THE PHILLIPS CURVE AND THE ITALIAN LIRA, 1861-1998

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The Phillips Curve and the Italian Lira, 1861-1998

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Abstract
We examine Italian inflation rates and the Phillips curve with a very long-run perspective, one that covers the entire existence of the Italian lira from political unification (1861) to Italy’s entry in the European Monetary Union (end of 1998). We first study the volatility, persistence and stationarity of the Italian inflation rate over the long run and across various exchange-rate regimes that have shaped Italian monetary history. Next, we estimate alternative Phillips equations and investigate whether nonlinearities, asymmetries and structural changes characterize the inflation-output trade-off in the long run. We capture the effects of structural changes and asymmetries on the estimated parameters of the inflation-output trade-off, relying partly on sub-sample estimates and partly on time-varying parameters estimated via the Kalman filter. Finally, we investigate causal relationships between inflation rates and output and extend the analysis to include the US and the UK for comparison purposes. The inference is that Italy has experienced a conventional inflation-output trade-off only during times of low inflation and stable aggregate supply.

Keywords: inflation, Phillips curve, Italian lira.

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1. Introduction

Inflation dominated the policy agenda across the 1970s and the 1980s. Afterwards, almost two decades of apparent price stability have pushed the dynamics of inflationary processes to the outer limits of the macroeconomic debate. This is unsatisfactory for various reasons. First, many aspects of past inflationary processes are still unsettled, as is the issue of the optimal level of the inflation rate, whether zero or low. Second, inflation is not dead, as its worldwide surge in the build-up to the current slowdown and the concerns about its medium-term outlook clearly show.\(^1\) Third, the study of past spells of low inflation could guide us to interpret the current state of affairs and to identify those forces that transform low rates of inflation into higher ones. This paper intends to stimulate the debate on these issues by investigating how the trade-off between inflation and output evolves over time.

We examine Italian inflation rates and their correlation with output developments with a very long-run perspective, one covering the entire existence of the Italian lira from political unification (1861) to the country’s entry in the European Monetary Union (end of 1998). Italy, as a case study, has at least two attractive features. The first is that existing evidence over relatively short intervals shows that this country has experienced, across a variety of monetary regimes, higher average and more volatile inflation rates than most industrialized countries. The second is that Italy differs from anglo-saxon market structures and institutions, whereas the bulk of the literature on the Phillips curve has concentrated mainly on those countries. The long historical reach of our study appears to be particularly suited to draw inferences from the experience of heterogeneous countries.

Methodologically, our paper first examines the volatility, persistence and stationarity of the Italian inflation rate over the long run and across various exchange-rate regimes that have shaped Italian monetary history (Fratianni and Spinelli, 2001a). Next, we study the correlation between inflation and the level of economic activity, leading to the identification of various specifications of the well-known Phillips equation. We also investigate the extent to which nonlinearities, asymmetries and structural changes characterize the inflation-output trade-off in the long run. We capture

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\(^1\) On 25 June 2008, the Financial Times’ main headline (European edition) ran: “Spectre of inflation over global economy”. 

the effects of structural changes and asymmetries on the estimated parameters of the inflation-output trade-off, relying partly on sub-sample estimates and partly on a time-varying parameter methodology. Finally, we extend the analysis to include the USA and the UK for comparison purposes.

The following are the main results of the paper. The rate, volatility and persistence of inflation display significant fluctuations over the entire sample 1861-1998. Fixed exchange rate regimes, particularly the international gold standard, are associated with lower inflation rates than more flexible exchange rate arrangements. The 1970s and 1980s stand out as the major non-war inflationary period. Inflation persistence and volatility are higher under flexible exchange rates, especially after the demise of Bretton Woods. In addition, non-stationarity appears to be also a feature of flexible exchange rates. As to the inflation-output trade-off, we provide, among other things, estimates of a consensus model that blends a conventional expectation-augmented Phillips curve with recent specifications based upon persistence and price/wage rigidity (Woodford, 2003). Strikingly, we detect a negative relationship between inflation and output over the whole sample, suggesting dominance of supply-side shocks and inflation expectations. Yet, when we account for the large effects of the two world wars and post-Bretton Woods inflation, the Phillips curve exhibits the textbook positive feedback from cyclical conditions to inflation. The inference is that Italy has experienced a conventional inflation-output trade-off only during times of low inflation and stable aggregate supply.

The paper is organized as follows. We start in Section 2 with a brief sketch of the Italian price level and its rate of change over the period from 1861 to 1998. We then analyze in Section 3 the time-series properties of the inflation rate. Section 4 is the core of the paper. There, we present and discuss estimates of a consensus Phillips curve; provide an alternative monetary specification; and examine non-linearities and time-varying parameters. In Section 5, we compare the Italian experience with that of the United States and the United Kingdom. Conclusions are drawn in the last section.

2. A brief sketch of prices and inflation from the Monetary History of Italy

As a starting point, we find it useful to identify the salient points of the behavior of the price level and its rate of change during the entire history of the lira, from
political unification in 1861 to Italy’s entry into the European Monetary Union (EMU) in 1998 (Fratianni and Spinelli, 2001a). We measure the price level by the logarithm of the annual price deflator of national income; see Figure 1.² Prices are relatively stable from 1861 to the start of World War I, a period largely characterized by the international gold standard. Three major upward movements in the price level stand out. The first two occur, not surprisingly, during the two world wars; the third in the modern period following the breakdown of Bretton Woods. On the other hand, only the years from 1927 to 1933 display a downward movement of the price level and hence a period of deflation.

![Figure 1. The log of the price deflator of Italian national income, 1861-1998.](image)

Figure 2 displays the inflation rate, computed as the log change of the price deflator. It confirms visually the mean-stationarity of the inflation rate during the international gold standard; the sharp accelerations imparted by the two world wars; the deflation of the inter-war years; the rise and persistence of inflation in the 1970s; its decline in the 1980s, in sympathy with other industrial countries, and the significant

² Some data limitations impair the study of the purchasing power of the Italian lira in the long run. However, several measures of the price level across the long time span considered in this paper have recently emerged. For instance, Spinelli and Trecroci (2008) examine time series of the implicit price deflator of national income, cost of living and wholesale prices. In this paper, we choose the first index, but experiments with the other indices show that our findings are qualitatively unaffected by the choice of the index. The sample period used is 1861–1998, except in the case of the UK, where the sample starts in 1872. The pre-1950 GDP, industrial production, population and price data were obtained from Flora (1983, 1987) and Mitchell (1992, 1993), whilst data on exchange rates, fiscal variables and the money supply come from Fratianni and Spinelli (2001a). We checked for consistency of the post-1950 data using standard sources (IFS, OECD).
disinflation of the 1990s. On average, Italian inflation has exceeded by five percentage points the inflation rate of the significant reference country. This Italian inflation excess was contained within one percentage point during the gold standard but rose to eight percentage points in the 1970s. If we exclude the war periods, the drivers of the Italian inflation rate were fiscal and monetary impulses affecting aggregate demand against a relatively stable aggregate output supply. Overall, the fiscal impulse was dominant in the sense that it determined the course of monetary policy (Fratianni and Spinelli, 2001b).

Figure 2. The log change of the price deflator of Italian national income, 1861-1998.

A distinctive feature of the most recent period is that inflation, once started, tends to persist. This is due in part to the dynamics of inflation expectations and in part to the overhang of the monetary base that declines slowly after the end of a monetary shock. Differences in the strength of inflation expectations, driven by credible monetary policy actions, explain differences in inflation persistence. For example, monetary tightening in 1926 and 1947 was well publicized and widely believed by the public to be permanent; inflation came down quickly. On the other hand, repeated monetary tightenings in the 1960s, 1970s, and 1980s were perceived to be temporary or easily reversible; inflation stuck on the high side.

Over the 138-year span of its history, the Italian lira has lived through several

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3 The reference country is either France up to World War I, the United Kingdom in the inter-war period, and the United States after World War II.
monetary regimes: it has swung from the gold standard to inconvertible fiat money; has alternated periods of fixed exchange rates with periods of flexible rates; and has experimented alternatively with interest rate, total domestic credit, monetary base, and inflation rate targeting. The fixed exchange rate regime was often adopted to signal the country’s determination to a course of deflation or disinflation, but just as often created unsustainable conflicts with other goals of economic policy and, hence, was not a credible pre-commitment device for deflation or disinflation.\(^4\) It is worth pointing out that the successful disinflation of the nineties, which made it possible for Italy to join EMU, instead, was the result of a tough-minded inflation rate targeting and was accompanied by stable output growth.

### 3. Statistical analysis of the Italian inflation process

To capture the evolution of the statistical properties of Italian inflation, we focus on both the whole span 1861-1998 and some sub samples defined in terms of the different monetary and exchange-rate regimes Italy adopted over the long period under observation. In particular, we adopt the following partition, put forward, among others, by Fratianni and Spinelli (2001a):

1) 1861-1913: international gold standard and fixed exchange rates;
2) 1914-1949: world wars and interwar years, mainly under flexible exchange rates;
2.1) 1920-1936: interwar years, with spells of both fixed and flexible rates;
3) 1950-1973: Bretton Woods system, hence fixed exchange rates;

Table 1 displays average inflation rates (\( \mu \)), their standard deviations (\( \sigma \)) and variation coefficients (\( cv = \sigma / \mu \)) for the whole sample and the five sub periods.

<table>
<thead>
<tr>
<th>SAMPLE</th>
<th>( \mu )</th>
<th>( \sigma )</th>
<th>( cv )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1861-1998</td>
<td>6.805</td>
<td>13.934</td>
<td>2.048</td>
</tr>
</tbody>
</table>

\(^4\) Del Boca et al. (2009) discuss the role of wage indexation and bargaining coordination in generating inflation in post-WWII Italy.
Table 1, Italian inflation rate, 1861-1998. Average ($\mu$), standard deviation ($\sigma$), coefficient of variation ($cv$), normality test, 1861-1998. ‘***’ indicates rejection of the null with a 99% confidence interval.

<table>
<thead>
<tr>
<th>Period</th>
<th>$\mu$</th>
<th>$\sigma$</th>
<th>$cv$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1861-1913</td>
<td>0.647</td>
<td>5.801</td>
<td>8.966</td>
</tr>
<tr>
<td>1914-1949</td>
<td>15.049</td>
<td>23.252</td>
<td>1.545</td>
</tr>
<tr>
<td>1920-1936</td>
<td>1.508</td>
<td>10.976</td>
<td>7.279</td>
</tr>
<tr>
<td>1950-1973</td>
<td>4.269</td>
<td>2.423</td>
<td>0.568</td>
</tr>
<tr>
<td>1974-1998</td>
<td>9.902</td>
<td>5.334</td>
<td>0.539</td>
</tr>
</tbody>
</table>

Excluding the war-heavy 1914-1949 years, the period with the highest average inflation was the post-1974 era of more flexible exchange rates, while the international gold standard and the Bretton Woods periods had the lowest inflation. Inflation volatility, as measured by the its standard deviation, was highest in 1914-1949, but adjusting this measure for its mean reveals much greater variability during the international gold standard and higher persistence in the last half of the 20th century. Overall, the inflation rate, on average, was lower under fixed exchange rates than under flexible exchange rates. Of the fixed exchange rate experiences, the Bretton Woods years had a much higher inflation rate, although less volatile, than the gold standard years. There is, however, ample time variation in the mean and standard deviation, which calls for a deeper examination of inflation’s stationarity properties.

Table 1 also contains the results of Jarque and Bera (1987) ($e_1$) and Doornik and Hansen (1994) ($e_2$) normality tests, which evaluate whether asymmetry and kurtosis of the series correspond to those of a normal distribution. There is clear evidence against the null hypothesis of a normal distribution. To evaluate persistence, we compute the autocorrelation function (ACF) up to the 10th lag; this is plotted in Figure 3 over the whole sample. The first lags have large coefficients, while negative values emerge only after 8-9 lags. The message is that Italian inflation was highly persistent. Figure 4 displays the correlogram for the four main sub periods; it confirms that persistence was higher under flexible exchange rates than under fixed exchange rates and reached a maximum after the demise of the Bretton Woods system.

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5 While the Jarque and Bera’s test has low power in small samples, Doornik and Hansen’s test adjusts for this bias.
6 Given the limited number of observations, we do not include results for the 1920-1936 sub sample.
Finally, we investigate the stationarity properties of the inflation process. To this end, we employ the Augmented Dickey-Fuller (ADF) test, which is implicit in the evaluation of the $t$ statistic of the $\hat{\beta}$ coefficient in:

$$\Delta \pi_t = \alpha + \mu \tau + \beta \pi_{t-1} + \sum_{i=1}^{n} \gamma_i \Delta \pi_{t-i} + u_t,$$

where $\tau$ is a deterministic trend. A significant statistic implies rejection of the null
hypothesis of unit root \( (H_0: \beta = 0) \) and therefore stationarity of the inflation rate.

Table 2 presents results for the whole sample and the four main sub periods. We include \( t \)-values of the \( \beta \) coefficient of a model with a constant and a model with a constant and a trend, each estimated with \( n = 3 \).\(^7\)

<table>
<thead>
<tr>
<th>SAMPLE</th>
<th>( i=0 )</th>
<th>( i=1 )</th>
<th>( i=2 )</th>
<th>( i=3 )</th>
<th>( i=0 )</th>
<th>( i=1 )</th>
<th>( i=2 )</th>
<th>( i=3 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1974-1998</td>
<td>-0.4841</td>
<td>-0.9693</td>
<td>-0.6881</td>
<td>-1.207</td>
<td>-3.719*</td>
<td>-3.690*</td>
<td>-3.374</td>
<td>-3.582</td>
</tr>
</tbody>
</table>

Table 2. ADF test of the Italian inflation rate, various sub samples. ‘*’ and ‘**’ indicate rejection of the null with a 95% and 99% confidence interval, respectively.

The results of the ADF test can be summarized as follows:

a) over the whole sample, inflation appears to be a stationary process: we reject the null of a unit root in both models at a 1% significance level;

b) the same applies to the gold standard;

c) on the contrary, the period 1914-1949 is unambiguously characterized by non-stationarity; and

d) for the Bretton Woods years and afterwards, overall results support non-stationarity.

These findings suggest that fixed exchange rates tend to be associated with stationary inflation, whilst flexible rates are best characterized by non-stationary inflation. However, the nature and frequency of the structural changes cannot be determined through unit root tests. The wartime “spikes” in inflation certainly play a big role in driving some of our results. However, the ADF test has low power in small samples and with variables containing MA components (Maddala and Kim, 1998). This calls for focusing on the series’ structural breaks rather than on their unit root properties and for identifying changes in the feedback linking inflation to output. We do this next, in the context of an expectations-augmented Phillips curve.

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\(^7\) The critical values for this procedure depend on the inclusion of the constant or of the constant and a trend term. The critical values we employ are those of MacKinnon (1991). A statistic significant at the 5% is identified by *, at the 1% by **.
4. Bringing Phillips into the picture

4.1 Inflation expectations

To start our analysis, it is useful to disentangle the temporary components of the inflation process from its long-term, more permanent component. In general equilibrium, inflation is equal to a long-term trend term (central bank’s long-run target in a perfectly credible regime), plus a zero-mean component that is unpredictable using past information. However, the long-standing empirical evidence on inflation persistence shows that both forward- and backward-looking (adaptive) components play a role in determining how agents set their expectations. Moreover, imperfect monetary policy credibility and shifts in central bank’s inflation target make the decomposition between trend and temporary inflation methodologically challenging. This is why there is no consensus in the literature on how to proceed. For instance, often trend inflation is derived through the application of Hodrick-Prescott (HP), linear or band-pass filters. Alternatively, one could rely on market surveys or measures extracted from inflation swaps or bond-based break-even inflation rates, but only for relatively short and recent samples of data. In this paper, we mainly rely on the Structural Time Series (STS) approach proposed by Harvey (1989) to generate a series for trend inflation that reflects in each time period only currently available information. The procedure amounts to decomposing the original series into trend, recursive stochastic cycles, and irregular components that vary over time. We extract time-varying measures of expected inflation that for each observation rely only on information available up to the point of estimation. This modelling approach applies a Kalman-filter estimation procedure, in line with a plausible learning process for both the central bank and private agents. Other procedures, like using alternative filtering methods or polynomial trends, did not yield significantly better fit for our model.

Figure 5 plots the estimated Kalman-filter-based trend along with that of a trend computed using the more conventional Hodrick-Prescott filter. We will use them in turn in our subsequent estimates.

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8 For more details, see Hamilton (1994) and Canova (2007). To ensure consistency with rational expectations, we stripped out any autoregressive and cyclical component. In addition, to avoid making our time $t$ estimates dependent on $t+1$ information through the updating stage of the Kalman filter, we employed the basic filter rather than a smoothing algorithm.
Figure 5. Trend Italian inflation rate, 1861-1998. The two measures of trend inflation are based on Hodrick-Prescott (HPINF) and Kalman (STSINF).

Figure 6 plots actual inflation and both the HP and STS measures of expected inflation over the most recent part of the sample, 1949-98. The third notable inflation process in the sample gathered significant strength in the early 1970s, peaked in 1980-82, and got back to moderate levels only at the end of the sample.

Figure 6. Trend Italian inflation rate, 1949-1998. The two measures of trend inflation are based on Hodrick-Prescott (HPINF) and Kalman (STSINF).

4.2 The inflation-output trade-off: a first pass

Figure 7 shows a scatter plot of inflation and our two measures of the output gap
(see below on how we derived them) over the whole sample, along with a regression line. In contrast with the conventional Phillips relationship, a weak but negative association emerges between inflation and deviations of output from its potential level. This striking finding originates from a very long sample spanning three significant inflationary episodes with at least as many potential structural breaks. This strengthens the case for performing the estimation over shorter sub samples as well and/or using time-varying coefficient techniques.

![Graph showing the relationship between Italian inflation and output gap, 1861-1998.](image)

Figure 7. The relationship between Italian inflation and output gap, 1861-1998. Inflation (INF) and Hodrick-Prescott (HPYGAP) and Kalman-filter (STSYGAP) measures of the output gap.

We will therefore examine the extent to which changes in the properties of the inflationary process observed in the previous sections can be explained by temporal shifts in its relationship with the level of economic activity.

Our reference framework is a model of current inflation and output that starts from the original expectations-augmented Phillips curve (Phelps, 1967; Friedman, 1968):

\[ \pi_t = \gamma (y_t - y_t^*) + E_{t-3} \pi_t \]  

\[ \text{(1)} \]
where $y_t - y_t^*$ denotes the output gap, defined as the difference between the current level of output and its NAIRU or natural level, and $E_{t-1} \pi_t$ is the expected current inflation rate, conditional on last period’s information. The dependence of current inflation on last period’s expectations comes by imposing rational expectations in a model with partial price rigidities. This implies that unexpected changes in aggregate demand affect both inflation and output; the stickier the prices, the lower $\gamma$, that is, the slope of the Phillips curve.

The literature has often discussed a forward-looking specification:

$$\pi_t = \gamma (y_t - y_t^*) + \beta E_t \pi_{t+1},$$  \hspace{1cm} \text{(2)}$$

which links the shifts of the curve to changes in current conditional expectations of future inflation. Theoretically, the difference between (1) and (2) is clear; in practice it is much less so, given that expected inflation displays a considerable amount of serial correlation.

Recently, some sort of a consensus has emerged on a specification that accounts for persistence and price/wage rigidity. In the framework commonly defined as the New Keynesian Phillips curve (NKPC), current inflation is determined by expected future inflation and current real activity, proxied by real marginal costs and empirically measured by income’s labor share. The result is a model where inflation is purely forward-looking. But robust empirical evidence, both micro and macro-based, also shows that inflation is characterised by a significant degree of inertia (see for instance, Fuhrer and Moore, 1995; Cogley and Sbordone, 2008). Building on these findings, most models add lagged inflation alongside forward-looking terms.9

In the context of our exercise, which, we remind, spans over a century of macroeconomic data, the lack of measures for the dynamics of real marginal costs, drastically reduces our degrees of freedom. Considering, furthermore, that Italy is a small open economy, it is appropriate to include the log change in the index of import prices ($\pi_t^*$) to account for the impact of foreign inflation and exchange rate pressures on

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9 Price indexation, rule-of-thumb behavior, non-linearities in price-setting mechanisms and time-varying trend inflation are amongst the theoretical explanations of inflation persistence.
the behavior of domestic prices. In line with much of the recent literature (Woodford, 2003), we arrive at the following reduced-form representation of the relationship between inflation and output:

\[ \pi_t = \beta E_t \pi_{t+1} + \omega \pi_{t-1} + \gamma (y_t - y_t^*) + \delta \pi_t^* + \epsilon_t \]  

(3)

Equation (3) is the reference model of our investigation. To measure the output gap, we employ again the STS approach. We fit a univariate model for real GDP, estimate cyclical, autoregressive and irregular components, and then extract time-varying measures of potential output. For each observation, we use information available up to the point of estimation. As a robustness check, we also employ two alternative techniques or measures: HP- and band-pass filters, and the log change in the index of industrial production. The resulting estimates do not change qualitatively by using alternative indicators/techniques; see below.

4.3 Was there a Phillips Curve in Italy?

First, we estimate equation (3) using OLS over the sample 1861-1998.\(^{10}\) For the output gap, we present results based on either the HP or STS definitions or the log change in industrial production (\(DIP_t\)). Equations (4)-(6) below show the estimates (heteroscedasticity and autocorrelation-consistent \(t\)-values in parentheses):

\[
\pi_t = 0.416 E_t \pi_{t+1} + 0.103 \pi_{t-1} - 0.315 (y_t - y_t^*)^{HP} + 0.5 \pi_t^* + \hat{\epsilon}_t \\
\text{(5.01) (2.67) (-3.15) (7.70)}
\]

(4)

\[
\pi_t = 0.272 E_t \pi_{t+1} + 0.197 \pi_{t-1} - 0.059 (y_t - y_t^*)^{STS} + 0.551 \pi_t^* + \hat{\epsilon}_t \\
\text{(4.15) (3.74) (-0.79) (7.86)}
\]

(5)

\[
\pi_t = 0.271 E_t \pi_{t+1} + 0.191 \pi_{t-1} - 0.001 DIP_t + 0.563 \pi_t^* + \hat{\epsilon}_t \\
\text{(4.08) (3.52) (-0.1) (7.91)}
\]

(6)

\(^{10}\) All specifications include a dummy variable that takes on value 1 for the wartime periods (1916-1920 and 1940-1947) and 0 elsewhere. The dummy is usually statistically significant.
Overall, real activity exerts little or no influence on inflation dynamics: using the HP-based definition, the output gap does become statistically significant, although with a negative sign. Industrial production is not statistically significant. On the contrary, forward-looking inflation expectations and lagged inflation are significant, and remain so over variously defined sub samples. What drives these findings is likely to be the recurrence in our sample of large output and inflation shocks, beyond those occurring around the world wars. Estimating our baseline specification over single shorter samples may yield results that are not statistically meaningful. On the contrary, Figure 8 shows scatter plots of inflation and output gaps obtained for the sub samples defined in Section 3. The slope of simple trend lines is everywhere negative, except for the immediate post-war and 1985-1998 periods, where instead a positive output-inflation relationship eventually emerges, albeit a weak one. We recall that 1973-1984 featured the deepest non-war inflationary (and stagflationary) episode of the entire sample, corroborating the view that the canonical output-inflation trade-off is detectable only in sub periods of limited real or monetary volatility.\textsuperscript{11}

\textsuperscript{11} Results are very similar when the change in industrial production is used.
4.4 Alternative specifications and robustness checks

In a famous 1980 paper, Robert E. Lucas argued that the quantity relation might not hold with high frequency data and in the short run.\textsuperscript{12} We complement our long-run evidence on the Phillips curve in Italy by performing a classical test of the quantity theory, namely that inflation responds to money growth. In the spirit of Lucas (1980), Figure 9 scatter plots the inflation rate against the annual growth rate of the broad money stock. The positive association between the two variables is tight and cannot be easily dismissed. This accords with further findings on filtered data and averaged observations (not shown here for brevity), which point to a validation of the quantity theory for Italy in the long run.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure9.png}
\caption{The relationship between Italian inflation rate (INF) and the growth rate of the broad money stock (DM), 1861-1998.}
\end{figure}

Therefore, we re-estimated our baseline inflation model, in which money growth replaced the output gap as a measure of economic activity. Below, we report our estimates over the sample 1861-1998:

\textsuperscript{12} For this reason, Lucas (1980) employed gradually stronger filtering to make the relation emerge with US data. Results obtained using filtered data show that inflation moves roughly one-for-one with money growth.
\[ \pi_t = 0.192 E_t \pi_{t+1} + 0.127 \pi_{t-1} + 0.218 \Delta m_t + 0.488 \pi^*_t + \hat{\varepsilon}_t \]  
\begin{align*} 
(2.90) & \quad (3.54) & \quad (2.61) & \quad (5.71) 
\end{align*}

Inflation is highly correlated with money growth, even after accounting for the decoupling of money and income during the war years. Ultimately, this result confirms the monetary roots of inflation and is in line with evidence gathered, over shorter periods, by Fratianni (1978) and Fratianni and Spinelli (2001a).

The coefficient of import prices remains highly significant, both statistically and economically. It should be noted, however, that import prices can change either because of changes in relative prices or as a result of changes in the nominal exchange rate. We cannot directly distinguish between these two sources, but we hypothesize that, given the substantial stability in the magnitude of all other coefficients, nominal exchange rate shifts are likely to drive most of the correlation between domestic inflation and import prices.

4.5 Non-linearities and time-varying parameters

We next turn our attention to possible non-linearities and/or asymmetries in the long-run Phillips curve. Starting already from Phillips (1958), a large body of literature has studied the presence of convexities in the transmission of shocks from output to inflation. According to this idea, an excess demand for output has a greater effect on inflation than an equivalent excess supply. To provide an indicative answer to this question, we use a series of residual-based tests designed to verify whether non-linear effects are present (Granger and Terasvirta, 1993). Retrieving the fitted residuals from specifications (4) and (7), we estimate the following auxiliary regression:

\[ \hat{\varepsilon}_t = \beta'_0 x_t + \beta'_1 x_t z_t + \beta'_2 x_t (z_t)^2 + \beta'_3 x_t (z_t)^3, \]  
\[ (8) \]

where \( x_t \) is the vector of regressors in the Phillips curve and \( z_t \) is any ‘transition’ variable, whether in or outside the model, which may be a source of non-linear

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13 Results based on residuals from the other specifications are broadly consistent with those we present here and are available from the authors upon request.
behavior. In what follows, we perform these tests primarily against the output gap and money growth. While we do not know the actual nature of the convexities, we hypothesize that the two transition variables capture the bulk of monetary and real factors. The power of the tests is high against most non-linear parametric approaches. Results, shown in Table 3, provide clear support in all cases for the presence of convexities in the response of inflation to changes in the Phillips curve’s regressors.

<table>
<thead>
<tr>
<th>SAMPLE: 1861-1998</th>
<th>$H_0 : \beta_1 = 0$</th>
<th>$H_0 : \beta_2 = \beta_3 = 0$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Model (7)</strong></td>
<td>$z_t = (y_t - y_t^*)$</td>
<td>4.8790**</td>
</tr>
<tr>
<td></td>
<td>$z_t = \Delta m_t$</td>
<td>27.841**</td>
</tr>
<tr>
<td><strong>Model (8)</strong></td>
<td>$z_t = (y_t - y_t^*)$</td>
<td>6.5323**</td>
</tr>
<tr>
<td></td>
<td>$z_t = \Delta m_t$</td>
<td>12.822**</td>
</tr>
</tbody>
</table>

Table 3. Granger-Terasvirta tests for non-linear inflation responses. The $H_0 : \beta_1 = 0$ test is distributed as an F(4, 120) variate, whilst the $H_0 : \beta_2 = \beta_3 = 0$ test is distributed as a F(8, 120) variate. (*), (**), (*** ) indicate that the null hypothesis of a zero restriction is rejected at respectively, at the 10%, 5% or 1% level.

All our findings for Italy so far are consistent with the hypothesis that the Phillips curve shows significant changes, if not breaks, in its key coefficients (Bai and Perron, 2003). The existing evidence attributes this evidence to shifts in the actual conduct of monetary policies or in the collective attitude towards the costs of inflation, or more generally in the monetary regime (see Cecchetti et al., 2007; Kim and Nelson, 2006; Cogley and Sbordone, 2008). Our findings and the evidence concerning other countries therefore motivate the use of a comprehensive time-varying parameter (TVP) approach, advocated among others by Granger and Jeon (2008). TVPs help to identify the conditional inflation-output trade-off and the causal links between observed institutional or behavioral changes and structural shifts in the curve’s coefficients.

We therefore compute additional estimates that explicitly allow for time

14 Alternatively, one could insert variously defined time trends in the model. We believe that the TVP approach yields much richer evidence about time variation, especially about aggregate demand and inflation expectations.
variation in the parameters of the Phillips curve. These estimates describe the temporal
evolution of the Phillips curve’s coefficients. To illustrate intuitively our simple
technique, we put the model in a general state-space form (Harvey, 1989; Kim and
Nelson, 1999):
\[
\begin{align*}
\pi_t &= c_t + x_t^T b_t + e_t \\
b_{t+1} &= d + T b_t + z_{t+1} 
\end{align*}
\]
(9)
where
\[e_t \approx N(0, \sigma^2), \quad z_t \approx N(0, Q), \quad b_0 \approx N(a_0, \Sigma_0),\]
with \(x_t\) containing the explanatory variables.

The first equation in (9) is the measurement or observation equation, where the
parameter vector \(b_t\) (representing the state variables) is time sensitive. The second
equation is the transition equation describing the temporal evolution of \(b_t\).\(^{15}\) In sum,
TVP involves forecasting the optimal state vector in each period, based on information
available up to the previous period.\(^{16}\) Thus, we can compute filtered estimates of all
parameters and residuals for each observation and account for the potential temporal
variation of the underlying structural parameters. The objective is to capture major
shifts, which are extremely likely in the long historical span of our dataset.

Figure 10 plots the times series of the estimated coefficient \(\gamma_t\) in equation (3),
the sensitivity of current inflation to changes in the output gap.\(^{17}\) The displayed
estimates were obtained with a HP-based measure of inflation expectations and,
alternatively, employing either STS or HP definitions of the output gap. Qualitatively
similar results were obtained by substituting industrial production for output.

\(^{15}\) We follow the prior distribution proposed by Doan et al. (1984), which assumes that changes in the
endogenous variable modelled are so difficult to forecast that in the AR(1) process of the unobserved
state vector the coefficient on its lagged value is likely to be near unity, while all other coefficients are
assumed to be near zero. The prior distribution is independent across coefficients, so that the MSE of the
state vector is a diagonal matrix. Measurement errors and the disturbances to transition equations are
assumed to be serially and mutually independent.

\(^{16}\) Under the normality and independence assumptions about the disturbances, the computation of the state
vector is obtained via application of the Kalman filter.

\(^{17}\) For brevity we do not show here the full results of our TVP estimation (including those obtained using
industrial production and money growth), which are available from the authors upon request.
Figure 10. Time-varying coefficient of the output gap of the Italian Phillips curve, 1861-1998. HP and STS refer to the Hodrick-Prescott and STS-based measures of the output gap.

The graph confirms the occurrence of wide swings of the coefficient linking inflation to output: the estimated coefficient drops in value periods of higher macroeconomic variability, regardless of the measure of capacity utilization. It becomes negative in World War II, when the conventional Phillips curve breaks down completely.

5. A comparison with the United States and the United Kingdom

In this section we compare the Italian findings with those in the United States and the United Kingdom using the same methodology and sample period. Figure 11 groups the annual inflation rates (based on the price deflator of national income) for the three countries. The Italian inflation easily emerges as having the highest mean and volatility\(^{18}\).

\(^{18}\) Higher Italian mean and volatility of inflation also holds for sub periods except one. Furthermore, Italian and UK inflation rates have similar persistence levels, both far higher than in the US.
Figure 11. Inflation rates in Italy, USA and UK, 1861-1998.

Turning to the inflation-output relationships across the three countries, Table 4 contains the results of the baseline Phillips specification, equation (3), estimated with OLS both for the entire sample and for the sub samples of the international gold standard, the two world wars, and the post-1949 period.\textsuperscript{19}

\begin{tabular}{|c|c|c|c|}
\hline
\textbf{USA} & & & \\
\textbf{Sample} & $E_t \pi_{t+1}$ & $\pi_{t-1}$ & $\left(y_t - y_t^*\right)$ \\
\hline
1861-1998 & 1.031 & 0.167 & 0.069 \\
& (7.16) & (2.07) & (1.08) \\
1861-1913 & 1.274 & -0.042 & -0.215 \\
& (4.52) & (-0.28) & (-1.48) \\
1914-1949 & 1.285 & 0.000 & 0.218 \\
& (3.83) & (0.00) & (1.94) \\
1950-1998 & 0.707 & 0.302 & 0.127 \\
& (6.02) & (2.67) & (2.16) \\
\hline
\textbf{UK} & & & \\
\textbf{Sample} & $E_t \pi_{t+1}$ & $\pi_{t-1}$ & $\left(y_t - y_t^*\right)$ \\
\hline
1861-1998 & 0.639 & 0.397 & 0.356 \\
& (7.04) & (5.83) & (4.62) \\
\hline
\end{tabular}

\textsuperscript{19} For these estimates, we measured real activity via either the output gap (HP-based series for potential output) or the log change in industrial production. As results do not qualitatively differ across specifications, we opted for presenting those based on output gaps.
Table 4. Phillips Curves for Italy, USA and UK, various samples. Selected coefficient estimates and \( t \)-values.

<table>
<thead>
<tr>
<th>Sample</th>
<th>( E_t \pi_{t+1} )</th>
<th>( \pi_{t-1} )</th>
<th>( (y_t - y_t^*) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1861-1998</td>
<td>0.416 (5.01)</td>
<td>0.103 (2.67)</td>
<td>-0.315 (-3.15)</td>
</tr>
<tr>
<td>1861-1913</td>
<td>0.574 (1.88)</td>
<td>-0.057 (-0.41)</td>
<td>-0.383 (-1.26)</td>
</tr>
<tr>
<td>1914-1949</td>
<td>1.031 (6.07)</td>
<td>0.049 (0.36)</td>
<td>-0.969 (-4.48)</td>
</tr>
<tr>
<td>1950-1998</td>
<td>0.369 (3.63)</td>
<td>0.630 (6.33)</td>
<td>0.023 (0.178)</td>
</tr>
</tbody>
</table>

The main results can be summarized as follows:

1. over the full sample, the output coefficient is statistically significant and positive only for the UK, and it is again negative for Italy;
2. over the sub samples, output is positively related to inflation in the USA in 1914-1949 and 1950-1998 and in the UK in all sub periods until WWII;
3. inflation expectations are almost always fundamental determinants of actual inflation rates; and
4. the international gold standard stands out as the sub period with the most ambiguous results.

Finally, to get a sense of the cross-country evolution of the inflation-output relationship, we also estimated TVP models for the United States and the United Kingdom. Figure 12 plots the output gap coefficients with the TVP methodology. The distinctive feature is that the United Kingdom and Italy share similar declines in the size of the output gap coefficient after WWII, although in the United Kingdom the long-run relationship seems to have held up. In the United States, the sensitivity of inflation to
output developments is both more sizeable and stable, with no fundamental breaks even during the stagflation of the 1970s. These findings broadly confirm, in a cross-country dimension, that the standard trade-off between inflation and output growth emerges only during periods of low inflation and limited macroeconomic volatility.

Figure 12. Time-varying coefficient of the output gap for Italy, USA and UK, 1861-1998. TVP coefficients based on STS.
5. Concluding remarks

Rather than discuss once more the various findings of the paper, we emphasize two conclusions. The first relates to the distinctiveness of the Italian inflation process, in the specific sense that inflation has been systematically higher and more variable than elsewhere in the industrial world, specifically in the anglo-saxon countries. The key finding of our study is that the standard trade-off between inflation and output growth breaks down during periods of high inflation and marked macroeconomic volatility. It follows that the peculiar nature of the Italian output-inflation trade-off is in part the consequence of the comparative disadvantage of the Italian economy to withstand adverse supply-side shocks and in part the result of the poor quality of its monetary policy. This conclusion resonates well with a famous message by Lucas on the properties of the trade-off (1973, pp. 332-333):

“In a stable price country like the United States, then, policies which increase nominal income tend to have a large initial effect on real output, together with a small, positive initial effect on the rate of inflation. Thus, the apparent short-term trade-off is favorable, as long as it remains unused. In contrast, in a volatile price country like Argentina, nominal income changes are associated with equal, contemporaneous price movements with no discernible effect on real output. These results are, of course, inconsistent with the existence of even moderately stable Phillips curves. On the other hand, they follow directly from the view that inflation stimulates real output if, and only if, it succeeds in "fooling" suppliers of labor and goods into thinking relative prices are moving in their favor.”

The second conclusion relates to the successful Italian disinflation of the 1990s, one that permitted the country to join the EMU. After an extraordinarily long period, the country was finally able to tame inflation. The evidence marshalled in the paper is consistent with the received wisdom that Italy has reined in inflation thanks largely to global disinflation pressures and the establishment of an independent central bank in the 1990s. We leave it to future research the determination of which of these two factors played a dominant role in the taming of inflation. Regardless of their relative importance, the question comes to mind whether Italy can sustain a low-inflation regime in the absence of a friendly global environment and of an independent central bank. While there is a high probability that the European Central Bank may remain independent from political pressures, the same cannot be said about Italian
membership in the EMU.

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