A Theory of Asset Price Booms and Busts and the Uncertain Return to Innovation*

BY SATYAJIT CHATTERJEE

Many observers believe that turbulence in asset prices results from bouts of optimism and pessimism among investors that have little to do with economic reality. While psychology and emotions are no doubt important motivators of human actions, an explanation for asset price booms and busts that ignores the fact that humans are also *thinking* animals does not seem entirely satisfactory or plausible. In this article, Satyajit Chatterjee presents a counterpoint to the view that "it's all psychology." He reports on a theory of asset price booms and busts that is based entirely on rational decision-making and devoid of psychological elements. The explanation suggests that asset price booms and crashes are most likely to occur when the value of the asset in question depends on an innovation whose full profit potential is initially unknown to investors.

Asset prices, such as the price of company stock, the price of houses in a particular location, or the price of a foreign currency, can often rise strongly for many periods and then crash spectacularly. Does such turbulence in asset prices result from irrational behavior on the part of market participants, or does it have a basis in rational behavior?

Many observers believe that the turbulence in asset prices results from bouts of optimism and pessimism among investors that have little to do with economic reality. More than 60 years ago, John Maynard Keynes attributed these highs and lows in the stock market to the "animal spirits" that motivate humans to collectively take on or shun financial risk. Given the recent history of booms and crashes in the industrialized world, the influence of mass psychology on asset prices has once again come to the fore. People wonder how much of the frenetic buying and selling in capital markets around the world serves any useful social purpose.

While psychology and emotions are no doubt important motivators of human actions, an explanation for asset price booms and busts that ignores the fact that humans are also *thinking* animals does not seem entirely satisfactory or plausible. Why would investors believe that an asset will rise strongly in value unless there is, at some level, a good reason for such a belief? As a counterpoint to the view that "it's all psychology," this article reports on a theory of asset price booms and busts that is based entirely on rational decision-making and devoid of psychological elements. The explanation suggests that asset price booms and crashes are most likely to occur when the value of the asset in question depends on an innovation whose full profit potential is initially unknown to investors. As investors learn over time about what that earnings potential is, the price of the asset can rise strongly for a while and then crash. As an example, think of the advent of the World Wide Web in 1990, an innovation that opened the door to the commercialization of the Internet.[1] Initially, it was not evident

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*The views expressed here are those of the author and do not necessarily represent the views of the Federal Reserve Bank of Philadelphia or the Federal Reserve System.

[1] The concept of the World Wide Web (or simply the web) was proposed by the English computer scientist Tim Berners-Lee and the Belgian computer scientist Robert Cailliau in 1990. The originators conceived of the web as a vast information repository that anyone anywhere in the world could access via the Internet.

how to make money using the web, but many new ideas were tried and investors and entrepreneurs learned over time what worked and what did not.

PRIMER ON THE DETERMINATION OF ASSET PRICES

What theory do economists use to discuss the determination of asset prices? The most basic and simplest of such theories asserts that the price an investor will pay to buy an asset today is related to the dividend the investor expects to receive on the asset in the future and the price at which he expects to sell the asset at a future date. An example will make this clear. Suppose that a single share in the stock of company X promises to pay $5 in dividends one year from today. Also suppose that investors expect the price of this single stock to be $100 a year from today. Ignoring taxes, an investor who can put his money in the bank and earn a 5 percent interest rate will not be willing to pay more than $100 for the stock today. If he paid $100, he will earn $5 in dividends and then sell the asset for $100. Therefore, he will have $105 from his investment a year from today. He can get the same dollar amount by saving $100 in the bank and earning a 5 percent return on it. Therefore, the market price of the asset cannot exceed $100. The market price of the asset cannot fall below $100 either because, if it did, then all investors who currently have their money in the bank would be better off removing their funds from the bank and buying the asset. They would earn a higher rate of return on the stock than on their bank accounts.

A bit more formally, the theory asserts that the current price of the asset, call it P, is simply the present discounted value of the dividend to be given out next period, call it D, plus the expected price of the asset next period, call it P^e. As we just saw, it must be the case that the amount one can earn by keeping the money in the bank, namely, P(1+r) (where r is the interest rate on the bank deposit), must equal the amount one can earn from the stock, namely, $[D+P^e]$. Therefore, P(1+r) must equal $[(D+P^e]$, so P must equal $[D+P^e]\div(1+r)$. The essence of the economic theory of asset price determination is the idea that the rate of return on different but equally risky assets should be equalized. In the above example, we assumed that the return from holding the stock for one year was perfectly certain so that the rate of return on the stock had to equal the interest rate on bank deposits. If the return on the stock is uncertain, the theory takes into account that investors would demand a higher rate of return on the risky asset as compensation for bearing that risk and the price of the stock will be correspondingly lower, resulting in an expected capital gain.

> What theory do economists use to discuss the determination of asset prices?

DIVIDEND GROWTH AND GROWTH IN ASSET PRICES

This simple theory of asset price determination, when coupled with a theory of how expectations about the next period's asset price are formed, makes predictions about the level and growth of asset prices that depend only on fundamentals, in this case the dividend flow from the asset and the interest rate on bank accounts. This connection between fundamentals and asset prices can be somewhat subtle, and we will approach it through some simple examples.

Imagine that the dividend from the stock is the same each period and the interest rate on bank deposits is constant over time. In this situation, an investor might reason that whatever the price of the asset is today, it will be the same in the next period. After all, if neither the dividend nor the interest rate changes, why should the price of the asset change? This kind of reasoning — which is at the heart of the theory of expectation formation that economists call *rational expectations* — leads to the prediction that the price of the asset will be the (constant) dividend flow D divided by the (constant) interest rate r.[2]

However, if dividends are growing over time at some constant rate and the interest rate is constant over time, the same investor might now reason that since the asset is becoming more profitable over time, its price should increase over time at the same constant rate as that of dividends. With this guess about the behavior of future asset prices, the theory predicts that the price of the asset in period t will be the dividend to be given out next period, D, divided by the difference between the interest rate, r, and the growth rate of dividends, g. That is, the current asset price will simply be D divided by (r-g). Since the dividend given out each period is growing over time at rate g, this

[2] This formula can be obtained by solving the equation P = [D+P]/[1+r] for P (in terms of D and r). The investor's guess that if the dividend flow and the interest rate are both constant over time then the price of the asset will be constant over time is employed to replace P^e (the future price) with P (the current price). Notice that the investor's guess that the future price of the asset will be the same as it is today is indeed verified by the resulting formula for P: the formula depends only on D and r, both of which are constant over time.

formula confirms the investor's guess that the asset price will grow at the same constant rate as dividends.[3]

Thus, the simple theory of asset price determination links the growth in asset prices to the growth in dividends. But this simple theory does not come to grips with the behavior of asset prices during a boom. During a boom, asset prices seem to grow faster than the growth rate of dividends. As an example of this phenomenon, Figure 1 displays the time paths of the logarithm of the S&P 500 index and of the logarithm of earnings per share for the index for the period around the tech boom.[4] On a logarithmic scale, steeper lines imply faster growth, and we can see that between 1995 and 2001, the index grew at a faster rate, while the growth in earnings did not show any tendency to grow faster.

One can see the increase in the growth rate of stock prices even more clearly in the time path of the NASDAQ composite index.[5] Figure 2 plots the logarithm of the NASDAQ index for the same time period as in Figure 1. Between 1990 and 1995, the time path is more or less a straight line, which implies that the index grew at a roughly constant rate. Following 1995, however, the angle of the path tilts up, implying faster growth in asset prices. This continues until the market crash we associate with the end of the dot-com boom. Unfortunately, there is no easily available series on earnings

FIGURE 1

Earnings and Stock Prices: S&P 500

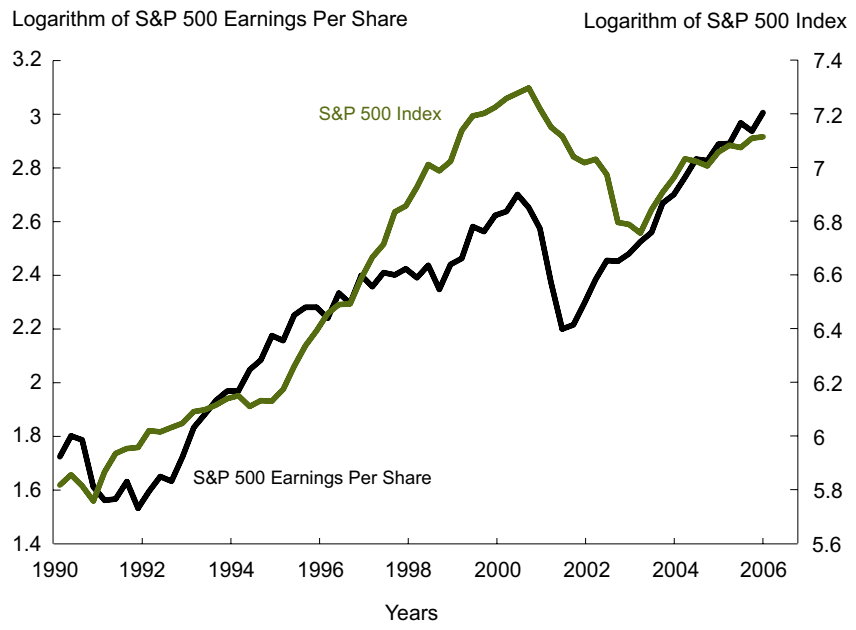
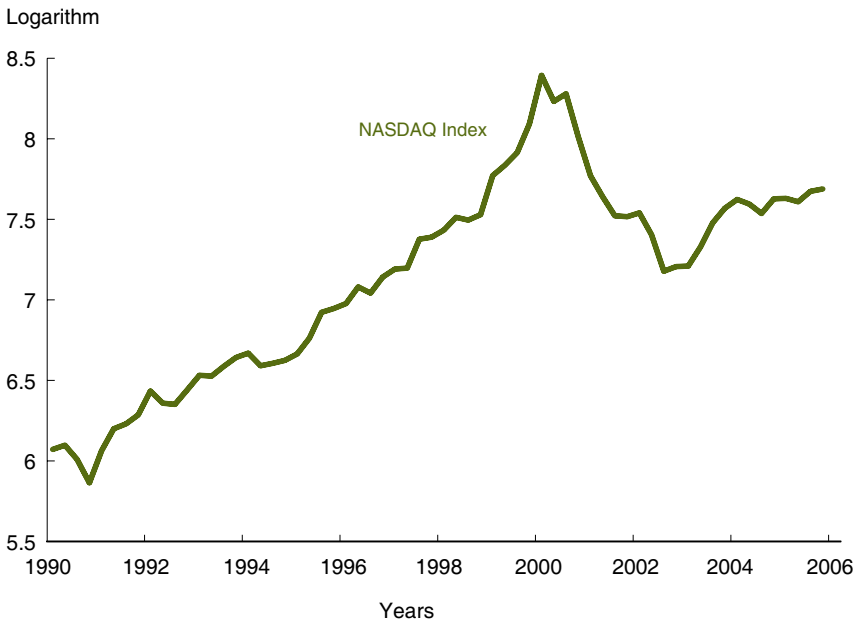


FIGURE 2

NASDAQ Index: Boom and Crash



[3] It is perhaps worth pointing out that the interest rate available on a bank account will typically depend on the dividend flow from other investments available in the economy. So, r and g will not be independent of each other. Indeed, the dependence of the interest rate on the dividend flow available in the economy is what guarantees that the interest rate, r, will always be greater than the growth rate, g. Without this ordering, the formula gives nonsensical results.

[4] The S&P 500 index is proportional to the average stock price of 500 large U.S.-based corporations whose shares are traded on U.S. stock markets. The theory outlined in the text applies equally well to such averages.

[5] The NASDAQ index is the average stock price of over 3,000 corporations (not necessarily U.S. based) whose shares are traded on U.S. stock markets and that are oriented toward high-technology areas.

growth for the NASDAQ index, but all anecdotal evidence suggests that there was no corresponding speed-up in the growth rate of earnings.

The apparent disconnect between the growth rate of fundamentals (in this case, earnings) and the growth rate of asset prices makes observers think that something other than fundamentals ("animal spirits" or mass psychology) is at work. While mass psychology may well influence asset prices, it turns out that the simple theory of asset price determination outlined above can shed considerable light on the origin and mechanics of asset price booms and crashes.

The key insight is that market participants' beliefs regarding how *long* dividend growth will continue may play a crucial role in generating an asset price boom and crash.[6] When there is an innovation, such as the World Wide Web, investors may be uncertain about the full profit potential of the innovation — that is, they do not know in advance how far, or in what ways, the World Wide Web can be used for commerce. This creates uncertainty about the duration of earnings growth. As the innovation continues to diffuse through the economy and earnings continue to grow, investors revise up their estimate of the profit potential of the innovation. This upward revision may temporarily make the asset price rise faster than earnings. When earnings growth comes to a halt and investors learn the limits of the innovation, the asset price crashes. Thus, a boom can happen without a speed-up in earnings growth, while the cessation of earnings growth can result in a crash.[7] These ideas are fleshed out in the next two sections.

[6] This discussion draws on the 1999 article by Joseph Zeira.

Cessation of Dividend Growth Can Induce an Asset Price Crash. As we have seen already, growth in dividends increases the price of the asset because the asset becomes more profitable for investors. Therefore, in order to value the asset today investors have to form beliefs about future dividend *growth*. In this situation, uncertainty about whether growth in dividends will continue or stop can have surprising consequences for the price of the asset.

Can uncertainty about the duration of dividend growth explain asset price booms and crashes?

Imagine that investors put a 50 percent probability on dividend growth coming to a stop next period and a 50 percent probability that dividends will continue to grow at the same rate as in the past. Then, if the growth in dividends does stop next period, the theory of asset price determination predicts that the price of the asset will *fall*. At first sight this might seem puzzling because the profitability of the asset hasn't fallen: The asset is generating the same dividend flow as it did in the previous period. However, investors yesterday had put an equal chance on dividends continuing to *grow* today and the price of the asset yesterday reflected that expectation. If dividends fail to grow today, the asset becomes less valuable to investors today compared with yesterday. Thus, the mere cessation of dividend growth will cause the asset price to fall.

Can uncertainty about the duration of dividend growth explain asset price booms and crashes? That is, can it provide an explanation for the phenomena displayed in Figures 1 and 2? To explore this question, we will work with a simple example. The interest rate available on bank accounts is taken to be 1 percent per quarter. Suppose that there is an asset whose dividend flow is currently $100. Next quarter, there is a ¾ probability that the asset's dividend flow will increase by 5 percent (i.e., rise to $105) and there is a ¼ probability that its dividend flow will stop growing and stay at $100 forever. If the dividend flow increases next quarter, the situation next quarter will be the same as in the current quarter: namely, there will be a ¾ probability that the dividend flow will increase by 5 percent again in the following quarter (to $110.25) and there will be a ¼ probability that the dividend flow will stabilize forever at $105. Thus, as long as dividends continue to grow, there is a constant probability that this growth will continue next period and a (complementary) constant probability that growth in dividends will come to a stop forever.

Figure 3 displays a snapshot of the time paths of the logarithms of

[7] From the point of view of valuing an asset, the main quantity of interest is the growth rate of earnings. But to assess the validity of an earnings-growth forecast, investors will examine many sources of information. For instance, they may track the increase in the number of visitors to a website as an indicator of commercial interest. During the tech boom, investor interest in various measures of Internet use (such as the number of websites and the number of "hits" per website) was quite intense, and these measures were used to justify very optimistic earnings forecasts for Internet-related businesses. The point, however, is that such optimism could be sustained because investors were truly uncertain about the profit potential of this new way of conducting commerce.

dividends and asset prices predicted by the simple theory of asset price determination. The theory predicts that as long as dividends continue to grow, the price of the asset will grow at the same rate as the growth in dividends. In the figure, this is what happens for the periods preceding period 45: The time plot of the logarithm of asset prices and dividends rises at the same rate. At period 45, however, dividends stop growing, and the time plot of the dividend path flattens out. As displayed, the cessation of dividend growth causes a crash in the asset price. Following the crash, the time path of the asset price flattens out as well: Recall that the theory of asset price determination predicts that if dividends are constant over time, so will be the price of the asset.[8]

The crash in the asset price reflects investors' re-assessment of the profitability of the asset. Prior to the cessation of dividend growth, investors placed a three in four chance on dividend growth continuing into period 45, a nine in 16 chance of dividend growth continuing into period 46, a 27 in 64 chance of growth continuing into period 47 and so on.[9] Consequently, the price of the asset in period 44 incorporated investors' belief that dividends will continue to rise in period 45 and beyond with high probability. When these beliefs are belied by events, the price of the asset tumbles.

It appears, then, that the simple theory of asset price determination predicts sudden drops in asset prices that stem simply from a downward re-assessment of the *growth* potential of the earnings flow underlying the asset. Because the bad news that leads to the crash concerns diminished prospects for future growth, the asset price may fall even if the current dividend flow does not fall.

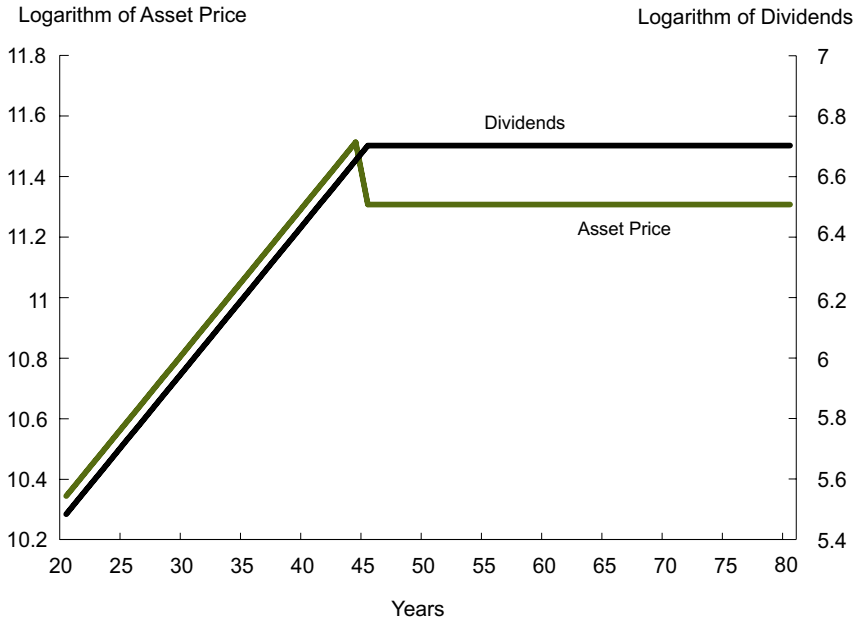
Learning About the Likely Duration of Dividend Growth Can Induce an Asset Price Boom and Crash. But how can this simple model of asset price determination account for the boom in the price of assets? As noted earlier, we cannot attempt to account for the tech boom in terms of faster dividend growth because there is no evidence of a speed-up in earnings growth during the boom phase.

It turns out that the model can account for the boom and the crash if we allow for the realistic possibility that investors' beliefs concerning the duration of dividend growth may evolve over time. Instead of imagining that investors assign a *constant* probability to dividend growth continuing (or, equivalently, a constant probability of it coming to an end), imagine that investors start off believing that dividend growth will last somewhere between eight and 15 years. That is, they believe that dividend growth will continue for sure until period 32 (since each period is a quarter, eight years amount to 32 quarters) and stop for sure by period 60. But they are uncertain about the duration of the expansion between these two dates.

Figure 4 displays the time plot of the logarithm of the asset price implied by these beliefs when dividend growth stops in period 45 (as before,

FIGURE 3

Asset Price Effects of a Cessation in Dividend Growth



[8] It is worth pointing out that in this example, the growth rate of dividends exceeds the interest rate on bank accounts (5 percent versus 1 percent). Nevertheless, the simple theory of asset price determination applies because investors recognize that dividend growth will not continue forever. According to the theory, the growth rate of dividends can be higher than the interest rate as long as the product of the probability of growth continuing and (1+g) is less than (1+r).

[9] The nine in 16 chance comes from recognizing that the probability that dividends will grow for two consecutive periods is simply the product of ¾ and ¾, or $(¾)^2$. Similarly, the probability that dividends will grow for three consecutive periods is $(¾)^3$ or 27 in 64. More generally, the probability of n consecutive periods is $(¾^3)^n$.

FIGURE 4

Boom and Crash Effects of a Cessation in Dividend Growth

we assume that the interest rate is 1 percent per quarter). Notice that the time plot of the logarithm of asset price grows at more or less a constant rate until period 32. But after period 32 and until the crash in period 45, the growth rate of prices is *faster*, although there is no change in the growth rate of dividends.

This surprising outcome is the result of the evolution of investors' beliefs regarding the likelihood of the different dates at which the expansion might stop. To understand this point, notice that in period 32, an investor assigns a 1/28 chance that the expansion will continue to period 33, a 1/28 chance that it will continue to period 34, and so forth, because there are 28 possible dates (33 to 60) at which the expansion might stop and the investor is equally uncertain about at which date the expansion will stop. But once this investor learns that the expansion has, in fact, continued into period 33, he will assign a *higher* chance to the expansion's continuing to period 34 and beyond. This is because there are now only 27 possible dates left, and investors will assign each date a 1/27 chance. Thus, as the expansion continues, the investor will assign a higher and higher probability to the expansion's continuing to the fewer remaining dates.

What all this amounts to is that as the expansion continues beyond period 32, investors successively eliminate the possibility of relatively unfavorable outcomes in favor of an increase in the likelihood of relatively favorable ones. For instance, if the expansion continues on to period 35, investors know that the expansion will go on until some date that lies between periods 36 and 60. This is a more favorable assessment of the asset's earning potential than what investors believed in any earlier period. Of course, once the expansion stops, all of the remaining favorable outcomes to which investors had previously assigned a positive chance are eliminated, and that elimination results in a sharp fall in the price of the asset.[10]

There are some additional points worth making. First, the boom and crash scenario depends on the timing of the cessation of dividend growth. If the expansion in dividends continues all the way to period 60, there will be a boom but no crash: The price of the asset will simply stabilize at its peak value and stay at that level forever. At the other extreme, if the dividend expansion comes to a stop in period 33, there will be a crash but no boom. To get a boom-bust scenario, the expansion in dividends must last longer than the minimum period of expansion but less than the maximum period of expansion. Of course, in reality, investors cannot be completely certain about the minimum and maximum periods of expansion. But the explanation will work as long as the duration of the expansion falls somewhere near the "middle regions" of the set of possible outcomes.

Second, Figure 1 indicates that there was also a crash in operating earnings when the tech boom ended, something that is not true of the explanation given above. But this is not an important deviation between theory and fact. There was a crash in earnings because learning also affected corporate decisions. High-tech corporations discovered that they had invested "too much" in information and communications

[10] For the example shown in Figure 4, the average annual growth in asset prices prior to period 33 is 3.13 percent, the annual growth between periods 33 and 44 is 9.80 percent, and the drop in asset value at the time of the crash is 31 percent.

technology capacity because they too believed there was some chance that the expansion in profit opportunities would continue beyond 2001.[11] The write-offs related to this "excess investment" contributed to corporate bankruptcies and a drop in operating earnings. Consistent with this situation, there was also a crash in information and communication technology (ICT) investment, which, in turn, led to the brief recession of 2001-02. The recession contributed to the drop in corporate earnings as well.

Third, Figure 1 also shows that following the crash in prices and operating earnings, growth in earnings recovered quickly, which seems inconsistent with the theory outlined above. However, we have to recognize that an index as broad as the S&P 500 is affected by more than just the high-technology sector. As we are all too well aware now, the high-tech boom was followed closely by a boom in housing and construction. Although a variety of factors contributed to the housing boom and subsequent bust, at the center of the boom and crash was yet another innovation — this time in financial markets in the form of the securitized subprime mortgage.[12]

INNOVATIONS AND ASSET PRICE BOOMS AND CRASHES

The above explanation of a boom-bust scenario is special. It assumes that the uncertainty regarding dividend growth is of a particular kind (uncertainty regarding the duration of expansion) and that investors put an equal probability weight on the expansion's stopping between two fixed future time periods. However, it is also true that boom-bust scenarios do not happen all the time, which suggests that their occurrence requires a particular confluence of events. The important question to ask is: Under what circumstances are the assumptions of the theory likely to be met?

Imagine a situation in which there is a new discovery or innovation that is truly novel. For such an innovation, the past is a poor guide for judging the innovation's profit potential. Investors understand that the innovation will create new opportunities, but no one is certain about the innovation's ultimate profit potential. In this situation, the basic assumptions of the simple model outlined above seem plausible. Investors know that the innovation will generate new business opportunities over time (increasing profits or dividends) until, at some point in the future, the innovation's profit potential will stabilize and profits will stop growing (or will grow at the rate of growth of the overall economy). But no one knows when this stage of "normal" profits (or profit growth) will arrive, and past experience is of no help in making a guess. In this situation, the principle of indifference suggests that investors may well put an equal probability weight on the expansion's stopping any time between the two future dates.[13] This will be the case, for instance, if investors currently expect the expansion to last somewhere between five to 10 years.

Historically, booms in asset prices have, in fact, followed truly novel innovations or events. In describing the genesis of financial crises in Western Europe, the financial historian Charles Kindleberger summarizes the historical record thus: "The macroeconomic system receives a shock…a 'displacement'. This displacement can be monetary or real. What is significant is that it changes expectations in financial markets with respect to the profitability of some range of investments. New profit opportunities are opened up, and people move to take advantage of them."[14] Again, in another work, Kindleberger states: "The nature of the displacement varies from one speculative boom to another. It may be the outbreak or end of war, a bumper harvest or crop failure, the widespread adoption of an invention with pervasive effects — canals, railroads, the automobile — some political event or surprising financial

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[11] See Robert Gordon's article on how ICT capacity outstripped ICT demand and led to corporate bankruptcies and a slowdown in ICT investment in early 2000.

[12] See the book by Gary Gorton for a discussion of the nature of the financial innovation in mortgage markets that, in part, contributed to the housing boom and, ultimately, to the current mortgage crisis.

[13] The "principle of indifference" asserts that if there is no knowledge indicating that any one outcome among N possible outcomes is more likely than another, each outcome should be assigned an equal chance of occurring, namely, a chance of 1/N.

[14] Kindleberger, 1993, p. 524.

success, or a debt conversion that precipitously lowers interest rates. But whatever the source of the displacement, if it is sufficiently large and pervasive, it will alter the economic outlook by changing profit opportunities in at least one important sector of the economy. Displacement brings opportunities for profit in some new or existing lines, and closes out others. As a result, business firms and individuals with savings or credit seek to take advantage of the former and retreat from the latter. If the new opportunities dominate those that lose, investment and production pick up. A boom is under way."[15]

The boom in house prices in the mid to late 2000s can, in part, be traced to a financial innovation — the securitized subprime mortgage — whose true profit potential was initially unknown. The tech boom of the 1990s was a direct consequence of the spread of ICT and the rise of the World Wide Web. The boom of the 1920s could arguably be traced to the revolutionary effects of the automobile. The boom of the 1850s (in the U.S.) could be traced to the revolutionary effects of railroads. Arguably, each of these booms ended in a crash when investors came to a more precise understanding of the innovation's profit potential.

[15] Kindleberger, 1978, p. 18.

The explanation for the boom-bust scenario described in this article is based on the fact that investors learn about the asset's profit potential over time. And what they learn can cause them to strongly revise their perception of the asset's value. The basic idea regarding the role of learning is present in other studies that go beyond the simple model discussed above. For instance, researchers have shown that the transaction costs of trading in financial markets coupled with learning about an asset's profitability over time can lead to abrupt and sharp movements in asset prices, so that asset prices may appear to be much more volatile than the flow of dividends.[16] This finding is important because the low variability of dividend flow compared with the high variability of asset prices is often taken as evidence that fundamentals (i.e., dividend flow) have little to do with asset price fluctuations.

[16] See the article by In Ho Lee for a discussion of this point. As the author explains, transaction costs can keep an investor from immediately trading on new information that becomes available to him. Thus, information relevant to the value of the asset can remain hidden until some shock (which could be relatively minor) forces all investors who had refrained from trading to trade. At that point, information that was hitherto dispersed and hidden among investors gets reflected in the price, which can cause the price to change abruptly.

SUMMARY

There is considerable circumstantial evidence supporting the notion that asset price booms and busts follow the advent of novel innovations that are expected to have pervasive effects on the economy. If this is accepted as a starting point for further analysis, the problem becomes one of understanding why and how innovation and novelty generate asset booms and busts. The simple model outlined above provides one explanation. It stresses the fact that truly novel innovations create uncertainty in the mind of investors regarding the innovation's ultimate profit potential, and the resolution of this uncertainty can first lead to a boom and then a crash.

The informational theory of booms and busts suggests that such episodes are inevitable, since they arise from deep-seated forces governing the evolution of industrial economies. It implies that there is more than a grain of truth to the notion that boom-bust scenarios are unique ("this time it's different") in that these episodes result from circumstances that are truly novel, such as the advent of railroads, the automobile, the personal computer, and the Internet.

REFERENCES

Gordon, Robert J. "Hi-Tech Innovation and Productivity Growth: Does Supply Create Its Own Demand?" NBER Working Paper 9437 (2003).

Gorton, Gary B. *Slapped by the Invisible Hand: The Panic of 2007.* Oxford: Oxford University Press, 2010.

Kindleberger, Charles P. *Manias, Panics and Crashes*. New York: Basic Books, 1978.

Kindleberger, Charles P. *A Financial History of Western Europe*, Second Edition. Oxford: Oxford University Press, 1993.

Lee, In Ho. "Market Crashes and Informational Avalanches," *Review of Economic Studies*, 65:4 (1998), pp. 741-59.

Zeira, Joseph. "Informational Overshooting, Booms and Crashes," *Journal of Monetary Economics*, 43 (1999), pp. 237-57.

How Do Businesses Recruit?*

BY R. JASON FABERMAN

Most economic theories of hiring and job seeking assume that businesses post vacancies when they demand more labor. Workers then apply for the job, and the most qualified candidate is hired. However, as those who have ever recruited or applied for a job know, the recruiting process is considerably more complex. In this article, Jason Faberman discusses some recent research on how employers recruit. It shows that the extent to which a business uses various recruiting channels depends on the characteristics of the employer, how fast the employer is growing (or contracting), and the overall state of the economy.

One question that has been on the minds of workers and policymakers alike over the past year is: when will a strong pickup in hiring take hold? The hiring of workers by businesses is a key component of the labor market. It is a common occurrence in both recessions and booms, and most individuals have been on one or both sides of the hiring process. In fact, according to the Bureau of Labor Statistics (BLS), nearly 5 million people, on average, are hired each month. Even at its lowest point during the last recession, total hiring in the U.S. totaled 3.9 million workers per month. Given how often hiring occurs, much of the economic evidence in this article will likely sound familiar to most readers. Nevertheless, the complexities and informalities associated with the hiring process have made it a difficult concept for economists to fully formalize in a theoretical framework, and consequently, these same elements have made it difficult to predict how aggregate hiring will behave over time.

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*The views expressed here are those of the author and do not necessarily represent the views of the Federal Reserve Bank of Philadelphia or the Federal Reserve System.

Most economic theories of hiring and job seeking assume that businesses post vacancies when they demand more labor. Workers then apply for the job, and the most qualified candidate is hired. As those who have ever recruited or applied for a job know, however, the recruiting process is considerably more complex. First, it takes time for businesses to find a suitable candidate and for workers to find acceptable employment. Economic theories characterizing these "search frictions" have become commonplace in economic research. In addition, businesses have multiple options for increasing their chances of hiring a qualified employee, for example, engaging in informal networking, increasing their recruiting efforts, or offering relatively generous pay or benefits. These channels make the recruiting process more complex, and economic theories on how businesses recruit have yet to fully capture these complexities.

In this article, I present some recent research that documents that the extent to which a business uses these other recruiting channels depends on its characteristics, such as its industry and the type of job it is recruiting for. It also depends on how fast the business is growing (or contracting). Last, it depends on the state of the economy. Recessions are periods when individuals find it hard to find work, and consequently, they are also times when businesses find it relatively easy to fill open positions.

ECONOMIC THEORIES OF HIRING AND RECRUITING

There are many economic models

of recruiting and hiring.[1] These models are generally based on theories of labor market search and matching that were recently recognized in the awarding of the 2010 Nobel Prize in economics. The models evaluate how workers find new jobs and how firms find new workers, given that there are frictions in matching the two. That is, it takes time for workers to figure out what jobs are available, and it takes time for employers to evaluate candidates for jobs. These frictions cause unemployed workers and vacant jobs to exist in the labor market simultaneously. Over the years, such models have proven valuable in evaluating the behavior of hiring, wages, and unemployment, most often over the business cycle, and in evaluating various labor market policies, such as employment protection and unemployment insurance benefits.

Central to many of these models is the notion of a vacancy or, more generally, that the frictions involved in matching workers to firms make recruiting a worker costly. Consequently, firms must weigh the expected cost of hiring a new worker, which consists of not only the wage they must pay but also the time and resources they must devote to the search process, against the expected benefit, which is generally how productive a firm expects its new hire to be.

Starting from this basic premise, different theories of labor market search and matching diverge widely in how the recruiting process occurs. For example, some theories implicitly model a link between wages and recruiting behavior. These models of "directed search," such as the one presented by Espen Moen, postulate that workers observe the wages offered by firms before they decide where to apply. The implication from these models is that firms can reduce the time it takes to find a worker by offering a wage higher than what their competitors offer (and thereby increase their number of applicants). Similarly, in his book, Christopher Pissarides presents a model in which firms vary in how much effort they put into recruiting rather than the wages they offer in trying to fill their vacancies.

In another example, Boyan Jovanovic addresses the uncertainty often associated with the hiring process by constructing a model in which workers are hired by (matched with) firms and both must learn about the match's "quality" over time. That is, they both learn whether or not each is happy with the employment relationship. This type of model implies that recruiting efforts are just one cost in a longer process to figure out whether a worker is a good fit with that firm.

There are also theories that ignore the search and matching aspect of recruiting and focus instead on its other complexities. For example, Michael Rothschild and Joseph Stiglitz present a model in which firms design contracts to screen their applicants to improve their chances of finding a suitable match.[2] James Montgomery develops a model in which the social networks of the existing workforce provide an alternative recruiting channel for firms.

Together, these lines of research underscore the need to understand exactly how firms recruit in the real world. The different types of models provide for very different characterizations of how firms hire workers and thus provide differing views on which channels are most important for recruiting, on how much recruiting differences affect the behavior of the labor market, and on what policies may best spur hiring. Only empirical evidence on employers' recruiting practices can shed light on which aspects of these models best describe what happens in the real world. In the remainder of this article, I summarize the existing evidence on these recruiting practices. A central theme that stands out is that no one theory captures what goes on in the data. This is partly because the different types of recruiting practices that firms use often depend on the characteristics of the position they are trying to fill. It is also because certain practices, such as informal recruiting methods, are not well captured at all by the existing theories.

It takes time for workers to figure out what jobs are available, and it takes time for employers to evaluate candidates for jobs. These frictions cause unemployed workers and vacant jobs to exist in the labor market simultaneously.

[1] Seminal work on this topic includes the 1985 study by Christopher Pissarides and the 1994 work by Dale Mortensen and Pissarides. Their work spawned a large literature on the issue, much of which is summarized in the survey piece by Richard Rogerson, Robert Shimer, and Randall Wright. Mortensen and Pissarides, along with Peter Diamond, shared the 2010 Nobel Prize in economics.

[2] The Rothschild-Stiglitz model is explicitly about contracts in insurance markets, but it has been extended to an understanding of labor markets.

EMPIRICAL ECONOMIC RESEARCH ON RECRUITING

Perhaps surprisingly, economic research on how firms recruit is relatively thin. This contrasts with the amount of research that exists on how individuals (both employed and unemployed) find new work (i.e., the labor supply counterpart to recruiting).[3] A major reason for this is a severe lack of data on recruiting. There are few surveys that capture the data needed for a complete study of recruiting behavior, and these surveys usually have relatively few observations and are often outdated.

Another major reason for the paucity of research on recruiting is that informal recruiting has proven to be an important channel. This point has been stressed in research dating back to work in 1966 by Albert Rees. Formal recruiting methods generally refer to explicit efforts by a business to find and hire a worker. These methods include posting a help wanted sign in the window or an ad in the newspaper or on the Internet, posting an opening at a job center (a common practice in European labor markets), and posting a vacancy announcement with an employment agency. While data on these recruiting methods are sparse, the methods themselves employ tangible measures of recruiting that an economist could study. Informal recruiting methods refer to hires made through channels such as referrals from acquaintances or existing employees, informal contacts made through networking, and the hiring of walk-in applicants who inquired about work without the existence of a formal job opening. Given their informal nature, these practices prove difficult to accurately measure even when surveys on recruiting explicitly try to account for them. Other actions related to recruiting have also proven difficult to accurately measure. These include the number of applicants and interviews for a particular position and the efforts a business undertook to hire someone.

Informal recruiting methods refer to hires made through channels such as referrals from acquaintances or existing employees, informal contacts made through networking, and the hiring of walk-in applicants who inquired about work without the existence of a formal job opening.

Nevertheless, research by Rees and more recent work by Jed DeVaro provide some useful insights on how firms recruit. For example, Rees finds that informal recruiting is an important part of hiring, primarily because it allows businesses to gather more information about a potential hire in a less costly way than more formal methods. Using a survey of employers in the Chicago area, Rees is able to document a variety of informal channels that firms use, such as relaxed hiring standards, and finds that the benefits these channels afford often made them preferable to the more formal methods provided by placement agencies that specialized in recruiting workers. DeVaro shows that the type of recruiting method used is closely related to the starting wage of the position. He finds that informal recruitment methods (such as referrals) have longer vacancy durations but lead to higher wage hires. The findings of both researchers underscore the importance of recruiting channels outside of the standard method of posting a vacancy.

EXISTING EVIDENCE ON VACANCIES AND HIRING

Other research has also shed light on how firms recruit. The existing evidence can be grouped into three categories: recruiting based on the characteristics of the business and the job, recruiting based on how much a business is growing (or contracting), and recruiting behavior over the business cycle.

Recruiting Behavior Varies with Business Characteristics. From an economist's point of view, one of the most important metrics for analyzing recruiting is the cost of recruiting, in terms of time, money, and resources. A big part of this cost is how long it takes to fill a vacant position. An open vacancy represents an unfilled job, meaning that a business has profitable work to be done, but there is no one currently doing it. Thus, one aspect of the cost of a vacancy that remains open is the opportunity cost of the unfilled position. A vacancy also signifies that there is some form of active recruiting undertaken by firms. This implies that the firm is devoting resources — in terms of the time and effort of its existing workers, as well as potential direct costs, such as advertising expenses — to recruiting a new worker. These costs and their effects on the recruiting behavior of individual firms can vary widely by the firm's industry and the characteristics of both the job and the firm.

[3] For example, see the 1999 review article by Henry Farber and the studies by Robert Hall, Shigeru Fujita and Gary Ramey, and Michael Elsby, Ryan Michaels, and Gary Solon, to name a few.

In my research with Steven Davis and John Haltiwanger, we show that one useful metric of how successful firms are in recruiting workers is the *vacancy yield*. The vacancy yield is the number of hires per vacancy posted (i.e., the success, in terms of a hire, of an employer's recruiting efforts). It is a simplified measure of the job-filling rate, which is the speed at which employers fill their vacancies.[4] When analyzed alongside the rates of hiring and vacancy posting, the vacancy yield can provide a more complete picture of the recruiting behavior of firms.

Table 1 shows how the number of hires as a percent of employment (the hiring rate), the number of vacancies as a percent of total jobs (employment plus vacancies), and vacancy yields vary across industries and across the major U.S. regions. The data come from published statistics from the BLS's Job Openings and Labor Turnover Survey (JOLTS).

On average, the hiring rate is 3.8 percent of nonfarm employment and the vacancy rate is 2.9 percent of total jobs (employment plus vacancies, i.e., filled plus unfilled jobs). The vacancy yield averages 1.3 hires over the month per vacancy open at the beginning of the month. In theory, the vacancy yield would take a value between zero and one. In practice, however, the yield can be greater than one, as is the case in Table 1. This is because data on hiring are often measured as a total amount over a period, while vacancies are usually measured as a stock at a specific point in time, in this case, at the beginning of the month. Consequently, the vacancy yield will capture the hires from vacancies that

[4] The main difference between the vacancy yield and the job-filling rate is that the latter accounts for the fact that some vacancies can be both posted and filled within a period, and therefore not show up in the data that are used to calculate the vacancy yield.

TABLE 1

Summary Statistics on Hiring and Vacancies

Category	Hiring Rate	Vacancy Rate	Vacancy Yield	Employment Growth Rate
Total Nonfarm	*3.8*	*2.9*	*1.32*	*-0.02*
Total Private	*4.2*	*3.0*	*1.41*	*-0.04*
Selected Industries				
Construction	6.0	1.9	3.24	-0.17
Manufacturing	2.5	1.9	1.35	-0.38
Retail Trade	4.8	2.5	1.93	-0.07
Transportation & Utilities	3.2	2.2	1.45	-0.07
Information	2.7	3.2	0.83	-0.30
Finance & Insurance	2.5	3.3	0.74	-0.01
Real Estate	4.0	2.5	1.55	-0.02
Professional & Business Services	5.4	3.8	1.41	-0.01
Education	2.5	2.0	1.24	0.21
Health Services	3.0	4.1	0.73	0.21
Leisure & Hospitality	6.8	3.6	1.88	0.08
Government	1.6	1.9	0.83	0.06
Region				
Midwest	3.7	2.5	1.44	-0.08
Northeast	3.3	2.7	1.23	0.02
South	4.0	2.9	1.34	0.01
West	3.9	2.9	1.34	-0.06

Source: Author's calculations from published JOLTS statistics from January 2001-May 2010. Hiring rates are percentages of employment. Vacancy rates are percentages of employment plus vacancies (i.e., total jobs). The vacancy yield is the number of hires during the month per vacancy open at the beginning of the month. The employment growth rate is the difference between total hires and total separations as a percent of employment. It is comparable to the growth rate obtained from calculating the change in payroll employment.

are posted and filled within the period but not from the vacancies that open during the period.[5] In addition, hiring done through informal channels may never use a vacancy, which could also push the average amount of hires per vacancy above one if these channels are prevalent enough. There is a large variation in these rates and in hires per vacancy across industries and across regions. Industries with high worker turnover (and thus high hiring rates), such as construction, retail, and leisure and hospitality, have relatively high vacancy yields. The high vacancy yield, in part, reflects the high turnover in these industries, but it also reflects the fact that many of their hires come from recruiting channels other than posting a formal vacancy. The converse is true for industries such as government, which has both low turnover and a low vacancy yield, the latter partly reflecting the fact that government agencies tend to have more formal recruiting practices than the private sector. The differences across regions generally reflect differences in the mix of jobs across areas, but they also reflect differences in growth, which generally coincides with a greater churning of workers (through greater migration, job-hopping, etc.).

Table 1 also shows that there is considerable variation across regions. The generally faster-growing South and West tend to have higher hiring rates (and, consequently, higher turnover), while the Midwest has the lowest growth but the highest vacancy yield. The Northeast, which tends to have a disproportionate share of industries and occupations that are low turnover and high wage, has both low hiring rates and low vacancy yields.

Research has also found that recruiting efforts and recruiting outcomes tend to be highly related to the starting wage offered. For example, Table 2, which is replicated from research by John Barron, John Bishop, and William Dunkelberg, shows that larger firms tend to pay higher wages, interview more workers, and invest more time in recruiting. This occurs primarily because high-wage jobs tend to require high or specialized skills. Finding workers with such skills often proves difficult. In addition, the opportunity cost of getting a poorly matched worker is relatively higher for these positions.

As some of my research with Guido Menzio shows, high-wage jobs also tend to have longer vacancy durations (Table 3). This is especially true for managerial and professional and technical jobs. Again, the skills required for the job strongly affect how much firms are willing to invest in the search process. Table 3 also shows that a sizable fraction (20 percent) of hiring occurs without any recruiting, as reported by the firms surveyed.[6] This is some of the most striking evidence in support of the informal channels

[5] My research with Davis and Haltiwanger, as well as several other studies (e.g., the study by Kenneth Burdett and Elizabeth Cunningham), finds that vacancy durations are relatively short, with the average vacancy remaining open for about three weeks.

[6] The survey asks how long it took for firms to fill their last vacancy, allowing for the special case where "no recruiting" took place.

TABLE 2

Characteristics of Recruiting by Firm Size, 1980

Name	Starting Wage (2009 $)	Number of People Interviewed	Number of Offers Made	Hours Spent Recruiting, Screening & Interviewing
All Firms	*10.73*	*6.3*	*1.3*	*8.0*
Size of Firm				
1-9 workers	10.10	5.2	1.2	6.2
10-25 workers	10.31	6.3	1.3	7.1
26-250 workers	11.09	7.0	1.4	9.4
251 or more workers	13.00	8.3	1.3	12.7

Source: Author's calculations and replication of estimates from Barron, Bishop, and Dunkelberg. The original estimates come from the 1980 Employment Opportunities Pilot Project.

TABLE 3

Characteristics of Recruiting by Occupation, 1980 and 1982

Name	Starting Wage (2009 $)	Avg. Vacancy Duration (days)	Pct. with No Recruiting	Number of Applications	Number of Interviews
All Hires	*11.42*	*22.0*	*20.1*	*12.6*	*7.0*
Selected Occupations					
Professional & Technical	14.71	37.1	22.0	9.3	8.0
Management	16.12	49.1	29.4	11.0	5.3
Clerical	9.32	17.7	15.1	16.4	8.7
Sales	10.64	29.7	16.9	13.0	7.2
Personal & Other Services	8.08	9.9	18.7	9.6	4.8
Processing & Machinery	11.36	19.3	25.4	9.3	7.2
Structural Work	15.58	23.4	27.8	8.3	6.3

Source: Author's work with Guido Menzio. Estimates come from the 1980 and 1982 waves of the Employment Opportunities Pilot Project. The fraction of hires with "no recruiting" refers to positions that were reported to have a vacancy open for zero days.

stressed by Montgomery, Rees, and DeVaro as an important recruiting tool.

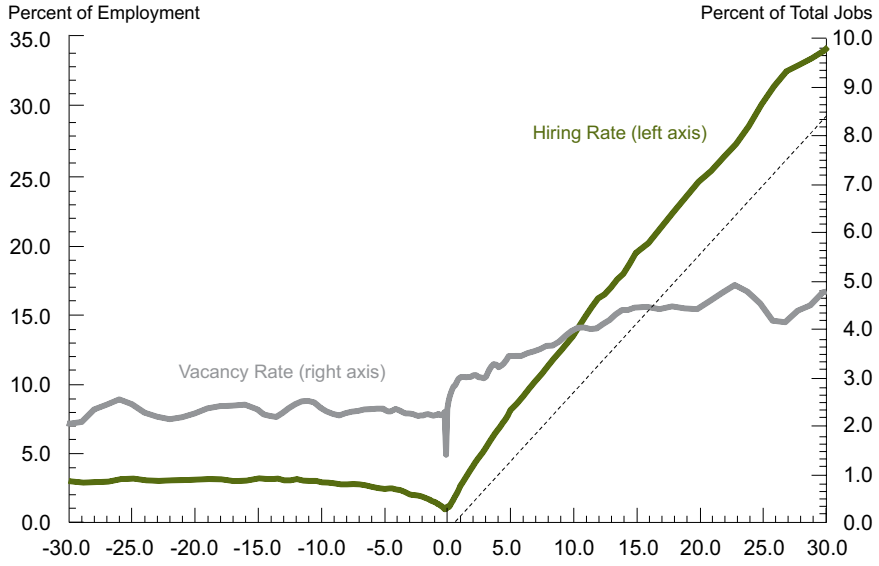
Recruiting Behavior Varies with Business Growth. In my research with Davis and Haltiwanger, we find that how fast a business is growing affects how it recruits. Namely, we find that the hiring rate rises nearly one-for-one with a business's employment growth rate but the vacancy rate rises much less than one-for-one with the growth rate (Figure 1). This implies that the vacancy yield (which is measured as hires per vacancy) also rises with the growth rate (Figure 2). The relationship of these variables to business growth is predominantly limited to when businesses expand. Contracting businesses have similar hiring rates, vacancy rates, and vacancy yields regardless of the size of the contraction.

The behavior of hires is mostly mechanical (the dashed line in Figure 1 represents the minimum hiring rate needed to grow by a certain percent), but there is no mechanical reason why the vacancy rate or vacancy yield should exhibit such behavior. In fact, most economic models of labor market search and matching imply a vacancy yield that is unrelated to business growth. In our research, however, we find that the vacancy yield rises even after controlling for the fact that fast-growing businesses may just post and fill vacancies very quickly. There are several reasons for this to be the case, although more research is needed to determine its exact causes. One hypothesis is that firms relax their hiring standards when trying to expand rapidly, making it easier to fill their vacant positions. Another hypothesis is that there are *scale economies* in recruiting, meaning that firms are able to benefit from added efficiencies when trying to hire many people at once. Yet another hypothesis is that firms rely more heavily on informal recruiting channels when trying to expand quickly, implying that hiring per (formal) vacancy would rise with growth.

Recruiting Behavior Varies over the Business Cycle. Finally, and perhaps most important, recruiting behavior varies over the business cycle. Obviously, when times are good, businesses are more likely to post vacancies and hire. Less obvious is the fact that a business's success rate

FIGURE 1

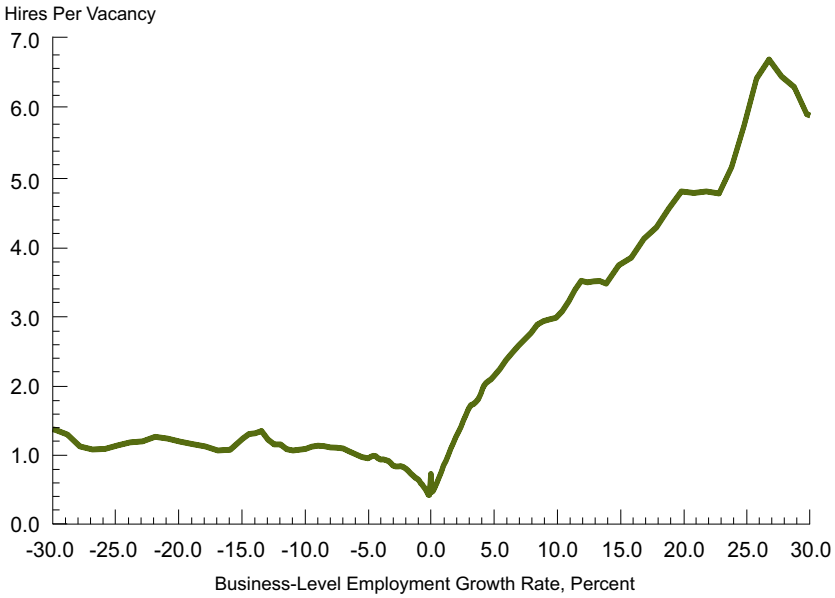
Hiring and Vacancy Rates by Business-Level Growth



Source: Estimates from my study with Steven Davis and John Haltiwanger, which uses establishment micro-data from JOLTS pooled over 2001-2006. The dashed line represents a 45-degree line emanating from the origin, representing the minimum amount of hiring to achieve a given growth rate.

FIGURE 2

Vacancy Yield by Business-Level Growth



Source: Estimates from my study with Steven Davis and John Haltiwanger, which uses establishment micro-data from JOLTS pooled over 2001-2006.

in recruiting and its potential use of alternative recruiting channels vary over the business cycle as well.

Figure 3 shows the behavior of the hiring rate, the vacancy rate, and the vacancy yield over the past 10 years, again from published JOLTS statistics. Recessions are indicated by the shaded bars. Hiring and vacancies are procyclical. They both increase during expansions and fall during recessions. Two things stand out for the hiring and vacancy rates in Figure 3. First, relative to the earlier recession, the 2008-09 period was a time of very steep declines in the rates of hiring and vacancy posting. Second, over the full period, the vacancy rate is more volatile than the hiring rate (that is, it rises relatively more during expansions and falls relatively more during recessions).

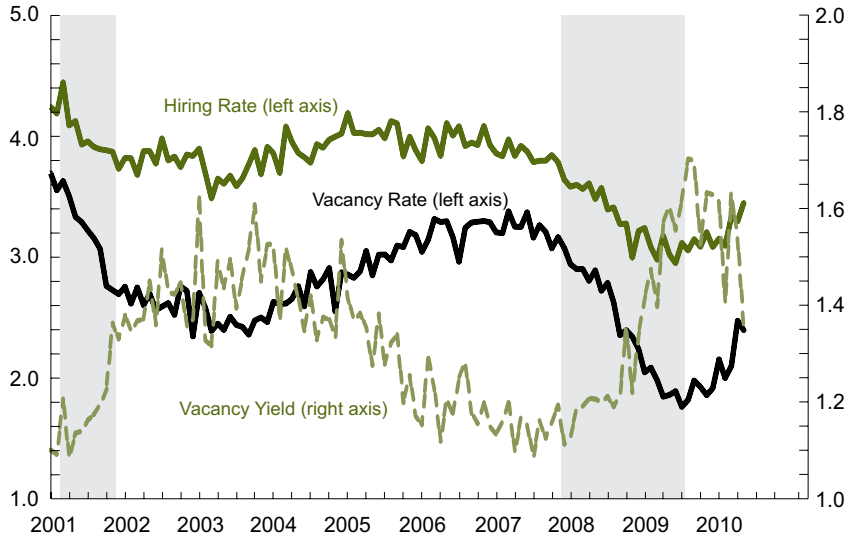
The vacancy yield is countercyclical. It rises during recessions and falls during booms and thus moves opposite to both hires and vacancies primarily because it is easier to fill openings during recessions when there are more unemployed workers applying for relatively fewer positions.

Figure 4 shows the movements of the daily job-filling rate and the monthly escape rate from unemployment over a longer time series.[7] The job-filling rate (the day-by-day rate at which vacancies are filled) is an estimate that comes from my research with Davis and Haltiwanger. As noted earlier, it is similar in concept to the vacancy yield. The main exception is that the job-filling rate accounts for the fact that some hires come from vacancies that are posted and filled within a month (such vacancies never appear as part of the monthly vacancy

[7] The time series in Figure 4 ends earlier (December 2009) than the series in Figure 3 (July 2010), which is why the job-filling rate does not exhibit the same decline observed with the vacancy yield.

FIGURE 3

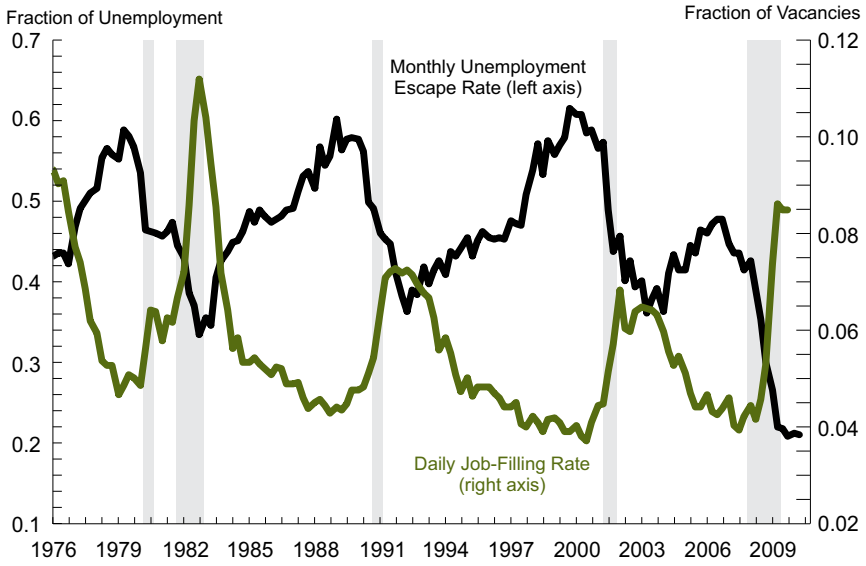
Hiring, Vacancies, and the Vacancy Yield over Time



Source: Author's calculations from published JOLTS data for nonfarm employment, January 2001-May 2010. Rates are expressed as percentages of employment. The vacancy yield is measured as the number of hires during the month per vacancy open at the start of the month. Shaded areas represent NBER-dated recessions.

FIGURE 4

Unemployment Escape Rate and Job-Filling Rate over Time



Source: Author's calculations from published CPS unemployment data, and vacancy rate estimates from the study by Regis Barnichon. Shaded areas represent NBER-dated recessions.

data). Its main limitation is that its calculation is more involved than that of the vacancy yield, so it is not as easily obtained from published statistics and, consequently, not as current as the vacancy yield series in Figure 3. The job-filling rate in Figure 4 is at the daily frequency, so it implies that businesses fill, on average, about 5.7 percent of their open vacancies on a given day. The monthly escape rate from unemployment is the percent of unemployed individuals from the previous month who are no longer employed in the current month. One shortcoming is that the measure does not distinguish between individuals who found new work and those who dropped out of the labor force, although research suggests that the escape rate closely tracks the rate at which the unemployed actually find new jobs.[8]

Despite the differences in measurement, Figure 4 shows that the job-filling rate, like its counterpart the vacancy yield, is strongly countercyclical. It exhibited its largest spike at the height of the 1982 recession, rising to over 11 percent of vacancies per day. The spike at the height of the most recent recession, at 8.6 percent, was the second highest on record. Businesses found it hardest to fill their vacancies during the boom times of the 1998-2000 period. The movements in the unemployment escape rate are almost a mirror image of the movements in the job-filling rate. The contrasting behavior of the two series over time is intuitive: recessions are periods when it is hard for workers to find a job but easy for firms to fill their vacancies. The opposite is true of expansions. It is worth noting that during the last recovery, the rate at which individuals escaped unemployment has remained well below the next lowest trough on

[8] See, for example, an earlier *Business Review* article by Shigeru Fujita.

record. This is a primary reason why the unemployment rate has remained persistently high during this period. The divergence currently remains a puzzle to economists. A rise in structural unemployment, perhaps due to the downturn in the housing market, changes in the industry composition of the economy, or changes in government policies (such as extensions of unemployment insurance benefits) have all been suggested as potential causes, although much work remains to be done on the issue.

CONCLUSION

Hiring and recruiting are key features of the labor market. While these features are common occurrences often experienced by most individuals, many economic models of the labor market still grapple with dealing with their complexities. The models do well in capturing the notion that many costs and frictions exist in the matching of workers to firms, but they have yet to fully characterize the fact that businesses use multiple channels, both formal and informal, to attract and recruit workers. Existing evidence on these channels shows that the extent to which firms use these channels, and their success with them, varies with the type of firm, the type of job, how much the firm is looking to expand, and economic conditions.

REFERENCES

Barnichon, Regis. "Building a Composite Help Wanted Index," *Economics Letters*, 109:3 (December 2010), pp. 175-78.

Barron, John M., John Bishop, and William C. Dunkelberg. "Employer Search: The Interviewing and Hiring of New Employees," *Review of Economics and Statistics,* 67:1 (1985), pp. 43-52.

Burdett, Kenneth, and Elizabeth J. Cunningham. "Toward a Theory of Vacancies," *Journal of Labor Economics*, 16:3 (1998), pp. 445-78.

Davis, Steven J., R. Jason Faberman, and John C. Haltiwanger. "The Establishment-Level Behavior of Vacancies and Hiring," NBER Working Paper 16265 (August 2010).

DeVaro, Jed. "Employer Recruitment Strategies and the Labor Market Outcomes of New Hires," *Economic Inquiry*, 43:2 (2005), pp. 263-82.

Elsby, Michael, Ryan Michaels, and Gary Solon. "The Ins and Outs of Cyclical Unemployment," *American Economic Journals: Macroeconomics*, 1:1 (2009), pp. 84-110.

Faberman, R. Jason, and Guido Menzio. "Evidence on the Relationship Between Recruitment and the Starting Wage," unpublished paper, 2010.

Farber, Henry. "Mobility and Stability: The Dynamics of Job Change in Labor Markets," in Orley E. Ashenfelter and David Card, eds., *Handbook of Labor Economics,* Vol. 3B, 1999, pp. 2439-83.

Fujita, Shigeru. "What Do Worker Flows Tell Us About Cyclical Fluctuations in Employment?" Federal Reserve Bank of Philadelphia *Business Review* (Second Quarter 2007), pp. 1-10.

Fujita, Shigeru, and Gary Ramey. "The Cyclicality of Separation and Job Finding Rates," *International Economic Review* 50:2 (2009), pp. 415-30.

Hall, Robert E. "Job Loss, Job Finding, and Unemployment in the U.S. Economy over the Past Fifty Years," *NBER Macroeconomics Annual*, Vol. 20 (2005), pp. 101-37.

Jovanovic, Boyan. "Job Matching and the Theory of Turnover," *Journal of Political Economy*, 87:5 (1979), pp. 972-90.

Moen, Espen. "Competitive Search Equilibrium," *Journal of Political Economy* 105:2 (1997), pp. 385-411.

Montgomery, James D. "Social Networks and Labor Market Outcomes: Towards an Economic Analysis," *American Economic Review,* 81:5 (1991), pp. 1408-18.

Mortensen, Dale T., and Christopher A. Pissarides. "Job Creation and Job Destruction and the Theory of Unemployment," *Review of Economic Studies,* 61:3 (1994) pp. 397-415.

Pissarides, Christopher A. "Short-Run Equilibrium Dynamics of Unemployment, Vacancies and Real Wages," *American Economic Review*, 75:4 (1985), pp. 676-90.

Pissarides, Christopher. *Equilibrium Unemployment Theory*, Second Edition. Cambridge, MA: MIT Press (2000).

Rees, Albert. "Information Networks in Labor Economics," *American Economic Review,* 56:1.2 (1966), pp. 559-66.

Rogerson, Richard, Robert Shimer, and Randall Wright. "Search-Theoretic Models of the Labor Market: A Survey," *Journal of Economic Literature*, 43:4 (2005), pp. 959-88.

Rothschild, Michael, and Joseph Stiglitz. "Equilibrium in Competitive Insurance Markets: An Essay on the Economics of Imperfect Information," *Quarterly Journal of Economics*, 90:4 (1976), pp. 629-49.

Rehypothecation*

BY CYRIL MONNET

How would you feel if even though you were making regular monthly payments, your mortgage bank sold your house? This may seem like an odd question, but this type of situation happens every day in financial markets in a practice known as rehypothecation. Although such practices may be hard for nontraders to understand, rehypothecation is widespread in financial markets. Following the crisis of 2007-2009, the Dodd-Frank Act put restrictions on rehypothecation for derivatives. To understand the scope of these restrictions, we need to understand the role of rehypothecation in financial trades. In this article, Cyril Monnet discusses questions such as: Which party to a financial trade does rehypothecation benefit? Are there limits to its advantages? And how should it be regulated? There are no hard and fast answers to the last question, but the author notes that we can make a more informed decision about the pros and cons of various forms of regulation if we understand the underlying economics.

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How would you feel if even though you were making regular monthly payments, your mortgage bank sold your house? This may seem like an odd question, but this type of situation happens every day in financial markets: A borrower pledges a security as collateral to a lender, and the lender sells the security to a third party, a practice known as *rehypothecation*. Although such practices may be hard for nontraders to understand, nonetheless, rehypothecation is widespread in financial markets.

It is easy to understand why a secured lender — a lender whose loans have been collateralized with a security — would want to put the security (that is, the collateral) to a profitable use. After all, if the borrower repays his loan, the lender could always use the proceeds to re-purchase the security and transfer it back to the borrower. And if the borrower defaults, the lender simply keeps the security. It is more difficult to see why a borrower would consent to this practice: The borrower must take into account the risk that the lender will not return his collateral when the borrower repays his loan. This risk is amplified when the borrower has consented to rehypothecation.

Following the crisis of 2007-2009, the Dodd-Frank Act, which was passed by Congress in July 2010, put restrictions on rehypothecation for derivatives. To understand the scope of these restrictions, we need to understand the role of rehypothecation in financial trades. Which party to a financial trade does it benefit? Are there limits to the advantages of rehypothecation? And, in the end, how should it be regulated? There are no hard and fast answers to the last question, but we can make a more informed decision about the pros and cons of various forms of regulations if we understand the underlying economics.

*The views expressed here are those of the author and do not necessarily represent the views of the Federal Reserve Bank of Philadelphia or the Federal Reserve System.

COUNTERPARTY RISK AND COLLATERAL

To understand the use of rehypothecation in financial markets and its consequences, it is first important to understand why and how trades are collateralized.

Traders demand collateral to insure against *counterparty risk* — the risk that the party they are trading with (their counterparty) defaults. Counterparty risk is more acute for long-term contractual obligations such as commodity futures or forward contracts — obligations to deliver a given quantity of a commodity (pork-bellies, soybeans, oil, etc.) at a fixed price, on a given date in the future.[1] In this article I will focus on commodity contracts just for concreteness, but the arguments also apply more generally.

Broadly, default comes in two types. First, traders may not fulfill their promises if it is not in their best interest to do so. This type of default is called *strategic default*. Second, the creditworthiness of each party to the trade can deteriorate over time, the results of poor market conditions or bad investments. If a trader defaults because it is insolvent, we say that this is a *nonstrategic default*. To illustrate, suppose that an onion farmer who wants to insure against the fluctuation of onion prices signs a forward contract with a merchant promising to deliver 100 onions at $1 each on May 1, 2011. If the crops are bad, the farmer may be unable to deliver 100 onions. There is not much traders can do to limit this default event because it is nonstrategic. Alternatively, price movements can trigger a strategic default: If the price of onions on May 1 is $2, the farmer has a strong incentive to renege on his promise and sell his 100 onions elsewhere for $2 each. More generally, if the price goes down, the buyer has a strong incentive to renege on its promises to pay the (higher) contract price, while if the price goes up, the seller has a strong incentive to renege on its promise to deliver the good at the (lower) contract price.

As a general rule, price fluctuations are very likely over time and creditworthiness is more likely to deteriorate over a longer time horizon. So contracts with a long maturity date, that is, contracts with settlement dates far in the future, are more prone to default by one of the traders, be it strategic or nonstrategic.

Requiring collateral is a nearly universal contractual way to address these risks of default. When traders carry out their business on an organized exchange, such as the Chicago Mercantile Exchange (CME), the exchange's clearing agent handles collateral requirements (CME Clearing, in the case of the CME), and there is little traders can do to modify these requirements. However, many other contracts, such as forward contracts, are traded over-the-counter and not on an organized exchange. In over-the-counter markets, traders directly negotiate bilateral contracts, including collateral requirements.

The amount of required collateral typically depends on the observable creditworthiness of the counterparty (for example, their credit rating), as well as overall market conditions, to control for strategic default. For example, if the price of onions falls between the day the contract is signed and the delivery date, the merchant may have to pledge more collateral; if the price increases, the farmer may have to pledge more collateral. Notice that the requirement to pledge collateral may switch from one party to the next, depending on how the price of onions moves. As a consequence, it is hard to predict who will need to pledge collateral at the time traders agree to a trade. To avoid confusion, I will refer to the trader who receives the collateral as the *receiver* and the one who offers the collateral as the *pledgor*. In our example, the pledgor will be the merchant if the price of onions goes down or the farmer if the price of onions goes up. Notice also that collateral requirements serve two distinct functions. First, collateral limits the receiver's losses in the event of default, whether strategic or nonstrategic. Second, collateral actually reduces strategic default by raising the pledgor's costs of defaulting.

Traders demand collateral to insure against *counterparty risk* — the risk that the party they are trading with (their counterparty) defaults.

The failure to pledge the required collateral generally triggers a default event that can terminate the trade.[2] However, posting collateral is costly, since traders have to keep assets, including cash, in reserve, for the sole purpose of securing their positions if need be, and they have to forgo the potential benefits of investing the

[1] A forward contract differs from a futures contract in that it is traded over-the-counter, i.e., traders negotiate the terms of the contract between themselves, while a futures contract is traded on a centralized exchange.

[2] When a trade is terminated, the obligations are cancelled and the collateral is returned to its owner.

assets somewhere else. Thus, traders have strong incentives to develop ways to conserve collateral. This is where rehypothecation plays a role.

REHYPOTHECATION, OR HOW TO SAVE ON COLLATERAL

Before explaining how rehypothecation works, let me define what it is precisely. There are two notions of rehypothecation. The first (narrow) notion of rehypothecation relates to how *broker-dealers*[3] (and no other market participants) should handle the securities of their customers: If they can use their customers' securities as they see fit, we say that broker-dealers enjoy a rehypothecation right. The second notion, as proposed by the International Swaps and Derivatives Association (ISDA), applies to any secured lender, not only to broker-dealers: The right of rehypothecation refers to the right of *a secured party* to sell, pledge, rehypothecate (in its narrow definition above), assign, invest, use, commingle, or otherwise dispose of posted collateral. In what follows, I will use the broader definition of rehypothecation, which, simply put, says that a lender with collateral can use it as if it was his own asset.

Now, picture yourself as a trader on an over-the-counter market. If business is good, you will be involved in many repeated interactions with traders at other firms. You will have to take thousands of positions during a typical day. So you can see that negotiating every aspect of each contract will be costly and very inefficient, since it would slow down your trading activity and others'. So, in order to speed things up, market participants typically transact under standardized contractual terms known as a *Master Agreement*.

Three Types of Master Agreements. A Master Agreement is a standardized form that specifies not only the terms of a trade, such as the price and the assets to be delivered, but also what constitutes events of default and termination events. These Master Agreements reduce legal uncertainty about how disputes will be resolved. The precise terms have evolved over time through the resolution of past disputes. Now, when two traders choose a Master Agreement, there is a body of case law that tells the contracting parties what the terms actually mean, how judges will interpret them, and so forth. In particular, a Master Agreement will specify the rights of the parties to a trade regarding the use of collateral in protecting their exposures. The most common Master Agreement is the ISDA Master Agreement.

To complement its Master Agreement, the ISDA provides three standard templates for handling collateral, known as the ISDA Credit Support Annexes. There are three types of Credit Support Annexes, and legally, they treat the handling of collateral very differently. Under the *English Credit Support Deed (CSD)* the pledgor remains the owner of the asset, and the receiver must open a segregated account in which the collateral cannot be combined with his own property. So the English CSD simply prohibits the reuse of collateral.

This is not the case under the *New York Credit Support Annex* (CSA). Although the pledgor remains the owner of the asset, the receiver gains broad rights to use the collateral. In particular, the receiver can rehypothecate any posted collateral it holds. By using the New York CSA and agreeing to rehypothecation, the pledgor gives up his right of redemption, that is, the pledgor loses his right to reclaim his collateral in case the receiver's exposure to the pledgor declines. Giving the pledgor an open-ended right to redeem collateral whenever the receiver's exposure changes would make it nearly impossible for the receiver to use the collateral in another transaction; after all, prices are constantly changing. Traders can choose to amend the New York CSA to disengage the provisions that make rehypothecation possible. However, we will see that this does not seem to happen in practice.

Finally, under the *English CSA*, the pledgor loses ownership over the pledged asset, and instead, the receiver gains full legal ownership of the collateral. However, and contrary to the New York CSA, the receiver has the obligation to return "equivalent"

To complement its Master Agreement, the ISDA provides three standard templates for handling collateral, known as the ISDA Credit Support Annexes.

[3] Under the Securities Exchange Act of 1934, a "broker" is defined as "any person engaged in the business of effecting transactions in securities for the account of others." A "dealer" is defined as "any person engaged in the business of buying and selling securities for [his] own account, through a broker or otherwise." If the person performs these functions on a private basis and not as a business, he is considered a trader. Depending on the securities traded, a significant proportion of trades can be conducted by broker-dealers.

property when the pledgor's exposure is reduced. To provide additional flexibility, traders can define the meaning of "equivalent" in the English CSA.

Why Choose One Type Over Another? There are reasons traders might prefer the New York CSA over the English CSA or vice versa. It is clear that the receiver enjoys more flexibility under the English CSA, since the receiver can return any type of collateral as long as it is judged equivalent. However, this flexibility imposes legal risk on the pledgor, who may not agree with either the receiver or a court that the collateral provided is truly equivalent. Then, why would the pledgor accept the English CSA? When negotiating the terms of trades, the pledgor may still accept this type of agreement if he gets a better price in exchange for the additional risk. Unfortunately, there are no data on the relative use of English versus New York CSAs, so it is difficult to check whether the price terms actually reflect this flexibility-risk tradeoff.

However, actual contracting practices strongly suggest that rehypothecation is useful. Traders could choose to prohibit rehypothecation, either by using an English CSD or by amending a New York CSA. But, interestingly, a high proportion of large traders choose to allow rehypothecation. From the 2010 ISDA margin survey, 44 percent of all respondents to the survey and 93 percent of large dealers report rehypothecating collateral. To put these numbers in some perspective, the survey was conducted after one of the most serious disturbances to financial markets in decades. As I will discuss later, the risk that a pledgor would be unable to recover his collateral became very real during the financial disturbances of 2008. Nonetheless, just over a year later, significant fractions of traders were willing to bear these risks again. Given that traders have a choice, rehypothecation appears to be useful. But how?

Rehypothecation Increases Market Liquidity When Collateral Is Scarce. Rehypothecation lowers traders' *funding liquidity needs,* the ease with which a trader can obtain funding. This is quite intuitive. When traders use rehypothecation, the receiver can again pledge collateral to borrow cash. Thus, the same collateral can be used to support more than one transaction, making it (more) liquid. So rehypothecation allows the receiver to fund his activity easily, rather than having to scramble for cash or to mobilize other assets on his balance sheet. For example, suppose that in addition to the onion futures, our merchant also bought apple futures for $2 and received $1 of collateral for them. Now suppose onion prices fall to 50 cents but there is no change in apple prices. It is then very likely that the onion farmer will demand more collateral, and in this case, our merchant could use the $1 pledged by the apple farmer to satisfy this added collateral requirement rather than use his own reserves.

Lowering traders' funding liquidity needs is important because it has market-wide effects. Funding liquidity affects *market liquidity,* the ease with which a trader finds a suitable counterparty. When it becomes easier to secure funding, traders are willing to take on some positions that would otherwise require too much capital. This improves market liquidity by increasing the number of traders willing to take positions (see the article by Markus Brunnermeier and Lasse Pedersen and the one by Ronel Elul). And a higher degree of market liquidity is usually associated with a higher level of social welfare.

Clearly, the receiver benefits from rehypothecation. But why should the pledgor agree to rehypothecation if the receiver is the real beneficiary while the pledgor bears more risk? While a more liquid market benefits everyone, individual traders capture only a small share of the total benefits that all traders receive from enhanced liquidity. However, the receiver's flexibility to reuse collateral could and should be reflected in more favorable terms of trade, at least in a competitive market. For example, if the pledgor uses cash collateral, the receiver could agree to pay a higher interest rate on this cash. Or perhaps the pledgor might be required to post less collateral if the receiver can reuse it.

That said, the amount of compensation traders must receive for allowing their counterparties to repledge their collateral will depend on various factors. One of these is market structure. Large dealers may be able to exploit their position in order to extract more profit from their customers. This is consistent with the evidence that large dealers use collateral rehypothecation relatively more than others. Also, according to Christian Johnson's article, traders (including dealers) may refuse to trade if they cannot rehypothecate the collateral. His account is consistent with a market in which large dealers simply make a take-it-or-leave-it offer to all other traders. The two-sided nature of the default risk is another factor. Recall that traders can end up as pledgor or receiver, depending on market conditions. In this case, *both* traders have an incentive to accept rehypothecation, since it lowers their funding costs if they turn out to be the receiver. As of yet, there is no formal empirical evidence on the relationship between rehypothecation and other contractual terms, and so it is difficult to evaluate the relative importance of these factors.

REHYPOTHECATION AMPLIFIES MARKET STRAINS

When market conditions deteriorate, rehypothecation can amplify market strains. Simply put, rehypothecation re-introduces counterparty risk in case a trader fails. This makes traders wary about agreeing to rehypothecation when conditions deteriorate. As a consequence, funding liquidity needs can increase, thus amplifying market strains. In this section, I describe each step in detail.

Rehypothecation Introduces Counterparty Risk. First, consider what happens if a trader fails. For example, suppose our merchant goes bust having rehypothecated the farmer's collateral. Legitimately, the farmer will want to recover his collateral. But since the merchant used it to secure another of his transactions, the farmer will not find it easy to get his collateral back.

Legally, several scenarios are possible. If the merchant has pledged the collateral to a third party, this third party has the right to seize the collateral to cover the merchant's obligations. In this case, the farmer loses his collateral. A second possible scenario is when the farmer owes a debt to the merchant; for example, the merchant has made an early partial payment to the onion farmer on the total due. In this case, the value of the farmer's collateral can be deducted from his debt. However, the law would treat the farmer as an unsecured creditor if the value of the collateral exceeds the value of his debt. As an unsecured creditor, the farmer will typically receive only a piece of the value of the collateral. In both scenarios, the farmer who pledged collateral ends up losing when the merchant fails.

So rehypothecation lowers the trader's coverage against counterparty risk. And in an interlinked market with rehypothecation, the actual amount of collateral in the market can be much lower than the amount of collateral that has been contractually committed. Think of a number of dealers linked in a chain of trades. In an extreme case, each dealer in the chain may find that he isn't collateralized at all, even if contracts fully collateralize traders' exposure! For example, suppose that the apple producer is $100 in debt to the merchant, who contracted a debt of $100 with the onion farmer, who himself owes a debt of $100 to the apple producer. If they all rehypothecate the collateral, then the trades do not look collateralized at all. If the onion farmer defaults, no collateral can really be seized, and it is as if no collateral had been pledged. Although this is an extreme example, it illustrates how rehypothecation can undo the beneficial effects of collateral. More realistically, rehypothecation can lead to chains of traders who are much less protected than they thought they were. The bottom line is that rehypothecation increases the same counterparty risk that the collateral requirement was supposed to tame. Note that if rehypothecation was prohibited or not used, the total available collateral would always equal the collateral that has been contractually committed, and each trader would recover his collateral in the event of default.

Thinking about chains of traders also helps to see another effect of rehypothecation: Rehypothecation increases the linkages between traders. In our example, the onion farmer and the third party who received collateral from the merchant had no formal contractual agreement at all. If you asked the onion farmer, he would say he had an agreement only with the merchant. Nonetheless, the merchant's ability to pledge the collateral means that the onion farmer and the third party are also interlinked. In this type of market, individual traders are potentially exposed to large numbers of participants with whom they have no formal agreement. Note, this effect is in addition to the liquidity effects I have already discussed.

Rehypothecation Amplifies Market Strains When Traders Become Nervous. When traders grow anxious about the possibility of a counterparty's default, they will tend to deny rehypothecation rights. In a time of crisis, the financial health of market participants can change by the hour. As dealers grow unsure of the quality of their counterparty, they prefer to take precautionary measures regarding their collateral. So it is natural that in a time of crisis, dealers become reluctant to agree to rehypothecation, to ensure that they know where their collateral is.

Unfortunately, dealers do not take into account the effects of their behavior on other traders, and this reversal in collateral policy makes funding pressures more severe. Other dealers might then scramble for collateral to secure the loans necessary for their business. If collateral becomes so scarce that dealers are unable to place orders to buy securities, the market can freeze.[4] Note that although every individual trader may be making the best possible decision for himself or herself, traders might act quite differently if they could all make a collective decision to continue to accept rehypothecation agreements. The freeze can be *inefficient* if traders are financially sound but lack the necessary liquid assets. In our simple

[4] See Yaron Leitner's *Business Review* article on market freezes.

example, while everyone would be better off if the (financially sound) merchant actually buys a forward contract from the onion farmer, the merchant's inability to pledge collateral means that he will have to buy onions on the *spot market* at a higher price[5] and will have to charge his clients more. This is inefficient, since the farmer, the merchant, and the merchant's customers would have preferred that a forward contract be written before buying and selling on the onion market revealed the actual spot price. So a sudden change in a trader's willingness to accept rehypothecation amplifies market strains and makes (inefficient) market freezes more likely.

Unfortunately, a sudden reduction in the practice of rehypothecation is not just a theoretical possibility, since it happened during the financial crisis of 2008-2009. In their 2010 article, Manmohan Singh and James Aitken show that rehypothecation declined rapidly after Lehman Brothers failed on September 14, 2008. The total collateral pledged that could be reused declined from $4.5 trillion at the end of 2007 to $2.1 trillion at the end of 2009. In their 2009 article, Singh and Aitken show that the total amount of assets available as collateral decreased by up to $5 trillion as a result of reduced rehypothecation and collateral hoarding. At the same time, credit markets seized up.

During the height of the crisis, dealers found it difficult to conduct their business, since they could not find proper counterparties that would lend to them without stringent contractual guarantees. For example, counterparties would accept only Treasury securities as collateral, and they would apply large collateral *haircuts*.[6] The Federal Reserve System (and other government agencies) viewed this market freeze as inefficient and felt that intervention was justified to "bolster market liquidity and promote orderly market functioning. Liquid, well-functioning markets are essential for the promotion of economic growth."[7] To ease large dealers' funding needs, the Federal Reserve put in place a back-stop facility for dealers, the Primary Dealer Credit Facility (PDCF). Under this program, large dealers could borrow from the Federal Reserve's discount window using as collateral a broad set of securities (with appropriate haircuts), not only Treasury securities. As described in the article by Tobias Adrian, Christopher Burke, and James McAndrews, PDCF usage immediately spiked to $40 billion before receding progressively, as conditions in the financing markets improved and the pricing of the PDCF became less attractive. As tensions from the Bear Stearns bailout abated, use of the PDCF stopped altogether in mid-July 2008. But then came the failure of Lehman Brothers on September 15. Perceiving that Lehman Brothers' difficulties could contaminate other dealers, lenders imposed higher haircuts and accepted only high-quality securities as collateral. As a result, dealers struggled to obtain funding. As a preventive policy, the Fed expanded the types of PDCF-eligible collateral on September 14. As a result, PDCF usage exploded to $59.7 billion on Wednesday, September 17, from no activity during the previous week. Eventually, PDCF borrowing reached more than $140 billion in October 2008. Adrian, Burke, and McAndrews conclude that in this instance, the PDCF fulfilled one of the purposes for which it was intended: to be available in the event that a failure of a primary dealer led to severe funding disruptions for the surviving dealers.

During the height of the crisis, dealers found it difficult to conduct their business, since they could not find proper counterparties that would lend to them without stringent contractual guarantees.

SHOULD REHYPOTHECATION BE PROHIBITED?

The possibility that (the lack of) rehypothecation can amplify

[5] A spot market is a market in which goods or securities are traded for cash, and each transaction is settled immediately.

[6] A haircut is a percentage that is subtracted from the value of the collateral. Hence, only collateral worth more than $100 will be accepted to secure a $90 loan with a 10 percent haircut.

[7] From the March 16, 2008 press release from the Federal Reserve Board announcing the creation of the Primary Dealer Credit Facility (PDCF).

[8] The act stipulates that (A) "a futures commission merchant shall treat and deal with all money, securities, and property of any swaps customer received to margin, guarantee or secure a swap cleared by or through a derivatives clearing organization as belonging to the swaps customer," and (B) "Money, securities, and property of a swaps customer described in (A) shall be separately accounted for and shall not be commingled with the funds of the future commission merchant or be used to margin, secure or guarantee any trades or contracts of any swaps customer or person other than the person for whom the same are held."

market strains and lead to inefficient market freezes provides a partial rationale for the Dodd-Frank Act's prohibition against rehypothecation for many derivative transactions. Precisely, the Dodd-Frank Act limits rehypothecation by requiring that most swap contracts be cleared by a derivatives clearing organization, such as a central counterparty, and that the collateral pledged be held in a segregated account with no possibility of rehypothecation.[8] These provisions of the Dodd-Frank Act will limit rehypothecation because a central counterparty imposes collateral requirements to clear trades and holds the collateral on behalf of the traders.[9] Therefore, the central counterparty is the sole receiver of the collateral, and it will not be rehypothecated. Other contracts that are not considered swap contracts under the act are not (yet) subject to these requirements (for example, commodity futures or some security futures). While a limit to rehypothecation will make trading safer for those market participants who need to pledge collateral, there may be significant costs to limiting this market practice for most derivatives contracts: The cost of pledging collateral may increase, funding liquidity needs may become more severe, and overall market liquidity may deteriorate.

During the financial crisis, in spite of increased counterparty risk, derivatives traders still agreed to rehypothecation (although at a lower level than before the crisis) and continued to do so after the crisis receded, as shown by Singh and Aitken in their 2010 article. This use of rehypothecation even under adverse conditions might suggest that traders view rehypothecation as valuable in itself. If traders did not find the benefits of rehypothecation greater than the costs, they did have means for preventing its practice. Traders could prohibit rehypothecation by, for instance, amending the New York CSA.[10] A second option is to use an English CSD. This option is rather inexpensive and guarantees that the pledgor will get his collateral back. The fact that some traders did not rely on either option suggests that they may have seen value in the practice, and that limiting rehypothecation via regulation may impose costs.

In light of the evidence of the use of rehypothecation, both theories are plausible, although they have very different implications for regulators. Unfortunately, without more micro-level data on the use of rehypothecation, it is difficult to know which of the two theories is correct.

CONCLUSION

Before the enactment of the Dodd-Frank bill, rehypothecation was widely used by market participants. In this article, I have tried to explain why this is so while also highlighting some of the drawbacks to individual traders and to the market as a whole. In a nutshell, rehypothecation reduces the cost of pledging collateral, it reduces funding liquidity needs, and it improves market liquidity. However, rehypothecation carries problems of its own, since it seemingly has the potential to introduce market-wide counterparty risks that are difficult for a single trader to control and can amplify market strains.

While, at this stage, it is not clear if rehypothecation should be encouraged or limited, the Dodd-Frank Act took the stance that the uncertainties in cases of default were too strong to leave current rehypothecation and clearing practices in place. Although central counterparty clearing is desirable for standardized contracts, it remains to be seen how prohibiting rehypothecation will affect the derivatives markets.

> Alternatively, we can't rule out the possibility that the practice occurred because some participants were able to exploit their market power to impose rehypothecation on other traders.

Alternatively, we can't rule out the possibility that the practice occurred because some participants were able to exploit their market power to impose rehypothecation on other traders. If the receiver has a monopoly over the provision of some securities, he can cut out any trader who refuses the rehypothecation of his collateral. In this case, we would also observe that market participants use rehypothecation during moments of stress, not because they want to but because they have to. In this case, limiting rehypothecation is an indirect way of addressing abusive positions in financial markets.

[9] See my earlier *Business Review* article or my working paper with Thorsten Koeppl for more details on central counterparty clearing.

[10] It is true that this option is costly, since traders who want to amend a CSA would need to agree on the content of the amendment. Because negotiation takes time, adding an amendment in itself might defeat the whole purpose of using a Master Agreement, and, in fact, it seems that the credit annexes are rarely amended.

REFERENCES

Adrian, Tobias, Christopher Burke, and James McAndrews. "The Federal Reserve's Primary Dealer Credit Facility," Federal Reserve Bank of New York, *Current Issues in Economics and Finance*, 15:4 (August 2009).

Brunnermeier, Markus, and Lasse Pedersen. "Market Liquidity and Funding Liquidity," *Review of Financial Studies*, 22:6 (2008), pp. 2201-38.

Elul, Ronel. "Liquidity Crises," Federal Reserve Bank of Philadelphia *Business Review* (Second Quarter 2008).

International Swaps and Derivatives Association. "Market Review of OTC Derivative Bilateral Collateralization Practices," ISDA (2010).

International Swaps and Derivatives Association. "ISDA Margin Survey 2010, Preliminary Results," ISDA (April 2010).

Johnson, Christian. "Derivatives and Rehypothecation Failure. It's 3:00 pm. Do You Know Where Your Collateral Is?'" *Arizona Law Review*, 30 (1997).

Koeppl, Thorsten, and Cyril Monnet. "The Emergence and Future of Central Counterparties," Federal Reserve Bank of Philadelphia Working Paper 10-20 (September 2010).

Leitner, Yaron. "Why Do Markets Freeze?" Federal Reserve Bank of Philadelphia *Business Review* (Second Quarter 2011).

Monnet, Cyril. "Let's Make It Clear: How Central Counterparties Save(d) the Day," Federal Reserve Bank of Philadelphia *Business Review* (First Quarter 2010).

Singh, Manmohan, and James Aitken. "Deleveraging After Lehman: Some Evidence from Rehypothecation," IMF Working Paper 09/42 (2009).

Singh, Manmohan, and James Aitken. "The (Sizable) Role of Rehypothecation in the Shadow Banking System," IMF Working Paper 10/172 (2010).

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A SURVEY OF EMPIRICAL RESEARCH ON FISCAL POLICY ANALYSIS BASED ON REAL-TIME DATA

This paper surveys the empirical research on fiscal policy analysis based on real-time data. This literature can be broadly divided into three groups that focus on: (1) the statistical properties of revisions in fiscal data; (2) the political and institutional determinants of fiscal data revisions and of one-year-ahead projection errors by governments, and (3) the reaction of fiscal policies to the business cycle. It emerges that, first, fiscal data revisions are large and initial releases are biased estimates of final values. Second, the presence of strong fiscal rules and institutions leads to relatively more accurate releases of fiscal data and small deviations of fiscal outcomes from government plans. Third, the cyclical stance of fiscal policies is estimated to be more "counter-cyclical" when real-time data are used instead of ex-post data. Finally, more work is needed for the development of real-time data sets for fiscal policy analysis. In particular, a comprehensive real-time data set, including fiscal variables for industrialized (and possibly developing) countries, published and maintained by central banks or other institutions, is still missing.

Working Paper 11-25, "Real-Time Data and Fiscal Policy Analysis: A Survey of the Literature," Jacopo Cimadomo, European Central Bank

A QUANTITATIVE EQUILIBRIUM MODEL OF THE HOUSING SECTOR

The authors construct a quantitative equilibrium model of the housing sector that accounts for the homeownership rate, the average foreclosure rate, and the distribution of home-equity ratios across homeowners prior to the recent boom and bust in the housing market. They analyze the key mechanisms that account for these facts, including the preferential tax treatment of housing and inflation. The authors then use the model to gain a deeper understanding of the recent housing and mortgage crisis by studying the consequence of an unanticipated increase in the supply of housing (overbuilding shock). They show that the model can account for the observed decline in house prices and much of the increase in the foreclosure rate if two additional forces are taken into account: (i) the lengthening of the time to complete a foreclosure (during which a defaulter can stay rent-free in his house) and (ii) the tightening of credit constraints in the market for new mortgages.

Working Paper 11-26, "A Quantitative Analysis of the U.S. Housing and Mortgage Markets and the Foreclosure Crisis," Satyajit Chatterjee, Federal Reserve Bank of Philadelphia, and Burcu Eyigungor, Federal Reserve Bank of Philadelphia

ESTIMATING SCALE ECONOMIES AT LARGE BANKS

Earlier studies found little evidence of

scale economies at large banks; later studies using data from the 1990s uncovered such evidence, providing a rationale for very large banks seen worldwide. Using more recent data, the authors estimate scale economies using two production models. The standard risk-neutral model finds little evidence of scale economies. The model using more general risk preferences and endogenous risk-taking finds large scale economies. The authors show that these economies are not driven by too-big-to-fail considerations. They evaluate the cost implications of breaking up the largest banks into banks of smaller size.

Working Paper 11-27, "Who Said Large Banks Don't Experience Scale Economies? Evidence from a Risk-Return-Driven Cost Function," Joseph P. Hughes, Rutgers University, and Loretta J. Mester, Federal Reserve Bank of Philadelphia

CAN MONETARY POLICY ENHANCE THE FUNCTIONING OF THE PRIVATE CREDIT SYSTEM?

The authors investigate the extent to which monetary policy can enhance the functioning of the private credit system. Specifically, they characterize the optimal return on money in the presence of credit arrangements. There is a dual role for credit: It allows buyers to trade without fiat money and also permits them to borrow against future income. However, not all traders have access to credit. As a result, there is a social role for fiat money because it allows agents to self-insure against the risk of not being able to use credit in some transactions. The authors consider a (nonlinear) monetary mechanism that is designed to enhance the credit system. An active monetary policy is sufficient for relaxing credit constraints. Finally, they characterize the optimal monetary policy and show that it necessarily entails a positive inflation rate, which is required to induce cooperation in the credit system.

Working Paper 11-28, "Optimal Monetary Policy in a Model of Money and Credit," Pedro Gomis-Porqueras, Monash University, and Daniel R. Sanches, Federal Reserve Bank of Philadelphia

HOW STRATEGIC COMPLEMENTARITIES INTERACT WITH MARKOV-PERFECT POLICIES

The literature on optimal monetary policy in New Keynesian models under both commitment and discretion usually solves for the optimal allocations that are consistent with a rational expectations market equilibrium, but it does not study whether the policy can be implemented given the available policy instruments. Recently, King and Wolman (2004) have provided an example for which a time-consistent policy cannot be implemented through the control of nominal money balances. In particular, they find that equilibria are not unique under a money stock regime and they attribute the nonuniqueness to strategic complementarities in the price-setting process. The authors clarify how the choice of monetary policy instrument contributes to the emergence of strategic complementarities in the King and Wolman (2004) example. In particular, they show that for an alternative monetary policy instrument, namely, the nominal interest rate, there exists a unique Markov-perfect equilibrium. The authors also discuss how a time-consistent planner can implement the optimal allocation by simply announcing his policy rule in a decentralized setting.

Working Paper 11-29, "On the Implementation of Markov-Perfect Monetary Policy," Michael Dotsey, Federal Reserve Bank of Philadelphia, and Andreas Hornstein, Federal Reserve Bank of Richmond

ANALYZING THE STRUCTURED FINANCE ASSET-BACKED SECURITIES CDO MARKET

This paper conducts an in-depth analysis of structured finance asset-backed securities collateralized debt obligations (SF ABS CDOs), the subset of CDOs that traded on the ABS CDO desks at the major investment banks and were a major contributor to the global financial panic of August 2007. Despite their importance, we have yet to determine the exact size and composition of the SF ABS CDO market or get a good sense of the write-downs these CDOs will generate. In this paper the authors identify these SF ABS CDOs with data from Intex©, the source data and valuation software for the universe of publicly traded ABS/MBS securities and SF ABS CDOs. They estimate that 727 publicly traded SF ABS CDOs were issued between 1999 and 2007, totaling $641 billion. Once identified, they describe how and why multisector structured finance CDOs became subprime CDOs, and show why they were so susceptible to catastrophic losses. The authors then track the flows of subprime bonds into CDOs to document the enormous cross-

referencing of subprime securities into CDOs. They calculate that $201 billion of the underlying collateral of these CDOs was referenced by synthetic credit default swaps (CDSs) and show how some 5,500 BBB-rated subprime bonds were placed or referenced into these CDOs some 37,000 times, transforming $64 billion of BBB subprime bonds into $140 billion of CDO assets. For the valuation exercise, the authors estimate that total write-downs on SF ABS CDOs will be $420 billion, 65 percent of original issuance balance, with over 70 percent of these losses having already been incurred. They then extend the work of Barnett-Hart (2009) to analyze the determinants of expected losses on the deals and AAA bonds and examine the performance of the dealers, collateral managers, and rating agencies. Finally, the authors discuss the implications of their findings for the "subprime CDO crisis" and discuss the many areas for future work.

Working Paper 11-30, "Collateral Damage: Sizing and Assessing the Subprime CDO Crisis," Larry Cordell, Federal Reserve Bank of Philadelphia; Yilin Huang, Federal Reserve Bank of Philadelphia; and Meredith Williams, Federal Reserve Bank of Philadelphia

NEW METHODOLOGIES FOR EVALUATING OUT-OF-SAMPLE FORECASTING PERFORMANCE

This paper proposes new methodologies for evaluating out-of-sample forecasting performance that are robust to the choice of the estimation window size. The methodologies involve evaluating the predictive ability of forecasting models over a wide range of window sizes. The authors show that the tests proposed in the literature may lack the power to detect predictive ability and might be subject to data snooping across different window sizes if used repeatedly. An empirical application shows the usefulness of the methodologies for evaluating exchange rate models' forecasting ability.

Working Paper 11-31, "Out-of-Sample Forecast Tests Robust to the Choice of Window Size," Barbara Rossi, Duke University, and Visiting Scholar, Federal Reserve Bank of Philadelphia, and Atsushi Inoue, North Carolina State University

EFFECTS OF FISCAL POLICY UNCERTAINTY ON AGGREGATE ECONOMIC ACTIVITY

The authors study the effects of changes in uncertainty about future fiscal policy on aggregate economic activity. Fiscal deficits and public debt have risen sharply in the wake of the financial crisis. While these developments make fiscal consolidation inevitable, there is considerable uncertainty about the policy mix and timing of such budgetary adjustment. To evaluate the consequences of this increased uncertainty, the authors first estimate tax and spending processes for the U.S. that allow for time-varying volatility. They then feed these processes into an otherwise standard New Keynesian business cycle model calibrated to the U.S. economy. The authors find that fiscal volatility shocks have an adverse effect on economic activity that is comparable to the effects of a 25-basis-point innovation in the federal funds rate.

Working Paper 11-32, "Fiscal Volatility Shocks and Economic Activity," Jesus Fernandez-Villaverde, University of Pennsylvania; Pablo Guerron-Quintana, Federal Reserve Bank of Philadelphia; Keith Kuester, Federal Reserve Bank of Philadelphia; and Juan Rubio-Ramirez, Duke University

INCORPORATING LONG-TERM DEBT INTO MODELS OF SOVEREIGN DEBT

In this paper, the authors advance the theory and computation of Eaton-Gersovitz style models of sovereign debt by incorporating long-term debt and proving the existence of an equilibrium price function with the property that the interest rate on debt is increasing in the amount borrowed and implementing a novel method of computing the equilibrium accurately. Using Argentina as a test case, they show that incorporating long-term debt allows the model to match the average external debt-to-output ratio, average spread on external debt, the standard deviation of spreads and simultaneously improve upon the model's ability to account for Argentina's other cyclical facts.

Working Paper 11-33, "Maturity, Indebtedness, and Default Risk," Satyajit Chatterjee, Federal Reserve Bank of Philadelphia, and Burcu Eyigungor, Federal Reserve Bank of Philadelphia

DO OIL PRICES HAVE A STABLE OUT-OF-SAMPLE RELATIONSHIP WITH THE CANADIAN/U.S. DOLLAR EXCHANGE RATE?

This paper investigates whether oil prices have a reliable and stable out-of-sample relationship with the Canadian/U.S. dollar nominal exchange rate. Despite state-of-the-art methodologies, the authors find little

systematic relation between oil prices and the exchange rate at the monthly and quarterly frequencies. In contrast, the main contribution is to show the existence of a very short-term relationship at the daily frequency, which is rather robust and holds no matter whether the authors use contemporaneous (realized) or lagged oil prices in their regression. However, in the latter case the predictive ability is ephemeral, mostly appearing after instabilities have been appropriately taken into account.

Working Paper 11-34, "Can Oil Prices Forecast Exchange Rates?," by Domenico Ferraro, Duke University; Ken Rogoff, Harvard University; and Barbara Rossi, Duke University, and Visiting Scholar, Federal Reserve Bank of Philadelphia

IMPLICATIONS OF ELIMINATING BANKRUPTCY PROTECTION FOR INDEBTED INDIVIDUALS

What are the positive and normative implications of eliminating bankruptcy protection for indebted individuals? Without bankruptcy protection, creditors can collect on defaulted debt to the extent permitted by wage garnishment laws. The elimination lowers the default premium on unsecured debt and permits low-net-worth individuals suffering bad earnings shocks to smooth consumption by borrowing. There is a large increase in consumer debt financed essentially by super-wealthy individuals, a modest drop in capital per worker, and a higher frequency of consumer default. Average welfare rises by 1 percent of consumption in perpetuity, with about 90 percent of households favoring the change.

Working Paper 11-35, "Dealing with Consumer Default: Bankruptcy vs. Garnishment," Satyajit Chatterjee, Federal Reserve Bank of Philadelphia, and Grey Gordon, University of Pennsylvania

STUDYING THE RELATIONSHIP BETWEEN THE SEVERITY OF THE LEMONS PROBLEM AND MARKET LIQUIDITY

The authors study a dynamic, decentralized lemons market with one-time entry and characterize its set of nonstationary equilibria. This framework offers a theory of how a market suffering from adverse selection recovers over time endogenously; given an initial fraction of lemons, the model provides sharp predictions about how prices and the composition of assets evolve over time. Comparing economies in which the initial fraction of lemons varies, the authors study the relationship between the severity of the lemons problem and *market liquidity*. They use this framework to understand how asymmetric information contributed to the breakdown in trade of asset-backed securities during the recent financial crisis and to evaluate the efficacy of one policy that was implemented in attempt to restore liquidity.

Working Paper 11-36, "Trading Dynamics in Decentralized Markets with Adverse Selection," Braz Camargo, São Paolo School of Economics—FGV, and Benjamin Lester, Federal Reserve Bank of Philadelphia

ESTIMATING THE VALUE OF THE TOO-BIG-TO-FAIL SUBSIDY

This paper estimates the value of the too-big-to-fail (TBTF) subsidy. Using data from the merger boom of 1991-2004, the authors find that banking organizations were willing to pay an added premium for mergers that would put them over the asset sizes that are commonly viewed as the thresholds for being TBTF. They estimate at least $15 billion in added premiums for the eight merger deals that brought the organizations to over $100 billion in assets. In addition, the authors find that both the stock and bond markets reacted positively to these TBTF merger deals. Their estimated TBTF subsidy is large enough to create serious concern, particularly since the recently assisted mergers have effectively allowed for TBTF banking organizations to become even bigger and for nonbanks to become part of TBTF banking organizations, thus extending the TBTF subsidy beyond banking.

Working Paper 11-37, "How Much Did Banks Pay to Become Too-Big-to-Fail and to Become Systemically Important?," Elijah Brewer III, DePaul University, and Julapa Jagtiani, Federal Reserve Bank of Philadelphia

THE CONTINUING IMPORTANCE OF PORTAGE SITES

The authors examine portage sites in the U.S. South, Mid-Atlantic, and Midwest, including those on the fall line, a geo-morphological feature in the southeastern U.S. marking the final rapids on rivers before the ocean. Historically, waterborne transport of goods required portage around the falls at these points, while some falls provided water power during early industrialization. These factors attracted commerce and

manufacturing. Although these original advantages have long since been made obsolete, the authors document the continuing importance of these portage sites over time. They interpret these results as path dependence and contrast explanations based on sunk costs interacting with decreasing versus increasing returns to scale.

Working Paper 11-38, "Portage and Path Dependence," Hoyt Bleakley, University of Chicago, and Jeffrey Lin, Federal Reserve Bank of Philadelphia

MACROECONOMIC AND WELFARE IMPLICATIONS OF RELAXING BORROWING CONSTRAINTS

Is the observed large increase in consumer indebtedness since 1970 beneficial for U.S. consumers? This paper quantitatively investigates the macroeconomic and welfare implications of relaxing borrowing constraints using a model with preferences featuring temptation and self-control. The model can capture two contrasting views: the positive view, which links increased indebtedness to financial innovation and thus better consumption smoothing, and the negative view, which is associated with consumers' over-borrowing. The author finds that the latter is sizable: The calibrated model implies a social welfare loss equivalent to a 0.4 percent decrease in per-period consumption from the relaxed borrowing constraint consistent with the observed increase in indebtedness. The welfare implication is strikingly different from the standard model without temptation, which implies a welfare gain of 0.7 percent, even though the two models are observationally similar. Naturally, the optimal level of the borrowing limit is significantly tighter according to the temptation model, as a tighter borrowing limit helps consumers by preventing over-borrowing.

Working Paper 11-39, "Rising Indebtedness and Temptation: A Welfare Analysis," Makoto Nakajima, Federal Reserve Bank of Philadelphia

EXAMINING THE FORECASTING ABILITY OF PHILLIPS CURVE MODELS

The Phillips curve has long been used as a foundation for forecasting inflation. Yet numerous studies indicate that over the past 20 years or so, inflation forecasts based on the Phillips curve generally do not predict inflation any better than a univariate forecasting model. In this paper, the authors take a deeper look at the forecasting ability of Phillips curves from both an unconditional and a conditional view. Namely, they use the test results developed by Giacomini and White (2006) to examine the forecasting ability of Phillips curve models. The authors' main results indicate that forecasts from their Phillips curve models are unconditionally inferior to those of their univariate forecasting models and sometimes the difference is statistically significant. However, the authors do find that conditioning on various measures of the state of the economy does at times improve the performance of the Phillips curve model in a statistically significant way. Of interest is that improvement is more likely to occur at longer forecasting horizons and over the sample period 1984Q1–2010Q3. Strikingly, the improvement is asymmetric — Phillips curve forecasts tend to be more accurate when the economy is weak and less accurate when the economy is strong. It, therefore, appears that forecasters should not fully discount the inflation forecasts of Phillips curve-based models when the economy is weak.

Working Paper 11-40, "Do Phillips Curves Conditionally Help to Forecast Inflation?," Michael Dotsey, Federal Reserve Bank of Philadelphia; Shigeru Fujita, Federal Reserve Bank of Philadelphia; and Tom Stark, Federal Reserve Bank of Philadelphia

POOLING INFORMATION IN ESTIMATES OF GDP TO CONSTRUCT A COMBINED ESTIMATE

Two often-divergent U.S. GDP estimates are available: a widely used expenditure-side version GDP_E, and a much less widely used income-side version GD_I. The authors propose and explore a "forecast combination" approach to combining them. They then put the theory to work, producing a superior combined estimate of GDP growth for the U.S., GDP_C. The authors compare GDP_C to GDP_E and GDP_I, with particular attention to behavior over the business cycle. They discuss several variations and extensions.

Working Paper 11-41, "Improving GDP Measurement: A Forecast Combination Perspective," S. Boragan Aruoba, University of Maryland, and Visiting Scholar, Federal Reserve Bank of Philadelphia; Francis X. Diebold, University of Pennsylvania, and Visiting Scholar, Federal Reserve Bank of Philadelphia; Jeremy Nalewaik, Federal Reserve Board of Governors; Frank Schorfheide, University

of Pennsylvania, and Visiting Scholar, Federal Reserve Bank of Philadelphia; and Dongho Song, University of Pennsylvania

STUDYING THE SPATIAL CONCENTRATION OF R&D LABS

The authors study the location and productivity of more than 1,000 research and development (R&D) labs located in the Northeast corridor of the U.S. Using a variety of spatial econometric techniques, they find that these labs are substantially more concentrated in space than the underlying distribution of manufacturing activity. Ripley's K-function tests over a variety of spatial scales reveal that the strongest evidence of concentration occurs at two discrete distances: one at about one-quarter of a mile and another at about 40 miles. These findings are consistent with empirical research that suggests that some spillovers depreciate very rapidly with distance, while others operate at the spatial scale of labor markets. The authors also find that R&D labs in some industries (e.g., chemicals, including drugs) are substantially more spatially concentrated than are R&D labs as a whole.

Tests using *local* K-functions reveal several concentrations of R&D labs (Boston, New York-Northern New Jersey, Philadelphia-Wilmington, and Washington, DC) that appear to represent research clusters. The authors verify this conjecture using significance-maximizing techniques (e.g., SATSCAN) that also address econometric issues related to "multiple testing" and spatial autocorrelation.

The authors develop a new procedure for identifying clusters — the *multiscale core-cluster* approach — to identify labs that appear to be clustered at a variety of spatial scales. They document that while locations in these clusters are often related to basic infrastructure, such as access to major roads, there is significant variation in the composition of labs across these clusters. Finally, the authors show that R&D labs located in clusters defined by this approach are, all else equal, substantially more productive in terms of the patents or citation-weighted patents they receive.

Working Paper 11-42, "The Agglomeration of R&D Labs," Gerald A. Carlino, Federal Reserve Bank of Philadelphia; Jake K. Carr, Federal Reserve Bank of Philadelphia; Robert M. Hunt, Federal Reserve Bank of Philadelphia; and Tony E. Smith, University of Pennsylvania

EFFECTS OF GOVERNMENT SPENDING CUTS ON ECONOMIC ACTIVITY IN AN ENVIRONMENT OF SEVERE FISCAL STRAIN

The authors analyze the effects of government spending cuts on economic activity in an environment of severe fiscal strain, as reflected by a sizeable risk premium on government debt. Specifically, they consider a "sovereign risk channel," through which sovereign default risk spills over to the rest of the economy, raising funding costs in the private sector. The authors' analysis is based on a variant of the model suggested by Cúrdia and Woodford (2009). It allows for costly financial intermediation and inter-household borrowing and lending in equilibrium but maintains the tractability of the baseline New Keynesian model. They show that if monetary policy is constrained in offsetting the effect of higher sovereign risk on private-sector borrowing conditions, the sovereign risk channel exacerbates indeterminacy problems: private-sector beliefs of a weakening economy can become self-fulfilling. Under these conditions, fiscal retrenchment can limit the risk of macroeconomic instability. In addition, if fiscal strain is very severe and monetary policy is constrained for an extended period, fiscal retrenchment may actually stimulate economic activity.

Working Paper 11-43, "Sovereign Risk and the Effects of Fiscal Retrenchment in Deep Recessions," Giancarlo Corsetti, Cambridge University; Keith Kuester, Federal Reserve Bank of Philadelphia; André Meier, International Monetary Fund; and Gernot J. Müller, University of Bonn

IDENTIFYING SOURCES OF THE DECLINE IN THE AGGREGATE JOB SEPARATION RATE

The purpose of this paper is to identify possible sources of the secular decline in the aggregate job separation rate over the last three decades. The author first shows that aging of the labor force alone cannot account for the entire decline. To explore other sources, he uses a simple labor matching model with two types of workers, experienced and inexperienced, where the former type faces a risk of skill obsolescence during unemployment. When the skill depreciation occurs, the worker is required to restart his career and thus suffers a drop in earnings. The author shows that a higher skill depreciation risk results in a *lower* aggregate separation rate and a *smaller* earnings loss. The key mechanisms are that the experienced workers accept lower wages in exchange for keeping the job and that the reluctance to

separate from the job produces a larger mass of low-quality matches. He also presents empirical evidence consistent with these predictions.

Working Paper 11-44, "Declining Labor Turnover and Turbulence," Shigeru Fujita, Federal Reserve Bank of Philadelphia

DEVELOPING A UNIFIED FRAMEWORK FOR MEASURING CONNECTEDNESS AT VARIOUS LEVELS

The authors propose several connectedness measures built from pieces of variance decompositions and argue that they provide natural and insightful measures of connectedness among financial asset returns and volatilities. They also show that variance decompositions define weighted, directed networks, so that their connectedness measures are intimately related to key measures of connectedness used in the network literature. Building on these insights, the authors track both average and daily time-varying connectedness of major U.S. financial institutions' stock return volatilities in recent years, including during the financial crisis of 2007-2008.

Working Paper 11-45, "Measuring the Connectedness of Financial Firms," Francis X. Diebold University of Pennsylvania, and Visiting Scholar, Federal Reserve Bank of Philadelphia, and Kamil Yilmaz, Koç University

EXAMINING INVESTORS' REACTIONS TO SEASONED EQUITY OFFERINGS

The authors examine investors' reactions to announcements of large seasoned equity offerings (SEOs) by U.S. financial institutions (FIs) from 2000 to 2009. These offerings include market infusions as well as injections of government capital under the Troubled Asset Relief Program (TARP). The sample period covers both business cycle expansions and contractions and the recent financial crisis. The authors present evidence on the factors affecting FI decisions to issue capital, the determinants of investor reactions, and post-SEO performance of issuers as well as a sample of matching FIs. They find that investors reacted negatively to the news of private market SEOs by FIs, both in the immediate term (e.g., the two days surrounding the announcement) and over the subsequent year, but positively to TARP injections. Reactions differed depending on the characteristics of the FIs, stage of the business cycle, and conditions of financial crisis. Larger institutions were less likely to have raised capital through market offerings during the period prior to TARP, and firms receiving a TARP injection tended to be larger than other issuers. The authors find that while TARP may have allowed FIs to increase their lending (as a share of assets) in the year after the issuance, they took on more credit risk to do so. They find no evidence that banks' capital adequacy increased after the capital injections.

Working Paper 11-46, "Large Capital Infusions, Investor Reactions, and the Return and Risk Performance of Financial Institutions over the Business Cycle and Recent Financial Crisis," Elyas Elyasiani, Fox School of Business, Temple University; Loretta J. Mester, Federal Reserve Bank of Philadelphia and The Wharton School, University of Pennsylvania; Michael S. Pagano Villanova School of Business, Villanova University