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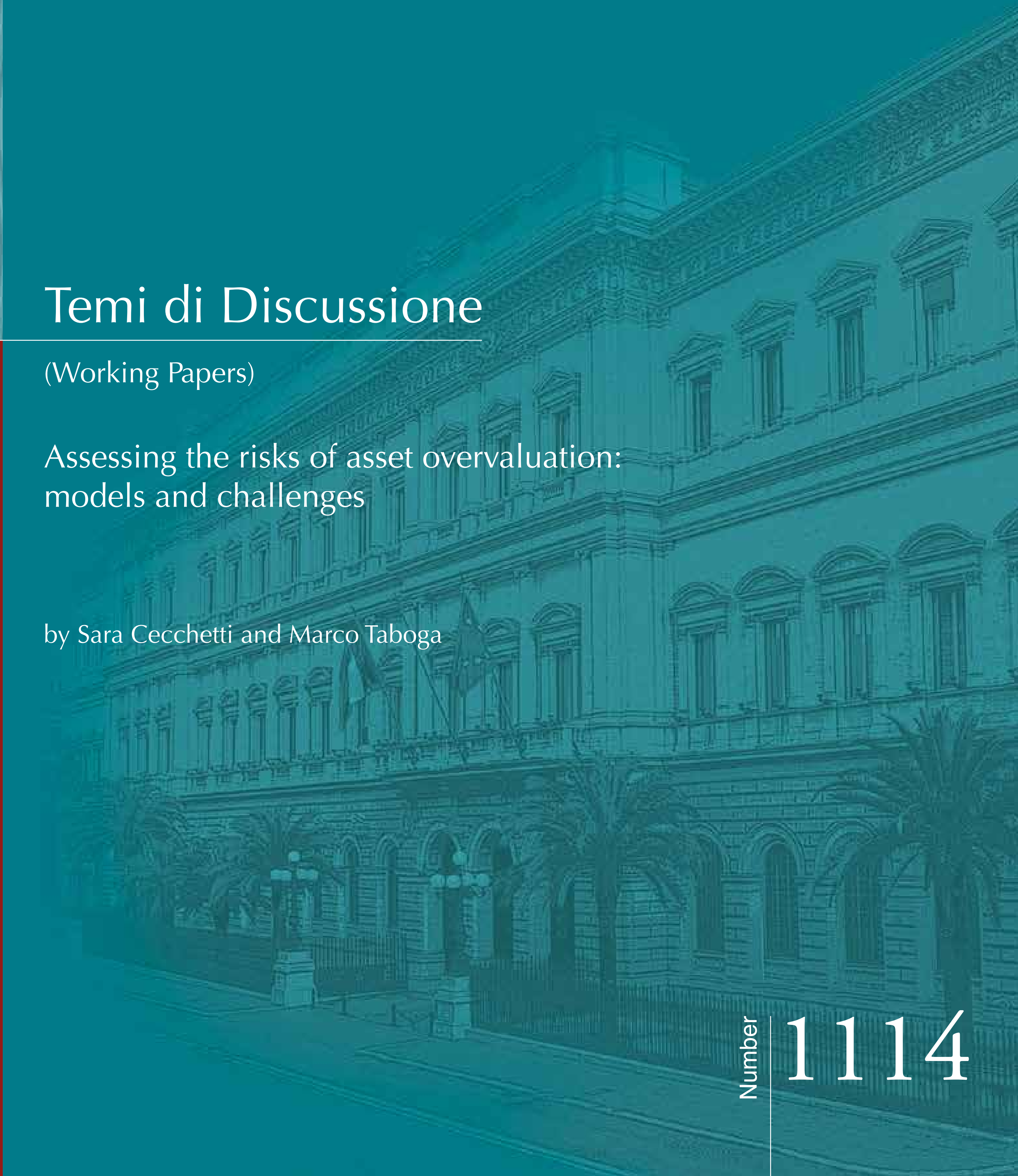
by Sara Cecchetti and Marco Taboga



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ASSESSING THE RISKS OF ASSET OVERVALUATION: MODELS AND CHALLENGES

by Sara Cecchetti* and Marco Taboga*

Abstract

We propose methods to compute confidence bands for the fundamental values of stocks and corporate bonds. These methods take into account uncertainty about future cash flows and about the discount factors used to discount the cash flows. We use them to assess the current degree of under-/over-valuation of asset prices. We find no evidence of over-valuation of the stocks and corporate bonds of the major economies.

JEL Classification: B26, C02.
Keywords: stock risk premium, bond risk premium, fundamental value, under-/over-valuation.

Contents

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1 Introduction

Concerns are insistently voiced that exceptionally easy monetary conditions in the major world economies might favor the formation of bubbles in financial asset prices, that is, of significant deviations of asset prices from their fundamental values (see Acharya and Naqvi 2015 and the references therein). The aim of this paper is to contribute to the debate about asset over-valuation at the current juncture. We propose methods to assess the degree of mis-valuation of asset prices in probabilistic terms, by producing confidence bands for the fundamental values of assets, and by comparing them with observed prices.

According to the standard definition (e.g., Diba and Grossman 1988a and 1988b), the fundamental value of an asset is the expectation of the present discounted[1] value of its future cash flows, which, in turn, reflects the utility that an infinitely lived economic agent derives from buying the asset and holding it forever. In several competitive equilibrium frameworks, the observed price can be different from the fundamental value because it can include a bubble component, that is, a component of the price that arises from speculative behavior. Roughly speaking, there is speculative behavior when agents recognize profit opportunities from buying an asset and re-selling it after a short period of time on expectations that the price will rise even if it does not reflect the fundamental value.

The main problem with estimating the fundamental value of an asset by using the standard definition is that there is considerable uncertainty in estimating both future cash flows and the discount factors that should be used to discount the cash flows. In this paper, we propose statistical procedures that aim at taking into account this uncertainty. Our approach is completely agnostic: we assign uninformative priors to sets of methods that are commonly used for predicting cash flows and to sets of discount factors that are derived from the empirical distributions of ex-ante risk premia estimated with standard asset pricing models. These agnostic priors translate into confidence intervals for the fundamental values of assets. The main economic assumption underlying our procedure is that values for the

[1] In general, each cash flow is multiplied by a stochastic discount factor that also depends on preferences.

risk premium that have been observed more frequently in the past are more likely to be "fair", that is, they are more likely to be reasonable estimates of the risk premium that a buy-and-hold investor might require at any given time.

We use the proposed method to analyze the prices of stock indices in the United States, euro area and Japan, and of investment grade bond indices in the United States and euro area.

As far as stocks are concerned, our results for the years preceding the 2008 financial crisis are in line with those in the literature. In particular, our results point to episodes of significant over-valuation (i.e., of observed prices above the upper bounds of the confidence bands for the fundamental values) in the euro area and the US at the end of the 1990s, before the burst of the so called dot-com bubble (e.g., Griffin et al. 2011), and in Japan in the late 1980s and early 1990s (at the peak of the so-called Heisei bubble; e.g., Shiratsuka 2005). Furthermore, observed prices are close to the upper bound of the bands around the years 2006 and 2007, before the market crash of 2008-9. Currently (at the beginning of of 2017), according to our results, there is no evidence of over-valuation in any of the stock markets we analyze.

As for investment grade corporate bonds, our analysis is, to our knowledge, completely novel and, as a consequence, there are no terms of comparison in the literature. We find evidence of over-valuation, albeit barely significant, in the years preceding the financial crisis, both in the US and in the euro area. On the contrary, there is no evidence of over-valuation at the current juncture, although the prices of euro denominated bonds are now close, but below the upper confidence bound for their fundamental values.

While the literature on the detection of financial bubbles is vast, the majority of studies focus on econometric tests for changes in the time-series properties of asset prices, based on the implications of theoretical models that predict a change in the persistence of the asset price process during the formation of a bubble (see Gürkaynak 2008, and Homm and Breitung 2012 for a review). These tests are conducted by looking only at the dynamics of asset prices, without investigating their determinants. In contrast, our method is based on the joint analysis of asset prices and of their economic determinants, that is, of the factors, such as corporate earnings, risk premia and risk-free interest rates, that contribute to determine the fundamental value of an asset. The closest approach to ours is probably that proposed by Shiller (2000 and 2014), who identifies deviations of stock prices from fundamental values based on forward and backward looking measures of corporate earnings and dividends. The main methodological innovation in our paper is a probabilistic framework that allows to simultaneously take into account several sources of uncertainty that hinder a precise identification of the fundamental value of an asset. Furthermore, we believe ours is one of the first studies to analyze both stocks and corporate bond valuations in the post-financial crisis period.

The rest of the paper is organized as follows: Section 2 describes the methodology; Section 3 describes the data; Section 4 presents the empirical results; Section 5 concludes.

2 Methodology

An asset price is defined to be over-valued when its market price P_t exceeds its fundamental value P_t^f, defined as the expectation of the present discounted value of the cash flows that the asset will produce in the future:

$$P_t^f = \sum_{j=1}^{\infty} \mathbb{E}[k_{t+j} d_{t+j}] \tag{1}$$

where d_{t+j} are the future cash flows and k_{t+j} are the stochastic discount factors used by economic agents to discount the future cash flows.

Differences between P_t and P_t^f (so-called bubble components, or rational bubbles) can arise in competitive equilibrium frameworks and can be rationalized under various pricing mechanisms (e.g., Diba and Grossman 1988a and 1988b, Santos and Woodford 1997). Intuitively, the fundamental value is the value that an economic agent derives from buying the asset and holding it "forever" (e.g., for a stock, the utility from consuming the stream of dividends; for a house, the utility from the housing services provided net of carrying costs). But the price can deviate from the fundamental value when agents recognize profit opportunities from buying and re-selling after a short period of time. Large deviations of the price from the fundamental are eventually corrected by market forces, but the correction tends to have harmful macro-economic consequences (e.g., Brunnermeier and Oehmke 2012).

There are two main difficulties in estimating the fundamental value P_t^f:

1. there is usually no standard methodology to assign a probability distribution to future cash flows;

2. stochastic discount factors depend on variables, such as preferences and covariances between macroeconomic outcomes and asset returns, that are generally unobservable and whose estimation is also subject to considerable uncertainty.

In this paper we aim at explicitly taking into account the uncertainty in estimating cash flows and discount factors. We do this by attaching uniform uninformative priors to sets of different estimates of the cash flows (obtained with various methods proposed in the literature) and to sets of estimated discount factors (obtained from the empirical distributions of estimated discount factors). Our priors translate into probability distributions (and confidence bands) over the fundamental values of assets.

2.1 Stocks

Under some commonly made hypotheses (e.g., Easton 2004 and Ohlson and Juettner-Nauroth 2005), it is possible to show that the fundamental value P_t^f of a stock can be written as

$$P_t^f = \frac{\overline{E}_t}{y_t^f} \tag{2}$$

where $\overline{E}_t$ is a measure of the permanent component of real earnings per share (obtained by filtering transitory components out of current earnings) and y_t^f is the real return that investors expect to obtain from equities over the long run.

The main assumption that allows to derive equation (2) is dividend irrelevance (Modigliani and Miller 1958, Brennan 1971, Stiglitz 1974). Under dividend irrelevance, a stock can be valued as if future earnings were entirely paid out as dividends, there were no net investments in the firm, and earnings (equal to dividends) did not grow in real terms. The permanent component of real earnings $\overline{E}_t$ is used in the formula (2) in order to take into account the fact that, even if no net investments are made, there can be oscillations in earnings due to the business cycle .

Time is indexed by $t = 1, \ldots, T$, where T is the last period in the sample and the data has monthly frequency.

We consider several methods for the estimation of $\overline{E}_t$:

- n-year moving averages of current earnings with n between[2] 8 and 12 years;
- exponentially weighted moving averages with monthly decay factor between 0.96 and 0.99;[3]
- HP filtered earnings with different parameters ranging from[4] 100,000 to 200,000.

By imposing a discrete uniform uninformative prior on the different methods, we obtain a probability distribution for $\overline{E}_t$.

Denote by $\overline{E}_{t,i}$ the estimate obtained with method $i \in I$, where I is the set of all methods used, and by

$$\varepsilon_t = \left\{ \overline{E}_{t,i} : i \in I \right\}$$

[2] One of the most popular methods for smoothing corporate earnings, proposed by Shiller (2000), is to take 10-year moving averages.

[3] With a grid step of 0.01.

[4] With a grid step of 20,000.

Denote the fair risk premium by

$$\rho_t^f = y_t^f - r_t \tag{3}$$

where r_t is the real return on a risk-free asset.

Define the set

$$R = \left\{ \rho_{t,i} = \frac{\overline{E}_{t,i}}{P_t} - r_t : i \in I, t \in \{1, \ldots, T\} \right\} \tag{4}$$

where P_t is the stock price observed at time t.

By equations (2) and (3), we have that

$$\rho_{t,i} = \frac{\overline{E}_{t,i}}{P_t} - r_t \tag{5}$$

is the fair risk premium required by investors if $P_t = P_t^f$ (i.e., if stocks are correctly valued at time t) and $\overline{E}_t = \overline{E}_{t,i}$ (i.e., if the estimate of $\overline{E}_t$ produced by method i is correct).

We represent our uncertainty about ρ_t^f (for each t) by assigning a discrete uniform uninformative prior to the set R. Intuitively, our economic hypothesis is that most of the times the observed price is close to the fundamental value and the estimate of permanent earnings is not too distant from the true value. As a consequence, the set R should mostly (but not only) contain values that are reasonable estimates of the risk premium that an investor might require at any given time.

Finally, by assuming independence between the prior on $\overline{E}_t$ and the prior on ρ_t^f, we obtain that the distribution of a couple $\left(\overline{E}_t, \rho_t^f\right)$ is uniform discrete on the Cartesian product $\varepsilon_t \times R$, which induces on

$$P_t^f = \frac{\overline{E}_t}{\rho_t^f + r_t} \tag{6}$$

an easily computable discrete distribution. In turn, the latter distribution can be used to compute confidence bands for P_t^f. In the empirical part, we set the level of confidence at 80%, by discarding the observations in the first and last decile. Roughly speaking, this corresponds to a belief that in the past the price has been in line with fundamentals at least 80% of the times. Lower (higher) levels of confidence can be chosen to match beliefs that prices might have deviated more (less) often from fundamentals. For example, in the Appendix, we set the level of confidence at 70% and 90%, and we show that our main results are left unchanged.

2.2 Corporate bonds

To our knowledge, and differently from stocks, there are no models in the literature that allow to simplify the formula (1) for the fundamental price P_t^f of a corporate bond. Therefore, we propose a new valuation method for corporate bonds.

The fundamental value of a corporate bond can be written as

$$P_t^f = \sum_{t_j} c_{t_j} \left(1 + y_t^f\right)^{-(t_j - t)} \tag{7}$$

where c_{t_j} are the cash flows of the bond (coupons and principal re-payments) and y_t^f is the equilibrium yield to maturity of the bond. In turn,

$$y_t^f = r_t + s_t^f \tag{8}$$

where s_t^f is the equilibrium ("fair") bond spread and r_t is a nominal risk-free rate. The observed spread s_t can be different from the fair spread, and, as a consequence, the observed yield to maturity

$$y_t = r_t + s_t \tag{9}$$

can be different from the equilibrium yield to maturity y_t^f.

In turn, the spread s_t can be written as

$$s_t = \delta_t + \rho_t \tag{10}$$

where δ_t is the compensation for expected default losses and ρ_t is the risk premium earned by bond-holders.

The compensation for expected default losses δ_t is determined by the probability of default of the issuer of the bond and by the recovery rate in case of default. In standard intensity-based models, it can be approximated by

$$\delta_t = \lambda_t (1 - R_t) \tag{11}$$

where λ_t is the default intensity[5] and R is the recovery rate.

The risk premium ρ_t earned by the holders of corporate bonds compensates them for, among other things: 1) the fact that the prices of corporate bonds tend to be more volatile than the prices of risk-free securities such as government bonds; 2) the low liquidity of corporate bonds; 3) the fact that default risk is not perfectly diversifiable and defaults are correlated with macroeconomic conditions. For a review of the determinants of the risk premium see, for example, Elton et al. (1998).

There is abundant empirical evidence that the default component δ_t is usually almost negligible for investment grade corporate bonds (e.g., Collin Dufresne et al. 2001, Collin-Dufresne et al. 2003, Driessen 2005 and Chen et al. 2015), so that most of the bond spread represents a risk premium, a phenomenon sometimes referred to as the *credit spread puzzle* (e.g., Chen et al. 2009, Elkamhi and Ericsson 2008). This appears to be true also in the dataset we are going to use (Merrill Lynch investment grade corporate bond indices). By computing various proxies of realized credit losses, we find that on average they are about one basis point per year. However, they are characterized by a significant time-variability. To take into account this variability and its possible impact on bond prices, we use in our valuation model estimates of $\widehat{\delta}_t$ obtained from different regression models (see section 4.2 for

[5] An average value λ for the default intensity can be estimated from statistics on average cumulative default rates d for T years:

$$\lambda = -\frac{1}{T} \ln(1 - d)$$

more details).

Denote by P_t the observed price of a bond and by D_t its modified duration. By using a standard first order approximation, we can write

$$P_t^f = P_t \left[1 - D_t \left(y_t^f - y_t\right)\right] \tag{12}$$

Therefore,

$$P_t^f = P_t \left[1 - D_t \left(s_t^f - s_t\right)\right] = P_t \left[1 - D_t \left(\rho_t^f + \delta_t - s_t\right)\right] \tag{13}$$

Denote by $\widehat{\delta}_{t,j}$ the estimate of expected losses obtained with model $j \in J$, where J is the set of models used, and by

$$\Delta_t = \left\{\widehat{\delta}_{t,j} : j \in J\right\} \tag{14}$$

Define the set

$$R = \left\{\rho_{t,j} = s_t - \widehat{\delta}_{t,j} : j \in J, t \in \{1, \ldots, T\}\right\} \tag{15}$$

By equations (10) and (13), we have that

$$\rho_{t,j} = s_t - \widehat{\delta}_{t,j} \tag{16}$$

is the fair risk premium required by investors if $P_t = P_t^f$ (i.e., if corporate bonds are correctly valued at time t) and $\widehat{\delta}_{t,j} = \delta_t$ (i.e., if the estimate of the expected default losses δ_t is correct).

As for stocks, we represent our uncertainty about ρ_t^f (for each t) by assigning a discrete uniform uninformative prior to the set R. Implicitly, we are assuming that the values for the risk premium that were observed more frequently in the past are more likely to be fair and the estimate of the expected losses is close to the true value. As a consequence, the set

R should mostly contain reasonable estimates of the risk premium required by investors. By assuming independence between the distribution of $\widehat{\delta}_t$ and the distribution of ρ_t^f, we obtain that the distribution of a couple $(\widehat{\delta}_t, \rho_t^f)$ is uniform discrete on the Cartesian product $\Delta_t \times R$, which in turn, by equation (13), induces an easily computable discrete distribution on the fundamental yield y_t^f and thus on the fundamental value P_t^f. Finally, this distribution can be used to compute confidence bands for P_t^f (see the comments in subsection 2.1 about the level of confidence).

3 Data

The analysis for the stock market is carried out on aggregate stock market indices for the euro area, the United States and Japan (the Datastream stock market indices - tickers TOTMKEM, TOTMKUS and TOTMKJP, respectively). For these indices two monthly time series are considered: the price (datatype PI) and price/earnings ratio (datatype PE). The time series of earnings per share is calculated as the ratio between these two. We also use consumer price indices for the different areas (Datastream ticker EMCONPRCF, USCONPRCE and JPCONPRCF, respectively) to compute real prices and earnings. Finally, we use 10-year benchmark government bond yields as a proxy of the risk-free rate (Datastream ticker BDBRYLD[6], USBD10Y and JPBRYLD, respectively) and we compute the corresponding real rates by subtracting 10-year expected inflation.[7] Our data sample for stocks goes from December 1980 to February 2017.

The analysis for the bond market is carried out on BBB Corporate indices[8] for the euro area and the United States[9] (the Datastream Bank of America Merrill Lynch BBB Corporate

[6]Using the German government bond for the euro area.

[7]We use Consensus Forecasts long-term inflation expectations since 1990 for the US and Japan, and since 2000 for the euro area. For the periods in which data from Consensus Forecasts is not available, we use a proxy for expectations computed as follows: we regress Consensus Forecasts expectations on 10-year rolling averages of CPI inflation (based on the assumption that past inflation can be used as a proxy for future inflation), and we use the estimated regressions to predict inflation expectations backwards.

[8]As of this writing, BBB bonds represent roughly half of the investment grade universe in Europe.

[9]Japan is not considered as the related time series is discontinued on June 2015.

bond indices - tickers ER40, C0A4). Four monthly time series are considered: the yield-to-maturity (datatype ML:RY), the option-adjusted spread (datatype ML:OAS), the modified duration (datatype ML:DM) and the price (total return index value, datatype ML:RILOC). We also use implied equity volatilities for the different areas (Datastream tickers VSTOXXI and CBOEVIX, respectively) to estimate the expected credit losses. Our data sample for bonds goes from December 1999 to February 2017.

4 Evidence

4.1 Stocks

Figures 1, 2 and 3 show the time series of the observed value of the aggregate stock market index (blue line) in the euro area, United States and Japan, respectively, and the estimated confidence[10] bands for their fundamental values (light blue area), both on a log-scale. Our results for the years preceding the financial crisis are in line with those in the literature.[11] In particular, our results point to episodes of significant over-valuation (i.e., of observed prices above the upper bounds of the confidence bands) in the euro area and the US at the end of the 1990s, before the burst of the so called dot-com bubble, and in Japan in the late 1980s and early 1990s (the so-called Heisei bubble). Furthermore, observed prices were close to the upper bound of the bands around the years 2006 and 2007, before the market crash of 2008-9. We find instead evidence of under-valuation in the aftermath of the 2008 financial crisis in the three stock markets we consider. For the current period, our model provides no evidence of over-valuation in any of the stock markets we analyze, as stock prices are closer to the lower bounds of the confidence bands than to the upper bounds. Our evaluation of the current level of stock prices is in line with that of Blanchard and Gagnon (2016) who conclude, by using various methods, that the S&P 500 stock market index was not

[10] As already anticipated, the level of confidence is 80%. The same plots obtained using confidence levels of 70% and 90% are displayed in the Appendix, in Figure A.1.

[11] See Taboga (2011) for a discussion.

over-valued at the beginning of January 2016.

4.2 Corporate bond markets

As the maturity of the corporate bonds included in the indices we use is on average around 4 years, we use predictions of default losses over a 4-year horizon to compute $\widehat{\delta_t}$.

As a first step, for each date t in our sample, we compute an approximation of realized default losses:

$$\delta_t^{\text{realized}} = ((1 + y_t)^4 - 1) - (RI_{t+4y}/RI_t - 1) - D_t \cdot (y_{t+4y} - y_t) \tag{17}$$

where RI_t is the total return index of the bond index at time t. The term

$$((1 + y_t)^4 - 1) \tag{18}$$

is the total return expected at time t in case of no default losses and no variations in the required yield to maturity y_t during the holding-period of 4 years.

The term

$$(RI_{t+4y}/RI_t - 1) + D_t \cdot (y_{t+4y} - y_t) \tag{19}$$

is the part of the realized total return that is not explained by changes in the required yield to maturity. By definition, the difference between the above two terms is an approximation of realized default losses.

In order to predict at time t the default losses that will be realized between t and $t + 4y$, we consider two variables that are frequently used in the literature to forecast corporate bond excess returns (e.g., Ilmanen 2011). In particular, we estimate predictive regressions where the corporate bond spread s_t and the implied equity volatility σ_t are used as predictors. Both of these variables are highly correlated with $\delta_t^{\text{realized}}$ (Table 1) and highly statistically significant in uni-variate and bi-variate regressions (Tables 2 and 3).

We compare (Figures 4 and 5) the out-of-sample forecasting accuracy of the predictive regressions with that of a random walk model for $\delta_t^{\text{realized}}$ and a baseline model in which we assume null expected losses ($\widehat{\delta}_t = 0$). The out-of-sample predictions are made on each month (by using only the information available up to that month to estimate the regression coefficients) between May 2010 and February 2017. We find that the out-of-sample forecasting performance of the best model (for each country) is only marginally better than the performance of the naive model $\widehat{\delta}_t = 0$. Furthermore, the differences in performance between the best model and the other models are sometimes not statistically significant (at the 99% confidence level), and the ranking of the models is not the same for the two countries considered. In view of the fact that the two regressors we employ are highly significant, but the ranking of their forecasting performance does not seem to be particularly robust, we use all the three models (the two uni-variate regressions and the bi-variate regression) and impose a discrete uniform prior on them to compute $\widehat{\delta}_t$ and the confidence bands for the fundamental price of corporate bonds. However, by performing some robustness checks, we find that the location and shape of the confidence bands for the fundamental price P_t^f are relatively insensitive to different choices of the predictive models used to estimate $\widehat{\delta}_t$. In particular, using only the naive model $\widehat{\delta}_t = 0$ does not produce significant changes in our assessment of the valuation of corporate bonds.

Figures 6 and 7 show the time series of the observed price of the Merrill Lynch BBB Corporate Index (blue line) in the euro area and United States, respectively, and the confidence band for their fundamental value (light blue area), both on a log scale.[12] We find evidence of under-valuation in both the areas between 2009 and 2010, after the most acute phases of the global financial crisis; in the euro area corporate bonds result under-valued also in 2012, during the sovereign debt crisis. Currently, according to the evidence from our model, both the prices of US and euro area corporates are, while still well within the band, closer to the upper bound.

[12] The same plots obtained using a confidence level of 70% and 90% are displayed in the Appendix, in Figure A.2.

5 Conclusions

The debate about financial bubbles continues to be heated in policy circles (e.g., BIS 2015, Nakaso 2016) because of fears that exceptionally accommodative monetary policies might be causing misalignments between asset prices and fundamental values, and because bubbles are increasingly recognized to have potentially serious consequences both from a macroeconomic point of view and from a financial one. As a matter of fact, financial bubbles can not only foster inefficient allocation of capital, which lowers economic growth, but they can also pose threats to financial stability[13] when they collapse (e.g., Brunnermeier and Oehmke 2012).

We contribute to the debate by proposing methods to assess the degree of under/over-valuation of stocks and corporate bonds, which allow to compare observed asset prices with estimates of their "fair" levels. The proposed methods explicitly take into account the high model uncertainty that is inevitably faced when trying to measure the "fair", or fundamental, values of assets. The results obtained with these methods are in line with those in the literature for the years preceding the financial crisis of 2008; in particular, they signal two major episodes of over-valuation in the stock markets: in the euro area and the US at the end of the 1990s, before the burst of the so called dot-com bubble, and in Japan in the late 1980s and early 1990s, before the burst of the so-called Heisei bubble. Instead, according to our results, not only there is no significant evidence of over-valuation at the current juncture in any of the markets we analyze, but stock prices are closer to the lower bounds of the confidence bands for their fair value than to the upper bounds. Our results for the stock market are in line with those of Blanchard and Gagnon (2016), who provide evidence that

[13] The standard mechanism is as follows: during a bubble, 1) the price of an asset rises much above its fundamental value, on expectations of further price increases; 2) the collateral value of the asset increases, and more money is borrowed by speculators through collateralized loans and used to buy increasingly greater quantities of the asset, which makes the price increase even more; 3) eventually, market forces start to push the price back towards the fundamental value, both from the supply side (e.g., in the case of stocks, more stocks are issued in IPOs, which can cause inefficient allocation of capital if the investments made with the proceeds of stock issuance are not productive) and from the demand-side (e.g., non-speculative buyers and long-term investors sell stocks); 4) when the bubble bursts, the price starts to decrease and margin calls on the collateralized loans can trigger fire sales, negative feed-back loops and eventually defaults; 5) if there is contagion and uncertainty about who is suffering the steepest losses from the burst of the bubble, there can be bank runs (classical, or of intermediaries on other intermediaries).

the S&P 500 stock market index was not over-valued at the beginning of January 2016, and conclude that stocks represented an attractive investment opportunity at that time, as compared to government bonds. The economic intuition behind their results and ours is similar: while earnings yields on stocks and yields to maturity on corporate bonds have decreased in recent years, their decrease has mainly reflected the sharp fall in risk-free rates; on the contrary, the risk premia on these assets have remained at levels that are in line with historical norms.

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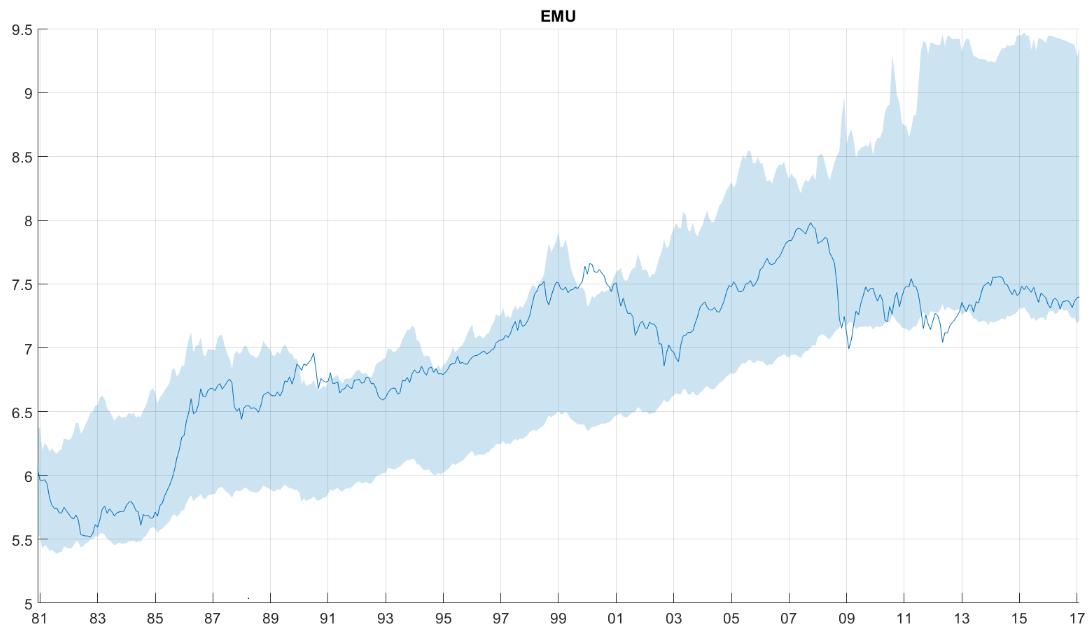
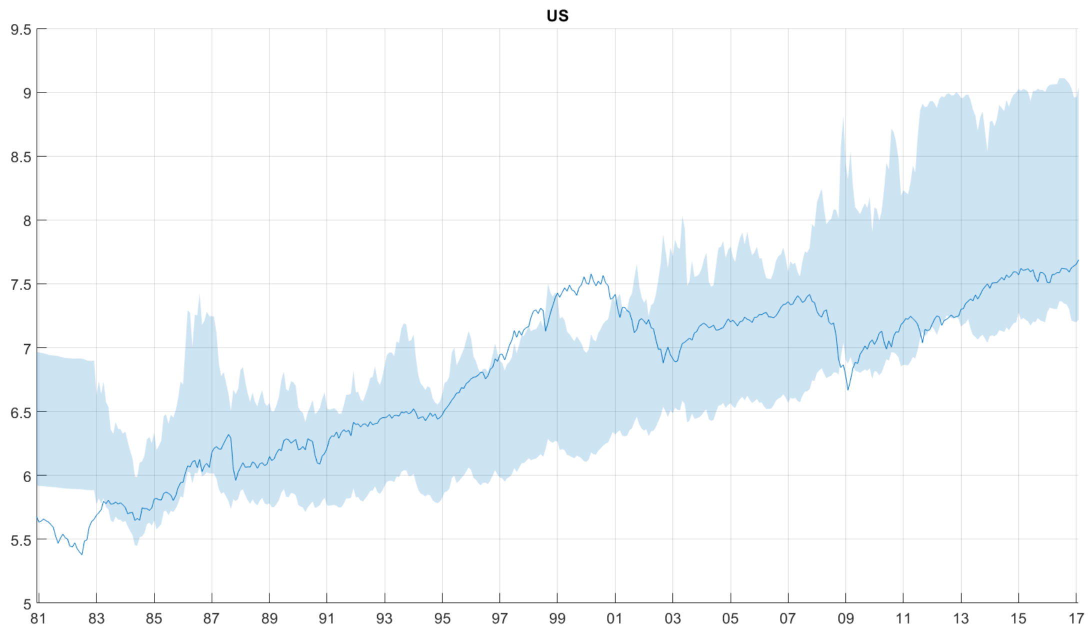
Figures

Figure 1: **Stocks - Euro area**



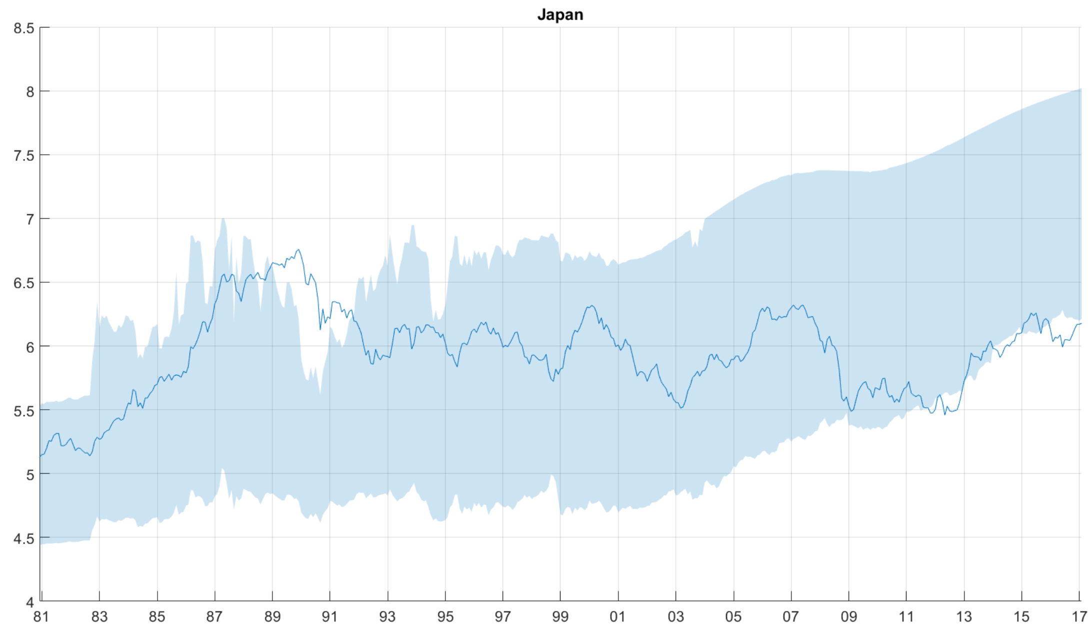
Note: The figure plots, on a log scale, the observed prices of the euro area stock market index (blue line) and the estimated confidence bands for its fundamental value (light blue area). The boundaries of the confidence bands correspond to the 10th and 90th percentiles of the distributions of fundamental values. The sample period goes from December 1980 to February 2017, for a total of 435 monthly observations.

Figure 2: **Stocks - United States**



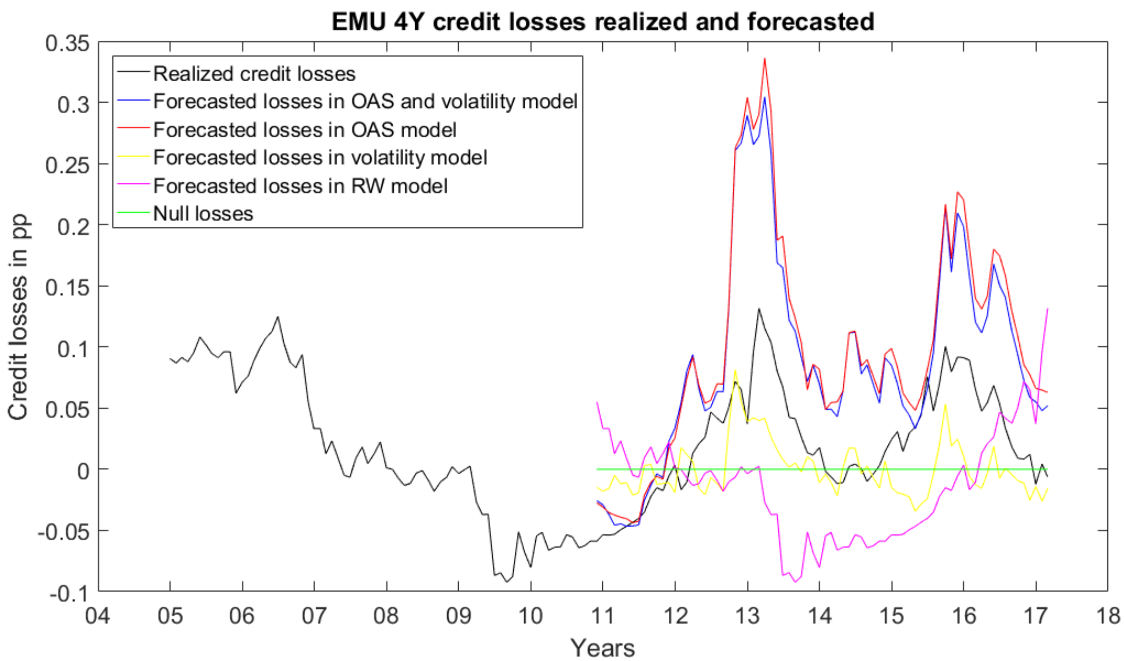
Note: The figure plots, on a log scale, the observed prices of the US stock market index (blue line) and the estimated confidence bands for its fundamental value (light blue area). The boundaries of the confidence bands correspond to the 10th and 90th percentiles of the distributions of fundamental values. The sample period goes from December 1980 to February 2017, for a total of 435 monthly observations.

Figure 3: **Stocks - Japan**



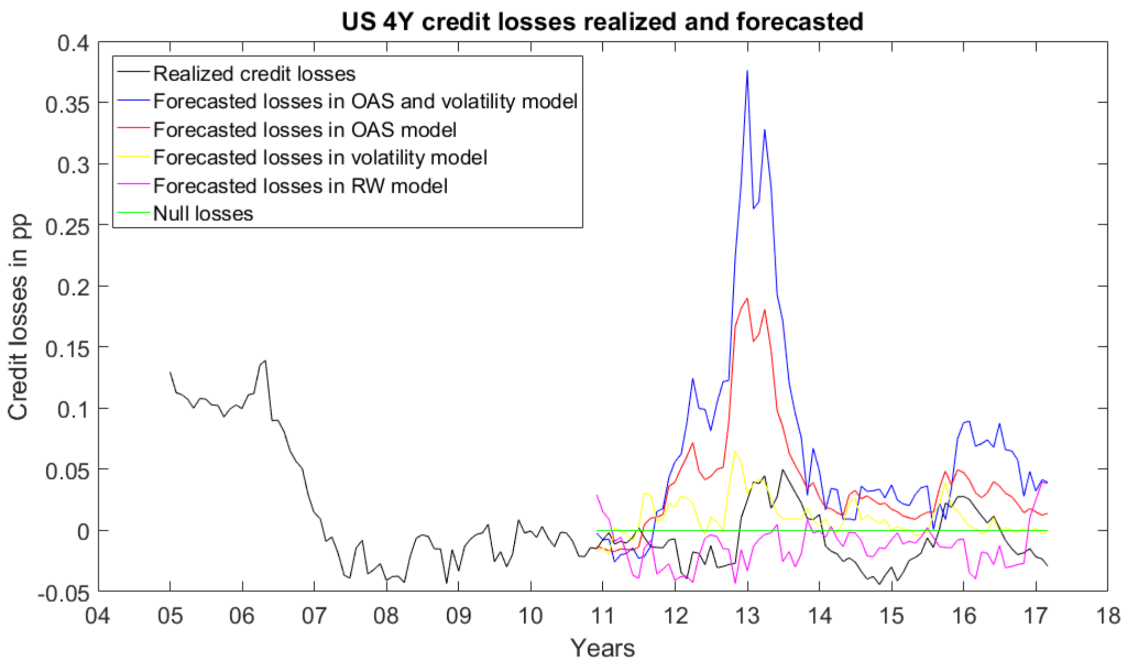
Note: The figure plots, on a log scale, the observed prices of the Japanese stock market index (blue line) and the estimated confidence bands for its fundamental value (light blue area). The boundaries of the confidence bands correspond to the 10th and 90th percentiles of the distributions of fundamental values. The sample period goes from December 1980 to February 2017, for a total of 435 monthly observations.

Figure 4: **Realized and forecasted credit losses - Euro area**



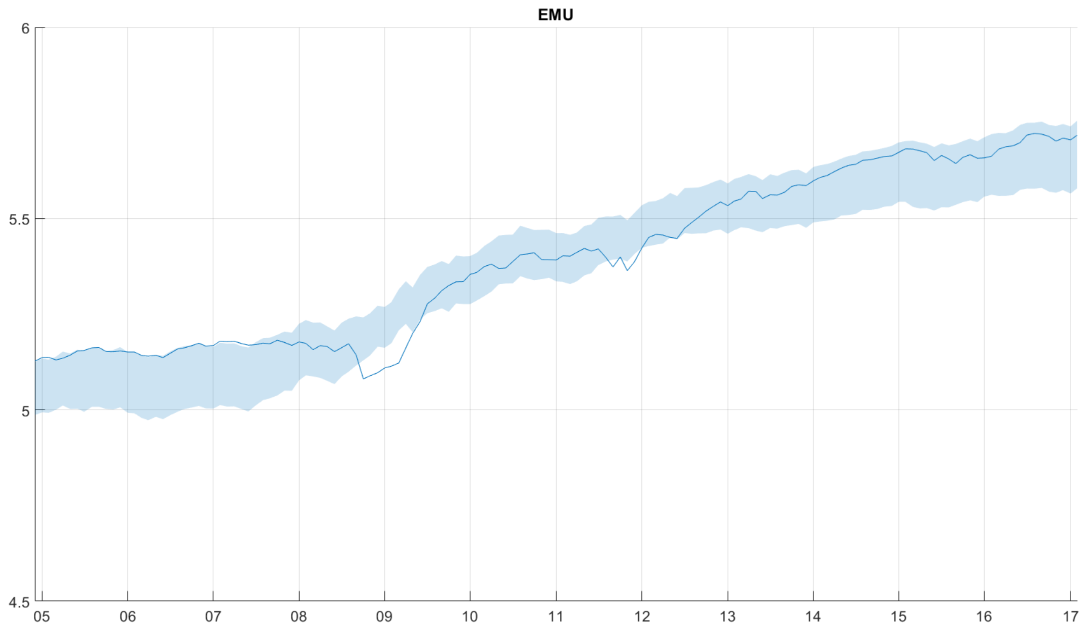
Note: The figure plots realized 4-year credit losses on the BBB bond index for the euro area, and their corresponding out-of-sample forecasts obtained with four different models: a model with the option adjusted spread and the stock market volatility as explanatory variables; a model with only the spread as explanatory variable; a random walk model; a model in which expected losses are null. The losses are displayed in percentage points.The in-sample period used for estimation goes from December 2004 to December 2009; the out-of-sample period used for forecasting goes from May 2010 to February 2017.

Figure 5: **Realized and forecasted credit losses - United States**



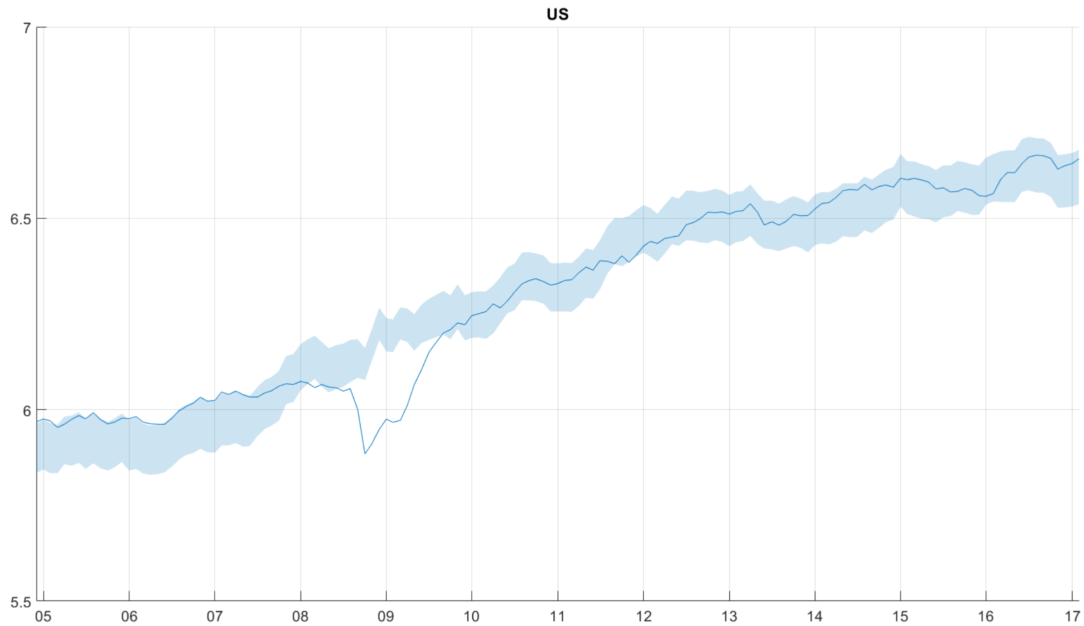
Note: The figure plots realized 4-year credit losses on the BBB bond index for the United States, and their corresponding out-of-sample forecasts obtained with four different models: a model with the option adjusted spread and the stock market volatility as explanatory variables; a model with only the spread as explanatory variable; a random walk model; a model in which expected losses are null. The losses are displayed in percentage points.The in-sample period used for estimation goes from December 2004 to December 2009; the out-of-sample period used for forecasting goes from May 2010 to February 2017.

Figure 6: **Bonds - Euro area**



Note: The figure plots, on a log scale, the observed prices of the euro area BBB bond market index (blue line) and the estimated confidence bands for its fundamental value (light blue area). The boundaries of the confidence bands correspond to the 10th and 90th percentiles of the distributions of fundamental values. The sample period goes from December 2004 to February 2017, for a total of 147 monthly observations.

Figure 7: **Bonds - United States**



Note: The figure plots, on a log scale, the observed prices of the US BBB bond market index (blue line) and the estimated confidence bands for its fundamental value (light blue area). The boundaries of the confidence bands correspond to the 10th and 90th percentiles of the distributions of fundamental values. The sample period goes from December 2004 to February 2017, for a total of 147 monthly observations.

Tables

Table 1 - Correlations between credit losses and financial variables

	EMU			US		
	Full sample	In-sample	Out-sample	Full sample	In-sample	Out-sample
Corr(4y CL, OAS)	63%	76%	90%	24%	70%	46%
Corr(4y CL, VOL)	61%	53%	71%	30%	55%	33%

Note: Correlations between 4-year realized credit losses (4y CL) and option-adjusted spread (OAS) and implied equity volatility (VOL). The full sample period goes from December 2004 to February 2017; the in-sample period goes from December 2004 to December 2009; the out-of-sample period goes from January 2010 to February 2017.

Table 2 - Regressions results - Euro area

	$s\sigma$ in-sample	s in-sample	σ in-sample	$s\sigma$ full sample
Constant	-0.097***$_{(-7.76)}$	-0.102***$_{(-8.08)}$	-0.067***$_{(-4.15)}$	-0.070***$_{(-7.26)}$
OAS	0.001***$_{(7.46)}$	0.0001***$_{(10.33)}$		0.0002***$_{(5.17)}$
VOL	-0.002**$_{(-2.16)}$	-	0.003***$_{(5.76)}$	0.002***$_{(4.12)}$
R^2	0.65	0.63	0.34	0.50
F stat	58.75	106.67	33.12	69.45
p-value	0	0	0	0
mse out-of-sample	0.0011	0.0067	0.0016	
mse RW	0.0084			
mse ZeroL	0.0029			
DM($s\sigma$,s)	-3.129			
DM($s\sigma, \sigma$)	-0.894			
DM($s\sigma$,RW)	-4.824			
DM($s\sigma$,ZeroL)	-2.931			

Note: The table displays the estimated regression coefficients (and related t-statistics in parentheses) for the in-sample period (December 2004 - December 2009) and for the full sample period (December 2004 - February 2017) for the following models: i) $s\sigma$ model: $\delta_t^{\text{realized}} = \alpha + \beta_1 s_t + \beta_2 \sigma_t + \varepsilon_t$; ii) s model: $\delta_t^{\text{realized}} = \alpha + \beta_1 s_t + \varepsilon_t$; iii) σ model: $\delta_t^{\text{realized}} = \alpha + \beta_1 \sigma_t + \varepsilon_t$. The p-values of the estimated coeffcients are marked by *** p<0.01, ** p<0.05, *p<0.1. The table also shows the R^2, F statistics, p-value and mean squared error (mse) of the out-of-sample predictions for each regression model, as well as the mse for the random walk (RW) model and for the model predicting constant null credit losses (ZeroL). Finally, the table displays the Diebold-Mariano (DM) test statistics for different couples of models.

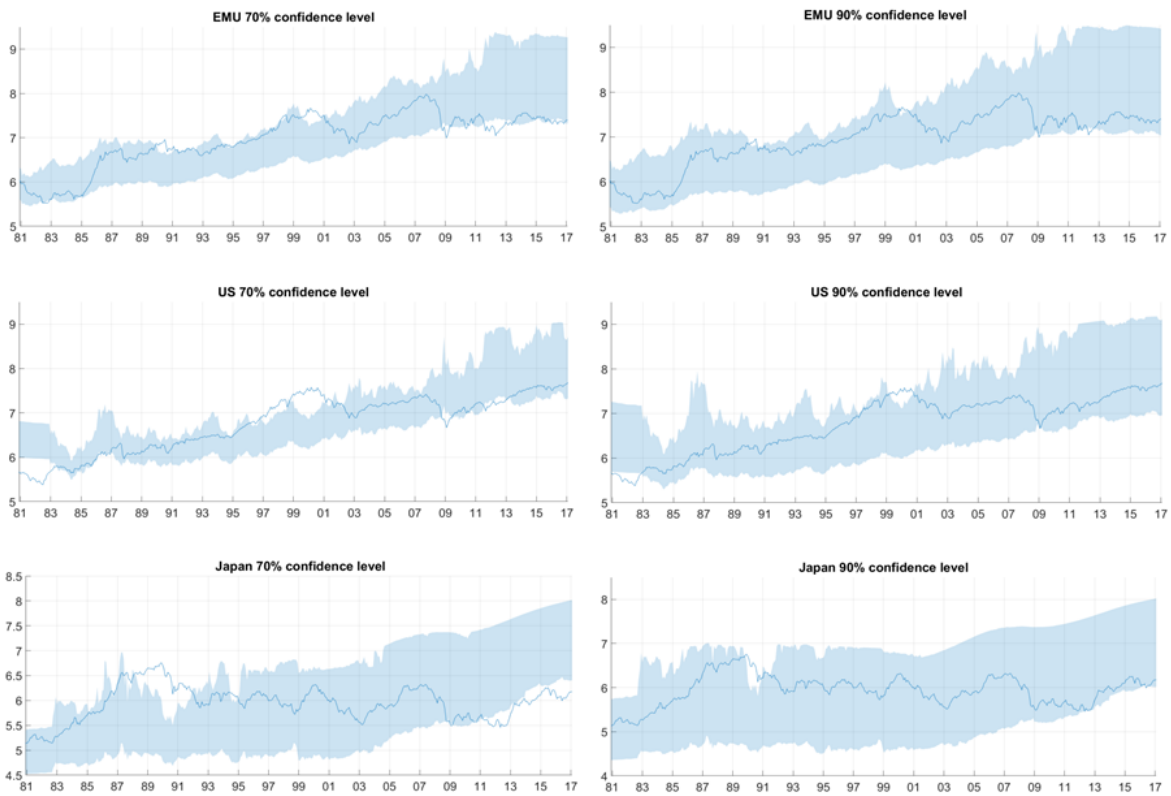
Table 3 - Regressions results - United States

	$s\sigma$ in-sample	s in-sample	σ in-sample	σ full sample
Constant	-0.087***$_{(-5.59)}$	-0.096***$_{(-6.17)}$	-0.075***$_{(-4.03)}$	-0.027***$_{(-2.69)}$
OAS	0.001***$_{(5.48)}$	0.0006***$_{(8.21)}$	-	-
VOL	-0.004**$_{(-2.23)}$	-	0.005***$_{(5.64)}$	0.002***$_{(3.79)}$
R^2	0.55	0.52	0.34	0.09
F stat	38.27	67.34	31.78	14.32
p-value	0	0	0	0
mse out-of-sample	0.0070	0.0017	5.5*10^{-4}	
mse RW	0.0015			
mse ZeroL	5.7*10^{-4}			
DM(σ,$s\sigma$)	-2.532			
DM(σ, s)	-2.132			
DM(σ,RW)	-3.134			
DM(σ,ZeroL)	-0.603			

Note: The table displays the estimated regression coefficients (and related t-statistics in parentheses) for the in-sample period (December 2004 - December 2009) and for the full sample period (December 2004 - February 2017) for the following models: i) $s\sigma$ model: $\delta_t^{\text{realized}} = \alpha + \beta_1 s_t + \beta_2 \sigma_t + \varepsilon_t$; ii) s model: $\delta_t^{\text{realized}} = \alpha + \beta_1 s_t + \varepsilon_t$; iii) σ model: $\delta_t^{\text{realized}} = \alpha + \beta_1 \sigma_t + \varepsilon_t$. The p-values of the estimated coeffcients are marked by *** $p<0.01$, ** $p<0.05$, *$p<0.1$. The table also shows the R^2, F statistics, p-value and mean squared error (mse) of the out-of-sample predictions for each regression model, as well as the mse for the random walk (RW) model and for the model predicting constant null credit losses (ZeroL). Finally, the table displays the Diebold-Mariano (DM) test statistics for different couples of models.

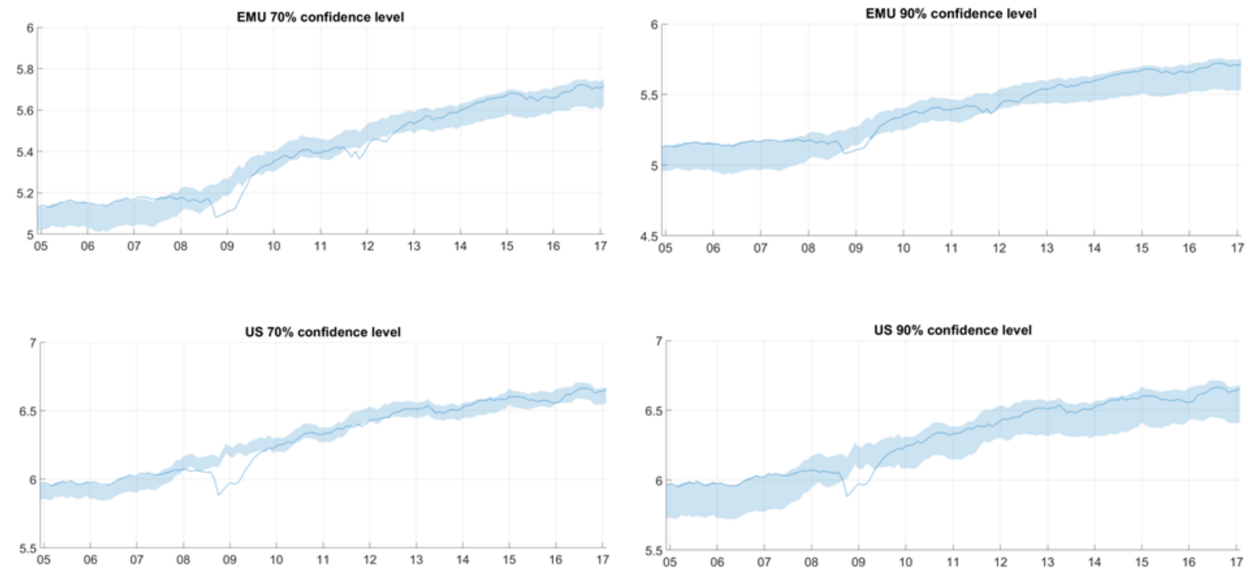
Appendix

Figure A.1: **Stocks - EA, US and Japan - 70% and 90% confidence interval**



Note: The figure plots, on a log scale, the observed prices of the stock market index (blue line) and the estimated confidence bands for its fundamental value (light blue area) for the euro area, the US and Japan. The boundaries of the confidence bands correspond to the 15th and 85th percentiles of the distributions of fundamental values where the confidence level is 70%; to the 5th and 95th percentiles percentiles where the confidence level is 90%.

Figure A.2: **Bonds - EA and US - 70% and 90% confidence interval**



Note: The figure plots, on a log scale, the observed prices of the BBB bond market index (blue line) and the estimated confidence bands for its fundamental value (light blue area) for the euro area and the US. The boundaries of the confidence bands correspond to the 15th and 85th percentiles of the distributions of fundamental values where the confidence level is 70%; to the 5th and 95th percentiles percentiles where the confidence level is 90%.

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