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# Noise

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**ABSTRACT**

The effects of noise on the world, and on our views of the world, are profound. Noise in the sense of a large number of small events is often a causal factor much more powerful than a small number of large events can be. Noise makes trading in financial markets possible, and thus allows us to observe prices for financial assets. Noise causes markets to be somewhat inefficient, but often prevents us from taking advantage of inefficiencies. Noise in the form of uncertainty about future tastes and technology by sector causes business cycles, and makes them highly resistant to improvement through government intervention. Noise in the form of expectations that need not follow rational rules causes inflation to be what it is, at least in the absence of a gold standard or fixed exchange rates. Noise in the form of uncertainty about what relative prices would be with other exchange rates makes us think incorrectly that changes in exchange rates or inflation rates cause changes in trade or investment flows or economic activity. Most generally, noise makes it very difficult to test either practical or academic theories about the way that financial or economic markets work. We are forced to act largely in the dark.

I USE THE WORD "noise" in several senses in this paper.

In my basic model of financial markets, noise is contrasted with information. People sometimes trade on information in the usual way. They are correct in expecting to make profits from these trades. On the other hand, people sometimes trade on noise as if it were information. If they expect to make profits from noise trading, they are incorrect. However, noise trading is essential to the existence of liquid markets.

In my model of the way we observe the world, noise is what makes our observations imperfect. It keeps us from knowing the expected return on a stock or portfolio. It keeps us from knowing whether monetary policy affects inflation or unemployment. It keeps us from knowing what, if anything, we can do to make things better.

In my model of inflation, noise is the arbitrary element in expectations that leads to an arbitrary rate of inflation consistent with expectations. In my model of business cycles and unemployment, noise is information that hasn't arrived yet. It is simply uncertainty about future demand and supply conditions within and across sectors. When the information does arrive, the number of sectors where there is a good match between tastes and technology is an index of economic activity. In my model of the international economy, changing relative prices become noise that makes it difficult to see that demand and supply

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conditions are largely independent of price levels and exchange rates. Without these relative price changes, we would see that a version of purchasing power parity holds most of the time.

I think of these models as equilibrium models. Not rational equilibrium models, because of the role of noise and because of the unconventional things I allow an individual's utility to depend on, but equilibrium models nonetheless. They were all derived originally as part of a broad effort to apply the logic behind the capital asset pricing model to markets other than the stock market and to behavior that does not fit conventional notions of optimization.

These models are in very different fields: finance, econometrics, and macroeconomics. Do they have anything in common other than the use of the word "noise" in describing them? The common element, I think, is the emphasis on a diversified array of unrelated causal elements to explain what happens in the world. There is no single factor that causes stock prices to stray from theoretical values, nor even a small number of factors. There is no single variable whose neglect causes econometric studies to go astray. And there is no simple single or multiple factor explanation of domestic or international business fluctuations.

While I have made extensive use of the work of others, I recognize that most researchers in these fields will regard many of my conclusions as wrong, or untestable, or unsupported by existing evidence. I have not been able to think of any conventional empirical tests that would distinguish between my views and the views of others. In the end, my response to the skepticism of others is to make a prediction: someday, these conclusions will be widely accepted. The influence of noise traders will become apparent. Conventional monetary and fiscal policies will be seen as ineffective. Changes in exchange rates will come to provoke no more comment than changes in the real price of an airline ticket.

Perhaps most important, research will be seen as a process leading to reliable and relevant conclusions only very rarely, because of the noise that creeps in at every step.

If my conclusions are not accepted, I will blame it on noise.

## I. Finance

Noise makes financial markets possible, but also makes them imperfect.[1]

If there is no noise trading, there will be very little trading in individual assets.[2] People will hold individual assets, directly or indirectly, but they will rarely trade them. People trading to change their exposure to broad market risks will trade in mutual funds, or portfolios, or index futures, or index options. They will have

[1] The concept of noise trading and its role in financial markets that I develop in this paper was developed through conversations with James Stone.

[2] Jaffe and Winkler [31] have a model where the traders who make speculative markets stable are those who trade to adjust their risk level or who misperceive their forecasting ability or who trade for reasons other than maximizing expected return for a given level of risk. Figlewski [23] has a model where there are two types of traders who differ in forecasting ability. Since neither kind of trader explicitly takes into account the information the other kind of trader has, each is to some degree trading on noise.

little reason to trade in the shares of an individual firm.[3] People who want cash to spend or who want to invest cash they have received will increase or decrease their positions in short term securities, or money market accounts, or money market mutual funds, or loans backed by real estate or other assets.

A person with information or insights about individual firms will want to trade, but will realize that only another person with information or insights will take the other side of the trade. Taking the other side's information into account, is it still worth trading? From the point of view of someone who knows what both the traders know, one side or the other must be making a mistake.[4] If the one who is making a mistake declines to trade, there will be no trading on information.

In other words, I do not believe it makes sense to create a model with information trading but no noise trading where traders have different beliefs and one trader's beliefs are as good as any other trader's beliefs. Differences in beliefs must derive ultimately from differences in information.[5] A trader with a special piece of information will know that other traders have their own special pieces of information, and will therefore not automatically rush out to trade.

But if there is little or no trading in individual shares, there can be no trading in mutual funds or portfolios or index futures or index options, because there will be no practical way to price them. The whole structure of financial markets depends on relatively liquid markets in the shares of individual firms.

Noise trading provides the essential missing ingredient. Noise trading is trading on noise as if it were information. People who trade on noise are willing to trade even though from an objective point of view they would be better off not trading. Perhaps they think the noise they are trading on is information. Or perhaps they just like to trade.[6]

With a lot of noise traders in the market, it now pays for those with information to trade. It even pays for people to seek out costly information which they will then trade on. Most of the time, the noise traders as a group will lose money by trading, while the information traders as a group will make money.

[3] Rubinstein [54], Milgrom and Stokey [50], and Hakansson, Kunkel, and Ohlson [30] show in a state preference world that differences in information may affect prices without causing people to trade. Grossman and Stiglitz [28] show that there may be no equilibrium when rational investors trade in the market portfolio. Grossman [27] shows the same thing for a world with trading in individual assets. Diamond and Verrecchia [21] redefine a rational expectations equilibrium in the presence of noise and show the conditions under which their equilibrium exists. In Tirole's model [61], "speculation" relies on inconsistent plans, and thus is ruled out by rational expectations. Kyle [36], [37], [38] and Grinblatt and Ross [26] look at quite different models of equilibrium where traders have market power. Kyle specifically examines the effects of changing the number of noise traders in both kinds of equilibrium.

[4] This assumes that the traders start with well diversified portfolios. In Admati [1], the traders start with suboptimal portfolios of assets.

[5] Varian [64] distinguishes between "opinions" and "information." He says that only differences in opinions will generate trading. In the kind of model he is working with, I think that differences of opinion will not exist.

[6] In Laffont [39], traders gather costly information because it has direct utility for reasons other than trading. Once they have it, they trade on it. If people start with efficient portfolios, though, even the arrival of free information may not make them want to trade. We may need to introduce direct utility of trading to explain the existence of speculative markets.

The more noise trading there is, the more liquid the markets will be, in the sense of having frequent trades that allow us to observe prices. But noise trading actually puts noise into the prices. The price of a stock reflects both the information that information traders trade on and the noise that noise traders trade on.

As the amount of noise trading increases, it will become more profitable for people to trade on information, but only because the prices have more noise in them. The increase in the amount of information trading does not mean that prices are more efficient. Not only will more information traders come in, but existing information traders will take bigger positions and will spend more on information. Yet prices will be less efficient.[7] What's needed for a liquid market causes prices to be less efficient.

The information traders will not take large enough positions to eliminate the noise. For one thing, their information gives them an edge, but does not guarantee a profit. Taking a larger position means taking more risk. So there is a limit to how large a position a trader will take. For another thing, the information traders can never be sure that they are trading on information rather than noise. What if the information they have has already been reflected in prices? Trading on that kind of information will be just like trading on noise.[8] Because the actual return on a portfolio is a very noisy estimate of expected return, even after adjusting for returns on the market and other factors, it will be difficult to show that information traders have an edge. For the same reason, it will be difficult to show that noise traders are losing by trading. There will always be a lot of ambiguity about who is an information trader and who is a noise trader.

The noise that noise traders put into stock prices will be cumulative, in the same sense that a drunk tends to wander farther and farther from his starting point. Offsetting this, though, will be the research and actions taken by the information traders. The farther the price of a stock gets from its value, the more aggressive the information traders will become. More of them will come in, and they will take larger positions. They may even initiate mergers, leveraged buyouts, and other restructurings.

Thus the price of a stock will tend to move back toward its value over time.[9] The move will often be so gradual that it is imperceptible. If it is fast, technical traders will perceive it and speed it up. If it is slow enough, technical traders will not be able to see it, or will be so unsure of what they see that they will not take large positions.[10]

Still, the farther the price of a stock moves away from value, the faster it will tend to move back. This limits the degree to which it is likely to move away from

[7] This result is specific to a model where noise traders trade on noise as if it were information. In Kyle's [36], [37], [38] model, having more noise traders can make markets more efficient.

[8] Arrow [4] says that excessive reaction to current information characterizes all the securities and futures markets. If this is true, it could be caused by trading on information that has already been discounted.

[9] Merton [47] describes a model where long run prices are efficient but short run prices need not be.

[10] Summers [60] emphasizes the difficulty in telling whether markets are efficient or not. This difficulty affects market participants and researchers alike.

value. All estimates of value are noisy, so we can never know how far away price is from value.

However, we might define an efficient market as one in which price is within a factor of 2 of value, i.e., the price is more than half of value and less than twice value.[11] The factor of 2 is arbitrary, of course. Intuitively, though, it seems reasonable to me, in the light of sources of uncertainty about value and the strength of the forces tending to cause price to return to value. By this definition, I think almost all markets are efficient almost all of the time. "Almost all" means at least 90%.

Because value is not observable, it is possible for events that have no information content to affect price. For example, the addition of a stock to the Standard & Poors 500 index will cause some investors to buy it. Their buying will force the price up for a time. Information trading will force it back, but only gradually.[12]

Similarly, when a firm with two classes of common stock issues more of one class, the price of the class of stock issued will decline relative to the price of the class of stock not issued.[13]

Both price and value will look roughly like geometric random walk processes with non-zero means. The means of percentage change in price and value will change over time. The mean of the value process will change because tastes and technology and wealth change. It may well decline when value rises, and rise when value declines. The mean of the price process will change because the relation between price and value changes (and because the mean of the value process changes). Price will tend to move toward value.

The short term volatility of price will be greater than the short term volatility of value. Since noise is independent of information in this context, when the variance of the percentage price moves caused by noise is equal to the variance of the percentage price moves caused by information, the variance of percentage price moves from day to day will be roughly twice the variance of percentage value moves from day to day. Over longer intervals, though, the variances will converge. Because price tends to return to value, the variance of price several years from now will be much less than twice the variance of value several years from now.

Volatilities will change over time. The volatility of the value of a firm is affected by things like the rate of arrival of information about the firm and the firm's leverage. All the factors affecting the volatility of a firm's value will change. The volatility of price will change for all these reasons and for other reasons as well. Anything that changes the amount or character of noise trading will change the volatility of price.

Noise traders must trade to have their influence. Because information traders trade with noise traders more than with other information traders, cutting back on noise trading also cuts back on information trading. Thus prices will not move

[11] I think this puts me between Merton [49] and Shiller [57], [58]. Deviations from efficiency seem more significant in my world than in Merton's, but much less significant in my world than in Shiller's.

[12] This effect was discovered independently by Shleifer [59] and Gurel and Harris [29].

[13] Loderer and Zimmermann [43] discovered this effect in connection with offerings in Switzerland, where multiple classes of stock are common.

as much when the market is closed as they move when the market is open.[14] The relevant market here is the market on which most of the noise traders trade.

Noise traders may prefer low-priced stocks to high-priced stocks. If they do, then splits will increase both the liquidity of a stock and its day-to-day volatility. Low-priced stocks will be less efficiently priced than high-priced stocks.[15]

The price of a stock will be a noisy estimate of its value. The earnings of a firm (multiplied by a suitable price-earnings ratio) will give another estimate of the value of the firm's stock.[16] This estimate will be noisy too. So long as noise traders do not always look at earnings in deciding how to trade, the estimate from earnings will give information that is not already in the estimate from price.[17]

Because an estimate of value based on earnings will have so much noise, there will be no easy way to use price-earnings ratios in managing portfolios. Even if stocks with low price-earnings ratios have higher expected returns than other stocks, there will be periods, possibly lasting for years, when stocks with low price-earnings ratios have lower returns than other comparable stocks.

In other words, noise creates the opportunity to trade profitably, but at the same time makes it difficult to trade profitably.

## II. Econometrics

Why do people trade on noise?

One reason is that they like to do it. Another is that there is so much noise around that they don't know they are trading on noise. They think they are trading on information.[18]

Neither of these reasons fits into a world where people do things only to maximize expected utility of wealth, and where people always make the best use of available information. Once we let trading enter the utility function directly (as a way of saying that people like to trade), it's hard to know where to stop. If anything can be in the utility function, the notion that people act to maximize expected utility is in danger of losing much of its content.

So we want to be careful about letting things into the utility function. We want to do it only when the evidence is compelling. I believe that this is such a case.

[14] French and Roll [25] find that the volatilities of stock returns are much lower across periods when markets are closed than across periods when markets are open.

[15] Ohlson and Penman [53] find that when stocks split, their return volatilities go up on the ex-split date by an average of about 30%. This may be due to a higher proportion of noise traders, though they also find no increase in trading volume on the ex-split date. Amihud [3] feels that another possible explanation for this result is the increase in the bid-asked spread following a stock split.

[16] For a discussion of the relation between earnings and stock price, see Black [13].

[17] Basu [5] summarizes the evidence that stocks with high earnings-price ratios have higher expected returns than stocks with low earnings-price ratios, even after controlling for size of firm and risk. DeBondt and Thaler [20] give more evidence on the existence of temporary dislocations in price, and on the psychological factors that may influence the noise traders who create these opportunities.

[18] Kahneman and Tversky [32] have a more sophisticated model of why people make decisions for what are seemingly non-rational reasons. Their theory may help describe the motivation of noise traders. For applications of their theory to economics and finance, see Russell and Thaler [55].

Another such case is dividend payments by firms. Given our tax laws, it seems clear that share repurchase in a non-systematic way is better than payment of dividends. If people want to maximize only expected utility of after-tax wealth, there will be no reason for firms to pay regular dividends. And when they do pay dividends, they will apologize to the stockholders (at least to individual stockholders) for causing them the discomfort of extra taxes.[19]

The idea that dividends convey information beyond that conveyed by the firm's financial statements and public announcements stretches the imagination.[20] It is especially odd that some firms pay dividends while making periodic offerings of common stock that raise more money than the firms are paying in dividends. For such firms, we cannot say that dividends force the firm to go through the rigors of a public offering of stock. Even if they pay no dividends, they will still be issuing common stock.[21]

I think we must assume that investors care about dividends directly. We must put dividends into the utility function.

Perhaps we should be happy that we can continue to think in terms of expected utility at all. There is considerable evidence now that people do not obey the axioms of expected utility. Of special concern is the finding that people will take certain gambles to avoid losses, but will refuse the same gambles when they involve prospective gains. Can this be consistent with risk aversion?[22]

I think that noise is a major reason for the use of decision rules that seem to violate the normal axioms of expected utility. Because there is so much noise in the world, people adopt rules of thumb. They share their rules of thumb with each other, and very few people have enough experience with interpreting noisy evidence to see that the rules are too simple. Over time, I expect that the transmission through the media and through the schools of scientific ways of interpreting evidence will gradually make the rules of thumb more sophisticated, and will thus make the expected utility model more valid.

Even highly trained people, though, seem to make certain kinds of errors consistently. For example, there is a strong tendency in looking at data to assume that when two events frequently happen together, one causes the other. There is an even stronger tendency to assume that the one that occurs first causes the one that occurs second. These tendencies are easy to resist in the simplest cases. But they seem to creep back in when econometric studies become more complex. Sometimes I wonder if we can draw any conclusions at all from the results of regression studies.

Because there is so much noise in the world, certain things are essentially unobservable.

For example, we cannot know what the expected return on the market is. There is every reason to believe that it changes over time, and no particular

[19] In Black [11], I described the dividend puzzle. The solution to the puzzle, I now believe, is that we must put dividends directly into the utility function. For one way of putting dividends into the utility function, see Shefrin and Statman [56]. For another way of resolving the dividend puzzle, and of relating it to the capital structure puzzle, see Myers [52].

[20] For a statement of the case that dividends do convey information, see Miller [51].

[21] Kalay and Shimrat [33] observe, however, that firms issuing common stock do tend to reduce their dividends.

[22] This phenomenon is discussed extensively by Tversky and Kahneman [63].

reason to believe that the changes occur smoothly. We can use the average past return as an estimate of the expected return, but it is a very noisy estimate.[23]

Similarly, the slopes of demand and supply curves are so hard to estimate that they are essentially unobservable. Introspection seems as good a method as any in trying to estimate them. One major problem is that no matter how many variables we include in an econometric analysis, there always seem to be potentially important variables that we have omitted, possibly because they too are unobservable.[24]

For example, wealth is often a key variable in estimating any demand curve. But wealth is itself unobservable. It's not even clear how to define it. The market value of traded assets is part of it, but the value of non-traded assets and especially of human capital is a bigger part for most individuals. There is no way to observe the value of human capital for an individual, and it is not clear how we might go about adding up the values of human capital for individuals to obtain a value of human capital for a whole economy.

I suspect that if it were possible to observe the value of human capital, we would find it fluctuating in much the same way that the level of the stock market fluctuates. In fact, I think we would find fluctuations in the value of human capital to be highly correlated with fluctuations in the level of the stock market, though the magnitude of the fluctuations in the value of human capital is probably less than the magnitude of the fluctuations in the level of the stock market.[25]

It's actually easier to list observables than unobservables, since so many things are unobservable. The interest rate is observable. If there were enough trading in CPI futures, the real interest rate would be observable. So far, though, there are not enough noise traders in CPI futures to make it a viable market.

Stock prices and stock returns are observable. The past volatility of a stock's returns is observable, and by using daily returns we can come close to observing the current volatility of a stock's returns. We can also come close to observing the correlations among the returns on different stocks.

Economic variables seem generally less observable than financial variables. The prices of goods and services are hard to observe, because they are specific to location and terms of trade much more than financial variables. Quantities are hard to observe, because what is traded differs from place to place and through time.

Thus econometric studies involving economic variables are hard to interpret for two reasons: first, the coefficients of regressions tell us little about causal relations even when the variables are observable; and second, the variables are subject to lots of measurement error, and the measurement errors are probably related to the true values of the variables.

Perhaps the easiest economic variable to observe is the money stock, once we agree on a definition for it. I think that accounts for some of the fascination it holds for economic theorists. In my view, though, this easiest to observe of

[23] Merton [48] shows how difficult it is to estimate the expected return on the market.

[24] Leamer [40] and Black [16] discuss the profound difficulties with conventional econometric analyses.

[25] Fama and Schwert [22] study the relation between human capital and the stock market. They do not find a close relation.

economic variables has no important role in the workings of the economy. Money is important, but the money stock is not.

Still, the money stock is correlated with every measure of economic activity, because the amount of money used in trade is related to the volume of trade. This correlation implies neither that the government can control the money stock nor that changes in the money stock influence economic activity.[26]

Empirical studies in finance are easier to do than empirical studies in economics, because data on security prices are of generally higher quality than the available data in economics. But there are major pitfalls in trying to interpret even the results of studies of security prices.

For example, many recent empirical studies in finance have taken the form of "event studies," which look at stock price reactions to announcements that affect a firm.[27] If there were no noise in stock prices, this would be a very reliable way to find out how certain events affect firms. In fact, though, the stock price reaction tells us only how investors think the events will affect firms, and investors' thoughts include both noise and information.

Moreover, if investors care directly about certain attributes of a firm (such as its dividend yield) independently of how those attributes affect its value, event studies will pick up these preferences along with the effects of the events on value. When a firm increases its dividend, its price may go up because investors like dividends, even though the present value of its future dividends in a world where the marginal investor is taxed may have gone down.

Is there any solution to these problems? No single, simple solution, I believe. Correlations among economic and financial variables do give us some information of value. Experimental studies in economics and finance have value. Analysis of "stylized facts" is often useful. Unusual events can provide special insight. In the end, a theory is accepted not because it is confirmed by conventional empirical tests, but because researchers persuade one another that the theory is correct and relevant.[28]

## III. Macroeconomics

If business cycles were caused by unanticipated shifts in the general price level or in the level of government spending, we might not call that kind of uncertainty noise. It's too simple. Because it is so simple, I don't think this kind of uncertainty can play a major role in business cycles. I have not seen any models with all the kinds of markets we have in the economy where shifts in the general price level or in the level of government spending are large enough or powerful enough or unanticipated enough to cause significant business cycles.[29]

On the other hand, if business cycles are caused by unanticipated shifts in the

[26] King and Plosser [35] look at the possibility that economic activity influences the money stock rather than the other way around.

[27] For a typical event study, together with discussion of a factor that may make event studies hard to interpret properly, see Kalay and Loewenstein [34].

[28] This point of view is taken in part from McCloskey [46].

[29] For a review of research in business cycle theory, see Zarnowitz [65]. For an attempt to explain large business cycles with seemingly innocent changes in the price level, see Mankiw [45].

entire pattern of tastes and technologies across sectors, we might call that uncertainty noise. I believe that these shifts are significant for the economy as a whole because they do not cancel in any meaningful sense. The number of sectors in which there is a match between tastes and technology varies a lot over time. When it is high, we have an expansion. When it is low, we have a recession.[30]

One reason the shifts do not cancel is that they are not independent across sectors. When the costs of producing goods and services that require oil are high, they will be high across many related sectors. When demand for vacation homes is high, it will be high for many kinds of related services at the same time. The more we divide sectors into subsectors, the more related the subsectors will be to one another.

It is not clear whether the increasing diversity and specialization that go along with the transition from a simple economy to a complex modern economy will be associated with larger or smaller business cycles. On the one hand, the diversity in a more complex economy means that a single crop failure or demand shock cannot have such a devastating effect; but on the other hand, the specialization in a more complex economy means that when there is a mismatch between tastes and technology, it is costly to move skills and machines between sectors to correct the mismatch.

Money and prices play no role in this explanation. Everything is real.[31] For a small sample of the kind of thing I have in mind, suppose I gear up to produce dolls, while you gear up to produce art books. If it turns out that you want dolls and I want art books, we will have a boom. We will both work hard, and will exchange our outputs and will have high consumption of both dolls and art books. But if it turns out that you want action toys and I want science books, we will have a bust. The relative price of toys and books may be the same as before, but neither of us will work so hard because we will not value highly that which we can exchange our outputs for.

This is just one kind of example. The variations can occur in use of machines as well as in use of people, and the underlying uncertainty can concern what we can make as well as what we want.

Unanticipated shifts in tastes and technology within and across sectors is what we call information in discussing financial markets. In economic markets, it seems more appropriate to call these shifts noise, to contrast them with shifts in the aggregates that conventional macroeconomic models focus on. In other words, the cause of business cycles is not a few large things that can be measured and controlled, but many small things that are difficult to measure and essentially impossible to control.

Noise or uncertainty has its effects in economic markets because there are costs in shifting physical and human resources within and between sectors. If skills and capital can be shifted without cost after tastes and technology become

[30] For a more extensive discussion of this point of view, see Black [15], [16].

[31] The most closely related work in the more conventional business cycle literature is Long and Plosser [44] and Lilien [41]. Bernanke [6] has an entirely real explanation for swings in the production of durable goods: it is sectoral in the sense that specific investments are irreversible. Topel and Weiss [62] use uncertainty about employment conditions in different sectors to help explain unemployment; their methods can also be applied, I think, to explaining cyclical fluctuations in unemployment.

known, mismatches between what we can do and what we want to do will not occur.

The costs of shifting real resources are clearly large, so it is plausible that these costs might play a role in business cycles. The costs of putting inflation adjustments in contracts or of publicizing changes in the money stock or the price level seem low, so it is not plausible that these costs play a significant role in business cycles.

Presumably the government does not have better information about the details of future supply and demand conditions within and between sectors than the people working in those sectors. Thus there is little the government can do to help the economy avoid recessions. These unknown future details are noise to the workers and managers involved, and they are noise twice over to government employees, even those who collect statistics on individual industries.

I cannot think of any conventional econometric tests that would shed light on the question of whether my business cycle theory is correct or not. One of its predictions, though, is that real wages will fluctuate with other measures of economic activity. When there is a match between tastes and technology in many sectors, income will be high, wages will be high, output will be high, and unemployment will be low. Thus real wages will be procyclical. This is obviously true over long periods, as from the Twenties to the Thirties and from the Thirties to the Forties, but is also seems true over shorter periods, especially when overtime and layoffs are taken into account.[32]

How do inflation and money fit into this picture?

I believe that monetary policy is almost completely passive in a country like the U.S.[33] Money goes up when prices go up or when income goes up because demand for money goes up at those times. I have been unable to construct an equilibrium model in which changes in money cause changes in prices or income, but I have had no trouble constructing an equilibrium model in which changes in prices or income cause changes in money.[34]

Changes in money often precede changes in income, but this is not surprising, since demand for money can depend on expected income as well as current income. Changes in wealth (measured at market value) also precede changes in income.

In the conventional story, open market operations change perceived wealth, which leads to a change in demand for existing assets, and thus to a change in the price level. But open market operations have no effect on wealth when wealth is measured at market value. They merely substitute one form of wealth for another. Some say that open market operations cause a change in interest rates, which then have further effects on the economy. But this cannot happen in an equilibrium model. There is no temporary equilibrium, with the price level and rate of inflation unchanged, where a different interest rate will be equal to the certain component of the marginal product of capital. If we allow the price level

[32] Bils [7] reviews previous work in this area, and gives evidence that real wages are indeed procyclical.

[33] My views are explained more fully in Black [8], [9], [10].

[34] For an analysis of possible explanations for some of the correlations between money and other variables, see Cornell [18].

and rate of inflation to change, then there are many equilibria, but there are no rules to tell us how one is chosen over another. There is no logical story explaining how the change in money will cause a shift from one equilibrium to another.

If monetary policy doesn't cause changes in inflation, what does?

I think that the price level and rate of inflation are literally indeterminate. They are whatever people think they will be. They are determined by expectations, but expectations follow no rational rules. If people believe that certain changes in the money stock will cause changes in the rate of inflation, that may well happen, because their expectations will be built into their long term contracts.

Another way to make the same point is this. Within a sector, the prices of inputs and outputs are largely taken as given. Decisions on what and how much to produce are made taking these prices as given. Thus each sector assumes that the rates of inflation of its input and output prices are given. In my models, this includes the government sector in its role as supplier of money. If we are in an equilibrium with one expected rate of inflation (assuming neither gold prices or exchange rates are fixed), and everyone shifts to a lower expected rate of inflation, we will have (with only minor modifications) a new equilibrium.

One way to describe this view is to say that noise causes changes in the rate of inflation.

If we have a gold standard, where the price of gold is adjusted over time to make the general price level follow a desired path, and where the government stands ready to buy or sell gold at the temporarily fixed price without allowing its inventory to fluctuate much, then inflation will be controlled rather than random.[35] But it seems unlikely that we will adopt a gold standard of this kind or of any other kind anytime soon.

Similarly, if a small country adopts a policy of varying its exchange rate with a large country to make its price level follow a desired path, where its government stands ready to buy or sell foreign exchange at the temporarily fixed rate without allowing its foreign exchange inventory to fluctuate much, then its inflation rate will be controlled rather than random. This is possible for any country that has wealth and stable taxing power, because the country can always sell assets for foreign exchange, and can then buy the assets back (almost) with the foreign currency it obtains.

However, it is not clear what is gained by controlling the price level. If business cycles are caused by real factors rather than by things that are affected by the rate of inflation, then many of the reasons for controlling inflation vanish.

In my view, then, there is a real international equilibrium that is largely unaffected by price levels or monetary policies, except in countries with unstable financial markets or national debt that is large compared with taxable wealth. This real equilibrium involves a world business cycle and national business cycles driven by the degree to which there is a match between tastes and technology.

The real equilibrium also involves changing relative prices for all kinds of

[35] For an old version of this argument, see Fisher [24]. For a new version, together with discussion of the possibility of keeping gold inventories roughly fixed while controlling the price of gold and the price level, see Black [14].

goods and services, including relative prices for the "same" goods and services in different locations. Different locations can be around the corner or around the world. Since information and transportation are so costly (especially information), there is no form of arbitrage that will force the prices of similar goods and services in different locations to be similar.

Moreover, the real equilibrium involves constantly changing trade flows for various pairs of countries. There is no reason for trade to be balanced between any pair of countries either in the short run or in the long run. And an imbalance in trade has no particular welfare implications.[36]

Since the real equilibrium is fixed at a point in time, though it is continually changing through time, a higher domestic currency price for an item at one point in time will mean a higher domestic currency price for all items at that same point in time. There will be some lags in making price changes, and many lags in posting or reporting price changes, but these will not affect the equilibrium significantly.

If we were able to observe the economy at a given point in time with two different domestic price levels, we would see that the real equilibrium is largely independent of price levels and exchange rates, and we might call this situation "purchasing power parity." Since we must actually observe the economy as it evolves over time, we cannot see that purchasing power parity holds. We see relative price changes occurring, and fluctuations in the level of economic activity, while exchange rates and money stocks are changing. We think that exchange rates and money are causing relative price changes and business fluctuations.[37]

But that is only because the noise in the data is clouding our vision.

[36] This is a common result in international economics. For my treatment of it, see Black [12].

[37] Davutyan and Pippenger [19] suggest some ways in which standard tests of purchasing power parity may be flawed. Moreover, our tests of purchasing power parity are inadequate unless we consider transport costs, as Aizenman [2] notes. Transport costs can be very large for services and some goods.

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