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Inflation in Portugal Through the Lens of the Fair Model

A Inflação em Portugal da Perspetiva do Modelo de Fair

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ABSTRACT
This study delves into the dynamics of inflation in Portugal, employing a cost-push model as the analytical framework. The model is estimated using data from 2000Q2 to 2020Q1, a period predating the onset of the COVID-19 pandemic and the surge in inflation. We then produce forecasts spanning from 2020Q2 to 2023Q2. The forecasts hint strongly at a structural break during this latter period, implying that the model offers insufficient representation of inflation dynamics in Portugal. We conclude with a discussion of the model's strengths and limitations in understanding inflation dynamics, shedding light on critical aspects that impact its explanatory power.
Keywords: Cost push; econometric modeling; Fair model; forecasting; inflation.

JEL Classification: E17; E31; E37.

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1. Introduction

In 2022-2023, inflation was one of the highest worries, if not the highest, around the world (e.g., World Economic Forum, 2022) and also in Portugal (e.g., Villalobos, 2023). From 2010 to 2021, average inflation in Portugal was 1%; in 2022 inflation was 7.8%. Economic policymakers have been urged to take action against it. However, the remedies prescribed have been met with controversy. For example, the Italian, Portuguese, and Spanish governments publicly criticized the ECB's decision to increase interest rates in June 2023 (Albert, 2023).

The question of what drives inflation is not only important for designing economic policy but also a highly contentious issue. A standard model of inflation is the cost-push model. In the cost-push model, inflation is viewed as determined by the evolution of production costs. Ray Fair's macroeconometric model of the USA (Fair, 2018) is a prominent example of this approach to modelling inflation. The cost-push model may be a good modelling choice in the current context, given that the recent inflation has been associated with rising production costs, in particular energy costs, coupled with the turmoil caused by the pandemic and the war (Lane, 2022). In this paper, we use the price level equation from Fair's model (equation 10 in that model) as the starting point for analyzing the evolution of inflation in Portugal in recent years. The results presented in Silva (2023) indicate that this model may perform better than alternative models in the Portuguese case.

In Section 2, we present Fair's price level equation and describe the procedure we used for constructing the corresponding time series for Portugal. In Section 3, we present the empirical results. We first estimate the model using data for 2000Q2-2020Q1, i.e., the period before the Covid-19 pandemic and the rise in inflation. We use the model to produce forecasts for 2020Q2-2023Q2. The forecasts, along with the results of a Chow test, strongly suggest that a structural break occurred during the latter period. Section 4 discusses the results and concludes the paper.

2. The Model and the Data

2.1. Fair's price level equation

The price level equation in Fair's model is the following:

$$\log PF_t = \beta_1 + \beta_2 \log PF_{t-1} + \beta_3 a_t + \beta_4 \log PIM_t + \beta_5 UR_t + \beta_6 t + \beta_7 CB_t + \beta_8 TB_t + \varepsilon_t \quad (1)$$

PF is the price deflator for nonfarm firm sales, *a* is a measure of wage costs (discussed below), *PIM* is the import price deflator, *UR* is the unemployment rate, *t* is time, *CB* is a dummy variable that represents a break in the intercept, and *TB* represents a break in the linear trend.

To use this equation for modelling inflation in Portugal, we must specify the Portuguese time series to replace the US time series. Note that we use seasonally adjusted data to remove seasonality, which would otherwise introduce additional variation. Note also that the model is based on quarterly data; whenever the original data were monthly, we converted them by calculating the mean value. The data sources are shown in Table 1. We use the consumer price index (CPI) for *PF*, the import price deflator (the ratio of nominal to real exports, from the national accounts) for *PIM*, and the unemployment rate for the population aged 16 to 74 years old for *UR*.

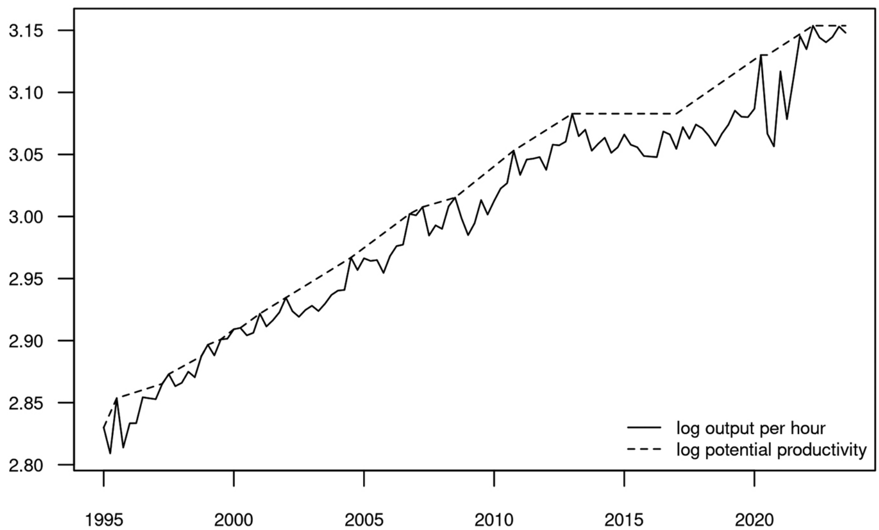
Table 1: Data sources

Time series	Sample
Imports of goods and services (current prices; quarterly)	1995Q1-2023Q3
Imports of goods and services (chain linked volume data; quarterly)	1995Q1-2023Q3
Gross domestic product at market prices (chain linked volume data; quarterly)	1995Q1-2023Q3
Total hours worked (quarterly)	1995Q1-2023Q3
Compensation of employees (current prices; quarterly) (S.1 Total economy)	1999Q1-2023Q2
Consumer price index (CPI, Base-2012)	1948M1-2023M11
Unemployment rate (Seasonally adjusted) in percentage of active population aged between 16 and 74 years old	1998M2-2023M10
Value Added Tax	1986M1-2023M11

Source: Statistics Portugal (INE) and economias.pt (in the case of VAT).

The measure of wage costs is the difference between the logarithm of the wage rate of the firm sector and the logarithm of potential productivity. We approximate the wage rate with the ratio between the compensation of employees and the number of hours worked, both from the national accounts. Fair adjusts the wage rate to incorporate the employer social security tax rate, but the Portuguese equivalent has been constant over the sample period. As for potential productivity, Fair determines it by choosing a set of peak dates and interpolating the logarithm of output per hour worked between each pair of consecutive peak dates. We proceed in a similar manner. First, we compute output per hour worked as the ratio of real GDP to the number of hours worked, both from the national accounts. Second, we determine the sequence of maxima in output per hour worked; this provides a list of candidate peak dates. Third, we eliminate candidate peak dates that result in short peak-to-peak intervals (we set the minimum size to six quarters). We then compute an interpolated series in each interval; the interpolation minimizes a function that weights the variation in the interpolated series and the deviation from the actual output per hour worked. Finally, we reintroduce some of the previously excluded candidate peak dates and recompute the interpolated series. Namely, we reintroduce those which are necessary to ensure that potential productivity is never below actual output per hour worked. The result is shown in Figure 1.

Figure 1: Potential productivity



2.2. Breaks

Fair's model of inflation also includes a deterministic component with breaks. The behaviour of inflation in Portugal has likewise been characterized by apparent breaks. Given the sample size, we allowed for five breaks and used the following algorithm to determine the break dates:

1. Start with an empty set of break dates, *A*.
2. For each date *t* in the sample:

    2.1. Add *t* to the set *A* to form a new candidate set *B*.
    2.2. Create the "break variables" corresponding to set *B*.
    2.3. Estimate a model with the break variables (besides the intercept and the linear trend) for the log of CPI (the "price level") and for the first difference of log CPI ("inflation").
    2.4. Save the sum of squared residuals (sum the squared residuals from both models).

3. Update set *A* to include the break date with the lowest sum of squared residuals in step 2.
4. If the number of break dates in *A* is less than five, return to step 2, otherwise stop.

Besides the variables used by Fair and the break variables, we included in the model the value added tax rate. One of the measures taken by the Portuguese Government to deal with the increase in inflation was to reduce the VAT rate on certain (essential) items. In the empirical model we use the normal VAT rate (currently 23%).

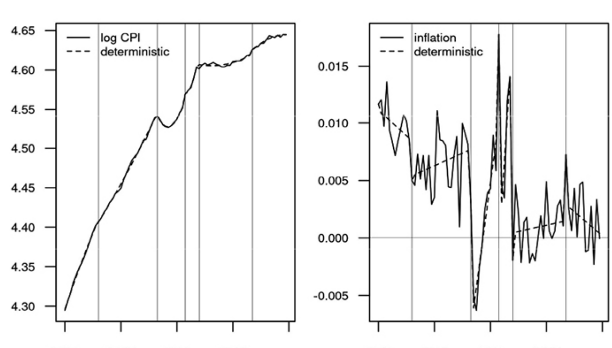
The "break variables" for each break date t_i were the following:

1) $\text{dbreak}_t = 1$ if $t = t_i$; $\text{dbreak}_t = 0$ otherwise
2) $\text{cbreak}_t = 1$ if $t \geq t_i$; $\text{cbreak}_t = 0$ otherwise
3) $\text{tbreak}_t = t - t_i + 1$ if $t \geq t_i$; $\text{tbreak}_t = 0$ otherwise
4) $\text{qtbreak}_t = (t - t_i + 1)^2$ if $t \geq t_i$ and $< t_{i+1}$; $\text{qtbreak}_t = 0$ otherwise

The quadratic terms were restricted to each interval, while the changes in the intercept and in the linear trend affected all the following observations. We made this choice because quadratic trends do not appear to be as common as linear trends in the data. Furthermore, the model for inflation used the dbreak_t, cbreak_t and tbreak_t variables, while the model for the price level used the cbreak_t, tbreak_t and qtbreak_t variables. In other words, we allow for a quadratic trend in the level, but not in the first difference. Recall that a quadratic trend in the level suggests a linear trend in the first difference, a linear trend in the level suggests a change in the intercept in the first difference, and a change in the intercept in the level suggests a dummy variable for the corresponding break date in the first difference.

In the determination of break dates, as well as in the initial analysis presented below, we used the sample 2000Q2-2020Q1. This excludes the most recent period (where inflation took off). The reason is that we want to see how a model estimated on the initial part of the sample behaves in the final part of the sample. We also exclude the initial part of the sample because there appeared to be another break in that period. Consequently, the procedure leads to the following break dates: 2003Q2, 2008Q3, 2011Q1, 2012Q2, and 2017Q1. The fitted values from the deterministic models corresponding to these break dates for the price level and for inflation are plotted in Figure 2. The vertical lines identify the break dates.

Figure 2: Fitted values of the deterministic models with breaks



3. Empirical Analysis

3.1. The pre-pandemic period

We started by estimating the following version of Fair's price level equation:

$$\log CPI_t = \beta_1 + \beta_2 \log CPI_{t-1} + \beta_3 a_t + \beta_4 \log PIM_t + \beta_5 UR_t + \beta_6 VAT_t + (\textit{break variables}) + \varepsilon_t \qquad (2)$$

However, the Breusch-Godfrey autocorrelation test rejected the null hypothesis of no autocorrelation up to order four. Therefore, we added one lag of the explanatory variables (apart from the break variables) to the model. We rewrote the model in an equivalent way in which the dependent variable is inflation and only levels lagged once and first differences appear as explanatory variables:

$$\Delta \log CPI_t = \beta_1 + \beta_2 \log CPI_{t-1} + \beta_3 a_{t-1} + \beta_4 \log PIM_{t-1} + \beta_5 UR_{t-1} + \beta_6 VAT_{t-1} + \beta_7 \Delta \log CPI_{t-1} + \beta_8 \Delta a_t + \beta_9 \Delta \log PIM_t + \beta_{10} \Delta UR_t + \beta_{11} \Delta VAT_t + (\textit{break variables}) + \varepsilon_t \qquad (3)$$

This version of the model is closer to the idea that inflation is essentially the result of an adjustment of the price level towards an "equilibrium" level defined in some way. In our model, a natural assumption is that the equilibrium level depends on the lagged levels (except the lagged price level) and on the break variables (except the observation-specific dummies). This amounts to assuming that inflation can be written as

$$\Delta \log CPI_t = \beta_2 (\log CPI_{t-1} - \textit{equilibrium level}_{t-1}) + (\text{short} - \text{run elements}) \qquad (4)$$

where β_2 should be between -1 and 0, for the adjustment towards the equilibrium level to actually occur. The "short-run elements" are assumed to have a zero mean, except in the case of observation-specific dummies.

The inclusion of the break variables greatly increases the number of explanatory variables. We use a stepwise regression procedure to eliminate statistically insignificant variables. The stepwise regression procedure removes the explanatory variable with the highest p-value exceeding 10%, re-estimates the model without that variable, and continues this process until no variable remains with a p-value exceeding 10%. The resulting model is in Table 2.

Table 2: Estimated model, 2000Q2-2020Q1

	coefficient	std. error	t-ratio	p-value
Constant	0.4009	0.0356	11.27	0.0000***
log CPI_{t-1}	-0.1270	0.0121	-10.47	0.0000***
log PIM_{t-1}	0.0296	0.0110	2.696	0.0091***
Δ log PIM_t	0.0642	0.0145	4.416	0.0000***
VAT_{t-1}	0.1204	0.0464	2.596	0.0119**
ΔVAT_t	0.2828	0.0336	8.419	0.0000***
qtbreak_20002	0.0001	0.0000	3.597	0.0007***
qtbreak_20032	0.0000	0.0000	6.189	0.0000***
cbreak_20032	0.0073	0.0023	3.233	0.0020***
tbreak_20083	0.0012	0.0002	7.762	0.0000***
dbreak_20083	0.0069	0.0013	5.189	0.0000***
qtbreak_20111	0.0006	0.0000	19.01	0.0000***
tbreak_20111	-0.0013	0.0002	-6.847	0.0000***
cbreak_20111	-0.0063	0.0013	-4.978	0.0000***
dbreak_20111	0.0094	0.0010	9.54	0.0000***
qtbreak_20122	0.0000	0.0000	2.706	0.0088***
cbreak_20122	0.0054	0.0011	5.101	0.0000***
dbreak_20122	-0.0037	0.0008	-4.518	0.0000***
cbreak_20171	0.0089	0.0029	3.035	0.0036***
dbreak_20171	0.0023	0.0007	3.544	0.0008***

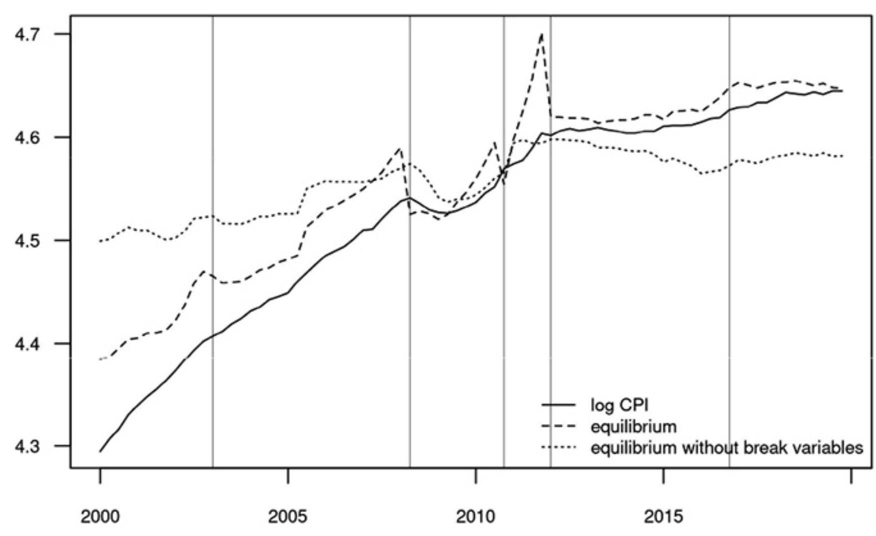
Mean dependent var	0.004525	S.D. dependent var	0.004742
Sum squared resid	0.00021	S.E. of regression	0.001872
R-squared	0.8816	Adjusted R-squared	0.844107
Log-likelihood	400.4406	Akaike criterion	-760.8812
Schwarz criterion	-713.2407	Hannan-Quinn	-741.7808
rho	-0.231809	Durbin-Watson	2.454941

Note: The dependent variable is inflation (in equation 3).

The signs of the coefficients are as expected. Namely, lagged CPI has a negative coefficient, implying a speed of adjustment towards the equilibrium level of 13% per quarter. The price of imported goods has a positive coefficient, reflecting the importance of imported inflation. The VAT rate also has a positive coefficient, suggesting that it influences the equilibrium level and therefore inflation during the adjustment period.

However, the model in Table 2 is missing two of the variables in Fair's equation: the wage pressure and the unemployment rate. This would imply that the Portuguese price level is driven by imported inflation, VAT adjustments, and a trend with breaks. In our view, this is likely an indication that the Fair model, in the format estimated here, is not well-suited to the Portuguese case. If we compare the evolution of the estimated equilibrium price level with and without the break variables – see Figure 3 – the conclusion is that the break variables account for most of the increase in the equilibrium price level. In fact, the change, from 2000Q2 to 2020Q1, in the equilibrium price level computed without the break variables is roughly one third of the change in the equilibrium price level computed with the break variables. The fact that the model does not tell us what makes the break variables behave as they do means that the model leaves a significant part of the evolution of the price level essentially unexplained.

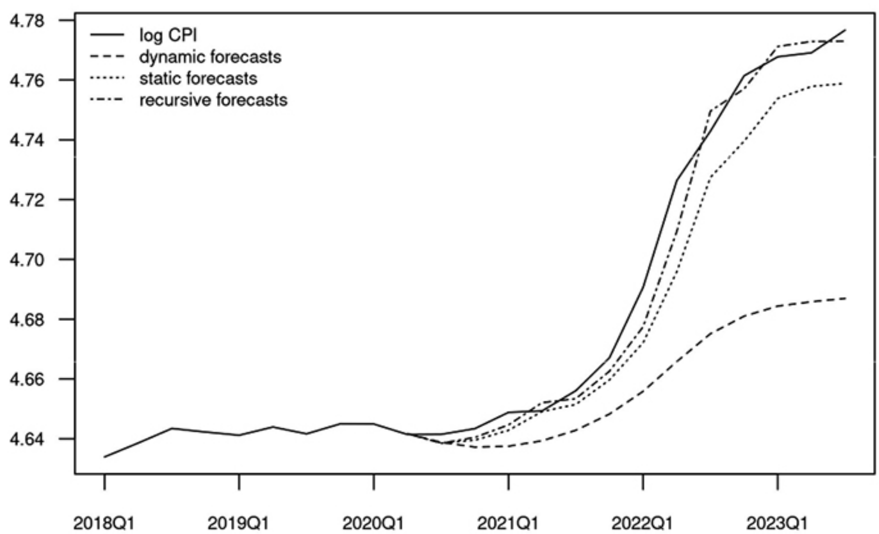
Figure 3: Equilibrium price level



3.2. Forecasts using the pre-pandemic model

Milton Friedman wrote that "The true test of a scientific theory-of a set of propositions about a class of observable phenomena-is whether it works, whether it correctly predicts the consequences of changes in conditions." (Friedman, 1968, p.15). Although in a different context, let us then give our model a chance to prove its worth in forecasting the subsequent (2020Q2-2023Q3) evolution of the price level in Portugal. We compute three sets of forecasts: dynamic, static and recursive. All of them employ the actual evolution of the explanatory variables during the forecast period. Dynamic forecasts use the forecast for the price level in the next period to forecast the price level in the period after. Static forecasts use the actual next-period price level to forecast the price level in the period after. Recursive forecasts also use the actual next-period price level to forecast the price level in the period after; in addition, the model is re-estimated in each period. The forecasts are plotted in Figure 4.

Figure 4: Forecasts 2020Q2-2023Q3



The dynamic forecasts signal an uptick in inflation (driven by import prices), but clearly understate its magnitude. Static forecasts perform better, but do not fully eliminate the gap to the actual price level. Recursive forecasts apparently track the evolution of the price level reasonably well. However, the fact that they perform much better than the other forecasts suggests that the model's parameters have changed, i.e., that another break has occurred. A Chow test, with the break date set to the beginning of the forecast period, 2020Q2, corroborates that view (test statistic $F(5,69) = 21.7086$ with p-value 0.0000).

Application of the procedure for selecting the break dates described in subsection 2.2. points to 2021Q4 as the new break date. This is the quarter before Russia invaded Ukraine. It is also a period when restrictive measures were once again imposed as a reaction to an increase in Covid-19 cases.

4. Conclusion

The analysis of the empirical model presented in this paper, based on Fair's (2018) cost-push model, sheds light on both its strengths and limitations in capturing the dynamics of inflation in Portugal. While the model incorporates explanatory variables such as import prices and VAT adjustments, and performs well in fitness measures, it falls short in fully explaining the observed fluctuations in inflation. There are several dimensions to this failure.

Firstly, the model omits variables such as wage cost pressure and the unemployment rate, which, within the framework of the model, are expected to be important for understanding inflation dynamics. Secondly, the dynamic, static, and recursive forecasts for the most recent years suggest the presence of a structural break. This hypothesis is supported by a standard Chow test. Our analysis suggests that the new break occurred in 2021Q4, coinciding with significant geopolitical and pandemic-related events. Thirdly, the dominant driver of the price level in the model is a deterministic component with breaks, but the determinants of this component remain unexplained. This leaves a notable gap in our understanding of what drives inflation.

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