Determinants of Inflation in Denmark and a Panel Data analysis of Denmark and 4 other countries.

Section I: Introduction

Inflation is generally defined as the sustained rise in the general price level (Blanchard, Amighini, & Giavazzi, 2021, p. 577).

The negative effects of inflation are well documented. One such cost of inflation is the “shoe leather cost” (Mishkin & Posen, 1997, p. 3) – the extra cost needed to conduct day-to-day transactions rises to >1% of GDP when inflation rates rise above 100%. Another cost is that inflation induces overinvestment in the financial sector: as price instability increases, arbitrage opportunities grow (*ibid*, p. 4); the rise in the financial sector share of GDP increases by 1pp for every 10pp rise in inflation (English, 1999). This transfer of resources out of the productive sector can be “as large as a few percentage points of GDP and can even be seen at relatively low or moderate rates of inflation.” (Mishkin & Posen, 1997, p. 4) Inflation is passed onto the population not only through increased prices – which reduce the purchasing power of an individual’s income – but also through fiscal drag. Fiscal drag occurs when nominal income rises while real income and tax brackets remain frozen; as a result, income after tax decreases in real terms; Fischer (1994, p. 14) estimates that an inflation rate of 10% could put the social cost of fiscal drag at 2-3% of GNP.

Due to the misallocation of resources and damage to the standard of living caused by inflation, governments around the world have decided to specifically target low and stable inflation as a policy objective of their monetary authorities (Mishkin & Posen, 1997). To succeed, these monetary authorities must have a clear model for producing inflation forecasts (Masson, Savastano, & Sharma, 1997, p. 9), and must consequently understand the determinants of inflation. This paper will contribute to this understanding by estimating the relationship between inflation and past inflation, money supply, exchange rates, and global energy prices. I have chosen first to conduct a timeseries analysis of inflation, from Q1 2001 to Q4 2023, in Denmark, and then a panel data analysis of inflation in Denmark, Sweden, Iceland, Norway and the UK.

Section II will review existing evidence on the determinants of inflation and examine the models and specifications used. Section III will cover a timeseries summary and analysis of Denmark, estimating inflation as an ARMA model and then as an ARDL model. Section IV will cover a panel data analysis of inflation in the five countries. Section V will use a probit model to estimate the average marginal effects (AME) and marginal effects at average (MEA) of a change in energy price on the probability of a country achieving their inflation target.

Section II: Literature Review

Among economists, there are competing explanations for the fundamental causes of inflation. Friedman provides the well-known monetarist explanation where inflation is the result of money supply rising faster than output (Leeson & Palm, 2012, p. 3). This view is popular and the relationship between money supply growth and inflation has been examined by a number of studies.

Holod (2000) uses a VEC model to investigate the relationship between price level, exchange rate and money supply in Ukraine; a VEC rather than VAR model is used because evidence of cointegration between the variables exists at a 5% significance level. Holod (2000) finds that the influence of money supply on inflation is not very strong, which he explains is due to concurrent fluctuations in the money demand.

Lim & Sek (2015) explore panel data on 28 countries by estimating inflation as an ARDL model against money supply (M4) and a number of other regressors. In high inflation countries, every 1% increase in the money supply is found to induce a 0.77% increase in inflation, in the long-run. In low-inflation countries, increased money supply does not have a significant effect in the long-run and decreases inflation in the short-run.

Money growth leads to inflation by increasing aggregate demand, known as demand-pull inflation. On the other hand, cost-push inflation, which follows a reduction in aggregate supply, has also been examined in the literature. Cost-push inflation is typically caused by high factor prices (Ellahi, 2017, p. 3). Global energy prices are one example of a variable which should have such an effect on factor prices, and this view is supported by existing evidence.

Jatuporn (2024) and Liang & Long (2018) both estimated the impacts of global oil price changes on CPI and PPI using ARDL and NARDL models to analyse Thailand and China, respectively. Both found evidence of cointegration using the bounds cointegration methodology introduced by Perasan at al. (2001). Both studies find that ARDL models do not find evidence of long-run effects of oil price shocks on inflation, however NARDL models can capture the effects at a 1% significance level. Jatuporn (2024) finds: +1% change in oil price led to +0.147% CPI change; -1% change in oil price led to -0.115% CPI change. Liang & Long (2018) did not find significant long-run effects due to a drop in oil prices, but found a +1% change in oil price led to a +0.143% CPI change.

Finally, there is also a lot of evidence examining the effects of a currency’s exchange rate on domestic prices. Movements in the exchange rate influence domestic prices through various channels, from direct effects on energy prices (discussed above) to indirect effects on import prices (Ha et al., 2019); this raises the price of inputs and thus the price of capital, reducing aggregate supply. The marginal effect of a 1% depreciation in the exchange rate on inflation is known as the exchange rate pass-through ratio (Ha et al., 2019, p. 271).

The exchange rate pass-through varies across countries and time (Ha, Kose, Ohnsorge, & Yilmazkuday, 2019, p. 284). Choudhri & Hakura (2001) estimated inflation as an ARDL model, using panel data of 71 countries. The explanatory variables were the nominal exchange rate and foreign CPI. No evidence of cointegration was found however the stationarity of the error term has not been settled (Choudhri & Hakura, 2001, p. 14). They find that the long-run pass-through rates in Denmark, Sweden, Norway, and the UK are 0.24, 0.03, 0.13, and 0.03, respectively – Iceland did not form part of the panel. They also determine that the main reason for cross-country variation in the pass-through rate is due to the different inflationary regimes between countries.

Section III: Timeseries variables, data and models

1. *Data sources*

The databases utilised are the IMF, OECD, Bank for International Statistics (BIS), and Federal Reserve Economic Data (FRED). CPI data was obtained from the IMF, money supply (M3) data from OECD, the exchange rate from BIS and global energy prices from FRED. The literature varies between using real effective exchange rates (Deniz, Tekce, & Yilmaz, 2016) and nominal effective exchange rates (Choudhri & Hakura, 2001; Campa & Goldberg, 2005) – in this paper I will use the nominal exchange rate following from Campa & Goldberg’s (2005) model where it is the nominal rate that influences decision-makers at the microlevel. Any monthly data was converted into quarterly data by taking the value for the last month of each quarter.

1. *Presenting and transforming the data*

Table I contains the summary statistics for Denmark in the studied period (2000:1-2023:4). This includes the consumer price index (cpi) in 2015=100, money supply aggregate M4 (m), nominal effective exchange rate index (xr) in 2020=100, and the global energy price index (gep) in 2016=100.

Table I

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Statistic** | **cpi** | **m** | **xr** | **gep** |
| Mean | 94.527 | 1271726.000 | 96.050 | 153.268 |
| Median | 96.967 | 1394929.000 | 96.120 | 148.764 |
| S.D. | 10.845 | 377165.800 | 3.815 | 64.919 |
| Min | 75.429 | 507134.000 | 85.430 | 61.703 |
| Max | 117.867 | 1922206.000 | 103.240 | 350.124 |
| Obs | 96 | 96 | 96 | 96 |

Figure I represents the variables visually in the studied period (2000:1-2023:4).

Figure I

|  |  |
| --- | --- |
|  |  |
|  |  |

To reduce data variability and find elastic relationships (Jatuporn, 2024), all variables have been transformed into logarithmic functions (lcpi, lm, lxr, lgep).

1. *Stationarity and cointegration*
2. *Testing for stationarity in each variable*

The Augmented Dickey-Fuller (ADF) test will be used to test for stationarity.

Each variable is first estimated as:

Where . To find the value of , we use the Breusch-Godfrey (BG) test which tells us how many lags should be included to eliminate serial correlation. Table II contains the , ADF test result, and order of integration for each . To calculate the order of integration, any nonstationary variables were differenced and the BG and ADF tests were conducted until a stationary differenced variable was found.[[1]](#footnote-1)

Table II

|  |  |  |
| --- | --- | --- |
| **Variable** | **ADF test result** | **Order of Integration** |
|  | ??? |  |
|  | Nonstationary |  |
|  | Nonstationary |  |
|  | Nonstationary |  |

1. *Testing for cointegration*

Because of the presence of cointegration in the literature, there is reason to suspect a long-run relationship between CPI and the money supply, exchange rate and global energy prices. If cointegration is present, nonstationary variables can be regressed without spurious correlation. Differencing leads to a loss of information and is at the expense of explanatory power (Nasir & Morgan, 2020, p. 7), so it is preferable to avoid it.

To test for cointegration, variables are estimated as follows:

Next, the fitted error term,  , is tested for stationarity using an ADF test. It is estimated as:

Where is the number of lagged autoregressive terms needed to avoid serial correlation. As in Section II.C.i, is calculated using a BG test.[[2]](#footnote-2)

In order to determine values of *p* and *q*, I will be using the AIC and BIC up to a maximum of .

Exchange rate fluctuations:

* There is reason to believe that an exchange rate peg can help to lower inflation.

1. See Appendix I for tables of ADF and BG test results [↑](#footnote-ref-1)
2. See Appendix II for tables of ADF and BG test results [↑](#footnote-ref-2)