

Does Deflation Threaten the Global Economy?

John Silvia and Azhar Iqbal¹

Abstract

What probability can we assign to the outlook for global deflation? Recently, much of the discussion around monetary policy in the United States, Eurozone and Japan has focused on the threat of deflation and how to avoid it. How likely is deflation for each of these countries, and more broadly, for the global economy as a whole? This paper provides an early-warning-system (EWS) to predict the probability of deflation/inflation in the near future. Specifically, we utilize an ordered probit approach to estimate the six-months ahead probability of three distinct scenarios for price levels: inflationary pressure, deflationary pressure or price stability.

We build models for five regions to generate a signal for each region's inflation outlook. Our first model assesses the inflation/deflation outlook for the global economy, while the second model generates the likelihood of each price scenario for the advanced economies. Our final three models forecast the probability of inflation/deflation for the U.S., Eurozone and Japan.

Our global model suggests deflationary pressure is more likely than other price scenario, with the model forecasting a 97 percent chance of deflationary pressure in the next six months. The advanced economies model suggests a 59 percent chance of deflationary pressure. The probability of deflationary pressure for the U.S. is 63 percent, 84 percent for Japan and 52 percent for the Eurozone.

Since 2013, all five models have consistently suggested that deflationary pressure is the most likely of the three scenarios. Given the historical accuracy of these models, and by combining all these signals into one frame, we predict that the risk of deflationary pressure is much higher than the other two price scenarios for the global economy in the near future.

Key Words: Ordered Probit; Global Economy; Deflation; Probability.

JEL Classification: E3; E31; C3.

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(Initial Draft, December 2014, do not cite)

Introduction

Economies evolve overtime, just as the nature of risks and challenges to economies changes. How can we estimate some early warning signals about an impending risk/crisis before it occurs? At present, some say deflation, not inflation, is a real threat for the global economy. How can we provide some signals to decision makers about the risk of deflation or inflation? Specifically, what probability can we assign to deflation in the global economy? Recently, much of the discussion around monetary policy in the United States, Eurozone and Japan has focused on the threat of deflation and how to avoid it. How likely is deflation for each of these countries, and more broadly, for the global economy as a whole? This paper provides an early-warning-system (EWS) to predict the probability of deflation/inflation in the near future. In particular, we utilize an ordered probit approach to estimate the six-months ahead probability of three distinct scenarios for price levels: inflationary pressure, deflationary pressure or price stability.

The Great Recession and financial crisis produced significant damages, in terms of output, employment and personal wealth loss, throughout the global economy. These events, in some sense, were an impetus to improve the quality of existing EWSs and to explore new methods of alerting authorities and decision makers of impending crises. A number of tools were introduced to predict the likelihood of economic crisis (i.e., predicting currency, banking and debt crises).² A EWS is a unique approach compared to traditional forecasting methods, since these methods usually predict levels or growth rates of one or more variables of interest. In the case of the EWS method, a researcher is more interested in predicting specific states, which are structurally different from one another. For instance, in the present case, the objective is to predict probabilities of inflationary pressure, deflationary pressure and stable prices, and these three scenarios for prices are

² See Candelon et al. (2010) for more detail and for a survey.

structurally different from each other. Furthermore, decision makers would have a different set of decisions for each of these three inflation scenarios.

Before we attempt to model and forecast an outlook for prices, it may be useful to first establish why inflation has been so sluggish recently. One key factor contributing to deflationary pressure has been the gap between actual and potential GDP growth, a schism that emerged in the wake of the Great Recession. Another key contributing factor has come from the labor market, where wage pressures remain subdued due to the gravity of the downturn in this sector, contributing further to downward price pressures. Third, higher expected taxes, to cover large budget deficits in many countries with serious debt-management issues, have led to expectations of restricted fiscal policy and to uncertainty about the pace of future growth and the risk of deflation.

On one hand, world inflation as well as several individual countries' inflation rates are troublingly low and thereby suggest a risk of deflation. On the other hand, some observers of international macroeconomics are betting on inflation. Their rationale is that key interest rates in several countries are at historically low levels, which, coupled with trillions of dollars of monetary and fiscal stimulus, leaves these countries vulnerable to an eventual run-up in prices.³ In sum, a high level uncertainty presently exists about the future path of prices in the global economy.

Typically, different inflation outlooks (inflationary vs. deflationary pressure, for instance) may require a different set of policy actions from decision makers. For example, one of the key goals of most central banks around the globe (for some central banks, it is the only goal) is price stability. Furthermore, these banks may change the stance of their monetary policy depending on their inflation outlook. Specifically, a higher probability of future inflation would have different policy implications than a higher probability of deflationary scenario for monetary policy makers. Therefore, for decision makers, it is more useful to know what the probability of any of these three inflation scenarios will be going forward. By assigning a probability forecast to each possible path of price pressures (inflationary/deflationary pressure or price stability)

³ For instance, policy rates in the U.S., Japan and Eurozone are at historical lower level. In addition, these countries' central banks have introduced several rounds of quantitative-easing (QEs) along with trillions of dollars in fiscal stimulus packages from these countries governments.

decision makers would be able to better allocate their resources for each scenario, which would subsequently improve decision making.

The International Monetary Fund (IMF) produces a measure of global prices known as the World Consumer Price Index (CPI). Since Q1-2009 (except for 2011 when inflation was higher than 4.4 percent), world CPI growth rates, on a year-over-year basis, have been well below the long-run average growth rate of 4.4 percent.⁴ The IMF also estimates a CPI for advanced economies. Advanced economies CPI growth rates are well below 2 percent since 2009:Q1 (except for 2011:Q1-2012:Q1 period).⁵ At the individual country level, inflation is also well below target levels. For instance, U.S. PCE inflation, the Federal Reserve's preferred measure of consumer inflation, has been below the Fed's 2 percent target since May 2012, and Eurozone CPI inflation has been below 2 percent since February 2013. In sum, inflation rates are well below the target level for many individual countries as well as aggregate measures of prices for the world and advanced economies.

Silvia and Iqbal (2014) developed an ordered probit model to forecast the probability of inflationary, deflationary pressure and prices stability. They utilized a monthly dataset for the U.S. and estimated the six-months ahead probability of three scenarios for inflation. We follow the Silvia-Iqbal approach and build several ordered probit models to estimate simultaneously the probability of inflationary, deflationary pressure and price stability. The ordered probit approach is employed to forecast probabilities of all three inflation scenarios for the world, advanced economies, Eurozone and Japan. In addition, we updated the Silvia-Iqbal model to predict probabilities of these scenarios for the United States.

Our global model suggests deflationary pressure is more likely than other price scenario, with the model forecasting a 97 percent chance of deflationary pressure in the next six months. The advanced economies model suggests a 59 percent chance of deflationary pressure. The probability of deflationary pressure for the U.S. is 63 percent,

⁴ The average growth rate of the world CPI for the 1996:Q1-2014:Q3 period is 4.4 percent, which is considered a long-run average growth rate.

⁵ The IMF characterizes 37 countries as advanced economies and the list of those countries can be found at IMF website. Since most of these countries' central banks have an inflation target of 2 percent, we utilize a 2 percent CPI growth rate benchmark for advanced economies CPI.

84 percent for Japan and 52 percent for Eurozone. Since 2013, all five models have consistently suggested that deflationary pressure is the most likely of the three scenarios. Given the historical accuracy of these models, and by combining all these signals into one frame, we predict that the probability of deflationary pressure is much higher than the probability of inflationary pressure or stable prices for the global economy in the near future.

The rest of the paper is organized as follows: Section 2 discusses why five different models are built to estimate probabilities of different inflation scenarios. Section 3 explains the econometrics of the early warning system. Section 4 presents the sources and definitions of the variables included in the analysis and the implementation strategy. Section 5 provides empirical results, and concluding remarks are summarized in section 6.

2. Why Five Different Models?

Expectations about the future growth rate of general prices (i.e., inflation rate) play a crucial role in decision making at practically every level (household, firm, public policy, etc.). From a head of a household to head of a central bank, one would consider a different set of decisions in an inflationary environment compared to a deflationary situation. For instance, a head of a household would spare more monetary resources for monthly (or quarterly) routine household expenditures, as well as the use of credit, during a time of inflationary expectations versus one of deflationary expectations, all else equal. Typically, central banks tend to follow a tight or contractionary monetary policy during inflationary periods and, usually, an expansionary policy during periods of potential deflation. Therefore, it would be much better to generate probabilities of each inflation scenario, which provides an early warning signal of upcoming prices scenario (55 percent chance of inflationary pressure, 30 percent probability of deflationary pressure and 15 percent chance of price stability, for instance). This would also help decision makers to make appropriate decisions to allocate limited resources and set policy stance according to the probabilities of the future path of inflation.

During the past eight years, a large number of economies, advanced economies in particular, experienced recessions, financial and debt crises and elevated unemployment rates, and some say these events may have put downward pressure on global inflation outlook.⁶ Therefore, to determine the risk of deflationary pressure and provide an early warning signal, we build a global ordered probit model using the IMF measure of global CPI (see the Data section for more detail).

The world economy is comprised of over 185 economies, and these economies, for the sake of simplicity, can be divided into two broader groups; developed and developing economies. In recent years, many developed economies have faced lower inflation rates, and most developing countries are not worried about deflationary pressure, as prices are in normal-to-high growth zone in developing economies. For example, IMF measures of advanced economies CPI growth rates have been below 2 percent since January 2012, while the average growth rate of the CPI for emerging markets and developing economies for the 2012-2014 period was 5.8 percent. To estimate the risk of deflationary pressure for the advanced economies, we utilize an ordered probit model.⁷

Some developed economies are large enough to affect other economies as well as the global economy, and thereby it would be important to estimate the risk of deflation for those economies individually. The U.S. economy is the largest economy in the world, and some say the U.S. Great Recession (2007-09) may have been a key reason for the global economic slowdown during that time period; the IMF reported global GDP growth rate for 2009 was -0.4 percent. Therefore, a higher risk of deflation in the U.S. may boost global deflation risk. By the same token, a higher risk of U.S. inflation either may reduce the risk of global deflation (assuming U.S. price pressure may offset other economies' deflationary pressure) or increase global prices rates (in the case of rising prices in the rest of the world).

⁶Major economies including, U.S., Eurozone, Japan and U.K. and many more, experienced several notable events such as recessions, elevated unemployment rates, dis-inflation or lower inflation, large output gap, budget gaps etc.

⁷Due to the data limitation problem, we are unable to build an ordered probit model for developing economies. In the future, if data become available (predictors of the model in particular) then it would be nice to build a model to predict prices scenarios for developing economies.

Inflation, as measured by the PCE deflator, in the U.S. has been below the Fed's target of 2 percent since April 2012. Although prices are below the Fed's target, the recovery is on solid footing and a number of factors may put upward pressure on prices in the near future. For instance, the unemployment rate fell below 6 percent in September 2014, and GDP growth rates were above 2 percent in 2012-2013 and are expected to stay above 2 percent for the 2014-2015 period. In addition, it is widely expected that the FOMC may raise key policy rates in the summer of 2015, which also indicates the U.S. economy does not need further monetary stimulus. Therefore, these activities may boost U.S. price growth. Our U.S. model will provide early signals for the six-months ahead environment for prices, whether it would be one of deflationary pressure, inflationary pressure or stable prices.

The Eurozone, as a single economic entity, is one of the largest economies in the world, but it has been struggling for the last several years, some say since the Great Recession. For instance, the unemployment rate in the Eurozone has been in the double digits since July 2011, and GDP growth rates have been below one percent since June 2013 (the Eurozone was in recession between December 2011 and March 2013). Consequently, CPI growth rates have been below one percent since October 2013. Given the magnitude and importance of the Eurozone economy to the world economy, we build a model to generate early warning of deflation in the Eurozone.

Japan economy is another major developed economy and it has been in and out of deflationary territory for the past couple of decades. The average growth rate of Japanese CPI for the 1990-2014 period was just 0.45 percent, and for the 2000-2014 period, the CPI growth rate was -0.06 percent. To add to the pain, Q2 and Q3 of 2014 reported negative GDP growth rates, sending Japan into its third technical recession in the last five years.⁸ Our final ordered probit model provides signals to Japanese price scenarios.

2.1 Are These Five Models Connected?

Five different ordered probit models are built to estimate early warning signals for the world, advanced and several major economies. Although, these are five different models representing different economies but these models are connected with each other

⁸ A technical recession is defined, sometimes, as two consecutive quarters of negative GDP growth rates.

and by combining signals from these model into one frame would enhance predictability of our EWS. How?

The global model includes information (dataset) from the both developed and developing economies. Furthermore, at present, developed economies are facing lower inflation rates and developing countries rate of inflation stays in normal-to-high growth zone, on average. First case, suppose the global model signal normal or stable price in the near future (higher probability of stable prices compared to inflationary and deflationary pressure probabilities) and advanced economies model produces higher probability of deflationary pressure. We can combined these two signals, about two different prices regime for two different economies, and the interpretation would be that developing economies higher prices may offset developed economies lower prices growth and overall global economy may not have a deflation threat.

In another scenario, if both the global and advanced economies models signal a risk of deflation (higher probabilities of deflationary pressure) then, by combining signals, we can say deflationary pressure of the advanced economies may have spread out to the global economy (developing economies unable to offset developed economies deflationary pressure).

A connection between advanced economies and individual country's models (U.S., Eurozone and Japan models) may exist. For instance, scenario one, if all four models signal deflationary pressure and then, by combining all deflation probabilities, it may be seen as a very strong signal of deflation because individual countries and advanced economies models are sharing the same sign. In other words, deflationary pressuer of the major economies is increasing the risk of deflation for the advanced economies group and there is nothing (normal-to-higher prices) to offset deflation. Scenario two, if advanced economies, Eurozone and Japan models, for example, suggest deflationary pressure but the U.S. model points toward normal prices. The combined signal may suggest deflationary pressure as the U.S. normal prices unable to offset Japan and Eurozone deflationary pressure because advanced economies model signal deflation. Furthermore, if all models (global, advanced economies, U.S., Eurozone and Japan models) suggest deflationary pressure then it would be a very strong indication of global

deflationary pressure as none of major economy individually or group of advanced economies collectively offsetting deflationary pressure which result in global deflation.

Summing up, for decision makers, it is imperative to predict the more likely near future prices regime, whether it will be inflationary, deflationary pressure or stable prices. Because different prices regime would require different set of decisions. Five different models are built to generate early warning signals for the potential inflation outlook. These five models also help us to analysis whether a country/group of countries' prices regime could spread out to others. That is, if advanced economies model signals deflationary pressure and the global model also produces higher deflationary probabilities then it may implies that the deflationary pressure of advanced economies would spread out to the rest of the world. With the help of these models we can narrow down the risk of deflation or source of deflation. For instance, if the U.S. and Japanese models produces higher probabilities of deflationary pressure, Eurozone model signal normal-to-higher prices and advanced economies model also suggest deflationary pressure then it may suggest that the Eurozone normal-to-higher prices are unable to offset the U.S. and Japanese deflationary pressure and as a result advanced economies are in deflationary pressure zone.

3. Econometrics of the Early Warning System

This paper provides an econometric framework to generate early warning signal of the near term global inflation outlook, in particular of three distinct scenarios: inflationary, deflationary pressure or price stability. A EWS is a unique approach compared to traditional forecasting methods, since these methods usually predict levels or growth rates of one or more variables of interest. In the case of the EWS method, an analyst is more interested in predicting specific states, which are structurally different from one another. For instance, in the present case, the objective is to predict probabilities of inflationary pressure, deflationary pressure and stable prices, and these three scenarios for prices are structurally different from each other.

Silvia and Iqbal (2014) proposed an ordered probit model to generate probabilities of inflationary, deflationary pressure and prices stability of the U.S. economy. We utilize

Silvia-Iqbal approach and build five different models to quantify global deflation risk. In the ordered probit modeling, frequently utilized in cross-section analysis, a dependent variable can take a finite number of values possessing a natural ordering.⁹ Hausman, Lo and Mackinley (1992) employed an ordered probit model using time series data and predicted trade-to-trade price changes of New York Stock Exchange (NYSE). Since then, several studies have utilized the ordered probit model in time series analysis, see Yang (2005), Greene (2008) and Silvia-Iqbal (2014) for more detail.

In the ordered probit modeling, the dependent variable is a latent (unobservable) continuous variable, say Y_t^* , and the conditional mean of the Y_t^* is a linear function of explanatory variables (Z_t). Furthermore, a discrete variable, say Y_t , can be generated based upon the Y_t^* values and then the Y_t can be utilized as a dependent variable in the ordered probit model. One of the ordered probit modeling conditions is that the dependent variable only contains integers with natural order (for instance, 0, 1, 2,... so on).

The following ordered probit framework is estimated to generate signal of the potential prices scenarios; inflationary pressure, deflationary pressure and stable prices. We begin by assuming an ordered probit model of the form:

$$Y_{T+h|T}^* = \beta' Z_t + \varepsilon_t \quad (1)$$

where $Y_{T+h|T}^*$ is an unobserved variable that determines, at time T , if the prices of a country/group of countries experience inflationary pressure, deflationary pressure or price stability within the next h periods.¹⁰ Z_t is a vector of right-hand side (predictors) variables; β is a vector of coefficients including an intercept; and ε_t is a normally distributed error term. Y_t^* is an unobservable continuous variable and an ordered probit model requires a discrete observable dependent variable for the estimation. Therefore, using the equation (2), a discrete dependent variable, Y_t , is generated.

⁹ For more detail see Maddala, G.S. (1983). *Limited-Dependent and Qualitative Variables in Econometrics*. Cambridge University Press, Cambridge, UK.

¹⁰ We utilize quarterly dataset for the world and advanced economies models and monthly for the U.S., Eurozone and Japan models. Therefore, $h=2$ (2-quarter out) for the world and advanced economies and $h=6$ (6-month out) for the U.S., Eurozone and Japan models.

$$\begin{aligned}
Y_t &= -1 && \text{if } Y_t^* < r_1 \\
Y_t &= 0 && \text{if } r_1 \leq Y_t^* \leq r_2 \\
Y_t &= 1 && \text{if } Y_t^* > r_2
\end{aligned} \tag{2}$$

$$Y_{T+h/T} = \beta' Z_t + \varepsilon_t \tag{3}$$

In order to generate Y_t , two threshold parameters, r_1 and r_2 , are created and $r_1 < r_2$. Furthermore, if $Y_t^* < r_1$ then $Y_t = -1$ and it considers prices are in a deflationary zone. The Y_t is equal to zero if $r_1 \leq Y_t^* \leq r_2$ and that is attached with a stable prices scenario. If $Y_t^* > r_2$ then $Y_t = 1$ and it shows inflationary pressure. Given historical data on the inflation, three scenarios (inflationary, deflationary pressure and price stability) are captured in Y_t and with a set of predictor variables represented by Z_t , a 6-months out probability of these three scenarios can be generated by estimating equation (3).¹¹

If the error term ε_t is serially uncorrelated, parameter vector β and its variance-covariance matrix can be estimated readily using the maximum likelihood method. For multi-period ahead forecasting, there is an overlapping data problem in that the forecast horizon is longer than the observation interval, this will cause serially correlated forecast errors (see for more detail Estrella and Mishkin, 1998). For instance, for the U.S., Eurozone and Japan, our dataset is monthly, but we are interested in the 6-month forward probability of prices. Under this situation, the standard estimation of parameter vector β is still consistent, but its variance-covariance matrix estimate needs a Newey-West type adjustment, so we assume ε_t can be serially correlated.¹²

Another point is the choice of estimation procedure, i.e., choice of probit or logit. There is not a clear answer as Stock and Watson (2007) suggested that probit and logit models frequently produce similar results and for practical purposes the two estimates are “very similar”. Silvia and Iqbal (2014) employed probit model and thereby we utilize probit models.¹³

¹¹ See next section for more detail about the threshold parameters, r_1 and r_2 .

¹² For more technical details, see Wright (2006)

¹³ For the sake of sensitivity analysis, we produce probabilities using probit as well as logit models and there is no change in the conclusion.

4. The Data and Implementation Strategy

Five different ordered probit models are built to predict probabilities of inflationary, deflationary pressure and prices stability. Our first model utilizes global data to estimate global risk of deflation. The IMF publishes a measure of global prices, known as world CPI. The year-over-year percent change (YoY) of the world CPI series is utilized to create the categorical (discrete) variable, which is the dependent variable of the global ordered probit model.¹⁴ The dependent variable of the ordered probit model only contains three values (-1, 0, 1).

Two threshold values of the world CPI growth rates are utilized to determine periods of deflationary, inflationary pressure and stable prices. Many central banks have a specific/explicit inflation target rate, i.e., the U.S./Eurozone and Japan's central banks have an inflation target rate of 2 or near 2 percent. However, there is no explicit inflation target for world prices and 2 percent seems very low. Since the world CPI consists of the both developed and developing countries prices and inflation rates in developing economies are much higher than the developed world, on average.

A practical solution would be to utilize the average value of the current-prices-cycle (long-run average) as benchmark and the average of the 1996-2014 period is 4.4 percent, which is the inflation target of the world prices.¹⁵ Furthermore, we use a 0.5 percent spread from 4.4 percent target (4.4 +/- 0.5) to generate three prices scenarios. That is, if the world CPI growth rate is between 3.9 percent and 4.9 percent then prices are in stable prices zone and categorical variable is zero, $Y_t=0$. The value of the dependent variable is one, $Y_t=1$, if the CPI growth rates are higher than 4.9 percent (4.4 + 0.5), which indicates inflationary pressure period. By the same token, a deflationary pressure zone represents prices below 3.9 percent (4.4 - 0.5) and $Y_t=-1$ (minus one).

¹⁴ In simple worlds, a continuous variable can take on any numerical (finite) value between its minimum and maximum values. If a variable is not continuous then it is discrete.

¹⁵ The CPI growth rates were, mostly, in the double digit during the mid-1970s to mid-1990s and since 1996 prices has been in the single digit growth rates. Therefore, it is more meaningful to use the average of the 1996-2014 period as it is more relevant to the future prices path. For example, the average of the 1985-2014 period is 9.6 percent and using 9.6 percent as benchmark would declare 1997-2014 period as deflationary pressure era which is not a realistic conclusion. As a result, 4.4 percent world CPI growth rate is our benchmark.

Therefore, a world CPI rate between 3.9% and 4.9% may be seen as stable prices, above 4.9% as inflationary and below 3.9% as deflationary.

After creating the dependent variable of the global ordered probit model, we select predictors of the model. Silvia-Iqbal utilized four predictors in their U.S. model and these predictors represent major sectors of the U.S. economy. We follow their approach and include four predictors measuring major sectors of the global economy in the global model. The predictors are (1) the global 10-year treasury yield, (2) the world equity prices (YoY), (3) the world unemployment rate and (4) the world index of leading indicators (world LEI, YoY).

The IMF publishes a measure of the global 10-year Treasury yields, which is the average of the G-7 countries' 10-year Treasury yields, and we utilize that series as a proxy for the global 10-year yield and predictor of our model. Morgan Stanly produces a measure of global equity prices, known as the MSCI world index. The MSCI world index (YoY) includes both emerging and developed market and is a good proxy for the global financial sector. The third predictor of the model is Bloomberg's measure of world unemployment rate.¹⁶ The final predictor is the proxy of the world LEI. The organization for the economic cooperation and development (OECD) estimates LEI which includes 33 OCED and 6 non-OECD (but major) economies and the OECD LEI is a reliable measure of the world LEI.¹⁷

These four predictors represent major determinants of inflation outlook. One of the key factors of inflation is interest rates/credit market as borrowing cost depends on interest rate among other factors and the 10-year treasury yield is a standard benchmark of interest rates/credit market. Labor market is another determinant of prices and unemployment rate is a vital indicator of the labor market. Financial sector plays a crucial rule in an economy and also influences on prices of that economy. An index of stock (equity) prices, MSCI world index, is a reliable proxy for the financial sector. The LEI is an important represent of an economy and would help us to predict future prices

¹⁶The Bloomberg's world unemployment rate is a quarterly series and goes back to 1996. Authors computed historical (before 1996 era) values of the unemployment rate series using trend estimation as well as information from the OECD unemployment rates. The IMF produces global GDP but that series is annual. Since we are interested in a quarterly model and unemployment rate is more appropriate for our model.

¹⁷The 6 non- OECD economies are Brazil, China, India, Indonesia, Russia and South Africa.

scenarios. The global ordered probit model utilizes a quarterly dataset for the 1975:Q1-2014:Q3 period.

The second model estimates early warning signal for the advanced economies. The IMF characterizes a group of 36 countries as advanced economies and produces a measure of prices for that group, known as advanced economies CPI.¹⁸ We utilize advanced economies CPI (YoY) series to create the dependent variable of the ordered probit model. We set 2 percent CPI (YoY) growth rate as inflation target rate since many central banks in the developed economies have a target of 2 percent (or near 2 percent) and it is safe to assume the same target for the whole group. Another reason, the average CPI growth rate of the past couple decades is around 2 percent (1.97 percent for the 1995-2014 period). Therefore, we use 2 percent as inflation target and a spread of 0.5 percent (2 +/- 0.5) to generate inflationary, deflationary pressure and stable prices zones for the advanced economies model. The advanced economies model also includes four predictors; the 10-year treasury yield, the unemployment rate, stock prices (YoY) and LEI (YoY). The global 10-year treasury yield (average of the G-7 countries 10-year treasury yields as proxy) is included in the model as a proxy for the advanced economies. The IMF produces unemployment rates for the advanced economies and Morgan Stanly publishes an index of developed markets stock prices and both of these series are utilized in the model. The OECD produces LEI for the OECD members and that index is considered a proxy of the advanced economies LEI. The advanced economies model uses a quarterly dataset for the 1983:Q1-2014:Q3 period.

We employed the Silvia-Iqbal (2014) ordered probit model to generate signal for the U.S. prices scenarios. Silvia and Iqbal utilized PCE deflator as a measure of the U.S. prices and to create the dependent variable. The reason to utilize the PCE deflator as a measure of inflation (instead of CPI, PPI etc.) is that decision makers, the FOMC for example, consider the PCE deflator as the benchmark measure for policy and thereby the focus for financial markets (see FOMC website for more detail). In addition, the FOMC provides a long-run target of at or below 2 percent as a stable price. This inflation target, provided by influential decision makers, helps us to categorize the PCE deflator time

¹⁸As of October 2014, there are 36 countries in the advanced economies group and a complete list of the countries can be found at the IMF website.

series into periods of inflationary, deflationary pressure and stable prices and thereby the dependent variable for the ordered probit model.

The FOMC stated that they may tolerate half of a percentage point above the long-run inflation target of 2 percent (for more detail, see FOMC's statement for the July 31, 2013 meeting). That is, an inflation rate higher than 2.5 percent would bring in a shift upward in inflationary expectations and may influence FOMC decisions. We can assume the similar downward spread, a half percentage point below 2 percent, may signal deflationary expectations. Therefore, a PCE deflator rate between 1.5 percent and 2.5 percent may be seen as stable prices, above 2.5 percent as inflationary and below 1.5 percent as deflationary. For the U.S. model, a categorical variable ($Y_t = -1, 0, 1$) is created; Y_t equals minus-one (-1) if PCE deflator (YoY) is below 1.5 percent, Y_t equals zero if PCE deflator (YoY) remains between 1.5% and 2.5% and Y_t equals one (1) if PCE (YoY) is greater than 2.5 percent.

Silvia and Iqbal (2014) model includes the following four predictors; the unemployment rate, the S&P 500 index (YoY), the 10-year Treasury yields and LEI (YoY). Since we updated Silvia-Iqbal model and thereby utilize the same predictors. The U.S. model utilizes a monthly dataset for the 1970:M1-2014:M9 time period.

The European Central Bank (ECB) inflation target is near 2 percent and ECB utilizes CPI (YoY) as a preferred measure of inflation rate. Following the U.S. model's logic that is we utilize 2 percent inflation target and 0.5 percent spread (2 ± 0.5) to create the dependent (categorical) variable for the Eurozone model. Specifically, if the Eurozone CPI (YoY) is in 1.5 percent and 2.5 percent range then $Y_t=0$, if CPI (YoY) is below 1.5 percent then Y_t equals minus-one (-1) and Y_t equals one (1) if CPI (YoY) is greater than 2.5 percent.

The four predictors of the Eurozone model are; the Eurozone 10-year treasury yield, the unemployment rate, the LEI (YoY) and Stock prices (the Euro STOXX 50 index, YoY). A monthly dataset for the 1997:M1-2014:M9 period is utilized for the Eurozone model.¹⁹

The final ordered probit model predicts the possibility of deflation/inflation for the Japanese economy. The Bank of Japan's inflation target is also 2 percent and we

¹⁹ The Eurozone CPI(YoY) only date back to 1997 and thereby the start date of the Eurozone model.

utilize CPI (YoY) as prices measure and 0.5 percent spread to create the dependent variable for the Japan ordered probit model. The predictors of the model are, the 10-year treasury yield, the unemployment rate, the LEI (YoY) and stock prices (NIKKEI, YoY). The model utilizes a monthly dataset for the 1982:M1-2014:M9 period.

4.1 The Implementation Strategy

We use a quarterly dataset for the world and advanced economies and a monthly dataset for the U.S., Eurozone and Japan models. The reason to utilize these two different datasets is that for world and advanced economies some data series (such as unemployment rate) only available in quarterly frequency. The forecast horizon for all models is same, which is 6-month out (2-quarter for world/advanced economies models and 6-month ahead for U.S./Eurozone/Japan models).

The two threshold parameters mentioned in equation (2) are r_1 and r_2 and $r_1 < r_2$. Two set of values for these parameters are utilized. For the world model, the values are $r_1=3.9$ percent and $r_2=4.9$ percent. That is, if the world CPI (YoY) is below 3.9 percent then it is considered deflationary pressure and CPI (YoY) above 4.9 percent indicates inflationary pressure. For the rest of the four models (the advanced economies, U.S., Eurozone and Japan models), the threshold parameters values are $r_1=1.5$ percent and $r_2=2.5$ percent. The value of a deflationary pressure threshold is 1.5 percent because if CPI (YoY) (PCE deflator (YoY) for the U.S.) is below 1.5 percent then it is measured as deflationary pressure. Similarly, a CPI (and again PCE deflator for the U.S.) value above 2.5 percent considers inflationary pressure and prices between 1.5 and 2.5 percent range are declared as stable prices.

Typically, we face non-stationary issue when we deal with a time series dataset. However, in the present case, our dependent variables are categorical variables (-1, 0, 1) and in all model two predictors, Stock prices and LEI, are in growth rates (first difference) and therefore, we may not face non-stationary issues. The unemployment rate and 10-Year treasury yields are tend to move around their long-run means and may be stationary.

5. The Results

The objective of this study is to provide early warning signals about the near future prices scenarios. Five different ordered probit models are built to generate 6-month (2-quarter out for the world/advanced economies) probabilities of inflationary, deflationary pressure and prices stability, simultaneously. Furthermore, the dependent variable in each model, Y_t , (categorical-variable) contains three distinct values which correspond to three different price regimes. $Y_t = 1$ represents an inflationary prices trend, $Y_t = -1$ (minus one) indicates prices are in a deflationary zone and $Y_t = 0$ is attached to a stable prices scenario. Given this information, it is important to note that instead of interpreting a probability closer to one (1), for instance, as outright inflation, we would qualitatively suggest that there exists a significant risk of a future (with-in the next 6 months) run-up in prices, i.e., strong signal of a higher than 2.5 percent (4.9 percent for the world prices) percent growth rate of prices. With the above caveats in mind, we should translate the forecasted probability of each inflation-scenario qualitatively, and as a signal, rather than quantitatively.

For the all models, we generate simulated real-time out-of-sample probabilities of prices scenarios. The major benefit of this exercise is that, as we have the actual prices-scenarios for that time period, we can evaluate ordered probit models' out-of-sample performance for each country, group of countries and the global model. For example, for the global model, the complete sample period is 1975:Q1-2014:Q3 and we generate simulated real-time out-of-sample probabilities for the 1994:Q1 to 2014:Q3 period. That is, we utilize 1975:Q1-1993:Q4 period for the estimation and generate probabilities for the next 2-quarters, then we include 1994:Q1 (estimation period now is 1975:Q1-1994:Q1) and again produce probabilities for the next 2-quarters, we follow this recursive approach until we reach the final available data point which is 2014:Q3 and predict 2-quarters out probabilities. This recursive method allows us to evaluate the global model's out-of-sample performance. We follow the same procedure for the rest of the four models as well.

The simulated real-time out-of-sample probabilities for the global model are plotted in the Figure 1. The bars (shaded area) above zero represent actual periods of inflationary prices. That is, the bars (shaded area) above the zero-line indicate that the

world CPI growth rates (YoY) were greater than 4.9 percent during that time periods. Similarly, the bars (shaded area) below the zero-line are attached to the periods of deflationary pressure, i.e., when CPI rates (YoY) were below 3.9 percent. The blank area, between 1999:Q4 and 2001:Q3 for instance, shows prices were in the stable zone (CPI growth rates (YoY) were between 3.9 and 4.9 percent).

In Figure 1, the brown line represents a 2-quarter out probability of inflationary pressure, the blue line indicates the probability of stable prices and the red line attaches to the probability of deflationary pressure. We converted probabilities of deflationary prices into a negative series (probabilities multiplied by minus one) and probability closer to -1 (minus one), the red line, indicates a significant risk of deflationary pressure within the next two quarters. Similarly, a probability closer to 1 (one), the brown line, shows a significant risk of an inflationary pressure. Finally, if the blue line, probability of stable prices, is close to one then it indicates a significant chance of stable inflation during the next two quarters.

The brown line, signal of inflationary pressure, is very consistent with the actual inflationary pressure zones. In our simulated out-of-sample period which is 1994:Q1-2014:Q3, for example, actual prices were in the inflationary zone between 1994:Q1 and 1999:Q3 and the probabilities of inflationary pressure were above 50 percent (above 0.5) for the 1994:Q1-1997:Q4 and 1998:Q4-1999:Q2 periods.²⁰The blue line, probability of stable prices, signaled stable prices for the 2000-2001 period as the probabilities were above 35 percent (above .35) during the 1999:Q3-2001:Q3 period. Furthermore, actual global prices were in the 3.9-4.9 percent range during the 1999:Q4-2001:Q3 period.

The prices were in deflationary pressure zone during the 2001:Q4-2007:Q3 period, except for the two quarters (Q1 2003 and Q4 2004) when prices were in stable regime. The global ordered probit model suggested deflationary pressure as probabilities of deflation pressure, red line, were higher than the other two prices scenarios for the 2002-2007 period. In addition, since 2009, most of the time, global prices has been in the deflationary pressure zone, except for 2011, when prices were in stable zone. The model persistently signaled deflationary pressure and for the last couple of years (since Q4

²⁰There is another very brief period (first 3 quarters of 2008) of inflationary pressure in our simulated sample period and model predicted elevated probabilities for the inflationary pressure for the 2007:Q3-2008:Q4 period and probabilities were above 0.2.

2012) probabilities are above 90 percent (above 0.90). In sum, the global model successfully predicted all three prices scenarios in our simulated out-of sample period. Furthermore, given the model track record and persistently higher probabilities of deflationary pressure (97 percent based on Q3 2014), we suggest there is a stronger possibility of deflationary pressure for the global prices in the near future.

The figure 2 shows probabilities of the three prices scenarios for the advanced economies group. The 1994:Q1-2014:Q3 period is utilized for the out-of-sample simulation. Prices were in the inflationary pressure zone during the 1994:Q1-1995:Q3 period and the model produced strong signals of inflationary pressure as probabilities of inflationary pressure, brown line, were above 65 percent during that time period. During the 2007:Q4-2008:Q3 period, the probabilities of inflationary pressure were above 50 percent and actual prices were in the inflationary zone for the same time period. The model signals an inflationary pressure as probabilities were elevated (above 35 percent) for the last three quarters of 2011 and that signal matched with the actual inflationary pressure during the same period.

During the 1995:Q4-1998Q2 (except for Q4 1996) and 1999:Q3-2001:Q4 (except for the Q2 2001) periods, advanced economies experienced stable prices era and the model also consistently estimated higher probabilities of stable prices for the same periods. Similar, the model consistently signaled stable prices for the 2002:Q4-2007:Q2 period and actual inflation rates were, mostly, in stable prices zone during the same period.

The advanced economies inflation rates were in deflationary zone during 1998:Q3-1999:Q4, first three quarters of 2002 and 2009 periods and probabilities of deflationary pressure for those periods were elevated, signaled deflationary pressure. In addition, the model consistently signal deflationary pressure since Q1 2013 as probabilities of deflationary pressure are higher than the two other scenarios' probabilities. Actual prices were in the deflationary pressure zone for the 2013:Q1-2014:Q1. In sum, the advanced economies model accurately signaled all three prices scenarios in our out-of-sample simulation. Furthermore, for the past couple of years, the model has been persistently produced higher probabilities of the deflationary pressure (59

percent based on Q3 2014), which suggests there is a significant risk of deflationary pressure for the advanced economies prices in the near future.

The U.S. model results are shown in the figure 3. The brown line, the probability of an inflationary pressure, is very consistent with the actual inflationary periods in our out-of-sample simulation period (which starts from September 1983). The probabilities for the inflationary pressure stay above 50 percent (or 0.5) for most of the 1983—1991 time period when actual inflation was also above 2.5 percent, except for the June 1986—June 1987 period when prices were in the stable zone. During the 1991—1997 period, the red line, the probability for deflationary period was lowest (in absolute terms), which is consistent with the actual prices pattern (prices were either in the inflationary zone or stable but not in deflationary period). Furthermore, the October 1997—August 1999 period was a deflationary era as actual inflation was below 1.5 percent, and it was the first time in our simulated out-of-sample period that this occurred. The deflationary pressure probabilities were in the double-digits for the May 1997—May 1999 period, which suggests a chance of deflationary pressure.

The 2000s decade (2000—2010) was very volatile for prices as prices moved frequently from one regime (inflationary pressure, for instance) to another (deflationary pressure, for example) and prices did not stay in a specific zone (inflationary or deflationary, for instance) for any consecutive two years. That is another example of price volatility. It is also evident from the three probability lines as none of them show persistently higher probabilities of a particular prices scenario. There are a few spikes, such as relatively higher probabilities, during the early and late periods of the last decade. Similarly, relatively higher (absolute) probabilities of deflationary pressure were seen during the 2003—04 period.

An important observation is that, for the past several years (since June 2011), the probability of deflationary pressure has been persistently higher than the other two scenarios. This pattern implies that there is a significant risk of deflationary pressure compared to inflationary pressure during that period. In addition, a persistently higher probability for a particular inflation scenario is consistent with the 1980s episode when the model predicted a relatively higher probability for several years for a particular inflation scenario. During that period, the model predicted relatively higher probabilities

for inflationary pressure and, in reality; the U.S. economy did experience a period of higher inflation. Based on September 2014 data, a risk of deflationary pressure is more likely (63 percent chance of deflationary pressure scenario) than the other two scenarios.

The simulated out-of-sample probabilities for the Eurozone inflation scenarios are plotted in the Figure 4. The simulation out-of-sample period starts from January 2005. Most of the 2005-2007 period (except for a few months in 2005 and 2006), Eurozone prices were in stable zone and the model produced elevated probabilities for stable prices, blue line, during that time period. The model signaled stable prices for 2010 and actual prices matched that scenario. During the October2007- July 2008 and 2011-2012 periods (except for the last two months of 2012), the Eurozone experienced inflationary pressure and our model accurately predicted that case as probabilities of inflation pressure, brown line, were at elevated level for that time period.

The red line, probability of deflationary pressure, was elevated (probabilities of deflationary pressure were higher than the other two probabilities, most of the time) for the 2009 and actual prices matched those probabilities as Eurozone inflation rates were in deflationary zone during 2009. Furthermore, prices in the Eurozone has been in the deflationary regime since September 2013 and probabilities of deflationary pressure has been consistently above 50 percent since March 2013 (52 percent based on September 2014 data). Consistently higher probabilities of deflationary pressure, higher than the other two scenarios' probabilities, suggest there is a significant risk of deflationary pressure in the near future for the Eurozone.

Our last model produced probabilities of the three prices scenarios for the Japanese economy, figure 5. Some say the last couple of decades are “lost decades” for the Japanese economy and one major reason is that the Japanese economy is in the deflationary pressure zone since 1993. For instance, since the January 1993 (which is the start of our out-of-sample simulation), there are only two periods of consecutive 12 months (April 1997-March 1998 and November2013-October2014) when prices were not in the deflationary pressure (prices were in stable and inflationary pressure zones in those periods). Furthermore, in the simulation period, there is not a single period of 12-consecutive-months when prices were either inflationary pressure or stable prices zone. Therefore, Japanese economy is in deflationary pressure zone for the last couple of

decades. The model produced above 50 percent probabilities of deflationary pressure, red line, in the complete simulation period, since January 1993. The most recent probability of deflationary pressure is 84 percent (based on the September 2014 data) which indicates there is no change in the prices regime for the Japanese economy and prices may stay in the same zone (deflationary pressure) in the near future.

5.1 Connecting Probabilities of the Five Models

A question arises, are probabilities of these five models connected? Or by integrating these probabilities, can we obtain a stronger signal for a particular prices regime for the global economy? The answer is yes, in our view. For instance, during the 2008, prices were in the inflationary pressure in all five economies (even Japanese prices were either in inflationary pressure or stable prices zone during the May-October 2008). During the 2008, all five models estimated an uptick in inflationary pressure/stable prices probabilities along with declining inflationary pressure probabilities. By the same token, during 2009, all five models produced an increasing trend in the deflationary pressure and actual prices were in the deflationary zone in all five economies during the same time period. This may suggest that if all models signal a particular prices scenario, deflationary pressure for instance, then that can be seen as a strong signal of that particular prices regime (deflationary pressure) for the global economy in the near future.

In addition, since 2013, all models have been consistently suggesting deflationary pressure, probabilities of deflationary pressure are higher than the other two scenarios. Given the historical accuracy of these models and by combining all these signals into one frame, we suggest that the risk of deflationary pressure is much higher than the inflationary scenario/stable prices for the global economy in the near future.

6. Concluding Remarks

What probability can we assign to the outlook for global deflation? Recently, much of the discussion around monetary policy in the United States, Eurozone and Japan has focused on the threat of deflation and how to avoid it. How likely is deflation for each of these countries, and more broadly, for the global economy as a whole? This paper provides an early-warning-system (EWS) to predict the probability of deflation/inflation in the near future. Specifically, we utilize an ordered probit approach to estimate the six-months ahead probability of three distinct scenarios for price levels: inflationary pressure, deflationary pressure or price stability.

We build models for five regions to generate a signal for each region's inflation outlook. Our first model assesses the inflation/deflation outlook for the global economy, while the second model generates the likelihood of each price scenario for the advanced economies. Our final three models forecast the probability of inflation/deflation for the U.S., Eurozone and Japan.

Our global model suggests deflationary pressure is more likely than other price scenario, with the model forecasting a 97 percent chance of deflationary pressure in the next six months. The advanced economies model suggests a 59 percent chance of deflationary pressure. The probability of deflationary pressure for the U.S. is 63 percent, 84 percent for Japan and 52 percent for the Eurozone.

Since 2013, all five models have consistently suggested that deflationary pressure is the most likely of the three scenarios. Given the historical accuracy of these models, and by combining all these signals into one frame, we predict that the risk of deflationary pressure is much higher than the other two price scenarios for the global economy in the near future.

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Figure 1: The Global Model: Probability of Inflationary, Deflationary-Pressure and Stable Prices:

The 6-Months Ahead Probability of Price Scenarios in the Global Economy

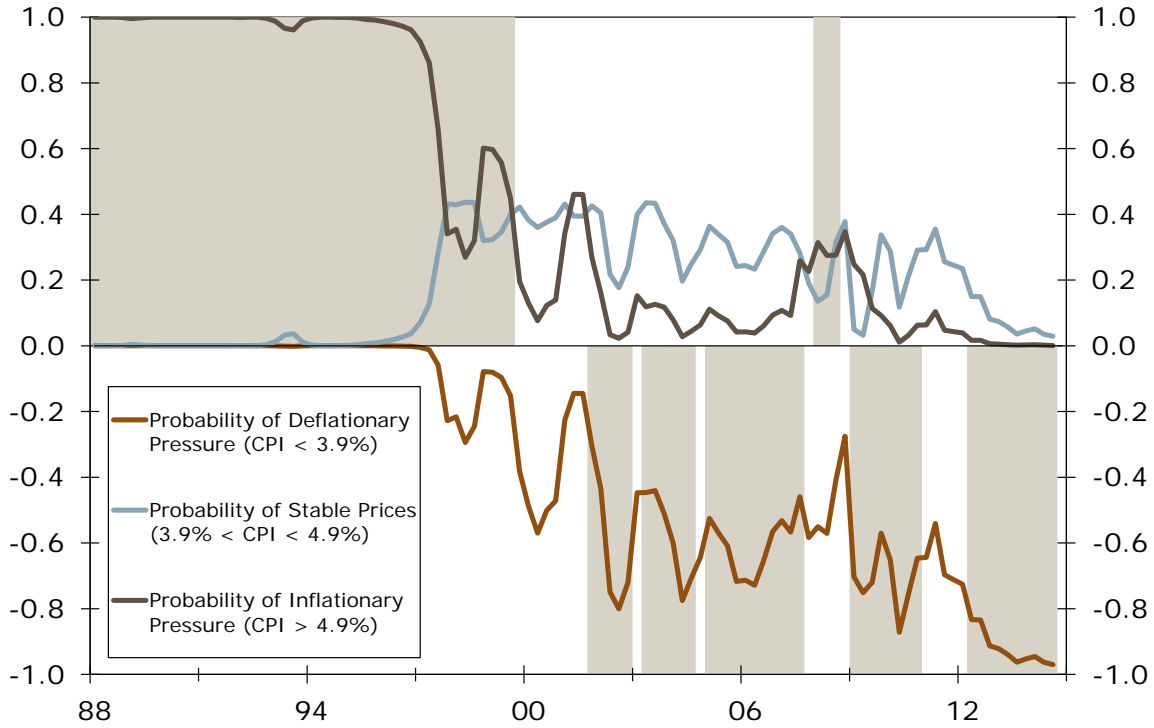


Figure 2: The Advanced Economies Model: Probability of Inflationary, Deflationary-Pressure and Stable Prices:

The 6-Months Ahead Probability of Price Scenarios in the Advanced Economies

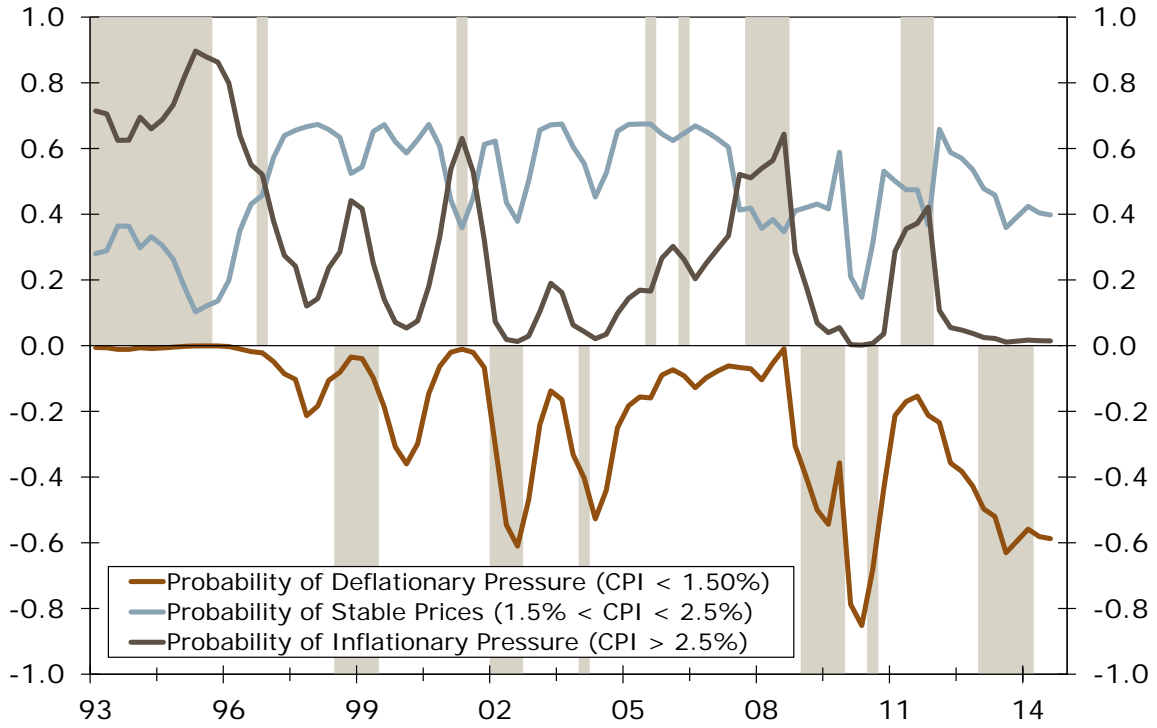


Figure 3: The U.S. Model: Probability of Inflationary, Deflationary-Pressure and Stable Prices:

6-Months Ahead Probability of Price Scenarios in the United States

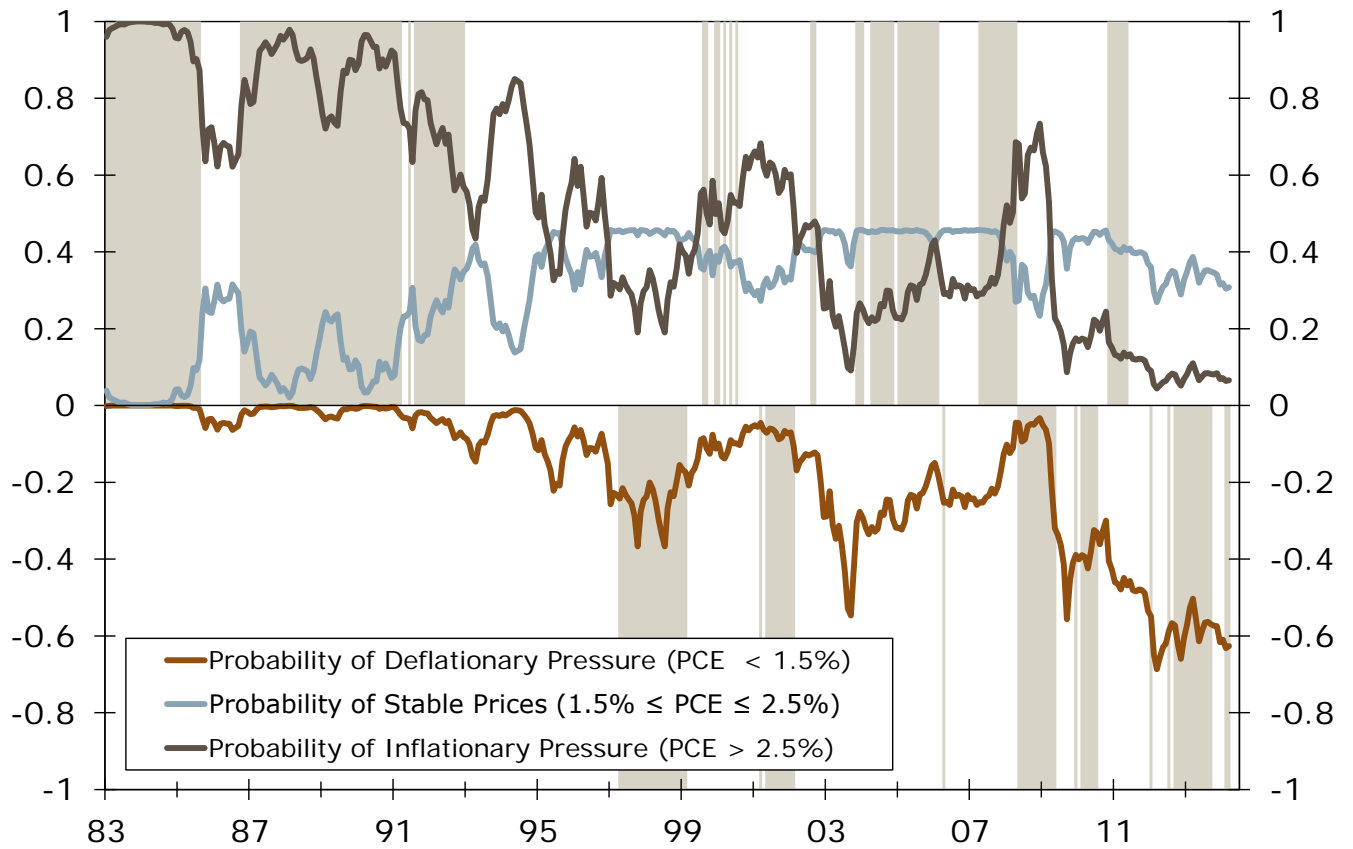


Figure 4: The Eurozone Model: Probability of Inflationary, Deflationary-Pressure and Stable Price:

The 6-Month Ahead Probability of Inflationary and Deflationary Pressure and Stable Prices in the Eurozone

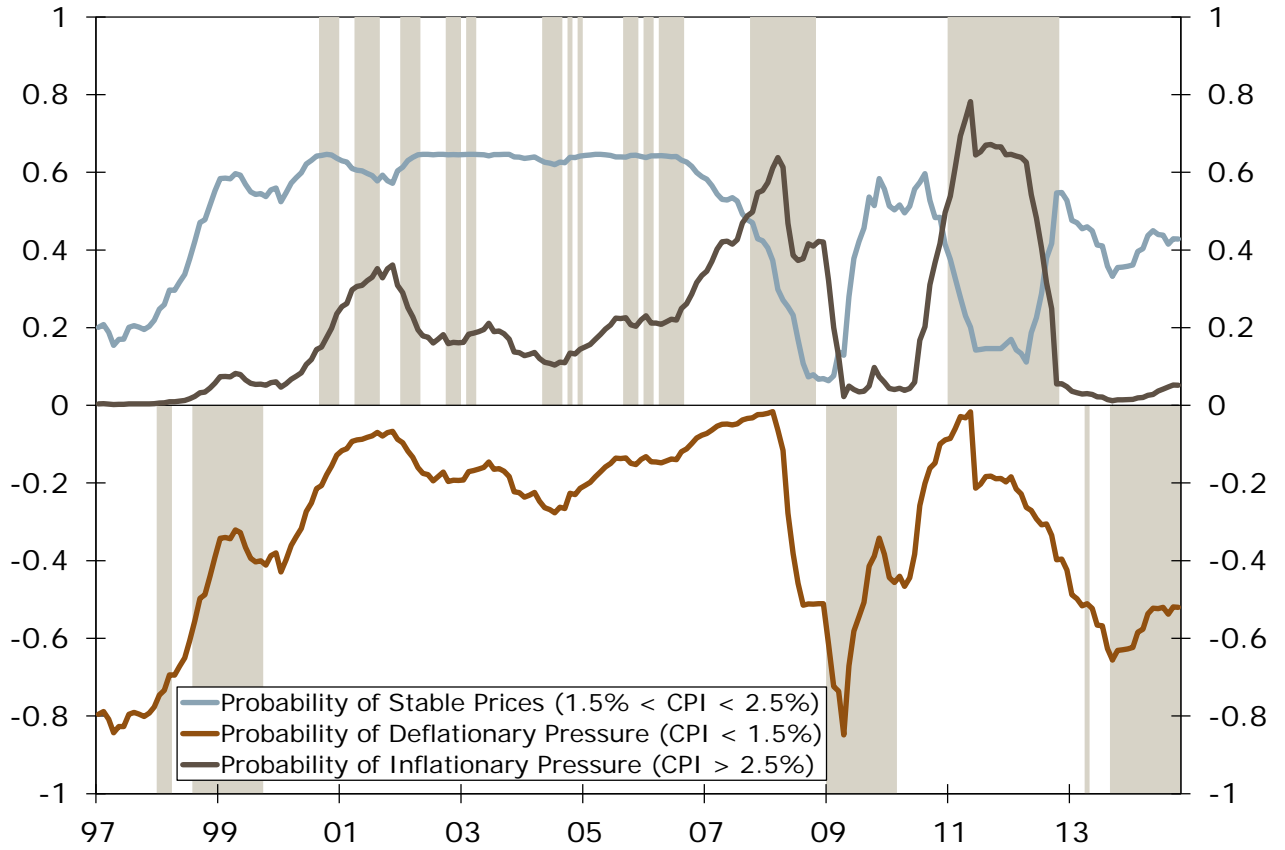


Figure 5: The Japan Model: Probability of Inflationary, Deflationary-Pressure and Stable Prices:

6-Months Ahead Probability of Price Scenarios in Japan

