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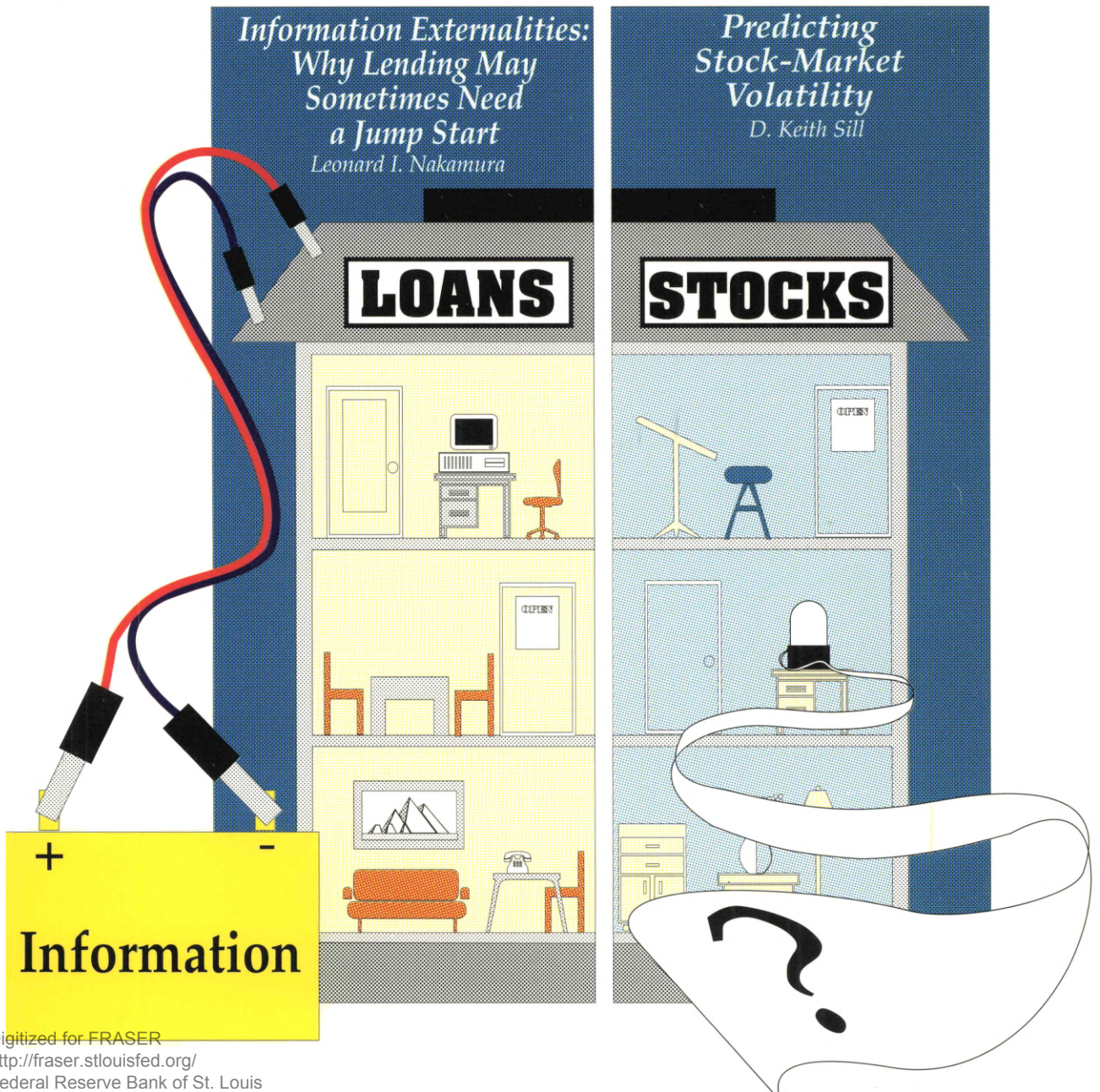
Leonard I. Nakamura

Predicting Stock-Market Volatility

D. Keith Sill



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Information Externalities: Why Lending May Sometimes Need a Jump Start

*Leonard I. Nakamura**

A banker, according to the comics, is someone who is willing to lend money to those who can prove they don't need it. As the joke ruefully suggests, the work of a lender (whether a banker or not) is to find someone who wants money now and will be willing and able to repay a larger sum in the future. From a banker's perspective, the first part of the requirement is all too easy to fill; the second part is the hard part. Bankers must compete to find and assess the good borrowers, and that puts bankers into the information business: the profitable lender is the one who best understands the businesses that borrowers are engaged in and the value of collateral that borrowers put up to guarantee loans.

Information about borrowers and collateral is thus essential to the flow of credit. But although information is crucial to the efficient operation of credit markets, it is often not itself produced efficiently. In credit markets where information flows are unsteady, private credit institutions may need public assistance or prodding.

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Information externalities constitute one reason credit markets are sometimes unreliable. An information externality in credit markets exists when each lender relies on information generated by the lending activities of other institutions. An information externality can cause a slowdown in lending activity to be self-perpetuating because the slowdown results in a shortage of information available to lenders.

One example arises in the mortgage market. A key informational need in a mortgage loan is an accurate measure of the value of the house that serves as collateral to guarantee the loan. The accuracy of appraisals is reduced when there are fewer recent sales. Where mortgage lenders cannot accurately evaluate collateral, elements of "mortgage redlining" can appear. In its most extreme form, mortgage redlining refers to neighborhoods in which mortgages cannot be obtained through conventional channels. Recent data collected under the Home Mortgage Disclosure Act (HMDA) show that mortgage applications of blacks and Hispanics are rejected more often than those of whites.[1] Some of this pattern of lending may be due to banks' having less information about the value of the houses that blacks and Hispanics intend to buy. When banks have poor information about house values, they will tend to reject more mortgage applications.

Another example arises in commercial lending, where banks attempt to estimate the likelihood that businesses will succeed. There is some evidence that during economic downturns, banks have a harder time knowing which borrowers are likely to be profitable. As a consequence, banks tend to raise their lending requirements more during an economic downturn, creating a "credit crunch" that may prolong the recession. Credit crunches, such as the one commercial real estate is struggling to emerge from now, are times in which some classes of borrowers have difficulty obtaining credit at any price.

Both examples involve a fundamental interaction between slower economic activity and the amount of information available to lenders. Because the lender knows less about the loan and whether it will succeed, it is riskier to the lender, who must charge more interest or require more collateral to earn a return. Because the lender charges more, some borrowers borrow less or drop out of the market, which can result in a sustained slowdown in economic activity. The reduction in economic activity leads to less information, less information leads to a further reduction in economic activity, and a vicious circle can ensue.

This dynamic interaction between information and economic behavior involves an externality, which is defined as occurring when the actions of one person or firm influence the opportunities and choices of another as a by-product. In this case, the externality is that the failure of one borrower to conclude a loan makes loans more costly and harder to obtain for later borrowers. In economic theory, externalities hold an important place in that when they exist, the "invisible hand" of the marketplace does not necessarily result in optimal interactions. For information externalities, this implies that government intervention—of the right kind—may help to improve credit market outcomes. In particular, government intervention to reduce mortgage redlining may improve society's welfare, even when the profit motive and not racial discrimination is the proximate cause of the redlining. And monetary policy to reduce interest rates may be a useful way to prime the credit pump during recessions.

Scholars have explored these and other aspects of the importance of information to lenders. Two other sources of information prob-

[1] See Glenn B. Canner and Dolores S. Smith, "Home Mortgage Disclosure Act: Expanded Data on Residential Lending," *Federal Reserve Bulletin* 77 (November 1991), pp. 859-81.

lems in loan markets are asymmetric information and coordination problems. These are discussed in *More Information Problems in Loan Markets*.

INFORMATION ABOUT COLLATERAL: MORTGAGES, APPRAISALS, AND REDLINING

Let's start with the information problem that can contribute to redlining in mortgage markets: assessing the value of the house that serves as collateral for the loan.[2] Lenders rely on the sale prices of recently sold comparable houses to help gauge the value of the house being mortgaged. When there are few such comparable houses, the value of a house is harder to estimate, and lending on the collateral of such houses is riskier. Bankers then may become reluctant to lend in these areas.

The mortgage market operates in this way: when a house is bought, the purchaser typically obtains a mortgage loan to cover most of the purchase price. This mortgage loan generally requires the purchaser to make a down payment as well as pay "closing costs"—the various fees, taxes, and escrow payments associated with the transaction. This down payment, which ensures that the house is worth more than the loan, plays a crucial role in the mortgage loan.

The lender has an important stake in the down payment because when the house is worth substantially more than the loan, the lender is doubly protected against loss.[3] First, the homeowner fears losing the house and will be unlikely to default. Second, if the homeowner cannot make payments, the house is more likely to be sold for more than the value of the loan, in which case the lender will receive full repayment of principal and accrued interest.

In a first mortgage that accompanies the sale of a house, the sale price is a matter of public record and indeed may shed some light on the size of the down payment. Unfortunately, for various reasons, the very real danger exists that the sale price overstates the likely resale value of the house.[4]

To safeguard against this, houses are typically appraised: a professional appraiser is asked to estimate the market value of the house. In the most common method of appraisal for existing single-family houses, an appraiser finds at least three recently sold houses that are similar to the house in question and are in the neighborhood. The appraiser, after adjusting the prices of the three "comparables" by adding or subtracting the value of features by which they differ from the house being appraised, weights the three adjusted values to come up with an estimate of the market value of the house being appraised, the appraised value. The "mortgage value" of the house is then calculated as the lesser of sale price or the appraised value.

Now consider a neighborhood in which there have been few recent sales. In this case, the appraiser must use house sales that are out-of-date or otherwise quite different from the house being appraised. The estimate that the appraiser then comes up with is likely to be less reliable and require more judgment on the part of the appraiser.

This will make it difficult for prospective home buyers to obtain financing for two rea-

[2]This section is based on William W. Lang and Leonard I. Nakamura, "A Model of Redlining," *Journal of Urban Economics* (forthcoming).

[3]The use of collateral in mortgages and lending generally is discussed in Leonard I. Nakamura, "Lessons on Lending and Borrowing in Hard Times," this *Business Review* (July/August 1991), pp. 13-21.

[4]One danger is that the buyer may have simply overpaid for the house. Another is that the buyer and seller may inflate the sale price of the house to reduce the borrower's down payment. Nakamura (1991) discusses explicitly how a seller's offer to pay closing costs inflates the sale price.

More Information Problems in Loan Markets

The information externalities addressed in this article are not the only information problems scholars have identified in credit markets. Two aspects of information that are also likely to be important in credit markets are information asymmetries and coordination problems.

First, in any economic interaction the parties have different knowledge of relevant information: a borrower will know more about her own business than the banker, and the banker may know more about business conditions generally than the borrower. These differences in information are called information *asymmetries*. Second, in many markets it is important to know the intentions of other market participants: the problem of economic *coordination*.

Information Asymmetry in Loan Markets. One extreme example of information asymmetry is loan fraud: borrowers know whether they are frauds or not, while lenders cannot always discern fraudulent borrowers. When interest rates rise, the fraudulent borrower is unaffected because he or she is never going to repay the loan. Some good borrowers, on the other hand, may well decide to wait to borrow until rates fall again. The increase in rates worsens the average quality of borrowers—and forces the lender either to raise rates even further or to increase the required collateral.

A similar mechanism operates whenever the lender has less information about the borrower's business prospects than the borrower does. A borrower who knows that the lender has underestimated the borrower's true risk and is charging too little interest is more likely to continue to borrow after an interest rate increase than a borrower who knows the lender has overestimated the borrower's true risk and whose interest rate is too high. Thus an increase in interest rates will generally cause unusually good borrowers to reduce their borrowing more than unusually bad ones.

Now, the information externality discussed in the main body of this article can lead to a decline in the information available to lenders during recessions. If this reduction in lender information worsens the information asymmetry between lenders and borrowers, making it harder for lenders to tell worse borrowers from better borrowers, then the two problems will reinforce one another.

Coordination Problems in Loan Markets. A basic problem of economic coordination is self-fulfilling prophecies. If one bank believes that other banks are unwilling to lend in a particular city and that business prospects in that city will worsen as a result, the first bank will itself be unwilling to lend to businesses in that city. Thus if all banks begin to think that other banks are unwilling to lend, none of them may lend: the prophecy could be self-fulfilling. If, on the other hand, the banks coordinate their lending, it might be possible for lending (and business in the city) to revive.

Some economists find self-fulfilling prophecies unlikely because formal models of this phenomenon require that the prophecy be fulfilled exactly, an unlikely occurrence in any actual economy. But for actual economies, adverse expectations that are only partially self-fulfilling may persist for long periods. Of course, a perspicacious investor may be able to profit from market mistakes of this kind, but even so, the misperceptions may disappear only very slowly.[a]

Coordination problems among lenders may exacerbate redlining. If lenders desert a neighborhood, default on a mortgage loan there is likely to be very costly to the lender, since selling the house will become very difficult. One reason for the success of the Delaware Valley Mortgage Plan is that it is a coordinated plan to which a number of the leading banks in the area have committed themselves.

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[a]For example, in the stock market, bad news about a stock apparently often drives the stock's value below its true worth. A result of this, confirmed by research by Bruce Lehmann and others, is that "contrarian" stock purchase strategies, buying stocks that have done poorly in the recent past, have consistently outperformed the U.S. market average. Thus the U.S. stock market has apparently suffered from misperceptions that the profit motive has been very slow to eradicate. Note that these adverse expectations about stocks increase the cost of raising funds for these companies, which would tend to make the adverse expectations self-fulfilling. See Bruce N. Lehmann, "Fads, Martingales and Market Efficiency," *Quarterly Journal of Economics*, 105 (February 1990), pp. 1-29, where he examines the performance of portfolios of stocks chosen according to a contrarian rule. He shows that a portfolio of stocks rebalanced weekly to reflect the previous week's returns compared to the market (with losers more strongly weighted) outperformed a balanced portfolio in all of the 98 quarters studied in the period from 1962-1986.

sons. First, the appraised value will more often be inaccurate and will be too high or too low more often than when better information on comparable sales is available. This reduces the value of the house whenever the appraised value comes in too low but doesn't raise it when the appraised value comes in too high. On average, appraised values will reduce mortgage values of houses, and larger down payments will be required. The need for a down payment remains an important barrier to home ownership for many households; larger down payments raise the height of the barrier.[5] Second, the mortgage lender will typically be able to see that the appraisal is inaccurate.[6] Even when the appraised value is above the sale price, the lender may be unwilling to lend because he or she implicitly discounts the appraisal.

Of course, when buyers are few, unsuccessful sellers must take stock and make a decision. Some will decide to rent, rather than sell, which reduces the public information available through house sales. Others will choose to lower their prices, but then falling prices will compound the riskiness that lenders perceive in these markets.

Thus once a neighborhood suffers a slowdown in house sales, difficulties in obtaining mortgages may perpetuate the difficulty in finding buyers. Ignorance about house sale values may thus feed on itself: the fewer the sales, the less information lenders have and the more likely they are to reject new loan applications, so even fewer sales occur. If lenders are sufficiently chary of lending in such a neighborhood, they might refuse to make any mortgages there, the extreme form of mortgage redlining.

This response on the part of the lender, while explainable in economic terms as an individual business practice, is not socially optimal. Indeed, since the passage of the Community Reinvestment Act of 1977, a bank's refusal to lend in neighborhoods in its market area may subject it to regulatory restrictions, reflecting the belief that banks have an obligation to their local communities to help them avoid lending traps such as "redlining." This type of government intervention in the marketplace can be justified theoretically, since the problem arises because of an externality (see *Externalities and the Coase Theorem*). Externalities imply that market decisions may not be social optimums because social benefits are not simply the sum of the private benefits to the parties to the market transaction. In this case, the externality is that a current house sale reduces the cost and increases the availability of mortgages to future house buyers.

This line of reasoning helps us understand a conundrum. This conundrum arises because many researchers believe that redlining results from discrimination by mortgage lenders. But mortgage markets appear to be highly competitive: entry into them is extremely easy, and there are dozens, if not hundreds, of mortgage lenders in the urban markets where redlining is alleged to occur. If good credit risks are being denied credit because of discrimination, why don't nondiscriminatory lenders enter these mortgage markets and profitably end redlining? Why is government prodding desirable? The answer is that at least some redlining occurs because information is in short supply in

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[5]See Peter Linneman and Susan Wachter, "The Impacts of Borrowing Constraints on Homeownership," *AREUEA Journal* 17 (1989), pp. 389-402, for a discussion of the down payment constraints in house purchases. One might think that recent changes in mortgage markets, including the introduction of a wide variety of types of mortgages, would eliminate down payment constraints as a barrier to house purchase. Linneman and Wachter's evidence is that down payments remain a significant barrier to house purchase: prospective buyers with less cash available for a down payment cannot buy as large a house as they otherwise would.

[6]The mortgage lender will see that the sales used in the appraisal comparisons are either far from the house being appraised or are out of date.

Externalities and the Coase Theorem

An externality exists when the actions of one or more economic agents affect the costs or benefits of another as an unmarketed by-product. For example, if the air pollution that is a by-product of a coal-burning electric generator lowers the demand for the services of a nearby hotel, an externality exists. When externalities exist, market pricing may not provide the right incentives to maximize social welfare. However, Nobel Prize winner Ronald Coase has pointed out that many externalities can be cured by the action of the free market provided that transaction costs are not too large.

Let's begin by briefly summarizing the argument that in the presence of externalities, competitive markets may not lead to socially optimal outcomes. In competitive markets without externalities, the invisible hand theorem assures that the marketplace provides appropriate social incentives for productive activities. The price of a good simultaneously reflects the private cost of production of an additional unit and the private benefit of consumption of an additional unit, which, when there are no externalities, are equal to the social cost and benefit, respectively. With externalities, on the other hand, part of the social cost or benefit of production is not reflected in the price of the good produced, so that social costs and benefits diverge from price and, in general, private production is either too little or too much.

One traditional example is bees and orchards. Beekeepers own hives and sell honey; orchard growers own trees and sell fruit. These two activities are intertwined, as the bees use nectar from the fruit trees to produce the honey, and fruit trees need the bees to pollinate their flowers. If the market for honey is weak and beekeepers reduce the size of their operations, orchard growers may suffer because their trees produce less.

Thus, prices in the honey market may not provide adequate social incentives to the beekeeper because they do not take into account the benefits that orchard growers derive from the bees. Before Coase's analysis, the presumption was that government intervention was proper when such an externality was known to exist. In the honey market example, a subsidy to beekeepers might be desirable.

What Coase pointed out is that beekeepers and orchard growers can, and in many cases do, contract privately between themselves to solve the problem created by the externalities. Each producer can be thought of as producing a joint product: the beekeeper produces honey and "pollination services"; the orchard grower produces fruit and "floral nectar." If pollination services are scarce, the orchard grower can pay a beekeeper to install hives in the orchard, providing the beekeeper an income for "pollination services." Or if there are too many bees and too few orchards, beekeepers can pay orchard growers for "floral nectar rights" by renting space in orchards. The fundamental idea is that if the relevant parties can be brought together with an assignment of property rights, private contracting will result in providing the right incentives provided no transaction costs exist.

Government intervention, according to Coase, should be sought only when the relevant parties cannot be easily brought to the negotiating table or if bargaining costs are likely to be large, that is, when transaction costs are high. To see where this may be necessary, fishing is a good example. The catch of one fishing boat may reduce the catch of other boats, and the collective catch of the fishing fleet in one year may reduce the catch in succeeding years.

Fishers may wish to write a contract that restricts their catch, but it may be hard to prevent entry by others who haven't signed the contract. An even more difficult problem is that future generations of fishers (and fish eaters) may not be adequately represented in the absence of government intervention on their behalf. As a consequence, government restrictions on fishing rights may improve on private arrangements.

Coase's idea directs us toward a clarification of exactly what transaction costs are and how they impede a private market solution. In the case of the financial markets we are discussing, because potential beneficiaries of improved information include future generations of borrowers and lenders, private market incentives are likely to be inadequate.

redlined neighborhoods. And as long as the information remains in short supply, profitable entry is not possible.

The dynamic information externality does not explain how redlining gets started, but rather why it is self-perpetuating. Redlining may begin from a discriminatory practice or from a temporary neighborhood decline. For example, the Depression of the 1930s had a very deep impact on the Harlem neighborhood in New York. Although not the only factor, information externalities help explain why the Depression might have hurt mortgage lending in Harlem long after the U.S. economy as a whole had returned to normal.

Also, the size of down payments is part of the reason redlining is self-perpetuating. In wealthy neighborhoods, where potential home buyers, on average, can afford larger down payments when they are required, uncertainty about house values will not retard sales nearly as much as in poorer neighborhoods, where down payments are critical barriers to homeownership.

REMEDIES FOR REDLINING

If a key problem in "redlining" is an information externality that increases the costs and risks of lending, appropriate remedies must take this into account. In particular, in neighborhoods where appraisals are less reliable, mortgage makers may need to be prodded to gather additional information about the house or borrower in question. Local community groups may be helpful in providing more detailed information about specific blocks and changing neighborhood boundaries. And with house equity a less secure source of repayment, the character of the borrower may become more important. Here again, local community groups may be useful in screening applicants.

The Delaware Valley Mortgage Plan (formerly called the Philadelphia Mortgage Plan) is one of the more successful banking coalitions aimed at attacking redlining.[7] Three key features of the mortgage plan result in relatively strong lending across diverse neighborhoods. First, all banks commit themselves to acquiring more information by lending on the basis of the specific block the house is on and by looking thoroughly for mitigating factors when a borrower's credit records are not spotless. This is particularly important in maintaining the stability of neighborhoods where some blocks have deteriorated but others have been maintained or upgraded. Second, the plan reduces the effective cost of transactions to the applicant. All applications recommended for rejection under the plan are reviewed by a credit committee to ensure that credit decisions are free of bias and consistent with the plan's policies. The committee can recommend that the bank reconsider its decision, and if the bank persists in declining the application, another member bank can consider the application. Thus each application is, in effect, an application to all the member banks, which directly reduces the applicant's transaction costs. Finally, the plan relies on extensive outreach, and referrals from community organizations play an important role in increasing applications under the plan.

These elements of the Delaware Valley Mortgage Plan together form a sensible and unusually successful attack on the underlying information problems that play an important role in redlining. Of course, the additional information and committee work are not costless. As a consequence, competitive pressures can erode lenders' willingness to participate in plans such as these. So legislation that requires mortgage lenders to take positive steps to support community borrowing can have a valuable role in making these types of plans viable.

Another approach is to reduce the down

[7]For a full discussion of the Delaware Valley Mortgage Plan, see Paul S. Calem, "The Delaware Valley Mortgage Plan: An Analysis Using HMDA Data," *Journal of Housing Research* (forthcoming).

payment constraint. The federal government assists mortgage borrowers with two mortgage loan programs, one run by the Federal Housing Administration (FHA) and the other by the Veterans Administration (VA). Both programs relax the down payment constraint and thus tend to make sales possible in neighborhoods that are informationally constrained.[8] The FHA mortgage program has the drawback that it requires a 3.8 percent mortgage insurance premium, making them more expensive than conventional mortgages with private insurance. VA mortgages are subsidized and less expensive than conventional mortgages but are available only to veterans. One concern that remains with these programs, as was emphasized in the discussion of the importance of the down payment to the lender, is that lower down payments tend to result in greater loan losses. In fact, delinquency and foreclosure rates are higher on FHA and VA mortgages. Thus while reducing down payments helps to make sales possible, it simultaneously increases the risk of undesirable outcomes. Indeed, it is conceivable that increased foreclosures in these government programs may, in certain circumstances, add to perceived risk in conventional mortgage lending. Thus reducing the down payment constraint cannot be viewed as a complete solution to the information problems in mortgage markets.

Thus far we have discussed the value of information in mortgage lending. For commercial loans, information—about the purpose of the loan and about the likelihood of the business success of the borrower—is often crucial to sound lending. Information about the demand for a proposed product or service, for example, is a key input to commercial lending: the success of a pizza parlor in a town is useful in judging the likely success of a pizza delivery service. It is to this type of information that we now turn.

INFORMATION ABOUT BUSINESS OPPORTUNITIES: COMMERCIAL LENDING AND CREDIT CRUNCHES

In this section, we focus on the special role of commercial banks in the financing of small businesses. The essence of this role is that banks must make judgments about whether businesses that ask for loans are likely to succeed. In making these judgments, each bank relies on information generated by past lending activity, its own and that of other banks. Hence, an information externality may be a source of "credit crunches" during recessions.

In the parable of perfect competition taught in undergraduate microeconomics, entrepreneurs are constantly searching for profit opportunities. If an entrepreneur is successful and achieves supranormal profits, other entrepreneurs observe this success, copy it, and eliminate the short-run profits of the pioneer. We thus are called to witness the triumph of the "invisible hand," and we are told this is a social optimum. In a static sense, it is. But this narrative describes a dynamic information externality: the information generated in one period is valuable for the allocation of resources in succeeding periods.[9]

Bank lenders are a crucial part of this infor-

[8]See, for example, Stuart S. Rosenthal, John V. Duca, and Stuart A. Gabriel, "Credit Rationing and the Demand for Owner-Occupied Housing," *Journal of Urban Economics* 30 (July 1991), pp. 48-63, for evidence that holders of VA and FHA mortgages face reduced noncredit constraints such as down payments.

[9]This section is based on William W. Lang and Leonard I. Nakamura, "Information Losses in a Dynamic Model of Credit," *Journal of Finance* 44 (July 1989), pp. 731-46, and "The Dynamics of Credit Markets in a Model with Learning," *Journal of Monetary Economics* 26 (October 1990), pp. 305-18.

mational chain in two ways.[10] First, the past loans that commercial bank lenders have made are unique sources of detailed data about the local economy and individual enterprises. In the course of making loans, banks typically obtain information about the borrower not elsewhere available. In particular, because of their access to the checking accounts of their borrowers, banks acquire more detailed information than other possible lenders.[11]

Second, to accurately evaluate the default risk of commercial borrowers, bank lenders continually compile and analyze both local and national information. For example, Robert Morris Associates, the association of bank loan and credit officers, collects and disseminates summary information from financial statements of different borrowers, classified by industry.[12] This enables lenders to compare the financial statements of borrowers with national industry norms. Of course, because local conditions are crucial to local lending, bank loan officers must be experts on their local economies and must continually search out information about local conditions.

Information about borrowers is of value in lending to large and small borrowers alike. However, banks have a relative advantage in lending to small, relatively risky borrowers rather than large, relatively safe borrowers because the local information banks are able to gather about their borrowers is of most value in lending to smaller, riskier borrowers.[13] Recent evidence on loans to smaller borrowers studied by Timothy Hannan shows that such borrowers pay higher interest rates in concentrated banking markets, that is, markets in which there is less competition among local bank lenders.[14] This implies that nonbank lenders (or nonlocal banks) find it harder to enter these markets to provide a check on the market power of the local banks, presumably because the nonbank lenders lack the local information that the local banks have.

Because past and existing loans convey information that is useful in the making of new loans, a decline in local lending and the concomitant decline in economic activity will tend to make future lending riskier. Bank lenders will have less information upon which to judge new applications, and that will make them more uncertain in their judgments.

This leads banks to raise their risk premiums in lending, which in turn makes borrowing riskier for the borrowers, who face a higher

[10]A classic discussion of the informational role of banks is found in Douglas B. Diamond, "Financial Intermediation and Delegated Monitoring," *Review of Economic Studies* 51 (July 1984), pp. 393-414.

[11]Fischer Black, "Bank Funds Management in an Efficient Market," *Journal of Financial Economics* 2 (1975) and Leonard I. Nakamura, "Commercial Bank Information: Implications for the Structure of Banking," in Lawrence J. White and Michael Klausner, eds., *Structural Change in Banking,* Irwin (forthcoming); both discuss aspects of the use of checking accounts as sources of information for commercial banks.

[12]*Annual Statement Studies*, Robert Morris Associates, Philadelphia. Robert Morris Associates also publishes the *Journal of Commercial Lending*, which regularly includes articles on lending to particular industries.

[13]See Nakamura, "Commercial Bank Information..." (forthcoming) for a fuller discussion of the evidence for this proposition. Specific evidence on bank lending to hospitals is in Paul S. Calem and John A. Rizzo, "Banks as Information Specialists: The Case of Hospital Lending," *Journal of Banking and Finance* (forthcoming). Theory and statistical evidence suggest that smallness and riskiness are associated and that both contribute to a firm's dependence on bank lending. It should be pointed out, however, that there exist large, risky firms and small, safe ones.

[14]Timothy H. Hannan, "Bank Commercial Loan Markets and the Role of Market Structure: Evidence from Surveys of Commercial Lending," *Journal of Banking and Finance* 15 (February 1991), pp. 133-49.

repayment[15] and a greater risk of bankruptcy. Note that the borrower's business prospects need not have changed. But although the expected return to the borrower's business is the same, the lender perceives a greater risk because lenders have less information. The net effect is a higher probability of bankruptcy for the borrower; the lender's uncertainty becomes greater risk for the borrower.[16] Borrowers then borrow less; the higher risk causes them to lower their planned economic activity. The higher risk faced by borrowers reduces their borrowing both because of the borrower's aversion to risk and because of the increased costs businesses face when financial distress occurs.

Banks also attempt to counter the loss of information by making the noncredit terms of lending more onerous—requiring more collateral or personal guarantees. The higher noncredit terms may be impossible for the borrower to meet, or the borrower may feel the terms entail an unacceptable degree of personal risk.

The loss of information may be exacerbated if the bank decides that specific types of lending are unlikely to be profitable for a sustained period of time or that the bank is carrying too much risk exposure in one area already. The bank may transfer personnel away from that area or lay them off, thus further reducing the information the bank has.

These information problems in lending are local. Are they important for entire economies? This is primarily an empirical matter. But on a theoretical level, economywide shocks can clearly be prolonged by this essentially local mechanism. If, for example, an oil price hike leads to fewer loans being made across the country, each local credit market thereafter has less information, which will in turn tend to reduce local lending in each market in the next period, creating an economywide impact of reduced lending.[17] As a result, the aggregate temporary dislocation can have prolonged effects through local channels. Similarly, the economywide impact of reduced mortgage lending can exacerbate and prolong recessions in the housing market.

Thus a temporary decline in aggregate lending may become prolonged because, in addition to the normal dampening effects of a reduction in demand on economic activity, banks also face a reduction in the information available to them about borrowers. As a consequence, banks will tend to reduce their holdings of loans to risky borrowers and increase their holdings of loans to less risky borrowers (including, possibly, their holdings of U.S. government and agency debt).

This means that recessions will, from the borrower's perspective, typically be characterized by periods of relatively tight credit, when little new lending is going on. Also, banks have less information during these periods, making it somewhat harder for them to discern when times are improving and new loans less risky.

The problem of information loss during re-

[15]The banks require a higher risk premium because as risk increases, the expected return to the loan decreases. With higher risk, the borrower fails to repay the full amount of the loan more often. Of course, if the bank is risk averse and cannot fully diversify the risk of the loan, the risk premium will increase by even more, and the impact of the information externality will be even greater.

[16]This analysis applies with both risk-averse and risk-neutral lenders. In the risk-neutral case, the greater uncertainty on the part of lenders implies that lenders will more often be either too optimistic or too pessimistic than when there is more information available. The borrower is then sometimes charged too much and other times too little. The uncertainty of the lender randomly redistributes borrowing costs across borrowers, which increases the effective risk faced by the average borrower. This increase in borrower riskiness results in a higher probability of bankruptcy and thus greater average borrowing costs for borrowers.

[17]See Lang and Nakamura (1990) for the underlying theory.

cessions and the fact that this information loss constitutes an externality imply that too little lending occurs during recessions. As a consequence, the monetary authority may wish to encourage lending by pushing short-term interest rates down to offset this effect during recessions.

In the absence of the externality, interest rates should reflect and mediate, in Irving Fisher's classic terminology, the impatience to spend (the preference for present over future consumption) and the opportunity to invest (the return on capital investment).[18] With no information externality, actions of the monetary authority to raise or lower the interest rate interfere with this equilibrium.

The transmission of information through credit markets is likely to be least efficient during recessions, as the evidence below points out. With this information externality, then, a reduction in interest rates during a recession may indeed improve social welfare by encouraging additional lending, which provides informational advantages as the recession turns to recovery.

Empirical Evidence on Information Losses During Recessions. The information theory just outlined applies primarily to smaller, riskier firms that are more dependent on bank credit. Larger, safer firms have access to nonbank sources of funds. A decrease in bank lending to these risky firms could have a prolonged effect on the availability of credit to these firms and thus on their economic activity if the theory is important empirically.[19,20]

Data taken from the Federal Reserve's Survey of Terms of Bank Lending suggest that recessions indeed appear to be foreshadowed by a "flight to quality" in which the ratio of "safe" commercial loans (to borrowers considered "prime" customers) to total commercial loans (the sum of prime and less than "prime" borrowers) increases.[21] Although these data are available only since 1979, all three recessions since then were foreshadowed by a flight to quality, as measured by the ratio of safe lending to total lending.

In each case, the flight to quality signals a persistent shift in real U.S. economic activity, as the theory just outlined suggests. The impact of a reduction in risky lending on real U.S. growth (as measured by real gross domestic product) grows for at least a year and persists strongly for at least two years.

Balance sheet data on corporate liabilities also support the point that small borrowers are affected crucially in recessions. Stephen Oliner and Glenn Rudebusch show that a decline in bank lending following a monetary contraction

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[18]Irving Fisher, *The Theory of Interest*. New York: Macmillan, 1930. This classic work is subtitled, "As Determined by IMPATIENCE To Spend Income and OPPORTUNITY To Invest It."

[19]If the junk bond market, for example, could substitute fully for banks in lending to risky borrowers during recessions, decreases in bank lending to these borrowers would likely not have much aggregate importance. The empirical evidence that follows shows that recent changes in the market structure of lending have not eliminated the aggregate importance of bank lending.

[20]The empirical question of whether credit disturbances play an important role in aggregate activity has been a recurrent one in economics. Ben Bernanke, in an influential article, has given evidence that the Depression of the 1930s was exacerbated by the bank failures that were endemic at that time. He argued that the bank failures led to a greater cost of financial intermediation: investment became more difficult because the bank failures greatly compromised the banking system's ability to evaluate and monitor loans. See Ben Bernanke, "Non-Monetary Effects of the Financial Collapse in the Propagation of the Great Depression," *American Economic Review* 73 (June 1983), pp. 257-76.

[21]The empirical evidence discussed here is in William W. Lang and Leonard I. Nakamura, "The Flight to Quality in Bank Lending," Working Paper 92-20, Federal Reserve Bank of Philadelphia, 1992.

depresses investment spending by small firms.[22] In a separate test, they show that small firms are more dependent on internal cash flows for investment during a recession.

Data on sales by small firms also tend to support this argument. Mark Gertler and Simon Gilchrist show that after a monetary tightening, the sales growth of small firms declines more sharply than that of large firms.[23]

These papers strongly suggest that reductions of bank lending to smaller, riskier borrowers are an important element in recessionary periods. They argue that bank loans to small firms are important to aggregate activity, making it appear likely that information externalities exacerbate declines in economic activity.

SUMMARY AND CONCLUSIONS

Commercial banks are information specialists. By and large, competition and the profit motive provide good incentives for banks to do an excellent job of information-gathering and loan analysis. Lenders depend, however, on past transactions to provide information to help them evaluate current loans. Periods in which loan markets become thin thus tend to become self-perpetuating, as the slowdown in lending reduces information and the resulting ignorance begets uncertainty and makes borrowing riskier, so even fewer loans are made. This represents a dynamic information externality. As a consequence, when information thins out, as when few mortgages are made in a given neighborhood or when lending to risky borrowers declines in a recession, there may be a useful role for the government to play in encouraging credit activity.

[22]Stephen D. Oliner and Glenn D. Rudebusch, "The Transmission of Monetary Policy to Small and Large Firms," mimeo, Federal Reserve Board, June 1992.

[23]Mark Gertler and Simon Gilchrist, "Monetary Policy, Business Cycles and the Behavior of Small Manufacturing Firms," NBER Working Paper No. 3892, 1991.

Other Dynamic Information Externalities

Information externalities are crucial to credit markets because the provision of credit is so intimately tied to information. Yet, information externalities exist not only in credit markets but throughout the economy.

For instance, Rafael Rob has shown that information externalities are important to capacity decisions in growing industries.[a] Rob's analysis begins with the point that in such industries, producers will be uncertain about the shape of the demand curve and must guess about how much capacity the market will bear. Each addition to capacity—as it comes to market—provides additional information about the demand for the product. This information is then of value to the next firm that adds capacity.

Another area in which information externalities are important is in new inventions and ideas. Although patent protection allows an inventor to keep some of the value of a new idea or invention, subsequent inventions and ideas that build upon it can appropriate much of this value. Basic research is subsidized for this reason, since basic research may have little immediate market value but may have great ultimate social value, value garnered by those who build on the original idea.

Indeed, the development of any new industry is likely to be rife with instances of firms' benefiting from the risks and ideas of others. For example, many personal computer manufacturers have benefited from the firms, such as Apple and IBM, that pioneered this market. If this is the case, society will benefit when research and development are subsidized.

[a]Rafael Rob, "Learning and Capacity Expansion Under Demand Uncertainty," *Review of Economic Studies* 58 (July 1991), pp. 655-75.

Predicting Stock-Market Volatility

*D. Keith Sill**

On October 19, 1987, the stock market posted its largest one-day decline ever when the Dow Jones Industrial Average fell 508 points, a drop of over 22 percent in a single day. Prior to the crash of 1987, the largest single-day drop in the stock market occurred on October 29, 1929, when the market fell by about 13 percent. While drops of this magnitude are rare, it is not uncommon for stock prices to rise or fall by 3 percent or more in a single month. Stock prices seem to be very unpredictable. In addition, economists have long recognized that stock prices go through turbulent and tranquil periods. Turbulent periods are times of high uncertainty when stock prices move sharply from month to month; tranquil periods are times when stock price movements are much more subdued.[1] However, only recently have economists begun modeling how stock-market volatility (or stock-price turbulence) changes through time.

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[1]This recognition of the changing variability of stock prices goes back to the early 1960s. An early, comprehensive study of the behavior of stock-market prices is that of Fama (1965).

Why does stock-market volatility vary through time? Is stock-market volatility predictable? To address these questions we will need to examine theories about how stock prices are determined. Then we can see whether the behavior of U.S. stock prices over the last 30 years is consistent with the implications of these theories. But first, we would like to know how stock-market volatility affects the economy.

HOW DOES STOCK-MARKET VOLATILITY AFFECT THE ECONOMY?

Economists argue that stock-market volatility can affect the economy in several ways: (1) it influences how much people spend and save; (2) it influences the prices of stocks; and (3) it influences the prices of financial options and thus affects how investors might hedge investment risk.

The Effect on Spending and Saving. How might an increase in stock-market volatility affect people's spending and saving decisions?[2] Consider the case of a hypothetical person named Walter Wealthy who has an uncertain future income because of his investments in the stock market.[3]

Walter's decision about how much to spend today depends on how much income he expects his stocks to produce. If he expects a high return from his investment in stocks, he may want to spend less (and save more) today.[4] Doing this allows Walter to spend more in the future (if the high expected return comes about). This incentive to save more today is called the substitution effect, since future spending is substituted for current spending.

Offsetting this substitution effect is an income effect, which leads Walter to want to spend *more* today. If the expected stock return is high, he feels richer today because he expects to have higher wealth in the future. Feeling richer, Walter may increase current spending. Thus, the income effect works to offset the substitution effect. However, empirical evidence suggests that usually the substitution effect dominates the income effect, so that saving increases with an increase in expected returns.[5]

We have seen that the expected return on stocks affects Walter's spending and saving decisions. His decisions also depend on the degree of uncertainty about the return on stocks. An increase in the degree of uncertainty means that a stock's expected return is unchanged, but there is an increased chance that the actual return will be farther away from the expected return. For example, suppose you buy a stock today for $100 that pays off $105 with a 10 percent chance, pays $110 with an 80 percent chance, and pays $115 with a 10 percent chance. The expected payoff on this asset is then (.10 x $105)+(.80 x $110)+(.10 x $115) = $110. An increase in uncertainty can come about either by an increase in the likelihood of getting a high

[2]In the following discussion of the effects of stock-return uncertainty on people's spending and saving decisions, we get the sharpest predictions by assuming that stocks are the only risky assets in which people can invest. Alternatively, we can assume that there are other risky assets but that an increase in stock-return uncertainty reflects an increase in return uncertainty of all risky assets. If the increase in stock-return uncertainty is specific to the stock market, then the primary consequence of the increase may be a portfolio shift away from stocks and into other assets. The overall effect on spending and saving is then more difficult to pin down. For details see the 1989 article by Robert Barsky listed in the References.

[3]In general, part of the income uncertainty that people face is due to their future labor income being uncertain. In the case of Walter Wealthy we will ignore labor income uncertainty in order to focus on the uncertainty associated with holding risky assets such as stocks.

[4]The return from holding stocks includes both the dividends paid to the stockholder plus capital gains that accrue when the price of the stock increases.

[5]For a fuller discussion of the income and substitution effects associated with changes in uncertainty, see the articles by Barsky (1989) and Abel (1988).

or low payoff, for example, a 20 percent chance of $105, a 60 percent chance of $110, and a 20 percent chance of $115 (note that the expected return remains $110); or by a change in the value of the high and low payoffs, for example, a 10 percent chance of $100, an 80 percent chance of $110, and a 10 percent chance of $120. Again, the expected return is $110.

In the case of an increase in uncertainty, as in the case of an increase in the expected return, there are offsetting effects. A precautionary-saving effect induces Walter to cut back on current spending and increase current saving.[6] He increases current saving to guard against the increased likelihood of a bad outcome, which is a low return. On the other hand, a substitution effect leads Walter to spend more today. He spends more today in an effort to sidestep the increase in risk because current spending looks more attractive in the face of increased uncertainty about the future.

Which effect dominates depends on Walter's attitude toward risk. If he has a strong-enough dislike for risk, the precautionary-saving effect dominates, so his current spending will fall, and his saving will rise in response to an increase in the uncertainty of returns.[7] Empirical studies of household preferences toward risk suggest that most people fall into this category.

We can also consider how an increase in uncertainty affects the current prices of stocks. If Walter dislikes risk, an increase in the uncertainty of returns on stocks can lead him to sell some of his stocks and buy other, less risky assets, such as bonds. Since other holders of stock will also behave like Walter, the current prices of the stocks will fall as people sell their shares. Therefore, an increase in the uncertainty of returns can lead to a fall in the current price of stocks.

So, if Walter has a strong-enough dislike for risk, an increase in uncertainty about stock returns may cause him to increase current saving to guard against the possibility of a very low return next period. Thus, increased stock-market volatility can affect how much people spend and save. In addition, increased uncertainty can lead to a fall in the current prices of stocks.

The Effect on Stock Options Prices. An increase in stock-market volatility also affects another variable of economic interest: the price of stock options. A stock option is merely a contract that gives its owner the right to buy or sell a specified number of shares of an underlying stock at a specified price, called the exercise (or strike) price, within a specified period. For example, on July 3, 1992, as reported in the *Wall Street Journal*, one could have purchased a call option on Intel stock that would give the owner the right to buy 100 shares of Intel at a price of $55 per share on or before the third Friday in August 1992. The price to purchase the contract was $350, and Intel stock was selling on the National Association of Securities Dealers Automated Quotation (NASDAQ) system for $55-7/8 per share.

Stock options are like insurance contracts: the owner of a stock option has paid a "premium" to acquire "insurance" that eliminates some of the downside risk associated with holding a share of stock (the chance that the price of the stock will fall dramatically). The writer of the option contract acts like an underwriter, agreeing to "insure" the buyer of the contract against a bad outcome. Options are used by investors, consumers, and producers to hedge against uncertainty.

Investors and producers who use options as part of their financial strategy are of course interested in whether particular options are priced appropriately. In a 1973 article, Fisher Black and Myron Scholes developed a popular and widely used model of option pricing that

[6]For more on precautionary savings, see Barsky (1989) and Blanchard and Fisher (1987).

[7]This increased savings will flow partly into assets that are less risky than stocks.

shows how the price of an option can be determined from certain characteristics of the underlying stock. One of these characteristics is the volatility of the stock price. In the Black-Scholes model, the higher the volatility of the stock price, the higher is the price of the option.[8] The intuition behind this result can be understood without going into the complexities of the model. With higher volatility of stock prices, there is a greater chance of receiving both a good outcome (high stock price) and a bad outcome (low stock price). However, the option bears no downside risk. The worst that can happen is that the option will expire worthless at maturity. Referring to our Intel example, suppose that the share price of Intel stock fell to $52 in August. Then the call option would expire worthless, since no one would want to exercise the option and purchase the stock for $55 when it could be bought on the stock market for $52. In that case, the option buyer would lose the $350 spent to purchase the option. However, even if Intel fell to $1 per share, the most that the option owner could lose would be $350, the price of the option contract. Note that the owner of 100 Intel shares would lose over $5400 dollars if the share price fell to $1. On the other hand, if Intel's price rises to $155 in August, the option owner would exercise the contract and buy 100 shares for $55 per share. She could then sell those shares for $155 per share and receive a profit of ($155 - $55)x(100 shares) = $10,000.

[8]We should note that in the Black-Scholes derivation of option prices, it is assumed that the volatility of the stock price is constant. Thus, when we compare the effects of higher variance on option prices we are really comparing options written on two different stocks. The arbitrage argument used in the valuation procedure is not sufficient to determine the price of the option when the option depends on variables that are not traded or that cannot be hedged by an existing security, as is the case with stock price volatility. When stock prices have a time-varying variance, more restrictive equilibrium asset-pricing models can be used to derive option prices.

Because the downside risk on a call option is limited and the potential gains on the upside are not, the price of an option should be higher when the volatility of the stock price is high. The higher the volatility, the greater the chance that at the option's expiration date the underlying stock price will exceed the option's exercise price.

There is also an indirect path by which a change in uncertainty might affect the price of a stock option. Recall that an increase in uncertainty can lead to a fall in the price of a share of stock. A fall in the share price will in turn lead to a decrease in the price of a call option written on that stock. Suppose that a stock is trading at a price that is below the exercise price of the call option on that stock. If the share price falls, the option would be less valuable, since the stock price will have to increase by a larger amount in order that, at the expiration date, the selling price of the stock exceeds the exercise price of the option. Thus, a fall in the current price of a share leads to a fall in the price of a call option written on that stock.

We see then that there are offsetting effects on options prices due to a change in the uncertainty of a stock. For a call option, the direct effect of an increase in volatility is to raise the price of the option. The indirect effect is to lower the price of the option through a change in the current price of the share. For a put option, which gives the owner the right to sell shares of the underlying stock at a fixed price, direct and indirect effects of an increase in volatility work in the *same* direction.

We have seen two examples of how stock-market volatility affects behavior. Increased stock-market volatility causes people to spend less and save more, and for a given spread between a stock price and option strike price, it raises the price of the option.

HOW DOES STOCK-MARKET VOLATILITY CHANGE OVER TIME?

We have seen how changes in stock-market

volatility can affect the economy. How has this volatility changed over time? To answer this question, we must first construct a measure of the volatility of the stock market.

A graph (Figure 1) called a histogram illustrates the idea behind volatility. Panel A shows annual returns on common stocks as measured by the Standard & Poor's 500 index (S&P 500), and Panel B shows annual returns on long-term government bonds. The height of the bars in each panel represents the number of times (frequency) a particular return was observed on a yearly basis from 1959 to 1991. A tall bar means that a particular return was observed relatively more often. The horizontal axis measures annual return in percent.

In Figure 1, the three tallest bars in the bond-return distribution account for more than 65 percent of the observations. In the common stock-return distribution, the three tallest bars account for only slightly more than 45 percent of the observations. The distribution of returns for common stocks is more spread out than is the return distribution for long-term bonds, which means that there is a higher likelihood of receiving either a high or a low return when investing in stocks versus investing in long-term bonds. This suggests that common stocks are riskier investments than government bonds, that is, stock returns are more volatile.[9]

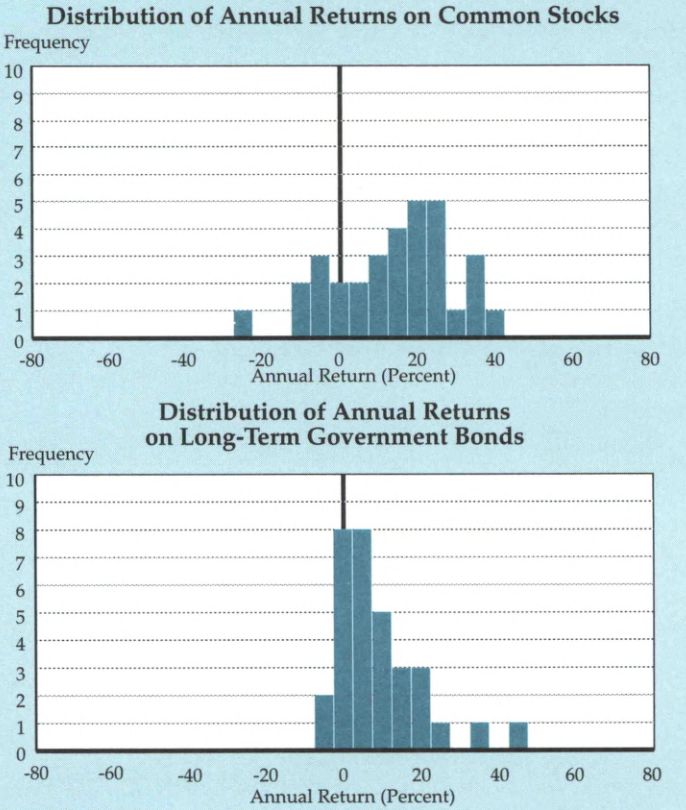
One useful way to measure the volatility of an asset is to look at its *variance*. Variance is a measure of dispersion—the larger the variance, the more spread out a distribution is. Another useful concept for measuring volatility is the *standard*

[9]Note, however, that an investor is rewarded for taking on the extra risk associated with holding common stocks. The average return on common stocks over this period is about 11 percent per year. The average return on long-term government bonds is 6.6 percent per year.

FIGURE 1

Asset Return Distribution

(1959 - 1990)



Source: Ibbotson Associates and author's calculations

deviation, which is defined as the square root of the variance (see *Calculating Variances and Standard Deviations* for technical details on variances and standard deviations).[10] In Figure 1 we saw that common stocks are more volatile than long-term government bonds. This is reflected in the statistic for the standard deviation: annual stock returns have a standard deviation of 15.6 percent, which is larger than the standard deviation of annual government bond returns of 10.8 percent.

Forecasting Stock-Market Volatility. People need to forecast how volatile the stock market is so that they can make better decisions about spending and saving and about pricing options. You might think that the best forecast of the volatility of the stock market is simply to calculate the variance of stock returns from a distribution like that shown in Figure 1. That calculation shows that the long-run standard deviation of annual stock returns is 15.6 percent. But this is not the best forecast of the variance at any particular date. Forecasts that use recent information are more efficient than forecasts that do not use recent information. If stock-market volatility is high this month, that may indicate an increased chance that volatility will be high next month. If this is the case, we want to use this information in making forecasts of stock-market volatility.

One method of forecasting the variance of the stock market is to use *time-series models*.[11] A

[10]A helpful rule of thumb is that 67 percent of the observations tend to fall within one standard deviation of the mean, and 95 percent of the observations tend to fall within two standard deviations of the mean. This rule of thumb is for symmetric distributions, which means that the tails of the distribution are mirror images of each other.

[11]Alternative methods of deriving and forecasting stock-return volatility are used as well. An estimate of the return variance can be derived using option-pricing theory. In the Black-Scholes model of option pricing, the variables that determine the current price of the option are the current stock price, the time to maturity of the option, the strike

Calculating Variances and Standard Deviations

Variance is a quantitative measure of how spread out a distribution of variables is. The variance is defined as the average value of squared deviations of a variable from its mean. If we have a sample of n observations on a variable x, the general formula for variance is given by:

$$\sigma^2 = \frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^2$$

where $\bar{x}$ is the sample mean:

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n}x_i$$

We can clarify this formula with a simple example. Suppose a stock yielded 3 percent one month, -2 percent the next month, and 1 percent and 6 percent in the following months. The average return on the stock is, in units of percent:

$$\frac{3 + (-2) + 1 + 6}{4} = 2$$

The variance is given by:

$$\frac{(3-2)^2 + (-2-2)^2 + (1-2)^2 + (6-2)^2}{4} = 8.5$$

The standard deviation of returns is given by the square root of the variance, or 2.92 percent. The standard deviations reported in Figure 1 were calculated this way, using 32 observations on annual returns.

The standard deviation of stock returns exceeds the standard deviation of bond returns in Figure 1 because actual individual stock returns are often quite different from the average value of stock returns. Individual government bond returns are usually much closer to their average value.

time-series model is simply a way to look at the relationship between current and past values of data. In the case of stock-return variance, a time-series model would show how this month's variance is related to the variance of the stock market over the past few months.[12] The best long-run forecast of monthly stock-market variance is the variance calculated from a distribution like that in Figure 1.[13] But the best short-run forecast of variance may be much lower or higher, depending on what the variance has been in recent months.

Economic theory suggests a method for forecasting stock-return variance: calculate the size of past errors in forecasting stock returns,[14] then use the squared values of these forecast errors to estimate the stock-return variance.[15] This method of forecasting stock-return variance makes intuitive sense as well. In calm times, our forecasting model for stock returns should predict relatively well, and so our forecast error should be relatively small and the predicted variance will be small. In a particularly volatile time, our model will not fit quite as well, so that the forecast error is large and the predicted variance will be large.

We have plotted a measure of stock-market volatility using forecast errors from a time-series model of stock returns (Figure 2). The figure shows the forecast errors from a forecasting model of monthly returns to the S&P 500 stock index from 1959 to 1992.[16] Note that the stock-market volatility measure shows a great deal of variation. Volatility does not appear to be constant. The highest spike corresponds to the month of October 1987. Recall that on October 19, 1987, the stock market experienced its sharpest one-day drop ever. This figure also suggests a correlation through time in return volatility. Visual evidence suggests that sharp upward spikes are bunched together. This pattern indicates that volatility may in part be predictable based on its own past values.

PREDICTING STOCK-MARKET VOLATILITY

Why is it that stock-market volatility changes over time? Are there regular patterns in the time-series behavior of volatility? To help us address these questions it is useful to have an economic model of how stock prices are determined.

price, the risk-free interest rate, and the variance of the stock price. Since the current price of the option is observed, the Black-Scholes formula can be inverted to solve for the variance. This method of calculating stock price variance is referred to as the "implied-volatility" method. See, for example, the 1991 book *Option Valuation: Analyzing and Pricing Standardized Option Contracts,* by Rajna Gibson. For a comparison of how well time-series methods and implied-volatility methods characterize stock-return volatility, see Day and Lewis (1992).

[12]Time-series modeling of variances is a very active area of research for economists. See the April/May (1992) issue of the *Journal of Econometrics,* which is devoted entirely to ARCH (autoregressive conditional heteroskedasticity) models of financial market data. In their simplest form, ARCH models assume that the current value of the conditional variance is a linear function of past squared deviations.

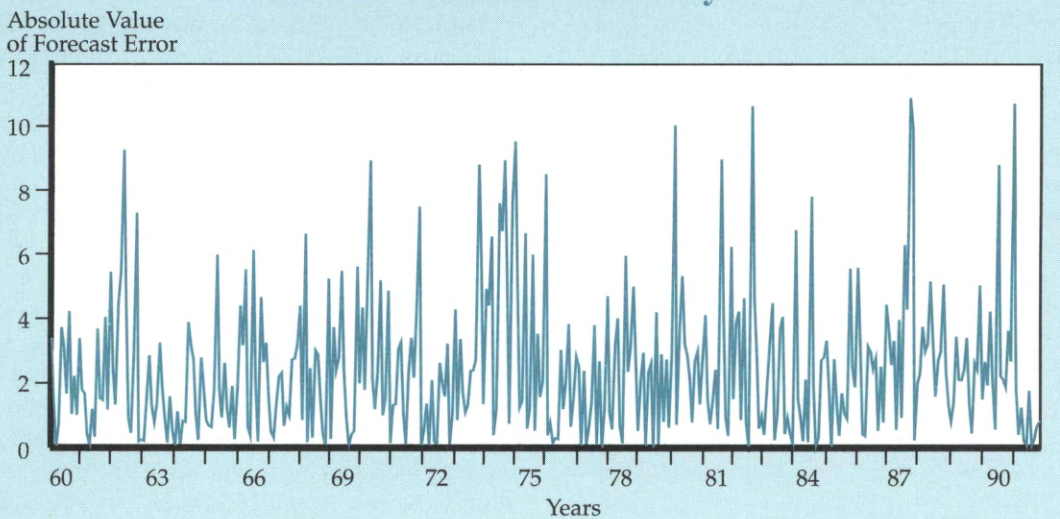
[13]We would need to calculate a distribution for monthly stock returns. The distribution in Figure 1 is for annual stock returns.

[14]This method of calculating the variance and standard deviation of stock returns follows Schwert (1989) and Salinger (1989). An alternative method is to calculate the variance of daily stock returns and then use these daily variance observations to calculate a monthly variance. Schwert presents graphical evidence indicating that the two measures are similar.

[15]The forecast errors are the in-sample residuals from the estimated model for returns. The variance that is estimated from these forecast errors is called the conditional variance of returns.

[16]The absolute value of each monthly forecast error is plotted in Figure 2.

FIGURE 2
Stock-Market Volatility



Suppose we take a simple model that expresses the current price of the stock as a positive multiple of current dividend payments.[17] This is certainly an oversimplification, but it will keep the discussion uncomplicated. For a stock portfolio as diversified as the S&P 500, current dividend payments might be proxied by current, economywide output. If the stock price is then represented as a positive fraction of current output, the expected variance of stock returns will be positively related to the expected variance of output *growth*.

In this model, the fundamental factor that drives stock prices is the level of output. We can think of output as indicating the state of the economy. When output growth is high, the state of the economy is good (expansions). When output growth is low, the state of the economy is bad (recessions). Any patterns over time in the volatility of output growth will be reflected in the volatility of stock returns. When we examine output growth (as measured by monthly industrial production), we find that output-growth volatility is correlated over time and that output-growth volatility is higher in recessions than it is in expansions. Our simple model suggests that we should see similar behavior in the time path of stock-market volatility.

Let us first examine whether stock-market volatility is correlated through time. One way to do this is by checking whether past volatility is useful in predicting current volatility. If we take monthly data on the S&P 500 from 1959 to 1992, we find that past volatility does help predict future volatility. However, the model's ability to predict future volatility is rather poor. Only a little over 1 percent of the total variation

[17]This result can be derived from an intertemporal model of asset pricing where investors face an uncertain future and have utility that is a logarithmic function of consumption. More general models of stock pricing suggest that the current price of a share of stock is related to the entire future stream of dividends that investors expect to receive. See Sargent (1987) for a technical discussion of these models.

in return volatility is explained by its own past values; over 98 percent of the movement over time in volatility evident in Figure 2 remains unexplained.

To test whether stock-market volatility is higher in recessions than it is in expansions we forecast volatility using data on its own past values and a variable that captures whether the economy is in a recession or an expansion. As suggested by our model, we find that the recession variable does help to explain volatility. Volatility is *higher* in recessions than in expansions. Based on our volatility measure we would forecast that the standard deviation of monthly returns would rise by about 2 percentage points in recessions.[18] By including the recession variable in the volatility forecast equation we can account for about 6 percent of the movement in stock-market volatility over time.

What other things might help us to improve our predictions of volatility? What about the seasons of the year? Is volatility predictably higher in one month than in another? A simple way to test for the presence of seasonal movement in volatility is to form a forecast of volatility using data on its own past values and a set of variables that account for the different months, or seasons, of the year. We can then test whether these seasonal indicators improve the forecast. Some evidence indicates that stock-market volatility is predictably lower in June, but in general, the evidence for a seasonal pattern in stock-market volatility is weak.

What have we learned so far about patterns in the behavior of stock-market volatility? First, stock-market volatility is not constant. It can be predicted, though rather imprecisely, using its own past values. Second, volatility tends to be higher in recessions than in expansions. Third, there is weak evidence of a seasonal movement in volatility.

Prediction Using Macroeconomic Variables. We have seen that there are identifiable patterns in stock-market volatility over time. The observation that stock-market volatility is higher in recessions than in expansions suggests that we might improve forecasts of volatility by using variables that predict recessions. If we can predict recessions, perhaps we can predict stock-market volatility. However, our test will be a little more demanding. Stock-market volatility itself predicts industrial-production volatility and so might predict recessions. Therefore, we will look at how well macroeconomic variables forecast stock-market volatility over and above the forecasting power of past stock-market volatility itself.

I examined a battery of macroeconomic variables to see if they predict future stock-market variability. These variables included inflation, various measures of money-supply growth, industrial production and consumer spending growth, and oil price shocks. Somewhat surprisingly, these macroeconomic variables did not improve forecasts of stock-market volatility over and above forecasts made using past levels of stock-market volatility. However, interest-rate variables did help to improve predictions of volatility because interest rates convey information about the risk of bankruptcy and about the stance of monetary policy.

When a firm borrows money, it might go bankrupt before paying off the loan. Lenders realize this and charge an interest rate on loans that reflects the firm's default risk, which is the likelihood that the firm will not pay off the loan. Strong firms, which are unlikely to go bankrupt, pay low interest rates, while weak firms pay higher interest rates. However, the whole schedule of interest rates changes as the economy changes. During recessions, all firms face an increased risk of bankruptcy, so all firms must pay higher interest rates on loans. Since the chance of bankruptcy is higher in recessions, expected dividend payments are

[18]The long-run standard deviation of monthly stock returns, measured by the S&P 500 index, is about 3.1 percent.

lower, and stock prices fall. Thus, there is a correlation between the default risk on corporate borrowing and stock prices.

How can we measure default risk? One way is to look at the interest rates on corporate bonds and compare them with the interest rates on default-free bonds, such as U.S. government bonds. The difference between these two interest rates, called an interest-rate spread, acts as a measure of default risk.

A different interest-rate spread may provide useful information about stock-market volatility in another way: the spread can indicate not just default risk but also changes in monetary policy. We have seen that stock-market volatility is higher in recessions than in expansions. If tighter monetary policy predicts future recessions, it will predict stock-market volatility. If monetary policy tightens, the cost of funds to banks increases. Banks will then have to increase the interest rates they pay on certificates of deposit (CDs). Since CDs and commercial paper are near-perfect substitutes, their interest rates will rise together; but Treasury bills are imperfect substitutes for CDs, so their interest rates won't rise as much. The overall effect is that the spread between interest rates on commercial paper and Treasury bills will increase. Another possibility is that banks may cut back on loans to customers, but again, the spread between commercial-paper interest rates and Treasury-bill interest rates could rise. In this case, firms issue commercial paper rather than borrowing from banks, causing interest rates on commercial paper to rise.[19] If the spread between the commercial-paper rate and the Treasury-bill rate is a measure of the stance of monetary policy, this spread could predict stock-market volatility because it predicts future recessions.

Examining the data, we find that the interest-rate spreads and their volatility help forecast stock-market volatility. In both cases, the default-premium variables have significant explanatory power for stock-market volatility. In fact, including the recession index and the interest-rate spreads, we can account for about 10 percent of the variation in stock-market volatility.

The Time-Series Behavior of Expected Volatility. The data show that stock-market volatility is difficult to predict. However, even though forecasts of volatility might be poor, the economic significance of these forecasts can be large. Forecasts of stock-market volatility are a measure of what people expect future stock-market volatility to be. After all, a forecast is just a best guess of what will happen in the future. Recall from our discussion of people's spending and saving decisions and the discussion of options prices that expected stock-market volatility affects behavior and prices. People act today based in part on their expectation of future events. Therefore, we would like to know if there are large changes over time in expectations of future stock-market volatility.

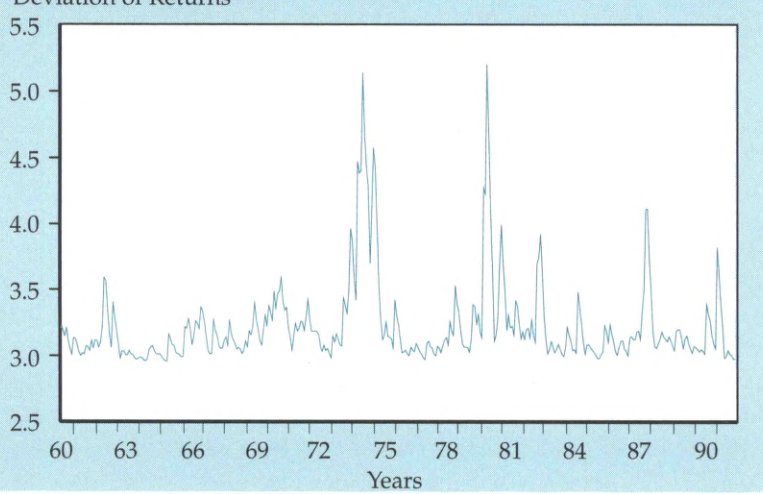
We have plotted the forecasted, or expected, stock-market volatility (Figure 3), constructed using past values of stock-market volatility and past values of the volatility of the interest-rate-spread variable.[20] Expected stock-market volatility clearly changes through time, though the movement is not as pronounced as the movement in the volatility displayed in Figure 2. (Recall that Figure 2 shows realized values of the forecast errors.) The sharpest upward movement in expected volatility occurs over the period 1973 to 1975, which coincides with

[19]See Bernanke (1990) for an in-depth discussion of the predictive power of interest rates and interest-rate spreads for future economic activity.

[20]This measure of expected volatility was constructed by using a bivariate ARCH model for stock returns and the T-bill/commercial paper spread. For details on how the measure of expected stock-market volatility was constructed, see my working paper listed in the References.

FIGURE 3

Expected Volatility of Stock Returns



the first OPEC oil price shocks and a recession. The next sharpest upward movement in expected volatility occurs in 1980, which also coincides with a recession. In fact, expected stock-market volatility in Figure 3 rises in each of the six recessions since 1959.[21]

How economically significant are these movements in expected volatility? Consider the case of option prices. The Chicago Board Options Exchange trades in call and put options on the S&P 500 index. Suppose that the current level of the S&P 500 index is 426.65, the call option contract has 30 days until maturity, and the strike price of the option is $425. Suppose further that the expected volatility of the index return is 3.1 percent. Under these conditions, the Black-Scholes option pricing formula predicts that the price of the call option is $6.87.[22] Suppose that we keep all parameters the same except for the volatility of returns, which increases by 2 percentage points, the amount that monthly volatility is predicted to increase during recessions. In this case, the Black-Scholes model predicts the call option price will be $10.19. Thus, the option price is quite sensitive to changes in expected volatility. Economic theory suggests that changes in expected volatility can also influence other economic variables such as consumption and investment. Measuring the effects of these changes in volatility is an active area of research for economists.[23]

VOLATILITY IN THE 1980s

The data on stock-market volatility have suggested that: (1) past levels of volatility predict future levels of volatility; (2) interest-rate spreads help to predict volatility; and (3) volatility is higher in recessions than expansions. However, if we test propositions (1) and (2) using data from 1980 through 1991, we find little evidence to support them. That is, in the

[21]The recessions occurred April 1960 to February 1961, December 1969 to November 1970, November 1973 to March 1975, January 1980 to July 1980, July 1981 to November 1982, and, most recently, the recession that began in July 1990.

[22]The parameters of the Black-Scholes pricing model include the time to maturity of the contract, the current price of the stock, the strike price of the contract, the volatility of the stock return, and the value of the risk-free interest rate. In the example in the text, the risk-free interest rate was assumed to be 4 percent per year.

[23]For a comprehensive survey of recent empirical work on time-series modeling of expected volatility, see Bollerslev, Chou, and Kroner (1992).

1980s, the forecasting power of past levels of stock-market volatility and the interest-rate spread deteriorated significantly. Why was this the case?

One possibility, suggested by the simple model of stock pricing, is that the time-series behavior of the volatility of output growth changed in the 1980s. However, when the data are examined we find that past values of output-growth volatility still have predictive power for future output-growth volatility in the 1980s. According to the simple model, past levels of stock-market volatility should still have predictive power for future volatility.

The change in the behavior of stock-market volatility may be related to developments in financial markets that occurred over the course of the 1980s. For example, the transaction costs of buying and selling stocks were much lower in the 1980s than in the early 1970s. Institutions, which account for about 80 percent of the trading on the New York Stock Exchange (NYSE), now pay less than 5 cents per share in commissions versus 80 cents per share in the early 1970s. These lower commission charges are reflected in the increased volume of trading on the market. This higher trading volume serves to make the stock market more liquid, thus helping to further reduce the costs associated with executing a trade. With these lower costs of trading, investors are able to react more quickly and more frequently to new information. These developments may have altered the time-series behavior of volatility.

Another possibility is that the time-series behavior of stock-market volatility has been influenced by the trend toward increasing integration of world financial markets. In the 1960s, transactions by foreigners accounted for about 12 percent of the dollar volume of trade on the NYSE.[24] In the 1970s the average had risen to about 16 percent. In the 1980s, the average reached over 19 percent. With the increasing interdependence of world markets, U.S. stock prices are influenced more and more by developments in foreign countries. This could contribute to a change in the time-series behavior of stock-market volatility.[25]

Why did the interest-rate variables have lower forecasting power in the 1980s? In a 1990 article, Ben Bernanke offers two possibilities. First, in the decade of the 1980s there have been changes in the way the Federal Reserve implements its monetary policy. These changes allowed short-term interest rates, such as the federal funds rate, to become more variable, all else equal. As a result, short-term interest rates may have become less tightly linked to the monetary policy actions that ultimately affect the economy.

A second possibility is that financial deregulation and financial innovation in the 1980s may have increased the substitutability between Treasury bills, commercial paper, and CDs. If these assets are closer substitutes, the sensitivity of interest-rate spreads to changes in monetary policy may be reduced. The weaker link between interest-rate spreads and monetary policy might then be reflected in a weaker link between the interest-rate spreads and the economy.

CONCLUSION

The data on stock returns suggest that: (1) stock-market volatility can be predicted based on its own past values; (2) volatility is higher in recessions than in expansions; (3) some variables that theory suggests might help explain

[24]The percent of transactions accounted for by foreigners is measured as the sum of sales by foreigners to Americans and sales to foreigners by Americans divided by the dollar volume of trade on the NYSE. These data are taken from various issues of the *New York Stock Exchange Fact Book*.

[25]Another innovation to financial markets in the 1980s has been the introduction of futures and options trading on stock market indexes. These contracts allow investors to buy and sell large baskets of stocks at a fraction of the cost required to execute the same trade in the stock market.

stock-market volatility (such as money-supply variability, inflation variability, and industrial-production variability) are not helpful; and (4) the spread between commercial-paper rates and Treasury-bill rates has predictive power for stock-market volatility. However, the best we can do with these variables is to explain about 10 percent of the variation in stock-market volatility over time. In addition, it appears that volatility became more difficult to predict in the 1980s.

Even though it is difficult to accurately predict stock-market volatility, the forecasts that people make about volatility are important. Economic theory argues that it is these expectations about future volatility that can affect people's decisions to spend and save. Changes in expected volatility can also affect stock prices and investment and the prices of stock options. The evidence suggests that there are substantial movements in expected stock-market volatility relative to the average level of volatility.

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