MEASURING THE MACROECONOMIC RISKS POSED BY ASSET PRICE BOOMS

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ABSTRACT

Modern central bankers are the risk managers of the financial system. They take actions based not
only on point forecasts for growth and inflation, but based on the entire distribution of possible macroeconomic
outcomes. In numerous instances monetary policymakers have acted in ways designed to avert disasters.
 What are the implications of this approach for managin the risks posed by asset price booms? To
address this question, I study data from a cross-section of countries to examine the impact of equity
and property booms on the entire distribution of deviation in output and price-level from their trends.
 The results suggest that housing booms worsen growth prospects, creating outsized risks of very bad
outcomes. By contrast, equity booms have very little impact on the expected mean and variance of
macroeconomic performance, but worsen the worst outcomes.

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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 that occurred as nominal interest rates and inflation approached zero simultaneously. All of these episodes demonstrate policymakers' willingness to take actions in order to reduce the chance of disaster, acting as the risk managers for the economic and financial system.

Then Federal Reserve Board Chairman Alan Greenspan put it best in 2003 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 suggests 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.

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[1] See Jorion (2001)

In some circumstances, VaR is all you need. For example, if it is being used to measure the probability of institutional insolvency, it doesn't really matter how insolvent you are. But policymakers may care about more than just VaR, may be concerned with the expected loss given that an event is in the lower tail – something called the *expected tail loss* (ETL). That is, not only that the fifth or tenth percentile of the distribution of GDP outcomes fell, but what happened to the expected value conditional on being in the lowest fifth or tenth percentile.

Risk-management measures like VaR and ETL are computed from the lower tail of the distribution of possible outcomes, 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 lower tail shifted – the probability and size of a very bad outcome – rose. Policymakers acted in response to the perception that the GDP at risk and expected tail loss had gone up.[2]

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.)

The risks posed by asset price booms and crashes are a prime candidate for the risk management approach. 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

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[2] Formally, this means that the central bank's loss function is not quadratic. For a recent discussion see Surico (forthcoming).

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.[3]

Asset price bubbles distort decisions throughout the economy and are a source of instability. 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.

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. [4]

In this paper I 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 various consequences of rising equity and housing prices for growth and inflation. I begin by investigating how asset price booms influence the mean and variance of deviations in (log) output and (log) price level from their (time-varying) trends. I then proceed to measure both the GDP at risk and the price-level at risk that these booms create.

The scarcity of booms and crashes, especially in property prices, mean that I must pool data across countries. From what data there is, I come to the following conclusions: Housing booms are bad in virtually every way imaginable; they create drive the output gap down, increase its

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[3] See the excellent essays in Chapter II of IMF (2003) for a summary of the evidence.
[4] For a somewhat more detailed discussion of the issues and the debate see Cecchetti (2003).

volatility, increase GDP at risk, and push the lower tail of outcomes (ETL) even lower (decreasing the expected value of the GDP gap conditional on being in the lower tail of the distribution). By contrast, equity booms have little impact on either the level or volatility of the output and price-level gaps at horizons on three years; do not change GDP at risk, but increase the risk of prices falling dramatically below trend; and drive the lower tail (ETL) even lower.
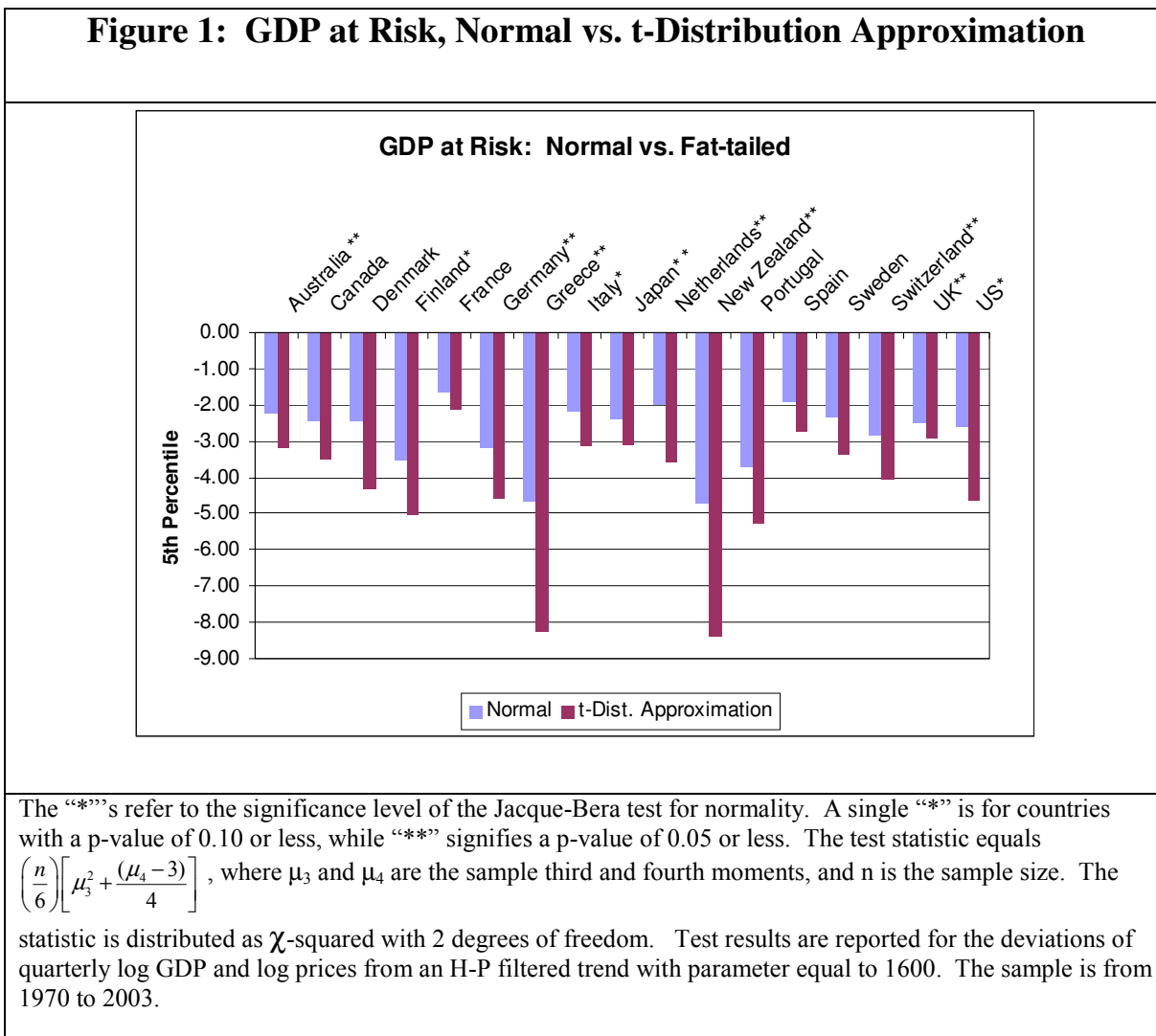
The remainder of this paper proceeds as follows. Section 2 provides overwhelming evidence that the distribution of output and price level deviations from their trends have fat tails implying that methods based on quadratic loss and normal approximations could be misleading. Then, in section 3, I characterized the distribution of output and price-level conditional on housing and equity booms. That is, I look at the mean, variance, value-at-risk, and expected lower tail of output and price-level conditional on asset price booms. Overall, 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 effective instrument in the battle to combat the deleterious macroeconomic effects of asset price bubbles.[5] At the same time, equity and housing booms and busts pose clear risks to macroeconomic stability. 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 this 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.

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[5] See Cecchetti (2006) for a discussion.

2. GDP and Prices: General Considerations

Financial economists employ concepts like 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.[6]

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

The "*"'s refer to the significance level of the Jacque-Bera test for normality. A single "*" is for countries with a p-value of 0.10 or less, while "**" signifies a p-value of 0.05 or less. The test statistic equals $\left(\dfrac{n}{6}\right)\left[\mu_3^2 + \dfrac{(\mu_4 - 3)}{4}\right]$, where μ_3 and μ_4 are the sample third and fourth moments, and n is the sample size. The statistic is distributed as χ-squared with 2 degrees of freedom.   Test results are reported for the deviations of quarterly log GDP and log prices from an H-P filtered trend with parameter equal to 1600. The sample is from 1970 to 2003.

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

Aggregate output and prices 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 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.[7] These results are plotted in Figures 1 and 2. (The appendix provides a more detailed description of the data.) The figures also include results for a Jacque-Bera test for normality – these are the *'s next to the country names. In 11 of the 17 cases presented, normality is rejected for 11 of 17 cases using the output gap and 10 of 17 using the price-level gap.

Figure 2:   Price-Level at Risk, Normal vs. t-Distribution Approximation
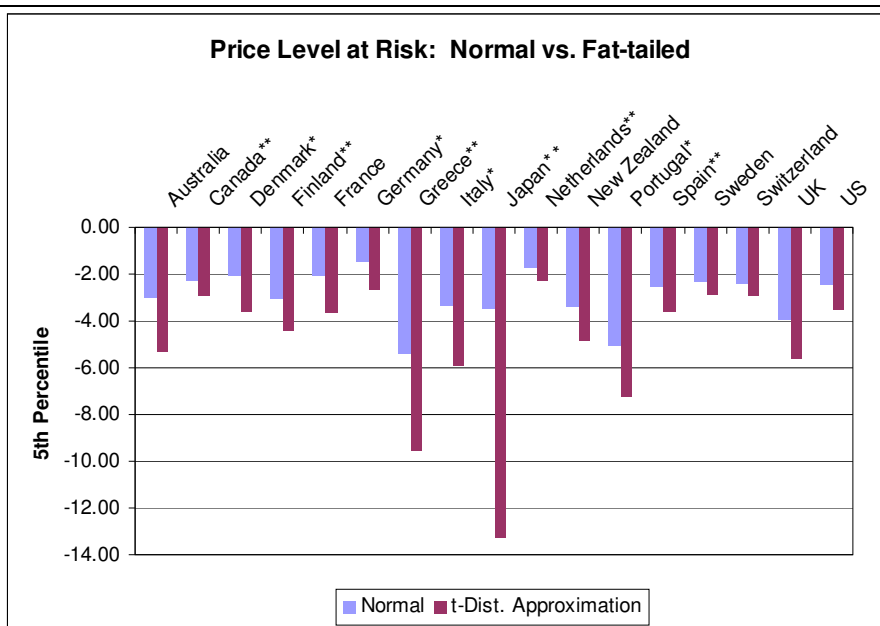
See explanatory note for Table 1 above.

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[7] I have also computed results for a shorter sample beginning in 1985 that verify the inaccuracies of the normal approximation reported below. In addition, the results throughout the paper are robust to using a smoothing parameter of 9600, rather than 1600; to using the residuals from a four-order autoregressions; and to using the residuals from the estimation of a two-equation aggregate demand – aggregate supply model based on Rudebusch and Svensson (1999) as implemented in Cecchetti, Flores-Lagunes, and Krause (2006) that includes interest rates.

The figures show the results for 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, the *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.[8]

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 equal to -2½% and the *t*-distribution approximation yielding an estimate of -3½%.

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

Managing risk means having information about the entire distribution of possible outcomes. That is, one needs to know not only the mean and variance, but tail probabilities as well. With that in mind, I now compute the mean, variance, value-at-risk, and expected lower tail for output and price-level deviations from their trends; all conditional on the asset price booms.

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[8] 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.

3.1 The Mean

How do asset price booms change the mean and volatility of output and price-level gaps? I examine this question using a series of regression, which allow straightforward statistical inference.

To study the conditional mean, consider the following regression:

(1) $x_{it} = a + b \, d_{it-k}(\alpha) + \varepsilon_{it}$,

where x_{it} is the either the level of the output (or price-level) gap; $d_{it-k}(\alpha)$ is a dummy variable that takes on the value 1 if k periods earlier the filtered asset price data exceeds the threshold α. The coefficient b measures the impact of the asset price boom on the distribution of the gap variable.

Before continuing, let me pause to describe the procedure used to construct the data.[9] 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 with a smoothing parameter equal to 1600 (the results are robust to using a parameter of 9600).   All data are quarterly, and most samples are from 1970 to 2003.[10]   To construct the dummy variable d_{it-k}, I filter the log equity and housing price data using a Hodrick-Prescott filter with smoothing parameter equal to 3200 (again, this is robust to increasing the parameter value). It is important to note that the use of a two-sided filter means that large positive deviations of asset prices from this trend – these are the booms – must be followed by crashes. Put another way, the booms I locate cannot continue indefinitely.

Finally, 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.[11]

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[9] 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.

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

[11] As in Section 2, the results in Section 3 are robust to use of residuals from a fourth-order autoregression; and use of residuals from a model that includes interest rates and external prices.

Table 1: Impact of Asset Price Booms on the Levels							
	Level of the Output Gap				Price Level		
	Lag of Asset Price (k)				Lag of Asset Price (k)		
EQUITY							
Threshold (α)	4	8	12	Threshold (α)	4	8	12
Data	*0.03*	*0.01*	0.00	Data	-0.07	0.00	0.04
	1.00	*0.96*	0.25		0.03	0.50	0.92
4	*1.05*	*0.28*	-0.21	4	-0.61	0.10	0.99
	1.00	*0.99*	0.10		0.30	0.58	0.94
12	*0.92*	*0.32*	-0.15	12	0.04	0.54	1.32
	1.00	*0.99*	0.23		0.51	0.71	0.92
20	0.85	0.16	-0.07	20	-0.65	0.71	1.58
	1.00	0.81	0.38		0.39	0.69	0.88
HOUSING							
Threshold (α)	4	8	12	Threshold (α)	4	8	12
Data	*0.06*	**-0.04**	**-0.09**	Data	*0.04*	*0.08*	*0.07*
	1.00	**0.00**	**0.00**		*0.99*	*1.00*	*1.00*
2	*0.46*	**-0.53**	**-0.92**	2	*0.62*	*0.96*	*0.70*
	1.00	**0.00**	**0.00**		*1.00*	*1.00*	*1.00*
6	*0.85*	**-0.50**	**-1.28**	6	*0.55*	*1.14*	*0.95*
	1.00	**0.01**	**0.00**		*0.98*	*1.00*	*1.00*
10	*1.10*	-0.42	**-1.42**	10	0.52	*1.19*	*1.04*
	1.00	0.12	**0.00**		0.92	*1.00*	*1.00*
The table reports the coefficient *b* in the regression $x_{it} = a + b\, d_{it\text{-}k}(\alpha) + \varepsilon_{it}$, where x is the deviation of either log GDP or the log price from an Hodrick-Prescott filtered trend, with parameter 1600; and *d* is either a dummy variable equal to one if the filtered asset price exceeds the threshold (in percent), or the filtered asset price data itself. In each case, the first row of numbers is the coefficient itself, while the second row is a p-value for the test that *b* is strictly less than zero, computed using Newey-West standard errors with lags equal to 1.5 times *k*. Italicized values are significantly greater than zero, while bold values are significantly less than zero, both at the 5-percent level. Samples are described in the data appendix.							

Returning to the results, Table 1 reports estimates for equation (1). To read the table, take the example of the last entry in the third column under housing. That's the one where the threshold α equals 10-percent and the lag *k* is 12 quarters. For this case, the estimate of *b* is -1.42 with a p-value of 0.00. This means that, conditional on seeing a housing boom that is 10-percent above trend, the mean of the output gap 12 quarters later is on average -1.42 percent – that seems like a big number, and it is precisely estimated.[12]

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[12] To address problems of heteroskedasiticity (throughout) and serial correlation (within each country) I have estimated the standard errors and resulting p-values using a panel version the Newey-West (1986) procedure with lags equal to 1.5*k*.

Overall, these results allow a number of conclusions. First, in the near term, at horizons of four quarters, both equity and housing booms lead to positive output gaps. This is for the simple reason that the at a four-quarter horizon, an asset-market boom is likely to continue, adding fuel to the general economic growth. Second, housing booms create future declines in output and increases in prices while equity booms do not. And third, the bigger the housing boom, the bigger the expected drop in output and the expected increase in the price level.

3.2 Volatility

Next, I examine the impact of asset price booms on the volatility of output and price deviation from trend. To do this, I regress the square of the gap, that is $(x_{it})^2$ on the dummy variable $d_{it-k}(\alpha)$. That is:

(2) $(x_{it})^2 = a' + b' \, d_{it-k}(\alpha) + v_{it}$.

To simplify interpretation, I standardize the data, dividing by the variance of the entire sample. This means that the coefficient is a measure of the percentage increase in the volatility. So, for example, a number like 5.28 (that's the estimate for a 10-percent housing price boom at a horizon of 4 quarters) means a 5.28-percent increase in volatility. The results are reported in Table 3, and they are quite stark. Housing booms increase the volatility of growth at all horizons, and that's it. Interestingly, neither housing nor equity booms have a measurable impact on the volatility of prices. And equity booms do not affect the volatility of growth – the estimates are both economically tiny and statistically irrelevant.

Focusing on the bottom left panel of the Table 3 – the impact of housing booms on GDP volatility – we see that the bigger the boom, the bigger the impact on volatility. But the bigger impact is at short horizons where we know from Table 2 that on average growth rises. So, while housing booms increase volatility, it seems to do it primarily on the up side.

Table 2: Impact of Asset Price Booms on Volatility						
	Volatility of the Output Gap				Price Level Volatility	
	Lag of Asset Price (k)				Lag of Asset Price (k)	
EQUITY						
Threshold (α)	4	8	12	Threshold (α)	4	8	12
Data	0.00	0.01	0.00	Data	0.00	0.00	0.00
	0.14	0.07	0.30		0.38	0.08	0.18
4	0.03	0.33	0.24	4	0.00	0.00	0.00
	0.43	0.08	0.14		0.15	0.54	0.46
12	0.15	0.05	0.19	12	0.00	0.00	0.00
	0.26	0.41	0.15		0.13	0.13	0.12
20	0.39	0.20	0.11	20	0.00	0.00	0.01
	0.12	0.27	0.34		0.16	0.11	0.06
HOUSING						
Threshold (α)	4	8	12	Threshold (α)	4	8	12
Data	**0.22**	0.12	0.05	Data	-0.02	0.00	0.02
	0.04	0.18	0.35		0.64	0.53	0.34
2	**2.46**	**2.84**	1.43	2	-0.09	0.50	0.66
	0.02	**0.01**	0.12		0.57	0.12	0.17
6	**4.39**	**4.75**	1.93	6	0.55	0.60	0.87
	0.01	**0.01**	0.12		0.18	0.10	0.16
10	**5.48**	2.46	**5.28**	10	0.88	0.38	0.80
	0.04	0.07	**0.04**		0.16	0.23	0.19

The table reports the coefficient b_2 in the regression $(x_{it})^2 = a_2 + b_2\, d_{it-k}(\alpha) + \eta_{it}$, where x is the deviation of either log GDP or the log price from an Hodrick-Prescott filtered trend, with parameter 1600; and d is either a dummy variable equal to one if the filtered asset price exceeds the threshold α (in percent), or the filtered asset price data itself (those are the rows labeled "data"). In each case, the first row of numbers is the coefficient itself, while the second row is a p-value for the test that b_2 is strictly greater than zero, computed using Newey-West standard errors with lags equal to 1.5 times k. Bold values are significantly greater than one at the 5-percent level.

3.3 GDP and Price-Level at Risk

Next, I turn to an examination of the tails of the distribution of output and price-level outcomes, conditional on asset price booms. 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?

Figure 3: GDP at Risk Following an Equity Boom
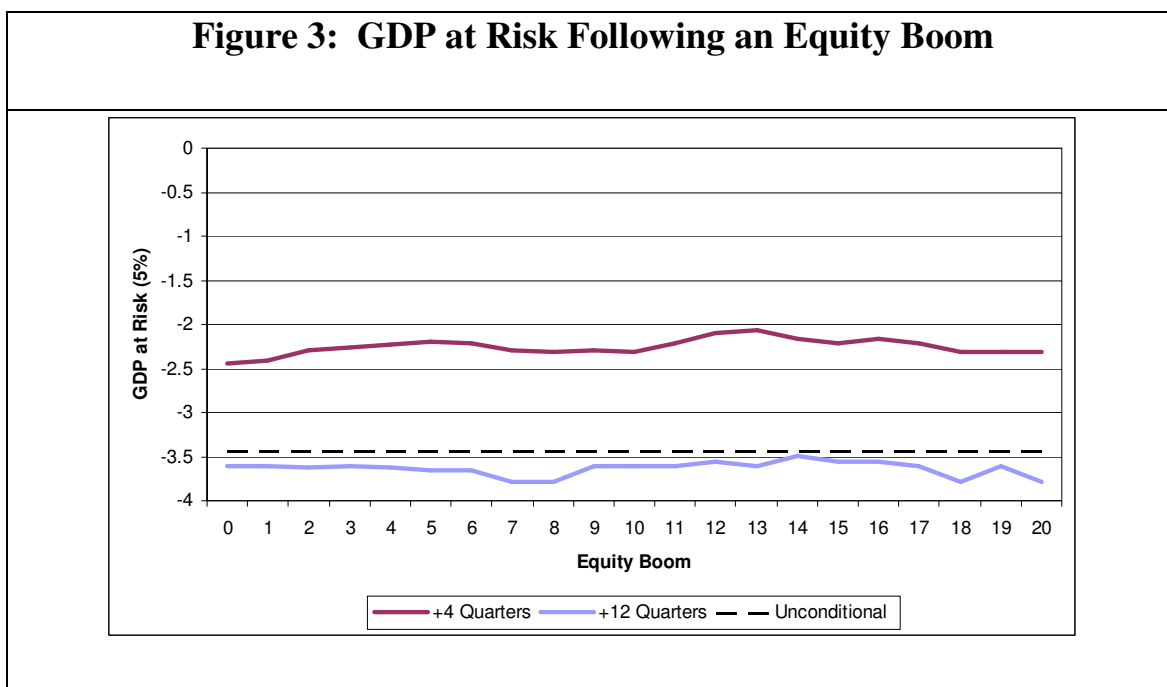
Equity Bubbles

   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 5th 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 5th 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 5th 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 4: Price-Level at Risk following an Equity 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
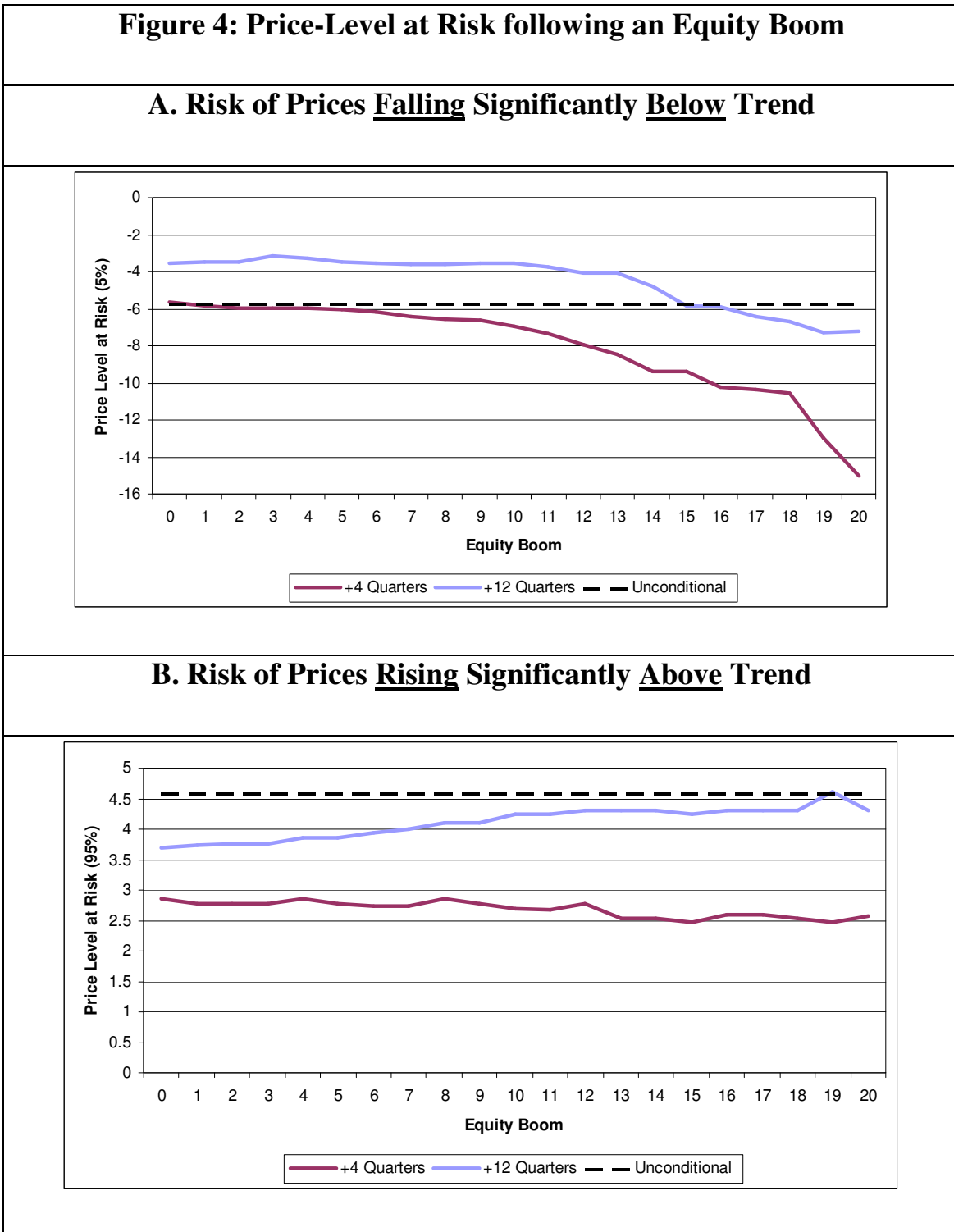

Figure 4 reports the results for price-level at risk following an equity boom. The price-level at risk results differ quite a bit from the GDP at risk results. Since some central banks will care

about prices 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 5th percentile of the distribution of price-level 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.
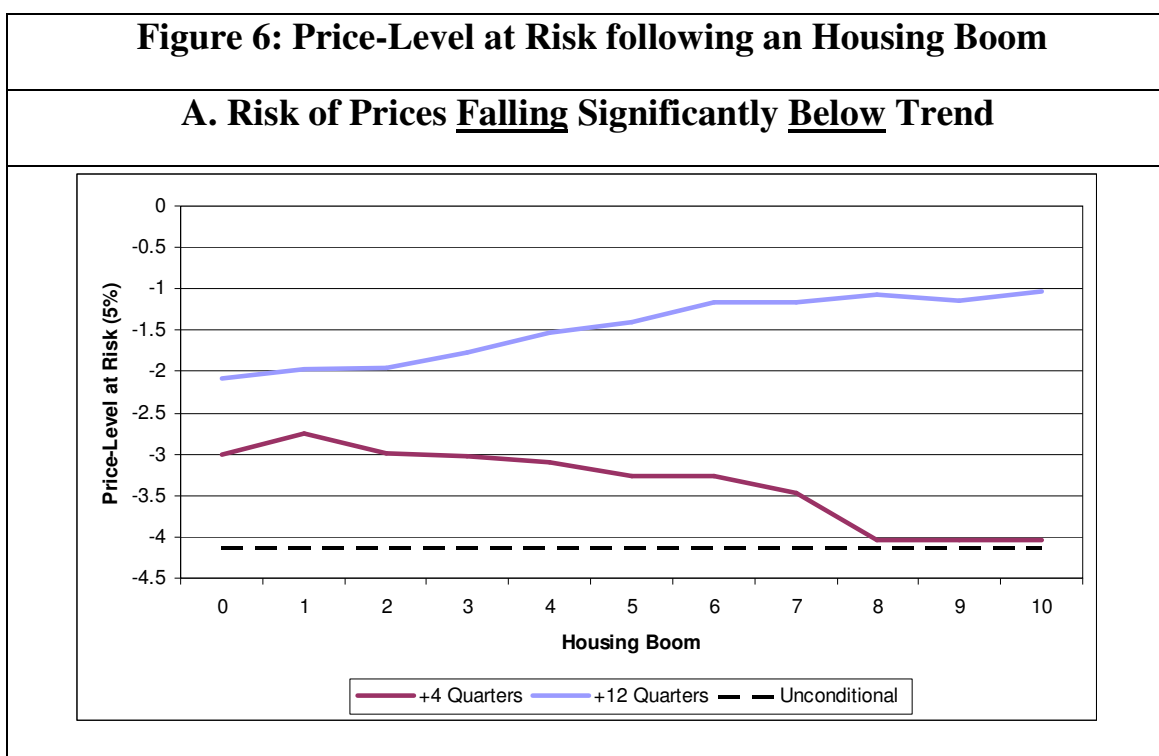
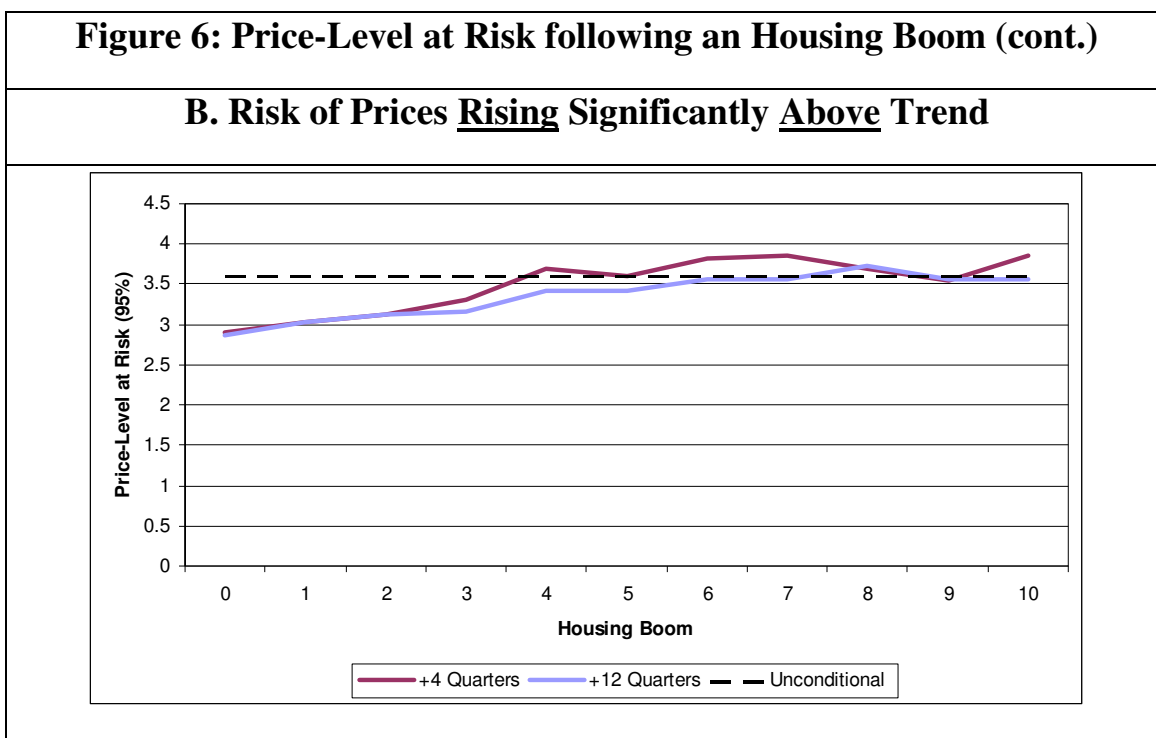**Figure 5: GDP at Risk Following an Housing Boom**
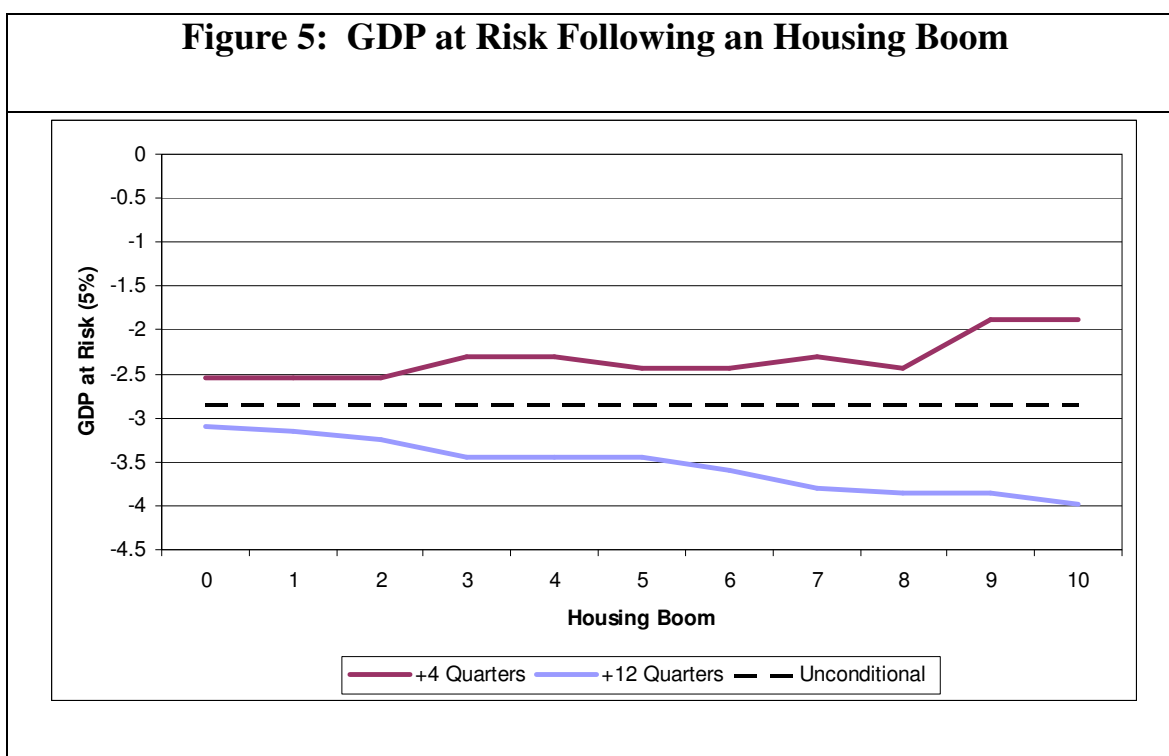
Housing Bubbles

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. Note 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%.[13]

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%.

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

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

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[13] 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 (cont.)

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

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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 -1.645 times the standard deviation of the distribution of output and price-level 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 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 employing a quadratic loss would likely overestimate the importance of an equity boom.

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

A. Conditional on an Equity Boom
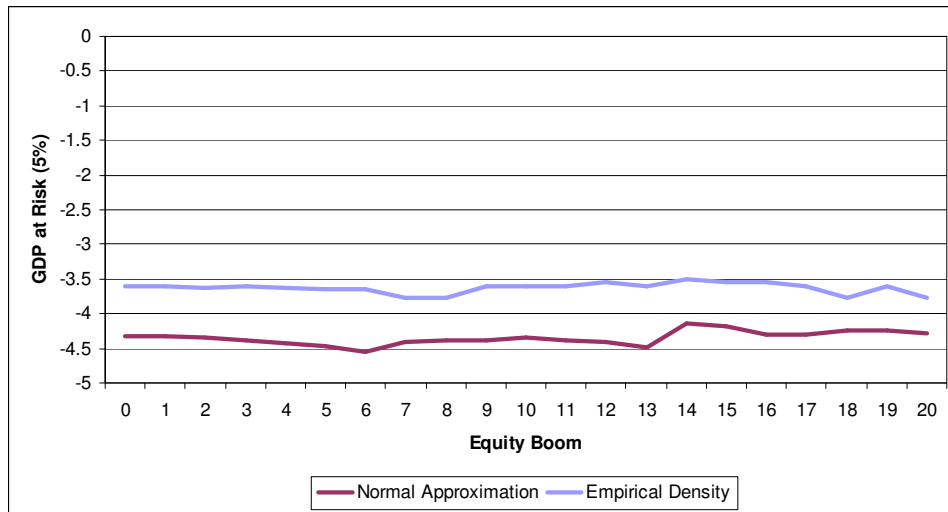
B. Conditional on a Housing Boom
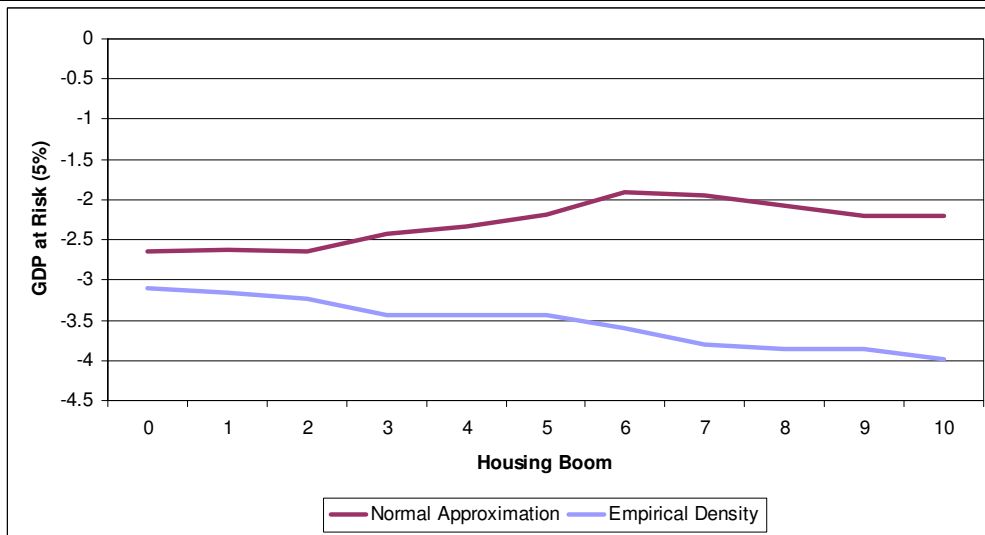
Housing is another story. Here the normal distribution gives an overly optimistic view of the true size of the lower tail. The 5th percentile of the empirical density is on average 1.25 percentage points below what is implied by the normal approximation. Since the probability of

extreme negative outcomes for the GDP gap is higher than suggested by a Gaussian distribution, a quadratic loss will underestimate the importance of a housing boom.

In the case of price-level 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.

3.4. Expected Lower Tail Loss

Direct statistical inference for a number like GDP at risk is difficult. Instead of constructing Monte Carlo experiments that might allow confidence interval estimation, I turn to the examination the *expected tail loss*. This is the expected value, conditional on being in the tail of the distribution. As in the case of the GDP at risk and price-level at risk, here I ask whether the expected tail loss changes when asset prices boom. In order to do inference, I run a regression similar to equation (1):

(3) $x_{it} = a + b_0\, d_{it-k}(\alpha) + b_1 tail(\beta)_{it} + b_3\, d_{it-k}(\alpha) x\; tail(\beta)_{it} + \eta_{it}$,

where x_{it} is the output or price-level gap; $d_{it-k}(\alpha)$ is a dummy variable equal to 1 if k periods earlier the filtered asset price data exceeds the threshold α; and $tail(\beta)_{it}$ as a dummy variable that equals 1 if x_{it} is in the β-percent lower tail of the distribution of all x_{it}.

The coefficient b_3 on the interaction term in equation (3) provides an estimate of the impact of an asset price boom of size α on the expected tail loss in the lowest β-percent of the distribution of the output or price-level gap. Because of the structure of the regression, it is possible to compute standard errors that are robust to both serial correlation and heteroskedasiticity in the error term η_{it}.[14]

The results of this regression are reported in Table 3, and they are quite striking. Asset price booms – both equity and housing – result in a fall in the expected lower tail loss. The decline is both economically and statistically significant. Put another way, equity and housing booms make it more likely that something bad will happen.

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[14] The estimation method is an adaptation of the Newey-West estimator to a panel in which there is serial correlation and heteroskedasiticity within a country, but no dependence between countries.

Table 3: Impact of Asset Price Booms on the Lowest Quartile						
	Output Gap				**Price Level Gap**	
	Lag of Asset Price (k)				**Lag of Asset Price (k)**	
EQUITY						
Threshold (α)	**4**	**8**	**12**	**Threshold (α)**	**4**	**8**	**12**
Data	-0.03	-0.02	0.01	Data	**-0.26**	-0.21	0.03
	0.10	0.12	0.63		**0.02**	0.06	0.59
4	**-3.81**	**-2.50**	**-1.87**	4	**-14.05**	**-16.12**	**-13.88**
	0.00	**0.00**	**0.00**		**0.00**	**0.00**	**0.00**
12	**-4.63**	**-1.75**	**-1.70**	12	**-16.38**	**-19.20**	**-16.35**
	0.00	**0.01**	**0.01**		**0.00**	**0.00**	**0.00**
20	**-5.37**	**-2.05**	**-0.85**	20	**-18.06**	**-20.73**	**-17.36**
	0.00	**0.02**	**0.05**		**0.00**	**0.00**	**0.00**
HOUSING						
Threshold (α)	**4**	**8**	**12**	**Threshold (α)**	**4**	**8**	**12**
Data	-0.01	-0.03	-0.01	Data	0.06	0.10	0.09
	0.35	0.11	0.35		0.67	0.84	0.76
2	**-1.53**	**-1.08**	**-0.69**	2	**-2.47**	**-4.03**	**-5.01**
	0.00	**0.00**	**0.00**		**0.00**	**0.00**	**0.01**
6	**-1.42**	**-1.15**	-0.28	6	**-2.89**	**-4.83**	**-9.22**
	0.00	**0.00**	0.18		**0.00**	**0.00**	**0.00**
10	**-1.16**	-0.34	-0.59	10	**-3.28**	**-3.91**	**-12.29**
	0.00	0.12	0.08		**0.00**	**0.00**	**0.00**

The table reports the coefficient b_3 in the regression $x_{it} = a + b_1 d_{it-k}(\alpha) + b_2 tail(\beta)_{it} + b_3 d_{it-k}(\alpha) x\ tail_{it}(\beta) + v_{it}$ where x_{it} is the deviation of either log GDP or the log price from an Hodrick-Prescott filtered trend, with parameter 1600; $tail_{it}(\beta)$ is a dummy variable that equals 1 if x_{it} in the lower β-percent tail; and d is either a dummy variable equal to one if the filtered asset price exceeds the threshold α (in percent), or the filtered asset price data itself (those are the rows labeled "data"). In each case, the first row of numbers is the coefficient itself, while the second row is a p-value for the test that b_3 (the coefficient on the interaction term) is strictly less than zero, computed using Newey-West standard errors with lags equal to 1.5 times k. Bold values are significantly greater than one at the 5-percent level.

3.5 Summary of the Results

   Table 4 summarizes the results of this section. The conclusion is that housing booms dramatically change the distribution of outcomes in virtually every way. By contrast, equity booms have little impact on the mean and variance of deviation from trend, but do affect the lower tail of the distribution.

Table 4: Summary of the Impact of Asset Price Booms on the Distribution of Macroeconomic Outcomes					
	Output Gap			**Price-Level Gap**	
	Lag of Asset Price			**Lag of Asset Price**	
Equity					
Moment	**k=4**	**k=12**	**Moment**	**k=4**	**k=12**
Mean	Higher	None	Mean	None	None
Variance	None	None	Variance	None	None
5% VaR	Better	None	5% VaR	None	Worse
25% Expected Tail Loss	Lower	Lower	25% Expected Tail Loss	Lower	Lower
Housing					
Moment	**k=4**	**k=12**	**Moment**	**k=4**	**k=12**
Mean	Higher	Lower	Mean	Higher	Higher
Variance	Higher	Higher	Variance	None	None
5% VaR	Better	Worse	5% VaR	Better	None
25% Expected Tail Loss	Lower	Lower	25% Expected Tail Loss	Lower	Lower
Table summarizes the results in Tables 1, 2, and 3 and Figures 3 to 6.					

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 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.[15] 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. [16] They emphasize that we care more about the impact of a 10% increase in the value of wealth than we

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[15] See, for example, Norman, Sebastia-Barriel and Weeken (2002).
[16] 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.

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.[17]

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.[18] 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. 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) discusses how 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 the distribution of macroeconomic outcomes than equity booms do.

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

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[17] 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.

[18] 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.

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 fairly high and there are significant risk of costly missteps. The conclusion is that interest rates may not be the best tool for combating the destabilizing effects of asset price bubbles

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.[19] 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?

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[19] 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.

   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.

   As a first step, I reproduce Figure 3 and 5 with the data for GDP at risk dividing the data
based on whether it comes from a country with a predominantly market-based or bank-based
financial system. 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.

   To examine this a bit further, and try to get a grasp on whether any of it is precise in a
statistical sense, I add the I add the financial structure variable to regressions (1), (2) and (3) –
both as a level and interacted with the asset-price boom dummy. Here's an example:

(1') $x_{it} = a + b\, d_{it\text{-}k}(\alpha) + cf_i + df_i\, d_{it\text{-}k}(\alpha) + \varepsilon_{it}$,

(2') $(x_{it})^2 = a' + b'\, d_{it\text{-}k}(\alpha) + c'f_i + d'f_i\, d_{it\text{-}k}(\alpha) + \upsilon_{it}$.

(3') $x_{it} = a + b_0\, d_{it\text{-}k}(\alpha) + b_1 tail(\beta)_{it} + b_3\, d_{it\text{-}k}(\alpha)x\, tail(\beta)_{it}$

$\qquad\qquad b_4\, f_i + b_5\, f_i\, d_{it\text{-}k}(\alpha) + b_6\, f_i\, tail(\beta)_{it} + b_7\, f_i\, d_{it\text{-}k}(\alpha)x\, tail(\beta)_{it} + \eta_{it}$.

where *fin* is the composite structure index from the CD-ROM that is distributed with Demirguc-
Kunt and Levine (2001).[20]

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[20] 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

**Figure 8: Market- vs. Bank-based Financial Systems
GDP at Risk at +12 Quarter Horizon**
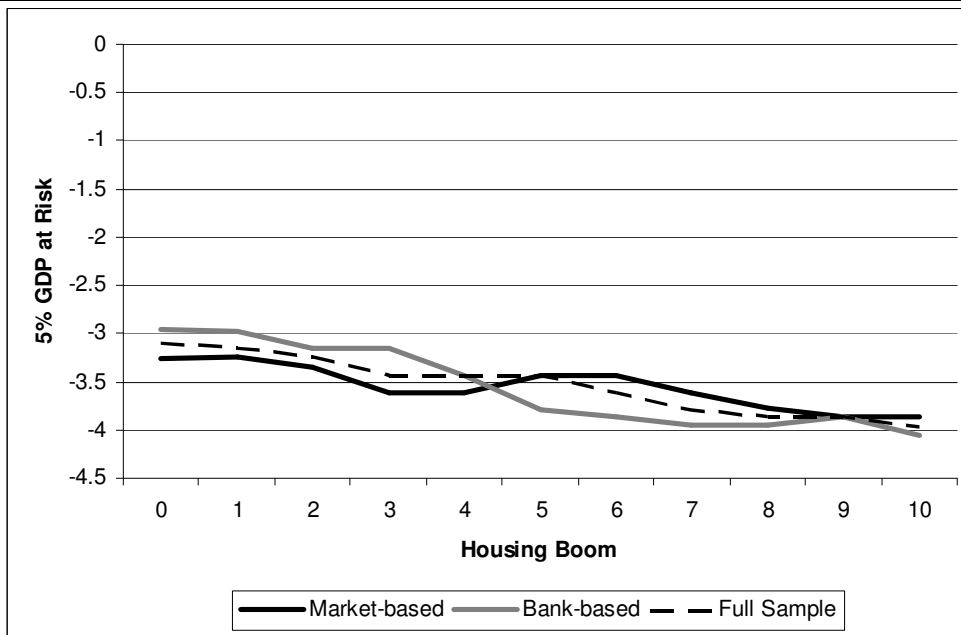
A. Equity Booms
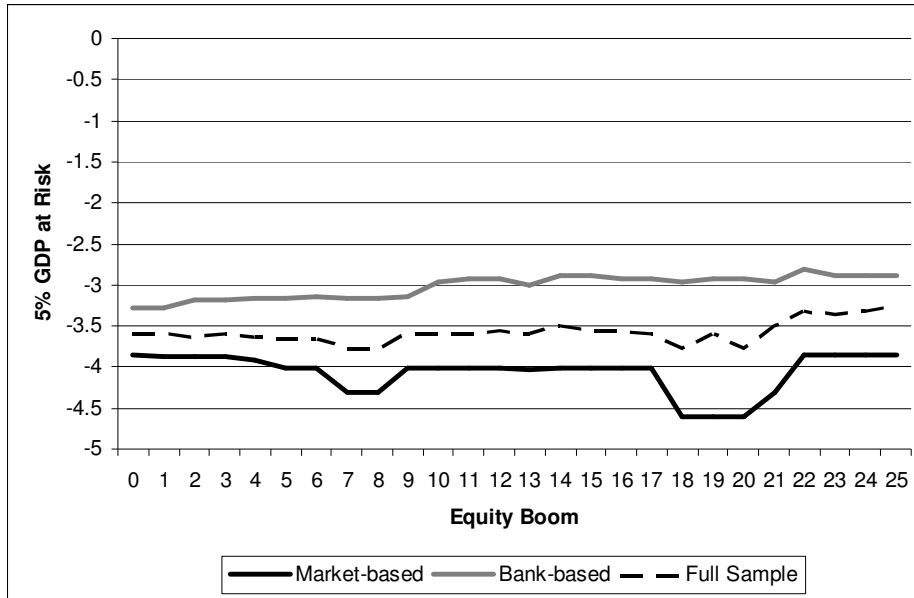
B. Housing Booms

Table 5 reports the estimated coefficients on the interactions terms in each of these; $f_i\, d_{it-k}(\alpha)$ in equations (1') and (2'), and $f_i\, d_{it-k}(\alpha)x\, tail(\beta)_{it}$ in equation (3'). These tells us whether differences in financial structure change the impact of an asset price boom on the mean,

variance, or lower tail events in the distribution of the output gap. I report the results for a lag of 4 and 12 quarters.   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.

Table 5: Financial Structure and the Impact of Asset Price Booms						
EQUITY						
	Mean		Variance		Lowest Quartile	
Threshold	Lag of Asset Price in Quarters					
(α)	4	12	4	12	4	12
	Mean		Variance		Lowest Quartile	
Data	*0.07*	-0.03	0.00	0.00	0.06	**-0.07**
	1.00	0.15	0.62	0.32	0.84	**0.10**
8	*1.50*	-0.60	0.01	-0.01	1.41	-1.20
	0.95	0.31	0.31	0.65	0.69	0.25
16	*2.31*	-0.87	0.01	0.00	3.68	-2.03
	0.97	0.26	0.30	0.45	0.74	0.11
20	2.88	-1.82	0.00	0.02	5.25	**-3.57**
	0.98	0.12	0.42	0.19	0.78	**0.06**
HOUSING						
	4	12	4	12	4	12
Data	**-0.14**	-0.04	0.00	0.00	-0.02	0.05
	0.07	0.36	0.65	0.54	0.44	0.64
4	-1.40	-1.60	0.03	-0.03	-1.06	0.59
	0.16	0.14	0.37	0.63	0.21	0.65
8	-1.90	-0.02	-0.09	-0.03	-0.50	0.19
	0.21	0.50	0.71	0.59	0.40	0.54
10	-0.83	0.04	-0.20	-0.04	-0.10	0.89
	0.38	0.51	0.77	0.58	0.49	0.61
Table reports the regression coefficients from the interaction of the financial structure measure with the asset price boom dummy variable in equations (1), (2), and (3). The more positive financial structure, the more market-based a countries financial system; the more negative, the more bank-based it is. Numbers in parentheses are p-values computed using heterskedasticity and autocorrelation consistent standard errors, as described in the notes to Tables 1, 2, and 3.						

Unsurprisingly, the strongest results are those for the mean. In countries with market-based financial systems, which is to say places where equity markets are important, the first and second column of the top panel in Table 5 shows that equity price increases lead to bigger short-horizon booms and bigger long-horizon crashes (although the latter are imprecisely estimated). Analogously, for bank-based economies, housing booms lead to bigger short-horizon GDP booms, but smaller long-horizon crashes. (These are the results in the first and second column of the bottom panel of the table.)

Turning to the volatility, there is no measurable impact on financial structure. The point estimates reported in the fourth and fifth columns of Table 5 are all small and the the p-values are never below 0.2 or above 0.8.

Finally, looking at the far right columns of Table 5, the results from estimating equation (3') there is some weak evidence that market-based economies fare somewhat worse at longer-horizons when hit with equity price booms. Again, this is really no surprise.

In the end, these results are disappointing. While we may believe that financial structure plays are role in the real economic impact of asset price booms, the available data do not show much evidence of it.

6. Conclusion

Stability is the watchword of monetary policymakers. Listening to most modern central bankers speak about their goals you are likely to hear about the desire for low, stable inflation and high, stable growth. Policymakers will explain how they raise and lower short-term interest rate targets in order to meet their stability-oriented objectives. But listen closely, and you will realize that the statements are 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, and to do this they consider the entire distribution of possible outcomes.

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 managing 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. The implication is that policy responses be designed to keep the lower tail of the distribution – as measured by value-at-risk or the expected tail loss – sufficiently small.

In this paper I use data from a broad cross-section of countries to examine the mean, variance, and lower tail risks arising from booms and crashes in equity and housing markets. The conclusion is that housing bubbles change the entire distribution of macroeconomic outcomes.

By contrast, equity bubbles tend to make the worst events even worse, leaving the mean and variance of the distributions roughly unchanged. The strongest conclusion is that approximations that use the normal distribution, and analyses based on quadratic loss functions, have the potential to be extremely misleading. Looking further, I present weak evidence suggesting that those countries with market-based financial systems, where stock market capitalization is relatively large, weather housing booms somewhat better and equity booms somewhat worse than countries with bank-based financial systems.

In closing, it is important to emphasize one 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. This is 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, 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.

References

Bernanke, Ben and Mark Gertler (1999). "Monetary Policy and Asset Price Volatility". In *New Challenges for Monetary Policy: A Symposium Sponsored by the Federal Reserve Bank of Kansas City*. Federal Reserve Bank of Kansas City, pp. 77-128.

_____ and _____. (2001). "Should Central Banks Respond to Movements in Asset Prices?" *American Economic Review*, May.

Bertaut, Carol "Equity Prices, Household Wealth, and Consumption Growth in Foreign Industrial Countries," International Finance Discussion Papers 724. Washington: Board of Governors of the Federal Reserve System, 2002.

Case, Karl E., John M. Quigley and Robert J. Shiller, "Comparing Wealth Effects: The Stock Market versus the Housing Market," *Advances in Macroeconomics*, vol. 5, no. 1 (2005).

Cecchetti, Stephen G. "The Brave New World of Central Banking: Policy Challenges Posed by Asset Price Booms and Busts," *Economic Review of the National Institute of Economic and Social Research*, May 2006.

Cecchetti, Stephen G., Alfonso Flores-Lagunes, and Stefan Krause, "Assessing the Sources of Changes in the Volatility of Real Output," *The Economics Journal* 116 (4) April 2006.

Cecchetti, Stephen G., Alfonso Flores-Lagunes, and Stefan Krause, 'Assessing the Sources of Changes in the Volatility of Real Growth,' in C. Kent and D. Norman, eds., *The Changing Nature of the Business Cycle*, Proceedings of the Research Conference of the Reserve Bank of Australia, November 2005, 115-138.

Demirguc-Kunt, Asli, and Ross Levine, "Bank-Based and Market-Based Financial Systems: Cross-Country Comparisons," in A. Demirguc-Kunt and R. Levine, eds., *Financial Structure and Economic Growth*, Cambridge, MA: MIT Press, 2001, pg. 81-140.

Dynan, Karen E., Douglas W. Elmendorf, and Daniel E. Sichel (2005), "Can financial innovation explain the reduced volatility of economic activity?" Carnegie-Rochester Conference on Public Policy

Greenspan, Alan, "Opening Remarks," in *Rethinking Stabilization Policy*, Proceedings of the Federal Reserve Bank of Kansas City Symposium, 2002.

Greenspan, Alan, "Opening Remarks," in *Monetary Policy and Uncertainty: Adapting to a Changing Economy*,' Proceedings of the Federal Reserve Bank of Kansas City Symposium, 2003.

Greenspan, Alan, "Risk and Uncertainty in Monetary Policy," *American Economic Review*, volume 94, no. 2, May 2004, pg. 33-40.

Gruen, David, Michael Plumb, and Andrew Stone, "How Should Monetary Policy and Asset Price Bubbles," in A. Richards and T. Robinson, eds., *Asset Prices and Monetary Policy*, Proceedings of the Research Conference of the Reserve Bank of Australia, November 2003, 260-280.

Hodrick, Robert J. and Edward C. Prescott, "Postwar U.S. Business Cycles: An Empirical Investigation," *Journal of Money, Credit, and Banking*, 29 (1), February 1997, 1-16.

Jorion, Phillipe. *Value at Risk*. 2nd edition. New York: McGraw-Hill, 2001.

Kishor, N. Kundan, "Does Consumption Respond More to Housing Wealth than to Financial Wealth? If So, Why?" unpublished manuscript, Department of Economics, University of Washington, June 2005.

LeBaron, Blake and Ritirupa Samanta, "Extreme Value Theory and Fat Tails in Equity Markets," unpublished manuscript, International Business School, Brandeis University, June 2005.

Levine, Ross, "Financial Development and Economic Growth: Views and Agenda," *Journal of Economic Literature*, 35 (2), June 1997, 688-726.

Newey, Whitney K. and Kenneth D. West, "A Simple, Positive Definite, Heteroskedasticity and Autocorrelation Consistent Covariance Matrix," *Econometrica* 55 (3), May 1987, 703-708.

Norman, Ben Maria Sebastia-Barriel and Olaf Weeken, "Equity wealth and consumption – the Experience of Germany, France and Italy in an International Context," *Bank of England Quarterly Review*, Spring 2002, pg. 78-85.

Rudebusch, Glenn D. and Lars E. O. Svensson (1999). `Policy Rules for Inflation Targeting' in J. B. Taylor (ed.), *Monetary Policy Rules*, University of Chicago Press, Chicago, pp. 203-246.

Surico, Paolo, "U.S. Monetary Policy Rules: The Case for Asymmetric Preferences," *Journal of Economic Dynamics and Control*, forthcoming.