emphasize further that the success or failure of a given firm cannot ever really be predicted. “Animal spirits,” as Keynes put it, ultimately dictate the success or failure of a business as much as any other variable.

Economists are uneasy with this notion. As noted earlier, the neoclassical model postulates that markets tend to *be* in equilibrium, whereas the neo-Austrian perspective merely argues that markets lean in that direction. To be in equilibrium implies some steady state of profits resting on an identifiable cost advantage or structural informational asymmetry. But concepts such as *information asymmetry* are completely non-testable. This makes theoretical economists nervous because it means that the success or failure of a firm cannot be related to a defined set of assumptions and parameters *ex ante*. And empirical economists get even more disgruntled because the success or failure of a firm cannot be explained *ex post*.

Nevertheless, this is the state of affairs. Economic theory says merely that firms strive to exploit perceived comparative informational advantages in disequilibrium situations where prices do not reflect every market participant’s information equally. Theory says nothing about firms’ being correct in their perceived advantages, nor does theory help us pinpoint precisely what those advantages are. These things are what the market is for.

Can Enron be generalized to suggest a “failure” of the theory underlying basis trading? In fact, Enron cannot be generalized *at all*. Looking purely at the firm’s *legitimate* business activities, Enron perceived a comparative informational advantage, pursued it, and was wrong. This makes neither the underlying economic model nor even Enron’s managers and shareholders wrong. If we could generalize the economic factors that explain why one firm succeeds and another fails, competition in the open market would serve no purpose. Instead, competition and the market are both judge and jury to a company’s perceived informational advantage. Unless a firm takes the risk of failure, it will never earn the premium of success (Knight, 1921).

There can be little doubt that Enron did many things wrong. Indeed, where it deviated from its asset lite strategy, Enron tended to engage in

businesses that were unprofitable. In addition, many of the firm's senior managers were basically unethical. But amidst all these legitimate criticisms of Enron, we must be careful not to indict *everything* the firm did. In some instances, Enron got it right. And, at a minimum, the firm entrepreneurially moved into new areas and put itself to the ultimate test of the market. Finally, Enron failed that test, but we must at least tip our hats to the part of Enron that was at least willing to try. (See Chapter 14.) Without that spirit of innovation, the process of capitalism would grind to a screeching halt.

## NOTES

1. The Austrian school of economics was developed in the nineteenth and twentieth centuries by a group of principally Austrian economists in response to several noted shortcomings in the neoclassical theory of the price system. The approach we adopt here, however, is more properly called *neo-Austrian*. Following Sir John Hicks' (1973) use of the term, a neo-Austrian approach recognizes some of the deficiencies of the neoclassical school and seeks to address those problems with a more Austrian perspective. We do not consider, as some do, the pure Austrian school to be a viable stand-alone theory of the price system. Rather than forcing a choice of theories in either/or fashion, the neo-Austrian approach recognizes instead that a little bit of Austrian insight can go a long way toward salvaging the neoclassical paradigm. See Hicks (1973) for another example of this theoretical approach.
2. For a full elaboration of these concepts, see Lachmann (1978).
3. Perhaps we should have all taken it as a bad omen that in its core one-sentence description of itself, Enron used a split infinitive.
4. A typical use of junk bonds during this period was providing funds to companies with otherwise questionable access to capital given their credit risk. Highly leveraged transactions such as leveraged buy-outs were thus a natural candidate for junk-bond financing.
5. EOG continued for two decades to spearhead all of Enron Corporation's exploration and production activities in oil and gas. In 1999, EOG exchanged the shares in EOG held by Enron for its operations in India and China. In so doing, EOG became independent of Enron Corporation and, changed its name the same year to EOG Resources, Inc. This firm still exists today.
6. In the huge interest rate swap market, dealers did essentially the same thing as the Enron GasBank—they used other swaps and futures contracts to manage the *residual* risks of running a dealing portfolio, called a *swap warehouse*.
7. This can be accomplished in various ways—see Chapters 5 and 13 for examples.
8. Early discussions of the economic rationale for basis or spread trading can be found in Johnson (1960) and Working (1948, 1949, 1962).

9. Alternative versions of this rely on different types of discounting and compounding assumptions, as well as allowing certain variables in the equation to be stochastic. But the spirit of all versions of the model is well captured by the representation here. See Culp (2003) for more detail.
10. Cost-of-carry pricing for forwards on financial assets, by contrast, is enforced by direct cash-and-carry arbitrage because financial assets pay *observable* and *explicit* dividends that are the same regardless of who holds the asset. See Culp (2003).
11. Commodity lending *does* occur, so this example is not unrealistic. See Williams (1986).
12. The classical U-shape is consistent with a production technology that demonstrates increasing returns to scale up to  $b^*$  and diminishing returns thereafter.
13. For a more general discussion, see Cochrane and Culp (2003a).
14. This is pseudo-arbitrage because it has the flavor of an arbitrage transaction but is far from riskless.
15. This seems heretical in the neoclassical microeconomic paradigm but is typical of the notion of *equilibrium* developed by economists in the Austrian and neo-Austrian tradition, such as Menger (1871), Hayek (1937, 1945, 1949, 1978a), Hicks (1973), and Lachmann (1978).
16. Cash flow mismanagement was not always the norm at Enron. Jeffrey Skilling's predecessor, Richard Kinder, was actually known for being a cash flow tightwad and kept the firm's financial health relatively strong during his tenure at the operational helm of Enron.