Guilty as charged: Violations of the law of one price in financial markets

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An informal description of recent events in the US equity markets and a survey of related literature.

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Laws come in two types. The first is laws that everyone automatically obeys, such as the law of gravity. The second is laws that people should obey, but sometimes don't, such as laws prohibiting littering. Science progresses by identifying the first type of law. One such law that economists have proposed is the law of one price. The law states that identical goods must have identical prices. For example, an ounce of gold should have the same price (expressed in US dollars) in London as it does in New York, otherwise gold would flow from one city to the other. One would only expect the law to hold exactly in competitive markets with no transactions costs and no barriers to trade. Although this law is often discussed in the context of international finance and trade, here I focus on the law of one price in financial markets.

Summers (1985) described finance professors as practitioners of ketchup economics: "They have shown that two quart bottles of ketchup invariably sell for twice as much as one quart bottles of ketchup except for deviations traceable to transactions costs …Indeed, most ketchup economists regard the efficiency of the ketchup market as the best established fact in empirical economics". Summers was right. Arbitrage, defined as the simultaneous buying and selling of the same security for two different prices, is the central concept of modern finance. The absence of arbitrage is the basis of almost all modern financial theory, including option pricing and corporate capital structure.

In capital markets, the law of one price says that identical securities must have identical prices, otherwise smart investors could make unlimited profits by buying the cheap one and selling the expensive one. It does not require that investors be rational or sophisticated, only that they are able to recognize arbitrage opportunities. Since one typically thinks of financial markets as being competitive, with low transactions costs and low barriers to entry, the law of one price should basically hold in financial markets. Moreover, unlike international trade where it may take some time to physically move gold from London to New York, one would expect the law of one price to hold not only in the long run, but almost instantaneously, since one can quickly buy and sell securities.

The law of one price should be a self-enforcing law, since arbitrageurs can make profits by enforcing it. In this sense, the law of one price, while not quite as automatic as the law of gravity, seems like a law almost that should be almost impossible to break in a well-functioning capital market. Unlike government-enforced laws prohibiting throwing trash on the sidewalk, arbitrage-enforced laws prohibiting throwing hundred dollar bills on the sidewalk will be rarely or never violated. No rational person would ever throw hundred dollar bills on the sidewalk, and if he did, market forces would quickly clean up the litter.

Ketchup economics

Does the law of one price hold? Before discussing the law of one price in financial markets, consider the case of ketchup. A search of several Internet grocers in January 2000 revealed that retail ketchup markets routinely violate the law of one price. For example, one grocer was selling a 36 ounce bottle of ketchup for $3.87 and a 46 ounce bottle for $3.27. These prices violate the law of one price, since ketchup sells for 11 cents per ounce in the smaller bottle and 7 cents in the larger. In fact, these prices are a flagrant violation since one can actually get more ketchup for less money. The extra ten ounces of ketchup in the larger bottle have a marginal cost of –60 cents. Relative to 36 ounce bottles, 46 ounce bottles should sell for $4.95 (3.87 * 46/36), so that the mispricing is $1.68 or 51 percent (1.68/3.27).

In understanding any violation of the law of one price, there are two questions. First, why don't arbitrageurs correct the mispricing by selling the overpriced security and buying the

underpriced security? Second, even if something prevents the arbitrageurs from correcting the mispricing, why would anyone ever buy the overpriced security when they can buy the underpriced security for less? In using the term "mispriced" and "overpriced", I speak in purely relative terms.

The answer to the first question is that the retail ketchup market is not a liquid market where one can buy and sell ketchup at low transactions costs. In theory, these ketchup prices are an arbitrage opportunity, since one can buy the 46 ounce bottle, remove ten ounces, and resell at a profit. In practice, such arbitrage profits are not achievable because of frictions. In particular, while we can buy ketchup at the grocery store, the grocery store does not stand ready to buy ketchup from us. One could go into the wholesale ketchup business, order a million crates of 46 ounce bottles over the internet, rebottle into 36 ounce bottles, and resell. But presumably transactions costs, such as the costs of purchasing the bottles, storing the ketchup, shipping, hiring labor, taxes, and other unpleasant details would make such activity unprofitable. Thus the relative pricing of ketchup is not an arbitrage opportunity, since one cannot profit from the apparent mispricing. But it is a violation of the law of one price, and thus any theory based on the law of one price does not hold. In the case of the ketchup market, the "deviations traceable to transactions costs" mentioned by Summers appear to be quite sizable, since prices are off by more that 50 percent.

The second question is why would anyone ever buy the 36 ounce bottle when they can buy the 46 ounce bottle for less. The answer probably involves preferences and costs of storage. Perhaps consumers prefer their ketchup in handy 36 ounce bottles rather than unwieldy 46 ounce bottles. Perhaps for consumers the costs of storing the excess ketchup (taking up scarce kitchen space) outweigh the benefits of lower price and more ketchup.

Capital markets as frictionless

Most financial economists would describe capital markets as vastly different from retail ketchup markets. First, arbitrage is easier. US capital markets in the twenty-first century are liquid, immense, and dynamic, with a multitude of different securities and markets, rapid transmission of information, and an accelerating pace of financial innovation. Indeed, most would argue that if any market approaches the economists' frictionless ideal of well-functioning markets with instantaneously flexible prices and Arrow-Debreu securities, it is today's capital markets. One can buy and short assets, create new securities by bundling and unbundling different cash flows, and generally do many wonderful things that one can't do with ketchup and a grocer. Moreover, since the stakes are huge, any arbitrage opportunities are likely to be quickly exploited by alert arbitrageurs, who rove across markets and countries looking for profitable mispricing. Traditional financial economists would argue that while a three dollar bottle of ketchup might be mispriced, a thirty billion dollar company would never be mispriced, since transactions costs are so low and potential arbitrage profits are so large.

Second, unlike consumer preferences for ketchup, investor preferences for financial assets are more straightforward and storage costs are lower. Most investors buy assets purely for investment purposes, and the assets (unlike ketchup) do not generate other benefits or costs through their size and shape. For example, even if there was no possible arbitrage in the gold market (say, short-sale constraints), its hard to imagine that anyone would be willing to buy 36 ounces of gold at a price higher than 46 ounces of gold, despite the existence of storage costs. Similarly, even if there was no possible arbitrage in the equity market, it's hard to think of a valid reason for anyone to buy 36 shares of IBM at a price higher than 46 shares.

Thus most financial economists would view the law of one price as one law that is strictly obeyed (with tiny deviations due to transactions costs) in the real world of capital markets. There is widespread agreement that arbitrage opportunities can not exist. Indeed, invoking arbitrage opportunities is a traditional way for finance professors to win arguments. If a finance professor tells you, with a knowing smile, that "what you claim implies an arbitrage opportunity," you know you have just been dismissed, in the same way as if a mathematician had said "what you claim implies that 2+2=5". Arbitrage opportunities are like hundred dollar bills lying on the sidewalk, something that most economists deem nearly impossible.

Thus the law of one price is a basic, common sense condition that should surely hold in a well-functioning capital market. And for this reason, theorists have used it as a noncontroversial minimal condition, a starting point that leads to other implications. Upon the law of one price, they have built the mighty evidence of modern financial theory, including the Modigliani-Miller capital structure propositions, the Black-Scholes option pricing formula, and the arbitrage pricing theory and related multifactor asset pricing models.

Unfortunately, evidence over the years has been accumulating, and the verdict is in: financial markets are guilty of violating the law of one price. In some cases, the law of one price is flagrantly violated, with malice aforethought, gross negligence, and reckless disregard. In some ways, the ketchup market looks better than US equity market, as its prices are set by sober grocers rather than investors intoxicated with tech stock mania. It seems clear that theories based on the law of one price will need to be rethought.

In recent years, financial economics has experienced a range of fierce controversies over whether markets are rational and whether assets are mispriced. For example, the value effect (the fact that stocks with low relative prices have high subsequent returns) has been identified and explained either as a rational phenomenon reflecting risk or an irrational phenomenon reflecting investor psychology. But these debates have not challenged the bedrock of no arbitrage opportunities, since no one ever claimed that buying value stocks was a riskless arbitrage (or even a near-arbitrage). Similarly, the recent high prices of internet stocks might seem implausible given reasonable expectations about cash flows and returns, but the plausibility is merely a matter of opinion. Internet stocks are difficult, but not impossible, to reconcile with rational pricing. In contrast, violations of the law of price are a stake through the heart of modern finance.

In proving this law-breaking activity, I proceed as follows. First, I explain how the law of one price is related to another important concept in finance, efficient markets, and why it is easier to prove violations of the law of one price than violations of efficiency. Second, I discuss briefly evidence of small violations of the law of one price, minor crimes equivalent to jaywalking or speeding. Third, I discuss the suspicious behavior occurring in obscure corners and back alleys of capital markets, behavior suggestive of major criminal activity. Fourth, I discuss flagrant, outrageous law-breaking, occurring in broad daylight in the center of town. Fifth, I discuss criminal motives. Last, I discuss approaches to law enforcement.

1. *Relationship to efficient markets*

Fama (1991) defines the efficient market hypothesis as "the simple statement that security prices fully reflect all available information," which in its strongest form requires that information and trading costs are zero. Fama (1991) goes on to describe the "joint-hypothesis" problem inherent in any test of market efficiency: "market efficiency per se is not testable. It must be tested jointly with some model of equilibrium, an asset-pricing model." Since testing

market efficiency requires testing whether prices "properly" reflect information, or whether prices are equal to "fundamental" value, it requires that the investigator take a stance on defining proper and fundamental.

Violations of the law of one price, in contrast, are easy to test for and do not involve the joint-hypothesis problem. One does not need to model the fundamental value of ketchup to know that the different bottles of ketchup are mispriced relative to one another. In this sense, the law one price is a more testable hypothesis than the efficient markets hypothesis. Since efficiency certainly implies the law of one price, but the law of one price does not imply efficiency, one can test efficiency by testing for violations of the law of one price. If a market is guilty of violating the law of one price, it is certainly guilty of violating the efficient market hypothesis. But unlike federal prosecutors who convict mobsters on tax code violations, the law of price is not a minor technicality. It is the core of modern finance.

What about transactions costs? Both strict market efficiency and the pure law of one price would only hold if transactions costs were zero. If transactions costs are not zero, then arbitrageurs are prevented from forcing price all the way to fundamental value, and the same security can have different prices. A weaker form of market efficiency is that prices reflect information up to the point where the marginal profits of acting on information equals the marginal cost. If the marginal costs (such as transactions costs) are large, then prices can be far away the frictionless price (defined as the price that would prevail in the absence of frictions). When transactions costs are not zero, then Fama (1991) describes an efficient market as one in which "deviations from the extreme version of the efficiency hypothesis are within information and trading costs."

By this weaker definition, the market for ketchup is efficient, since it is impossible to make arbitrage profits after accounting for transactions costs. Nevertheless, the ketchup market is very far from the ideal of frictionless market, as the price of ketchup is off by 51%. A more extreme example is a market with short-sale constraints, that is, where it is impossible to short a stock. This constraint is equivalent to making transactions costs infinite for short sales. In this market, a stock could be infinitely overpriced, yet since there is no way for arbitrageurs to make money, the market is still efficient. Thus an "efficient market" can be infinitely far from a well-functioning, frictionless market.

2. Misdemeanors: Fixed income and derivative markets

In many (perhaps most) situations, the law of one price works well. One example is put-call parity, a relation between options prices, share prices, and interest rates that is implied by the law of one price. Technically, put-call parity need only hold exactly for European options and stocks not paying dividends, but in practical terms put-call parity should approximately hold for American options as well. A variety of studies (such as Klemkosky and Resnick 1979) have found that put-call parity basically holds, with small, rare violations due perhaps to nonsynchronous prices and transactions costs.

In other situations, the law of one price appears to be mildly violated due to issues such as liquidity, taxes, and market segmentation. In the past few decades, financial innovation has produced a bewildering variety of new financial instruments, many of which are derivative securities that merely combine or separate existing assets. Presumably, much of this bundling and unbundling takes place because it causes some increase in value (otherwise, why would anyone bother to do it). For example, one can unbundled mortgage-backed securities into interest only and principal only components. These unbundled components typically sell for

slightly more than the underlying assets. This value increase might occur because the separated components have higher liquidity or have greater convenience and appeal for distinct classes of investors who want to hold one component but not another.

Implied option prices should not be negative

Another mild violation is the apparent arbitrage opportunity between some callable and non-callable US Treasury bonds. In theory, callable bonds should be worth less than equivalent non-callable bonds because they contain an embedded option that can only hurt the bond's holder. Longstaff (1992) found that in fact, some callable bonds were worth more than equivalent portfolios of non-callable bonds, a clear violation of the law of one price. This violation implied that the option to call the bond had negative value (just as the ketchup pricing implies that 10 ounces of ketchup have a price of –60 cents), a theoretical impossibility. The result is surprising since the US Treasury market is one of the most liquid markets in the world, with sophisticated investors and well-developed institutions for shorting bonds.

As with any mispricing, the two questions are how can this mispricing persist, and why does anyone buy the overpriced security. In answering the first question, Longstaff (1992) found that one explanation is the cost and difficulty of shorting the overpriced security for many years (despite the ease of shorting over short periods). In answering the second question, Longstaff (1992) discusses practitioner reports that the holders of the overpriced securities were smaller, less-sophisticated institutions.

Bonds: As time goes by

Another explanation for the apparent mispricing of callable and noncallable bonds is liquidity. If otherwise identical securities have different liquidity, their prices can be different if investors value liquidity. A standard example from the Treasury market is the difference between yields of "on-the-run" and "off-the-run" bonds. In the market for US Treasuries, the most recently issued Treasury bond is known as the "on-the-run" bond and slightly older bonds are known as "off-the-run" bonds. For example, the most recently issued 30-year bond is on-the-run while 30-year bonds issued last year, which are now 29-year bonds, are off-the-run. While these bonds, both issued by the US Treasury, have nearly identical credit risk and maturity, the 30-year bond typically has a slightly lower yield than the 29-year bond since it has high liquidity. Due to institutional arrangements and convention, the most recently issued bond is more widely traded and thus is more liquid. Since investors value this liquidity, they are willing to pay more for the 30-year bond, despite the fact that it too will become less liquid when it goes off-the-run within the year.

These yield differences between 29-year and 30-year bonds are typically small, and in early August 1998, the difference in yield was around 8 basis points, or 0.08 percent. With the dramatic events of late August 1998, however, this liquidity premium rose, and by the end of the year, the spread was 22 basis points. At the end of December 1998, the 30-year Treasury bond (due in November 2028) was yielding 5.09 percent, while 29-year bond (due in November 2027) was yielding 5.31 percent.

One probably does not need to take an position lasting 30 years in order to take advantage of these relative yields. Due to the march of time, we know that next year the 30-year bond will become a 29-year bond and the 29-year bond will become a 28-year bond. Thus we know that in 1999 the November 2028 bond's price is likely to fall (in relative terms) as its liquidity decreases. Thus an arbitrageur should not have long to wait before the yields move closer

together. Using hindsight, this strategy looks good, as the current yield spread between the November 2027 and November 2028 bonds is (as of 3/13/00) only two basis points (for the same date, the spread between the current on-the-run 30-years and 29-years is still fairly high, at 12 basis points).

These examples from fixed income markets, while puzzling, must be classed a misdemeanor offense because the violation is small. Longstaff found that the negative implied option value was at most 1.26 percent of par value, so the provable deviation from the law of price is relatively minor. In terms of the liquidity premium on US Treasury bonds, the yield difference of 22 basis points corresponds to a price difference of around 3 percent, also relatively minor. Thus, compared to the ketchup market, the US Treasury market looks good.

3. Suspicious behavior: International equity markets

Here I discuss three types of situations from international equity markets, all of which violate the law of one price. The first is closed-end country funds. Closed-end funds are portfolios of assets, controlled by a management company, with a publicly traded value that may differ from the value of the underlying assets. The relationship between closed-end fund prices and values can vary across funds and across times. Lee, Shleifer, and Thaler (1991), for example, find that a specific domestic fund, the Tricontinental Corporation, varied from a discount of 25 percent to a premium of 2.5 percent between 1960 and 1986. Lee, Shleifer, and Thaler (1991) found a few cases of funds with discounts or premiums exceeding 50 percent.

While closed-end fund discounts and premiums appear to be a violation of the law of price, they are not pure examples since the two assets (the underlying securities owned by the fund, and the fund itself) are not precisely identical. One reason is that the portfolio manager of the fund charges a fee for his services and incurs other expenses, and thus the cash flows going to the holders of the fund are different from the cash flows going to the holders of the underlying assets. Nevertheless, some have argued that the deviations from the law of one price have a magnitude and a variation that is too large to be explained by such differences.

Since the period studied by Lee, Shleifer, and Thaler (1991), the range of discounts and premiums in closed-end funds has grown substantially larger. The late 1980's saw a proliferation of closed-end country funds, which trade on US exchanges but hold equities in a specific foreign country (Klibanoff, Lamont, and Wizman (1998)). These country funds often had huge deviations between price and value. An extreme example is the Taiwan Fund trading on the New York Stock Exchange. During early 1987 (shortly after its start), it had a 205 percent premium, meaning that the price was more than three times the asset value (the premium stayed above 100 percent for ten weeks and above 50 percent for 30 weeks). This mispricing can persist due to legal barriers preventing US investors from freely buying stocks trading in Taiwan. Still, the question remains why US investors were willing to pay a dollar to buy less than 33 cents worth of assets.

Another extreme example is the behavior of the Germany Fund when the Berlin Wall fell in late 1989. At the beginning of 1989, the Germany Fund had a small discount of about nine percent. As political developments in 1989 made the fall of the Communist regime and the eventual reunification of Germany more likely, German stocks went up. The value of the Germany Fund, traded on the New York Stock Exchange, went up even more, and by September 1989 the fund had a premium instead of a discount. By January 1990, the premium was 100 percent. After that, the euphoria in the US wore off, the price of Germany Fund shares fell, and the premium returned to about zero in April 1990. This example is less easy to explain using

international barriers to capital, since it is much easier for US investors to invest directly in Germany than in Taiwan.

American Depositary Receipts: Coming to America

The second situation from international equity markets is the pricing of American Depositary Receipts, or ADR's. ADR's are shares of specific foreign securities held in trust by US financial institutions, usually banks. Claims to these shares trade in US markets. Like closed-end funds, ADR's can have prices different from the value of the underlying assets. A particularly remarkable ADR valuation is Infosys, an Indian information technologies company trading in Bombay, and the first Indian company to list on an American exchange (NASDAQ).

As March 7, 2000, Infosys had experienced a huge increase in value, as its ADR was trading at $335 but had been introduced at $17 (split-adjusted) in March 1999. In March 6, 2000, Infosys accounted for 24 percent of benchmark Bombay index. However, as with the Germany Fund in 1989, the enthusiasm of American investors appeared to be greater than that of local investors, and thus American investors were willing to pay a far higher price for a share of Infosys's future profits. The ADR was trading at a 136 percent premium to the Bombay shares, so that an American investor paid one dollar for 42 cents worth of stock.

Again, since official barriers prevent Americans from buying the shares trading in Bombay, there is no way for arbitrageurs to instantly profit from this relative valuation. Unlike the case with ketchup, it is not that American investors are ignoring the underpriced asset and buying the overpriced asset. Rather, it is as if the American investors are shopping at a convenience store with only one bottle of ketchup priced at $10 a bottle. One might wonder why their need for ketchup is so great that they are willing to pay such a premium, but it is hard to prove that American investors are acting irrationally in buying Infosys. After all, perhaps the Bombay shares are underpriced and the ADR's are correctly priced. Less judgmentally, with segmented markets, it is perfectly rational for the same asset to have two different prices in two different markets, reflecting differences in supply and demand. In the case of Infosys, the interpretation would be that American investors value Infosys because its returns are uncorrelated with other assets held by Americans, so Infosys offers valuable diversification. Indian investors, on the other hand, correctly place a lower value on Infosys since it confers no diversification benefit to them.

One piece of evidence contradicts this explanation. The India Fund, a closed-end country fund holding Indian equities and trading on the NYSE, had a discount of 31 percent on March 3, suggesting the US investors have no special appetite for Indian equities. Further, in early 2000 16 percent of the India Fund's assets were in Infosys; the India Fund also had extensive holdings in other Indian computer and technology companies. Based on the relative ADR price, the India Fund's position in Infosys alone should have given it a .16*136 = 22 percent premium rather than a discount. Apparently, the value of Infosys is somehow lower when present in the India Fund. Thus in valuing Infosys, the market committed multiple violations of the law of one price. Bombay investors gave one price for Infosys, NASDAQ investors gave second, far higher one, and New York Stock Exchange investors gave a third, slightly lower one.

Twins: Siamese but not identical

The third situation from international equity markets is Siamese Twins. Siamese Twins, as discussed in Rosenthal and Young (1990) and Froot and Dabora (1999), are firms that for historical reasons have two types of shares with fixed claims on the cash flows and assets of the

firm. An example is Royal Dutch/Shell, which has both Royal Dutch shares (traded in Amsterdam) and Shell (traded in London). There is only one firm, the Royal Dutch/Shell Group, but based on the 1907 merger agreement, all cash flows are split so that Royal Dutch shares receive 60 percent and Shell shares receive 40 percent. Given this setup, the ratio of the market value of the Royal Dutch to the market value of Shell should be 60/40. The ratio can move far from its theoretical value, from 30 percent too low in 1981 to more than 15 percent too high in 1996; the ratio is currently around five percent too high, meaning that Royal Dutch is overpriced relative to Shell.

This deviation is somewhat surprising since both Royal Dutch and Shell have ADR's trading in the US. Thus, to profit from the mispricing, a US investor doesn't need to trade in international markets. All that is necessary is to short the underpriced shares, buy the overpriced shares, and hold forever; this strategy is called a "pairs trade". Costs to this strategy include initial transactions costs and holding costs, which might well make the strategy unprofitable (also, there are small differences in taxes paid by American investors in British and Dutch securities). Nevertheless, one wonders why any US investor would buy Royal Dutch when they could replace it with an equivalent amount of the cheaper Shell. Since the market capitalization of Royal Dutch is $116 billion, investors with $116 billion in wealth must think they have some good reason for holding a security that is overpriced when a nearly identical substitute is readily available. One commonly given reason is that Royal Dutch is a member of the S&P 500, making it important for index funds to hold it.

In summary, the evidence from international equity markets shows the law of one price can be violated dramatically when international barriers prevent arbitrage. Even without international barriers, as in the case of domestic closed end funds and the ADR's of Royal Dutch and Shell, puzzling valuation disparities exist. I classify this evidence as at best circumstantial, however, for the central question of whether capital markets are generally well approximated by the frictionless ideal. These violations of the law of one price are highly suspicious, but since these examples involve relatively obscure securities, each with special circumstances and institutional details, the crime is not proven beyond a reasonable doubt. Even if the frictionless model is a bad description in international equity markets and closed-end funds, it could be a good description of US equity markets. The next section, however, shows that the crime rate hardly seems lower in US equity markets.

4. Heinous crimes: US equity markets

This section describes, in gory detail, shocking crimes committed against the law of one price. It is intended for mature audiences only.

On March 2, 2000, 3Com Corp sold a fraction of its stake in Palm, Inc. to the general public. In this transaction, called an equity-carve out, 3Com sold about 4 percent of its stake in Palm in the initial public offering, sold about 1 percent to a consortium of firms, and retained ownership of 95 percent of the shares. Palm makes hand-held computers. 3Com, in addition to owning Palm, has a profitable business providing computer network systems and services.

Prior to the issue, Palm's underwriters had originally estimated the offering price to be $14 to $16 per share. After gauging investor demand, they increase the estimated offering price to $30 to $32. Finally, the night before the offer, they chose $38 as the final issuing price. On the first day of trading, Palm immediately went to $150, and later rose as high as $165, before ending the day at $95.06 a share.

Based on the relative number of shares of Palm and 3Com, a shareholder of one share of 3Com stock indirectly owned 1.5 shares of Palm stock. Thus, based on 3Com's ownership of Palm alone, at the end of the first day of trading, 3Com shares were worth at least $142.59. In addition, 3Com held cash and securities worth more than $10 per share, and operated a substantial and profitable network business. One analyst estimated that, in all, 3Com's non-Palm component was worth $35 a share. So 3Com was worth at least $142.59, and possibly as much as $177.59.

Despite this high implied value, 3Com's actual value at the end of trading was $81.81 (in fact, 3Com's stock price actually fell 21 percent during the day). The "stub value," or implied value of 3Com's non-Palm assets and businesses, is the difference between the lower bound of $142.59 and observed price $81.81, or -$60.78. For some reason, the equity market gave a negative implied value to 3Com's other assets, just as the ketchup market gave an implicit price of –60 cents to an additional 10 ounces of ketchup. Looking at totals instead of per share figures, the total market value of Palm's equity was $54 billion and the total market value of 3Com was $28 billion. Since 3Com's stake in Palm was worth about $51 billion, the market made an error worth at least $23 billion dollars. In percentage terms, this mispricing could be described as an 82 percent undervaluation of 3Com relative to Palm, or a 43 percent overvaluation of Palm relative 3Com.

Something is terribly wrong here. This negative implied "stub value" should not be happening. Large capitalization stocks trading in US exchanges (both stocks trade on NASDAQ) should not be mispriced. While one might be able to dismiss closed-end funds and ADR's as freakish anomalies, one should not be able to prove that the market loses track of $23 billion with a math error that would make a sixth grader blush.

Exit strategy

Most puzzling of all, 3Com had publicly announced its intention to spin-off its remaining shares of Palm, pending an IRS decision on the tax status of the spin-off. This spin-off was expected to take place by the end of the year, and a favorable IRS ruling was highly likely. Thus, in order to profit from the mispricing, an arbitrageur would need to buy one share of 3Com, short 1.5 shares of Palm, and wait less than a year. In essence, the arbitrageur would be buying a security worth as much as $35 (and at worst worth zero) for -$60.78, and would not need to wait very long to realize the profits.

This likely terminal date makes the strategy very different from the strategy in closed-end funds or Siamese twins. If the spin-off occurs, one is guaranteed a profit. This situation is not exactly riskless arbitrage (since there is no certainty that the spin-off will take place as planned), but it comes mighty close. There is a tiny chance that the IRS decision will be negative (one analyst stated that the IRS had approved 500 similar transactions). There is a somewhat higher chance that 3Com will change its mind in the interim, and decide not to spin-off the remaining shares of Palm. Some other party could intercede and prevent the spin-off from taking place, perhaps by acquiring 3Com. Nevertheless, this situation seems almost as close as one could get to riskless arbitrage without being riskless. It is very close to being a pure arbitrage opportunity.

This mispricing was not in an obscure corner of capital markets, but rather took place in a widely publicized initial public offering that attracted frenzied attention. The nature of the mispricing was so simple that even the dimmest of market participants and financial journalists was able to grasp it. On the day after the issue, the mispricing was widely discussed, including in two articles in the Wall Street Journal and one in the New York Times.

History repeats itself

It was also not the first time that such a mispricing had occurred. Numerous press articles had described similar situations, and at least one academic paper had documented the phenomenon (Schill and Zhou, 1999). As of January 2000, Chicago-based Spin-off Advisors had compiled a list of 64 situations for which one could calculate stub values. Of these, 18 (24 percent) were negative. These mispricings often involved technology and internet stocks, with the more exciting internet stock being overpriced and the more traditional stock underpriced. In the case of 3Com and Palm, in order for the negative stub value to be rational, it must be true that the market believes 3Com has a huge liability that will appear prior to the terminal date. While this explanation is plausible for some companies with negative stub values, such as Nabisco Group Holdings with potential tobacco liabilities, it is absurd for 3Com.

A previous example, complete with terminal date, is uBid. In December of 1998, Creative Computers sold 20% of its subsidiary uBid in an equity carve-out. As in the case of 3Com/Palm, the law of one price was violated and at one point the non-uBid component of Creative Computers had an implied value of -$0.5 billion. This mispricing occurred despite the fact that, as with 3Com, Creative Computers had announced its intention to spin-off its remaining shares of uBid. The remaining shares were duly spun off six month later, and those who had taken arbitraging positions were rewarded as uBid's stock price fell.

A somewhat older example comes from the 1920's. In 1923, a young man named Benjamin Graham, later to co-author a classic book on security analysis, became the manager of what would now be called a mutual fund. Graham noticed that although Du Pont owned a substantial number of GM shares, Du Pont's market capitalization was about the same as the value of its stake in GM. Du Pont had a stub value of about zero, despite the fact that Du Pont was one of America's leading industrial firms with other hugely valuable assets. Graham bought Du Pont, shorted GM, and profited when Du Pont subsequently rose.

A shortage of shorts

What prevents arbitrage from taking place? A widespread explanation for the pricing disparity was the inability of investors to short Palm. To be able to sell short a stock, one must borrow it, and for institutional reasons borrowing shares can be difficult or impossible for many equities, especially on the day of the IPO. Even weeks after the IPO, shorting can be difficult. In order to borrow shares, an investor needs to find an institution or individual willing to lend shares. Much of this borrowing is typically done through financial institutions, such as mutual funds, trusts, or asset managers, who lend their securities. In the case of Palm, retail investors rather than institutions probably held most of the shares, thus making Palm hard to borrow.

Shorting, though difficult, was not impossible. I am personally aware of a short sale made by a finance professor on March 8th, when the implied stub value was -$26.69 per share. On March 15th, total short interest in Palm was about 5 million shares (out of about 23 million shares trading), or about $279 million. Thus total inability to short cannot be the whole answer. Since there are investors who are exploiting the Palm opportunity and did exploit the uBid opportunity, these are by definition exploitable opportunities, although it may be costly and time-consuming to find shares to short. While these investors are not making infinite arbitrage profits, they are making very high returns on near-arbitrage opportunities. For example, one finance professor who took the uBid opportunity used the proceeds to buy a 1999 BMW M3 convertible (for the record, I drive a 1992 Honda Civic). Finance professors are not generally known for their market savvy, street smarts, or stock picking success. Compared to large institutional

investors, finance professors certainly have higher information-gathering and trading costs. Thus the apparent ability of some finance professors to earn excess returns is troubling for the efficient markets hypothesis.

Figure 1 shows the movement over time in the stub value for 3Com. The initial stub value of -$60.78 fell to around -$20 after two weeks, a smaller violation but still objectionable. One explanation is that arbitrageurs entered the market via short sales and options (exchange traded options started trading on March 16th).

Outrageous options pricing

Put-call parity is a relationship that only holds exactly for European options with no transactions costs; with American options in the presence of transactions costs, put-call parity is a set of bounds on prices rather than an exact relationship. One can speak loosely of put-call parity holding for American options, meaning that the relationship between securities prices approximates the exact situation with European options. One way of expressing put-call parity for Palm is to say that synthetic shares of Palm (constructed using options and borrowing and lending) should have the same price as actual shares of Palm. The law of one price should hold.

A weaker condition than put-call parity, which should always hold for non-dividend paying American options, is the following inequality: C-P > S-X, where C is the price of a call, X is the strike price, P is the price of put, and S is the price of the underlying security. For options that are at-the-money (so that S is equal to X), this inequality says that call prices should be greater than put prices. Since Palm does not pay dividends, this inequality should hold for Palm options.

Most empirical studies of options prices have found that the inequality is almost always satisfied, with small violations due perhaps to transactions costs. Options on Palm proved to be a dramatic exception to this pattern. Exhibit 1 shows options prices for Palm for March 16th, on the first day that exchange options traded. At-the-money puts were about twice as expensive as at-the-money calls, massively violating the inequality.

Exhibit 1 shows the implied cost of synthetic securities. For example, on March 16th one can create a synthetic short position in Palm by buying a November put, selling a November call, and borrowing dollars. The payoff from holding the synthetic short until November is identical to the payoff from shorting the stock and holding until November. These calculations are done in a back-of-the-envelope fashion using simple assumptions (for example, assuming that one borrow from March to November at the 6-month LIBOR rate). Buying a November put (at the ask price), writing a November call (at the bid price), and borrowing, on March 16th the cost of synthetic short was about $37, far below the actual price of about $54 for Palm. This constellation of prices is a significant violation of the law of one price, since the synthetic security is worth about 30 percent less than the actual security. April options also showed smaller, but still sizeable deviations from the law of one price, with synthetic short positions costing about $49 a share. Exhibit 1 shows that 11 days later, on March 27th, both April and November options prices were more in line with Palm's price, although the November options were still significantly violating the inequality.

Thus we have three ways of inferring Palm's true value: the embedded value reflected in 3Com's share price, the value reflected in options prices, and the actual price. The market for November options and the shareholders in 3Com seemed to agree: Palm was worth far less than its market price. The direction of the deviation from the law of one price is consistent with the difficulty of shorting Palm. To profit from the difference between the synthetic security and the

underlying security, one would need to short Palm and buy the synthetic long. If shorting is costly, then the deviation from the law of one price can be interpreted as the cost of borrowing (shorting) Palm shares.

Where are the arbs?

Another explanation for the persistence in the mispricing is the absence of arbitrageurs. Investment banks are one type of institution that engages in arbitrage. On Wall Street, the word "arbitrage" has a broader meaning than the used here, and generally involves taking bets on a range of outcomes rather than just the convergence of two relative prices. Starting in the late 1980's, however, the very word "arbitrage" had acquired negative associations, and seemed to many to imply illegal activity or insider trading. When the famous arbitrageur Ivan Boesky was arrested in 1986, it set in motion a general retrenchment of arbitrage activity. On February 12, 1987, armed federal officers arrested Robert Freeman on the trading floor of Goldman Sachs. Freeman was the chief of risk arbitrage and head of international equities. Although Freeman, Goldman Sachs, and their lawyers believed Freeman to be innocent of the charge of insider trading, Freeman eventually pled guilty. After polling prototype jurors, the lawyers determined that the public dislike for Wall Street in general and arbitrage in particular was too strong for a fair trail. Lawrence Pedowitz, Goldman Sach's lawyer, said "Arbitrageurs were thought of somewhere below lawyers."

In the 1990's, many investment banks scaled back or shut down their arbitrage operations. Salomon Brothers, which had perfected arbitrage trades such as off-the-run vs. on-the-run Treasury arbitrage, is a case in point. After Salomon Brothers was taken over by the Travelers Group in 1997, its stock arbitrage unit suffered losses and was shut down. In 1998, Salomon's famous bond arbitrage group was also disbanded. Many refugees from Salomon and elsewhere joined hedge funds. These hedge funds were engaged in arbitrage, although since arbitrage was a dirty word they preferred to call it a "relative value" or "convergence" strategy. After great success, however, many hedge funds failed in 1998, most prominently Long-Term Capital Management. Many arbitrageurs left the stage in 1998.

Why would anyone buy Palm?

Putting aside the failure of arbitrage, the second question is why anyone would ever buy one share of Palm for $95.06 when they can buy one share of 3Com (embedding 1.5 shares of Palm) for $81.81. One superficially appealing explanation for the mispricing following equity carve-outs is supply and demand. Inherent in a carve-out is the fact that only a small portion of the subsidiary firm is sold, and most of the shares are held off the market by the parent. Of the small number of shares issued in the initial public offering, some are allocated to institutional investors who have promised not to "flip," or immediately resell, their shares. According to this argument, the price of Palm is high because demand for shares outstrips supply. Once 3Com sells the remaining 95 percent of Palm, supply of Palm stock will rise and thus the price will fall. While this argument could be true, it certainly is inconsistent with market efficiency, with rationality, and with the law of one price.

Since Palm's market total market value was $54 billion and 4 percent of the equity was publicly trading, investors worth more than $2 billion thought that Palm was a better buy than 3Com. While it is impossible to say what, if anything, was going through these investors minds, press reports offer some clues. Numerous press reports mentioned that without Palm, 3Com's future expected growth was expected to be lower. For example, in the week after the IPO, the

Wall Street Journal headline read "3Com Faces Bleaker Future Without Palm". Thus investors may have simply pursued the idea that Palm was good, and 3Com was bad, without pausing to do the math.

More generally, early 2000 was a time of incredible optimism about technology stocks. Between February 1999 and February 2000, the tech-heavy NASDAQ Composite Index more than doubled. One dramatic illustration of technology optimism occurred in Hong Kong. In February 2000, chaos erupted in the street of Hong Kong. Huge crowds gathered around 10 different banks. The police were called in to maintain order. Some branches closed their doors, while others extended their hours to accommodate the impatient mob. A bank run? Sort of. But instead of fighting to get their money out, these people were fighting to get their money in. They were applying to subscribe to the IPO of tom.com, a new internet company. According to some sources over 300,000 people stood in line to hand in an application, and more that 453,000 applications were submitted, so that almost seven percent of the population of Hong Kong subscribed to the IPO.

Many of the negative stub situations in early 2000 involved exciting and potentially revolutionary products. One example is Abgenix, a glamorous biotech firm that developed XenoMouse technology, a method of producing genetically engineered mice with applications to treating cancer. Another example is Plug Power, a firm developing environmentally friendly fuel cell technology for residential energy needs. Numerous other examples included cellular phones, Internet telephony, and e-commerce.

General Motors: Approaching negative value?

Even the largest companies in the world are being affected by this kind of mispricing. In 1999, General Motors was in the top fifty firms of the New York Stock Exchange in terms of market capitalization. GM had tracking stock for its Hughes Electronics unit, and also had a 20% stake in publicly traded Commerce One. Tracking stock is a separate share of equity with rights to the cash flows generated by a specific entity within the parent company. Hughes Electronics operated in the growing and glamorous field of direct satellite TV, Commerce One was a red-hot e-commerce company, while the rest of General Motors operates a finance company (GMAC) and manufactures obscure devices known as automobiles. Hughes and Commerce One were losing money (as is typical with technology companies), while GM's other business was profitable.

Between September 1999 and January 2000, Hughes stock rose 97 percent and Commerce One stock rose 413 percent. Due to the high valuations of its components, the stub value for GM's auto business was low. According to one analyst, in March 2000, GM's $75 price per share included $60 per share of Hughes and Commerce One shares, leaving only $15 for the rest of GM (the part that designs, manufactures and markets automobiles, trucks and related parts, designs and manufactures locomotives and heavy-duty transmissions, and operates a financial services and insurance company). The stub value of GM was only $15 a share, despite the fact that the GM's earnings (not including the losses generated by Hughes and Commerce One) were $10 a share. According to this analyst, the market thus assigned GM's auto business a price/earnings ratio of 1.5, at the same time Ford's price/earnings ratio was 7 and DaimlerChrysler's was 12.

While these specific comparisons depend on a number of assumptions, it seems clear that the market is assigning a very low value to GM's auto business (or is assigning differing values to the public shares and embedded shares in Hughes and Commerce One). Although the stub

value was not negative, in early 2000 it was no longer impossible to imagine a future scenario in which GM's auto business was given a negative value by the stock market.

In summary, US equity markets in early 2000 look as bad or worse than ketchup market. Companies large and small appear to be flagrantly mispriced, where "mispriced" has a clear and provable meaning. Although the calculations of the examples discussed here are certainly sensitive to specific assumptions, the weight of the evidence is overwhelming. Beyond a reasonable doubt, US equity markets are violating the law of one price.

5. *Motives for law-breaking*

What motivates this criminal activity? Given that the law is not being enforced, what is it that causes prices to get out of line? One explanation is behavioral finance. According to this explanation, inspired by facts from cognitive psychology, investors are systematically making cognitive errors when valuing assets. This explanation is consistent with some of the evidence discussed here, since one common theme running through several of these examples is over-reaction. Prices of the Germany Fund seem to have over-reacted to the fall of the Berlin Wall, while prices of the Infosys ADR seem to have over-reacted to the success of Infosys. Here, I use the word "over-reaction" to mean that the price of one security over-reacts relative some other security.

More generally, several studies of international markets have documented the following systematic pattern of over-reaction to some variables and under-reaction to others. For prices of the same asset traded in country A and country B, country A prices react more to country A events, and country B prices react more to country B events, even though in theory the prices should be the same and should therefore react the same to all events. In this sense, country A prices over-react to country A events and under-react to country B events. Hardouvelis, LaPorta, and Wizman (1994) show that country fund prices in the US over-react to changes in US aggregate stock prices, and under-react to foreign stock prices and exchange rates. Froot and Dabora (1999) show similar patterns for Siamese twins. Klibanoff, Lamont, and Wizman (1998) show that country fund prices react more to foreign news when that news appears on the front page of the New York Times. One interpretation of this evidence is that, when rational investors are prevented (by international barriers) from arbitraging away mispricing, irrational investors can affect market prices.

Another broad explanation is segmented markets. I have already discussed official barriers to trade that prevent US investors from buying Indian equities. In addition to such legal barriers, there are also informal barriers involving information costs, language, agency concerns, and institutional arrangements. For example, US mutual fund managers may be perfectly aware that Palm is overpriced relative to 3Com. But the Investment Company Act of 1940 places severe restrictions on the ability of mutual funds to short; most mutual funds rarely or never go short on any security (the law changed in 1997, allowing mutual fund managers greater freedom to use derivatives and short sales). All the fund managers can do is avoid owning Palm. In this sense, the market for Palm and the market for 3Com are segmented; money does not flow from one security to the other to equilibrate prices.

With segmented markets, differences in supply and demand can cause violations of the law of one price. For example, the price of gold in London and New York can be different when no one arbitrages the difference between the two cities. In this case, the difference is not due to behavioral finance. Some of the evidence on "over-reaction" and "under-reaction" can also be interpreted from this perspective. For example, suppose Dutch investors decide to defer

consumption and increase their savings by investing more in the stock market. In the absence of cross-country arbitrage, this increase drives the prices of all Dutch securities up, including the price of Royal Dutch. Suppose Shell, which trades primarily in London, is unaffected. We can legitimately describe this situation as Royal Dutch "over-reacting" to Dutch stock prices and Shell "under-reacting," but in this case cognitive psychology is not the driving factor.

6. Law enforcement and crime prevention

One mechanism for enforcing the law of one price is issuing firms. If firms believe that some of its securities are mispriced, and if they act in the best interest of existing shareholders, then firms should sell the overpriced securities and repurchase the underpriced securities (Stein, 1996). Buy low, sell high. And in fact, in February 2000, GM announced plans to repurchase its (allegedly underpriced) common stock and issue more of its (allegedly overpriced) Hughes Electronics stock, taking advantage of the mispricing. In the case of 3Com, the planned spin-off of Palm is another mechanism that both eliminates the mispricing and benefits the shareholders. In the spin-off, each existing shareholder of 3Com will receive 1.5 shares of Palm. The shareholders are then free to sell these shares to other investors who apparently believe them to be more valuable.

Another mechanism to eliminate mispricing is shareholder activism. In the case of closed-end funds trading a discount, shareholders can attempt to force (through shareholder votes and takeover attempts) the fund to open-end, effectively forcing the price to rise to asset value. In the case of firms with negative stub values, shareholders can try to force the firm to spin-off the overpriced assets, thus "unlocking hidden value."

Long-Term Capital in a short-term world

Arbitrageurs enforce the law of one price. Like cops on the street, arbitrageurs face risks. These risks are particularly large in situations without a terminal date. One risk is that, after taking a position, the valuation disparity widens, causing the net wealth of the arbitrageurs to fall. In extreme cases, this widening spread can cause the arbitrageur to approach bankruptcy, as his net worth becomes negative and he no longer has the collateral to hold his positions. A prominent example is Long-Term Capital Management (LTCM), a hedge fund that held many "convergence trades," or bets that mispricings would narrow. Most of LTCM's bets involved mispriced bonds and derivative securities, but LTCM had equity positions as well, included many of the examples discussed here. For example, LTCM had a $2.3 billion pairs trade on Royal Dutch/Shell (Businessweek, 11/9/98). When spreads widened in 1998, diverging instead of converging, LTCM entered financial distress. Other savvy investors also lost money at the same time since they were taking the same convergence trades. For example, one loser was Harvard Management Company (which invests $13 billion of Harvard University's endowment), which lost money in convergence trades using closed end country funds in 1998 (WSJ 10/13/98).

LTCM attempted to raise new money, but found no takers, despite the fact that the convergence strategy had presumably become more attractive as the value disparity increased. LTCM was forced to enter into an agreement with its creditors, leading to an eventual liquidation of its positions. This withdrawal of arbitrage capital at the time when it was needed most is a striking example of the phenomenon described one year earlier by Shleifer and Vishny (1997). Shleifer and Vishny (1997) discuss the possibility that arbitrage opportunities may fail to be eliminated, and mispricings may widen, if arbitrageurs are driven out of business by adverse market movements.

The tears of a clone

Another dramatic example is Teleclone, a Canadian company that traded on the Toronto stock exchange. Teleclone was set up by a group of stock brokers in June of 1998 exclusively to take a position in the stub value of BCE minus its subsidiary Nortel. BCE is a holding company with ownership in a variety of companies, including stakes other publicly traded firms and 100 percent ownership of Bell Canada. Teleclone's sole assets consisted of shares in BCE, and its sole liabilities consisted of short positions in Nortel. Thus investors who purchased equity in Teleclone were essentially buying the stub value of BCE's non-Nortel business. This type of intermediation makes sense if Teleclone had access to shorting that was not available to individual investors. Teleclone was established not to take advantage of a negative stub value (the stub value was positive), but rather to allow investors to buy BCE without having to own Nortel. Some investors believed that BCE's stub value was too low relative to the value of the assets, and was "being dragged down" by Nortel.

Unfortunately for Teleclone, the prices of BCE and Nortel diverged so the stub value shrank. As the pricing worsened, Teleclone's liabilities outstripped its assets. By October 1999, Teleclone had defaulted on the terms of its loans, and was forced to renegotiate with its creditors. Fortunately, Teleclone was able to renegotiate a lower collateral requirement with its lender, and it announced plans to issue more securities; like LTCM, Teleclone needed additional financing to stay afloat. In November, the prices diverged again and Teleclone was once again in default. Teleclone's stock price, which (reflecting the positive stub value in 1998) had been issued at $29, dropped to $5. According to the Globe and Mail, (11/12/99), " 'It's been a nightmare,' TeleClone president Ed Collins sighed in between fielding calls from irate brokers who put their clients into TeleClone." Teleclone defaulted twice more in November, and its stock price dropped to $1.75 on November 19th. Teleclone defaulted again in December, and the company issued a press release (12/10/99) stating "TeleClone will be required to deliver additional collateral as margin to meet its margin requirements by the close of business on Monday, December 13, 1999. TeleClone does not have any additional assets to pledge as collateral under the Stock Loan. If TeleClone defaults under the Stock Loan, the Stock Lender will be entitled to terminate the Stock Loan and take steps to realize on its security, which action would require the wind-up of the Company." Nortel's market value had almost quadrupled in 1999 while BCE had only doubled, leading to the decrease in stub value.

Teleclone survived its brush with death as its creditor exercised restraint, however, and by the end of December its value was up as news arrived that BCE planned to spin-off Nortel. By January 27th, 2000, Teleclone was back to $34, up 2,152% from its low of $1.51. Unlike LTCM, Teleclone survived a near-death experience due to divergence, and reaped the benefits of the subsequent convergence.

Greater fool risk

Another risk faced by arbitrageurs is what I call "greater fool" risk. The greater fool theory is that one should buy an overpriced asset if one believes the asset can be sold for an even higher price to an even greater fool. When one takes a short position in a stock, greater fool risk is the risk that a greater fool will want to buy the stock and will have the ability to force you to close your position at a loss.

An example is Cordant Technologies. At the end of 1999, Cordant owned 84.6 percent of Howmet International. On 11/11/99 Cordant's price was 29.9375, Howmet's price was

14.0625, and each share of Cordant was entitled to 2.308 shares of Howmet (the precise number of embedded shares depends on assumptions about stock-based incentives given to Howmet's management). Thus the stub value for Cordant was -$2.51. This disparity had persisted for months and was the subject of a Wall Street Journal article on 9/28/1999, in which Cordant's CEO said "the sum of the parts would seem to be worth more than what the stock is selling for. We think it's undervalued." The article also quoted an analyst saying "with these kinds of values, either Cordant will close the value gap, or someone else will do it for them."

While shortly thereafter Cordant took steps to correct this misvaluation, they seem to have been the wrong steps. The standard advice is that firms should issue overpriced stock and buy back underpriced stock, as GM did. According to this advice, Cordant should have sold Howmet stock and repurchased Cordant stock. Instead, on 11/12/1999 Cordant made an offer to buy all of the outstanding shares of Howmet not currently owned by Cordant for a price of $17.00 per share in cash (or a total of approximately $261 million), a significant premium over the market price of $14.0625. Cordant preferred to repurchase overpriced stock at a premium.

Cordant is not the only example of this buy high, sell low strategy. Another example is the Japanese supermarket chain Ito-Yokado, which owns a stake in convenience store chain 7-Eleven. Due to 7-Eleven's new e-commerce strategy, it became a hot internet play. An article in *The Economist* (2/26/2000) discussed the fact that the relative valuations of the two companies gave Ito-Yokado a negative stub value. Four days later, on 3/1/00, 7-Eleven announced that Ito-Yokado was investing an additional $540 million in 7-Eleven, at an 83 percent premium to the market price.

Suppose an arbitrageur, reading of the valuation disparity in September 1999, had decided to buy Cordant and short Howmet. If Howmet's directors had decided to accept Cordant's offer, this arbitrageur would have been bankrupted by a greater fool, since he has no choice but to close out his short position at a loss. Fortunately for arbitrageurs, this story has a happy ending. Howmet did not accept Cordant's initial offer (Cordant later raised it to $18.75). As predicted in by the *Journal* article, someone else stepped in to close the value gap, and in March 2000, Cordant agreed to be taken over by Alcoa at a 93 percent premium, thus rewarding any arbitrageurs who continued to hold positions in Cordant. Alcoa also announced it was initiating talks to acquire the remaining 15 percent of Howmet.

Crime prevention

So much for correcting existing violations of the law of one price. What about crime prevention? One key area is security design. Issuers can profit by designing securities that are immune from mispricing. An example is closed-end country funds. One purpose of closed-end country funds is to allow US investors to diversify into foreign markets by providing them with liquid securities. Unfortunately, closed-end funds are not particularly liquid, and do not provide investors with pure exposure to foreign country stocks. In buying the Germany Fund, one not only acquires a position in German stocks, one also becomes exposed to variations in the discount of the Germany Fund.

Thus an ideal instrument would be one that is impossible to misprice, one that would never have premiums and discounts. To eliminate any mispricing, it is necessary to have some equilibrating mechanism that allows the supply of the security to adjust in order to eliminate mispricing. Such securities are broadly known as exchange traded funds or ETF's. Currently traded ETF's include SPDRs (Standard & Poor's Depositary Receipts which track the S&P Composite index), WEBs (World Equity Benchmark shares), and a host of others. ETF's,

widely seen as a potential rival to traditional mutual funds, are essentially closed end funds with fixed holdings in a defined index and with a flexible supply of shares.

Consider WEBs. The WEB for Germany holds shares corresponding to the Morgan Stanley Capital International index for Germany. Like a closed-end fund, the WEB has both a price and value of underlying assets. Unlike the Germany Fund, however, which has a fixed number of shares, the WEB has a flexible number of shares. Investors can create an additional share of the WEB by depositing the necessary securities, and can redeem their WEB shares in return for the underlying securities. Thus if the WEB for Germany was ever trading at a discount, arbitrageurs would rush to redeem their WEBs; if it was trading at a premium, arbitrageurs would rush to create WEBs. As a consequence, WEBs have only tiny deviations from fundamental value.

Another example at the level of individual firms is the merger of Daimler-Benz and Chrysler in 1998. After the merger, the combined entity replaced their separate shares with DaimlerChysler shares, global shares that are traded on the New York Stock Exchange, Frankfurt Stock Exchange, and 19 other exchanges. Institutional arrangements, including a global share register, mean that there is no need for ADRs or other derivative securities. Thus DaimlerChrysler can be bought and sold around the world, 24 hours a day, and investors don't need to worry about Infosys-style mispricing.

7. Conclusions

Financial economists have traditionally regarded "frictions," such as transactions costs, as minor concerns. Using the analogy from physics, the trajectory of a baseball thrown in the air often can be predicted well using a simple formula which ignores complicating frictions such as wind resistance; one can pretend that the ball has been thrown into an airless vacuum. While all agree that transactions costs, like wind resistance, exists, the traditional view is that these minor deviations are safe to ignore. I argue that this is a misleading analogy. The examples discussed here show that frictions are not a minor detail, but rather are central to understanding the determination of market prices. It is as if the baseball, rather than being thrown into the purity of an airless vacuum, is hurled into a tornado. The trajectory of the ball can be erratic as it is blown up, down, and sidewise by the wind. Although one is sure that the ball will eventually return to earth, ignoring complications is not a good idea in this situation.

Ross (1987) wrote "to make a parrot into a learned financial economist, he only needs to learn the single word 'arbitrage.'" It may be time to teach the parrot new tricks. We may come to the conclusion that capital markets are about as poorly functioning as ketchup markets.

Over the past few decades, financial innovation has made the world a better place, and we seem to have gotten closer to the ideal of frictionless markets that allocate capital to productive uses and allow investors to reduce risk. Yet recent innovations, such as ADRs, closed-end country funds, equity carve-outs, spin-offs, and tracking stock, also seem to have given investors more opportunities to get it wrong. If markets are flunking this no-brainer, what else are they getting wrong?

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Exhibit 1, Palm options

Stock and options prices at about 2:20 ET 3/16/00							
LIBOR							
1-month	6.07125						
3-month	6.19125						
6-month	6.4000						
One-year	6.81625						
Stock prices							
	Bid	Ask	Last				
PALM	54 3/16	54 3/8	54 3/16				
3Com			63 13/16				
Options Prices							
	Call		Put			Synthetic	
	Bid	Ask	Bid	Ask		Short	Long
April 55	3 7/8	5	8 3/8	9 7/8		48.47	51.33
November 55	9 7/8	11 3/8	22 7/8	25 7/8		36.78	41.25

Stock and options prices at about 3:40 ET 3/27/00							
LIBOR							
1-month	6.13125						
3-month	6.28						
6-month	6.5025						
One-year	6.94						
Stock prices							
	Bid	Ask	Last				
PALM	55 1/16	55 1/8	55 1/16				
3Com			67 1/8				
Options Prices							
	Call		Put			Synthetic	
	Bid	Ask	Bid	Ask		Short	Long
April 55	4 1/2	5 1/4	4 3/4	5 1/2		53.75	55.22
November 55	9 7/8	10 7/8	19 1/8	20 1/8		42.50	44.50

Quotes are from Pacific Stock Exchange. April options expire 04/22/2000, November expire 11/18/2000. Neither COMS nor PALM pay a dividend (3Com last paid a dividend in August 1995). Source of options and stock price data: CBOE web page. Source of LIBOR: subsequent day Wall Street Journal.

Exhibit 2
3Com/Palm Chronology

12/13/99 3Com files for Palm IPO

3/2/00 Palm IPO

3/16/00 Exchange traded options on Palm introduced

3/20/00 3Com announces quarterly earnings and new reorganization plans

3/27/00 3Com Chairman Eric Benhamou says he expects to receive by August, three months earlier than expected, a ruling declaring the distribution of Palm shares to existing 3Com shareholders a tax-free event.

Figure 1: 3Com stub