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Does Deflation Threaten the Global Economy?

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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 inflation/deflation in the near term. Specifically, we utilize an ordered probit approach to estimate the six-month ahead probability of three distinct scenarios for the inflation outlook: 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 inflation scenario for the advanced economies. Our final three models forecast the probability of inflation/deflation for the United States, the Eurozone and Japan. Our global model suggests deflationary pressure is more likely than the other two inflation scenarios, with the model forecasting a 99 percent chance of deflationary pressure in the next six months. The advanced economies model suggests a 58 percent chance of deflationary pressure. The probability of deflationary pressure for the United States is 60 percent, 72 percent for Japan and 56 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 framework, we predict that the risk of deflationary pressure is much higher than the other two inflation scenarios for the global economy in the near term.

Keywords: ordered probit, global economy, deflation, probability
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1 Introduction

Economies evolve overtime, just as the nature of an economy's risks and challenges 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 (deflationary pressure) or inflation (inflationary pressure)? 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 inflationary/deflationary pressure in the near term. In particular, we utilize an ordered probit approach to estimate the six-month ahead probability of three distinct scenarios for inflation outlook: inflationary pressure, deflationary pressure or price stability.[1]

A EWS is a unique approach compared to traditional forecasting methods, since traditional 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 inflation are structurally different from each other. Furthermore, decision makers would have a different set of decisions for each of these three inflation outlooks. Typically, different inflation outlooks (inflationary pressure 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 usually associated with 2 percent inflation in many countries. Furthermore, these central banks may change the stance of their monetary policy depending on their inflation outlook. Specifically, a higher probability of future inflationary pressure would have different policy implications than a higher probability of deflationary pressure for monetary policy makers. Therefore, for decision makers, it is more useful to know what the probability

1 We utilize deflation and deflationary pressure (or inflation and inflationary pressure) interchangeably. Furthermore, if inflation rate of a region is below (above in the case of inflationary pressure) a threshold value then deflationary pressure or deflation. See the Data section for more detail about threshold values.

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

Before we attempt to model and forecast the outlook for inflation, 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 (deflationary) pressures. Third, higher expected taxes, to cover large budget deficits in many countries with serious debt-management issues, have led to expectations of restrictive fiscal policy and uncertainty about the pace of future growth and the risk of deflationary pressure.

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 inflationary pressure. 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.[2] In sum, a high level of uncertainty presently exists about the future path of inflation in the global economy.

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 4.34 percent), world CPI growth rates, on a year-over-year basis, have been well below the long-run average growth rate of 4.34 percent.[3] The IMF also estimates a CPI for advanced economies. Advanced economies CPI growth rates have been well below 2 percent since 2009:Q1 (except for 2011:Q1–2012:Q1 period).[4] At the individual country level, inflation is also well

2 For instance, policy rates in the U.S., Japan and Eurozone are at historically low levels. 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.

3 The average growth rate of the world CPI for the 1996:Q1–2015:Q2 period is 4.34 percent, which is considered a long-run average growth rate.

4 The IMF characterizes 36 countries (as of October 2014) 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.

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 less than one percent since October 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.

The Great Recession and financial crisis produced significant damage 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) as a result of the global downturn.[5]

Silvia and Iqbal (2015) developed an ordered probit model to forecast the probability of inflationary pressure, deflationary pressure and price stability. They utilized a monthly dataset for the U.S. and estimated the six-month 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 pressure, deflationary pressure and price stability. The ordered probit approach is employed to forecast probabilities of all three inflation scenarios for the world, advanced economies, United States, Eurozone and Japan.

Our global model suggests deflationary pressure is more likely than other price scenario, with the model forecasting a 99 percent chance of deflationary pressure in the next six months. The advanced economies model suggests a 58 percent chance of deflationary pressure. The probability of deflationary pressure for the U.S. is 60 percent, 72 percent for Japan and 56 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 framework, 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

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

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 rising inflationary expectations versus one of rising 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 deflationary pressure. Therefore, it would be much better to generate probabilities of each inflation scenario, which provides an early warning signal of the upcoming inflation 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 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, or advanced, economies and developing economies. In recent years, many advanced economies have faced lower inflation rates, and most developing countries are not worried about deflationary pressure, as prices are in normal-

6 Major 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.

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/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 the risk of global deflation. By the same token, a higher risk of U.S. inflation either may reduce the risk of global deflation (assuming U.S. inflationary pressure may offset other economies' deflationary pressure) or increase global inflation rates (in the case of rising inflation rates in the rest of the world).

Inflation, as measured by the PCE deflator, in the U.S. has been below the Fed's target of 2 percent since May 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 its key policy rate in the second half of 2015, which also indicates the U.S. economy does not need further monetary stimulus. Therefore, these activities may boost U.S. inflation rates. Our U.S. model will provide early signals for the six-month 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 May 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

7 Due 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 inflation scenarios for developing economies.

percent since October 2013. Given the magnitude and importance of the Eurozone economy to the world economy, we build a model to generate an early warning of deflationary pressure in the Eurozone.

Japan is another major developed economy and it has been in and out of actual 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, Japan recoded negative GDP growth rates in Q2 and Q3 of 2014, sending the country into its third technical recession in the last five years.[8] Our final ordered probit model provides signals for Japanese inflation 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. Are these five models connected with each other and, by combining signals from these models into one framework, can we enhance the predictability of our EWS? If so, 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 face a rate of inflation in normal-to-high growth zone, on average. First, suppose the global model signals normal or stable inflation in the near future (higher probability of stable prices compared to inflationary and deflationary pressure probabilities) and the advanced economies model produces a higher probability of deflationary pressure. We can combine these two signals and the interpretation would be that developing economies' higher inflation may offset developed economies lower inflation, and the global economy may not face the threat of deflationary pressure which is faced by the advanced economies.

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 in the advanced economies may have spread out and subsequently exerted deflationary pressure on the global economy.

A connection between advanced economies and individual countries' models (U.S., Eurozone and Japan models) may exist as well. For instance,

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

if all four models signal deflationary pressure, it may be seen as a very strong signal of deflation. In other words, deflationary pressure in the major economies is increasing the risk of deflation for the broader advanced economies group and there is not a strong-enough inflationary force in any country to offset this pressure. On the contrary, if the advanced economies, Eurozone and Japan models suggest deflationary pressure but the U.S. model points toward stable prices, the combined signal may suggest deflationary pressure, as price stability in the U.S. would be offset by deflationary pressure in Japan and the Eurozone. 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 the major economies individually or collectively offset the deflationary pressure.

In sum, it is imperative for decision makers to attach a probability to the more likely near-term inflation scenario. Since different inflation scenarios would require a 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 analyze whether a country/group of countries' inflation environment could spread out to others. With the help of these models we can identify where the risk of deflationary pressure is most prevalent.

3 Econometrics of the Early Warning System

This paper provides an econometric framework to generate an early warning signal of the near-term global inflation outlook, in particular of three distinct scenarios: inflationary pressure, deflationary pressure or price stability. A EWS is a unique approach compared to traditional forecasting methods, since traditional 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 inflation states are structurally different from each other.

Silvia and Iqbal (2015) proposed an ordered probit model to generate probabilities of inflationary, deflationary pressure and prices stability of the U.S. economy. We utilize the 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 et al. (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 and Iqbal (2015) 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 a signal of the potential inflation scenarios; inflationary pressure, deflationary pressure and stable prices. We begin by assuming an ordered probit model of the form:

$$Y^*_{T+h|T} = \beta' Z_t + \varepsilon_t \qquad [1]$$

Where $Y^*_{T+h|T}$ is an unobserved variable that determines, at time T, if the price level of a country/group of countries experiences 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 eq. [2], a discrete dependent variable, Y_t, is generated.

$$\begin{array}{lll} Y_t = -1 & \text{if} & Y_t^* < r_1 \\ Y_t = 0 & \text{if} & r_1 \le Y_t^* \le r_2 \\ Y_t = 1 & \text{if} & Y_t^* > r_2 \end{array} \qquad [2]$$

$$Y_{T+h/T} = \beta' Z_t + \varepsilon_t \qquad [3]$$

In order to generate Y_t, two threshold parameters, r_1 and r_2, are created, where $r_1 < r_2$. Furthermore, if $Y_t^* < r_1$, then $Y_t = -1$, implying that inflation is in a deflationary zone. Y_t is equal to zero if $r_1 \le Y_t^* \le r_2$, which would imply stable prices. Finally, if $Y_t^* > r_2$, then $Y_t = 1$, signifying inflationary pressure. Given

9 For more detail see Maddala (1983).

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.

historical data on inflation, we capture three scenarios (inflationary pressure, deflationary pressure and price stability) in Y_t and, with a set of predictor variables represented by Z_t, a 6-month (2-quarter) out probability of these three scenarios can be generated by estimating the equation in [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, so 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 outlook. In 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 issue is the choice of estimation procedure, i. e., probit or logit. There is not a clear solution, 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 (2015) employed a probit model and thereby we utilize probit models.[13]

4 The Data and Implementation Strategy

We build five different models to predict probabilities of inflationary pressure, deflationary pressure and price stability. Our first model utilizes global data to estimate the global risk of deflationary pressure. The IMF publishes a measure of global prices, known as world CPI. We utilize the year-over-year percent change (YoY) of the world CPI series 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 inflationary pressure, deflationary pressure and stable prices. Many central banks have a specific, often explicit inflation target rate. For example,

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.

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.

the central banks in the United States, the Eurozone and Japan have an inflation target rate of or near 2 percent. However, there is no explicit inflation target for world prices, and 2 percent seems low since the world CPI consists of 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 a benchmark and the average of the 1996–2014 period is 4.4 percent, which, for our purposes, is the inflation target for world CPI.[15] We use a 0.5 percent spread from this 4.4 percent target (4.4 +/- 0.5) to generate three inflation scenarios. That is, if the world CPI growth rate is between 3.9 percent and 4.9 percent, then inflation is in the stable prices zone and the 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. By the same token, deflationary pressure is represented by prices below 3.9 percent (4.4–0.5) and $Y_t = -1$ (minus one).

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 bond yield, (2) world equity prices (YoY), (3) the world unemployment rate and (4) the world index of leading indicators (LEI) (YoY).

The IMF publishes a measure of the global 10-year government bond yield, which is the average of the G-7 countries' 10-year government bond yields, and we utilize that series as a proxy for the global 10-year yield and predictor in our model. Morgan Stanley produces a measure of global equity prices, known as the MSCI world index. The MSCI world index (YoY) includes both emerging and developed markets and is a good proxy for the global financial sector. The third predictor of the model is Bloomberg's measure of the world unemployment rate.[16]

15 The CPI growth rates were, mostly, in the double digit during the mid-1970s to mid-1990s and since 1996 prices have 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.

16 The 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.

The final predictor is the proxy of the world LEI. The Organization for the Economic Cooperation and Development (OECD) estimates a LEI which includes 33 OCED and 6 non-OECD (but major) economies and is considered a reliable measure of the world LEI.[17]

These four predictors represent major determinants of the global inflation outlook. One of the key factors determining inflation is the level of interest rates, as borrowing costs (interest rates) directly affect aggregate demand for goods and thus, in turn, the price of goods. We use the 10-year government bond yield because it is the standard benchmark in the credit market. The labor market is another important determinant of prices, and the unemployment rate is a vital indicator of the labor market. The financial sector plays a crucial role in an economy and influences the inflation rate of a given economy. An index of stock (equity) prices, such as the MSCI world index, is a reliable proxy for the financial sector. The LEI is an important measure of economic trends and would help us predict future inflation scenarios. The global ordered probit model utilizes a quarterly dataset for the 1975:Q1–2015:Q2 period.

The second model estimates the 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 the advanced economies CPI.[18] We utilize the advanced economies CPI (YoY) series to create the dependent variable of the ordered probit model. We set 2 percent CPI (YoY) growth rate as the inflation target rate since many central banks in the developed economies have a target of 2 percent (or near 2 percent) and we believe it is safe to assume the same inflation target for the whole group. Another reason for this assumption is that the average CPI growth rate for advanced economies over the past few decades is around 2 percent (1.97 percent for the 1995–2014 period). Therefore, we use 2 percent as an inflation target and a spread of 0.5 percent (2 + /- 0.5) to create inflationary pressure, deflationary pressure and stable prices zones for the advanced economies model. This model also includes four predictors; the 10-year bond yield, the unemployment rate, equity prices (YoY) and LEI (YoY). The global 10-year bond yield (average of the G-7 countries 10-year yields) is included in the model as a proxy for the advanced economies. The IMF produces unemployment rates for the advanced economies, and Morgan Stanley 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

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

18 As 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.

that index is considered a proxy of the advanced economies LEI. The advanced economies model uses a quarterly dataset for the 1983:Q1–2015:Q2 period.

Switching to the individual country-level models, we employ the Silvia and Iqbal (2015) ordered probit model to generate a signal for the U.S. inflation scenarios. Silvia and Iqbal utilized the PCE deflator as a measure of the U.S. inflation in order 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, namely the Federal Open Market Committee (FOMC), consider the PCE deflator as the benchmark measure for policy, thereby making it the focus for financial markets (see FOMC website for more detail). In addition, the FOMC provides an explicit long-run target of 2 percent, and characterizes this as consistent with their mandate for stable prices. This inflation target helps us to categorize the PCE deflator time series into periods of inflationary pressure, deflationary pressure and stable prices and thereby defines 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 might bring a shift upward in market 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 percent and 2.5 percent and Y_t equals one (1) if PCE (YoY) is greater than 2.5 percent.

We utilize the Silvia and Iqbal (2015) model and the model includes the following our predictors; the unemployment rate, the S&P 500 index (YoY), the 10-year Treasury yield and LEI (YoY). The U.S. model utilizes a monthly dataset for the 1970:M1–2015:M6 time period.

The European Central Bank (ECB) inflation target is roughly 2 percent, and ECB utilizes the CPI (YoY) as its preferred measure of inflation. Following the U.S. model's logic, we utilize a 2 percent inflation target and a 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 the 1.5 percent 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 government bond yield, the unemployment rate, the LEI (YoY) and equity prices (the Euro STOXX 50 index, YoY). A monthly dataset for the 1997:M1–2015:M6 period is utilized for the Eurozone model.[19]

The final ordered probit model predicts the possibility of inflation/deflation for the Japanese economy. The Bank of Japan's inflation target is also 2 percent, and we utilize CPI (YoY) as the inflation measure and a 0.5 percent spread (2 + /– 0.5) to create the dependent variable for the Japanese ordered probit model. The predictors of the model are the 10-year government bond yield, the unemployment rate, the LEI (YoY) and equity prices (NIKKEI, YoY). The model utilizes a monthly dataset for the 1982:M1–2015:M6 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) are only available at a quarterly frequency. The forecast horizon for all models is the same: 6-months out (2-quarters for the world/advanced economies models and 6-months ahead for U.S./Eurozone/Japan models).

We utilize a 0.5 percent spread from the long-run inflation target rate (for example, 4.4 ± 0.5 for the global model and 2.0 ± 0.5 for rest of the models) to generate thresholds values of r_1 and r_2. We followed the FOMC approach of the spread value as the FOMC stated that they may tolerate half of a percentage point (0.5 percent) above the long-run inflation target of 2 percent.[20] That is, an inflation rate higher than 2.5 percent might bring a shift upward in market inflationary expectations and may influence FOMC decisions. Furthermore, we can assume the similar downward spread, a half percentage point below 2 percent, may signal deflationary expectations. Therefore, for all five models, a 0.5 percent spread from the long-run inflation target is utilized to generate the values of the r_1 and r_2, and thereby the categorical variables.

The two threshold parameters mentioned in eq. [2] are r_1 and r_2 and $r_1 < r_2$. Two sets 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

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

20 For more detail, see FOMC's statement for the July 31, 2013 meeting.

(the advanced economies, U.S., Eurozone and Japan models), the threshold parameter values are $r_1 = 1.5$ percent and $r_2 = 2.5$ percent.

Typically, we face a 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 five models, two predictors, equity prices and LEI, are entered as growth rates (first differences). Therefore, we may not face non-stationary issues. The unemployment rate and 10-Year bond yield tend to move around their long-run means and may be stationary, see Silvia et al. (2014) for more detail.

5 The Results

The objective of this study is to provide early warning signals for near-term inflation scenarios. Five different ordered probit models are built to generate 6-month (2-quarter out for the world/advanced economies) probabilities of inflationary pressure, deflationary pressure and price stability, simultaneously. Furthermore, the dependent variable in each model, Y_t, (categorical-variable) contains three distinct values which correspond to three different inflation scenarios. $Y_t = 1$ represents an inflationary prices trend, $Y_t = -1$(minus one) indicates prices are in a deflationary zone and $Y_t = 0$ corresponds 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 (within the next 6 months) run-up in inflation, i. e., strong signal of a higher than 2.5 percent (4.9 percent for the world prices) growth rate of prices. With the above caveats in mind, we translate the forecasted probability of each inflation scenario qualitatively, and as a signal, rather than quantitatively.

For all five models, we generate simulated real-time out-of-sample probabilities of inflation scenarios. The major benefit of this exercise is that, as we have the actual inflation data for a subset of our forecasted time periods, we can evaluate the ordered probit models' out-of-sample performance. For example, for the global model, the complete sample period is 1975:Q1–2015:Q2 and we generate simulated real-time out-of-sample probabilities for the 1994:Q1 to 2015:Q2 period. That is, we utilize the 1975:Q1–1993:Q4 period for predicting inflation in the 1994:Q1–1994:Q2 period, 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 2015:Q2, 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 pressure. That is, the bars above the zero-line indicate that the world CPI growth rates (YoY) were greater than 4.9 percent during that time period. Similarly, the bars below the zero-line correspond to periods of deflationary pressure, i. e., when CPI inflation (YoY) was 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).

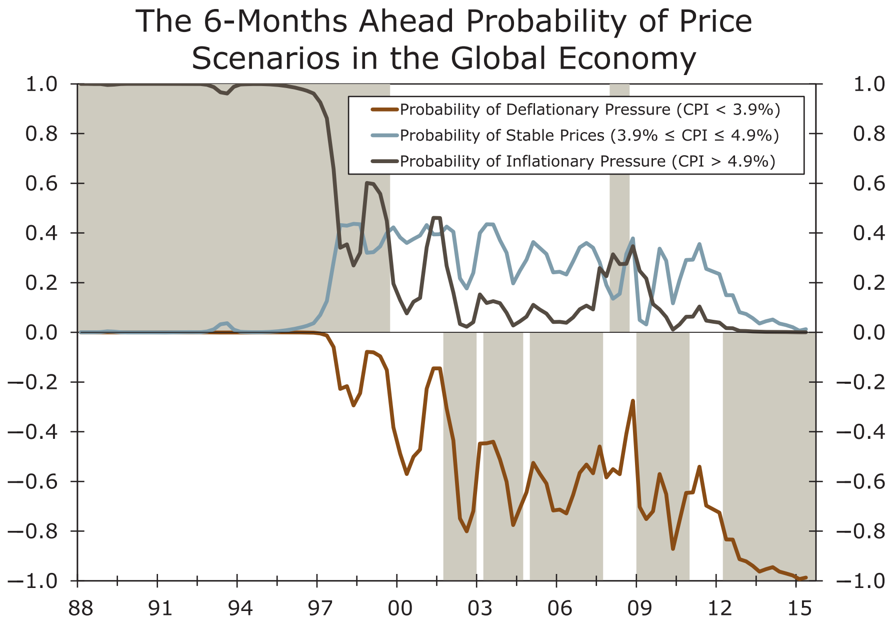

Figure 1: The global model: probability of inflationary, deflationary-pressure and stable prices.

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

The line representing the probability of inflationary pressure is very consistent with the actual periods of inflationary pressure. In our simulated out-of-sample period, which is 1994:Q1–2015:Q2, 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.[21]The blue line, the 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. Actual global inflation rates were in the 3.9–4.9 percent range during this period.

Inflation rates were in the deflationary pressure zone during the 2001:Q4–2007:Q3 period, except for the two quarters (Q1 2003 and Q4 2004) when inflation rate was in the stable range. The global model suggested deflationary pressure was the most likely scenario during the 2002–2007 period. Furthermore, global inflation rates have been in the deflationary pressure zone for most of the past five years, except for 2011, when inflation was in the stable zone. The model consistently signaled deflationary pressure for the last couple of years (since Q4 2012), as probabilities have been above 90 percent (above 0.90). In sum, the global model successfully predicted all three inflation scenarios in our simulated out-of sample period. Given the model's track record and recent readings of higher probabilities of deflationary pressure (99 percent based on Q2 2015), we suggest there is a stronger possibility of deflationary pressure for the near term global inflation outlook.

Figure 2 shows probabilities of the three inflation scenarios for the advanced economies group. The 1994:Q1–2015:Q2 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, the 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 signaled inflationary pressure (probabilities above 35 percent) for the last three quarters of 2011 and that signal matched with the actual inflationary pressure during the same period.

21 There 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.

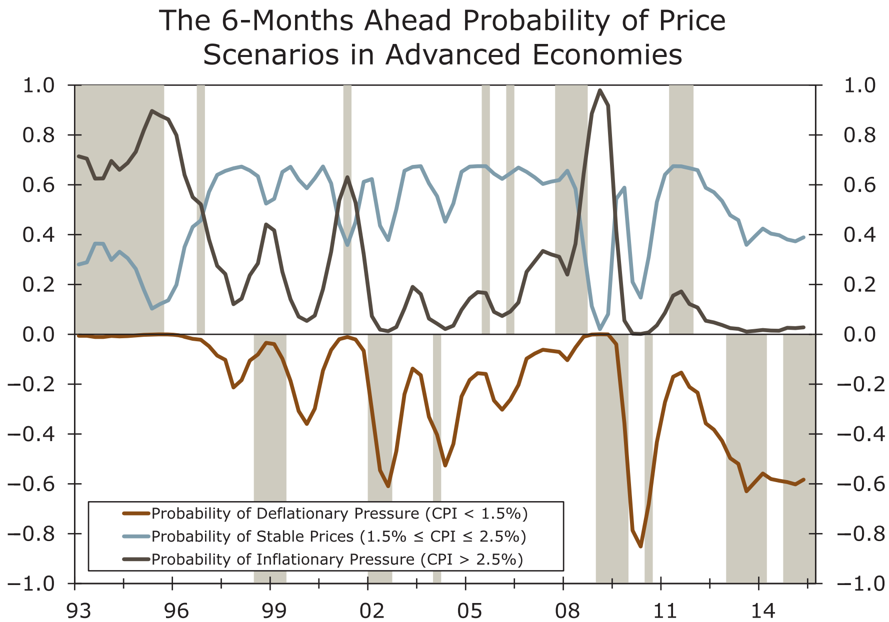

Figure 2: The advanced economies model: probability of inflationary, deflationary-pressure and stable prices.

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

The advanced economy's inflation rates were in the deflationary zone during 1998:Q3–1999:Q4, the first three quarters of 2002 and 2009, and the probabilities of deflationary pressure for those periods were elevated – signaling deflationary pressure. In addition, the model consistently signaled deflationary pressure since Q1 2013, as the probabilities of deflationary pressure were higher than the two other scenarios' probabilities. Actual inflation rates were in the deflationary pressure zone for the 2013:Q1–2014:Q1 and 2014:Q4–2015:Q2 periods. In sum, the advanced economies model accurately signaled all three inflation scenarios in our out-of-sample simulation. Furthermore, for the past couple of years, the model has persistently produced higher probabilities of deflationary pressure (58 percent based on Q2 2015), which suggests there is a significant risk of deflationary pressure for the advanced economies in the near future.

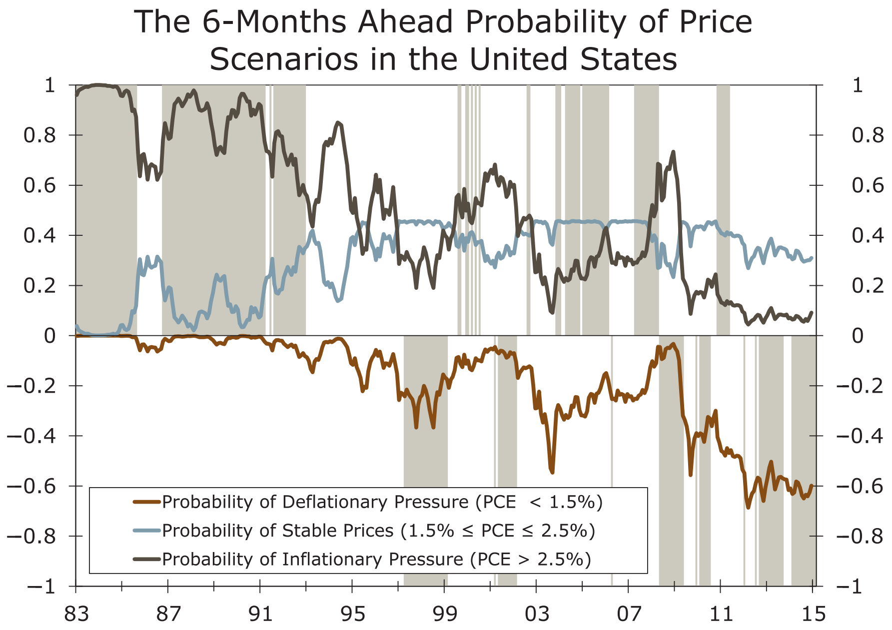

Figure 3: The U.S. model: probability of inflationary, deflationary-pressure and stable prices.

The U.S. model results are shown in the Figure 3. The brown line, the probability of inflationary pressure, is very consistent with the actual inflationary periods in our out-of-sample simulation periods (which start from September 1983). The probabilities for 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 inflation rates were in the stable zone. During the 1991–1997 period, the red line, the probability for a deflationary pressure period, was lowest (in absolute terms), which is consistent with the actual inflation pattern (inflation rates were either in the inflationary zone or stable but not in deflationary territory). Furthermore, the October 1997 – August 1999 period was a period of deflationary pressure, 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 indicates a chance of deflationary pressure.

The 2000s decade (2000–2010) was very volatile for inflation rates, as inflation moved frequently from one regime (inflationary pressure, for instance) to another (deflationary pressure, for example) and inflation did not stay in a specific zone (inflationary or deflationary, for instance) for any consecutive two years. This volatility is evident in the three probability lines, as none of them show persistently higher probabilities of a particular inflation scenario. There are a few probability 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 2003–2004 period.

An important observation is that, for the past several years (since July 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. During that period, the model predicted relatively higher probabilities for inflationary pressure and, in fact, the U.S. economy did experience a period of higher inflation. Based on June 2015 data, deflationary pressure is more likely (60 percent chance) 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

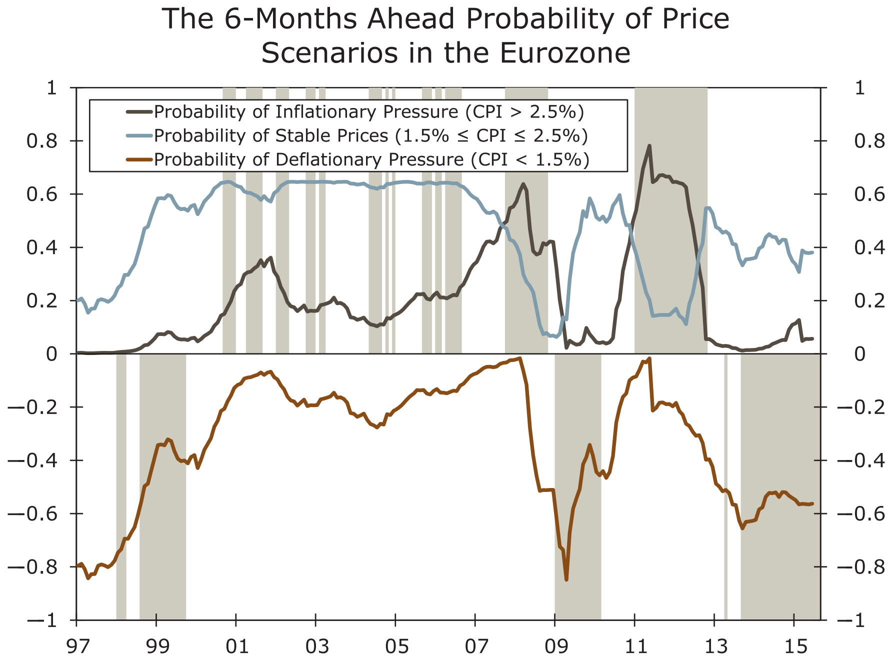

Figure 4: The eurozone model: probability of inflationary, deflationary-pressure and stable price.

January 2005. For most of the 2005–2007 period (except for a few months in 2005 and 2006), Eurozone inflation was in the stable zone, and the model produced elevated probabilities for stable prices, the blue line, during that time period. The model signaled stable prices for 2010 and actual inflation matched that prediction. During the October 2007- 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 inflationary pressure, the brown line, were at an elevated level for that time period.

The red line, the probability of deflationary pressure, was elevated (probabilities of deflationary pressure were higher than the other two probabilities, most of the time) for 2009 and actual inflation matched those probabilities. Furthermore, inflation in the Eurozone has been in the deflationary regime since August 2013, and the probabilities of deflationary pressure have been consistently above 50 percent since March 2013 (56 percent based on June 2015 data). Probabilities of deflationary pressure consistently 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 inflation scenarios for the Japanese economy, Figure 5. Some say the last couple of decades are "lost

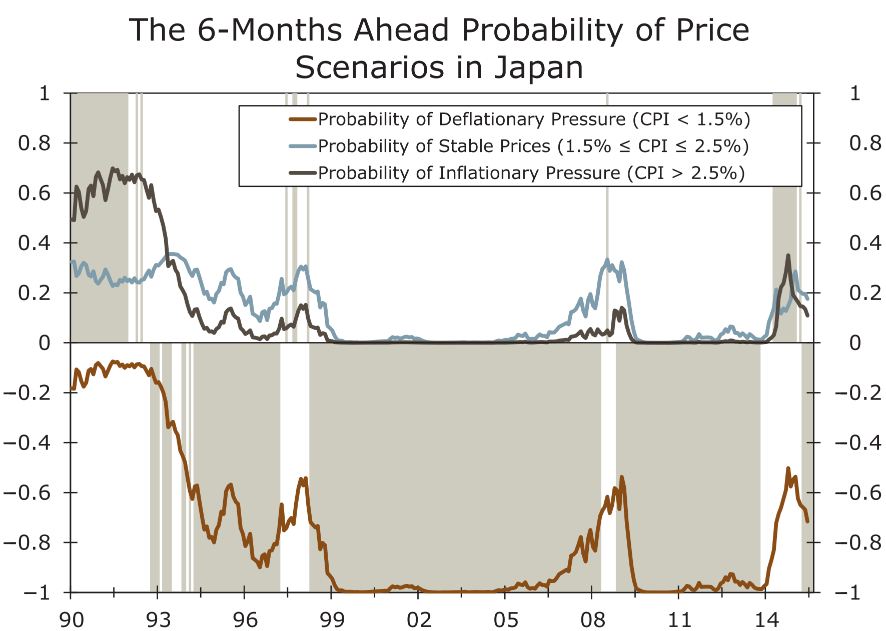

Figure 5: The Japan model: probability of inflationary, deflationary-pressure and stable prices.

decades" for the Japanese economy, and one major reason is that the Japanese economy, most of the time, has been in the deflationary pressure zone since 1993. For instance, since January 1993 (which is the start of our out-of-sample simulation), there are only two periods of a consecutive 12 months (April 1997-March 1998 and November 2013-March 2015) when inflation was not under deflationary pressure (inflation was in the stable and inflationary pressure zones in those periods). Furthermore, in the simulation period, there is not a single period of 12 consecutive months when inflation was either in the inflationary pressure or stable prices zone. Therefore, the Japanese economy has been in the deflationary pressure zone for the past couple of decades. The model produced probabilities of deflationary pressure above 50 percent, red line, in the complete simulation period, since January 1994. The most recent probability of deflationary pressure is 72 percent (based on June 2015 data) which indicates that inflation may stay in the same zone (deflationary pressure) for the Japanese economy in the near-term.

5.1 Connecting Probabilities of the Five Models

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

In addition, since 2013, all models have been consistently suggesting deflationary pressure as the most likely of the three scenarios. Given the historical accuracy of these models and by combining all these signals into one framework, we suggest that the risk of deflationary pressure is much higher than the inflationary pressure/stable prices scenarios for the global economy in the near-term.

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 to predict the probability of inflation/deflation in the near-term. Specifically, we utilize an ordered probit approach to estimate the six-month ahead probability of three distinct scenarios for inflation outlook: inflationary pressure, deflationary pressure or price stability.

We build models for five geographic 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 inflation regime scenario for the advanced economies. Our final three models forecast the probability of inflationary/deflationary pressure for the U.S., Eurozone and Japan.

Our global model suggests for the near-term, that deflationary pressure is more likely than the other two inflation scenarios, with the model forecasting a 99 percent chance of deflationary pressure in the next six months. The advanced economies model suggests a 58 percent chance of deflationary pressure. The probability of deflationary pressure for the U.S. is 60 percent, 72 percent for Japan and 56 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 framework, we predict that the risk of deflationary pressure is much higher than the other two inflation scenarios for the global economy in the near-term.

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