Financial Econometrics, Financial Innovation, and Financial Stability

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Introduction

I am pleased and flattered to have been invited to speak to you today at your inaugural conference. Academic work, both theoretical and empirical, in financial econometrics has had a tremendous impact on the form and structure of modern global financial markets. It has promoted both innovation and growth in an industry that is critical to the efficient allocation of capital and risk. Yet recent events have raised a number of questions about the stability and robustness of these complex markets and the role played by financial innovation. A more thorough understanding of such issues is important not only for researchers and market participants but for policymakers as well. In my remarks I would like to offer my perspective on some of these issues and raise some questions whose answers might provide some useful insight for policymakers and others in thinking about financial stability.

The functioning of financial markets has been a major focus of attention since last summer. The turmoil we have witnessed was triggered by unexpectedly large losses on subprime mortgages issued in the U.S. over the last couple of years. Many, if not most, of these mortgages had been bundled into asset-backed securities and sold to investors in tranches, presumably reflecting different risk characteristics. When these securities began to sustain losses in excess of those expected given the credit ratings they had been assigned, investors began to question the reliability of the ratings. While in many cases these complex asset-backed securities had been sold to a wide array of investors, their inherent complexity resulted in market participants' having a difficult time valuing them. This happened in part because the underlying default rates became highly uncertain, but also because it was difficult to determine which institutions had exposure to these assets and to what degree. Indeed, the holdings have turned out to be more concentrated than many of us expected. Nonetheless, investors pulled back and banks and other financial institutions found it difficult to sell these securities or use them as collateral to obtain funds in the short-term money markets. In general, we saw a rapid and substantial widening of risk spreads, and, in certain financial markets, trading either became extremely thin or completely shut down.

These events and the Federal Reserve's efforts to mitigate the financial disruptions that ensued raise a long list of questions for policymakers and students of the financial markets. The questions and proposed answers will no doubt be the subject of numerous studies by academics and other interested observers. My hope is that some of you may find such questions intriguing and your research will contribute to our understanding of them in an effort to improve policy.

Innovation in Financial Markets

Before I discuss some issues that raise challenging questions for financial economists, I would like to offer my perspective on the role of innovation in financial theory and practice. Observers have suggested that excessive innovation and new products in finance have been important contributors to the financial disruptions we have witnessed, implying that there is a danger in too much innovation. I have a somewhat different perspective.

Developments in finance theory and financial econometrics have played a critical role in spurring innovation and growth. Innovation in financial markets has led to substantial deepening of global capital markets. For example, technical advances have made it possible to convert many assets that were relatively illiquid or non-tradable into newly created tradable securities. Theoretical and econometric techniques have enhanced the ability to develop and estimate sophisticated relative pricing models for a wide array of structured assets. In addition, financial innovation has generated greater efficiency in the allocation of risks by breaking the links between origination and ownership and by creating securities that more finely allocate risks to different investor classes.

I believe the boom in financial market innovation and growth has undoubtedly generated efficiencies in the allocation of capital, lowered the cost of capital, and contributed to economic growth worldwide. Nevertheless, not every innovation is successful. In markets for consumer goods and services, or industrial goods, some new products fail. They fail to perform as anticipated or have adverse unforeseen consequences. In other

words, they fail to meet the market test. Some products just disappear, never to see the light of day again. Other products are refined or improved to meet the demands of the marketplace and thus return to the market in some modified form. Product failures, of course, can be costly to investors and customers alike. Yet winning and losing are important elements of a dynamic market-driven economy and efforts to stifle or limit the winning or losing will generally yield sub-optimal outcomes.

I see innovation in the financial markets in a similar light. Financial engineering has enabled firms to construct a wide variety of new "products" and instruments. However, just because a security can be created does not guarantee that it can or will survive in the marketplace. I suspect that many of the newly created products — for example, structured investment vehicles, or SIVs — may not return, or if they do, they will have a different form or contract structure. The message is that financial innovation as a whole is beneficial to society and has improved the functioning of our capital markets. That does not mean that every new innovation will succeed, but that is the nature of progress and we should take care that regulation does not unnecessarily inhibit such innovation.

However, the financial market spillovers from events in the subprime mortgage market do raise questions about potential weaknesses in our financial system. While I don't know the answers to many of the questions raised by these recent developments, let me highlight three questions that are of interest to me and other policymakers and that many of you can help address in your research.

1. In assessing risk in financial models, how effective are current modeling methodologies in incorporating model error or model uncertainty? Specifically, have these models appropriately captured the implications for underlying statistical relationships of the impacts of aggregate shocks?

2. Do we have adequate tools and methodologies to stress test these models? This is particularly challenging in the area of consumer credit portfolios and their dependence on expected loss distributions. [This is an area in which the Philadelphia Fed's staff has a particular interest.]

3. How should we evaluate the trade-off, if any, between undertaking policy interventions aimed at combating short-run financial instability and the potential

financial market distortions and moral hazard that could result from those interventions?

Robustness, Stress Testing, and Model Uncertainty

In discussing my first question, let me begin with some general observations about assessing risk in financial models. As a bank regulator, the Federal Reserve gets a bird's-eye view of how large financial institutions measure and manage their risk. For example, the Federal Reserve Bank of Philadelphia houses a group of experts who examine banks' risk models for consumer credit portfolios — credit card loans, mortgages, auto loans, etc. This allows us to see more clearly some of the strengths and weaknesses of the modeling approaches used at large, sophisticated banking organizations.

The complex risk models used by financial institutions to analyze portfolio risk provide the basis for the pricing of derivative securities based on the returns from these assets. Most investors in the asset-backed securities markets probably know fairly little about the underlying risk models or the strengths and weaknesses of those models. Of course, this situation is not unique to newer financial instruments. Modern finance theory has developed various models of markets in which investors have different degrees of information and different degrees of sophistication. So, perhaps there is little difference in some of these newer markets.

It certainly could be the case, however, that where models are relatively new and complex, investor confidence in these underlying models may undergo substantial shifts. These shifts in confidence could amplify the volatility generated by shocks to investors' views about the likely realizations of stochastic state variables, such as interest rates or macroeconomic conditions. That is, when data reveal substantial departures from prior forecasts, it may be difficult to untangle whether this outcome is a result of shifts in state variables or a result of modeling errors, particularly when the underlying modeling apparatus is opaque.

The broad market reaction to the Enron bankruptcy in 2001 provides a parallel to this idea. Why did the fall of Enron cause such disruption in the financial markets? The disruption was not primarily a result of a change in market views about economic conditions, but rather it reflected a broad loss of confidence in the reliability of accounting statements. In the case of the recent turmoil in financial markets, to what extent was this turmoil exacerbated by investors' loss of confidence in the ratings given by rating agencies to various tranches of asset-backed securities and derivative products? Clearly, investors' perception of the riskiness of a variety of securities changed in a short period of time. But it's not clear that current modeling methodologies that incorporate such things as model error or model uncertainty could have captured this sudden change in investors' confidence in modeling the risk associated with these securities. Perhaps more attention must be focused on the potential for greater volatility and even breakdowns in the underlying structures on which the pricing relationships depend and exploring the types of shocks that might generate such outcomes.

The degree to which confidence in modeling approaches may be shaken depends in part on the models' degree of transparency as well as the quality of the models that rating agencies and other financial institutions use to measure risk. While there have been enormous advances in this type of modeling over the last two decades, there are still notable weaknesses. The Philadelphia Fed has focused on modeling consumer credit, so I'll focus on modeling in that sector — particularly mortgage risk modeling — in discussing my second question: How do you determine an appropriate method for stress testing the model parameters to take into account the uncertainty in parameter estimates?

Modeling Consumer Credit

Consumer lenders use a host of sophisticated credit scoring techniques to assess borrower risk. These models have proven extremely valuable in practice and have a significant track record. This modeling apparatus is geared primarily to forecasting expected losses. However, the modeling of portfolio loss distributions in consumer credit is still relatively new. Models of portfolio loss distributions have applied concepts taken from

developments in financial theory and practice, which emphasize the importance of modeling structures of correlations for determining portfolio risk. The models are primarily used for determining economic capital and measuring risk-adjusted returns. Increasingly, bank regulation is using this type of modeling by incorporating these tools into the new international regulatory capital requirements for banking firms, known as Basel II. Our staff at the Philadelphia Fed is responsible for much of the Fed System's work on reviewing banks' Basel II models for consumer credit.

Nevertheless, there are some difficult challenges in modeling higher moments of the risk distribution of consumer credit portfolios. One of these challenges is the relatively short data histories used by modelers. For example, many financial institutions built mortgage risk models based on proprietary data that did not span a very long time period. In many cases, the models did not include data from the last housing recession of the early 1990s. While various longer data sources for mortgages exist, the internal proprietary data at banks are richer, and many firms believed that data from earlier periods would not be able to incorporate the very dramatic changes in the mortgage market over the last decade. One example of this type of change is subprime lending, which was not a substantial factor in the last housing recession in the early 1990s.

The relatively short history encompassing a period of strong housing markets generated potential weaknesses in the ability of mortgage models to incorporate the effects of a stressed housing market. While this problem was understood by experts working in the field, and there were attempts to measure the impact of stress on portfolio performance, this lack of a longer data series still posed a very difficult empirical problem. Obviously, in hindsight, it's clear that the market underestimated both the potential for a broad downturn in the housing market and the impact this stress would have on losses in the mortgage market.

While forecasting errors would likely have been lower if modelers had access to high-quality data covering multiple housing cycles, these models have other potential sources of weakness. For example, portfolio credit risk models used in the market are reduced-

form equations that look at the historical relationship between risk factors and outcomes. For reasons that have long been discussed by econometricians, this kind of reduced-form model may perform poorly when there are significant structural or behavioral changes in the economy.

There is some reason to believe that this type of structural shift did occur in mortgage markets. There is considerable evidence that rapid house price growth led to a substantial increase in the investment or speculative motive for those "optimistic" home buyers who believed that prices would continue to rise. Such borrowers chose larger homes and higher leverage and were more likely to default when housing prices fell relative to past episodes of house price decline.

This phenomenon certainly existed in the past during periods of rapid house price appreciation, and it is possible that this phenomenon would be observed in models with longer data histories. However, the recent boom in housing also occurred during a period of unprecedented expansion in the supply of consumer credit. Much of this expansion was fueled by the development of information technology. Lenders were able to store and analyze vast amounts of data on individual consumers and to estimate models of an individual's creditworthiness using these data. To add to this overall trend in credit expansion, recent years saw an unusually sharp decline in mortgage underwriting standards that further expanded credit. While there are many suggestions as to the cause of these lower lending standards, I think we do not yet have a clear understanding of why this occurred. In any event, the broadening of consumer credit availability, the lowering of lending standards, and potential adverse selection problems during this housing market boom all contributed to the situation we found ourselves in this past year.

In principle, analysts can attempt to incorporate model uncertainty into their risk assessment. However, this has been a difficult area and one that has probably not received sufficient attention. For example, when rating mortgage CDOs (collateralized debt obligations), the rating agencies would run their models through a stress scenario to determine an appropriate rating. However, the losses that occur in those models are quite

sensitive to the estimated correlations in the model. In particular, structural or macroeconomic shocks can result in very poor forecasts from such reduced-form models. So this leads to the second question I posed at the beginning: How do you determine an appropriate method to "stress" the model parameters to take into account the uncertainty in parameter estimates from such reduced-form models?

I have suggested that shifts in the degree of confidence in new and complex valuation models might be a source of instability in financial markets. Therefore, improving these modeling methodologies and increasing transparency, as well as obtaining better measures of model uncertainty, will be factors in improving the functioning of certain financial markets. The Federal Reserve and other banking regulators have been devoting more resources to looking at this modeling apparatus for the purpose of assessing bank risk management techniques. Increasingly, we are also looking at these issues from the financial stability perspective. I believe that many of you could make great contributions in this arena, and we at the Philadelphia Fed are certainly interested in maintaining a dialogue with researchers in these areas.

While the sources and characteristics of financial instability have changed along with changes in our financial system, shocks to the financial system are not a new phenomenon. When they do occur, there are often calls for the central bank to smooth out the volatility in the marketplace and, in some cases, to prevent the failure of a major financial institution.

It is clear that the smooth functioning of financial markets is a central element of a modern economy and is important for the achievement of central banks' objectives. However, it is less clear how to distinguish disruptions in the efficient functioning of financial markets that call for central bank intervention from necessary market corrections to asset prices. Developing a clearer understanding of this distinction is critical for determining appropriate policy and the appropriate tools of policy.

Moral Hazard and Financial Stability

If a central bank's financial stabilization policy is designed simply to smooth out fluctuations in asset prices, it runs the risk of delaying necessary price adjustments and creating substantial inefficiencies in the marketplace. Financial stabilization policies, if misapplied, can effectively subsidize risk-taking by systemically important financial institutions. Such policies run the risk of increasing moral hazard and ultimately raise the risk of systemic instability rather than lowering it. That brings me to my third question: How should we evaluate the trade-off, if any, between undertaking policy interventions aimed at combating short-run financial instability and the potential financial market distortions and moral hazard that could result from those interventions?

When faced with such a situation, policymakers must evaluate the trade-offs based on the knowledge and evidence we have at the time. Improving our understanding of financial markets and the effects of financial market innovation will be important for improving the efficiency of those markets, and it will be very important to central bank policymakers throughout the world.

The issues surrounding financial market instability raise important questions about how financial markets value assets as well as questions about the nature of liquidity. But as I have been suggesting, it also raises important questions about the role of the central bank in fostering financial stability. Indeed, the recent financial disruptions have led the Federal Reserve to take some extraordinary measures to meet our central bank responsibility of ensuring financial stability.

These events highlight a very important distinction between a central bank's responsibility for financial stability and its responsibility for monetary policy. These responsibilities are closely related, but clearly distinct.

The role of monetary policy is to ensure the stability of the purchasing power of the nation's currency so that markets are not distorted by inflation. The Federal Reserve is

also charged with supporting sustainable economic growth. I believe that maintaining price stability is the most important contribution a central bank can make to promoting sustainable growth. To promote financial stability, central banks seek to ensure the smooth functioning of the payment system and the orderly functioning of the financial markets. Most important, this means taking actions that reduce the chances of contagion and systemic risk. Such actions generally fall into the category of the central bank's lender-of-last-resort function. These two responsibilities — monetary policy and supporting financial stability — are related because in some circumstances financial instability can have consequences for the broader economy and, conversely, macroeconomic conditions can sometimes have consequences for financial stability. However, because these two objectives are distinct, central banks will generally use different tools, depending on their objectives.

In the U.S., the Federal Reserve's instrument for achieving its monetary policy objectives is, of course, the federal funds rate. In contrast, in attempting to promote financial stability during the past year, the Fed has employed a variety of discount window lending arrangements.

Just as there are debates about potential trade-offs in monetary policy between short-run increases in output and maintaining a credible commitment to low and stable inflation, there are debates about trade-offs between policy interventions aimed at combating short-run financial instability and the potential financial market distortions that could result from those interventions. As I said earlier, policy interventions in financial markets run the risks of increasing moral hazard and inhibiting efficient price discovery. Moreover, interventions intended to quell instability can, by creating moral hazard, actually make instability more severe in the long run.

Fortunately, central banks do not have to act as a lender of last resort very often. However, recent events suggest to me that we should review very carefully this responsibility in light of the global developments and advances in the nature of our financial markets. How do we define an institution that is systemically important and

therefore an appropriate candidate for lender-of-last-resort loans from the central bank? What do we need to know about those institutions and their balance sheets in such circumstances? Do we need to know only the value of the collateral they post or something more? These are difficult questions, and I do not pretend to know the answers.

I do believe, however, that lender-of-last resort policies should take a lesson from what we have learned from the theory of monetary policy. In particular, policy should have important rule-like features. Specifying in advance the conditions or states of the world under which the central bank will lend is an essential first step. But policy must also make credible commitments to act in a systematic way consistent with explicit ex-ante guidelines. Discretion in lending practices runs the risk of exacerbating moral hazard and encouraging financial institutions to take excessive amounts of risk. Nevertheless, the issue of trading off financial stability and moral hazard will likely remain. How to do that is a difficult and unresolved question. How should a policymaker evaluate such trade-offs? Are they quantifiable? I do not know the answers, but I do know that coming to grips with such questions is important for policymakers' calculus.

Summary

In closing, I look forward to the results of your research efforts. I hope that over time your work will help answer some of the questions I posed, as well as some of the many other related questions raised by the extraordinary events since last August. I know that a number of our staff members at the Philadelphia Fed have a great interest in seeing the results of your ongoing efforts to model and understand the complex elements of our financial markets.