GDP at RISK:

A Framework for Monetary Policy Responses to Asset Price Movements

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Abstract

In analyzing the macroeconomic impact of asset price booms and crashes, it is the disasters that are the true concern. This suggests a different approach to risk; one based on examining the keeping the probability of output deviating from its trend (or price level deviations from its target trend) over some time horizon below some fixed threshold. Policy responses should be built in order to keep this "GDP at risk," or it analog "Price-level at risk," sufficiently small.

In this paper I use data from a broad cross-section of countries to examine GDP at risk and price-level at risk arising from booms and crashes in equity and property markets. I show that the distribution of GDP and price-level deviations from their trends have fat tails, so the probability of extreme events is higher than implied by a normal distribution. Specifically, housing booms create outsized risks of output declines. This means that policymakers who are intent on averting catastrophes should react. The question is: How?

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1. Introduction

We pay central bankers to be paranoid. One of their primary responsibilities is to do extensive contingency planning, preparing for every possible calamity. And when they do their job well, most of us don't even notice. In the past decade there are numerous examples of the central bank actions that were taken in response to an increase in the probability of disaster. These include the Federal Open Market Committee's interest rate reductions in the fall of 1998 that followed the Russian government's bond default, the preparations for the century date change, the enormous liquidity injections in the immediate aftermath of the September 11, 2001 terrorist attacks in the U.S., as well as the discussions occurred as nominal interest rates and inflation approached zero simultaneously. All of these actions show policymakers' willingness to take actions in order to reduce the chance of disaster, acting as the risk mangers for the economic and financial system.

Then Federal Reserve Board Chairman Alan Greenspan put it best when he said that "a central bank seeking to maximize its probability of achieving its goals is driven, I believe, to a risk-management approach to policy. By this I mean that policymakers need to consider not only the most likely future path for the economy but also the distribution of possible outcomes about that path." (Greenspan 2003, pg. 3) Importantly, the common practice of risk management requires controlling the probability of catastrophe. For a financial intermediary, the focus is on reducing the risk of significant monetary loss. For a central banker it means acting to reduce the chances that output or the price level will be substantially below trend.

To control risk in financial institutions, risk managers employ the concept of *value-at-risk*, or VaR for short. Value-at-risk measures the worst possible loss over a specific time horizon, at a given probability.[1] A commercial bank might say that the daily VaR for a trader controlling $100 million is $10 million at a 0.1 percent probability. That means that, given the historical data used in the bank's models, the trader cannot take a position that has more than one chance in one thousand of losing 10 percent in one day.

[1] See Jorion (2001)

The VaR is computed from the lower tail of the distribution of possible outcomes, by examining the worst events that could occur. This requires moving beyond simple quadratic measures of risk like variance or standard deviation. It is fairly easy to imagine circumstances where the worst possible events have become worse, but the standard deviation of the distribution of all the possibilities is the same. This is one view of the case in the fall of 1998. The point forecasts for the aggregate price level and the GDP gap, and their standard deviation stayed roughly the same. But the probability in the lower tail – the chance of a very bad outcome – rose. Policymakers acted in response to the perception that the GDP at risk had gone up.

A risk-management approach comes naturally to central bankers. It is the basis for the creation and maintenance of the lender of last resort: The policy of providing loans to private financial intermediaries that are illiquid but not insolvent helps to ensure that the payments system continues to operate smoothly. Together with deposit insurance, central bank lending is designed to reduce the probability of bank runs to a negligible level. (The implementation of prudential regulation and supervision is the response to the moral hazard created by these policies.)

All of this makes it surprising that so many central bankers are so hesitant to address the potential risks created by asset price booms and crashes – what I will call "bubbles." The evidence is not in dispute. Bubbles increase the volatility of growth, inflation, and threaten the stability of the financial system. The 2003 IMF *World Economic Outlook* estimates that the average equity price bust lasts for 2½ years and is associated with a 4 percent GDP loss that affects both consumption and investment. While less frequent, property (or housing) busts are twice as long and are associated with output losses that are twice as large. [2]

Asset price bubbles distort decisions throughout the economy. Wealth effects cause consumption to expand rapidly and then collapse. Increases in equity prices make it easier for firms to finance new projects, causing investment to boom and then bust. The collateral used to back loans is overvalued, so when prices collapse it impairs the balance sheets of financial intermediaries that did the lending. It is the job of central bankers to eliminate the sort of economic distress caused by asset price bubbles. Although the rhetoric has been changing slowly, especially in the case of

[2] See the excellent essays in Chapter II of IMF (2003) for a summary of the evidence.

the responses to Australian and British housing market booms, most monetary policymakers remain reluctant to act directly to manage these risks.

As the IMF evidence makes clear, any discussion of bubbles must distinguish between equity and property prices. This is true for several reasons. First, the efficient markets hypothesis is more likely to apply to equity than to property. Arbitrage in stocks, which requires the ability to short sell, is at least possible. In housing and property, it is not. Second, even in the few countries with sizeable equity markets, ownership tends to be highly concentrated among the wealthy – people whose consumption decisions are well insulated from the vicissitudes of the stock market. By contrast, home ownership is spread much further down the income and wealth distribution. Finally, in many countries housing purchases are highly leveraged leaving the balance sheets of both households and financial intermediaries exposed to large price declines. This suggests that the macroeconomic impact of a boom and crash cycle in property prices might be larger in countries that have more credit outstanding. [3]

In the remainder of this paper I will examine equity and housing price booms and crashes from a risk management perspective. Using equity price data from 27 countries and housing price data from 17 countries, I will look at the consequences of rising equity and housing prices for growth and inflation, measuring both the GDP at risk and the price-level at risk that they create.

The scarcity of booms and crashes, especially in property prices, mean that I must pool data across countries to derive any conclusions at all. From what data there is, I come to the following tentative conclusions. Equity booms do not change GDP at risk, but increase the risk of prices falling dramatically below trend. Housing bubbles increase GDP at risk while lowering price-level at risk. In the somewhat odd conventions used in the discussion of value at risk, equity booms increase inflation at risk, while housing booms increase GDP at risk but reduce price-level at risk.

The remainder of this paper proceeds as follows. Section 2 provides overwhelming evidence that the distribution of output and price level deviations from their trends have fat tails implying

[3] For a somewhat more detailed discussion of the issues and the debate see Cecchetti (2003).

that methods based on quadratic loss and normal approximations could be misleading. Section 3 examines the distribution of output and inflation gaps following equity and housing booms. The focus is on computing the GDP and price-level at risk conditional on booms of a certain size. Again, the results suggest that normal approximations are inadequate. Section 4 expands the discussion contrasting housing and equity booms.

There is a growing consensus that traditional interest rate policy is not a very useful policy instrument in the battle to combat the deleterious macroeconomic effects of asset price bubbles.[4] At the same time, it is clear that policymakers cannot ignore the threat that equity and housing booms and bust pose for central bankers' stabilization goals. Adopting a risk management perspective means asking whether there are institutional solutions to the problem. That is, are there ways to structural the financial system that will then inoculate the real economy from the adverse effects of bubbles? With question in mind, I examine relative impact of asset price booms in economies with market- versus bank-based financial systems. The results, reported in Section 5, suggest that market-based systems have a somewhat higher GDP at risk in the aftermath of equity booms, but the systems weather housing booms equally poorly.

2. GDP and Inflation at Risk: General Considerations

Financial economists employ value-at-risk in order to address the problems created by fat tails. That is, cases in which a normal (Gaussian) distribution provides an overly optimistic picture of the likelihood of extreme events. Equity returns are notorious for exhibiting high probabilities of extreme events in their lower tail. Because these "bad" outcomes are so important for controlling the risk of large losses, modeling them has attracted substantial attention.[5]

Output and inflation share some of the properties exhibited by equity returns. The distribution of deviations of (log) output and the (log) price level from their respective trend exhibit fat tails. That is, the probability of observing a large negative realization is substantially higher than one would infer from a Gaussian distribution. To see this, I have calculated the 5th percentile of the

[4] See Cecchetti (2006) for a discussion.
[5] See LeBaron and Samanta (2005) for a discussion of the issues surrounding modeling fat-tailed distributions.

distribution of log output and log price level deviations from their Hodrick-Prescott (1997) trends, with smoothing parameter set to 1600, for a series of countries using quarterly data from 1970 to 2003.[6] These results are plotted in Figures 1 and 2. (The appendix provides a more detailed description of the data.)

The figures show the results of the following calculation. For the normal distribution, this is just -1.645 times the standard deviation of the series. The alternative, that takes the fatness of the tails of the distribution into account, begins by the computation of a Hill index. As described in LeBaron and Samanta (2005), the Hill index is an estimate of the number of moments of a distribution that exist. For a normal distribution, the index is infinity. After computing the index, the tail is approximately distributed as a Student t with degrees of freedom equal to the Hill index value. So, t-distribution approximation to the 5th percentile of the deviations of log GDP or the log price level from their trend is equal to the standard deviation of the series times the 5% level of the t-distribution with degrees of freedom equal to the series' Hill index.[7]

As one would expect, in some countries the deviations of output and prices from trend – their output and price-level gaps – have fatter tails than others. But if one were to use the normal distribution, the errors would be large – averaging roughly 50%. For the U.S., the 5th percentile of the normal distribution implies a deviation of output from trend of slightly more than -2½%. Taking the fatness of the lower tail of the actual data into account yields an estimate of more than -4½%. That is the 5% GDP at risk for the U.S. (without conditioning on anything). For the price level, the estimates diverge by less with the normal distribution giving a 5%. Price-level at risk estimate of -2½% and the t-distribution approximation yielding an estimate of -3½%.

[6] I have also computed results for a shorter sample beginning in 1985 that verify the inaccuracies of the normal approximation reported below.
[7] Computation of the Hill index requires the decision about where the tail of the distribution starts. I take LeBaron and Samanta's advice and use the bottom 10% of the observations.

Figure 1: GDP at Risk, Normal vs. t-Distribution Approximation

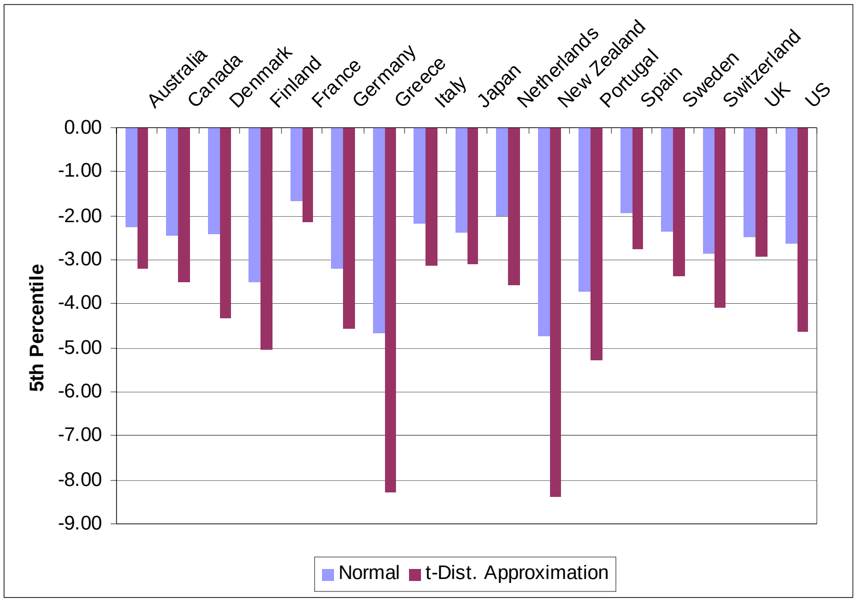
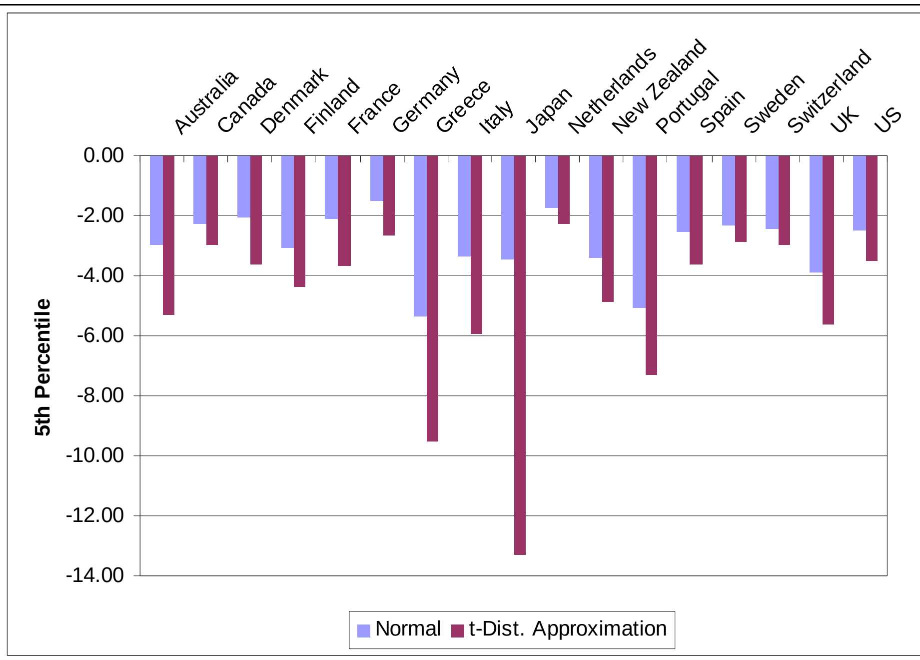


Figure 2: Price-Level at Risk, Normal vs. t-Distribution Approximation



It is important to keep in mind that standard statistical and econometric procedures are designed to characterize behavior near the mean of the data, so they are particularly ill-suited to the examination of tail events, especially when the data have fat tails. This means that when extreme events are more likely than the normal distribution implies, and we care about them, it is important to adopt techniques that explicitly account for fat tails.

3. Risks Created by Asset Price Bubbles

An interesting application of GDP at risk and price-level at risk is to the case of asset price bubbles. These are booms followed by crashes that create the risk of extreme events. And since the distribution of output gaps and price-level gaps is fat-tailed, this increases the risk of a severely negative outcome. But are GDP at risk and price-level at risk are affected by the equity or housing booms or busts? If, for example, there is a dramatic increase in equity prices should this change our view of the possibility of bad events? And, importantly, are normal approximations likely to give the wrong signal?

In thinking about these questions it is important to keep in mind that most of the theoretical results in monetary economics are based on assuming that central bank objectives can be well approximated by quadratic loss functions. When distributions of macroeconomic outcomes are close to normal, this is fine. But if extreme events are more likely than a Gaussian distribution would predict, then we need to reconsider the robustness of these conclusions.

Returning to the data, I examine the distribution of output and inflation gaps conditional on bubbles using real equity price data from 27 countries and real housing price data from 17. For each country I construct measures of GDP and inflation at risk using the following procedure.[8] First, for each country I take the deviation of the log of each series – real GDP, the aggregate price level, the real equity price index, and the real housing price index – from its Hodrick-Prescott filtered trend.[9] All data are quarterly, and most samples are from 1970 to 2003.[10]

[8] The 17 countries in the housing price sample are Australia, Belgium, Canada, Denmark, Finland, Greece, Ireland, Israel, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, the U.K, and the U.S. The 27 countries in the equity price data sample add Austria, Chile, France, Germany, Italy, Japan, Korea, Mexico, Peru, and South Africa.

[9] The HP-filtering parameter is 1600 for the output and aggregate price data, and 3200 for the equity and housing data.

[10] While it would be interesting to look at shorter samples, there is simply not enough data to do it.

Large positive deviations of asset prices from this trend suggest booms, while large negative deviations suggest busts. Defining an equity peak and trough to be a deviation of at least 20 percent from the trend, I find a total of 118 equity peaks and 121 equity troughs, or an average 4¼ over the 20+ year sample in each of the countries. Housing booms and busts are much less, with each country experiencing an average of only 1½ of each during the sample. (There are 26 housing price peaks and 26 housing price troughs.)

Taking deviations from country-specific (and time-varying) trends has the advantage that it removes country fixed effects. While there are surely numerous conditions that vary in these countries over the sample, this is at least a minimum condition for pooling. I use the pooled data to ask a series of questions of the following type: If equity prices are at least 10 percent from their trend today, what is the 5 percent GDP at risk 4 or 12 quarters into the future? That is, if I see an equity deviation of +10, what is the fifth percentile of the distribution of GDP in 4 or 12 quarters?

Equity Bubbles

For equity booms, the answer to this question is reported in Figure 3. The horizontal axis in the figure plots the minimum size of the equity price deviation, and the vertical axis plots the fifth percentile of the distribution of future outcomes for the GDP gap – the 5% GDP at risk. The two lines show the 5% GDP at risk 4 quarters ahead and 12 quarters ahead. So, for example, if equity prices are at least 10 percent above trend, the 5^{th} percentile of the distribution of the GDP gap 12 quarters into the future is -3.6. As it turns out, this is only slight below the 5^{th} percentile of the unconditional distribution for deviations of GDP from trend, which is -3.44, so it isn't very troubling. In other words, the GDP at risk from a 10 percent equity boom is only very slightly below than the unconditional GDP at risk. The upper line in the figure, the 5% GDP at risk 4 quarters ahead, is always significantly *above* the unconditional 5^{th} percentile of the GDP gap distribution. The reason for this is that all booms are likely to continue, so the horizon for the collapse of equity prices and GDP both is beyond 4 quarters.

Figure 3: GDP at Risk Following an Equity Boom

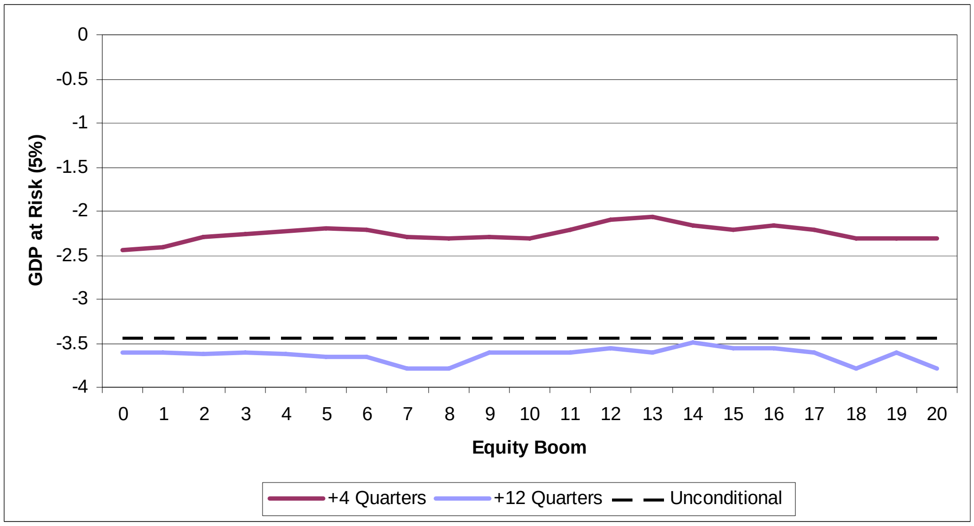
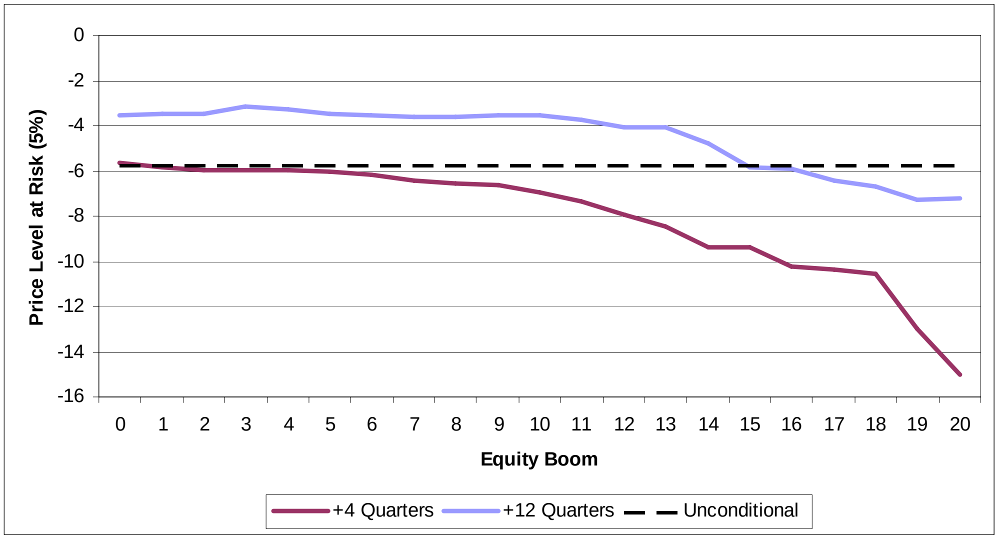


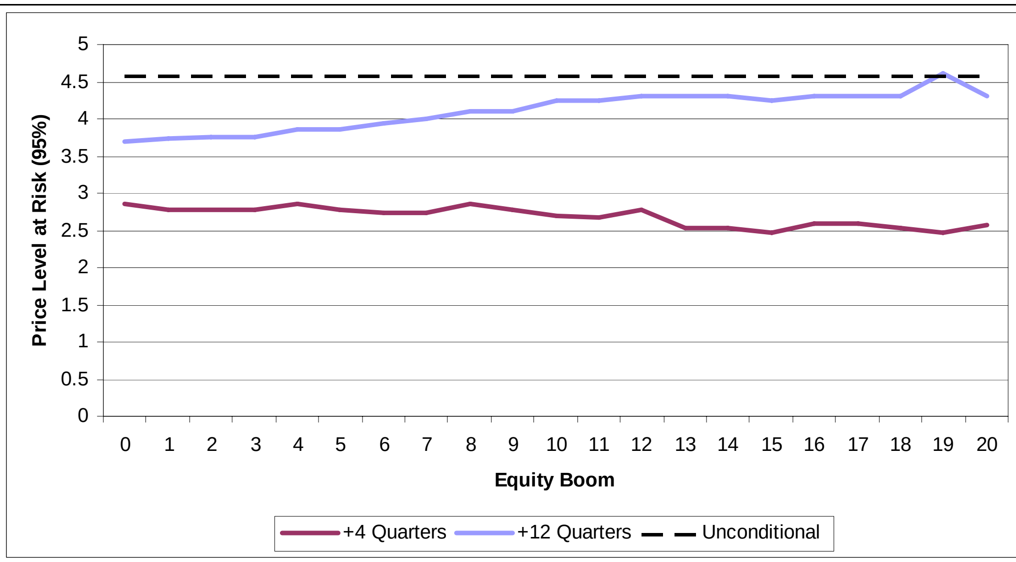
Figure 4 reports the results for price-level at risk following an equity boom. The price-level at risk results differ quite a bit from the GDP at risk results. Since some central banks will care about inflation rising while others may care more about prices falling, I report the risk results for both tails of the distribution. These are referred to as the 95% price-level at risk. As the equity boom grows, the risk of the price-level falling below trend (shown in Panel A of Figure 4) grows substantially. When real equity prices are 15 percent or more above trend, the 5^{th} percentile of the distribution of inflation gap 4 quarters out is more than –9 percent. Depending on the current level of inflation, that could be a significant risk. By contrast, the risk of the extreme positive price level gaps (in Panel B of Figure 4) goes down. Conditional on an equity boom, the distribution of price level deviations from trend shifts down.

Figure 4: Price-Level at Risk following an Equity Boom

A. Risk of Prices Falling Significantly Below Trend



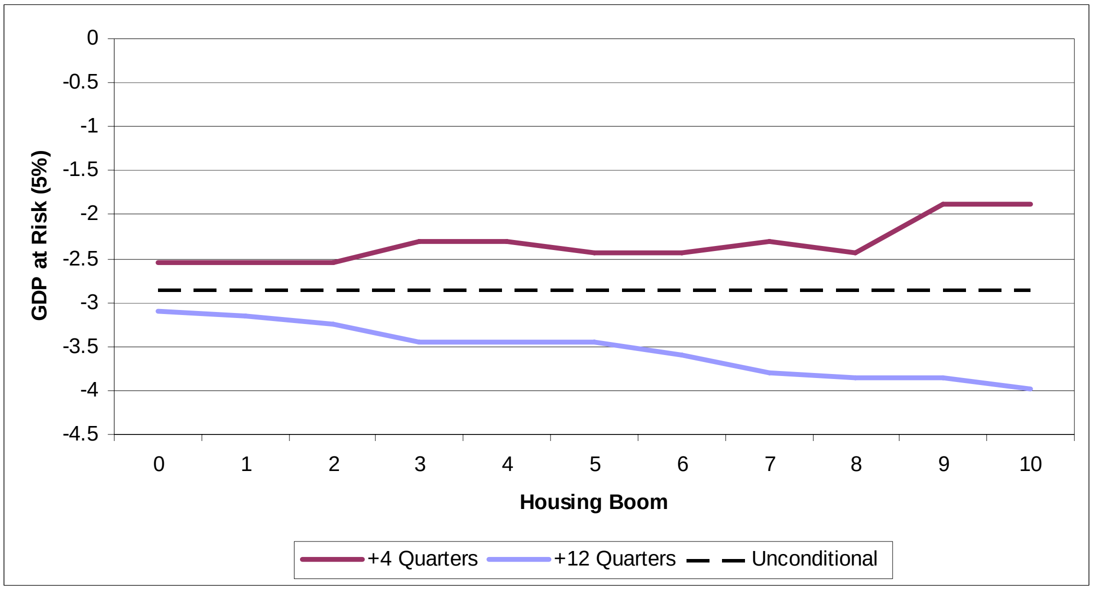
B. Risk of Prices Rising Significantly Above Trend



Housing Bubbles

Turning to housing bubbles, Figures 5 and 6 report computations analogous to those reported in Figure 3 and 4. The results in these two figures suggest that housing booms are followed by an increased risk of a large decline in GDP in 4 to 12 quarters, and a decreased risk of prices falling below trend. Not from the scale that the GDP at risk is quite large. When real house prices are 5% or more above trend, there is a 5% probability that 12 quarters later GDP will be at least 3.44% below trend – substantially below the unconditional 5th percentile of -2.86%.[11]

Figure 5: GDP at Risk Following an Housing Boom

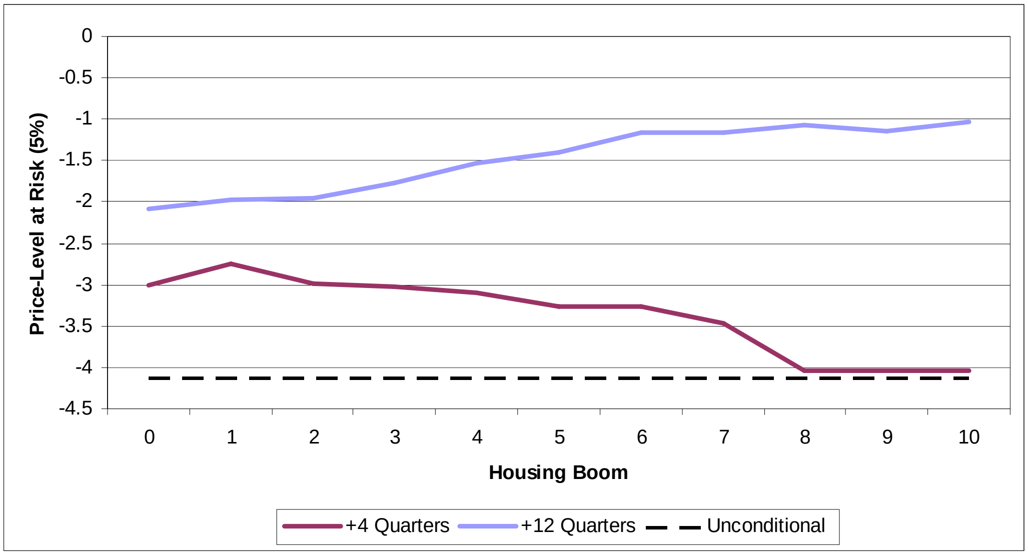


Housing booms affect the price-level at risk as well. The information in Figure 6 suggests that a housing boom has very little impact on the upper tail of the price-level distribution, but dramatically eliminates the lower tail – at least at a 12-quarter horizon. Unconditionally, the upper tail 5% price-level at risk 12 quarters following a 10% housing price boom is roughly one-quarter the unconditional 5th percentile – that is, it -1% as compared with -4%.

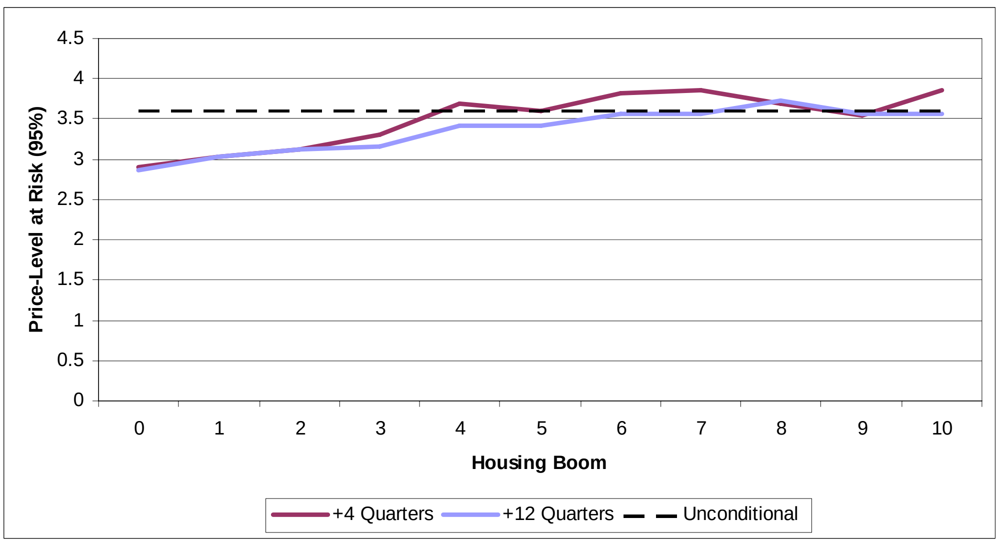
[11] Note that because the countries in the sample differ, the unconditional distributions for the price-level and GDP gaps are different between the equity and housing booms.

Figure 6: Price-Level at Risk following an Housing Boom

A. Risk of Prices <u>Falling</u> Significantly <u>Below</u> Trend



B. Risk of Prices <u>Rising</u> Significantly <u>Above</u> Trend

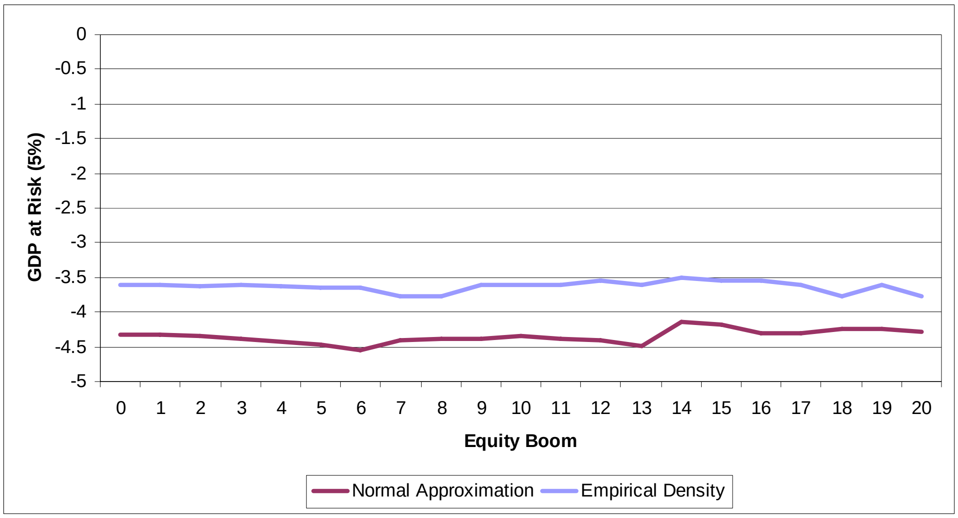


Comparing the Normal Approximation and the Empirical Density

It is important to ask whether there is any difference between the results in Figures 3 and 5 and those that from a simple normal approximation. That is, if a central banker had been looking at the -1.64 times the standard deviation of the distribution of output and inflation gaps, conditional on an equity market boom, would they have done anything different? The results suggest that the answer to this is yes.

Figure 7: Comparing the Normal Approximation with the Empirical Density GDP at Risk at +12 Quarter Horizon

A. Conditional on an Equity Boom



B. Conditional on a Housing Boom

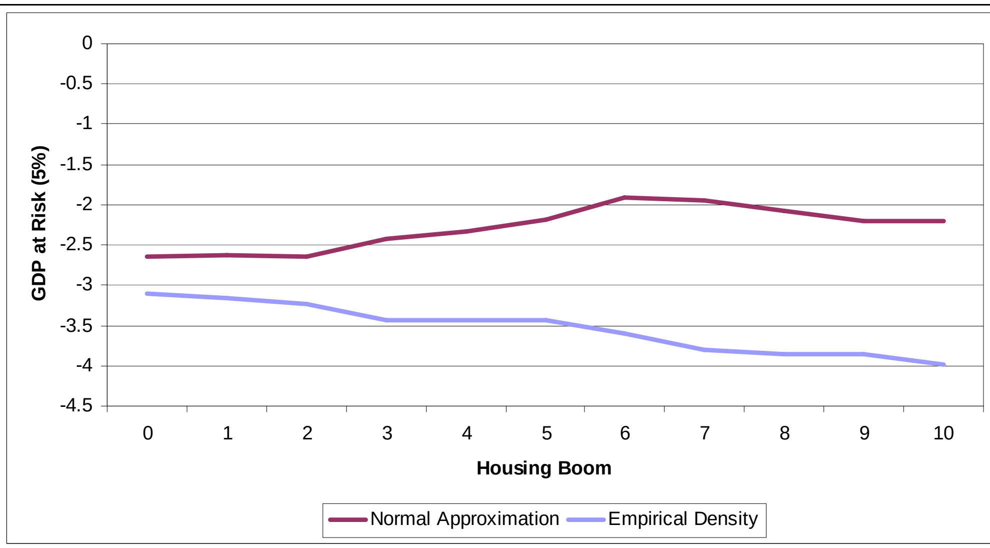


Figure 7 compares the 5th percentile for the GDP gap computed using a normal approximation with one from the empirical density. For equity booms, the normal approximation gives an overly pessimistic view of the size of the lower tail. The average distance between the two estimates of the 5th percentile of the distribution is roughly three-quarters of one percentage point. This particular example suggests that a policymaker using a quadratic loss would likely overestimate the importance of an equity boom.

Housing is another story. Here the normal distribution gives an overly optimistic view of the true size of the lower tail. The 5th percentile of the empirical density is on average 1.25 percentage points below what is implied by the normal approximation. Since the probability of extreme negative outcomes for the GDP gap is higher than suggested by a Gaussian distribution, policymakers focusing on quadratic loss will underestimate the importance of a housing boom.

In the case of inflation outcomes, normal approximations are also misleading. For example, twelve quarters following a housing boom, the 5th percentile of the upper tail of outcomes is 2½ percentage points *smaller* than would be implied by simply multiplying the standard deviation of the observed outcomes by 1.64.

Robustness

Before proceeding, I note that the results reported up until this point are robust to two important changes in the computation of output and price-level gaps: (1) Use of residuals from a fourth-order autoregression. And (2), use of residuals from a model that includes interest rates and external prices.[12] That is, the 5% GDP for equity booms is near the unconditional estimate, while that for housing booms is below. And for prices, the character of the results is the same as well.

4. The Difference between Equity and Housing Bubbles

To understand the differential impact of equity and housing bubbles, it is useful to focus on their consumption effects. Booms in either equity or property prices drive up the wealth of individuals. The natural response to an increase in wealth is to raise consumption. If you are

[12] The model is a two-equation aggregate demand – aggregate supply specification based on Rudebusch and Svensson (1999) as implemented in Cecchetti, Flores-Lagunes, and Krause (2006).

rich, you can buy a fancy car, purchase a bigger and flatter television, go on nicer vacations, eat in expensive restaurants, and the like. And, the data show that this is exactly what happens.

A useful rule of thumb is that a $1 increase in US wealth generates between 2 and 5 cents of additional consumption by American households.[13] That is, the marginal propensity to consume for wealth is in the range of 0.02 to 0.05.

As Norman, Sebastia-Barriel and Weeken (2002) note, the marginal propensity to consume is of somewhat less interest than the elasticity of consumption with respect to wealth. [14] They emphasize that we care more about the impact of a 10% increase in the value of wealth than we do about the number of cents or pence that consumption rises per dollar or pound of additional wealth. This is especially true of equity wealth, since the size of equity markets vary so widely across countries. Bertaut (2002) reports that, at the end of 2001, total equity market capitalization equaled 153% of GDP in the U.K., but only 59% of GDP in Germany. To understand the importance of this, consider the impact of a 10% increase in equity prices on consumption in each country, assuming that the marginal propensity to consume is the same. The estimated impact in the UK the impact would be roughly 3 times as large as that in Germany.[15]

This highlights the importance of thinking about bubbles in housing and equity prices separately. There are two reasons for this. First, equity prices are substantially more volatile than housing prices, so the former is much less likely to be permanent than the latter. Reasonably, households respond more aggressively to changes in wealth that they perceive to be permanent.[16] Second, equity ownership tends to be concentrated among the wealthy – people who are much less likely to adjust their consumption levels. Housing ownership, by contrast, is distributed more broadly.

[13] See, for example, Norman, Sebastia-Barriel and Weeken (2002).
[14] The elasticity of consumption with respect to wealth is equal to the marginal propensity to consume out of wealth times the ratio of wealth to consumption.
[15] Careful econometric estimates show an even larger disparity. Bertuat (2002) reports that 10% increase in stock market creates 0.5 to 1.0% increase in consumption in the long run in the US and U.K., but only 0.07 in Germany where the equity is less than 60% of GDP.
[16] Kishor (2005) estimates that while 98% of the change in housing wealth is permanent, only 55% of the change in financial wealth is. This suggests that the housing wealth effect should be roughly twice the stock-market wealth effect.

And while the quality of housing and the concentration of ownership vary across countries, the differences are far less dramatic.

Returning to the evidence, using data from 14 developed countries Case, Quigley, and Shiller (2005) estimate that a one percent increases in housing wealth raises consumption by between 0.11 and 0.17 percent. By contrast, they find that the stock-market wealth elasticity of consumption is substantially smaller, only 0.02. It is natural that the housing booms would have more of an impact on GDP at risk than equity booms.

5. Policy Responses: Risk Management and Financial Structure

Is there anything to be done about all of this? Can we provide any useful guidance on how to avoid the risks bubbles pose? Researchers have investigated a myriad of possible responses including, but not restricted to reacting only to bubbles insofar as they influence inflation forecasts; reacting only to the fallout of a bubble after it bursts; leaning against a bubble as it develops; including asset prices in the price index central bankers target; and examining various regulator solutions involving margin and lending requirements. In Cecchetti (2006) I summarize the traditional debate in each of these cases. Briefly, there is a consensus building against the purely activist view. As Gruen, Plumb, and Stone (2003) discuss, the information requirements for the activism are extreme and the risk of costly missteps large. To put it another way, interest rates do not appear to be the risk instrument for the job.

From a risk management perspective, the discussion of central bank responses to asset price bubbles is unnecessarily restrictive. Why focus only on traditional monetary policy? Risk managers do more than simply monitor and react to developments; they build institutional structures that are unlikely to collapse when hit by large shocks. The regulators and supervisors of the financial system have built mechanisms exactly like this. Are there similar responses to bubbles? When subjected to equity and property price bubbles, are some financial systems more resilient than others?

Recent work by Dynan, Elmendorf and Sichel (2006) and Cecchetti, Flores-Lagunes, and Krause (2005) suggests that changes in the financial system have been an importance source of stabilization over the past several decades. Their results suggest that enhanced household access to credit has allows for increased consumption smoothing that has been a major factor in reducing the volatility of aggregate real growth.[17] This brings up the natural question: Does the impact of housing and equity bubbles on GDP at risk or price-level at risk depend on financial structure?

To examine this, I begin with data on financial structure taken from Demirguc-Kunt and Levine (2001). Briefly, Demirguc-Kunt and Levine have constructed a data set on financial indicators during the 1990s covering a broad cross-section of countries. Included are measures of the relative size of a country's stock market and banking sector, as well as a measure of the relative efficiency of the two. Countries with "market-based financial systems" are those with bigger more efficient stock markets. I examine the relationship of this composite financial structure index and the behavior of an economy following booms in equity or housing prices.

Table 1 reports the results of a set of regressions. The dependent variable in the regressions is the deviation from the Hodrick-Prescott filtered trend of either log GDP or the log of the price level 12 quarters after asset prices hit peak. For equity, the peak must be at least above trend; for housing it is 5% above trend. The right-hand-side variables are the size of the boom when its peak is reached (this comes after the threshold) and the composite structure index from the CD-ROM that is distributed with Demirguc-Kunt and Levine (2001).[18] The financial structure index is positive for market-based economies and negative for bank-based ones. For example, it takes on a value of +0.17 for the US and –0.18 for Greece.

[17] The argument is that there is a linkage not only between financial system development and the *level* of real growth, as describe in Ross Levine's (1997) survey, but also between financial development and the stability of real growth.
[18] The index average of deviations from the mean of (1) stock market capitalization divided by deposit money bank assets (relative size of stock market compared to banking sector), (2) total value traded in stock market divided by claims on private sector by deposit money banks (relative activity of stock market compared to banking sector), and (3) total value traded in stock market as a share of GDP divided by banking overhead costs as a share of total assets (relative efficiency of stock market compared to banking sector). The actual data are column EQ in the file called "request8095.xls." These data are the same as those

Table 1: Asset Price Booms and Financial Structure +12 Quarters after Threshold				
	Equity Boom		**Housing Boom**	
	Size	Financial Structure	Size	Financial Structure
GDP	-0.002	-1.13*	0.003	2.72**
	(-0.39)	(-1.70)	(0.57)	(2.17)
Prices	0.007	4.08**	0.002	-0.99
	(0.74)	(2.47)	(0.29)	(-0.39)

Coefficient in univariate regression of GDP or price-level deviation from trend 12 quarters after asset price peak is reached on the size of the boom when the peak is reached and the financial structure index "structur" in colum EQ of the file"request8095.xls" on the CD-ROM included with Demirguc-Kunt and Levine (2001) financial structure index. Equity threshold is 10% above trend; housing threshold is 5% above trend. Robust t-ratios are in parentheses.

Recalling that the financial structure variable is positive for market-based systems and negative for bank-based ones, the results in Table 1 tell us that on average, countries with market-based systems fair better during housing booms, while bank-based systems fair better during equity booms. That is to say, three years after the peak of a boom in equity prices, a country with a relatively large stock market will on average have output below trend and prices above trend. Countries with bank-based financial systems suffer the same fate following a housing boom. By contrast, market-based financial systems appear to inoculate a country's economy against the destabilizing effects of housing booms; and bank-based financial systems attenuate the growth and inflation impact of equity booms.[19]

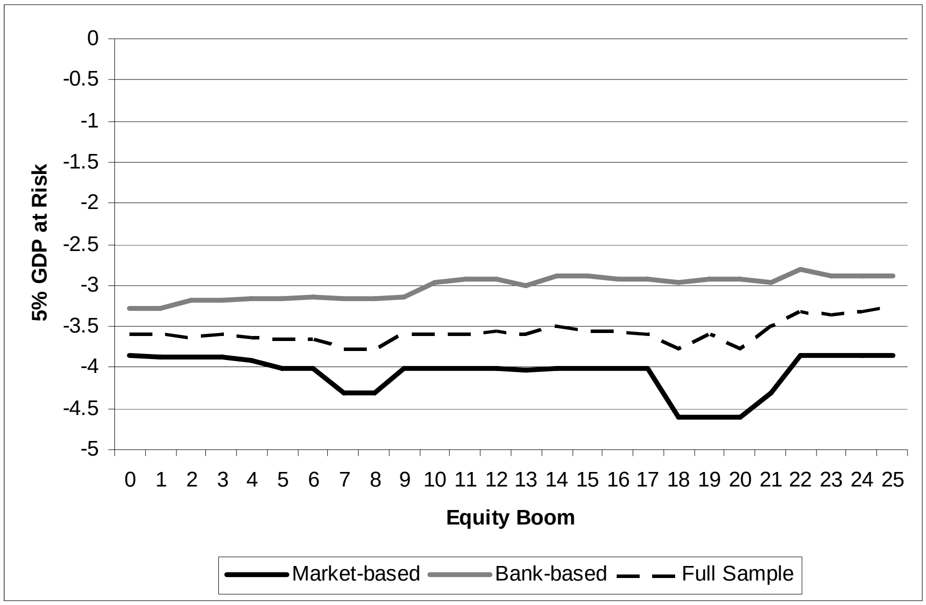
In order to see how big the impact is of financial structure, it is useful to compare two representative countries. Take the case of a market-based economy like the United Kingdom, with index levels of 0.21, and contrast that with a bank-based country like Italy, with financial structure indices around -0.19. The estimates in Table 1 imply that three years after real equity prices peak at level more than 10% above trend, the market-based economy will have GDP one-half of one percentage point and prices one percentage point above trend (relative to the bank-based country). In the aftermath of the housing boom, the difference in growth is roughly twice

[19] This is not all that surprising given that equity-market capitalization is one input into financial structure index, so a country with a very small stock market is (reasonably) classified as having a bank-based economy. With a small stock market, equity price movements should be irrelevant for aggregate activity.

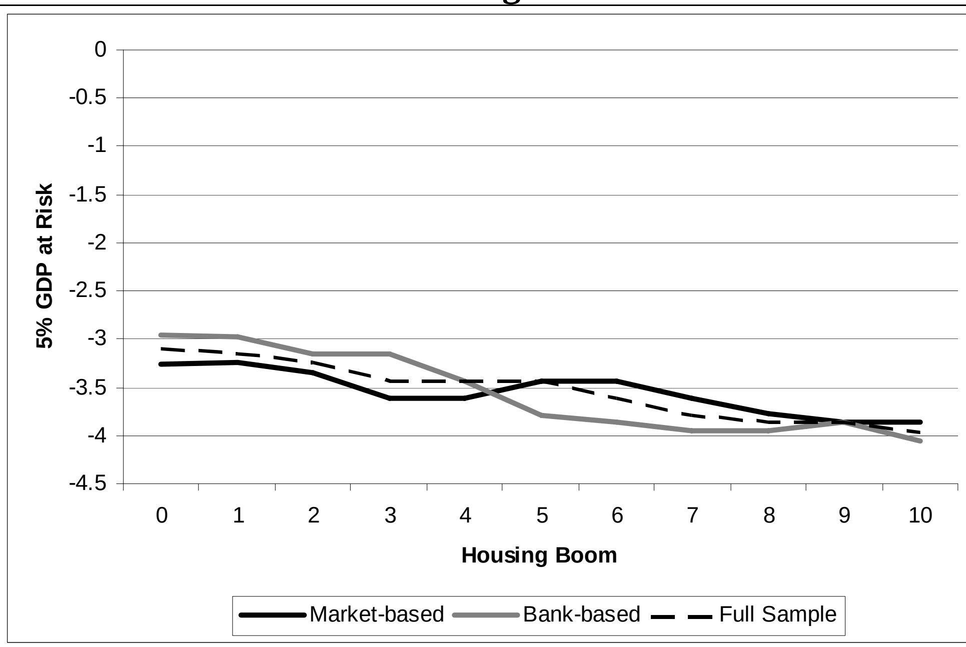
that following an equity boom – one percentage point – but there is only a small difference in prices, 0.25 percentage points.

Figure 8: Market- vs. Bank-based Financial Systems
GDP at Risk at +12 Quarter Horizon

A. Equity Booms



B. Housing Booms



As interesting as these regression results are, they do not address the risk management issue that is central to this essay. To do this, I have taken the data used to construct the earlier figures and divided it based on whether the Demirguc-Kunt and Levine index was positive (market-based) or negative (bank-based). I then reconstructed Figures 3 and 5, GDP at risk following a boom in either equity or housing prices. The results, reported in Figure 8, show that for countries where equity markets are important, equity booms increase GDP at risk. By contrast, GDP at risk following a housing boom is not sensitive to financial structure as characterized by this index.

Taking these two pieces of information together, the results suggest that the shift from a bank-based to a market-based financial system is a two-edged sword. By providing households with a mechanism for increasing leverage, especially through mortgage lending, the market-based financial system could be increasing the chances of catastrophe following an equity price bubble. Ready access to loans allows individuals to bid up the prices of existing homes has the potential to create frenzies that result in booms followed by crashes – e.g. bubbles. The risk is that when the bubble bursts there will be a large number of defaults.

6. Conclusion

Stability is the watchword for central bankers. Listen to most modern monetary policymakers speak about their goals and you are likely to hear about the desire for low, stable inflation and high, stable growth. They will explain how they raise and lower their short-term interest rate target in order to meet their stability-oriented objectives. But listen closely, and you will realize that the statements are more nuanced. While stability is the ultimate objective, it is the possibility of catastrophe that keeps central bankers awake at night. They want to ensure that nothing really bad happens.

In analyzing the macroeconomic impact of asset price booms and crashes, it is the disasters that are the true concern. This suggests a different approach to risk; one based on keeping the probability of output deviating from its trend (or price level deviations from its target trend) over some time horizon below some fixed threshold. Policy responses should be built in order to keep this "GDP at risk," or it analog "Price-level at risk," sufficiently small.

In this paper I use data from a broad cross-section of countries to examine GDP at risk and price-level at risk arising from booms and crashes in equity and housing markets. The conclusion is that housing bubbles create bigger risks than equity bubbles do, and that the evaluation of those risks is distorted by use of a simple normal approximation. Looking further, I find that countries with market-based financial systems, where stock market capitalization is relatively large, whether housing booms somewhat better and equity booms somewhat worse than countries with bank-based financial systems.

In closing, it is important to emphasize one a critical implication of adopting a risk management view. As mentioned earlier, econometric modeling tends to provide go characterizations of what happens near the mean of the data. In fact, in order to improve the quality of estimates, researchers have a tendency to remove outliers. These sometimes done in the guise of sensitivity analysis, and other times using limited-influence estimation that explicitly truncates tail observations. This means that standard modeling strategies provide virtually no information about the behavior of the economy when it is under stress. As a result, evaluating the problems posed by extreme events, which is at the core of risk management, is necessarily requires judgment. And, to quote Chairman Greenspan (2004) one final time: "Such judgments, by their nature, are based on bits and pieces of history that cannot formally be associated with an analysis of variance."

Data Appendix

Price Data: Computed for consumer price inflation data was obtained from the *International Financial Statistics* on line and the OECD Economic Outlook No. 76, December 2004.

GDP data was obtained from the *International Financial Statistics CDROM* (December 2004) and the OECD Economic Outlook No. 76, December 2004.

Equity Prices are from the *International Financial Statistics* on line.

Housing Prices: Data for Australia, Belgium, Canada, Denmark, Finland, Ireland, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, U.K, and U.S. are all from the BIS. Data for Hong Kong are from the Hong Kong Monetary Authority, Census and Statistics Department, Monthly Digest of Statistics, Table 5.9 column 6. Data for Israel are from the Israel Central

Bureau of Statistics, on line. Data for Japan are from Goldman Sachs. Data for New Zealand are from the Reserve Bank of New Zealand.

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