

# Understanding Asset Values: Stock Prices, Exchange Rates, And the “Peso Problem”

*Keith Sill*

Sometimes, the present depends on the future: people carry umbrellas when there is a forecast for stormy weather; football teams in the lead play zone defense late in the game, since they expect their opponents to pass; advance-purchase airfares are higher for holiday-travel times, when passenger traffic is expected to be heavy. In each of these cases, and many others

we can think of, what people expect will happen affects how they behave today. Exchange rates and prices of assets such as stocks and bonds depend not only on the most likely future outcomes but also on possible but less likely outcomes. Sometimes a possible outcome can be so different from today’s conditions that asset prices, which incorporate such extreme possibilities, make financial markets look flawed, even if they are not. Economists call such a condition a “peso problem.”

No one knows the precise origin of the term

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peso problem, but it is often attributed to Nobel laureate Milton Friedman in comments he made about the Mexican peso market of the early 1970s. At that time, the exchange rate between the U.S. dollar and Mexican peso was fixed, as it had been since 1954. At the same time, the interest rate on Mexican bank deposits exceeded the interest rate on comparable U.S. bank deposits. This situation might seem like a flaw in the financial markets, since investors could borrow at the low interest rate in the United States, convert dollars into pesos, deposit the money in Mexico and earn a higher interest rate, then convert the proceeds back into dollars at the same exchange rate and pay off their borrowings, making a tidy profit. Friedman noted that the interest rate differential between Mexico and the United States must have reflected financial market concerns that the peso would be devalued. Otherwise, the interest-rate differential would soon disappear as investors increasingly took advantage of it. In August 1976, those concerns were justified when the peso was allowed to float against the dollar and its value fell 46 percent. The difference in return on comparable U.S. and Mexican assets—which looked like an anomaly to analysts who thought the exchange rate would remain fixed because it had been fixed for 20 years—could be explained once investors' recognition of the possibility of a large drop in the value of the peso was factored in.

More generally, peso problems can arise when the possibility that some infrequent or unprecedented event *may* occur affects asset prices. The event must be difficult, perhaps even impossible, to accurately predict using economic history. Peso problems present a serious difficulty for economists who like to build and estimate models of the economy and financial markets, then use them to interpret economic data. Empirical economic models are designed to match features of the economy. They are calibrated or estimated using current and historical data on economic variables.<sup>1</sup> If the historical data used to calibrate or estimate models do not accurately reflect the

probabilities of bad (or good!) things happening, model-based forecasts can prove inaccurate and the policy advice that rests on them can suffer.

### **PESO PROBLEMS, ECONOMIC FORECASTS, AND EXPECTATIONS**

Expectations are often an important ingredient in our everyday actions and decision-making. For example, grocery stores become more crowded than usual when the weather forecast calls for a severe snowstorm. Firms may make additional investments in plant and equipment today in order to meet projections of strong future demand for their products. In the financial realm, prospects for variables like economic growth and inflation help determine asset prices and exchange rates.

The most useful forecasts give the best approximations of what actually ends up happening in the economy. We judge the "goodness" of forecasts by the properties of their forecast errors, which are the differences between a sequence of forecasted values of a variable and its actual, or "realized," values. Good forecasts have forecast errors that are zero, on average. If forecast errors aren't zero on average, the forecast is *biased*: the forecast is more often too high than too low, or vice versa. The presence of bias means that the forecaster is repeatedly making the same mistake, a mistake we would expect to be eliminated as the forecaster learns from his past misses. Good forecasts also have errors that aren't predictable. If they were, the forecast could obviously be improved by correcting those predictable errors.

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<sup>1</sup>Calibrating an economic model is a two-step process. First, the economist must construct a set of measurements on economic variables that are consistent with the variables that appear in the model. Second, values must be assigned to the model's parameters so that the behavior of the model economy matches as many features of the constructed data set as possible.

When the economy is stable, forecasters using historical data have a hope of predicting the future with some accuracy. “Stable,” in this context, doesn’t mean unchanging. Rather, it means that the future is similar to the past in that the likely occurrence of any future economic outcome is about the same as what we observed in the past. For example, if people conclude, based on an analysis of economic history, there’s a 1 percent chance the stock market will crash in any given year, they can confidently extrapolate that analysis into the future if the economy is stable. But if the economy is unstable, such an extrapolation may not work well. If the economy is not stable, people’s beliefs about the likelihood of future events may, correctly, be different from what was observed in the past.

Peso problems may occur when the economy faces this sort of instability. In this environment, using historical data to predict the future is difficult because the future may be much different from the recent past.<sup>2</sup> Wars, nationalizations of industries, and severe political turmoil are examples of unusual events that are extremely difficult to predict. But when markets think there is a chance such events may occur, that perception can have a dramatic impact on forecasts and forecast errors. Forecasts may capture the possibility of unusual events, but until the events actually occur, forecasters may seem to make persistent errors and their forecasts may look biased to someone who is not aware of the possi-

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<sup>2</sup>More technically, peso problems can be interpreted as a failure of the methodology of rational expectations econometrics, which requires that the *ex post* distribution of economic variables be equal to the expected *ex ante* distribution of the same variables. Another way to interpret the peso problem is as a small-sample problem in statistics. If the sample of data is large enough in the sense that the occurrence of rare events in the data coincides with their true likelihood of occurrence, then the *ex post* and *ex ante* distributions will be the same and analysts will have more success modeling investors’ expectations.

bility of an unusual or unprecedented outcome. Indeed, forecasts may look bad despite the fact that forecasters make their estimates using the best information at their disposal and the best practices. When peso problems are present, forecasts that look bad may actually be good.

**The Forward Premium Puzzle.** Economists have examined whether peso problems can account for some apparent anomalies in the behavior of asset returns. One such anomaly is the forward premium puzzle in foreign-exchange markets.<sup>3</sup> This puzzle is closely related to the forecasting issues we have been discussing.

In the foreign-exchange market, investors can purchase forward contracts on currencies. A forward contract is an agreement to buy or sell a currency on a certain future date for a certain future price, called the forward rate. We might think that the forward rate would be a good predictor of what the spot exchange rate will turn out to be on the day the forward contract matures, since the forward rate is a price that embodies financial market participants’ beliefs about the future value of the spot rate. (The spot rate is the price at which a currency can be bought or sold for immediate delivery. If you go to your local bank and convert dollars to francs, the conversion takes place at the spot exchange rate.) In an efficient market, the forward rate will equal the market’s expectation of what the spot exchange rate will be when the forward contract matures. The forward rate prediction may be high or low in any given month, but on average, it ought to be correct.<sup>4</sup> Economists would then say that the forward rate is an unbiased predictor of the future spot rate.

However, when we look at the data, the forward rate is *not* an unbiased predictor of the fu-

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<sup>3</sup>See the 1994 article by Gregory Hopper for more on the forward premium puzzle and the efficiency of the foreign-exchange market.

<sup>4</sup>Assuming investors are risk-neutral.

ture spot rate. Statistical analysis shows that the forward rate tends to stay above or below the spot exchange rate for extended periods. One contributing explanation for this finding is the peso problem.<sup>5</sup> If foreign-exchange markets think there is some chance the exchange rate will fall, then until it actually does, the forward exchange rate will remain below the spot value of the exchange rate, since the forward rate embodies the market's expectation. Research by Martin Evans and Karen Lewis shows that the peso problem is potentially an important component in an explanation of the forward premium puzzle.<sup>6</sup>

Let's look at a simple example. Suppose the spot exchange rate has been fixed at 20 cents per peso, and investors think there is a 95 percent chance it will remain at 20 cents but a 5 percent chance that the exchange rate will fall to 10 cents per peso. Then the expectation, or expected value, of the future exchange rate is 19.5 cents ( $[0.95 \times 20] + [0.05 \times 10]$ ). As long as the exchange rate remains fixed at 20 cents per peso, a forecast error of 1/2 cent per peso will persist—it will occur every period until either the peso is devalued or markets revise their expectations about devaluation. Someone casually evaluating these forecasts might conclude that market participants are irrational, since they seem to be making the same mistake over and over. An economist is more likely to think that the market is getting things about right. We can then turn the problem around and use the market's fore-

casts to infer beliefs about the future value of the peso or the probability of a devaluation.

### REGIME SWITCHING AS AN EXPLANATION OF PESO PROBLEMS

One approach economists have used to model peso problems is to suppose that the economy goes through *changes in regime*.<sup>7</sup> In general, regimes represent different environments. A simple example of changes in regime involves political parties and control of the legislature. Sometimes Democrats are in control, sometimes Republicans, and over time, control of the legislature switches back and forth between the two parties. Legislation and fiscal policy might be different under each of these regimes, and the overall performance of the economy could be regime-dependent as well.

While politics offers a good example of a regime-switching process, we want to think more generally about the economy's shifting randomly between two (or more) regimes. Examples of regimes might include periods of high or low inflation, periods of rising or falling exchange rates, or economic recessions and expansions. The key is that in one regime the disturbances to the economy are different from what they are in another regime.<sup>8</sup> These disturbances affect economic variables, so the behavior of variables such as inflation, interest rates, or real output growth could be different in the different regimes. Regime switches are irregular events for the

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<sup>5</sup>Another possible explanation is risk premiums in the foreign-exchange market. Risk premiums represent compensation to the asset holder for taking on the risk of holding the asset. See the survey article by Karen Lewis for an in-depth discussion of risk premiums and the peso problem as explanations for the predictability and variability of excess returns.

<sup>6</sup>However, Evans and Lewis find that the peso problem by itself cannot resolve the forward premium puzzle. They do show that the bias introduced by peso problems can be economically significant.

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<sup>7</sup>This view is somewhat different from the view that peso problems are due to small probabilities of catastrophic events that may happen only once. The problem with one-time events is that they are very hard to model. If an event is repeated, even infrequently, there is a possibility of its being described statistically. See the 1996 article by Martin Evans for a survey of research on the regime-switching view of the peso problem.

<sup>8</sup>A disturbance is an unpredictable event that affects the economy. Examples include dramatic changes in oil prices, weather-related catastrophes, or technological innovation.

economy: they happen repeatedly but infrequently. We can easily see how this regime-switching instability could give rise to peso problems. Suppose the economy has been in one regime for a long time, but people now think there is a sizable chance that it will switch to another regime. Their behavior, which reflects their belief that the economy may switch regimes, could be hard to interpret if we looked just at recent history and falsely assumed the economy would always stay in the current regime.

How prevalent is this regime-switching instability? We see it in many economic and financial variables. As an example, consider output growth over the business cycle. Recessions are repeated but infrequent events—there have been nine recessions since World War II. The economy behaves differently in recessions than in expansions. In recessions, unemployment rises, real output falls, and investment and consumption drop. In expansions, unemployment falls, real output rises, and investment and consumption increase. We can think of recessions as one regime for the economy and expansions as another, different regime. Indeed, economists such as James Hamilton have successfully modeled real output growth in the United States as following re-

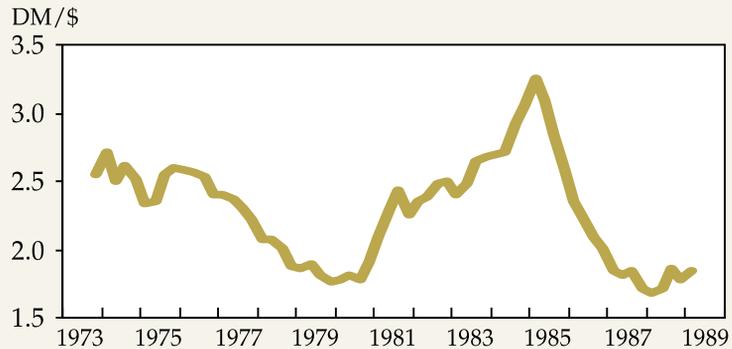
gime-switching behavior.<sup>9</sup>

Another variable that seems to undergo regime-switching is the exchange rate. Research by Charles Engel and James Hamilton and by Martin Evans and Karen Lewis found that, from

<sup>9</sup>See the article by James Hamilton for technical details on fitting regime-switching models to data.

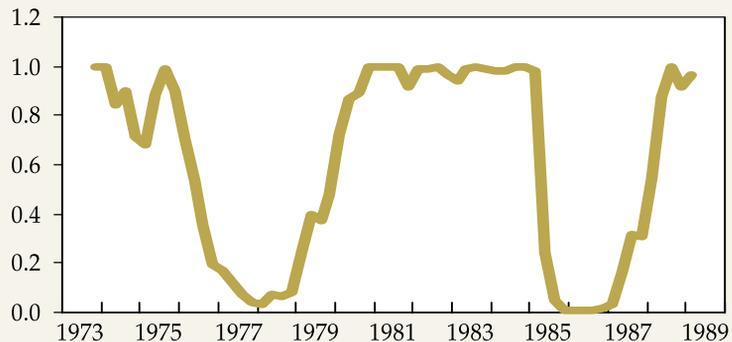
**FIGURE 1: Regime Switching and the Exchange Rate**

**Marks per Dollar Exchange Rate**



Source: Author's calculations

**Probability That Dollar Is in Appreciating Regime**



Source: Author's calculations

the early 1970s to the late 1980s, the U.S. dollar went through roughly three appreciating and two depreciating regimes against the German mark. My own calculations, using similar methods, confirm their results (Figure 1). The figure's upper panel shows the pattern of the mark/dollar exchange rate over the sample period. The figure's lower panel shows the probability that the dollar was in the appreciating regime. The closer the probability is to 1, the more likely that the dollar was in the appreciating regime. The closer the probability is to zero, the more certain that the dollar was in the depreciating regime. The bottom panel indicates that the dollar was in the depreciating regime twice and in the appreciating regime three times over the sample period.

Many economic variables display behavior that looks like regime switching. Properly interpreting economic forecasts and forecast errors can be difficult when this type of instability is present. In the mark/dollar example, just as we saw in the simple dollar/peso exchange-rate example, if forecasters expect a regime switch to occur and it does not, their forecasts may appear to be biased. Further, the bias will persist until the regime switch occurs or expectations are revised. But persistent bias doesn't necessarily mean that forecasters are doing something wrong. It may be that we don't have enough information to see the full range of possible outcomes that forecasters are considering. If we did, we could approximate how often regime switches are likely to occur, then use that information to help us interpret forecasts. If we had enough data to correctly assess the full range of possible outcomes, forecast errors that appear biased when we look at an incomplete sample would look unbiased when we used all the data. Good forecasts would *look* good.

#### **PESO PROBLEMS, ASSET VALUES, AND FUNDAMENTALS**

Exchange rates are not the only financial variables that can be influenced by peso problems.

Any asset whose current price depends on uncertain future payments could be affected. Take the case of stock prices. A standard model of stock prices relates the current price of a share to the stream of future dividends that the stockholder expects to receive from owning the share. All else equal, when expectations of future dividends are revised up, the price of stock goes up. When expected future dividends are revised down, the price of stock goes down. But in an economy where peso problems can occur, the link between stock prices and information about future dividends becomes more complicated.

Let's suppose the economy goes through regime changes that affect stock prices. In other words, the behavior of dividends over time depends on which regime the economy is in. In the "good" regime, dividend growth tends to be high. In the "bad" regime, dividend growth tends to be low. It can still be the case that in some years dividend growth is low in the good regime or high in the bad regime, but these are unusual outcomes. Since stock prices depend on expected future dividends, stock prices will also depend on which regime the economy is in. If the regime is good, stock prices will be high. If the regime is bad, stock prices will be low.

However, because dividend growth can be low in the good regime or high in the bad regime—although it doesn't happen very often—investors can't be certain which regime the economy is in at any given time. Therefore, investors must form a belief about the current regime based on their observations of the economy. New information on economic variables may strengthen or weaken investors' belief that the economy is in a particular regime. They may believe fairly strongly that the economy is in one particular regime, but it is unlikely they are ever absolutely certain. This uncertainty means that stock prices will be a weighted average of the good-regime dividends and the bad-regime dividends. The weights reflect the strength of investors' beliefs about which regime the economy is in.

In this environment, news about future dividends can affect stock prices in three ways: (1) there may be new information about good-regime dividends; (2) there may be new information about bad-regime dividends; (3) there may be new information that changes investors’ beliefs about which regime the economy is in.

Suppose investors believe the economy is currently in the good regime and news arrives that suggests future dividends in the good regime will be higher. As we have already stated, this news will lead to an increase in stock prices.

Alternatively, the economy might be in a good regime when news arrives that leads investors to believe that, were the economy to switch to the bad regime, dividends would be even lower than they previously thought. Dividends in the good regime may be unaffected by this news, but the stock price drops right away because the stock price is a weighted average of the good-regime dividends and the bad-regime dividends. So stock prices could change even if expected dividends in the current regime don’t change.<sup>10</sup>

Finally, new information may affect investors’ beliefs about which regime the economy is in. For example, they may become more confident that the economy is in the good regime. Recall that stock prices are a weighted average of the share price in each regime and that the weights depend on the strength of people’s beliefs about the economy’s current regime. If those beliefs change, stock prices will change.<sup>11</sup>

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<sup>10</sup>More technically, when peso problems are present, financial markets take account of future capital gains and losses associated with regime switches. See the 1996 article by Martin Evans for a detailed discussion.

<sup>11</sup>Researchers have fit regime-switching models to stock dividends and fundamentals. See the papers by Evans (1993); Shmuel Kandel and Robert Stambaugh; and Steve Cecchetti, Pok-Sang Lam, and Nelson Mark for examples. These papers illustrate the conditions under which peso problems can influence the behavior of stock returns.

Thus, in an environment where peso problems may be present, new information about dividends can affect stock prices in complicated ways. Stock prices may jump around even if there is no new information about dividends in the current regime. Stock-price models may also be affected by peso problems. If dividends do indeed depend on which regime the economy is in, an investigator may falsely conclude that a particular model performs poorly if he fails to account for regime switching when evaluating the model’s performance using historical data. Peso problems can lead to stock-price behavior that appears inconsistent with the view that stock markets are efficient and investors are rational (see *Stock Market Bubbles*).

**An Equity Return Puzzle.** A striking fact about the U.S. economy relative to the economies of other industrialized nations is the extent of the real appreciation of the stock market. The empirical facts are well laid out in a paper by Philippe Jorion and William Goetzmann: the real return on equities has averaged about 4.7 percent for the United States, compared to a median real return of 1.5 percent for a sample of 39 other countries.<sup>12</sup> No country has a higher real return than the United States over the period 1921 to 1995 (Figure 2), even though many other countries’ stock markets have long histories of continuous operation.

Why does the United States have this uniquely high real return to equities? Jorion and Goetzmann conjecture that it may be due to the fact that disasters have largely bypassed the U.S. economy. For example, at the beginning of the 1920s there were active stock markets in many countries, including France, Russia, Germany, Japan, and Argentina. But the stock markets of all of these countries were interrupted by war,

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<sup>12</sup>The real return on equities is measured as the realized return from capital gains and dividends minus the inflation rate.

## Stock Market Bubbles

The text focuses on the case where stock prices are determined by their dividends. But stock prices may have another component: a bubble. The bubble theory of stock prices suggests that stocks might go through long periods of under- or overvaluation relative to the value implied by their fundamentals.<sup>a</sup> One type of bubble is a rational bubble. Rational bubbles reflect investors' self-fulfilling beliefs that the price of a stock (or other asset) depends on variables unrelated to fundamentals. When bubbles are rational, there are no obvious profit opportunities to exploit; investors are efficiently using all relevant information to assess the asset's value.<sup>b</sup>

Whether rational bubbles can be found in asset prices is a matter of ongoing research for economists. Some statistical tests give results consistent with the presence of bubbles. Others show that bubble components seem to be unimportant.<sup>c</sup> One difficulty in testing for bubbles is that peso problems can give rise to the appearance of bubbles, even if they are not really there. Take the case where dividends are either in a good or bad regime. Suppose the economy is in a good (high-dividend) regime and positive news arrives about future dividends in the bad (low-dividend) regime. As described in the text, the current price of stocks will adjust to this news, even though dividends and fundamentals in the current regime may be unchanged. The change in the price of stocks might therefore be unrelated to the observed fundamentals in the current regime: it looks like a bubble. Thus, environments in which peso problems are present may make it look as if there is a bubble component to asset prices even when asset prices are actually being driven only by their fundamentals.

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<sup>a</sup>Fundamentals are the factors that economic theory suggests are important determinants of stock prices. They include such variables as profits, interest rates, and dividends.

<sup>b</sup>See the article by Lee Ohanian for more on rational bubbles in asset prices.

<sup>c</sup>See the article by Ohanian for a review of the literature on testing for bubbles. The evidence is mixed. One major problem in testing for bubbles is that it involves a joint test of a particular model of asset prices and the presence of a bubble. That is, researchers may find evidence for bubbles simply because their model of fundamentals is wrong.

hyperinflation, or political turmoil.

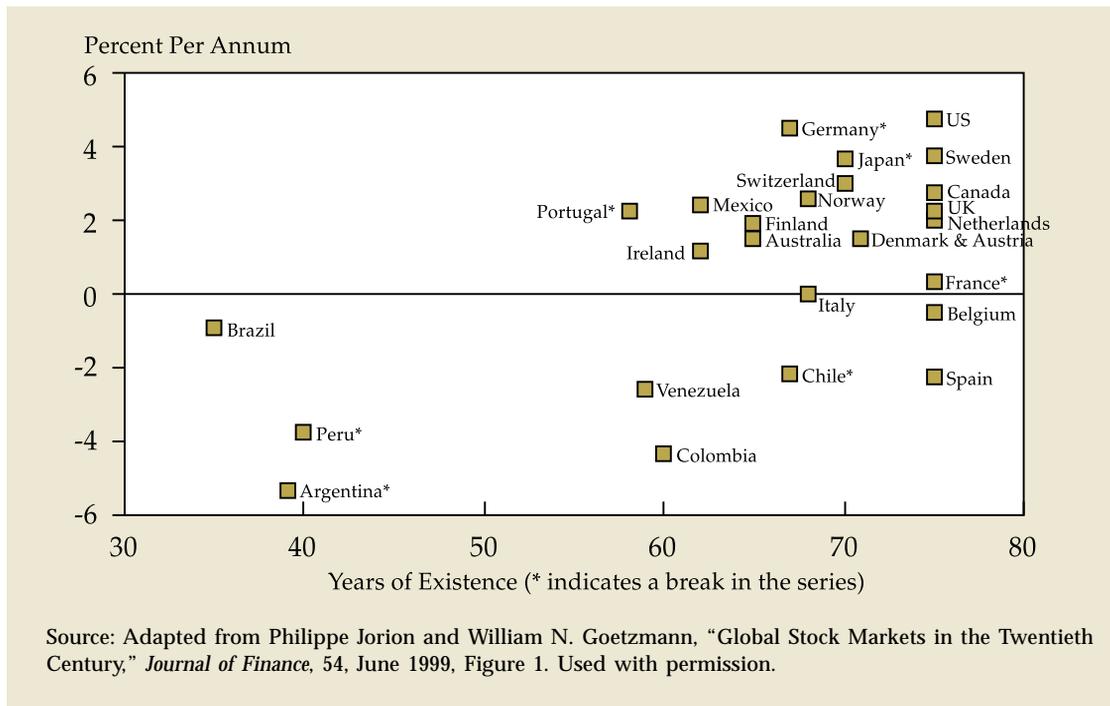
Presumably investors thought there was some probability that the U.S. market would be disrupted as well. But this event has not occurred, so historical equity returns have not reflected it. The large realized return in the United States may be tied to investors' recognition of the possibility of economic disruption and stock market interruption that never materialized—it may be, in part, a peso problem.

Investors generally do not like risk. Risk-averse stock market investors want a high return on investment in normal times to compensate them for the risk of the extreme losses they would incur if the stock market crashed or was interrupted by war or political turmoil. The United States has not experienced the extreme financial market disruptions that many other countries have. Perhaps, by the luck of the draw, U.S. stockholders have been rewarded for catastrophic events that happened not to occur.<sup>13</sup>

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<sup>13</sup>The real return on equities can be interpreted as an *equity premium*. A very influential statement of the equity premium puzzle in the U.S. data is the paper by Rajnish Mehra and Edward Prescott. Building on Mehra and Prescott, the paper by Thomas Rietz attempts to explain the equity premium puzzle using a model that has a peso problem environment. More recently, the paper by Jean-Pierre Danthine and John Donaldson investigates peso problem implications for the equity premium in a production economy. Other research has tried to explain the equity premium puzzle in a model where stock market fundamentals follow a regime-switching process. These efforts have been less

**FIGURE 2: Real Returns on Global Stock Markets**



**Peso Problems Spell Trouble for Value At Risk Models.** Value at risk (VAR) models estimate the largest loss a portfolio of assets is likely to suffer under relatively normal circumstances. Financial institutions use VAR models to determine the potential losses on their portfolios.<sup>14</sup> For example, a bank may want to know the maximum loss it might incur on its portfolio over a specific period. A VAR calculation might show that, on average, in 95 trading days out of 100, the maximum loss on the bank’s portfolio is not expected to exceed \$10 million in a day.

VAR models are constructed using historical

returns on the assets that make up an institution’s portfolio. Because VAR models rely so heavily on the historical pattern of asset returns, they may be unreliable in environments where peso problems are present.

Suppose that the day-to-day change in asset returns switches between small-change and large-change regimes. If a VAR model is constructed using historical data from only the small-change regime, it would understate the maximum loss a portfolio would suffer should asset returns switch to the large-change regime. A VAR model would be less likely to understate potential losses if the historical data used to construct it included both small-change and large-change regimes. In practice, though, VAR models tend to weight the most recent observations on historical returns most heavily. As we have seen, when peso problems are present, the recent past is not a good guide to the true underlying distri-

successful. See the 1996 survey article by Martin Evans for a technical discussion and references.

<sup>14</sup>See the 1996 article by Greg Hopper for more on VAR models.

bution of asset returns. Thus, VAR models may not accurately estimate the maximum loss a portfolio may suffer.

## CONCLUSION

Peso problems can arise when people assign a positive probability to events that might occur but that are not well-represented in historical data. Because asset prices embody the financial market's perceived probabilities about possible future values of economic variables, they are particularly sensitive to peso problems. Peso problems do not reflect a market failure or a market inefficiency. Rather, peso problems reflect economic analysts' difficulties in using historical data to properly model people's expectations about the future. While the peso problem most commonly comes up when analyzing foreign-exchange markets, we have seen that it may affect any asset market where expectations determine prices. The principal consequence of the

peso problem is that it makes it more difficult to correctly interpret the predictions of economic forecasts and asset-pricing models.

Whether peso problems contribute to asset-pricing anomalies is largely an empirical issue. We have discussed mechanisms by which peso problems can potentially affect asset prices. The principal difficulty in studying peso problems is how to model people's expectations when the economic environment is unstable. Small changes in expectations can often lead to large changes in people's behavior and, thus, in the behavior of economic variables such as asset prices. The literature on testing for the presence of peso problems and the literature on building economic models that incorporate peso-problem explanations of asset-price behavior are promising but still new. Nonetheless, the literature makes clear that it can be dangerous to base forecasts about the future behavior of financial variables solely on their recent behavior.

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