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Research Article

Further evidence on core inflation in Malta: A dynamic factor model approach

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Abstract. A good core inflation measure is best placed to explain the true price pressures seen in an economy, rather than the overall index of consumer prices. This is especially so in periods of heightened inflation caused by short-lived or transitory shocks. This study defines a core inflation measure for Malta based on harmonised indices of consumer prices data from January 2006 to August 2022, using a dynamic factor model. The measure indicates that price inflation experienced in Malta post-March 2021 was not transitory in nature, and the current high rate of overall inflation is consistent with a period of persistent and generalised inflation. An understanding of the difference between core and headline inflation is particularly important for a small, open economy like Malta. The inflation rate presented in this paper is well-behaved, with a number of desirable properties: It is stable, unlike headline HICP inflation, and unbiased. The core inflation measure appears to be a good signal for policymakers and social institutions with an interest in price pressures and wage bargaining.

Keywords: Malta, core inflation, dynamic factor model.

1 Introduction

This study aims to define a measure for core inflation for Malta, that informs policymakers and is able to lead to better understanding of inflationary pressures within the Maltese economy. This is achieved in a dynamic factor model framework. A core inflation measure ought to be a timely and accurate tool for policy design. A key element of the model is the disaggregation of the inflation indices between the underlying inflationary pressure (which is defined as "core inflation") and other components that incorporate volatile or short-lived shocks to inflation indices. Typically, these tend to be found in components such as energy products or fresh food.

The idea behind this framework is that core inflation is best placed to explain the true price pressures seen in the economy, rather than the overall index of consumer prices which may include the temporary effects of energy or food price shocks. These effects will, by definition, be caused by extraneous shocks to the underlying price dynamics.

The importance of core inflation is all the more evident in the current inflationary environment. In a way, interest in the concept of core inflation increases in periods of high volatility in inflation rates. This is similar to the current environment, where higher energy, transport and food prices have been largely responsible for the upward pressures seen in inflation rates in Europe.

This upheaval resulted from the lengthening of the international geopolitical crisis following the Russian invasion of Ukraine, which affected the prices for many raw materials, such as oil, but especially natural gas. Together with supply chains reeling from the effects of the COVID19 pandemic, core inflation measures surged across the world—indicating a radically different scenario for inflation than was otherwise projected up until a year ago.

Over the past two years, the non-technical bystander has had to contend with surging prices for basic foodstuffs, and other frequent out of pocket purchases. In many cases, this environment has been very difficult to navigate.

Consumer price indices published in Malta remained stable for longer than the inflation perceptions of households. Prices do appear to rise in official indices, but not as strongly as the increase experienced by households. This study's first contribution is to try and see whether a generalised increase in prices occurred using a dynamic factor model framework. Furthermore, many other core inflation measures end up excluding such volatile components purely because of the magnitude of the price increase—even if that price increased may have mattered

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a lot to consumers. In this case, this study's second contribution is a benefit of the methodology, namely to retain these components, even if other measures exclude them.

The disconnect between observed and measured inflation results from methodological and definitional issues behind consumer price indices, which are very difficult to communicate and explain to laypersons. Typically, inflation indices are based on individual price changes to many components, which are weighted in price baskets, that are refreshed periodically to reflect household consumption patterns. Nonetheless, the difference between what is measured by statisticians and what is faced by consumers remains stark. And one is implicitly always assuming that the underlying quality of the good being measured remained the same over time. This may not always be the case in the real world. Taken together, all these pressures and pieces of information may affect how consumers form their price expectations months, or even years, ahead. Unfortunately, while prices for some items may rise strongly, overall inflation itself also has the tendency to be affected by volatility across its subcomponents. A surge in food prices may be offset by lower inflation contributions brought about by changed spending patterns, or even offset by simultaneous shifts to disinflation in inflation indices that are not frequently purchased by households.

In this sense, it is crucial to leverage as much data, at its most granular form, and apply quantitative methods to understand price dynamics. Methods that include all possible price signals—rather than those that exclude or trim volatile time series—have the distinct advantage of including all the series that matter to consumers. Crucially, any findings relating to core inflation ought to be communicated regularly to supplement the formation of price expectations by consumers.

The concept of core inflation therefore lies at the heart of monetary policy. Policymakers need to have good measures for the underlying inflationary pressures in the economy. Such measures help predict future inflation developments, allow for informed policy design, and have a recognised role in discussions dealing with collective wage bargaining, and in other social dialogue fora.

Malta, as part of the Eurosystem, follows from the European Central Bank's monetary policy decisions. The Maltese economy thus benefits from the ECB's inflation targeting regime, which focuses on annual changes in the harmonised index for consumer prices (HICP). Another important indicator for inflation in Malta is the Retail Price Index (RPI), which is the basis for the country's cost-of-living adjustment mechanism.[1]

[1] For an in depth discussion on the differences and similarities between the HICP and the RPI, refer to NSO (2008).

However, in reality, monetary policy is conducted using various inflationary measures, rather than just the overall index. This is because the HICP includes both persistent—or core—inflationary pressures, as well as temporary effects caused by such things as exchange rate movements, tax changes, as well as short-lived inflationary shocks linked with the prices of raw materials, or energy. These transitory inflation effects, that are temporary in nature, are usually ignored in the formation of monetary policy.

While core inflation is an important instrument in the monetary policy toolbox, there is no generally agreed definition for it. Thus, there are many different measures of core inflation. Those published for the Maltese economy be defined to be either statistical or exclusionary in nature. The exclusionary measures are calculated by Eurostat, which computes a monthly measure of inflation that excludes volatile subcomponents such as energy, food and others. These indices may also be thought of to reflect supply shocks, as well as those prices that are regulated by government. Finally, the statistical measures remove volatile subcomponents from the HICP based on some statistical ranking or ordering, typically over the span of a month.

2 Literature review

The literature on core inflation is wide-ranging in terms of definitions, applications and use for this particular term. Going back to Eckstein (1981), core inflation was identified as the change in prices that happens when an economy is on its long-run growth path. A monetarist perspective, followed by Bryan and Cecchetti (1994), links core inflation with money supply growth rate patterns. Quah and Vahey (1995), on the other hand, relate core inflation with the part of observed inflation which has no medium or long run effect on real output.

Blinder (1997) defines the durable element of measured inflation as "core inflation", suggesting that is an important component to forecast overall inflation rates. Wynne (1999) suggested a series of desirable properties that ought to be part of an ideal core inflation estimate. This study suggests that a core inflation measure should be unbiased, in that it only removes the volatile or transitory element from the inflation rate.

The measure should be timely, that is, computable in real-time and easily comparable with the overall inflation rate. In that regard, it should be stable over time and not overly sensitive to vintages of data—unless the underlying data is changed significantly. Finally, the core inflation measure should be easily understood by the general public. Ideally, it should also be reproducible without unduly complex computations. Fuhrer (2009) provides a further definition for core inflation, by using a Phillips curve-based model with rational expectations, and splits inflation persistence using intrinsic, extrinsic and expectations-based definitions.

Turning to Malta, Ellul (2011) proposed a trimmed mean core inflation measure for Malta, while Gatt (2014) carries out an evaluation of different core inflation measures for the Maltese economy. Micallef and Ellul (2020) look into the discussion of the persistence of prices in Malta, compared to the rest of the euro area.

An established measure for core inflation is found in the factor model literature. Using disaggregated indices, an underlying component which is common to all subindices is extracted, and this in turn will represent general inflation developments. Various academics and central banks have applied these methods. Kapetanios (2002) builds a dynamic factor model to estimate a common inflation component for the UK.

Cristadoro et al. (2005), apply the same approach for the euro area, and Giannone and Matheson (2007) define one for New Zealand. Kim and Ahn (2012) study a dynamic factor-based measure for South Korea, while Einarsson (2014) constructs a core inflation measure for Iceland. More recently, Bańbura and Bobeica (2020) build a persistent and common component measure of underlying inflation in the euro area using a dynamic factor model.

3 Data

The HICP and its subindices are published monthly by the National Statistics Office and Eurostat. Once series with discontinuities or having missing values are removed, a total of 76 subindices remain. For the purposes of this study, the time period is limited to January 2006 to August 2022. The overall HICP inflation is excluded in the panel for the computation of core inflation. The model is estimated using the annual change in the index, which is then standardised by subtracting its mean and dividing by the standard deviation, before estimation.

Annual inflation, as measured by the HICP, averages 1.9% in the 200 months from January 2006 to August 2022, with a standard deviation of 1.50. Before 2022, the maximum observed for overall HICP is 5.7% in October 2008, while the minimum is - 1.1% in April 2007. Likewise, the pattern for inflation as measured by the RPI is similar to the annual inflation in the HICP. It averages 1.8% for the comparable period, with a standard deviation of 1.38.

4 Methodology

This model assumes that HICP inflation, π_t, can be split in two components that are orthogonal to one another.

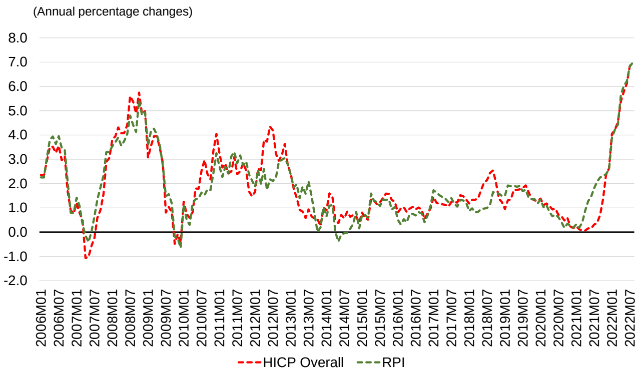

Figure 1: Inflation in Malta.

One is a core component of inflation, π_t^C, while the other is a non-core component, π_t^{NC}, or mathematically:

$$\pi_t = \pi_t^C + \pi_t^{NC} \tag{1}$$

and π_t^C captures all the underlying pressures of inflation caused by 'core', generalised or persistent inflation, while π_t^{NC} refers to transitory changes in prices, which are exceedingly short-lived and reflect non-core inflationary pressures. The use of a factor model can be justified if one assumes that π_t^C or core inflation is that part of inflation that is common across all sub-categories of the HICP, and π_t^{NC} is idiosyncratic. Factor models describe changes within a number of variables in terms of the sum of one, or multiple, variables which mirror the co-movement of the variables themselves—along with an error term that captures the idiosyncratic effect, that remains unexplained. Furthermore, by assuming some sort of distributed lag relationship within the panel and cast the variables, their co-movement and the error term, in a time series dimension, one is able define a dynamic factor model. To simplify, for a group of inflation series derived from multiple sub-indices, π_{it}, a simple dynamic factor model can be defined as:

$$\pi_{it} = L_i F_t + e_{it} \tag{2}$$

and F_t is the common factor—which changes over time—while L_i are the factor loadings for each inflation sub-index i in the panel. Moreover, F_t follows an AR(2) process, such that:

$$F_t = c + \rho_1 F_{t-1} + \rho_2 F_{t-2} + v_t; \quad V(v_t) = Q \tag{3}$$

e_{it} is assumed to follow an AR(1) process, such that:

$$e_{it} = \alpha_i e_{it-1} + \epsilon_{it}; \quad V(\epsilon_{it}) = R_i \tag{4}$$

The same concept was applied in Ellul and Ruisi (2022) to GDP data, with the factor model estimated here shar-

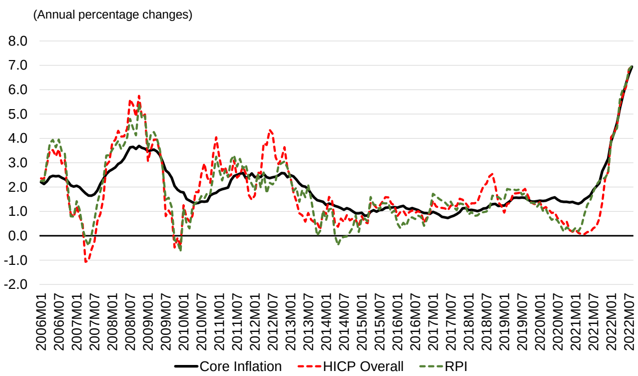

Figure 2: Core inflation in Malta.

ing a very similar estimation methodology.[2] The inclusion of the Kalman filter in the model introduces a drawback due to the revision of the estimation. As the HICP index, however, is very rarely revised, the revisions are expected to be minimal in nature, and linked with the end-bias problem, rather than with the model's estimation method. By combining (1) and (2) above, it can be shown that core inflation is the multiple of the factor loading L_i for overall inflation and the common factor. Implicitly, this means that the transitory component will be subsumed in the idiosyncratic error term.

5 Results

The core inflation series, resulting from the dynamic factor model, is presented in Figure 2 along with the HICP overall inflation and that derived from the RPI. One can see immediately that the core inflation measure follows very closely developments in HICP and RPI, but—crucially—does not have the sharp volatility seen in the other time series. In fact, the only time it diverges significantly from the other two indices occurs from mid-2020 onward. While the HICP and the RPI tracked down, the core inflation measure remained in the region of 1.5%. It then accelerated sharply from March 2021, with the RPI inflation catching up to it only in July 2021 and HICP inflation in February 2022. The three inflation rates remain in close proximity thereafter, meaning that inflation has become more persistent. The largest difference with respect to core inflation occurs in April 2007 for the HICP inflation series (2.8 percentage points) and in December 2009 for the RPI (2.4 percentage points). Both periods where characterised by sharp and short-lived price shocks caused by the prices of energy and other raw commodities. Interestingly, the period of decelerating and negligible price inflation seen in official statistics from March 2020 to early 2021 appears to be missing from the dynamics of core inflation completely. In fact, the core inflation measure remains steady in this period at around 1.5%. It then begins a sharp upward increase, together with the inflation as measured by the RPI, and then—finally—joined by the overall HICP annual inflation rate.

5.1 Evaluation

The correlation between the core inflation measure and HICP inflation stands at 0.79, while that with respect to RPI inflation is 0.86. One has to be careful when constructing tests to check for core inflation's ability to track generalised price developments. As noted above, overall inflation has elements within it that are by definition excluded from core inflation. It should not be expected that the inclusion of core inflation in an equation with headline inflation will bring a meaningful improvement in residual mean square errors (RMSEs).[3] The approach discussed in Cogley (2002) remains the benchmark in the literature. In fact, the same, or a similar framework for predictive evaluation is applied in various studies on core inflation or stickiness in prices, such as Reiff and Várhegyi (2013) for Hungary, Erlandsen (2014) for Norway, Einarsson (2014) for Iceland, and Amstad and Potter (2009) for the US. In this approach, to test the core inflation index's ability to track headline inflation, two equations are estimated at varying steps ahead, that is:

$$\pi_{t+h} - \pi_t = \alpha + \beta(\pi_t - \pi_t^C) \quad (5)$$

$$\pi_{t+h}^C - \pi_t^C = \gamma + \zeta(\pi_t^C - \pi_t) \quad (6)$$

where π_t is overall HICP inflation and π_t^C is the core inflation measure discussed above. The first equation tests if the core inflation rate specified in the dynamic factor model "forecasts" future inflation. The definition used here is a check on whether the difference between headline inflation and core inflation forecasts the headline inflation rate over a step ahead of h. In this framework, the coefficient for β has to be statistically significant and negative. Moreover, if one cannot reject that $\alpha = 0$ and $\beta = -1$, the core inflation measure will be an unbiased predictor for inflation at step h.

The second test specified in this framework is a weak exogeneity test on the difference between the core inflation rate against the headline inflation rate over a step

[2] The model presented in this study, however, is estimated in Python 3.10.

[3] In fact, adding core inflation lagged by one period to track headline inflation does not lead to significant RMSE improvements. Relative RMSEs with respect to a simple autoregressive model for headline inflation equal unity only at the 12-step ahead horizon. Relative RMSEs stand at 1.6 in the 1-step ahead horizon, 1.4 in the 2-step horizon, and stand in a range between 1.1 and 1.2 for the 3 to 11 step ahead scenarios, before reaching unity in the 12-step ahead horizon.

		Equation (5)		Equation (6)	
		α	β	γ	ζ
3-month	Coefficient	-0.04	-0.35	0.07	0.02
	t-Statistic	-0.54	-4.89	2.50	0.59
	Standard error	0.07	0.07	0.03	0.03
6-month	Coefficient	-0.03	-0.82	0.11	-0.06
	t-Statistic	-0.29	-8.06	2.14	-1.07
	Standard error	0.10	0.10	0.05	0.05
9-month	Coefficient	0.01	-1.38	0.12	-0.23
	t-Statistic	0.06	-12.26	1.78	-3.35
	Standard error	0.11	0.11	0.08	0.08
12-month	Coefficient	0.00	-1.82	0.12	-0.39
	t-Statistic	0.04	-16.32	1.60	-4.98
	Standard error	0.11	0.11	0.08	0.08
18-month	Coefficient	0.00	-1.74	0.14	-0.53
	t-Statistic	-0.84	-14.50	1.60	-5.74
	Standard error	0.11	0.12	0.08	0.09
24-month	Coefficient	-0.11	-1.30	0.13	-0.42
	t-Statistic	-0.93	-10.18	1.41	-4.21
	Standard error	0.12	0.13	0.09	0.10

Table 1: Estimates for coefficients - Predictive ability and weak exogeneity.

ahead period h. This is done by testing if $\gamma = 0$; $\zeta = 0$. The results for these tests are presented in Table 1.

Equation (5) and Equation (6) are estimated for six h-horizons, namely the 3-month, 6-month, 9-month, 12-month, 18-month and 24-month ahead scenarios. Focusing on the α parameter from Equation (5), it is never statistically significantly different from zero. The β is always negative, and statistically different from zero.

A check on the weak exogeneity of the core inflation measure can be carried out by looking at the rightmost columns of Table 1. The parameter γ is either not statistically significantly from zero, or the coefficient is very close to zero (0.07 in the 3-month ahead period, 0.11 in the 6-month ahead). On the other hand, the ζ parameter indicates that while no bias is seen in the 3-month to 6-month ahead horizons, a negative bias of between -0.2 and -0.5 may be occurring in the core inflation measure with respect to overall HICP. This may be explained by the post-March 2020 observations, and the sharp downward swings seen in Maltese overall HICP rates.

The measure appears to benefit from a set of desirable properties as a measure of core inflation. It tracks well inflationary developments, and is a more smooth and unbiased measure of inflation in Malta. This confirms broadly the same findings for the euro area as a whole from Bańbura and Bobeica (2020).

6 Conclusion

The core inflation rate measure discussed in this study appears to be able to provide an unbiased and weakly exogenous forecast for overall inflation in the short to medium term. Factor modelling is admirably suited to extract common trends from HICP sub-indices. The core inflation measure appears to have a number of desirable properties for policymakers. For example, the inflation rate presented by the core inflation dynamic factor model does not have the sharp upward or downward swings found in Maltese overall HICP data, and it appears to be a good signal for policymakers and social institutions with an interest in price pressures and wage bargaining. It is not only smoother, but also unbiased.

The results confirm that underlying inflation in Malta remained high through out 2020, while all other official inflation statistics showed lower inflation rates. This means that households in Malta have been experiencing inflationary pressures for a far longer period than official statistics suggests. This matters because any collective wage-bargaining based on official statistics that do not capture these inflationary biases will discriminate in favour or against households—depending on the deviation of official statistics with respect to core inflation.

Some potential avenues for further research and drawbacks of this approach have to be highlighted. An extension of the core inflation exogeneity and unbiasedness tests with other measures for core inflation, such as trimmed mean indices, persistence weighted or exclusion measures can be a valid contributor to this area of research. Finally, the Kalman filter element within the dynamic factor model defined here may lead to some revisions in the core inflation rate at the end-points, as additional data are added.

In any case, the dynamic factor model-based core inflation measure is able to describe the true, underlying inflationary pressures in the Maltese economy, and highlights the unique nature of the inflationary environment from March 2021 onward, and the implications to Maltese households

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