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Economic Scenario Generator: A Case Study on Conditional Simulations for Future Eurozone Inflation

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Introduction

Economic Scenario Generator (ESG) is the cornerstone of a market-consistent valuation of the balance sheet. In particular, ESG represents what we consider to be the appropriate tool to properly monitor and manage both market and credit risk from an integrated perspective.

With regard to the Pillar 1 and the Solvency Capital Requirement calculations, ESG can be used for both Solvency Capital Requirement calculation and Best Estimate valuation. Its potential use in the ORSA Pillar 2 framework may be geared towards governance aspects, ranging from encompassing additional risk types to model validation.

Beyond its relevance as a key prospective element in the context of Solvency 2, ESG represents an appropriate tool for an efficient ALM strategy but also for a better understanding of the market risk drivers embedded into some complex life insurance products (e.g.: variable annuities).

The following case study presents a combined qualitative and quantitative modelling approach for the inflation-rate variable in the Eurozone.

Case Study for Eurozone Inflation: Conditional Simulation

Recognizing the uncertainty associated with the forecasting process – and properly allowing for it – is crucial in formulating a fully-informed decision process. By explicitly taking into account a comprehensive set of uncertainty sources, Moody's Analytics approach to scenario generation aims to enrich the information-set that decision-makers rely on.

Our approach relies on three methodological cornerstones.

I. An integrated framework, where the background macroeconomic scenario is fully calibrated to reflect our alternative assumptions on the relevant risks to Moody's Analytics baseline forecast. The macroeconomic scenario is then correlated to the relevant financial and credit metrics to produce the output results.
II. A truly dynamic approach, where the time-dimension of correlations between exogenous and endogenous variables is explicitly taken into account through multivariate time-series analysis.

III. Scenario customization to meet client requirements. We acknowledge that market, credit and operational risks which businesses are exposed to are different and change over time. We rely on our country economists' expertise to translate systemic-risk factors into fully specified macroeconomic assumptions.

This article highlights our approach to scenario generation by creating simulations of Eurozone inflation, conditional on a given (very pessimistic) set of assumptions for the European economy. In particular, using the sample we considered a sovereign shock for the first year (September 2010-August 2011) and generated conditional simulations for inflation going forward (a "bootstrapping" exercise).

Here are the main results of the case study:

I. Considering the Case of a Sovereign Default in the Eurozone

In this case study we consider a scenario where a sovereign shock in the Eurozone – triggered by default of Greece and Portugal on their debt obligations – causes a worldwide plunge in consumer and business sentiment, followed by a severe drop in household spending and a marked retrenchment in demand for intermediate and investment goods and services.

As a result of a widening output gap, and growing slack in the labour market, core inflation in the area would fall into negative territory. Meanwhile, the global nature of the crisis would translate into downward pressure on demand for commodities and, in turn, on prices of energy-intensive goods. With scope for fiscal spending impeded by bond-market participants scrutinizing public finances, the policy burden would mostly rely on monetary authorities. In the Eurozone, in particular, the ECB would likely implement a set of measures aimed at providing cheap liquidity to the region's banks in a bid to alleviate liquidity tensions and foster lending to households and businesses.

However, the deterioration in financial markets, with plummeting stock prices and rise in credit spreads pushing corporate funding costs upward, would threaten lenders' balance-sheets robustness and impede the transmission of the ECB policy measures to the real side of the economy. The Eurozone's economy would fall into a liquidity trap similar to the one experienced by Japan during the last decade in the 1990s, where inflation expectations failed to pick up despite the loose monetary policy because of policymakers' inability to affect agents' expectations through alternative channels.

II. Modelling Eurozone's Inflation Using Time Series Analysis

Each month, Moody's Analytics 60+ country analysts run our international structural model to produce baseline forecasts for a specified set of variables. This macro-econometric model explicitly takes into account trade, confidence and financial markets cross-country spillovers associated to the global nature of the economy. Moreover, each month (for the U.S. economy) and quarter (for the rest of the world economy), parameters of our structural model are calibrated to reflect scenarios based on a set of clear assumptions about some relevant tail-risks associated to our baseline forecast. The calibration exercise relies on the country economists expertise to assure that idiosyncratic, country-specific features are taken into account along with systemic, country-wide risks, as identified by a panel of senior economists.

The purpose of this case study is to illustrate Moody's Analytics approach to scenario analysis. It follows that we are focused on making the process clear to the reader, rather than trying to build the best statistical specification for an inflation model.

We defined inflation as the year-on-year change in the harmonized consumer price index released by Eurostat. We sampled the index at a monthly frequency from January 1999 through August 2010, and built year-on-year percentage changes. **Table 1** shows some descriptive statistics of the series over the period considered.

TABLE 1

Euro zone's inflation. Descriptive statistics

MEAN	MAXIMUM	MINIMUM	STD. DEV.	SKEWNESS	KURTOSIS	AR(1)	AR(12)
1.98	4.00	-0.60	0.80	-0.48	4.45	0.94	-0.26

It is interesting to note that inflation has been *on average* close to the 2% rate targeted by the ECB. The series shows strong persistence in the short term, with a close-to-1 coefficient at the 1-month displacement, while some mean-reversion pattern emerges as we move towards longest displacements. Skewness and kurtosis suggest that the inflation distribution is not Normal in-sample[1].

Table 2 shows the outcome of the Dickey-Fuller test for stationarity, augmented with 12 lags of the dependent variable[2]. While the test suggests that the series has a unit root, we decided to model the variable in levels and not in first difference. It is well known that the power of the ADF test is low when the time period considered is short (in this case, just 10 years) and/or the adjustment towards equilibrium is non-linear in population.

TABLE 2

Euro zone's inflation. Euro zone's inflation. Test for non-stationarity

NULL HYPOTHESIS: The series has a unit root			
EXOGENOUS: Constant			
LAG LENGTH: 12			
		T-STATISTIC	PROB.*
AUGMENTED DICKEY-FULLER TEST STATISTIC		-1.9114	0.3262
TEST CRITICAL VALUES:	1% level	-3.4825	
	5% level	-2.8843	
	10% level	-2.5790	
*MacKinnon (1996) one-sided p-values.			

In order to achieve both simplicity and high out-of-sample forecast performance, we applied the parsimony principle and some theoretical results to come up with a straightforward and insightful specifications. To exploit both the persistence and mean-reversion features of the series, we used lags of the dependent variable at 1 and 6 displacements. To capture the dependence on the financial side of the economy, we used the ECB's benchmark refinancing-rate as a fully exogenous

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1 The p-value associated to the Jarque Bera test, not showed in the table, suggests that the underlying stochastic process is not-Normal in population.

2 The number of lags has been selected according to the Schwartz Information Criterion (SIC). A maximum number of 12 lags was imposed.

variable. It can be easily argued that this specification does not control explicitly for the bi-directional causality between price expectations and the monetary policy stance. However, as **Table 3** shows, the Granger Causality Test suggests that causality is stronger from monetary policy to inflation, rather than from inflation to monetary policy.[3]

TABLE 3

Euro zone's inflation. Granger Causality Test[4]

NULL HYPOTHESIS:	F-STATISTIC	PROB.
Monetary policy does not Granger Cause inflation	2.5977	0.0551
Inflation does not Granger Cause monetary policy	2.0839	0.1055

It is interesting to note that the monetary-policy variable enters the equation into *lead* – rather than *lag* specification – given that agents know *with certainty* the path of future monetary policy,[5] and they know that the central bank will tighten its policy stance when inflationary pressures intensify because of either a positive output gap or higher energy prices (or both). Since both a positive output gap and higher energy prices makes the value of consumption *tomorrow* lower than the value of consumption *today*, agents will start substituting tomorrow's consumption with today's. This will cause an increase in inflation *today* – hence the positive coefficient attached to the monetary policy variable. The parsimonious nature of the model means that agents use the policy rate as a gauge of the business cycle, rather than an opportunity cost for money *per se.*[6]

TABLE 4

Euro zone's inflation. In-sample estimate

DEPENDENT VARIABLE: Inflation

METHOD: Least Squares

VARIABLE	COEFFICIENT	STD. ERROR	T-STATISTIC	PROB.
CONSTANT	0.1252	0.0778	1.6083	1.6083
INFLATION (-1)	0.9423	0.0384	24.5704	0.0000
INFLATION (-6)	-0.0914	0.0336	-2.7213	0.0074
ECB RATE (3)	0.0643	0.0231	2.7813	0.0062
ADJUSTED R-SQUARED	89.75%			

[3] This is somewhat consistent with the modern monetary policy theory, which states that expected, rather than historical inflation enters the central bank's reaction function. This forward-looking feature of the policy-maker decision rule is not properly accounted for by the Granger Causality Test.

[4] We selected 3 lags for the test to allow for somewhat slowly-learning agents causing delays in the expectations update process.

[5] Equivalently, agents are said to be endowed with perfect foresight. This is a stricter assumption than the rational expectations one.

[6] While positively signed coefficients load on leads of the policy rate, negative coefficients load on its lags. This is related to the delays associated to the monetary policy transmission, which makes the impact of yesterday's rate hikes on *today*'s inflationary pressures negative.

Table 5 shows some descriptive statistics of the model residuals. The first column illustrates that the model gives unbiased coefficient estimates or, equivalently, that the in-sample estimate is on average able to match the population value. Shocks are small and not persistent, and the third and fourth moment of the in-sample distribution approach those of a Standard Normal.[7] The appealing feature of residual Normality is that all the relevant information about inflation is considered in the first two moments of the distribution. A graphical inspection of the in-sample fit is available in **Chart 1**.

TABLE 5

Euro zone's inflation. Residuals, descriptive statistics

MEAN	MAXIMUM	MINIMUM	STD. DEV.	SKEWNESS	KURTOSIS	AR(1)	AR(12)
0.00	0.62	-0.83	0.25	-0.17	3.47	0.10	0.07

III. Simulating Future Inflation Paths

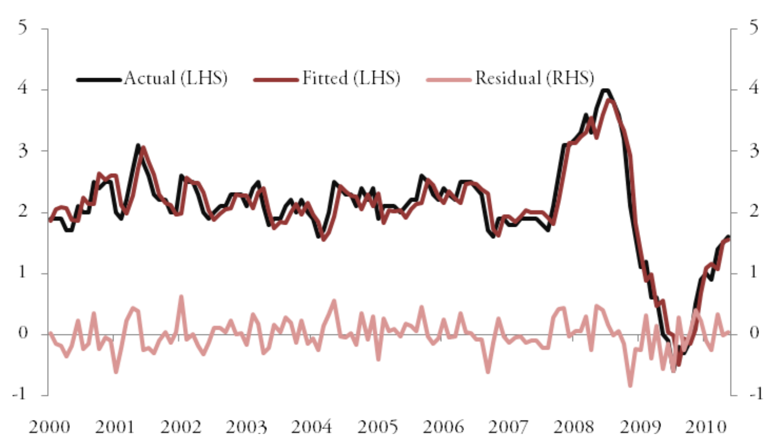
The estimated equation from **Table 4** was used to generate simulations around the future path of inflation. For the September 2010-August2011 period, we considered two single forecasted paths:

a. A baseline, consistent with the ECB rate holding at the current 1% level until the third quarter of 2011 with the current trend of slow credit growth persisting.

b. An alternative forecast consistent with a sovereign shock taking place in the region at the beginning of 2011. In order to allow for the ease in inflationary pressure as a consequence of the deterioration in the business cycle and the widening output gap, we re-calibrated the coefficients in **Table 4**. We also assumed a new path for the ECB rate, consistent with the assumption of further loosening of the monetary policy stance and impaired credit and money markets.[8]. Results are provided in **Table 6**.

Chart 1

Euro zone's inflation. In-sample fit



[7] According to the Jarque-Bera test, we cannot reject the hypothesis of Normality of the data generating process.

[8] The alternative scenario for the ECB rate was estimated up to November 2011, so as to allow for the lead in the equation in Table 4.

TABLE 6
Euro zone's inflation. In-sample estimate

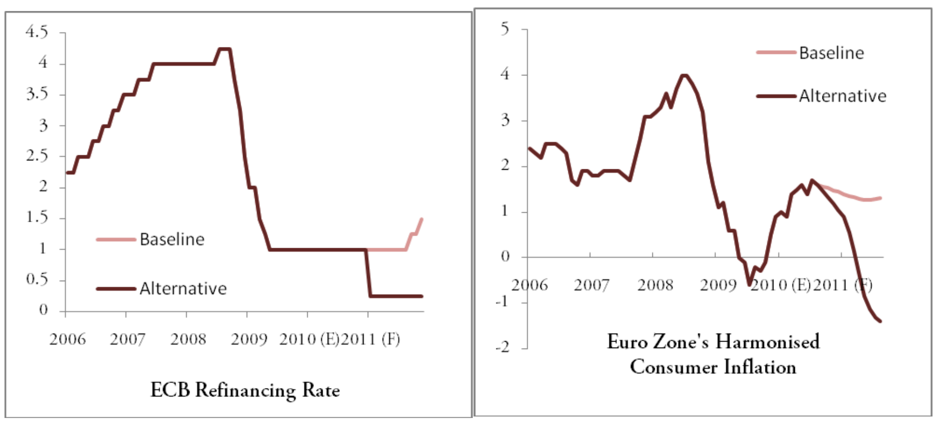
DEPENDENT VARIABLE: Inflation
METHOD: Least Squares

VARIABLE	COEFFICIENT	STD. ERROR	T-STATISTIC	PROB.
CONSTANT	0.0120	0.0621	0.193	0.8466
INFLATION (-1)	0.9814	0.0336	29.188	0.0000
INFLATION (-6)	-0.1007	0.0322	-3.1264	0.0021
ECB RATE (3)	0.0784	0.0205	3.8190	0.0002

Chart 2 illustrates the evolution of inflation and policy rates under the baseline and the alternative scenario.

Chart 2
ECB Refinancing Rate

Euro Zone's Harmonised Consumer Inflation

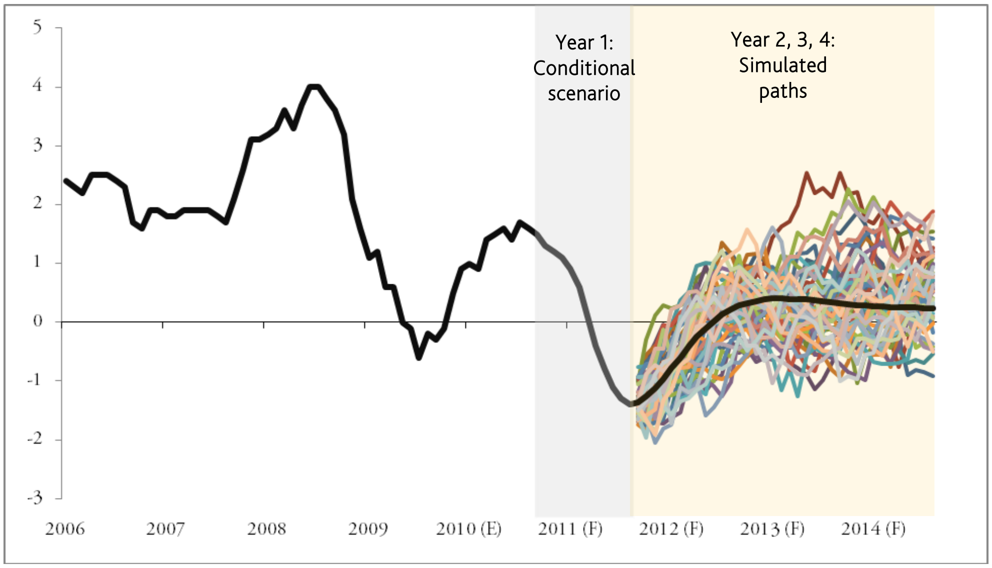


Starting from September 2011, we produced a set of *n=1, 2, 3… 36* forecasts for inflation up to August 2014, conditional on coefficients calibrated according to **Table 6**. Consistent with the assumption of a liquidity trap similar to that experienced by Japan in the 90s, where historically cheap liquidity could not revive the economy because of the impaired credit markets and the inability of the Bank of Japan to fuel agents' inflation expectations, we assumed that the ECB would keep its policy rate at 0.25% for the whole forecasted period. In order to produce the first set of *n*-step ahead forecast, we drew randomly (with replacement) from the sample of fitted residuals without assuming any a-priori restriction on their population distribution.[9] Keeping coefficients fixed to their in-sample values, we obtained a first path for the *n*-step ahead forecast. We repeated this procedure 10,000 times and obtained a set of distributions for each point forecast (or expected value). Results for a sub-sample of 50 simulated paths and the associated point forecasts is shown in **Chart 3**.

[9] This simulation procedure, known as bootstrapping, allows for greater flexibility than assuming a Standard Normal distribution for the residuals.

Chart 3

Euro zone's inflation. Conditional simulated forecast



With the results from the simulations, we can also analyze the evolution of the distribution of inflation rates over time. In a bid to capture the uncertainty associated with the forecasting exercise, we created histograms for the 10,000 simulated inflation paths for every month starting in September 2011. Below we report the histogram for June 2012, 2013 and 2014, respectively. The rightward shift of the distribution is significant from 2012 to 2013, while no clear shift takes place between 2013 and 2014. This is consistent with our earlier argument about a liquidity trap taking place over the forecast horizon. The concept dates back to Keynes, and it has been used since the 60s to justify the importance of fiscal policy when monetary policy becomes unsuccessful at impacting consumers' and investors' expectations. In its simplest formulation, a liquidity trap takes place when market participants retain large amounts of cash, made available to them through loose monetary policy, rather than spending it or investing it. With credit supply constrained, growth of the broad monetary aggregate also slows down hence pushing inflationary pressures downward. With monetary policy unable to re-activate its transmission channel, and consumer price expectations hovering around 0% growth, the economy would shift progressively away from consumption and investment and towards the external sector, and also shrink in size because of the knock-on effects from the remuneration of labour and capital.

With monetary policymakers' room for maneuver limited by the zero-bound on the policy rate, fiscal policy may provide a powerful impulse to the economy. Unfortunately, in a scenario such as the one considered in this case study, the recession is prompted by a sovereign event. With public finances deteriorating further following the shock, scrutiny from bond market participants would increase over governments in the region. This in turn limits the room for counter-cyclical fiscal policies similar to those enacted during the 2008-09 recession. With household spending stifled by the troubled labour market and the negative wealth effect associated to the decline in stock and house prices, the Eurozone's economy would enter a prolonged period of anemic economic growth, similar to that which Japan experienced in the 1990s.

Chart 4a.

Euro zone's inflation. Conditional simulated forecast, June 2012

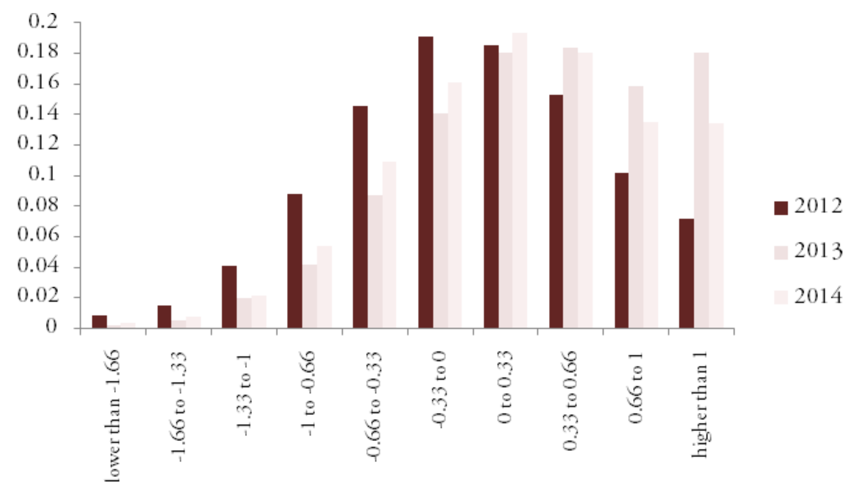


Chart 4b.

Euro zone's inflation. Conditional simulated forecast, June 2013

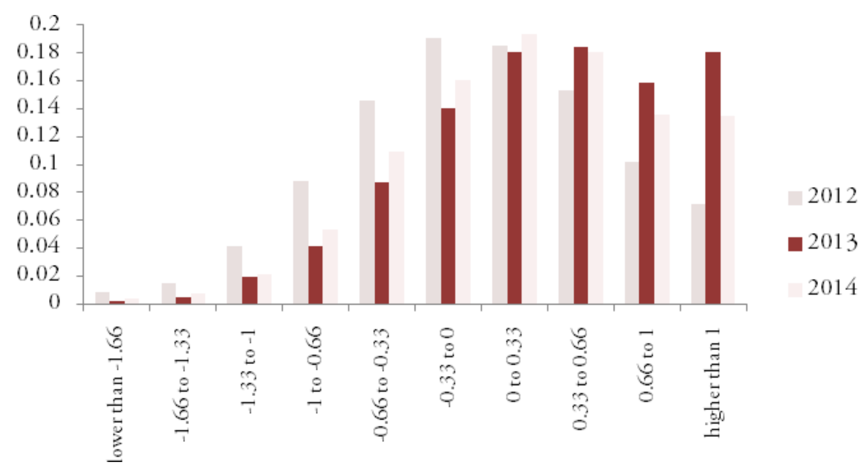
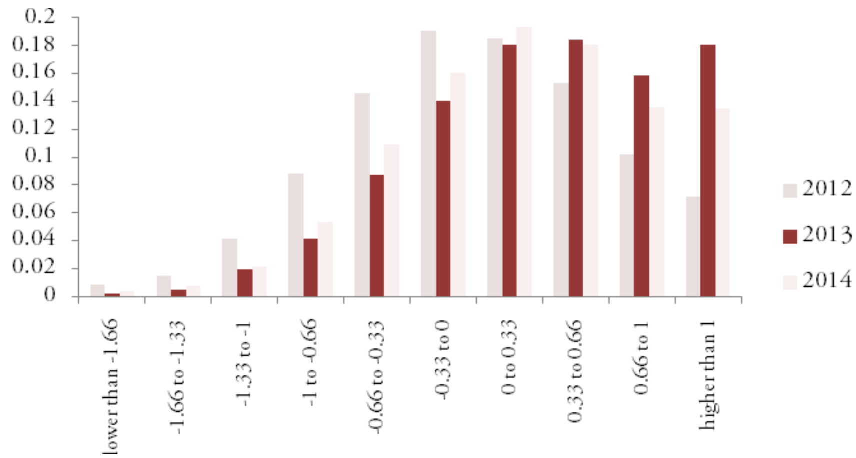


Chart 4c.
Euro zone's inflation. Conditional simulated forecast, June 2013



Concluding Remarks

The purpose of this case study was to develop a series of conditional simulations for Euro Zone inflation rates. The results for this exercise can be used as inputs into solvency and other risk calculations. Moody's Analytics has developed similar analysis for other macro-financial series (e.g., interest rates, home prices, CDS spreads, yield and swap curves, rating transitions, etc,) and implemented conditional and unconditional simulations.

Transparency of Methodology and Models

It is very important to note that our methodology is completely open and that the models will not follow a black box approach. Moody's Analytics will provide a comprehensive and detailed report outlining the analytical properties and assumptions used in all the underlying models.

AUTHOR

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