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III. Explaining Inflation With the Help of the New Keynesian Phillips Curve[25]

A. Introduction

39. Following a long period of disinflation, underlying consumer price inflation in France edged up again in 2001 and 2002. After having fallen to below 1 percent in the late nineties, it rose back to 1.3 percent in 2000, 1.9 percent in 2001, and above 2 percent in the first seven months of 2002. Inflation rates calculated on the basis of the GDP deflator—more clearly reflecting developments on the production side and domestic labor market—had also fallen to less than one percent per annum in the late nineties but increased to 1.1 percent in 2000 and 1.6 percent in 2001 (Figure III.1).

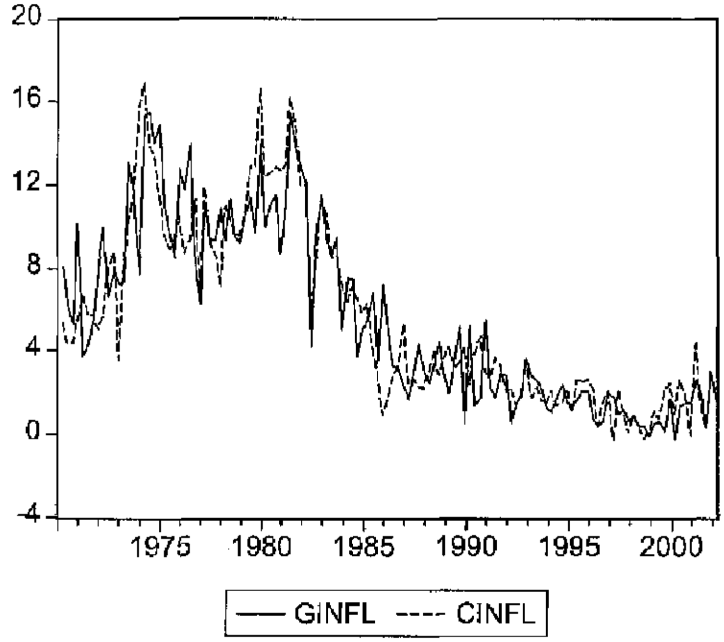
40. While temporary factors have played a key role in the rise of inflation, unit labor costs, and related wage and productivity developments, also exerted a significant influence. The influence of one-off or temporary factors affecting food, energy and service prices (adverse weather conditions, livestock diseases, oil price increases, the euro depreciation of 2001 and the euro-conversion of January 2002) appears to explain only part of the recent inflation acceleration. At the same time, unit labor cost growth also rose, from 0.5 percent in 1999 to 2.5 percent in 2001.

41. This chapter concludes that (i) the so-called New Keynesian Phillips curve can explain French inflation, although with some limitations, and that (ii) the New Keynesian Phillips curve captures more of the recent increase in inflation than its conventional counterpart. The first result contrasts with the findings of an earlier study by Jondeau and Le Bihan (2001) but is consistent with the findings of Gali and Gertler (1999) and Gali, Gertler and Lopez-Salido (2001) that the New Keynesian Phillips curve explains inflation in the euro area as a whole (though they did not study French data in isolation). Different estimation specifications contribute to this contrast. It is worth noting that the New Keynesian Phillips curve performs well only if it integrates elements of the conventional Phillips curve (i.e., lagged inflation expectations) and only when applied to the GDP deflator as opposed to the CPI. The second finding emerges from a comparison of fitted inflation from estimations of the New Keynesian Phillips and the conventional Phillips curves during the period 1999 to 2001.

[25] Prepared by Hans Weisfeld.

Figure III.1: GDP Deflator and CPI Inflation Rates, 1970:2–2002:2

(In percent)



Legend: GINFL and CINFL are the annualized quarterly inflation rates for the GDP deflator and the harmonized CPI index, respectively.
Sources: OECD Analytical Database and INSEE

B. The New Keynesian Phillips Curve

42. The New Keynesian Phillips curve relates today's inflation to expectations of future inflation and to real marginal costs or, under additional assumptions, to the output gap (see Appendix).[26] It is given by

$$\pi_t = \beta E_t \pi_{t+1} + \lambda mc_t$$

in a formulation comprising marginal production costs, and by

$$\pi_t = \beta E_t \pi_{t+1} + \lambda h(y_t - \bar{y}_t)$$

[26] See, e. g., Goodfriend and King (1997) and King (2000) for discussions of New Keynesian economics.

in a version showing the output gap; where π_t denotes the inflation rate of period t, β is a so-called discount factor expressing firm's valuation of future income relative to present income, $E_t\pi_{t+1}$ is the best expectation of the inflation rate in period t+1 that individuals can form based on information available in period t, λ is a parameter linked to the discount factor and the frequency of price adjustments, mc_t is the percentage deviation of marginal costs (the costs of producing one additional unit of output) from its long-term average (the so-called steady state), h is a parameter linked to the assumed production function, y_t denotes the economy's output, $\bar{y}_t$ potential output, and $(y_t - \bar{y}_t)$ the output gap.

43. The New Keynesian Phillips curve is derived from an optimization-based theory of firm's price setting that relates today's prices in a positive fashion to present and expected future marginal costs. Higher present and expected marginal costs lead to higher prices, and higher present and expected increases in marginal costs to higher inflation rates. The expected inflation term on the right-hand side of the New Keynesian Phillips curve embodies expectations about future marginal costs. The output-gap based version of the New Keynesian Phillips curve is derived from the marginal cost based form, using additional assumptions about production technology and the short-run determination of capital used in production. For a derivation, see Appendix.

44. In attempts to improve the fit of the New Keynesian Phillips curve, both forward- and backward-looking price setting has been included. While the inclusion of backward-looking price setting does not correspond very well with the rationality hypothesis on which the New Keynesian Phillips curve is founded, it can be seen as resulting from rule-of-thumb pricing (see Appendix). The hybrid New Keynesian Phillips curve is then given by

$$\pi_t = \gamma_b \pi_{t-1} + \gamma_f E_t \pi_{t+1} + \lambda mc_t$$

based on marginal costs, and

$$\pi_t = \gamma_b \pi_{t-1} + \gamma_f E_t \pi_{t+1} + \lambda h(y_t - \bar{y}_t),$$

using the output gap, where γ_b and γ_f are functions of behavioral parameters.

45. For the same reason, variants using more than one lag and leads of (expected) inflation as explanatory variables have been suggested. While the microeconomic foundations of this enlarged Phillips curve are generally seen as being limited, integrating additional inflation terms has advantages for empirical modeling. Following Fuhrer (1997) and Roberts (2001), using three-quarter leads and lags yields

$$\pi_t = \omega \frac{1}{3}\sum_{j=1}^{3} \pi_{t-j} + (1-\omega)\frac{1}{3}\sum_{j=1}^{3} \pi_{t+j} + \lambda mc_t,$$

and

$$\pi_t = \omega\frac{1}{3}\sum_{j=1}^{3}\pi_{t-j} + (1-\omega)\frac{1}{3}\sum_{j=1}^{3}\pi_{t+j} + \lambda(y_t - \bar{y}_t),$$

where ω is the weight of backward looking price setters.

C. Estimation Methodology, The Data, and Estimation Results

46. The New Keynesian Phillips curve, both in its pure and its hybrid forms, and alternatively with marginal costs and the output gap was estimated using the General Methods of Moments (GMM) methodology. GMM estimation involves formulating freedom-of-correlation conditions derived from economic theory. Here, the property of rational expectations precludes expectations errors from being correlated with information available at the time expectations are formed. This leads to the conditions

$$E[(\pi_t - \beta\pi_{t+1} - \lambda mc_t)z_t] = 0$$

for the marginal cost based Phillips curve and

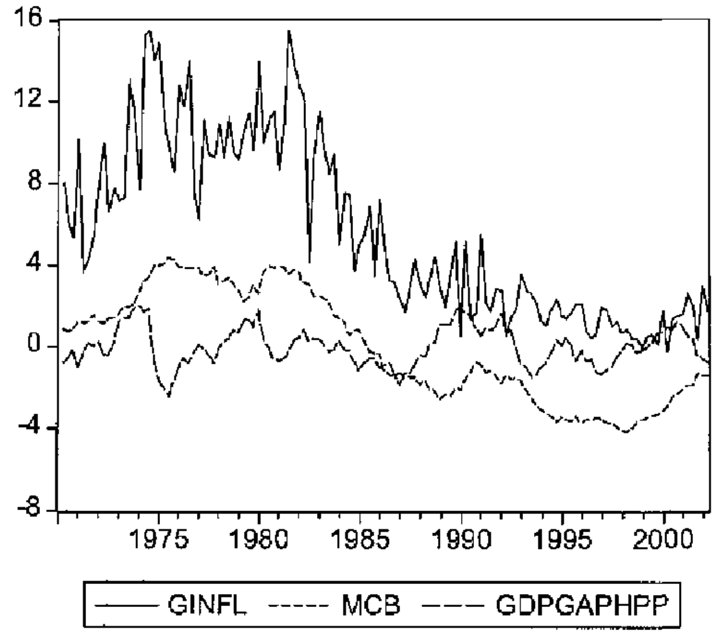
$$E[(\pi_t - \beta\pi_{t+1} - \lambda h(y_t - \bar{y}_t))z_t] = 0,$$

for the output gap based relationship, where z_t is a vector of instruments comprising the inflation rate, marginal cost, the output gap, and real GDP growth before and up to period t. Inflation has been calculated as annualized quarterly changes of the GDP deflator; the real marginal costs variable as the deviation of real unit labor costs from their long-term average, with as real unit labor costs the ratio of the business sector nominal wage bill and nominal GDP[27] (for a motivation of this measure see the Appendix); the output gap as the cyclical component of GDP computed with the help of the Hodrick-Prescott filter; and real GDP growth as annualized quarterly changes of real GDP. Figure III.2 shows the inflation, marginal cost and output gap series.

[27] Using private sector GDP instead of overall GDP did not alter the results.

Figure III.2: Inflation, Marginal Costs, and The Output Gap, 1970:2–2002:2

(In percent)



Legend: GINFL is the annualized quarterly inflation rate calculated using the GDP deflator, MCB is the deviation of marginal cost from the long-term average of marginal costs in the business sector, and GDPGAPHPP is the output gap, shown here as a percentage of potential output.
Sources: OECD Analytical Database and INSEE

47. The following estimation result was obtained:[28]

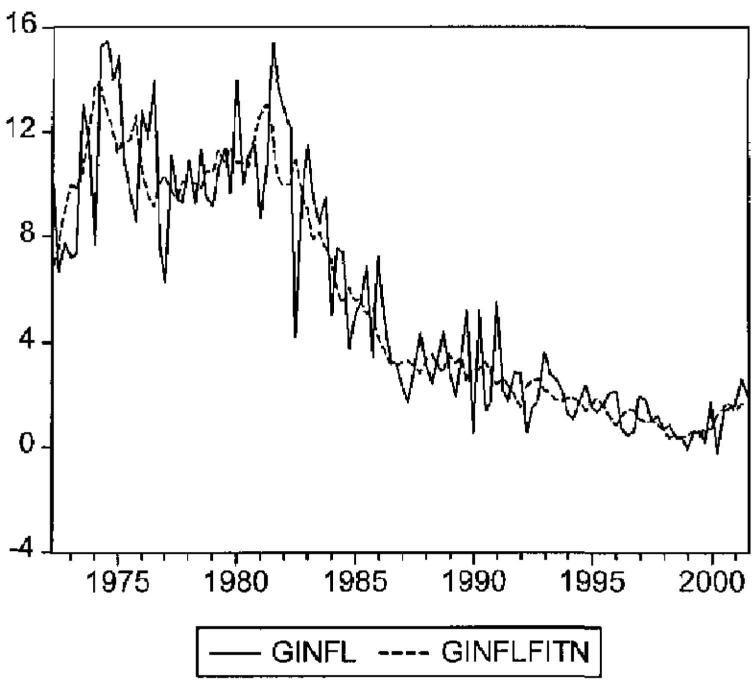
$$\pi_t = \underset{5.21}{0.276}\frac{1}{3}\sum_{j=1}^{3}\pi_{t-j} + \underset{13.67}{0.724}\frac{1}{3}\sum_{j=1}^{3}\pi_{t+j} + \underset{1.81}{0.017}\,mc_t,$$

where t-values are shown beneath estimated parameters. All estimated coefficients have the expected signs and are significant at the 10 percent level. The estimation results suggests that price setting is mostly forward looking and that above-average marginal costs in the form of

[28] This estimation used 118 observations after adjusting endpoints and covered the period 1972:2 to 2001:3, with remaining raw data in the sample used for calculation of explanatory variables. As instruments we chose 8 lags of inflation and 3 lags each of marginal costs, the output gap and real GDP growth. Estimation relied on prewhitening, a quadratic kernel and the Newey-West bandwidth. Further, we imposed the restriction that the estimated coefficients on lagged and future (expected) inflation sum to one.

higher real unit labor costs lead to higher inflation. Significance of the parameter associated with marginal costs at conventional confidence levels is maintained across a limited range of estimation specifications. Significance is, however, often lost when the quadratic kernel is substituted by a Bartlett kernel, as in Jondeau and Le Bihan (2001).[29] Also, while estimation results are robust to some data transformations (for example, similar results were obtained when we computed the output gap using a linear trend of real GDP), they show sensitivity to others. Further, the marginal cost parameter ceased to be significant for all or most test specifications when lagged inflation was excluded, the CPI index was used for inflation calculation, or the output gap was substituted for marginal costs. The reported regression explains inflation up to and including 2001:3, with later inflation observations used as explanatory variables. Figure 3 shows actual and fitted inflation. Unfortunately, the presence of future (expected) inflation rates among the explanatory variables makes forecasting and an analysis of forecast performance impossible.

Figure III.3: Actual Inflation and Inflation Explained by the New Keynesian Phillips Curve, 1972:2–2001:3
(In percent)



Legend: GINFL is the actual and GINFLFITN the fitted annualized quarterly inflation rate emerging from the reported estimation of the New Keynesian Phillips curve.
Sources: GINFL - OECD Analytical Database, INSEE; GINFLFITN - Fund staff calculations.

[29] We are not aware of any reasons that would let one kernel appear superior to the other.

48. The New Keynesian Phillips curve explains a larger part of the recent increase of inflation than its conventional predecessor. In order to compare the performance of the New Keynesian in explaining the recent increase of inflation to that of the conventional Phillips curve

$$\pi_t = \sum_{j=1}^{k} \delta_j \pi_{t-j} + \lambda(y_t - \bar{y}_t),$$

we also estimated the latter. We obtained the following result:[30]

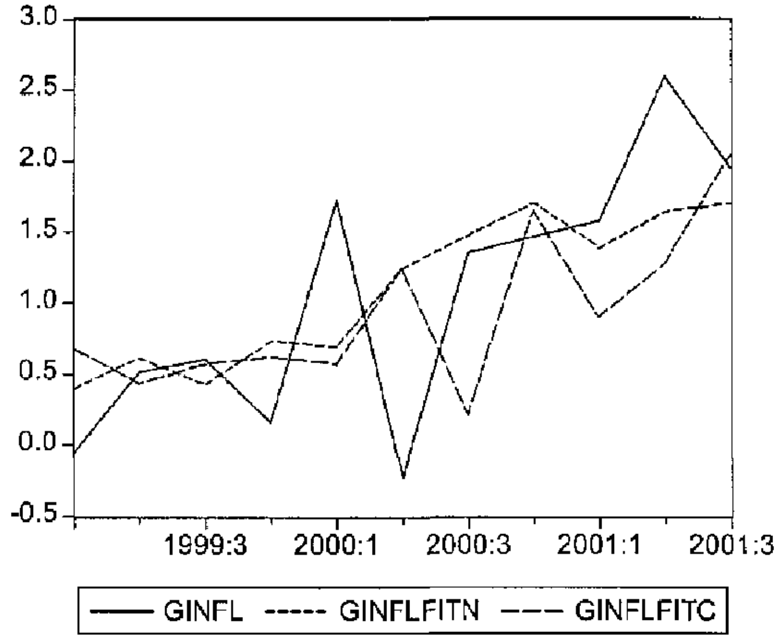
$$\pi_t = \underset{5.68}{0.426}\pi_{t-1} + \underset{3.54}{0.278}\pi_{t-3} + \underset{3.80}{0.296}\pi_{t-6} + \underset{2.19}{0.041}(y_t - \bar{y}_t).$$

As is usually the case with estimations of the conventional Phillips curve, the coefficient associated with the output gap term is significant. Comparing fitted inflation rates between the year of lowest inflation 1999 and the year 2001 (first three quarters), the New Keynesian Phillips curve performs better than its conventional counterpart: while actual inflation rose from 0.3 percent in 1999 to 2.0 percent in 2001, the New Keynesian Phillips curve explains an increase from 0.5 percent in 1999 to 1.6 percent, and the conventional relationship a rise from 0.6 percent to 1.4 percent (see Figure III.4). Thus, while both versions underpredict the recent observed increase in inflation, the New Keynesian Phillips curve fares better than the conventional relationship.

[30] Using the ordinary least squares estimator, we started with eight lags of inflation, eliminated insignificant lags, and successfully tested and imposed the restriction $\sum_{j=1}^{k} \delta_j = 1$ that assures the accelerationist Phillips curve, excluding a long-run trade-off between output and inflation. The estimated residuals were free of autocorrelation but showed signs of heteroskedasticity. In order to account for this, we conducted a GARCH (1,1) maximum likelihood estimation. After adjusting for endpoints, the sample covered the period 1971:4-2002:2 and comprised 123 observations.

Figure III.4: Actual Inflation and Inflation Explained by the New Keynesian and the Conventional Phillips Curves, 1999:1–2001:3

(In percent)



Legend: GINFL is actual inflation, and GINFLFITN and GINFLFITC are the fitted annualized quarterly inflation rates emerging from the reported estimations of the New Keynesian and the conventional Phillips curves.
Source: GINFL - OECD Analytical Database, INSEE; GINFLFITN and GINFLFITC - Fund staff calculations.

D. Conclusions

49. The New Keynesian Phillips curve appears to provide a good analysis of inflation determination in France, although with some limitations. Forward-looking price setting is an important part of French firms' price setting, and higher expected unit labor costs lead to higher inflation. The New Keynesian Phillips curve explains a larger share of the recent increase in inflation than the conventional Phillips relationship. That it, too, underpredicts inflation, can at least in part be attributed to unexpected events such as livestock diseases and adverse weather conditions that affected agricultural output negatively and pushed food prices up in 2001.

Deriving The New Keynesian Phillips Curve

50. This appendix presents some steps needed for deriving the New Keynesian Phillips curve in its different forms. For a complete derivation, see, e.g., Goodfriend and King (1997).

Timing of price adjustments and price stickiness

51. The economy is inhabited by a large number of firms that differ only in that each produces a differentiated good. Each period, a firm has a probability $(1-\eta)$ of setting a new price and a complementary probability of η of not being able to choose a new price. Thus, firms face a probability of η^j of still having, in period $t+j$, the price that was set in period t, and the probability of first adjusting a price in j periods is $(1-\eta)\eta^{j-1}$. The expected duration of a price remaining unchanged is therefore

$$1(1-\eta)+2(1-\eta)\eta+\ldots(j+1)(1-\eta)\eta^j+\ldots=(1-\eta)\sum_{j=0}^{\infty} j\eta^{j-1}=\frac{1}{1-\eta}.$$

The parameter η thus summarizes price stickiness. In a quarterly model, with a value of $\eta=0.75$, for example, prices would be adjusted on average once per year.

Determining the price level

52. The overall price level is the average over all prices. The fraction of firms adjusting prices in period t is equal to the probability of price adjustment $(1-\eta)$ and the fraction of firms stuck with a price that is j periods old is $(1-\eta)\eta^j$. Denoting the (log of the) price chosen by all adjusting firms in period t by p_t^*, the (log of the) price level by p_t is therefore given by

$$p_t=(1-\eta)\sum_{j=0}^{\infty}\eta^j p_{t-j}^*=\eta p_{t-1}+(1-\eta)p_t^*.$$

Price setting

53. Firms consider future market conditions when setting prices. Optimal pricing is governed by

$$p_t^*=(1-\beta\eta)\sum_{j=0}^{\infty}(\beta\eta)^j E_t[mc_{t+j}]=\beta\eta E_t p_{t+1}^*+(1-\beta\eta)[mc_t],$$

where β is a discount factor, $E_t(z_{t+j})$ the expected value of variable z_{t+j} based on information available at time t, and mc_t the percent deviation of real marginal cost from its steady state. Thus, the price chosen by firms can be seen as a weighted average of present and expected future marginal costs, or, equivalently, as an average of present marginal costs and the price level expected for the next period.

Introducing the output gap

54. In a final step, it is often assumed that the deviation of real marginal cost from its steady state is positively related to the output gap:

$$mc_t = h(y_t - \bar{y}_t),$$

where y_t represents (the log of) output and $\bar{y}_t$ (the log of) potential output. A positive value of the parameter h is the result of conventional assumptions about the aggregate production function and factor supply elasticities. Real marginal costs would rise with the level of economic activity if the economy had some fixed factors such as a predetermined capital stock.

Solving for the rate of inflation

55. Combining the above equations and using the definition of the inflation rate $\pi_t = p_t - p_{t-1}$ leads to

$$\pi_t = \beta E_t \pi_{t+1} + \lambda mc_t$$

in a formulation comprising marginal costs and

$$\pi_t = \beta E_t \pi_{t+1} + \lambda h(y_t - \bar{y}_t)$$

in a version showing the output gap, with $\lambda = \dfrac{(1-\eta)(1-\beta\eta)}{\eta}$.

Introducing the hybrid Phillips curve

56. Suppose that a fraction ω of firms performs backward, rather than forward, looking pricing. The price level still evolves according to

$$p_t = (1-\eta)\sum_{j=0}^{\infty} \eta^j p_{t-j}^* = \eta p_{t-1} + (1-\eta)p_t^*,$$

only price setting is now determined through

$$p_t^* = \omega p_t^b + (1-\omega) p_t^f,$$

where p_t^b is the price set by backward-looking firms and p_t^f the price set by forward-looking firms. Backward looking pricing is assumed to accord to the rule of thumb

$$p_t^b = p_{t-1}^* + \pi_{t-1},$$

so that last period's inflation rate is used by backward looking firms as a predictor of the current inflation rate. The resulting hybrid Phillips curves are

$$\pi_t = \gamma_b \pi_{t-1} + \gamma_f E_t \pi_{t+1} + \lambda mc_t$$

and

$$\pi_t = \gamma_b \pi_{t-1} + \gamma_f E_t \pi_{t+1} + \lambda h(y_t - \bar{y}_t),$$

where parameters are functions of ω, η and β.

Measuring marginal costs

57. Let A_t denote technology, K_t capital, and N_t labor. Assuming a Cobb-Douglas production function, output Y_t is given by

$$Y_t = A_t K_t^{\alpha_k} N_t^{\alpha_n}.$$

With capital fixed in the short run, short run real marginal cost MC_t is given by the ratio of the wage rate to the marginal product of labor, i.e., $MC_t = (W_t / P_t)/(\partial Y_t / \partial N_t)$, where W_t represents nominal wages. Thus,

$$MC_t = \frac{S_t}{\alpha_n},$$

where $S_t \equiv W_t N_t / P_t Y_t$ is real unit labor costs (equivalently, the labor income share). Log-linearizing around the steady state yields

$$mc_t = s_t,$$

where s_t is the percentage deviation of real unit labor costs from their steady state. Thus, the percentage deviation of marginal costs from their steady state is equal to the percentage deviation of real unit labor costs from theirs. We use the sample average of real unit labor costs as an estimator of the steady state.