Inflation Dynamics and Business Cycles

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This paper aims to investigate whether the effect of inflation expectations, exchange rate, money supply, industrial production and import prices on inflation depends on business cycle. For this purpose, a two states Markov Switching Auto Regression model with time varying transition probabilities to a generic inflation model is implemented for the period 2003-2013. In the model the states are assigned whether output gap is positive or negative. The inflation forecasting in-sample and out-of-sample is also utilized by adopting mean squared error and Diebold Mariano test to measure explanatory and forecasting power of our model. Our main finding provides that the determinants of inflation have different dynamics during boom periods as compared to recessions.

Keywords: Inflation; Output Gap; Markov Switching Autoregressions; Business Cycles

JEL: C32, E30, E31, E37, E58

1. Motivation

Money supply has increased substantially by the central banks especially in the United States and in the European Union since the 2007-2008 financial crises. However it did not cause inflationary pressures; instead there are concerns of deflation emerged in these regions. This anomaly leads us to make the following argument that there may be some other variables influence the relationship between inflation and the factors that determine the inflation such as money supply, exchange rate (pass-through) and output. In the literature,
these variables are usually named as state variables. In this paper, we will attempt to evaluate whether the output gap as one of the possible factors determining the different dynamics, which take important role in explaining inflation during the business cycles.

**Figure 1.** The Keynesian View

![Keynesian View Diagram](image)

Our motivation comes from the Keynesian view that when the economy is below its potential ($Y_{FE}$ in Figure 1), a shift in aggregate demand (AD) or in money supply may not have an important impact on the rate of inflation. So, basically, this is the theoretical framework and the motivation behind our work.

2. **Short Literature Review**

Unfortunately, there is not much literature about the effects of business cycle on inflationary factors even though there is considerable literature on exchange rate pass-through. According to Tatom (1978), to the extend that procyclical variations of the economy is caused by in the money stock, one would expect procyclical movements in the inflation. Joey Chew et al (2011) find for Singaporean economy that there is asymmetric exchange rate
pass through. They documented that the exchange rate pass-through occurs more during recessionary periods than it occurs during expansionary periods.

Nidhaleddine (2012) detected that there is nonlinear exchange rate pass through for 12 EU Countries. Higher exchange rate pass-through is detected when inflation exceeds a certain threshold.

Oinonen et al (2013)’s study provided evidence that economic dynamics of inflation US has changed and output gap became more important in US since 1990.

In the following graphs (Figure 2, 3 and 4), bar graphs are output gap, red line is the rate of inflation and blue line is broad definition of money supply which is M2, import price index and manufacturing industrial production index. One can see from the figures that, there is no strong linear relationship between inflation and money supply. Similarly, there is not any linear pattern between inflation and import prices and between inflation and industrial production index. We analyze the relationships among those variables using Markov switching regression method.

**Figure 2.** Output Gap, Inflation and Money Supply (%), Jan. 1998 - March 2014
3. Methodology

Markov switching regression model was first used pretty early in 1953 by Quant and Goldfeld and became popular by Hamilton’s work in 1990s.
Markov switching regime models are basically space models. The relationship between two variables depends on observed state variable. The unobserved state variable follows a Markov chain.

Markov regime switching model assume that the observed changes in a variable between two-consecutive periods are a random draw from two distributions. The unobserved state variable evolves according to Markov chain. Probabilities of switching from one state to another -transition probability- is not exogenous but endogenous. Basically we use two normal distributions each of which has a different mean and standard deviation in this article.

State variables \((S_t)\) determine the distribution for the period. In a two-state case, when

\[ S_t = 1 \] the observed changes are a random draw from: \[ y_t / s_t = 1 \sim N \left( \mu_1, \sigma_1^2 \right) \] and

\[ S_t = 2 \] from: \[ y_t / s_t = 2 \sim N \left( \mu_2, \sigma_2^2 \right) \]

Mean and the variance of the \(y_t\) depend on the state. Density of \(y_t\) is conditional on \(S_t\) and is as follows:

\[
\left( f \left( y_t | S_t = i \right) = \right) \frac{1}{\sqrt{2 \pi \sigma}} \exp \left( -\frac{(y_t - \mu_i)^2}{2\sigma_i^2} \right)
\]

4. Model

We use a generic inflation model (Goldberg and Knetter, 1997) by running monthly data for the period 2003\(^1\) and 2014 which is as follows:

\(^1\) 2003 is especially picked for the beginning of the analysis period because it is the start of inflation targeting regime in Turkey.
\[ inf_t = \alpha_{11} inf^e_t + \alpha_{12} \Delta ms_t + \alpha_{13} \Delta prod_t + \alpha_{14} \Delta neer_t + \alpha_{15} \Delta imp_t + \epsilon_t \]

where

\( inf_t \) : The rate of inflation in consumer prices,

\( inf^e_t \) : Backward looking inflation expectation

\( \Delta ms \) : Change in money supply,

\( \Delta prod \) : Change in industrial production index,

\( \Delta neer \) : Change in nominal effective exchange rate,

\( \Delta imp \) : Change in import price index,

\( \epsilon_t \) : Error Term.

If output gap is used as state variables,

State 1: When output gap is positive.

State 2: When output gap is negative

\[ inf_{1t} = \alpha_{11} inf^e_{1t} + \alpha_{12} \Delta ms_{1t} + \alpha_{13} \Delta prod_{1t} + \alpha_{14} \Delta neer_{1t} + \alpha_{15} \Delta imp_{1t} + \epsilon_{1t} \]

\[ inf_{2t} = \alpha_{11} inf^e_{2t} + \alpha_{12} \Delta ms_{2t} + \alpha_{13} \Delta prod_{2t} + \alpha_{14} \Delta neer_{2t} + \alpha_{15} \Delta imp_{2t} + \epsilon_{2t} \]

5. Results

Markov regime switching regression has two sets of coefficients; one for each state. In other words coefficients for the recessionary periods (negative output gap) are different than the coefficients for the expansionary periods (positive output gap).
According to the results, when the output gap is negative which is State 1, a change in money supply interestingly reduces the rate of inflation as opposed to the expectations. Moreover, an increase in manufacturing industrial production increases the inflation. They are statistically highly significant. However, regarding to nominal effective exchange rate and import price index, they are not statistically significant. This is just we found the opposite of Singaporean economy. During the recessionary times, we do not see exchange rate pass through for the Turkish economy when the output gap is negative whereas the powerful pass-through exists when the output gap is positive that is to say, during the boom times, expansionary periods. Money supply and industrial production are still statistically insignificant, yet if you look at the pass-through coefficient, nominal effective exchange rate and import prices are highly significant. Their total pass-through effect is 0.07.

Table 1. Coefficients Estimated by Two-State Markov Switching Process

<table>
<thead>
<tr>
<th>States</th>
<th>Variables</th>
<th>Coefficients</th>
<th>t-ratios</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negative</td>
<td>inf_{t-1}</td>
<td>α_{11}</td>
<td>1.0535</td>
</tr>
<tr>
<td>Output</td>
<td>Δm_2</td>
<td>α_{12}</td>
<td>-0.0307</td>
</tr>
<tr>
<td>Gap</td>
<td>Δprod</td>
<td>α_{13}</td>
<td>0.1019</td>
</tr>
<tr>
<td>(State 1)</td>
<td>Δneer</td>
<td>α_{14}</td>
<td>-0.0114</td>
</tr>
<tr>
<td></td>
<td>Δimp</td>
<td>α_{15}</td>
<td>-0.0196</td>
</tr>
<tr>
<td>Positive</td>
<td>inf_{t-1}</td>
<td>α_{21}</td>
<td>0.8948</td>
</tr>
<tr>
<td>Output</td>
<td>Δm_2</td>
<td>α_{22}</td>
<td>0.0212</td>
</tr>
<tr>
<td>Gap</td>
<td>Δprod</td>
<td>α_{23}</td>
<td>-0.0296</td>
</tr>
<tr>
<td>(State 2)</td>
<td>Δneer</td>
<td>α_{24}</td>
<td>0.0268</td>
</tr>
<tr>
<td></td>
<td>Δimp</td>
<td>α_{25}</td>
<td>0.0456</td>
</tr>
</tbody>
</table>

*, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

Additionally, Wald test is implemented in order to see whether the coefficients in both states are statistically different from each other or not. Wald test results are encouraging.
According to these results, all the coefficients are significant. Therefore, in each state for all the variables are statistically significantly different from each other.

**Table 2. Wald Test Results**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Test Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inf_{i-1}</td>
<td>8.0107</td>
</tr>
<tr>
<td>Δm2</td>
<td>7.9264</td>
</tr>
<tr>
<td>Δprod</td>
<td>15.1797</td>
</tr>
<tr>
<td>Δneer</td>
<td>4.194</td>
</tr>
<tr>
<td>Δimp</td>
<td>10.0332</td>
</tr>
</tbody>
</table>

*Note: All numbers indicate that a variable is significant at 5% significance level according to the χ²-distribution.*

We also did in-sample estimation in order to understand the success of our model. In-sample estimation mimics the realized inflation. We also used random walk and ordinary least square estimation of the same model whether the model is success. In terms of mean square errors, Markov processed model produces significantly lower errors than that of OLS and also the random walk.

**Figure 5. Coefficients Estimated by Two-State Markov Switching Process**
Graph 4 shows the transition probabilities of the output gap which we will be derived with the HP filter, nominal exchange rate and money supply of State 1.

In addition to in-sample estimation, out-of-sample estimation is also done. It is seen that the model successfully predicts mimics of ups and downs the rate of inflation. We used 16 periods as out-of-sample observations (Figure 5&6). The $R^2$ of the model is 80 per cent. We take out the previous inflation from the model is still around above 30 per cent. Therefore, the model from that point of view seems to be promising.

**Figure 6.** Realized Inflation and Out-of-Sample Estimation
6. Conclusions

Our main conclusion is that inflation dynamics depends on the business cycles. Therefore, the determinants of inflation have different dynamics during boom periods as compared to recessions. For example, exchange rate pass through for the Turkish economy cannot be seen when the output gap is negative, that is to say, during the recessionary times whereas the powerful pass-through exists when the output gap is positive.

Agenda for future research is that states may be determined whether the expected inflation is realized or not and reel effective exchange rate is overvalued or undervalued. Cross country analysis can also be done by using the same model and methodology.
Reference


Joey Chew et all, 2011


Oinonen, S., M. Paloviita and L. Vilmi 2013. “How have inflation dynamics changed over time? Evidence from the euro area and USA”, *Bank of Finland Research Discussion Papers* 6
