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December 2016

Working Paper 2016-6

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Examining the Time-Variation of Inflation Persistence in Ten Euro Area Countries

Nektarios A. Michail*

Abstract

Inflation persistence in ten Euro Area economies is examined, using a long series of monthly data. Full sample estimates find persistence to be close to unity and tests for structural breaks show that while these exist, they are rare. Rolling estimates of persistence, based on a mean reversion measure, suggest that even though persistence has been volatile, it has not reached values below 0.8. The findings lend support to the view that the introduction of the common currency has reduced inflation persistence in many countries. In contrast, the global financial crisis appears to have had a positive impact on persistence.

Keywords: inflation, persistence, euro area, mean reversion

JEL Classification: E31, C22, E52

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1. Introduction

Persistence is the economic analogue of inertia in physics, i.e. whether a variable shows a tendency to stay near where it has been recently, absent other economic forces that move it elsewhere (Fuhrer, 2009). Understanding the patterns and examining the path of inflation persistence is important for policy-makers since persistence, and subsequently price-stickiness, has immediate consequences for the conduct of monetary policy.

Specifically, knowing the extent to which inflation tends to approach its equilibrium level after shocks, offers important information to central banks regarding their appropriate response for the restoration of price stability. For example, the horizon over which monetary policy should aim for price stability depends on the persistence of inflation: higher persistence suggests that inflation can take longer to stabilise following a shock. As such, the degree of inflation persistence can be seen as an important factor for determining the medium-term orientation of monetary policy while, in addition, it can be argued that the persistence of inflation is a major determinant of the economic costs of disinflation through its influence on the “sacrifice ratio” (see Fuhrer, 1995; Fuhrer and Moore, 1995; Roache, 2014).

As a consequence, a great part of the academic literature has dealt with this issue. Of the most important contributions are O’Reilly and Whelan (2005) who examine inflation persistence over time using a euro area aggregate series and Pivetta and Reis (2007) who test for changes in persistence for the US. Both find that persistence, while high, does not vary much over time and, notably, both suggest that most of the shocks in inflation took place in the 1970s.

Other euro area studies such as Angeloni et al (2006), who employ data on six euro area countries, suggest that despite all the benefits of the European Monetary Union (EMU), it did not have a direct effect on inflation persistence. Franta et al (2007), using autoregressive and structural models, compliment this result and test whether there are differences in the inflation persistence of new EU member states compared to the existing member states. Their results suggest that persistence may not be so different, once time-varying means are employed.

A comprehensive study was conducted by Lunnemann and Mathä (2004) who analyse the degree of inflation persistence across 94 HICP sub-indices and 17 EU countries. The results indicate substantial heterogeneity across countries and indices and a very moderate mean and median persistence at the disaggregate level. Based on both parametric and non-parametric measures, they reject the unit root hypothesis of persistence, but cannot reject the hypothesis of zero persistence. Similar results were also presented by Gadzinski and Orlandi (2004).

An innovation in the inflation persistence literature is found in Dias and Marques (2010) who propose the use of a non-parametric measure of inflation persistence. This measure uses the fact that persistence and mean reversion are inversely correlated and measure mean crossings to obtain the level of persistence. As such, this measure is defined independently of the underlying data generating process, thus making it broader than other measures and, as a consequence, making it immune to potential model misspecification. Given that it is a non-parametric statistic, it is also robust against outliers in the data.

Nevertheless, with all the benefits of this measure, it has not yet been employed to examine time-variation in inflation persistence. In addition, most of the above studies are limited by the small sample span of indices and since most euro area studies employ quarterly data, dangers from temporal aggregation (see, Paya et al, 2007) exist.

By making use of a long series of monthly data for ten euro area economies, the rest of the paper suggests that full sample estimates show persistence to be close to unity. Testing for structural breaks shows that while these exist, they are rare in the data. In addition, rolling estimates of the non-parametric measure suggest that even though persistence has been volatile through time, it has not reached values below 0.8.

The findings of this paper lend support to the view that the introduction of the common currency in 1999 may have reduced inflation in most countries, while it had no effect in others. In contrast, the global financial crisis appears to have had a positive impact on persistence in some countries. Overall, the evidence is in line with the persistence of low inflation in the euro area since at least 2012.

The rest of the paper is organised as follows: the next section offers an outline of the usual persistence measures and the mean reversion one, section 3 presents an overview of the data with descriptive statistics and full sample estimates, section 4 shows the findings from the rolling estimates and section 5 concludes.

2. Measuring persistence

2.1. Common measures of persistence

In order to specify persistence, the following k^{th} order autoregressive representation for inflation is usually estimated:

$$\pi_t = \theta_{0,t} + \sum_{i=1}^{k} \vartheta_{i,t}\, \pi_{t-i} + \epsilon_t \qquad (1)$$

This structure explicitly allows for changes in persistence over time to be driven by changes in the $k+1$ parameter vector $\theta_t' = (\theta_{0,t}, \theta_{1,t}, \theta_{2,t}, \dots, \theta_{k,t})$. Intuitively, the estimates of persistence at time t will reflect what inflation is expected to be at time $t+s$ conditional on all the present and past values of inflation from time t backwards. To measure the effects of persistence, two scalar functions of the parameter vector θ_t, which serve as measures of persistence have usually been employed.

The first is the largest autoregressive root (LAR), denoted by ρ. If L denotes the lag operator $L^j x_t = x_{t-j}$, then the lag polynomial associated with equation (1) can be specified as $1 - \theta_1 L - \dots - \theta_k L^k = (1-\rho L)(1-b_1 L) \dots (1 - b_{k-1} L)$ where $\rho, b_1, \dots, b_{k-1}$ are the autoregressive roots of which ρ is the largest. The size ρ is a key determinant of how long the effects of a shock will persist since, in the distant future, the impulse response of inflation to a shock will be dominated by the largest autoregressive root. The second measure of persistence, and the most commonly used, is the sum of coefficients in the autoregressive process (SUM), defined as $\gamma = \sum_{i=1}^{k} \theta_k$. Intuitively, a larger γ corresponds to higher persistence of inflation, while the cumulative effect of a shock is given by $1/1-\gamma$, for $\gamma \in (-1,1)$. [1]

However, even though both measures can be good approximations to persistence, both have important issues: for example, LAR ignores the effects of other roots, which can have a strong effect on the results, while SUM is prone to model mis-specifications. Furthermore, SUM does is not well-suited to be employed for the estimation of the speed of decay and can provide misleading inferences as it is larger for processes in which inflation rises quickly.

[1] In some studies (e.g. Pivetta and Reis, 2007), the half-life of a shock, defined as the number of periods in which inflation remains above 0.5 after a unit shock, is also employed. While this measure also has its faults and benefits, it has been more popular in the PPP literature.

2.2. Mean-reverting measure of persistence

To overcome the drawbacks of these measures, Dias and Marques (2010) provide an alternative, more intuitive and yet statistically valid measure of persistence. Specifically, they base the measure on the fact that persistence and mean reversion are inversely correlated: the higher the frequency of mean crossings the less persistent the series is. For example, if a persistent series is the one which converges slowly to its equilibrium level (i.e. the mean) after a shock, then such a series should, by definition, exhibit a low level of mean reversion. In contrast, a non-persistent series should revert to its mean very rapidly.

Building on this, they show that persistence can be measured non-parametrically using the following specification:

$$\hat{\gamma} = 1 - \frac{n}{T} \qquad (2)$$

in which $\hat{\gamma}$ denotes the measure of persistence (henceforth denoted as MR), n the number of mean-crossings and T is the number of periods. Specifically, the sample mean is estimated and then subtracted from the inflation series in order to obtain a series of mean-deviations. Then, n is computed by measuring the periods in which the mean-deviation series crosses zero.

To test whether persistence is statistically different from a random walk (in which case $\gamma = 0.5$), Dias and Marquez (2010) offer the following statistic:

$$\frac{\sqrt{T}(\hat{\gamma} - 0.5)}{\sqrt{0.5}} \qquad (3)$$

which is asymptotically normally distributed and thus inference can be made using conventional methods.

An important benefit of this measure is that $\hat{\gamma}$ is defined independently of the underlying data generating process (DGP), provided that stationarity is assumed, which makes it a broader measure than ρ. This has the additional benefit of making $\hat{\gamma}$ immune to potential model misspecification. In addition, given that it is a non-parametric statistic, it is also robust against outliers in the data.

3. Data description and full sample estimates

Monthly data on the Consumer Price Index were obtained from the IMF's International Financial Statistics (IFS) to serve as the measure for the price level (P_t). As Paya et al (2007) demonstrate, the use of monthly data avoids the issue of generating persistence due to temporal aggregation at the quarterly level. Inflation is defined as the monthly percentage change of the price level from a year ago. The choice of sample countries was based solely on data availability. Sample countries and data ranges can be found in Table 1.

Table 1: Data description

Country	**Data Range**
France	1960:01-2015:03
Italy	1960:01-2015:03
Spain	1960:01-2015:03
Netherlands	1960:01-2015:03
Belgium	1960:01-2015:03
Austria	1960:01-2015:03
Finland	1960:01-2015:03
Portugal	1960:01-2015:03
Greece	1960:01-2015:03
Germany	1992:01-2015:03

Table 2 presents the average inflation rates in the sample countries covering six decades. As can be observed, inflation started at relatively low rates in the 1960s in most countries. In the 1970s, following the oil shock, inflation increased and reached its peak in most countries (excluding Portugal and Greece), while in 1980s it remained at higher rates.

Table 2: Mean inflation per decade

Country	1960s	1970s	1980s	1990s	2000s	2010s
France	3.87	8.90	7.39	1.89	1.73	1.32
Italy	3.48	12.47	11.39	4.13	2.27	1.61
Spain	5.77	14.40	10.26	4.22	2.96	1.55
Netherlands	4.13	7.06	2.88	2.45	2.13	1.80
Belgium	2.66	7.14	4.90	2.15	2.12	1.84
Austria	3.35	6.10	3.84	2.41	1.99	2.13
Finland	5.05	10.41	7.32	2.14	1.76	1.83
Portugal	4.02	17.17	17.70	5.94	2.60	1.46
Greece	1.95	12.38	19.50	11.13	3.16	1.18
Germany	N/A	N/A	N/A	2.35	1.59	1.42
Average	**3.81**	**10.67**	**9.46**	**3.88**	**2.23**	**1.61**

From the 1990s onwards, inflation decreased to values less than 4% in most countries, continuing its decrease into the 2000s and stabilising at values close to 2% in the 2000s. In the 2010s inflation further decreased, an outcome of both the global financial crisis as well as the European sovereign debt crisis.

3.1. Full sample estimates

The full sample estimates of inflation persistence using the three measures presented above can be found in Table 3. For the estimation of LAR and SUM, the number of lags in the inflation process was selected on the basis of the significance of the lagged terms. Specifically, only those lags which were significant at the 5% level were included in the full sample estimation.

In all three measures, full sample inflation persistence is close to unity, suggesting the possible existence of a unit root in the estimates. However, if the conditional mean of the coefficient estimates is not constant over time. As Marquez (2004) and O'Reilly and Whelan (2005) comment, full sample estimates lack the ability to capture this possible time-varying behaviour. The implications of such failure could as Franta et al

(2007) suggest be important. Consequently, it is of interest to test the general null hypothesis of parameter stability.

Table 3: Full Sample Estimates

	No. of lags	LAR	SUM	MR
France	3	1.23	0.99	0.98
Italy	3	1.31	0.99	0.98
Spain	2	1.2	0.99	0.96
Netherlands	2	0.87	0.98	0.95
Belgium	2	1.26	0.99	0.96
Austria	1	0.97	0.97	0.92
Finland	3	0.93	0.99	0.97
Portugal	2	1.17	0.99	0.98
Greece	2	1.32	0.99	0.99
Germany	1	0.95	0.95	0.88

To perform such an analysis, instead of carrying out a traditional Chow test, in which a specific break date is defined, three alternative tests, which do not assume any prior knowledge of potential break dates, are employed. The first is the Quandt-Andrews sup-F statistic, which is the maximum of a sequence of traditional Chow χ^2tests for structural change, each based on a different potential breakpoint (see Quandt, 1960 for the original specification and Andrews, 1993, for its asymptotic distribution). The second is the exp-F statistic which is based on a weighted average of the full sequence of χ^2tests (see Andrews and Ploberger, 1994). Finally, the third breakpoint test is by Bai and Perron (2003), which allows for more than one unknown structural break in the data. The test results are shown in table 4.

All three tests suggest that in most countries a break in the series has occurred, usually in the early 1970s. The only country in which a structural break is not found is Germany, a result attributed to the small sample size. For the rest of the sample countries, the Quandt-Andrews test suggests the rejection of the null of parameter stability at least at the 10% level. In addition, the dates in which the maximum Chow test values is reported are in accordance with the Bai-Perron break dates. This further strengthens the case in favour of parameter instability, but also suggests that, as with Lunnemann and Mathä (2004), breaks appear to be rare in the series.

Table 4: Unknown breakpoint tests for structural breaks

	Quandt-Andrews			Andrews-Ploberger		Bai-Perron	
	F-statistic	p-value	Date	F-statistic	p-value	Break 1	Break 2
France	8.03	0.00	1982M04	2.38	0.00	1972M06	1982M04
Italy	10.08	0.00	1974M11	2.23	0.00	1974M11	1983M05
Spain	4.19	0.08	1977M09	1.07	0.13	None	None
Netherlands	12.48	0.00	1969M01	3.11	0.00	1969M01	None
Belgium	8.25	0.00	1974M12	1.58	0.03	1974M12	None
Austria	14.61	0.00	1970M03	4.69	0.00	1970M03	None
Finland	5.96	0.00	1972M02	1.33	0.04	1972M02	1981M07
Portugal	5.18	0.03	1991M07	0.66	0.40	1991M07	None
Greece	15.58	0.00	1974M12	5.60	0.00	1974M12	1991M01
Germany	1.88	0.77	None	0.27	0.83	None	None

Tests report overall parameter instability (both intercept and persistence). Separate tests for the two are available upon request. In all three tests, the usual 15% observation trimming was used. The results in this table make use of the Likelihood Ratio (LR) form of the test, but similar conclusions are reached using the alternative Wald tests.

It should be remembered though that, as Diebold and Chen (1996) suggest, concerns regarding the reliability of estimates in finite samples are likely to be important. In addition, as O'Reilly and Whelan (2005) show, asymptotic distributions can overstate the evidence for structural breaks in the inflation process of the sample countries. Thus, to further examine the extent of the change in coefficient values, and, more specifically, how these behaved after 2010, the following section presents rolling regression estimates of inflation persistence.

4. Rolling estimates of persistence

Despite being more informal and providing more varied results, rolling estimates have the advantage of allowing for greater flexibility in detecting structural changes over time, since each rolling sample allows for completely different sample mean. Estimates are reported from a sequence of short rolling samples, in this case a 10-year window.

Specifically, the MR measure is estimated by computing the unconditional mean of 120 observations for each rolling sample, and then deducting from the actual values to create the mean-deviation series. The amount of mean (zero) crossings is then calculated. Using equation (3), all results are statistically different from a white noise process (0.5) at the 1% level.

Figure 1 presents the results of this exercise. Overall, inflation persistence is higher than 0.8 in all countries across all rolling samples. The maximum value of inflation persistence was 0.99 and was usually associated with oil-shock period of the 1970s. Nevertheless, country-specific periods of high persistence also appear in the results, such as the late 1980s-early 1990s for France, the early-to-mid 1990s for Netherlands, the late 1990s for Portugal and the early 2000s for Italy and Greece.

The estimates also suggest that inflation persistence has been on a declining path since the introduction of the common currency in 1999. This is more evident in the case of France, Italy, Spain, Austria and Portugal. Even though it is less evident for Netherlands and Belgium, it should be noted though that for these two countries inflation persistence was on average less during the 2000s than the 1990s. In Greece, inflation persistence declined only after 2005, but was also lower on average during the 2000s than the 1990s. A comparison for Germany cannot be made due to the small sample size.

The periphery countries and France, faced an increase in inflation persistence after the global financial crisis and the subsequent sovereign debt crisis. Specifically, inflation persistence in Greece increased by approximately 15% in the last rolling window, compared with 2008, while double-digit percentage increases are also observed in Portugal, France and Spain. In Netherlands, the increase was much more gradual, with a similar response observed in Germany and Finland. Belgium, Austria and Italy did not register substantial changes in inflation persistence post-2008.

Consequently, the results of this section lend support to two insights: first, the introduction of the euro assisted in reducing inflation persistence in most of the sample countries. Even though for some countries this reduction cannot be observed clearly from Figure 1, overall inflation persistence during the 2000s was lower than the 1990s. Second, the global financial crisis in conjunction with the European sovereign debt crisis has increased inflation persistence, mostly in the countries which were more severely hit (Greece, Portugal, Spain and to a lesser degree France). This insight is in line with the persistence of low inflation in the euro area since 2012 (ECB, 2014).

5. Conclusions

Overall, the results from this analysis suggest that while inflation persistence has been high in full sample estimates, it has not been stable over time. Specifically, it appears that the introduction of the euro may have had a negative effect on inflation persistence in most sample countries, while it has not affected others. In contrast, the global financial crisis and the subsequent sovereign debt crisis appear to have increased persistence, especially in the countries which were more severely hit. The latter is in line with the persistence of low inflation in the euro area since 2012.

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Figure 1: Rolling Sample Estimates of Mean-Reverting Measure of Persistence

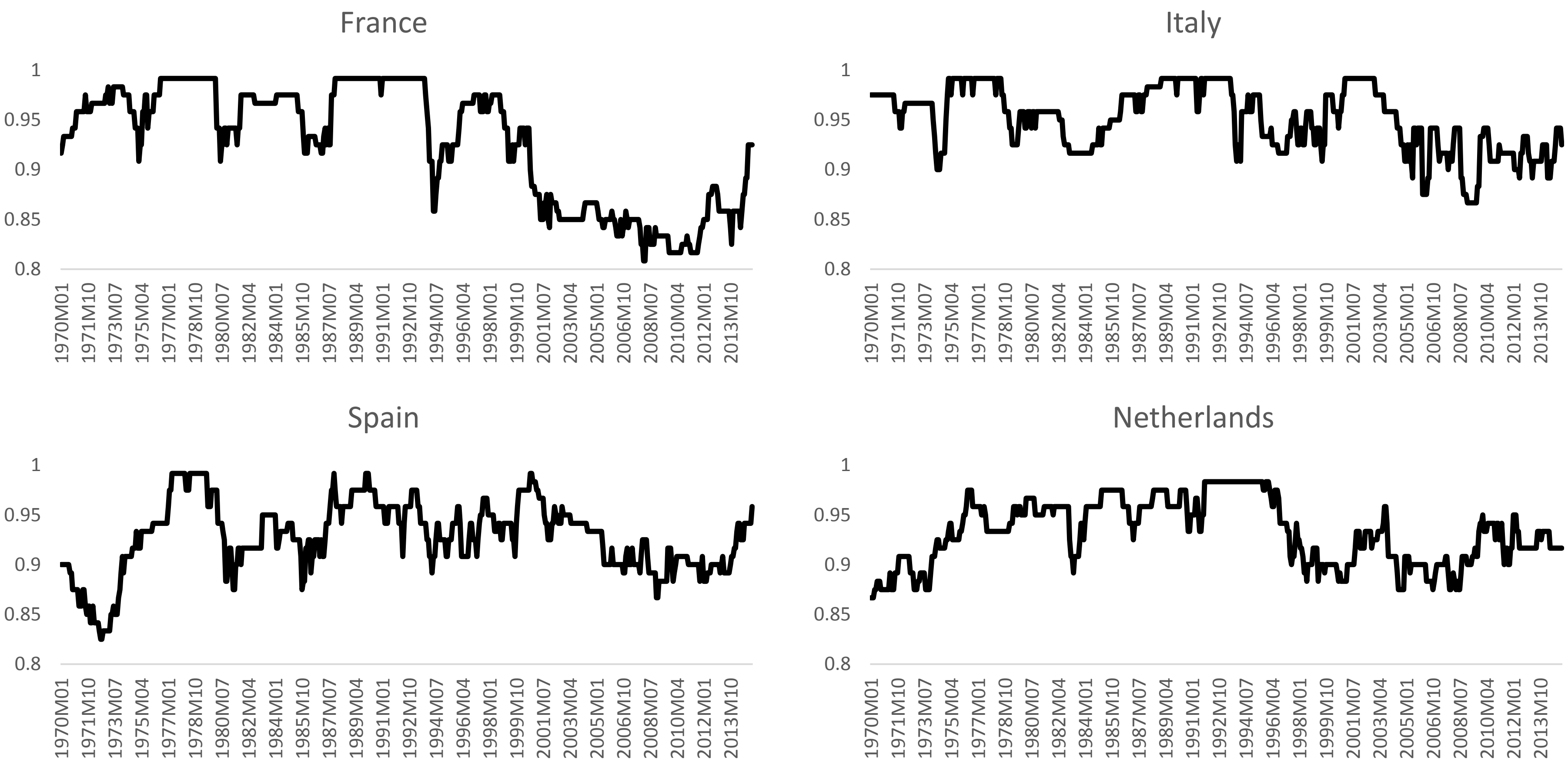

Figure 1: Rolling Sample Estimates of Mean-Reverting Measure of Persistence (cont.)

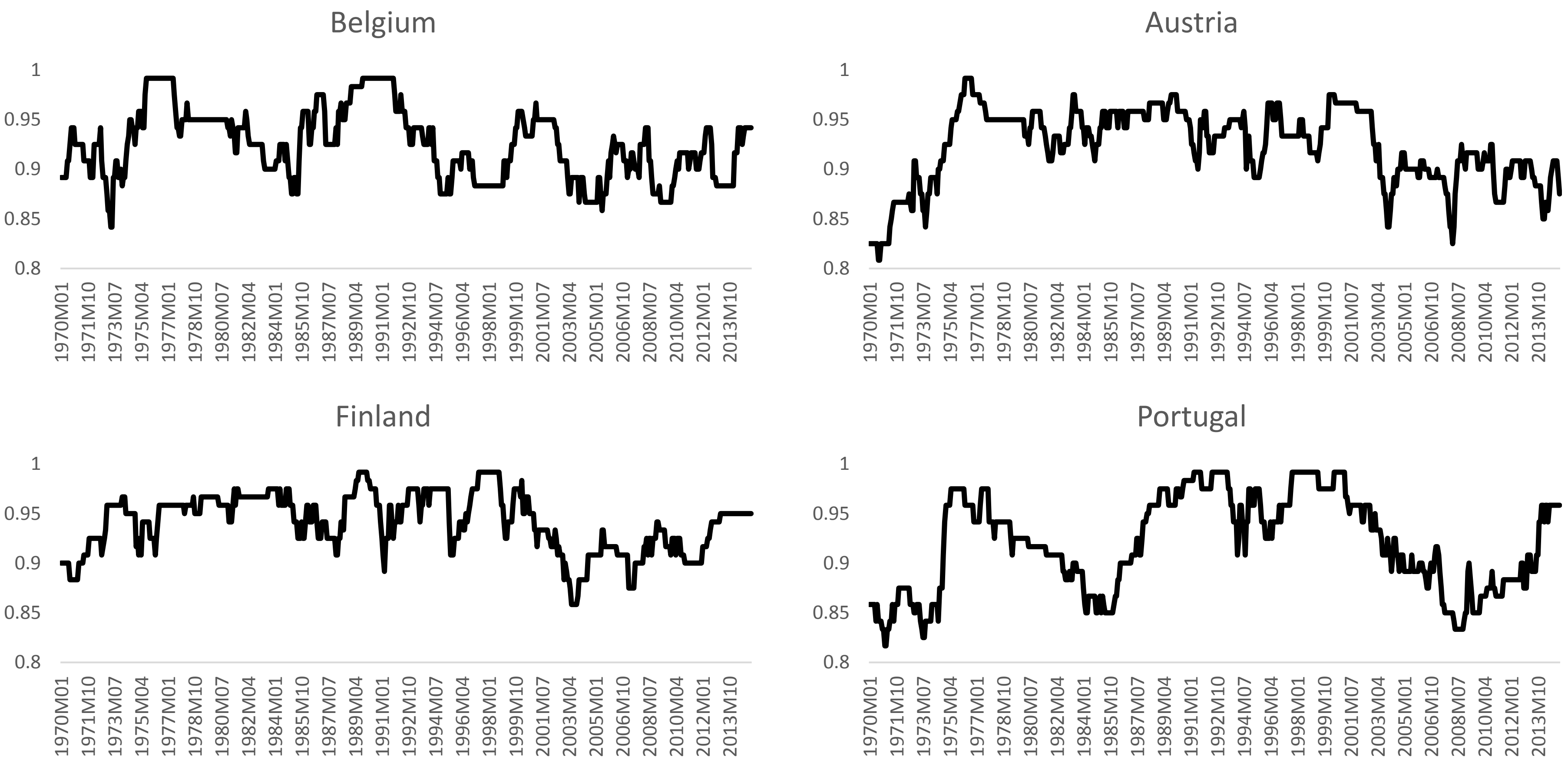

Figure 1: Rolling Sample Estimates of Mean-Reverting Measure of Persistence (cont.)