Misperceptions about the Frequency of Price Adjustments and Asymmetric Fed's Preferences – An Assessment of their Impact on Inflation and Monetary Policy Under Burns and Miller

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September 18 2008

Preliminary

Paper prepared for the NBER **Great Inflation Conference,** Woodstock, Vermont, Seprember 25-27 2008

Abstract

Using counterfactual simulations anchored on a New Keynesian model whose parameters are based on a combination of micro calibrations and estimation methods this paper evaluates quantitatively the impacts of misperceptions about the frequency of price adjustments (FPAM) and of recession avoidance preferences (RAP) at the Fed on the economy

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over the Burns/Miller era. The impacts examined are those on inflation, the paths of the federal funds rate, the output gap and of inflationary expectations. Interactions between each of FPAM and RAP one one hand, and output gap misperceptions (GM) on the other are also considered.

The paper's simulations reveal that: 1. Given the state of output gap misperceptions, underestimation of the frequency of price adjustment by the FOMC during the seventies raised the average value of inflation by up to a third. 2. About one third of this additional inflationary impact was transmitted through endogenous adjustments in inflationary expectations. 3. In the absence of RAP the upward, policy induced, impact of GM on inflation is more than offset by the direct downward effect of (private sector) pessimistic output gap expectations on the actual gap and inflation. However, the presence of **both** RAP and GM raises inflation over the seventies by up to a third.

1 Introduction

The great inflation under Burns/Miller and its aftermath under Volcker are some of the most traumatic event of US economic history during the second half of the twenthieth century. Many explanations have been offered for the rise and fall of that inflation. Among those are initially faulty models of the economy, political pressures and limiteds independence of the Fed, direct inflationary impacts of the two oil shocks, large and persistent underestimation of potential output by policymakers at the Fed and overexpansionary fiscal policy leading to deficits and a higher Federal debt.

Using a combination of estimation and calibration methods, this paper attempts to quantitatively evaluate two additional factors that, to this date, received little or no attention. These factors are misperceptions on the part of policymakers at the Fed about the frequency of individual price adjustments and asymmetric attitudes on their part to negative and to positive output gaps.

Combination of micro and macro evidence from countries like Israel that went through various inflationary steps shows that the frequency of individual price adjustments went up with the general level of inflation.[1] Theoretical micro models of price adjustment from the eighties also predict that the frequency of these adjustments should rise with inflation.[2] It is therefore natural to expect that after several years of high inflation during the end of the sixties and the beginning of the seventies the speed of individual price adjustments in the US also went up. This hypothesis takes its root from the observation that during the fivteen years preceding the beginning of the great inflation rates of inflation were similar to those experienced in the US under Greenspan's as chair while from the end of the sixties to the early eighties average inflation rose above 7 percent and peaked well above 15 percent.[3]

Unfortunately, there is no direct evidence on changes in the frequency of price adjustment between the period of the great inflation and the earlier period of price stability. However, extensive micro evidence on the relation between the frequency of individual price adjustments and the general rate of inflation in the US has been provided recently for the 1988-2005 period by Nakamura and Steinsson (Forthcoming), (NS inthe sequel). To obtain a quantitative assessment of the impact of the inflation differential between the great inflation period and the price stability period that preceded it, this paper applies the sensitivity of the frequency of price adjustment

[1] Using detailed micro data underlying the Israeli CPI during the seventies and the eighties Lach and Tsiddon (1992) and Hanoch and Galyam (1985) show that sustained increases in the general level of inflation are accompanied by non negligible oncreases in the frequency of adjustment of individual prices. Evidence about the "steps" or different inflation regimes experienced by the Israeli economy appears in Liviatan and Piterman (1986).

[2] An early example is Sheshinski and Weiss (1983).

[3] From the beginning of the sixties till the third quarter of 1967 quarterly average CPI inflation was 1.75 percent. The corresponding average for the period of the great inflation was 7.21 percent. Here the great inflation period is identified as occuring between the fourth quarter of 1967 and the third quarter of 1982. The beginning of the period is chosen as the point at which quarterly CPI inflation rose above 4 percent for the first time and its end is marked by the fact that it stayed below 3 percent in at least two consecutive quarters for the first time.

to inflation derived by NS to the average inflation differential between the great inflation period and the seven years of price stability preceding it. This calculation reveals that there has been a substantial increase in the frequency of price adjustments (or equivalently, a substantial reduction in average price duration) between those two periods.

A maintained hypothesis of this paper is that policymakers at the FOMC did not realize that the frequency of price adjustment has changed until quite late in the great inflation. Several considerations support this view. First, since that inflation followed on the heels of an extended period of price stability it was natural for policymakers to think in terms of an exogenously given speed of price adjustment. The current popularity of the Calvo (1983) process which postulates a constant frequency of price adjustments attests to that. Second, the inflationary episode of the seventies was largely a first time experience for policymakers and micro models relating individual price adjustments to inflation had yet to be developed.[4] The paper refers to the delayed realization of the macro implications of changes in the speed of price adjustment by policymakers as frequency of price adjustment misperceptions (FPAM) and investigates how policy and inflation would have differed if policymakers had been aware of that change in real time. This is the focus of the first and main part of the paper.

The second and shorter part of the paper evaluates the potential impact of asymmetric attitudes of policymakers to positive and to negative output gaps during the Burns\Miller era on the policy rule followed by the Fed and through it on the policy rate and inflation. Cukierman and Muscatelli (2008) produce evidence supporting the view that during this period the policy rule followed by the FOMC was consistent with stronger aversion to positive than to negative output gaps. Using their terminology I refer to this phenomenon as recession aversion preferences (RAP). The conjunction of output gap uncertainty and RAP leads policymakers to take stronger exante precautions against negative than against positive output gaps. Thus RAP is generally

[4] As a matter of fact, their development was triggered by the inflationary acceleration of the seventies.

conducive to more expansionary policies and higher inflation.

Orphanides (2001) argues convincingly that part of the great inflation was due to real time output gap underestimation by the FOMC. More precisely policies were based on the belief that the output gap was even more negative than it really was at the time. This led the FOMC to choose policies that were overexpansionary in comparison to the policies it would have followed, had it realized that the recession was actually milder. The basic hypothesis of the second part of the paper is that the presence of **both** output gap misperceptions (GM) and RAP compounds this overexpansionary bias of policy and of the related inflationary impact. The intuition is that a given underestimation of the gap induces more overexpansion of monetary policy in the presence of RAP than in its absence. Utilizing counterfactual analysis, the paper evaluates the quantitative contribution of RAP and of its interactions with GM on inflation and monetary policy during the seventies.

The New Neoclassical synthesis\New Keynesian framework provides a natural framework for the counterfactual analysis in the paper.[5] This framework is generally attractive because it recognizes that prices are set and adjusted by individual firms, that an important determinant of actual inflation is expected inflation, and because it realistically formulates policy in terms of the nominal short term interest rate. An important advantage from the point of view of this paper is that it establishes a mapping between the speed of price adjustments at the micro level and the slope of the aggregate Phillips relation making it possible to utilize micro evidence to calibrate some parameters of macro models.

Another advantage of the New Keynesian (NK) framework from the vantage point of this paper is that, in spite of data paucity about changes in the speed of price adjustment between the seventies and the preceding decades, this framework makes it possible to assess the quantitative

[5] Early formulations of this framework are due to Goodfriend and King (1997) and Rotemberg and Woodford ((1997) The first label is due to Goodfriend and King and the second has been popularized by Clarida, Gali and Gertler (1999). For brevity and since it is more widely used I refer to the framework as New Keynesian.

importance of interactions between FPAM and GM, as well as between RAP and GM. The simulation exercises in the paper offer separate quantitative assessments of the consequences of FPAM and of RAP for inflation, monetary policy, the output gap and inflationary expectations under the chairmanships of Burns and Miller. A quick verbal summary of the main results and of the methodologies used appears in the concluding section.

2 A framework for evaluation of changes in the frequency of price adjustment triggered by the great inflation

The analysis is anchored on a benchmark NK model of the type presented in chapters 3 and 5 of Gali (2008) along with commonly used calibrations for some of the parameters of the real sector underlying such models. Aggregate economic behavior within this framework can be reduced to two aggregate relations the first of which is commonly refered to as a dynamic IS equation (DIS) and the second as a New Keynesian Phillips Curve (NKPC). Gali shows that for a period's utility function with Constant Relative Risk Aversion (CRRA) specifications of utility from consumption and disutility from work those two (log linear) relations can be written respectively as

$$\widetilde{y_t} = -\frac{1}{\sigma}\left(i_t - E_t\pi_{t+1} - r_t^e\right) + E_t\widetilde{y_{t+1}} \tag{1}$$

$$\pi_t = -\kappa\widetilde{y} + \beta E_t\pi_{t+1} + \kappa\widetilde{y_t} + u_t \tag{2}$$

where

$$r_t^e = \rho + \sigma E_t\Delta y_{t+1}^e. \tag{3}$$

Here $\widetilde{y_t}, y_t^e, i_t, \pi_t, r_t^e$, $\Delta a_{t,}$ u_t denote the output gap, (the log of) the efficient level of output, the nominal interest rate, inflation, the real interest rate that supports the efficient allocation, the rate of change in a common multiplicative productivity shock and a cost shock. The symbol E_t

stands for an expectation conditionned on information available in period t, $\frac{1}{\sigma}$ is the intertemporal elasticity of substitution, β is the representative household discount factor, $\rho \equiv -\log \beta$, and

$$\kappa \equiv \frac{1-\alpha}{1-\alpha+\alpha\varepsilon}\left(\sigma+\frac{\varphi+\alpha}{1-\alpha}\right)\frac{(1-\theta)(1-\beta\theta)}{\theta}. \tag{4}$$

Here $1-\alpha$ is the exponent of labor input in the common production function available to each of a large number of monopolistically competitive firms, ε is the Dixit-Stiglitz elasticity of substitution in consumption between different varieties, φ is the exponent of hours worked in the houshehold's utility function and $1-\theta$ is a Calvo parameter that characterizes the (fixed across time and firms) probability that a firm will obtain the right to adjust its nominal price in any given period. $\widetilde{y}$ is the value of the welfare-relevant output gap in the zero inflation steady state (or equivalently, in the flexible price equilibrium).[6] It reflects an inflation bias due to the existence of a steady state distortion. Assuming that the change in the efficient level of output is driven by expected productivity shocks

$$E_t \Delta y^e_{t+1} = \psi^n_{ya} E_t \Delta a_{t+1} \tag{5}$$

where ψ^n_{ya} is a combination of parameters that determines the impact of the expected change in productivity on the efficient level of output. Substituting equation (5) into equation (3), substituting the resulting expression into equation (1) and rearranging the DIS becomes[7]

$$\widetilde{y_t} = \frac{\rho}{\sigma} + \psi^n_{ya} E_t \Delta a_{t+1} - \frac{1}{\sigma}\left(i_t - E_t \pi_{t+1}\right) + E_t \widetilde{y_{t+1}}. \tag{6}$$

I turn next to the estimation of the system in equations (6) and (2).

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[6] In the presence of a monopolistic competition or tax distortions $\widetilde{y} < 0$. A fuller discussion of the NKPC in the presence of a distorted steady state appears in Chapter 5 of Gali. See, in particular, equation (18).

[7] A fuller discussion of the DIS appears in Gali (2008). See in particular equation (22) in chapter 3 for the case of no distortions and equation (4) in chapter 5 for the case in which such distortions are present.

2.1 Estimation of the dynamic IS (DIS) and of the New Keynesian Phillips Curve (NKPC)

To estimate the parameters of the DIS and of the NKPC during the great inflation I chose, following some experimentation, the period starting in the first quarter of 1970 and ending in the last quarter of 1984.

2.1.1 Estimation of the DIS

Three of the four explanatory variables in the DIS are expected future values of the output gap, of inflation and of the rate of productivity growth. This requires proxies for those perceptions as formed at the time. Greenbook forecasts of the real time output gap and of GDP inflation a quarter ahead are taken from Orphanides (2004). The advantage of such proxies is that they not rely on the assumption of model consistent expectations.[8] A proxy for the expected rate of change in labor productivity has been generated using data on the rate of change of output per hour from the same quarter a year ago from the Bureau of Labor Statistics (BLS). After some experimentation with alternative lag specifications I settled for the following functional form

$$(\Delta LPNFY)_t = \rho_0 + \rho_1(\Delta LPNFY)_{t-1} \tag{7}$$

where $(\Delta LPNFY)_t$ is the rate of change of output per hour from the same quarter a year ago in the non farm business sector.[9] Equation (7) was estimated by least squares (LS) with quarterly data between 70:1 and 84:4. Using the estimated parameters, the proxy for the expected rate of change in labor productivity is specified as the value predicted by equation (7). The actual

[8] Use of these expectations presumes that there were no systematic differences between the public expectations and those of the Fed's staff. Comparison of the Greenbook forecasts with those from the Survey of Professional Forecasters supports this view for inflationary expectations.

[9] This procedure was repeated for the whole business sector. However since results were very similar the estimated DIS is presented only for the non farm business sector.

output gap, $\widetilde{y_t}$, is based on retrospective values of this variable constructed by using retrospective estimates of the potential output provided by the Congressional Budget Office.[10] Finally, i_t is proxied by the annual effective yield on federal funds from Orphanides (2004).

LS estimation of the the DIS in equation (6) yields[11]

$$\widetilde{y_t} = 3.82 + 0.24E_t\Delta a_{t+1} - 0.35\left(i_t - E_t\pi_{t+1}\right) + 0.67E_t\widetilde{y_{t+1}}. \tag{8}$$

The adjusted R-squared is 0.76, and all estinated parameters are significant (labor productivity at the 0.06 level and all the remaining coefficients at more than the 0.001 level).

2.1.2 Estimation of the NKPC

Due to some missing observations at the beginning of the period the NKPC in equation (2) is estimated by LS with quarterly data over the period 70:3-84:4 rather than from the beginning of 1970. π_t is proxied by the quarterly rate of inflation in the GDP deflator and $E_t\pi_{t+1}$ by the one quarter ahead Greenbook forecast of this variable from Orphanides (2004). Finally to account for the impact of the oil shocks of the seventies u_t is proxied by the quarterly rate of change in the refiners' acquisition cost of crude oil.[12] All quarterly rates of change are measured at yearly rates. Experimentation with the number of lags on the oil shock proxy suggested that the best

[10] This gap is calculated as the percentage deviation of actual real output (from the OECD Main Economic Indicators) from the retrospective value (as of 2006) of potential output provided by the Congressional Budget Office.

[11] Equation (6) assigns a coefficient of 1 to the expected output gap. Since estimation subject to this restriction substantially reduced the goodness of fit the constraint is not imposed.

[12] This variable is obtained from the Energy Information Administration of the US Government. During most of the seventies and the early eighties price controls on the price of domestically produced crude oil were in effect. I experimented therefore with both the imported acquisition cost as well as with a composite.of these costs from both sources. Since the results with either proxy were very similar only the version of the NKPC estimated with the composite cost is presented.

specification is achieved with a two quarters lag on the rate of change in the acquisition cost of crude oil to refiners. The resulting NKPC is given by

$$\pi_t = 1.439 + 0.887 E_t \pi_{t+1} + 0.229 \widetilde{y}_t + 0.004 u_{t-2} \tag{9}$$

where u_t is proxied by the rate of change in the acquisition cost of crude oil to refiners between quarter $t-1$ and quarter t. The adjusted R-squared is 0.76, and the estinated parameters are significant (the output gap at the 0.056 level, the shock to the price of oil at the 0.001 level and expected inflation at the 0.082 level).

3 Using the estimated benchmark NK framework along with micro evidence to backup the change in the frequency of price adjustment triggered by the great inflation

3.1 Overview of the methodology

Equation (4) provides a relation between the parameter, κ, of the output gap in the NKPC and the frequency of price adjustment at the individual firm's level as characterized by the Calvo parameter, θ. Thus, given estimated or calibrated values of the other parameters it is possible to use the estimate of κ from equation (9) (labelled κ_{GI}) to backup a "guesstimate" of θ (labelled θ_{GI}) during the great inflation. The recent work of NS provides a link between the frequency of price adjustment (FPA) at the micro level and the general rate of inflation in the US over the 1988-2005 period. Assuming that this relation is stable over time the NS estimated parameter can be used along with θ_{GI} to obtain a guesstimate (labelled θ_{LI}) of the FPA during the low inflation period preceding the great inflation. Finally equation (4) can be used again to calculate the value of κ implied by θ_{LI} (labelled κ_{LI}) for the low inflation era that preceded the great inflation.

3.2 Backing up θ_{GI}

Equations (2) (4) and (9) imply[13]

$$0.229 = \frac{1-\alpha}{1-\alpha+\alpha\varepsilon}\left(2.86+\frac{\varphi+\alpha}{1-\alpha}\right)\frac{(1-\theta_{GI})(1-0.887\theta_{GI})}{\theta_{GI}}. \tag{10}$$

Using the benchmark values $1-\alpha=\frac{2}{3}; \varepsilon=6; \varphi=1$, values commonly found in the business cycle literature this equation can be used to solve for θ_{GI}.[14] The outcome is

$$\theta_{GI} = 0.679. \tag{11}$$

Note, for future reference, that since the model is specified in quarterly terms, this implies an average price duration of 3.115 quarters or, equivalently, 9.346 months.[15]

3.3 Using the Nakamura Steinsson (NS) relation between the FPA and inflation to backup θ_{LI}

Using microeconomic data on individual prices over the 1988-2005 period NS find that a one percent increase in aggregate inflation is associated with, approximately, a one percent increase in the monthly frequency of price adjustment, f^m. This relation is utilized here in order to

[13] Here use has been made of the 0.35 coefficient of $i_t - E_t\pi_{t+1}$ in equation (8) which implies that $\sigma = 1/0.35 = 2.86$ and of the 0.887 estimate of β from equation (9).

[14] Further details appear in chapter 3 of Gali (2008).

[15] The relation between the average quarterly price duration, d_{GI}, and the Calvo parameter is calculated by using $d_{GI} = \frac{1}{1-\theta_{GI}}$.

evaluate the change in the FPA from the low inflation period preceding the great inflation to the great inflation period. Taking the period 60:1 through 67:3 with an average CPI inflation of 1.75% as representative of the low inflation period preceding the great inflation and taking the period 67:4 through 82:3 with an average CPI inflation of 7.21% as representative of the great inflation period this implies that, on average, f^m was higher by 5.46% during the great inflation than during the low inflation period that preceded it.

The 9.346 months average price duration found for the great inflation period in the previous subsection is equivalent to a monthly frequency of price adjustment of 10.15% implying that, on average, a bit over ten percent of firms adjusted their prices each month during that period.[16] Using the NS finding regarding the relation between inflation and the monthly FPA this implies that, prior to the great inflation the monthly frequency of price adjustment was 4.69% (10.15%-5.46%). This implies in turn that, during the low inflation period preceding the great inflation, the average price duration was 20.818 months or 6.94 quarters – which is equivalent to a quartely Calvo parameter of 0.8558.[17] Rounding up, the upshot is that

$$\theta_{LI} = 0.856. \tag{12}$$

Using equation (4) along with the same parameters values used to backup θ_{GI} this implies that the coefficient of the output gap in the NKPC during the low inflation period preceding the great inflation is $\kappa_{LI} = 0.049$. The upshot of this analysis is that

$$\kappa_{LI} = 0.049; \quad \kappa_{GI} = 0.229. \tag{13}$$

[16] The formula used for the conversion (with percentages expressed in decimal points) is $d^m = -\frac{1}{\ln(1-f^m)}$.where d^m is the average monthly price duration. Further details appear in footnote 13 of NS.

[17] The next section argues that, altough such a long average price duration may appear high from today's perspective, it might have been normal in view of the virtual absence of peace time inflation during the forty five years ending in 1967.

4 The impact of delayed recognition of changes in the frequency of price adjustment (FPA) on monetary policy and inflation: A methodological introduction

4.1 An historical motivation for the methodology

The great US inflation came on the heels of almost half a century of price stability. Except for war times (WW-II and briefly around the Korean war) the US had enjoyed price stability since the 1920's with prices actually **decreasing** during parts of the 1930's.[18] Given those circumstances the onset of a high (by US standards) and persistent inflation at the end of the sixties was a completely novel experience. It is, therefore, very likely that it took Fed's policymakers quite a while to realize the acceleration in the FPA and its impact on the tradeoff between economic activity and inflation triggered by a persistently higher inflationary environment.[19]

To assess the quantitative impact of such frequency of price adjustment missperceptions (FPAM) on the Fed's policy rule, and through it on inflation during the seventies I make two assumptions. First, that under Burns/Miller the Fed's policy rule was based on the belief that the tradeoff coefficient was still governed by the κ_{LI} parameter from the sixties rather than by the κ_{GI} parameter from the seventies. Second, that monetary policy was conducted in a discretionary manner and that, given its informational limitations, the FOMC chose the policy rate, i_t, in an optimal manner.

[18] An extreme example of very long price duration prior to the sixties is documented in Levy and Young (2004). They report that the price of a 6.5 oz. Coca-Cola was six and a half cents from 1886 until 1959.

[19] The belief in a stable tradeoff was part of the academic consensus in the sixties (Samuelson and Solow (1960)). Admittedly, Lindsey, Orphanides and Rasche (2005) document pronounements suggesting that, over the seventies, some Fed officials had already internalized Friedman's view that the long run Phillips curve is vertical. But, believing in a distant long run vertical Phillips curve and slowly realizing the impact of changes in the FPA on the short and intermediate run trade-offs between real economic activity and inflation are not incompatible.

Orphanides (2004) provides estimates of the Fed's policy rule during the great inflation using real time data for the output gap and expected inflation. He finds that the coefficient of expected inflation in the rule was substantially larger than one. His results support the view that policy during the seventies was overly expansionary due to biased downward output gap estimates rather than because of insufficient conservativeness on the part of the FOMC. I take the estimated policy rule from Orphanides (2004) as representing the conservativeness of the Fed and its output gap and inflation perceptions under the postulate that FOMC members believed that the tradeoff coefficient in the NKPC was still κ_{LI} and refer to it as the **actual policy rule**.

Combining this postulate along with the assumption of discretion and the NK economic structure above with Orphanides policy rule it is possible to backup the (implicit) degree of conservativeness of the FOMC and utilize it to derive a **counterfactual policy rule.** The counterfactual is based on the alternative postulate that under Burns/Miller Fed's policymakers were fully aware o[20]f the higher tradeoff coefficient, κ_{GI}. A comparison of the simulated paths of the federal funds rate and of inflation under the two rules is then used to assess the ceteris paribus contribution of FPAM to the great inflation. The following subsection discusses the details underlying the construction of the counterfactual.

4.2 Construction of a counterfactual policy rule (based on full knowledge of actual FPA by policymakers)

4.2.1 The policy rule under discretion

With the benchmark NK economic structure in equations (1) and (2) optimal policy under discretion requires that the CB set the short rate of interest so as to statisfy the following

[20] A derivation of this well known result appears in Clarida, Gali and Gertler (1999) and in chapter 5 of Gali (2005).

relation in every period

$$\widetilde{y_t} = -\frac{\kappa}{\alpha_y}\pi_t,\ t = 1, 2, .. \tag{14}$$

where α_y is the relative weight assigned by the CB to stabilization of the output gap relative to inflation. The higher α_y, the lower the effective level of conservativeness of the bank.[21] Basically this condition states that the CB equates the losses from the inflation and output gaps at the margin. Substituting equation (2) into (14) and rearranging

$$\widetilde{y_t} = -\frac{\beta\kappa}{\alpha_y + \kappa^2}\left(E_t\pi_{t+1} + u_t\right) \tag{15}$$

Substituting equation (1) into (15) and rearranging yields the following policy rule for the policy instrument.

$$i_t = \left(1 + \frac{\sigma\beta\kappa}{\alpha_y + \kappa^2}\right)E_t\pi_{t+1} + \sigma E_t\widetilde{y_{t+1}} + r_t^e + \frac{\sigma\kappa}{\alpha_y + \kappa^2}u_t. \tag{16}$$

This rule explicitly links the choice of policy rate, i_t, to the values of the output gap and of inflation as perceived by monetary policymakers ($E_t\widetilde{y_{t+1}}$ and $E_t\pi_{t+1}$ respectively) . Table 1 of Orphanides (2004) provides estimates of equation (16) that utilize real time Greenbook forecasts of the output gap and of inflation expected for each of the four upcoming alternative horizons between one and four quarters An important advantage of those estimates is that they do not rely on the assumption of model consistent expectations. Depending on the horizon, the coefficient of expected inflation varies in a narrow range between 1.49 and 1.59. A representative

[21]Note that α_y may be high and conservativeness low either because the bank is subject to political influence, or because its decision makers are not very conservative, or for both reasons.

version of Orphanides policy rule for the period 66:1-79:2 is[22]

$$i_t = 1.95 + 1.53E_t\pi_{t+1} + 0.46E_t\widetilde{y_{t+1}} + 0.68i_{t-1} - 0.26i_{t-2} \tag{17}$$

4.2.2 Backing up α_y given the existence of FPAM ($\kappa = 0.034$)

Equating the coefficients of expected inflation across equations (16) and (17)

$$1.53 = \left(1 + \frac{\sigma\beta\kappa}{\alpha_y + \kappa^2}\right). \tag{18}$$

Using the estimated values $\sigma = 2.86$ and $\beta = 0.887$ along with the maintained hypothesis that the policy rule in equation (17) reflected the FOMC belief that $\kappa = 0.034$ one can use equation (18) to find the implied value of α_y. The resulting figure is

$$\alpha_y = 0.23 \tag{19}$$

which implies that the Fed's reaction function during the great inflation is consistent with a (quadratic) loss function that assigns about five times as much weight to a one percent inflation gap than to a one percent output gap. This paints a picture of a relatively conservative Fed during the 66:1-79:2 period, which runs contrary to the judgement of many Fed watchers (a prominent example is Meltzer (2005, Forthcoming)). But when one recalls the postulated low perceived value of κ and examines the range of variation of the real time output gaps with which the Orphanides equations have been estimated, this conclusion appears somewhat more

[22]This equation shows the estimated parameters when the one quarter ahead Greenbook expected inflation is used except for the estimate of the inflationary expectations coefficient. This coefficient is equal to the average of this parameter over the four equations estimated with alternative forecast horizons. The real time data for the output gap in Orphanides actually refers to the within quarter forcast of this gap rather than to the future expected gap. But, since those forecasts display subsatantial serial correlation I treat the within quarter forecast as a proxy for next quarter's forecast.

believable. In particular the average value of the (uniformly negative) output gap over the seventies, as perceived by Fed's policymakers is 6.6 percent, reaching a maximum of over 16 percent and remaining stubbornly above 10 percent during the mid seventies.

4.2.3 Construction of the counterfactual (no FPAM; $\kappa = 0.20$)

Inserting the estimated values $\sigma = 2.86$ and $\beta = 0.887$ along with equation (19) and the **actual** value of the tradeoff coefficient, $\kappa = 0.229$, into the right hand side of equation (18) we find that if (other things the same) there had been no FPAM at the Fed, the coefficient of expected inflation would have risen to 3.06. Since κ only appears in that coefficient the counterfactual policy rule becomes

$$i_t = 1.95 + 3.06 E_t \pi_{t+1} + 0.46 E_t \widetilde{y_{t+1}} + 0.68 i_{t-1} - 0.26 i_{t-2}. \quad (20)$$

Summarizing, given the Fed's conservativeness as characterized by α_y, the optimal response to inflationary expectations rises when the FPA, and therefore κ, as perceived by policymakers rises. Using simulations the next section explores the consequences of FPAM for the conduct of policy and inflation during the great inflation.

5 How did slow recognition of changes in the frequency of price adjustment affect monetary policy and inflation? – A simulation analysis

5.1 Overview

To quantitatively assess the potential contribution of slow recognition of changes in the FPA by the Fed on the federal funds rate and inflation during the seventies this section compares the simulated behaviors of the model economy under two alternative discretionary rules. One is the actual rule in equation (17) that is presumed to be subject to FPAM. The other is the counterfactual policy rule in equation (20) that is derived under the presumption that there are no FPAM. In both cases the economic structure used in the simulations is given by the estimated DIS and NKPC in equations (8) and (9). The impact of FPAM is evaluated by comparing the simulated behavior of inflation, the federal fund rate, the output gap and, when relevant, inflationary expectations.

To examine wether there are interactions between the impacts of FPAM and of output gap missperceptions (GM) these comparisons are repeated twice. Once in the presence, and once in the absence of GM. Furthermore, in order to evaluate the consequences of the different policy rules on inflationary expectation the various comparisons are repeated with two alternative procedures for the generation of expectations. In the first, one quarter ahead Greenbook inflationary expectations as reported in Orphanides (2004) are used. In the second, the corresponding expectation formation process estimated in Cukierman (2008) is used to relate the current Greenbook inflationary expectation to past actual inflation rates and oil shocks.[23] It is

[23]In both cases the simulations do not distinguish between inflation forecasts by Fed officials and the general public.

given by

$$E_t\pi_{t+1} = 0.75 - 0.37D_{O1} + 1.35D_{O2} + 0.38\pi_{t-1} + 0.13\pi_{t-2} + 0.07\pi_{t-3} + 0.17\pi_{t-4} \tag{21}$$

where D_{O1} and D_{O2} are dummy variables for the periods of the first and the second oil shocks (73:4-74:4 and 79:1-80:2 respectively). It may be worth disgressing briefly to note that the "adaptive" appearance of this process does not necessarily contradict its rationality.[24]

The same experiments have been replicated with two, three and four quarters ahead inflationary expectations from the Greenbook. Since the results were broadly similar only the results using one quarter ahead inflationary expectations are presented. The first (static) set of comparisons abstracts from the impact of different policy rules and of GM on expectations while the second (dynamic) set takes those differential impacts on inflationary expectations into consideration thereby capturing additional differential impacts on actual inflation.

5.2 A four ways comparison of the paths of inflation and of related variables in the presence and in the absence of FPAM and of GM

5.2.1 Overview

In order to uncover potential interactions between the impact of misperceptions regarding the frequency of price adjustment and misperceptions regarding the output gap four types of comparisons are performed. The first two comparisons focus on paths differences between the case in which misperceptions about the FPA are present and between the case in which they are

[24] In the presence of uncertainty about the permanence (Brunner, Cukierman and Meltzer (1980)) or persistence (Cukierman and Meltzer (1986)) of inflationary shocks rational forcasts of inflation will generally rely on past actual rates of inflation. This basic thruth goes back to Muth (1960) and is well known from the literature on economic applications of Kalman filters. See also Friedman (1979).

absent. In the first of those, the paths of GDP inflation, of the federal fund rate and of the output gap are compared between the case with and the case without FPAM given the presence of GM. The second comparison is similar except that it is carried out assuming no GM. The last two comparisons focus on paths differences between the case in which misperceptions about the output gap are present and between the case in which they are absent. In the first of those the comparison is carried out given the existence of FPAM and in the second it is carried out assuming perceptions about the FPA are correct. For clarity the model economy is reproduced in what follows.

$$\widetilde{y_t} = 3.82 + 0.24 E_t \Delta a_{t+1} - 0.35 \left(i_t - E_t \pi_{t+1} \right) + 0.67 E_t \widetilde{y_{t+1}} \quad \text{(DIS)} \tag{22}$$

$$\pi_t = 1.439 + 0.887 E_t \pi_{t+1} + 0.229 \widetilde{y_t} + 0.004 u_{t-2} \quad \text{(NKPC)}. \tag{23}$$

Here equations (22) and (23) are the dynamic IS and the New Keynesian Phillips curve during the great inflation.The policy rules in the presence and in the absence of FPAM are given repectively by

$$i_t = 1.95 + 1.53 E_t \pi_{t+1} + 0.46 E_t \widetilde{y_{t+1}} + 0.68 i_{t-1} - 0.26 i_{t-2} \tag{24}$$

$$i_t = 1.95 + 3.06 E_t \pi_{t+1} + 0.46 E_t \widetilde{y_{t+1}} + 0.68 i_{t-1} - 0.26 i_{t-2}. \tag{25}$$

In the second, counterfactual, case the response of the interest rate to expected inflation is stronger since, in the absence of misperceptions about the FPA, policymakers realize that the reponse of inflation to the output gap is high and optimally adjust their discretionary rule accordingly.[25]

The presence or absence of GM feeds into the model through the variable used to proxy

[25] Further details appear in section 4 above.

the perceived output gap, $E_t\widetilde{y_{t+1}}$. In the first case real time gap perceptions from Orphanides (2004) are used.[26] In the second, counterfactual, case perceptions about the output gap are assumed to be correct so that $E_t\widetilde{y_{t+1}} = \widetilde{y_{t+1}}$. The proxy for the "true" output gap, $\widetilde{y_t}$, is constructed from retrospective values of potential output provided by the Congressional Budget Office.[27]

Finally all comparisons are performed for two alternative sets of one quarter ahead inflationary expectations. In the first case comparisons are made taking the path of one quarter ahead Greenbook inflationary expectations from Orphanides (2004) as given. In this preliminary case different policy rules or actions are not allowed to affect the paths of those expectations. In the second set of comparisons the impact of different policy rules or actions on expectations are taken into consideration by feeding lagged rates of inflation produced by the simulation into the expectation formation process in (21). For brevity I often shall refer to the first set of experiments as "comparisons with **exogenous** expectations" and to the second set as "comparisons with **endogenous** expectations". Presentation of results for both types of expectations separates the direct impacts of different types of misperceptions from their impacts through the induced changes in inflationary expectations.

5.2.2 Some useful notation

The simulations focus on comparison of the paths of four variables under different conditions regarding perceptions about the speed of price adjustment and the output gap. The variables

[26] To be precise Orphanides provides the real time perception of the current output gap ($E_t\widetilde{y_t}$) rather than its perception, $E_t\widetilde{y_{t+1}}$, for the next period. However since, in the data, actual gaps are highly serially correlated it is likely that $E_t\widetilde{y_t}$ is a reasonable proxy for $E_t\widetilde{y_{t+1}}$.

[27] This gap is calculated as the percentage deviation of actual real output (from the OECD Main Economic Indicators) from the retrospective value (as of 2006) of potential output provided by the Congressional Budget Office.

are inflation, π_t, the federal funds rate, i_t, the (actual) output gap, $\widetilde{y}_t$, and the one quarter ahead inflationary expectation, $E_t\pi_{t+1}$. Let

(i) $z_t(g_m, f_m, e_x)$ be the simulated value of z_t in the presence of both output gap and frequency of price adjustment misperceptions when inflationary expectations are exogenous.

(ii) $z_t(g_m, f_c, e_x)$ be the simulated value of z_t in the presence of output gap misperceptions.and correct perceptions about the frequency of price adjustment when inflationary expectations are exogenous.

(iii) $z_t(g_c, f_m, e_x)$ be the simulated value of z_t in the presence of correct gap perceptions.and misperceptions about the frequency of price adjustment when inflationary expectations are exogenous.

(iv) $z_t(g_c, f_c, e_x)$ be the simulated value of z_t in the presence of correct perceptions about the output gap and the frequency of price adjustment when inflationary expectations are exogenous.

where

$$z_t = \pi_t, i_t, \widetilde{y}_t, E_t\pi_{t+1}. \tag{26}$$

For quick memorization of the notation note that "g" stands for "gap", "f" for "frequency" and "e" for "inflationary expectation". For the subscripts, "m" stands for "misperception", "c" for "correct" and "x" for "exogenous". Thus, e_x represents a state in which the simulation is run with the **exogenously** given one quarter ahead inflationary expectation from the Greenbook. In anticipation of later discussion in this section note that e_n represents a state in which the simulation is run with one quarter ahead inflationary expectations generated

endogenously within each of the simulations by using the process in equation (21). Let

$$\begin{aligned} dz_t(f_m, f_c; g_m, e_j) &\equiv z_t(g_m, f_m, e_j) - z_t(g_m, f_c, e_j) \\ dz_t(f_m, f_c; g_c, e_j) &\equiv z_t(g_c, f_m, e_j) - z_t(g_c, f_c, e_j) \\ dz_t(g_m, g_c; f_m, e_j) &\equiv z_t(g_m, f_m, e_j) - z_t(g_c, f_m, e_j) \\ dz_t(g_m, g_c; f_c, e_j) &\equiv z_t(g_m, f_c, e_j) - z_t(g_c, f_c, e_j) \end{aligned} \tag{27}$$

where z_t is a dummy variable that runs over the variables in equation (26) and $j = x, n$. It is useful to illustrate the meaning of those definitions by stating the meaning for one of them in words. When $z = \pi$ and $j = x$, and $dz_t(f_m, f_c; g_m, e_j)$ specializes to $d\pi_t(f_m, f_c; g_m, e_x)$ which stands for the difference between the simulated value of inflation in the presence and in the absence of FPAM given that GM are present and that inflationary expectations are exogenous.

5.2.3 A quick look at actual values of relevant variables over the Burns/Miller era

Before plunging into the simulation analysis of the differential impacts of FPAM and of GM on inflation and other variables, it is useful to have a quick look at actual and expected inflation, the federal funds rate and the output gap as benchmarks. Figure 1a shows actual quarterly GDP inflation at yearly rates and the Greenbook forecast for that quarter formed in the previous quarter during the Burns/Miller era. Although inflation started to accelerate already a couple of years prior to this period and continued at substantial levels for several years under Volcker the analysis here is centered on the Burns/Miller era. This was done for two reasons. First, existing evidence (see, inter alia, Clarida, Gali and Gertler (2000), Fair (2007) and Cukierman and Muscatelli (2008)) strongly supports the view that the policy rules under Burns/Miller differed from that under Volcker. Second, it is hard to maintain the assumption that policy was subject to FPAM under Volcker who stepped in as chair of the Fed after more than ten years of high and variable inflation.

Figure 1 here

Figure 1a shows that prior to the first oil shock inflation fluctuated within a 3 to 6 percent range. It then accelerated for over a year reaching a temporary peak of over 12 percent in 1974. Between 1975 and the second oil shock it fluctuated within a 5 to 8 percent range reaching a second peak of about ten percent during the second oil shock toward the end of the period. The average value of inflation over the Burns/Miller period is **6.80 percent**. Eyeballing suggest that Greenbook inflation forecasts display a clear positivive correlation with actual inflation but are lower than actual inflation during the bulk of the period. The mean value of those forecasts is **5.69 percent**.

Figure 1b shows the actual behavior of the federal funds rate and of the retrospective output gap taken as representing the actual value of this gap. Although the average value of the actual gap is negative over the period its absolute value is small (**-0.38 percent** with a standard deviation of **2.21**). It even becomes positive for several years once immediatly prior to the first and once prior to the second oil shock. The real time gap.is uniformly and substantially lower than the retrospective gap. The average value of the former over the period is **-6.76 percent** with a standard deviation of **3.93**. The FFR fluctuates in a broad range between a minimum of around **4 percent** prior to the first oil shock and a maximum of over **13 percent** in 1975.

5.3 Comparisons of the paths of inflation, the policy rate and the output gap for alternative counterfactuals and exogenous inflationary expectations during the Burns/Miller era

Figures 2a, 3a and 4a show the differences between the simulated paths of inflation, the federal funds rate and the output gap in the presence and in the absence of misperceptions about the frequency of price adjustment, given the path of Greenbook inflation forecasts from Figure 1. To account for possible interactions between misperceptions about the FPA and about the output gap these comparisons are done twice. Once in the presence of GM and once in their absence.

Figures 2b, 3b and 4b show the differences between the simulated paths of inflation, the federal funds rate and the output gap in the presence and in the absence of misperceptions about the output gap, given the path of Greenbook inflation forecasts from Figure 1. Again, to account for interactions the comparisons are done twice. Once in the presence of FPAM and once in their absence.

A quick glance at the figures suggests that, for the case of exogenous expectations, there are no interactions between FPAM and GM since, for each variable considered, the differential path is the same independently of wether a comparison is made with the variable not subject to comparison assumed to be subject to a misperception or not. To illustrate consider Figure 1a which shows the difference between inflation rates in the presence and in the absence of FPAM. As suggested by the labeling on the top right hand side of the figure this comparison is done once when GM are assumed to be present and a second time under the assumption that they are absent. In general this should yield the two lines labeled $d\pi(f_m, f_c; g_m, e_j)$ and $d\pi(f_m, f_c; g_c, e_j)$. The first difference is represented by dots and the second by circles. The Figure clearly shows that those two lines collapse to one single path.[28] This implies that, for the case of exogenous expectations considered in this subsection, the impacts of FPAM and of GM can be discussed separately.

In view of this, the reader may wonder why the discussion goes into the trouble of specifying both. The reason is that, when inflationary expectations are generated endogenously by the simulations **there are** interactions between the two kinds of misperceptions for reasons that are discussed later. The introduction of this issue at this juncture is meant to provide a

[28]This can also be shown analytically by using the structure of the economy in equations (22), (23) and the policy rules with and without FPAM in (24), (25) along with, alternately, real time and retrospective output gap misperceptions.

benchmark for the comparisons with endogenous expectations in the next subsection.

Figures 2, 3 and 4 here

5.3.1 The impact of FPAM

Figure 2a shows that the presence of FPAM misperceptions uniformly raises actual inflation in comparison to the case in which such misperceptions are absent. The marginal inflationary impact of this misperception fluctuates between 0.5 and about 1.8 with a mean value of 1.19. The upshot is that in the absence of FPAM on the part of the Fed average (GDP deflator) inflation over the seventies would have been lower by about **twenty** percent (**4.90 percent** in the absence of FPAM versus **6.1** percent in its presence as predicted by the simulated benchmark, given the presence of GM).

By contrast Figure 3a shows that in the absence of FPAM the federal funds rate (FFR) would have been substantially higher. In particular, in the absence of FPAM it would have been higher by **14.90** percentage points on average. The conjunction of such a large differential impact on the FFR with the relatively small differential impact on inflation may appear surprising at first blush. The basic reason is that, given the path of inflationary expectations, the marginal impact of an increase in the FFR on inflation is given by the product of the coefficient of the real interest rate on the output gap in the DIS and the coefficient of the output gap in the NKPC. Using the estimated values in equations (22), (23) this marginal impact is only $-(0.35).(0.229) = -0.08$. Thus, to reduce inflation by one percent, the FFR would have to be raised by **over 12 percent**.

Finally, Figure 4a shows that, by inducing policymakers to choose a lower path for the FFR, the presence of FPAM raises the output gap so that the output gap differential is uniformly positive over the seventies. In the absence of FPAM this gap would have been 5.22 lower on average, fluctuating roughly between two and eight percentage points following the first oil shock.

5.3.2 The impact of GM

Figure 2b shows that the presence of GM misperceptions uniformly reduces actual inflation in comparison to the case in which such misperceptions are absent. This runs contrary to recently acquired wisdom (see, inter alia, Orphanides (2001), (2004)) and appears like a puzzle at first blush. The resolution of this seeming puzzle lies in recognizing that, within the New Keynesian framework used in this paper perceptions about the gap affect inflation through two different channels that influence the output gap in opposite directions. On one hand, by leading policymakers to believe that the gap is more negative than it really is GM induce a more expansionary monetary policy, a higher output gap and through the NKPC a higher rate of inflation. This mechanism is the one stressed by Orphanides and several coauthors.

But, as can be seen from equation (22) the perceived gap also affects the actual gap directly with a positive coefficient of 0.67 over the great inflation period. This is the standard consumption smoothing mechanism which states that, when individuals expect future output to be lower, they reduce current consumption demand – which reduces the current output gap and inflation with it. In the presence of a real time gap estimate that is lower than the true gap this mechanism reduces inflation. The upshot is that through the reaction of monetary policy a downward biased gap forecast raises inflation, but reduces it through the reaction of the private sector. Which of those two mechanisms dominates the impact on inflation is therefore an empirical issue. The estimates in this paper imply that, on balance, GM reduce inflation.[29]

[29] This argument relies on the assumption that the gap forecasts of the private sector and of policymakers are identical. Note that to have the mechanism stressed by Orphanides dominate, private sector perceptions of the gap should have been systematically more favorable than those of policymakers over the seventies. This appears as a stronger presumption than the assumption that the two sets of perceptions were largely similar. Obviously, if private sector gap perceptions are more pessimistic than those of policymakers, their negative impact on inflation is even stronger.

The upshot is that, given the estimated economic structure, the simulations imply that gap misperceptions reduced average inflation over the seventies by **0.57 percentage points** in spite of the fact that they led the Fed to choose an interest rate path that, over the seventies, was lower on average by about **five percent**. Due to the consumption smoothing behavior of the private sector the GM induced, on balance, a downward pull of about **2.5 percent** on the actual gap in spite of the Fed's over-expansionary monetary policy. The detailed behavior of the differences between the paths of the FFR and of the output gap in the presence and in the absence of GM over the seventies appears in Figures 3b and 4b respectively.

5.4 Comparisons of the paths of inflation and of related variables for alternative counterfactuals: Further impacts through endogenous expectations

5.4.1 Endogenous expectations, the emergence of interactions and qualitative robustness

When inflationary expectations are endogenous they adjust across simulations in line with changing past values of inflation according to the process specified in equation (21). Relatively higher past inflation in a given simulation translates, through this expectation process into a higher current expectation which raises inflation further via the NKPC and so on. Thus, endogenous expectations amplify the impact of inflation differentials across simulations.

Figure 5a shows that, with endogenous expectations, the additional inflation due to the presence of FPAM is larger in the absence than in the presence of GM. Figure 5b shows that, with endogenous expectations, the additional inflation due to the presence of GM is larger in the absence than in the presence of FPAM. Both figures imply that, with endogenous expectations, the impact of the interaction between the two misperceptions on inflation is negative. By contrast the discussion in the previous subsection showed that, with exogenous expectations, there are no interactions. Thus, the presence of endogenous expectations destroys the independence between the impacts of the two types of misperceptions.

Figure 5 here

But, independently of the identity of the state of perceptions about the variable or parameter that is held constant in any given comparison, FPAM uniformly raise inflation and GM reduce it.[30] Thus, the introduction of endogenous, instead of exogenous expectations, does not alter the qualitative results of the inflation comparisons in the previous subsection . Similarly, the appearance of interactions in the presence of endogenous expectations does not alter the directions of the impacts of FPAM and of the OG on the remaining variables. For brevity the figures showing these comparisons are ommitted.

5.4.2 Endogenous expectations and the amplification of the impacts of FPAM and of GM

The impact of FPAM As argued above, the presence of endogenous (or simulation dependent) inflationary expectations is expected to amplify the impacts of FPAM and of GM on inflation and possibly on related variables as well. Figures 6, 7 and 8 replicate some of the comparisons of the previous subsection in the presence of endogenous expectations. To obtain a quick visual evaluation of the marginal impact of endogenous expectations in comparison to the case of exogenous expectations discussed above each of the figures also presents the corresponding comparison for the case of exogenous expectations as a benchmark. These comparisons can be done while holding the state of perceptions with respect to the variable or parameter not being compared at either "misperceived" (subscript "m") or "correctly perceived" (subscript "c"). The figures focus on the set of cases in which the variable or parameter held fixed within

[30]The "perception state" for each variable or parameter considered may assume one of the two following states. It is either misperceived or correctly perceived.

each comparison is misperceived.[31]

The lines marked by circles in Figures 6a, 7a and 8a show the impact of FPAM on the simulated paths of inflation, the federal funds rate and the output gap in the presence of GM with endogenous inflationary expectations. The lines marked by dots in each of those figures replicates the same comparisons respectively for exogenous inflationary expectations. Figure 6a clearly shows that the positive impact of FPAM on inflation is amplified through the endogeneity of expectations. In the absence of FPAM inflation over the Burns/Miller era would have been about **thirty** percent lower (**3.82** percentage points compared to a **5.49** percentage points benchmark with both misperceptions) instead of **twenty** percent when the path of expectations is taken as given. Thus, the endogenous adjustment of expectations raises the inflationary impact of FPAM by a factor of **1.5**.

Figure 7a shows that, when expectations are endogenous, the FFR is still higher in the absence of FPAM but by much less than in the case of exogenous expectations (**6.88** percentage points on average instead of **14.9** for the case in which gap misperceptions are present). The reason is that a substantial part of the reduction in inflation is achieved through the reduction in expectations when a regime with FPAM is replaced by one with correct perceptions about the FPA. This effect is reminiscent of the benefits of commitment for the alleviation of the stabilization bias discussed in Clarida, Gali and Gertler (1999). An important difference, however, is that here the (in this case beneficial) impact through the adjustment of expectations operates even under discretion (that is, when the expectation formation process is taken as given by policymakers). Finally, Figure 8a shows that the presence of FPAM raises the output gap but by less than in the case of exogenous expectations.

Figures 6, 7 and 8 here

[31]The results for the set of cases in which they are correctly perceived are quite similar and are ommitted.

The impact of GM The lines marked by circles in Figures 6b, 7b and 8b show respectively the impacts of GM on inflation, the FFR and the output gap in the presence of endogenous expectations. For comparison purposes the lines marked by dots replicate the same impacts for the case of exogenous expectations. Figure 6b shows that the presence of endogenous expectations amplifies the negative impact of GM on inflation. Now inflation over the seventies is lower, on average, by **eighteen** percent (**5.49** versus a **6.71** benchmark) rather than by about **nine** percent (**6.10** versus a **6.67** benchmark with no gap misperceptions) when expectations are exogenous. Figures 7b and 8b show that, with endogenous expectations, GM reduce the FFR by more and raise the output gap by more than in the case in which the path of expectations is taken as given.

5.4.3 The impacts of FPAM and of GM on the paths of (endogenous) expectations

Figures 9a and 9b show respectively the impact of FPAM and of GM on the paths of expectations when those expectations adjust endogenously. Not surprisingly FPAM, by raising actual inflation, induce a rise in expectations, and GM, by reducing actual inflation, lead to a reduction of inflationary expectations. On average, over the seventies, inflationary expectations are higher by **over** thirty percent (**4.88** versus **3.73** percentage points) due to FPAM and lower by **fivteen** percent (**4.88** versus **5.74** percentage points) due to GM.

Figure 9 here

5.5 The impacts of GM and of FPAM on the variabilities of endogenous variables

The main finding from the simulations here is that GM tend to raise the standard deviations of the output gap and of the FFR. By contrast FPAM tend to reduce the standard deviations of the output gap and of the FFR. The effects of GM and of FPAM on the other variables are relatively small.

5.6 The combined impact of misperceptions about the frequency of price adjustment and the output gap

To evaluate the combined marginal impact of FPAM and of GM on inflation and other endogenous variables this subsection briefly discusses the difference between the paths of those variables when both misperceptions are present and the corresponding paths when both misperceptions are absent. Figure 10a presents those impacts for inflation and inflationary expectations and Figure 10b for the FFR and the output gap for endogenous inflationary expectations.[32] The combined impacts on all endogenous variables are positive. The combined marginal impacts of **both** misperceptions are **0.73** percentage points for inflation , **0.48** for inflationary expectations and **1.3** for the output gap . The combined marginal impact of both misperceptions on the FFR is very large and positive (**15.42** percentage points). Essentially, the positive marginal impacts of FPAM alone on the first three variables are partially offset by the negative effects of GM alone through the conflicting effects that FPAM and GM have via the DIS. But in the case of the FFR the marginal impacts of FPAM and of GM reinforce each other.

Figure 10 here

[32]The results for exogenous expectations are similar and are not presented.

6 The impact of interactions between recession avoidance preferences and output gap misperceptions during the Burns/Miller era

6.1 Overview

Recession avoidance preferences (RAP) refer to situations in which policymakers possess a stonger aversion to negative than to positive output gaps. In conjunction with a benchmark NK economic structure RAP implies that the reaction function of the central bank should be non linear. More precisely, sufficiently strong RAP are predicted to give rise to concave reaction functions making it possible to examine empirically wether there is evidence of RAP by testing for the existence and the form of nonlinearities in estimated reaction functions. Using hyperbolic tangents to allow for potential nonlinearities Cukierman and Muscatelli (2008) detect the presence of RAP in the Fed's reaction function during the Burns/Miller era.[33]

Orphanides (2001, 2004) shows that real time perceptions of the output gap were substantially biased downward during the great inflation in comparison to retrospective (and more precise) estimates of the same gap. He convincingly argues that those misperceptions led the FOMC to choose policies that came to be considered overly expansionary with the benefit of hindsight, thus contributing to part of the great inflation. The main idea underlying the analysis of this section is that, as a theoretical matter the presence of RAP should amplify the inflationary impact of downwardly biased output gap perceptions. The intuition underlying this statement

[33] Interestingly the notion that losses from the output gap are subject to asymmetries actually goes back to the seventies. At the time, the staff of the Fed used a loss function that quadratically penalizes **only** upward deviations of unemployment from 4.8% to evaluate the impact of alternative policy choices by means of the MPS and other econometric models (Craine, Havenner and Berry (1978), equation (1)). Although there is no evidence that the Board officially endorsed this loss function it is reasonable to presume that the staff would not have proposed it, if it had not been in the ball-park of the implicit objectives of the Board and the FOMC at the time.

can be understood by comparing the impact of output gap misperceptions (GM) on monetary policy in the presence and in the absence of RAP. In both cases GM induce policymakers to opt for policies that, given the true and higher value of the output gap, are overexpansionary. However in the presence of RAP the push towards a lower interest rate path is larger due to the stronger attempt by policymakers to avoid an even larger recession.

The main objective of this section is to provide a quantitative illustration of the potential relative contributions of GM and of RAP to the great inflation of the seventies. This is done by comparing two counterfactual simulations based on the economic structure in equations (22) and (23) and on two alternative policy rules, one with and another without RAP. The implementation of those two alternative cases is done by carying a non linear term in the Fed's reaction function in the first case and by omitting it in the second.

6.2 Methodology

Cukierman and Muscatelli (2008) find that during the Burns/Miller era, the reaction function of the Fed is given by

$$i_t = 0.83 + 0.86 E_t \pi_{t+1} + 0.55 E_t \widetilde{y_{t+1}} + \gamma_2 E_t \widetilde{y_{t+1}} \tanh\left(0.2 E_t \widetilde{y_{t+1}}\right) + 0.42 i_{t-1} \qquad (28)$$

where the sign of the coefficient γ_2 on the nonlinear term, $E_t \widetilde{y_{t+1}} \tanh\left(0.2 E_t \widetilde{y_{t+1}}\right)$, determines wether the reaction function is concave or convex in the output gap. When γ_2 is negative the reaction function is concave in the output gap. Cukierman and Muscatelli find that γ_2 is equal to -0.90 and that it is significantly different than zero. This supports the existence of RAP during the Burns/Miller period. In view of this, the policy rule in equation (28) is taken as representative of a reaction function displaying RAP. For the no RAP benchmark the same equation with a zero coefficient on the nonlinear term ($\gamma_2 = 0$) is used.

Before proceeding a qualification is in order. Equation (28) is estimated by GMM with retrospective data on the output gap and inflation using the rational expectation assumption that the forecasts of policymakers are unbiased estimates of the subsequent realizations of those variables. Owing to the persistent deviations between real time and retrospective output gap figures during the great inflation I tried to reestimate it by non linear least squares using the real time forecasts of the output gap and inflation from Orphanides (2004) instead of retrospective values. Unfortunately, the estimation procedure did not converge and the nonlinear parameter could not be identified. Consequently the simulation exercise based on comparison of the paths generated by equation (28) and of its linear counterpart should be viewed as illustrations of the potential inflationary impact of the interaction between RAP and GM with ballpark parameters rather than a definitive quantitative assessment.

Using real time perceptions of potential output and Greenbook inflation forecasts from Orphanides (2004) along with the estimated DIS in (22), expectations about the rate of change in labor productivity generated by using (7), and a variant of the NKPC in (23), equation (28) and its linear counterpart are used to generate two alternative paths for the federal funds rate, inflation and other endogenous variables.[34] The first family of paths, generated with the concave policy rule in equation (28), corresponds to the case in which there is RAP while the second, linear policy rule, corresponds to the case in which RAP is absent.

To evaluate the contribution of the interactions between RAP and GM the path comparisons are repeated in the absence of GM by using retrospective instead of real time data on the output gap. Further, in order to evaluate the impact of RAP on the formation of inflationary

[34] The estimated NKPC used here is
$\pi_t = 1.10E_t\pi_{t+1} + 0.20\widetilde{y}_t + 0.04u_{t-2}$ instead of equation (23). The main difference between these two Phillips curves is that the latter estimates an intercept while the former constraints the intercept to be zero. In the presence of steady state distortions the correct specification is the one with the estimated constant. The use of an estimated NKPC without a constant is due to an oversight and will be corrected in the next version. Note however that the results in this section are unlikely to change appreciably because the constant does not affect differences between paths and, except for the coefficient of expectations, the parameters of the remaining variables are not very different. It may, however reduce the differences in the impacts of RAP and of GM between the cases of endogenous and of exogenous expectations in Figures 14-16.

expectations and on their feedbacks, the path comparisons are replicated with the endogenous expectation formation process in equation (21) instead of the one quarter ahead Greenbook forecasts from Orphanides (2004).

6.2.1 Some notation

Let

(i) $z_t(g_m, r_p, e_s)$ be the simulated value of z_t in the presence of both output gap misperceptions and recession avoidance preferences when inflationary expectations are in state s.

(ii) $z_t(g_m, r_a, e_s)$ be the simulated value of z_t in the presence of output gap misperceptions and in the absence of recession avoidance preferences when inflationary expectations are in state s.

(iii) $z_t(g_c, r_p, e_s)$ be the simulated value of z_t in the absence of output gap misperceptions and in the presence of recession avoidance preferences when inflationary expectations are in state s.

(iv) $z_t(g_c, r_a, e_s)$ be the simulated value of z_t in the absence of both output gap misperceptions and of recession avoidance preferences when inflationary expectations are in state s.

where z_t is a dummy variable defined in equation (26) and $s = x, n$ (expectations are either in their exogenous or endogenous state). Let

$$\begin{aligned} dz_t\left(r_p, r_a; g_m, e_s\right) &\equiv z_t\left(g_m, r_p, e_s\right) - z_t\left(g_m, r_a, e_s\right) \\ dz_t\left(r_p, r_a; g_c, e_s\right) &\equiv z_t\left(g_c, r_p, e_s\right) - z_t\left(g_c, r_a, e_s\right) \\ dz_t\left(g_m, g_c; r_p, e_s\right) &\equiv z_t\left(g_m, r_p, e_s\right) - z_t\left(g_c, r_p, e_s\right) \\ dz_t\left(g_m, g_c; r_a, e_s\right) &\equiv z_t\left(g_m, r_a, e_s\right) - z_t\left(g_c, r_a, e_s\right) \end{aligned} \tag{29}$$

Thus, $dz_t(r_p, r_a; g_m, e_s)$ represents the simulated differences in the paths of variable z in the presence and in the absence of RAP given the presence of GM and inflationary expectations in state s.

6.3 Marginal impacts of RAP and of GM for exogenous expectations ($e_s = e_x$)

6.3.1 The impact of RAP

Figures 11a, 12a and 13a show the differences between the simulated paths of inflation, the federal funds rate and the output gap in the presence and in the absence of RAP, given the path of Greenbook inflation forecasts from Figure 1. The solid line in each figure shows the difference for the variable under consideration in the presence of GM and the broken line shows the same difference in the absence of GM. A quick glance at all three figures suffices to establish that, in the absence of GM, the impact of RAP is negligible. However, in the presence of GM, this impact is more substantial. In this case the presence of RAP raises average inflation by about **ten** percent (from **6.63** to **7.27** percentage points), reduces the average value of the FFR by over **9** percentage points and raises the output gap by over **three** percentage points.

Figures 11, 12, 13 here

6.3.2 The impact of GM

Figures 11b, 12b and 13b show the differences between the simulated paths of inflation, the federal funds rate and the output gap in the presence and in the absence of GM, given the exogenous path of one quarter ahead Greenbook inflation forecasts. The solid line in each figure shows the difference for the variable under consideration in the presence of RAP and the broken line shows the same difference in the absence of RAP. Figure 11b reveals that in the second case the impact of GM, is negative and relatively small. But it becomes largely positive, although still small, in the presence of RAP. Thus, RAP raises the relative importance of GM through their effect on policy relatively to their effect through the consumption smoothing behavior of the private sector. Similarly the impact of GM on the FFR and on the output gap is substantially stronger in the presence than in the absence of RAP. In the former case, GM reduce the FFR by almost **14** percentage points and raise the output gap by about **half** a percentage point.

The results from all six figures are consistent with the conclusion that, although the impacts of either RAP or GM alone are limited, they become more substantial in the presence of both of them.

6.4 Marginal impacts of RAP and of GM with endogenous expectations ($e_s = e_n$)

Figures 14, 15 and 16 replicate some of the comparisons of the previous subsection in the presence of endogenous expectations. To obtain a quick visual evaluation of the marginal impact of endogenous expectations in comparison to the case of exogenous expectations discussed above each of the figures also presents the corresponding comparison for the case of exogenous expectations as a benchmark. Since we saw in the previous section that most of the impacts of RAP and of GM operate in the presence of both, all the comparisons are confined to cases in which the marginal impact of RAP is evaluated in the presence of GM and the marginal impact of GM is evaluated in the presence of RAP.

6.4.1 The impacts of RAP with endogenous expectations

Figures 14a, 15a, 16a and 17a show the marginal impacts of RAP on inflation, the FFR, the output gap and expectations. The solid line in each figure shows the relevant difference in the presence of endogenous expectations and the broken line presents the same comparison for exogenous expectations to provide a benchmark. Figure 14a shows that endogenous expectations substantially amplify the marginal impact of RAP on inflation. Now RAP raises average inflation over the period by **over a third** (from **6.46** to **8.78** percentage points) rather than by **ten** percent under exogenous expectations.

Figure 15a shows that, when expectations are endogenous, the FFR is higher in the absence of RAP than in its presence, as was the case under exogenous expectations. The reason is that a substantial part of the reduction in inflation is achieved through the reduction in expectations when a regime with RAP is replaced by one with symmetric output gap policy preference. But the difference between the average value of the FFR under the two expectation regimes is small. Finally, Figure 16a shows that the presence of RAP raises the output gap roughly by the same extent under either type of expectation implying that the amplification effect of endogenous expectations on the gap is negligible.

Figure 17a confirms that, by raising inflation, RAP leads to uniformly higher inflationary expectations. The presence of RAP raises the average expectation over the Burns/Miller era by **twenty eight** percent (from **5.53** to **7.10** percentage points).

Figures 14, 15, 16 and 17 here

6.4.2 The impacts of GM with endogenous expectations

Figures 14b, 15b, 16b and 17b show the marginal impacts of GM on inflation, the FFR, the output gap and expectations. The solid line in each figure shows the relevant difference in the presence of endogenous expectations and the broken line presents the same comparison for exogenous expectations to provide a benchmark. The first three figures reveal that the amplification effects of endogenous expectations on the impacts of GM are generally small. Figure 17b shows that GM led to some reduction in expectations till the mid seventies and to some increase in them thereafter. The average difference in expectations in the presence and in the absence of GM over the period is negligible.

6.5 The impacts of RAP and of GM on the variabilities of endogenous variables

By and large both RAP and GM tend to raise the standard deviations of all endogenous variables. Again, this may provide a partial explanation for the great moderation as GM moderated substantially over the eighties and with the advent of a linear reaction function under Volcker.[35]

6.6 The combined impact of recession avoidance preferences and of output gap misperceptions

To evaluate the combined marginal impact of RAP and of GM on inflation and other endogenous variables this subsection briefly discusses the difference between the paths of those variables when both RAP and GM are present and the corresponding paths when both are absent. Figure 18a presents those impacts for inflation and inflationary expectations and Figure 18b for the FFR and the output gap for endogenous inflationary expectations. The combined marginal impacts of **both** RAP and GM on the output gap is negligible. The combined impact on inflation and inflationary expectations is negligible till the mid seventies. But it becomes positive during the second half of the seventies reaching a peak of almost 2 percentage points. The combined marginal impact of both RAP and GM on the FFR (in Figure 18b) is very large and positive reflecting a powerful positive interaction between those two factors.

Figure 18 here

[35] Cukierman and Muscatelli (2008) find evidence in favor of RAP under Burns/Miller but no such evidence under Volcker.

7 Summary and conclusions

Using counterfactual simulations anchored on a New Keynesian (NK) model whose parameters are based on a combination of micro calibrations and estimation methods this paper evaluates quantitatively the contributions of two main factors to inflation, the path of the federal funds rate, the output gap and inflationary expectations over the Burns/Miller era. The two factors are misperceptions about the frequency of price adjustments (FPAM) and recession avoidance preferences (RAP). Orphanides (2001) provides convincing evidence supporting the view that, during this period, the FOMC was subject to substantial (biased downward) misperceptions about the output gap (GM). Since there often are interactions between FPAM and RAP on one hand and GM on the other, the paper also reevaluates, as a byproduct, the impact of GM on inflation during the seventies.

The paper presents two distinct sets of counterfactual simulations. The first set evaluates the contributions of FPAM and of GM to inflation and related variables. The second set evaluates the contributions of RAP and of GM to the paths of the same variables. The implementation of the counterfactual simulations proceeds in several steps. In the first step the dynamic NK IS relation (DIS) and the NK Phillips curve (NKPC) are estimated for the period of the great inflation with real time data for the output gap and inflation forecasts from the Greenbook.[36] The resulting economic structure is then used to evaluate the contributions of both FPAM as well as that of RAP. From this point and on the contributions of FPAM and of RAP are evaluated separately. In both cases the existence of GM is taken into consideration.

The contribution of FPAM is obtained by comparing counterfactual simulations with a benchmark simulation that utilizes the estimated economic structure and a policy rule estimated with real time data in Orphanides (2004) with a counterfactual policy rule. It is assumed

[36] Throughout the estimations and simulations any discrepencies between the Greenbook forcasts and those of the private sector are abstracted from.

that, although the frequency of price adjustments increased between the price stability period preceding the great inflation and the great inflation period, policymakers did not internalize the macroeconomic consequences of this change till the end of the Burns/Miller era. The benchmark policy rule from Orphanides is therefore taken as reflecting both FPAM and GM.

The counterfactual policy rule is constructed under the alternative assumption that, over the seventies, policymakers were fully aware of the correct frequency of price adjustment during this period. This is done in several steps. First, using conventional calibrations for some of the micro parameters of the NK model from Gali (2008) the actual frequency of price adjustment during the seventies is backed up from the estimated NKPC in terms of a Calvo parameter. Second, a Calvo parameter for the preceding period of price stability is calculated by applying the sensitivity of the frequency of price adjustment to aggregate inflation from Nakamura and Steinsson (Forthcoming) comprehensive microeconomic study. This yields a higher Calvo parameter for the low inflation period which is taken to represent the (mistaken) beliefs of policymakers during the seventies. Third, this parameter is then used in the reaction function from Orphanides (2004) along with the NK economic structure and the assumption that (although discretionary and subject to both frequency and gap miperceptions) actual policy was conducted in an optimal manner to back up the weight of the output gap relative to inflation in the (quadraratic) loss function of policymakers over the seventies. Finally this parameter (denoted α_y) is used to calculate the optimal rule under discretion given the counterfactual assumption that, over the seventies, policymakers were fully aware of the higher frequency of price adjustment and of its implications for the NKPC.[37] This doubles the response of the nominal interest rate to expected inflation in the policy rule estimated by Orphanides (from an average value of 1.53 to 3.06).

[37] Relatively to the beliefs of some observers this parameter turns out on the low side implying that Burns/Miller were rather conservative in Rogoff (1985) sense. However it is argued in the paper that, in view of the large GM that existed at the time, this is not so surprising.

To illustrate the potential impacts of RAP and of its interactions with GM a nonlinear Taylor rule estimated for the Burns/Miller period in Cukierman and Muscatelli (2008) is used to represent the presence of RAP on the part of policymakers. The absence of RAP is represented by the same rule with the coefficient of the nonlinear term (that captures the recession avoidance) set equal to zero. Those two alternative rules are then used along with the estimated NK economic structure to generate path differences in endogenous variables in the presence and in the absence of RAP.

To isolate the direct impacts of FPAM and of RAP for given inflationary expectations from the efffects of those misperceptions when inflationary expectations are allowed to adjust in line with the different types of policy rules the various comparisons are done once with exogenously given expectations and once with expectations that adjust endogenously in line with past realizations of inflation. Both the marginal impacts of FPAM and of RAP as well as their impacts combined with those of GM are evaluated. A highlight of main results follows starting with the impacts of FPAM in the presence and in the absence of GM.[38]

1. When the path of expectations is exogenous to the simulation there is no interaction between FPAM and GM. But when expectations adjust endogenously in line with the outcomes generated by a simulation there is an interaction between the two kinds of misperceptions.

2. Given the state of GM, FPAM raises inflation and reduces the FFR. The average increase in inflation over the Burms/Miller period is about twenty percent when expectations are exogenous and about thirty percent when they are endogenous. Thus, endogenous inflationary expectations amplify the impact of FPAM on actual inflation. In particular those numbers imply that about one thirds of the marginal inflationary impact of FPAM operates through the effect via endogenous expectations. The absolute value of the reduction FPAM causes in the FFR is substantially larger. The discrepency between the magnitudes of the impacts on inflation and

[38] This replication of comparisons is made to uncover potential interactions between those two types of misperceptions.

on the FFR is due to the fact that, given expectations, the marginal impact of a change in the FFR on inflation via the DIS and the NKPC is relatively small. Consequently, other things the same, a one percent change in inflation is associated with a change of about fourteen percent in the opposite direction of the FFR.

3. Given the state of FPAM, GM reduces **both** inflation and the FFR. The negative impact of GM on inflation is due to the fact that downwardly biased perceptions of the output gap trigger two opposing effects on inflation. On one hand, they induce policymakers to reduce the FFR – which raises inflation. This is the effect stressed by Orphanides (2001, 2004). On the other hand, lower perceptions of the future gap induce, through the consumption smoothing behavior of the private sector a decrease in the current output gap – which reduces inflation. Given the parameter estimates of the DIS and the NKPC and the magnitude of GM over the great inflation, the second effect dominates the first leading to a small decrease of inflation in spite of the associated large decrease in the FFR.[39] Again, endogenous expectations amplify the (in this case negative) impact on inflation.

4. The combined impact of FPAM and of GM on inflation is positive but moderate. It amounts to 0.73 percentage points on average over the Burns/Miller period. Essentially, the positive marginal impact of FPAM alone on inflation is offset by the negative effects of GM alone through the conflicting effects that FPAM and GM have via the DIS. But in the case of the FFR the marginal impacts of FPAM and of GM reinforce each other inducing a substantial drop in the FFR.

I turn now to a brief discussion of the consequences of RAP. The apriori expectation is that, by inducing policymakers to take stronger precautions against recessions, RAP reinforces the bias toward overexpansion due to downwardly biased gap perceptions. The simulations provide a quantitative evaluation of this mechanism. In particular

[39] This argument relies on the assumption that output gap forecasts of policymakers and of the private sector were similar over the seventies.

1. The impacts of RAP in the absence of GM and of GM in the absence of RAP on inflation are negligible. However, in the presence of GM a moderate inflationary impact of RAP becomes apparent even with exogenous expectations. Although moderate, this positive impact is meaningful since, in the absence of RAP, the average impact of GM is negative. In the presence of both GM and endogenous expectations RAP raises average inflation over the seventies by about a third.

2. In the presence of GM, RAP exerts a large negative effect on the FFR.

3. Endogenous expectations amplify the impacts on inflation but not on other variables like the FFR and the output gap

4. The combined (positive) impact of RAP and GM on inflation is negligible during the first half of the seventies but becomes substantial during the second half, reaching almost two percentage points in 76-77.

Are there any lessons from the discussion of the great inflation under Burns/Miller for current inflation and monetary policy? I will conclude with two remarks. First, the evidence in the paper supports the view that about a third of the inflationary impact due to delayed recognition of the rise in the frequency of price adjustment by policymakers was transmitted through the adjustment of inflationary expectations.

Second, even if it occurs again, such a mistake is likely to have a milder inflationary impact for two reasons. One is that current policymakers routinely monitor the evolution of inflationary expectations and possess better indicators of their evolution. The other is that, after the experience of the great inflation, both policymakers and the economic profession are more aware of the fact that the frequency of price adjustment rises with inflation For younger generations of policymakers and others who might have forgotten this lesson, this paper sounds a warning against the repetition of a similar mistake.

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Figure 1a: Actual and expected (from the Green Book) one quarter ahead inflation, yearly rate

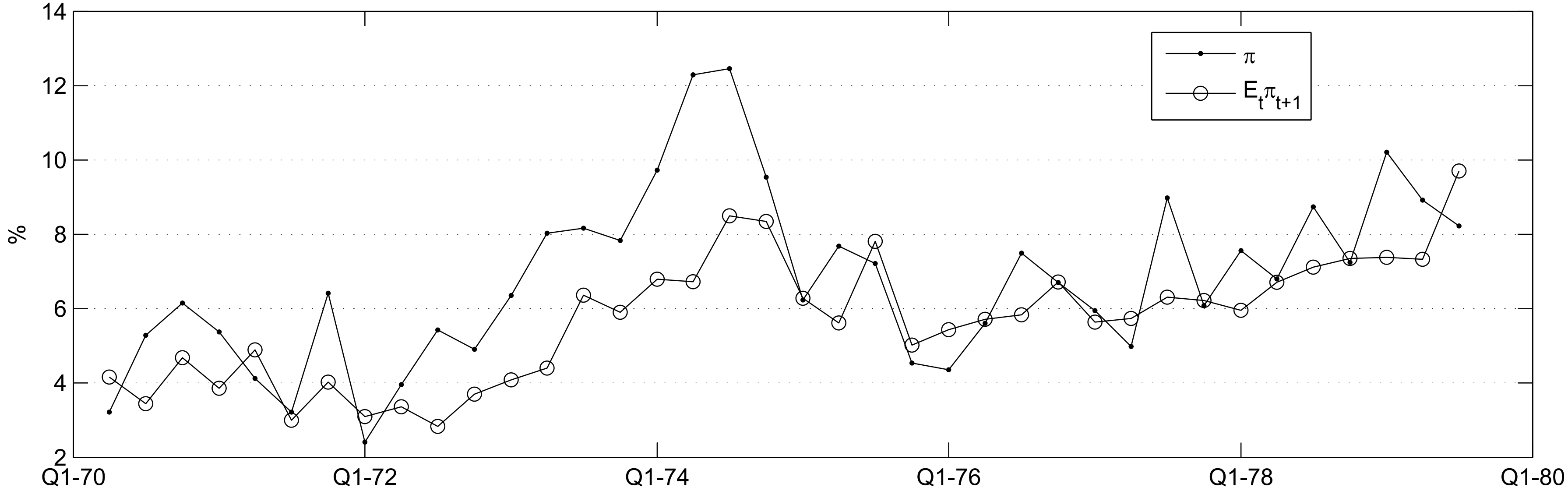

Figure 1b: Actual Fed funds rate and output gap

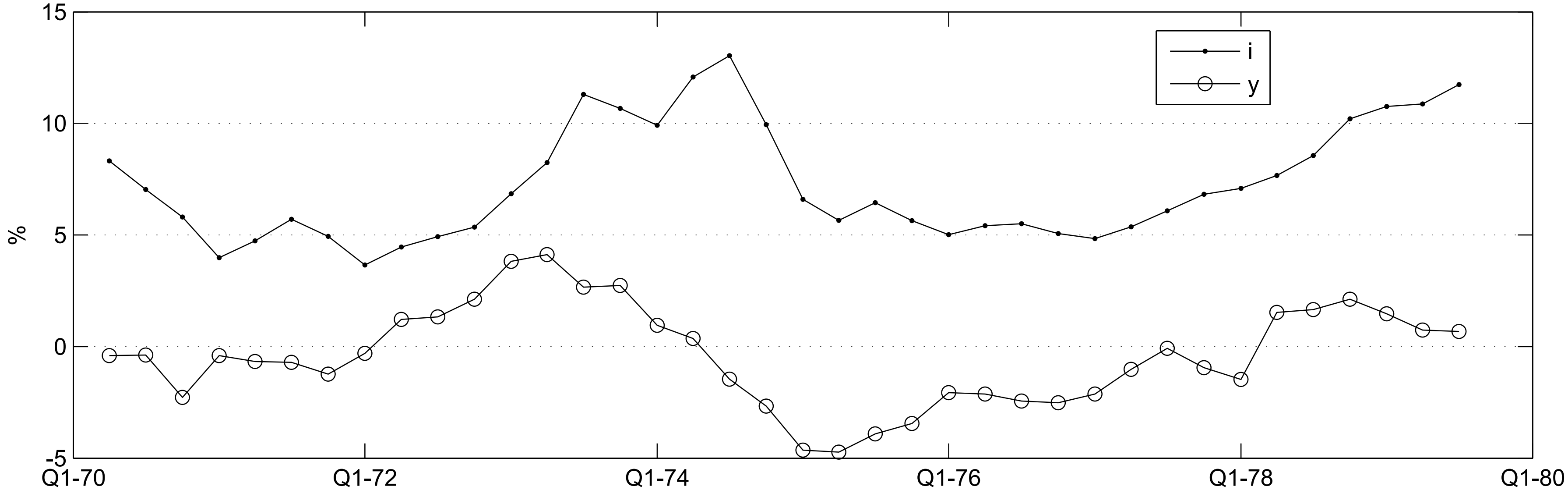

Figure 2a: Marginal impacts of FPAM on inflation (given exogenous expectations) in the presence and in the absence of GM

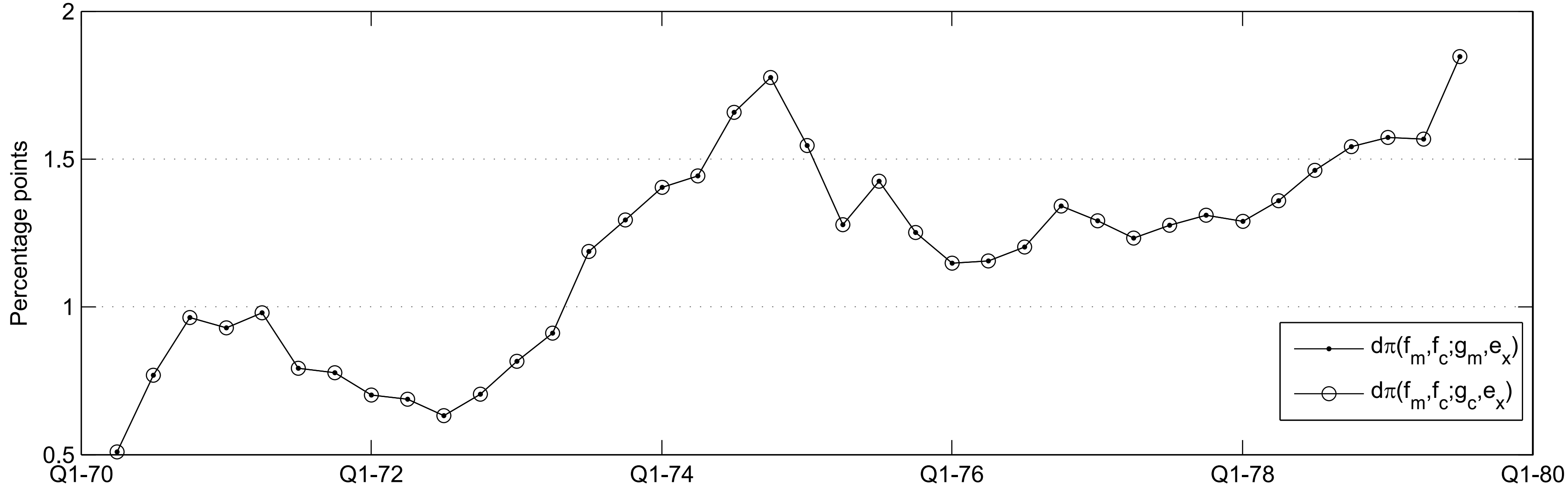

Figure 2b: Marginal impacts of GM on inflation (given exogenous expectations) in the presence and in the absence of FPAM

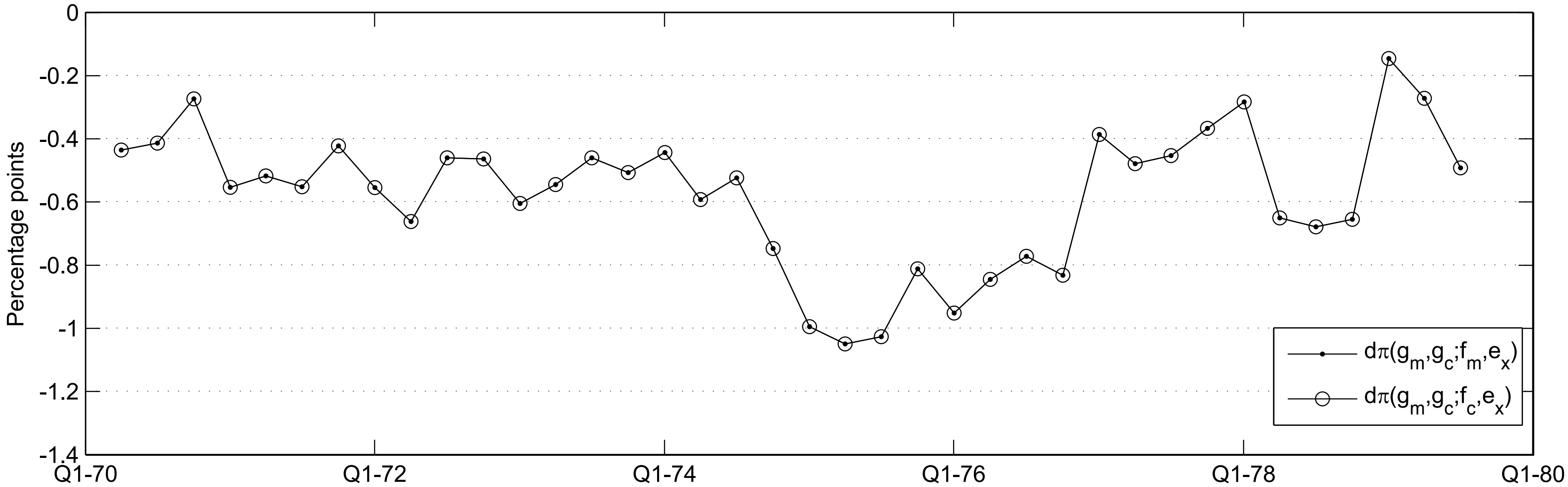

Figure 3a: Marginal impacts of FPAM on Fed funds rate (given exogenous expectations) in the presence and in the absence of GM

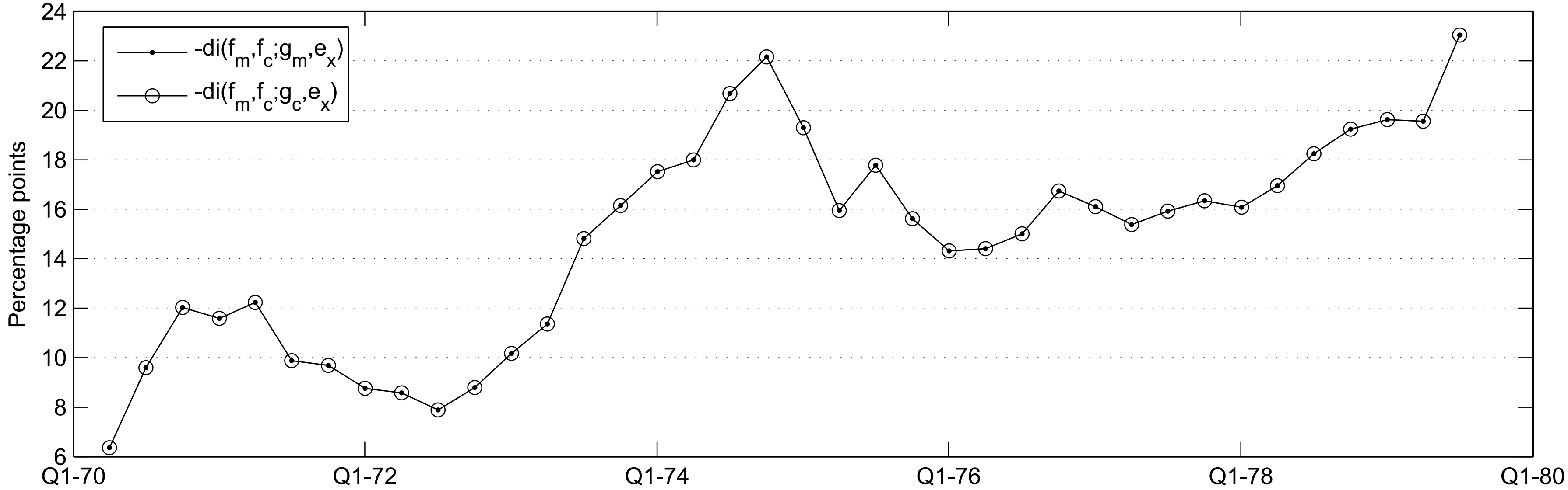

Figure 3b: Marginal impacts of GM on Fed funds rate (given exogenous expectations) in the presence and in the absence of FPAM

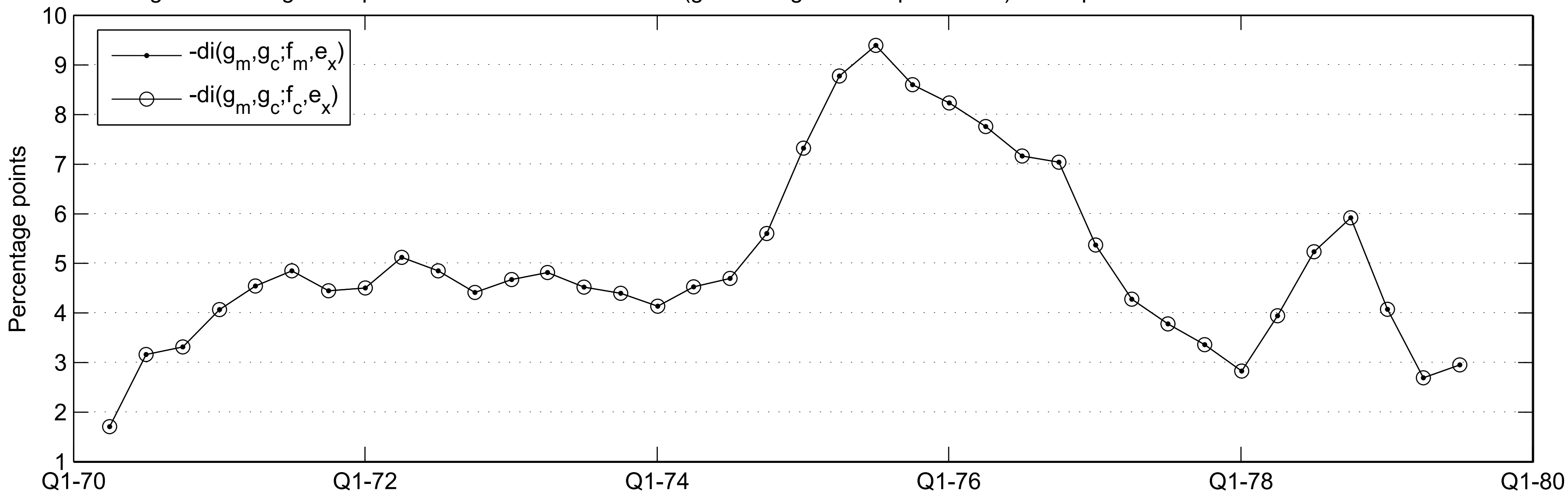

Figure 4a: Marginal impacts of FPAM on output gap (given exogenous expectations) in the presence and in the absence of GM

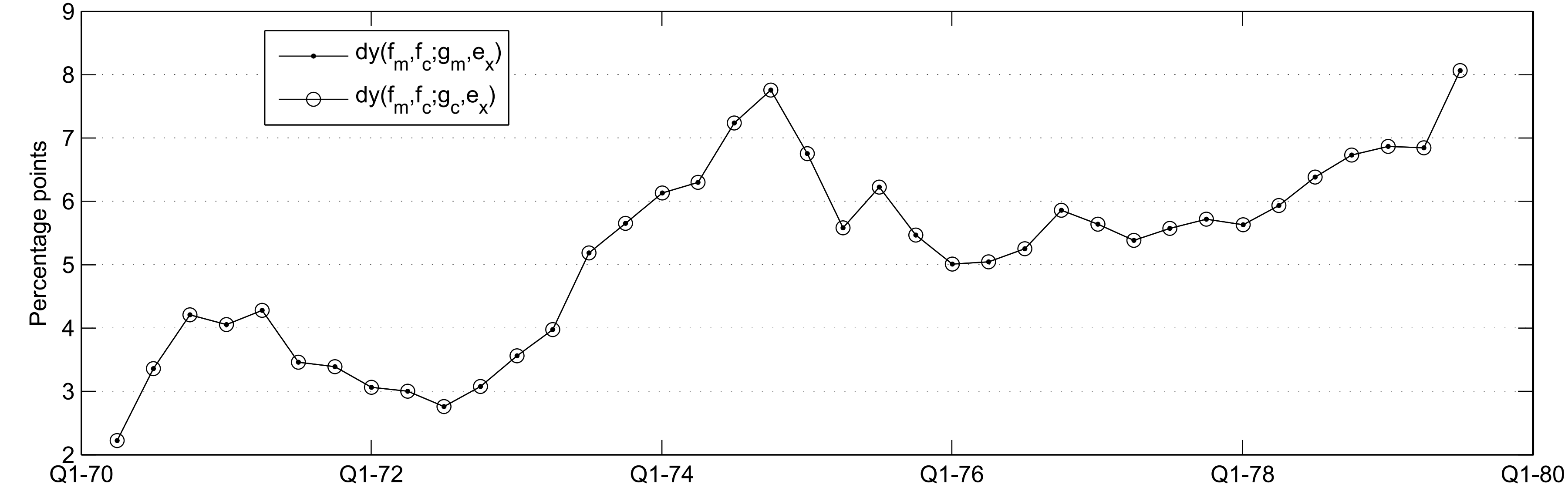

Figure 4b: Marginal impacts of GM on output gap (given exogenous expectations) in the presence and in the absence of FPAM

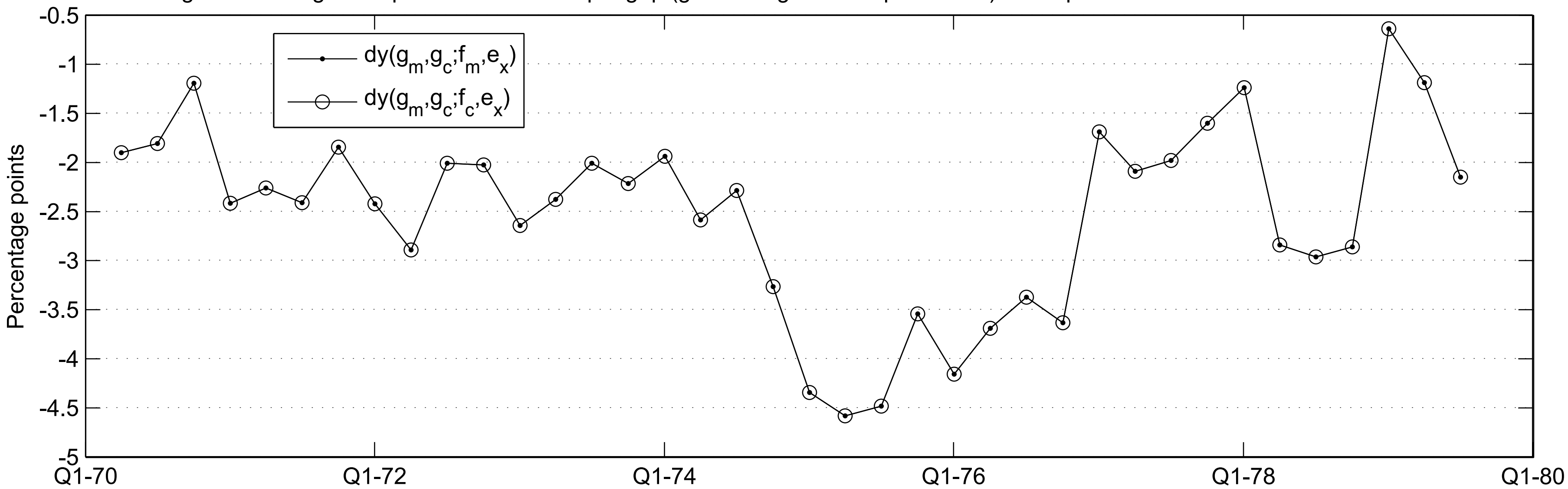

Figure 5a: Marginal impacts of FPAM on inflation (given endogenous expectations) in the presence and in the absence of GM

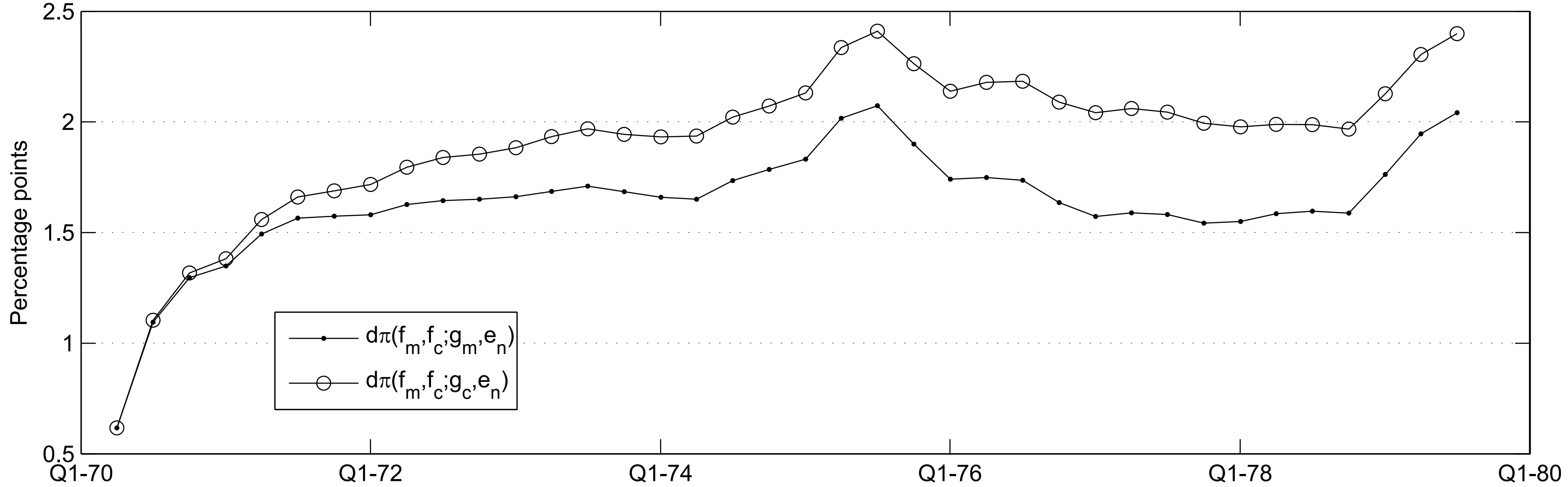

Figure 5b: Marginal impacts of GM on inflation (given endogenous expectations) in the presence and in the absence of FPAM

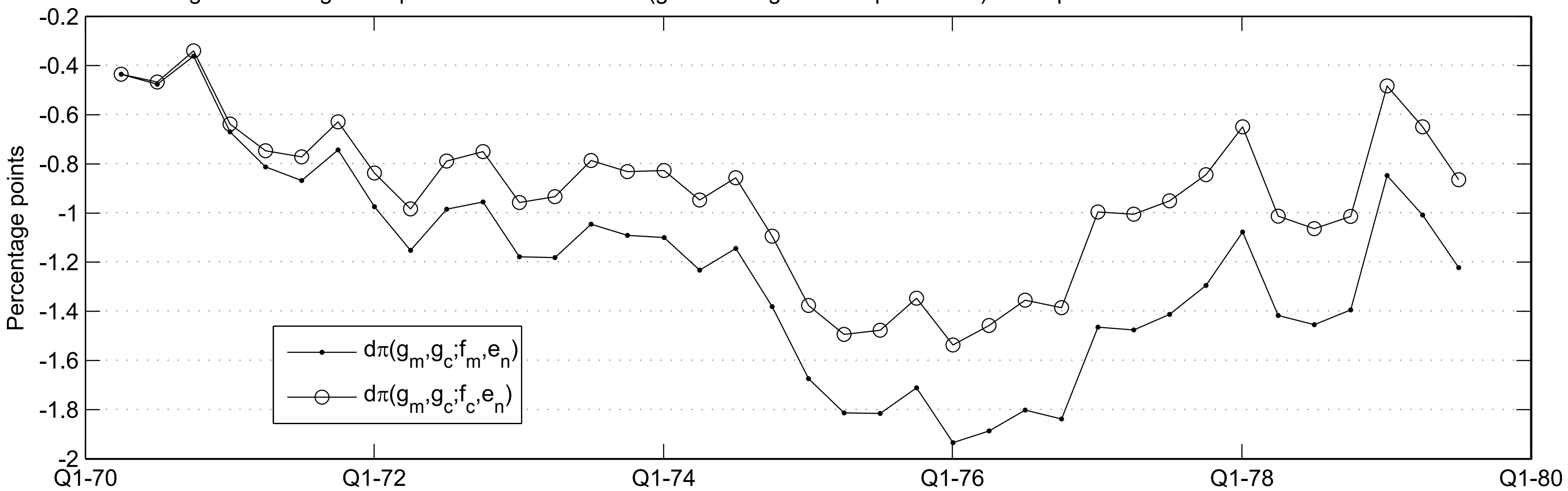

Figure 6a: Marginal impacts of FPAM on inflation (given GM) for exogenous and for endogenous inflationary expectations

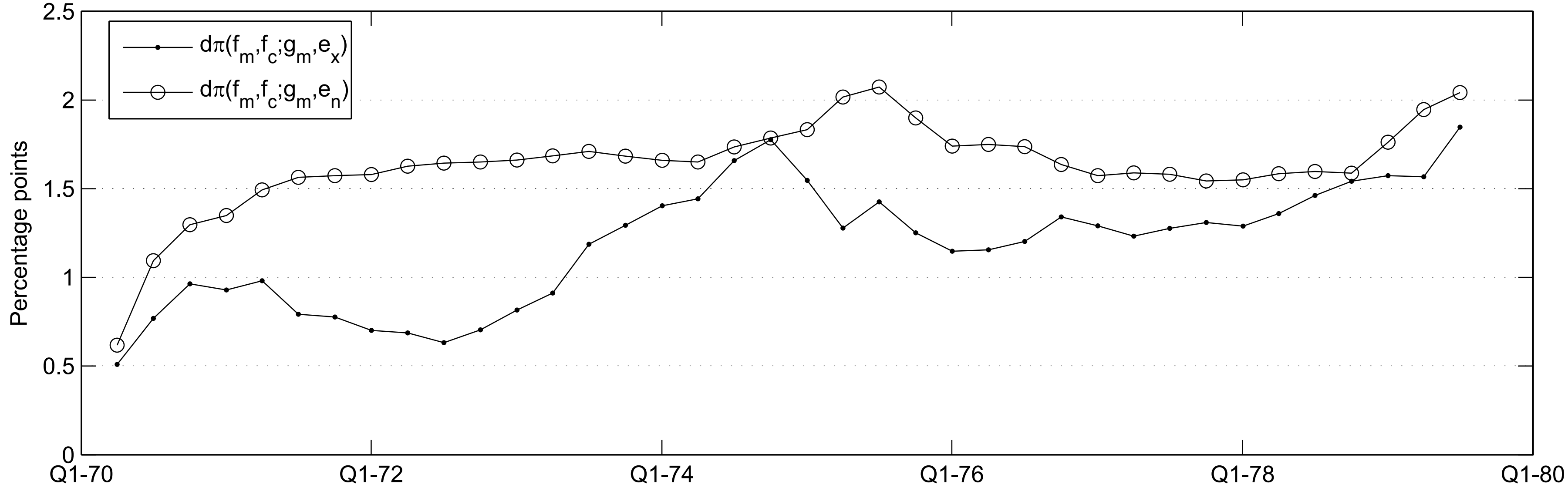

Figure 6b: Marginal impacts of GM on inflation (given FPAM) for exogenous and for endogenous inflationary expectations

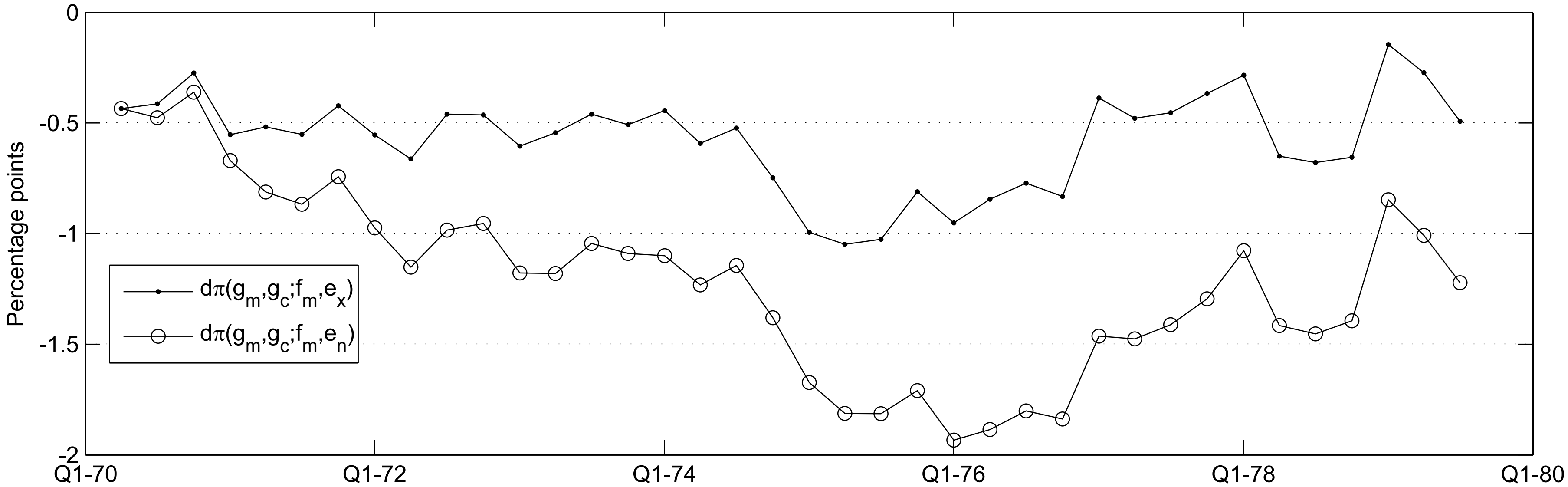

Figure 7a: Marginal impacts of FPAM on Fed funds rate (given GM) for exogenous and for endogenous inflationary expectations

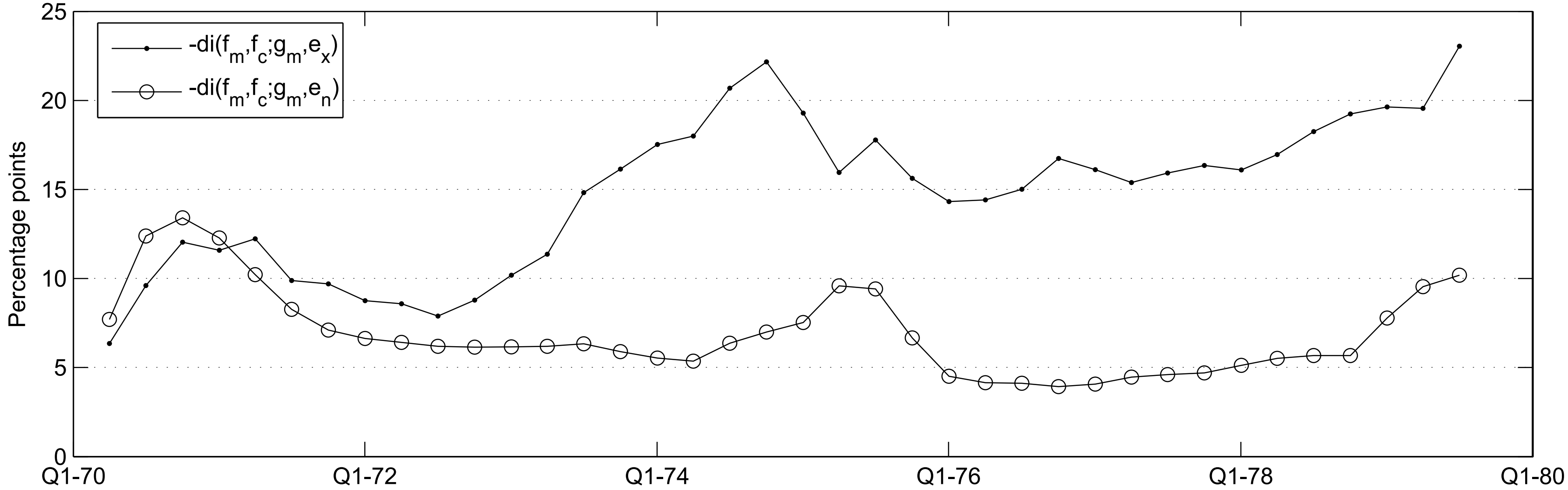

Figure 7b: Marginal impacts of GM on Fed funds rate (given FPAM) for exogenous and for endogenous inflationary expectations

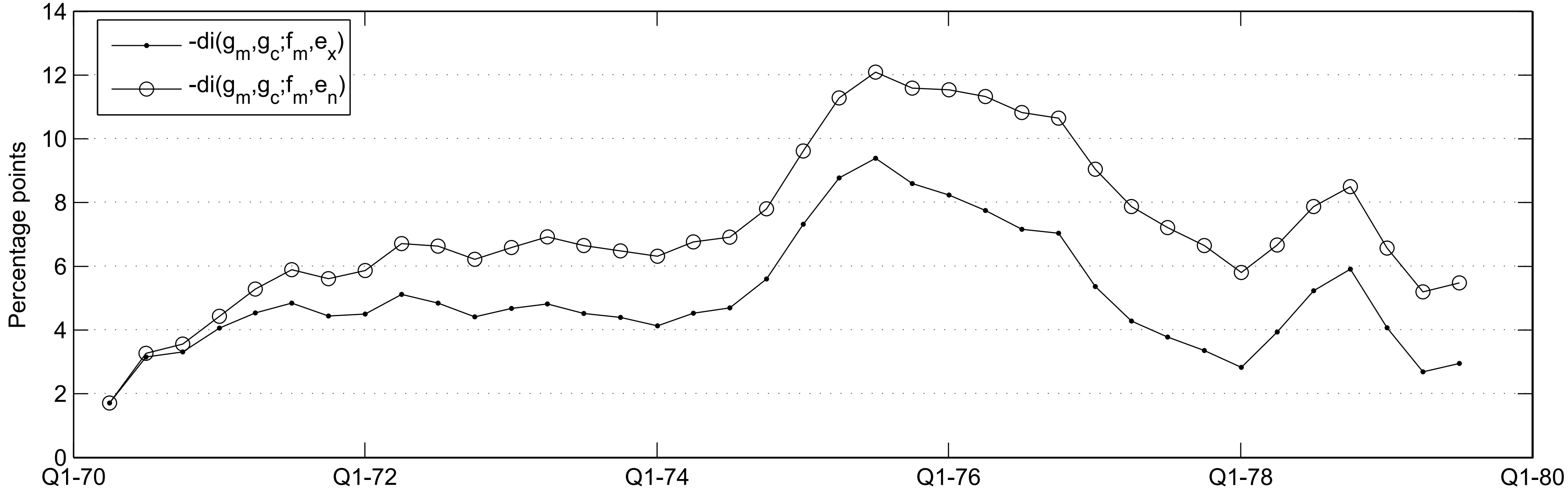

Figure 8a: Marginal impacts of FPAM on output gap (given GM) for exogenous and for endogenous inflationary expectations

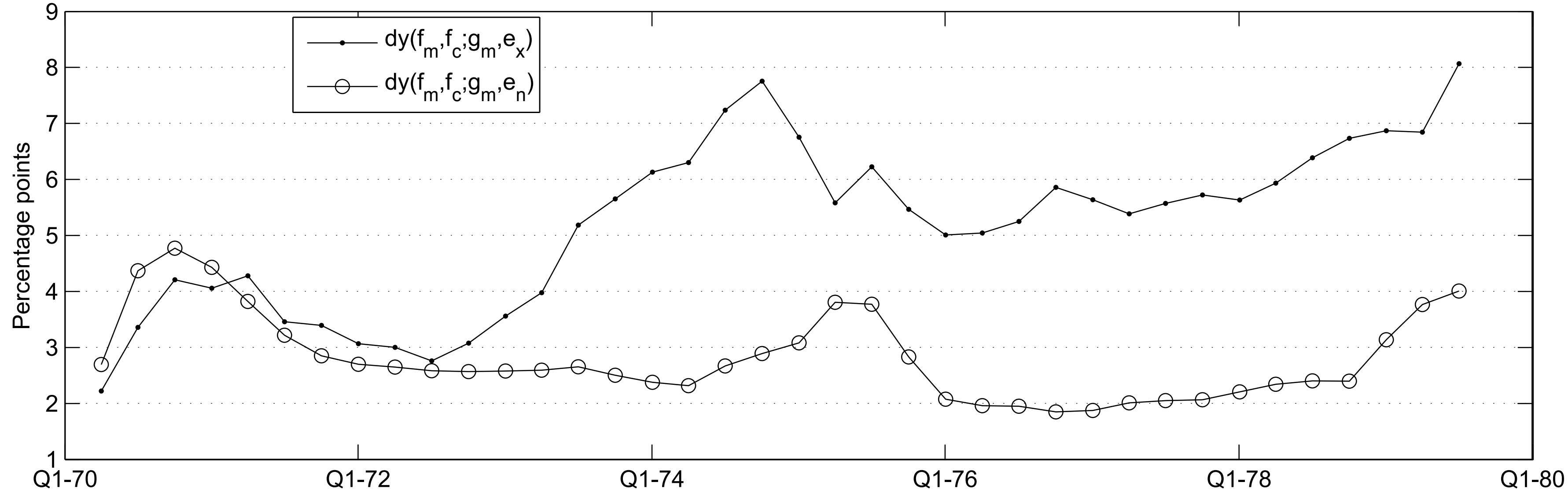

Figure 8b: Marginal impacts of GM on output gap (given FPAM) for exogenous and for endogenous inflationary expectations

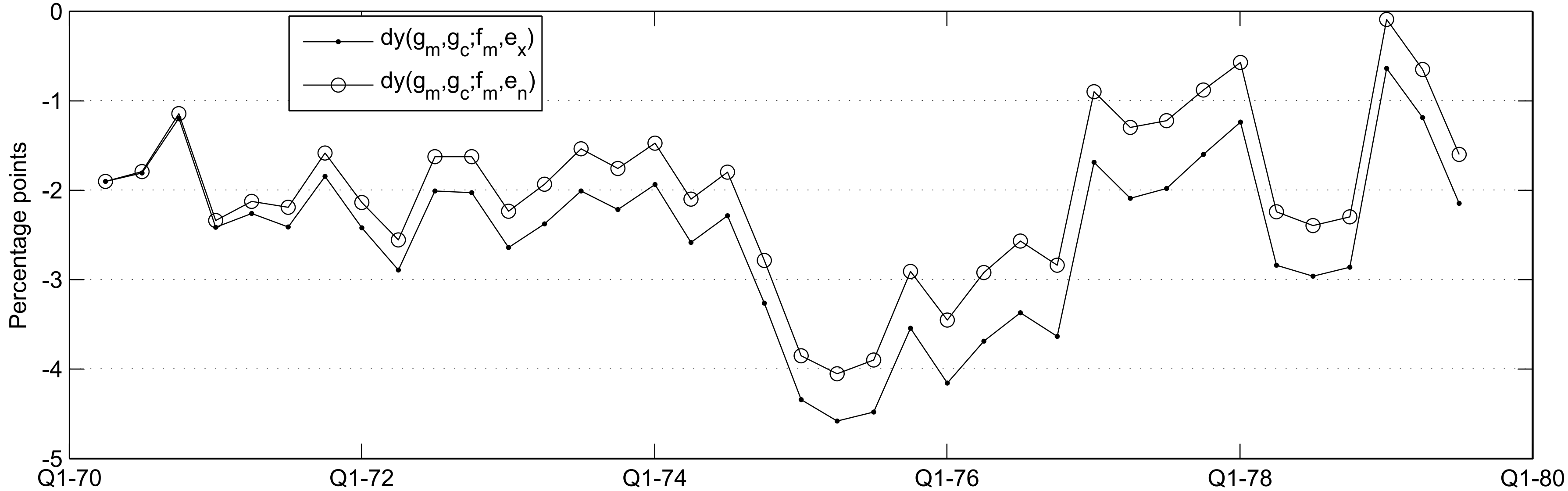

Figure 9a: Marginal impact of FPAM on endogenously simulated inflationary expectations (given GM)

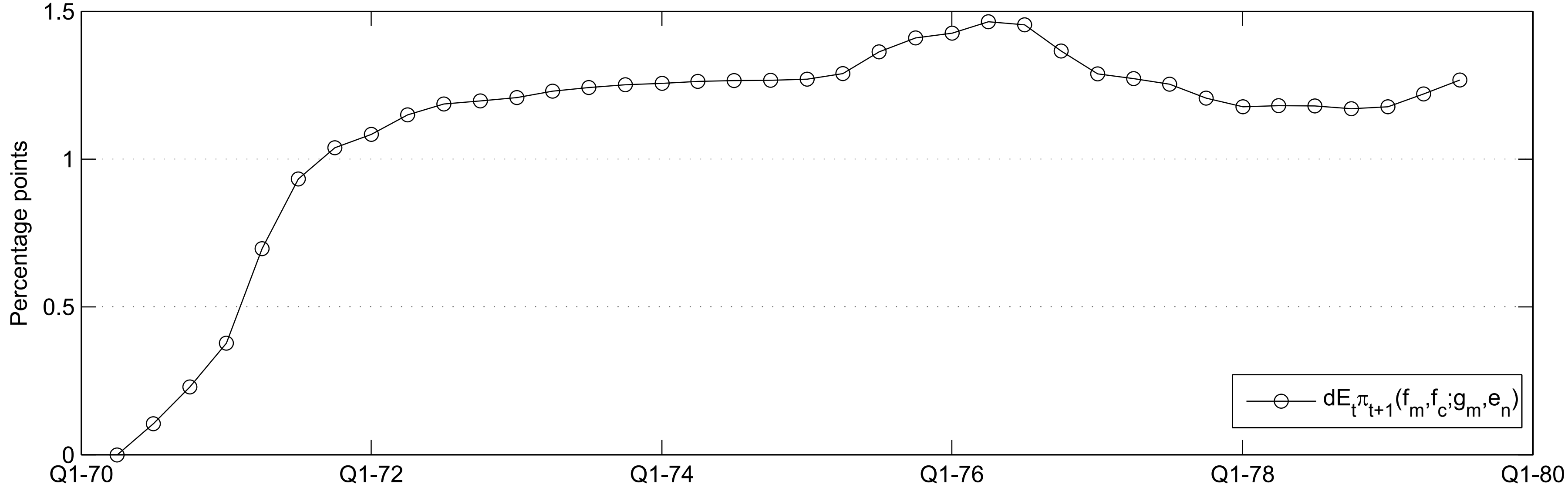

Figure 9b: Marginal impact of GM on endogenously simulated inflationary expectations (given FPAM)

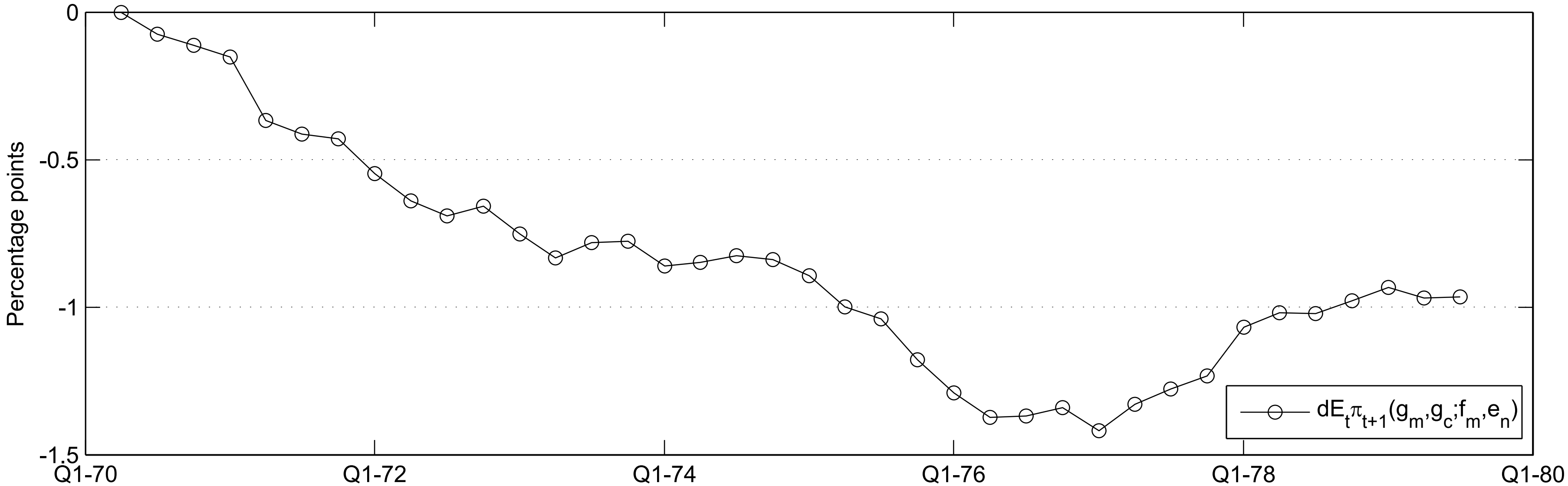

Figure 10a: Combined impact of FPAM and GM on inflation and on endogenously simulated inflationary expectations

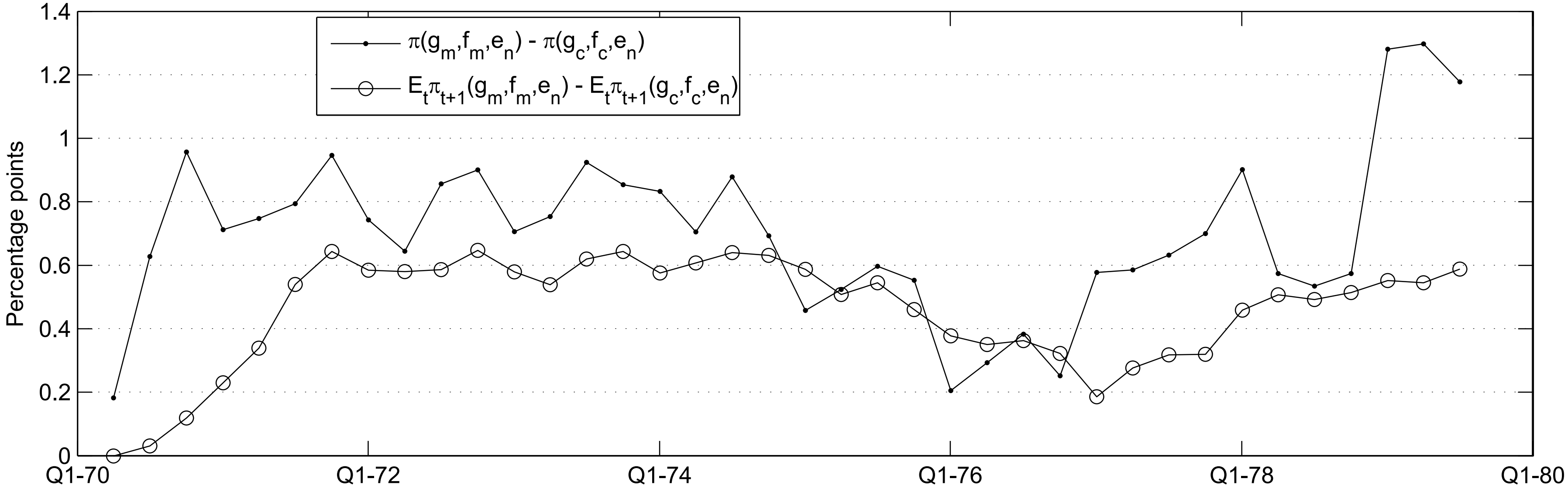

Figure 10b: Combined impact of FPAM and GM on Fed funds rate and on the output gap (given endogenous expectations)

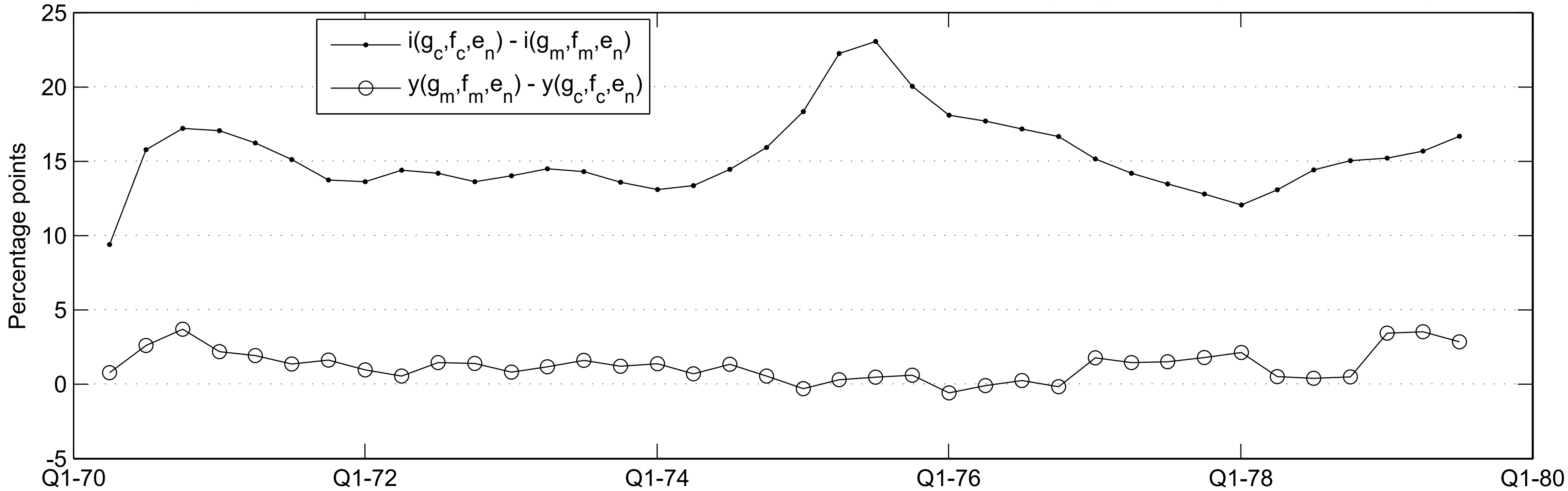

Figure 11a: Marginal impacts of RAP on inflation (given exogenous expectations) in the presence and in the absence of GM

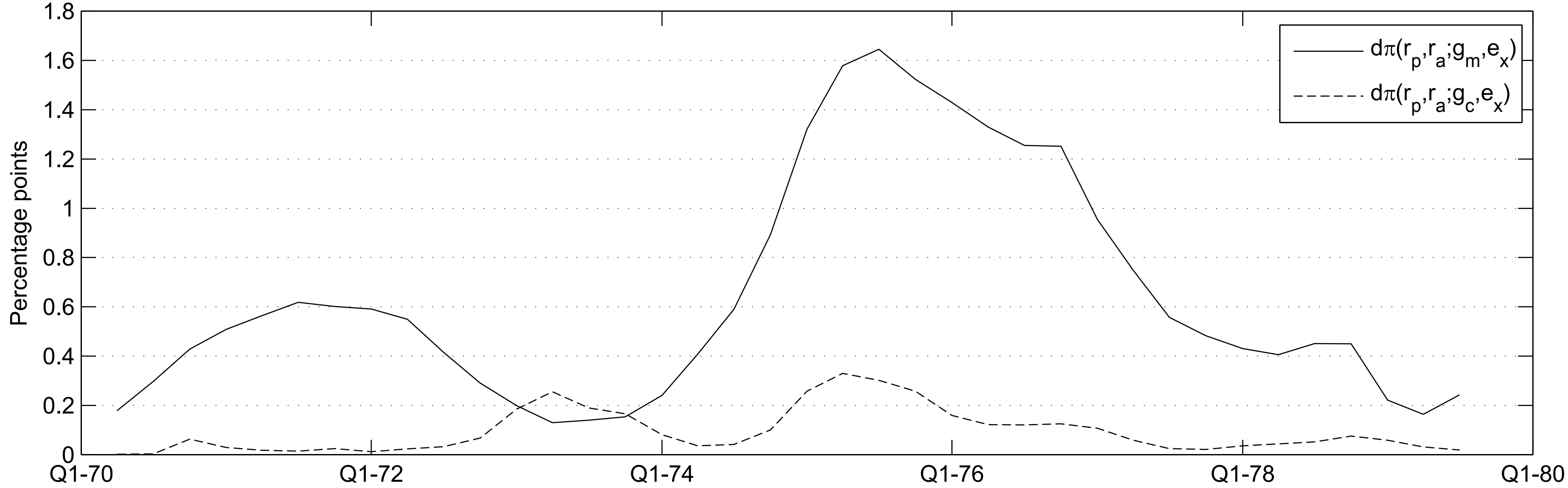

Figure 11b: Marginal impacts of GM on inflation (given exogenous expectations) in the presence and in the absence of RAP

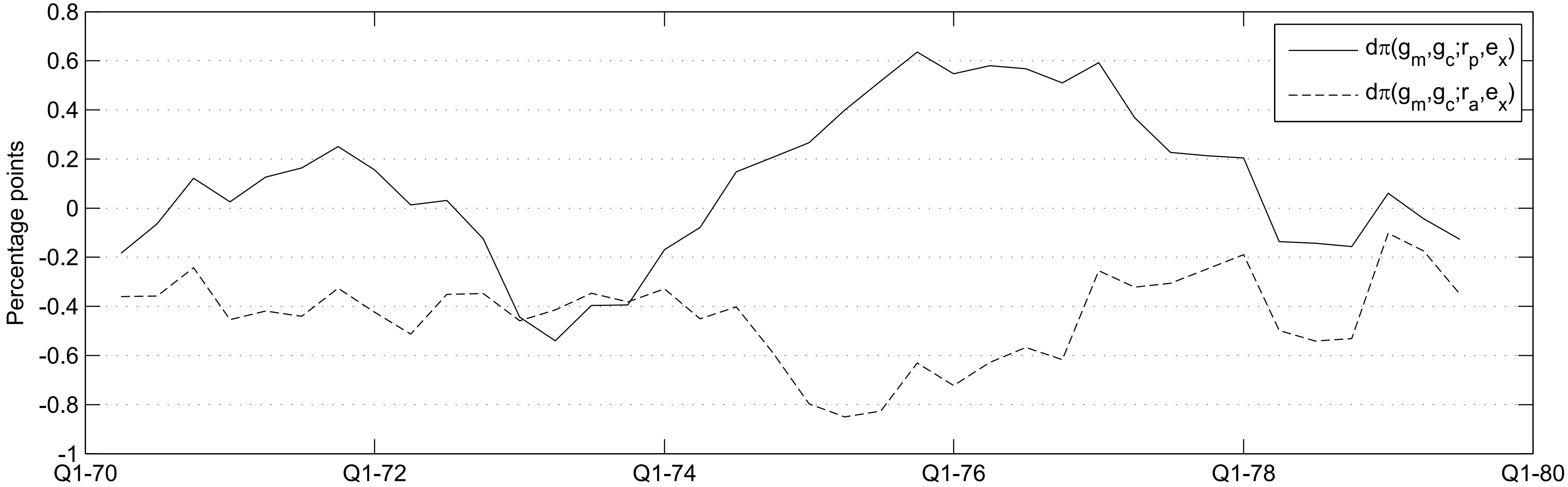

Figure 12a: Marginal impacts of RAP on Fed funds rate (given exogenous expectations) in the presence and in the absence of GM

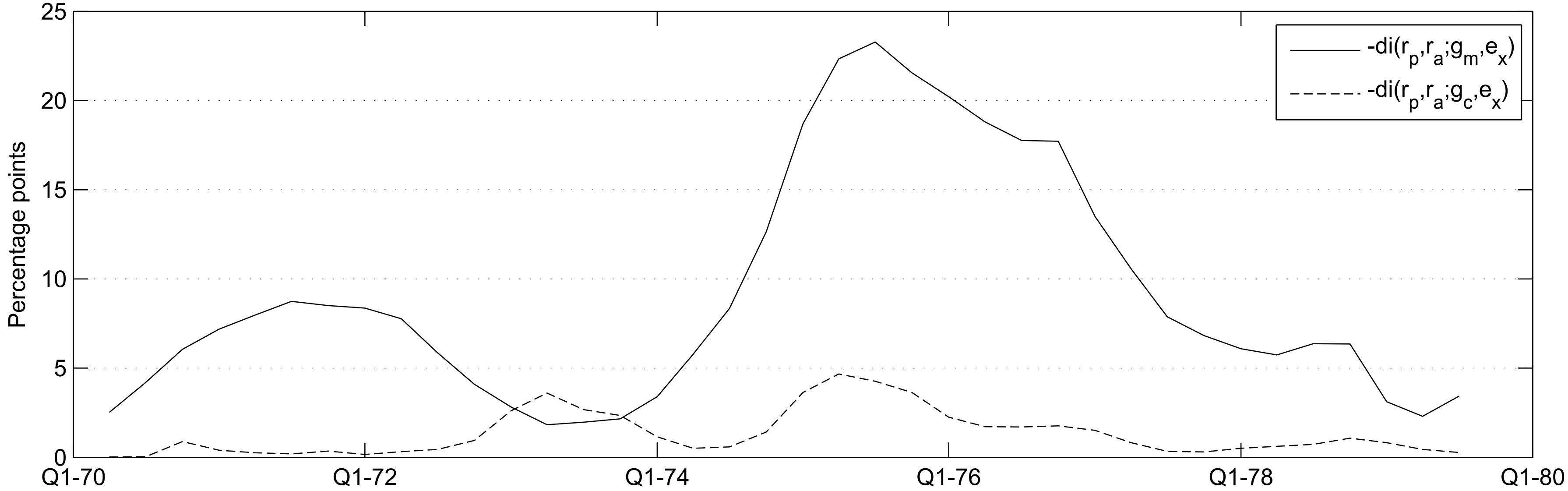

Figure 12b: Marginal impacts of GM on Fed funds rate (given exogenous expectations) in the presence and in the absence of RAP

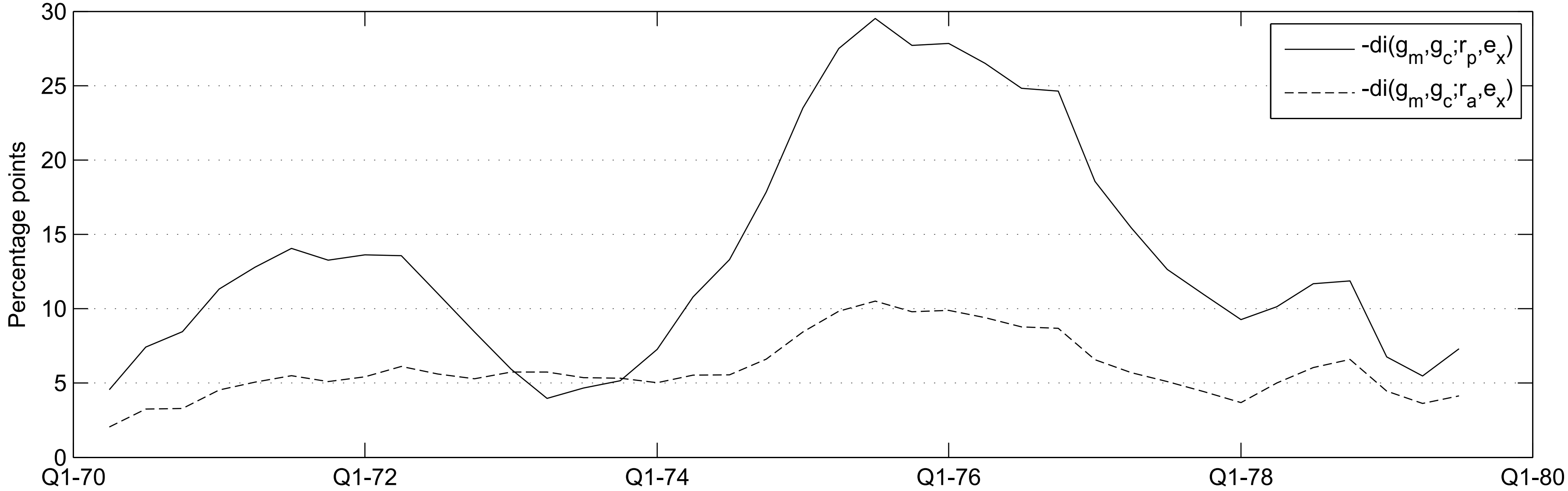

Figure 13a: Marginal impacts of RAP on output gap (given exogenous expectations) in the presence and in the absence of GM

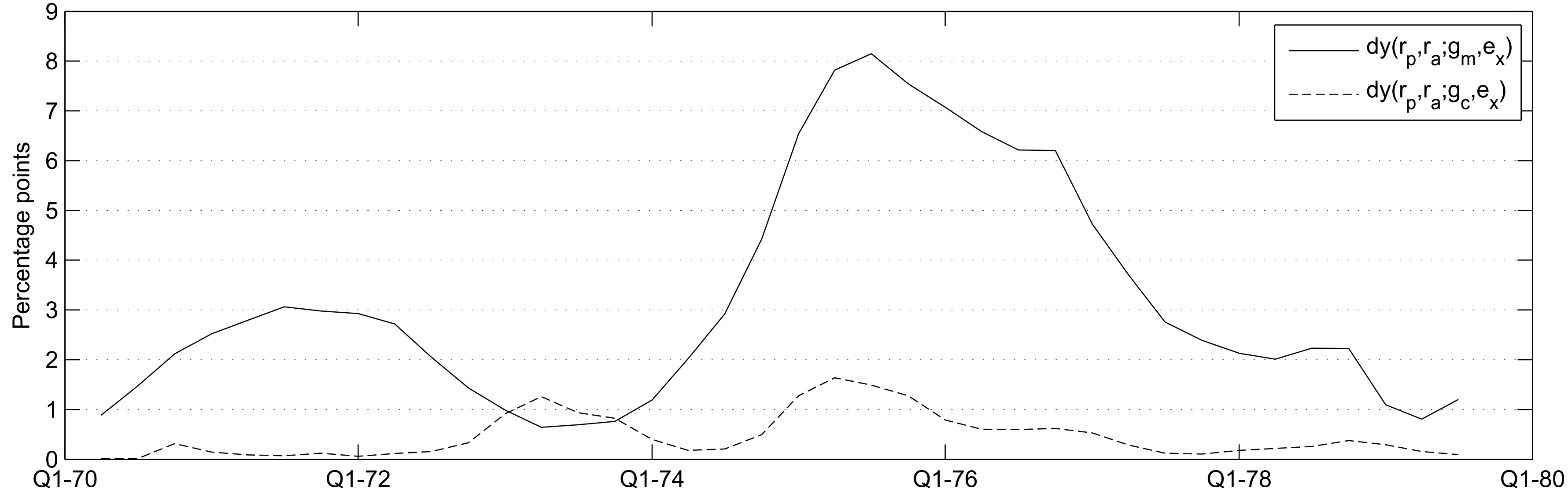

Figure 13b: Marginal impacts of GM on output gap (given exogenous expectations) in the presence and in the absence of RAP

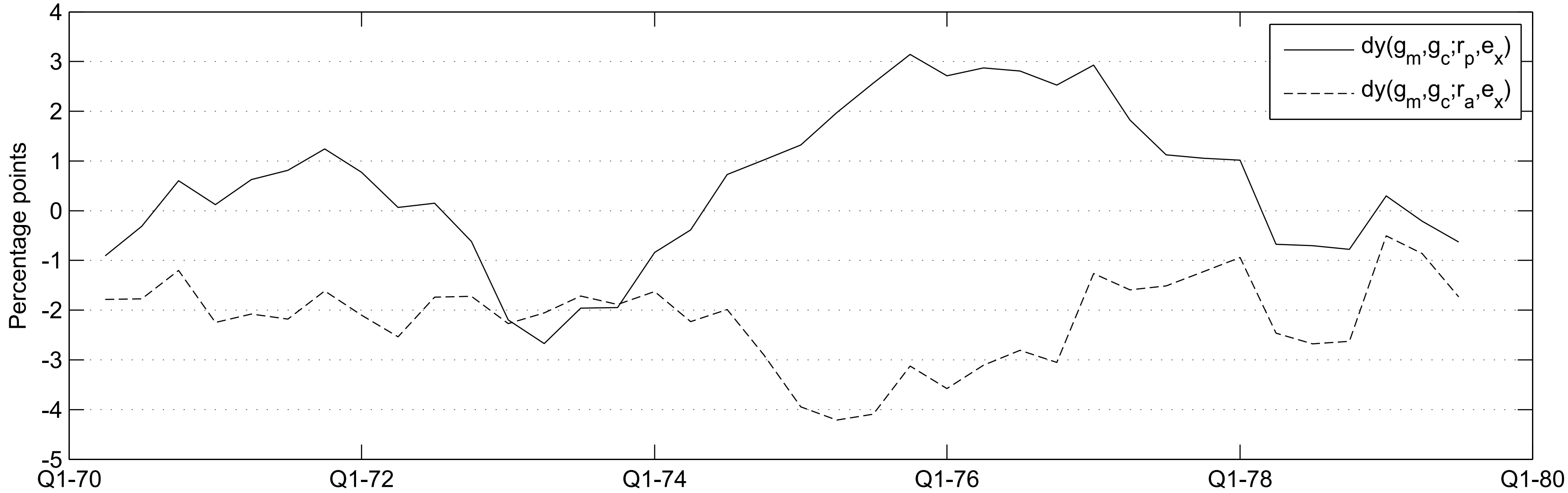

Figure 14a: Marginal impacts of RAP on inflation (given GM) for exogenous and for endogenous inflationary expectations

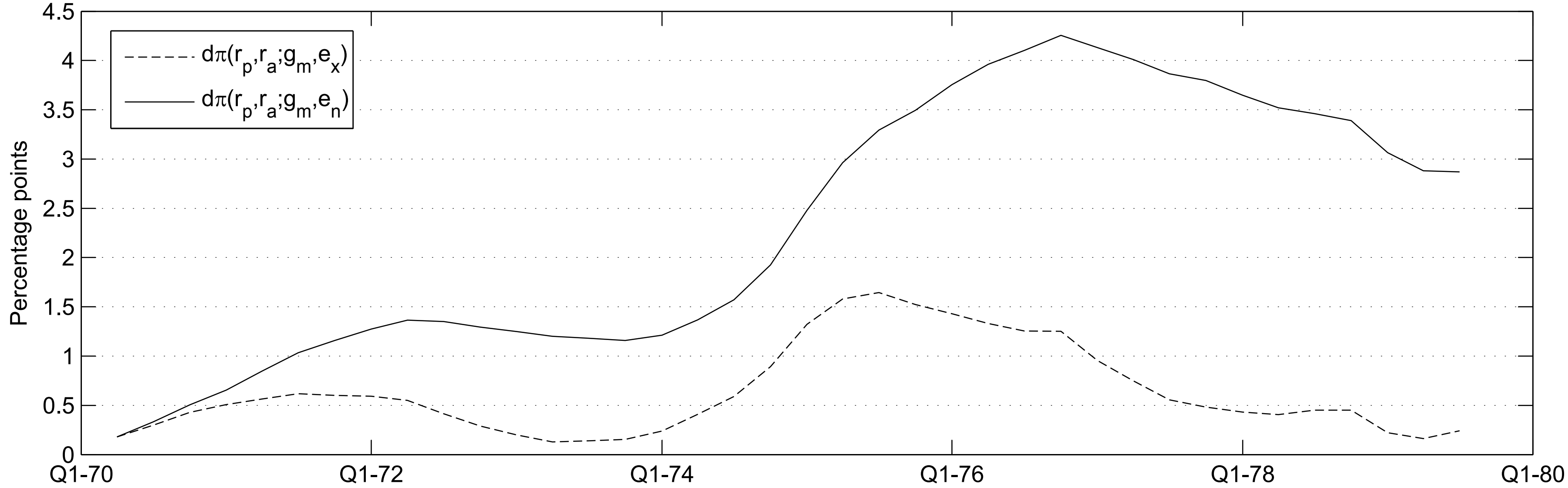

Figure 14b: Marginal impacts of GM on inflation (given RAP) for exogenous and for endogenous inflationary expectations

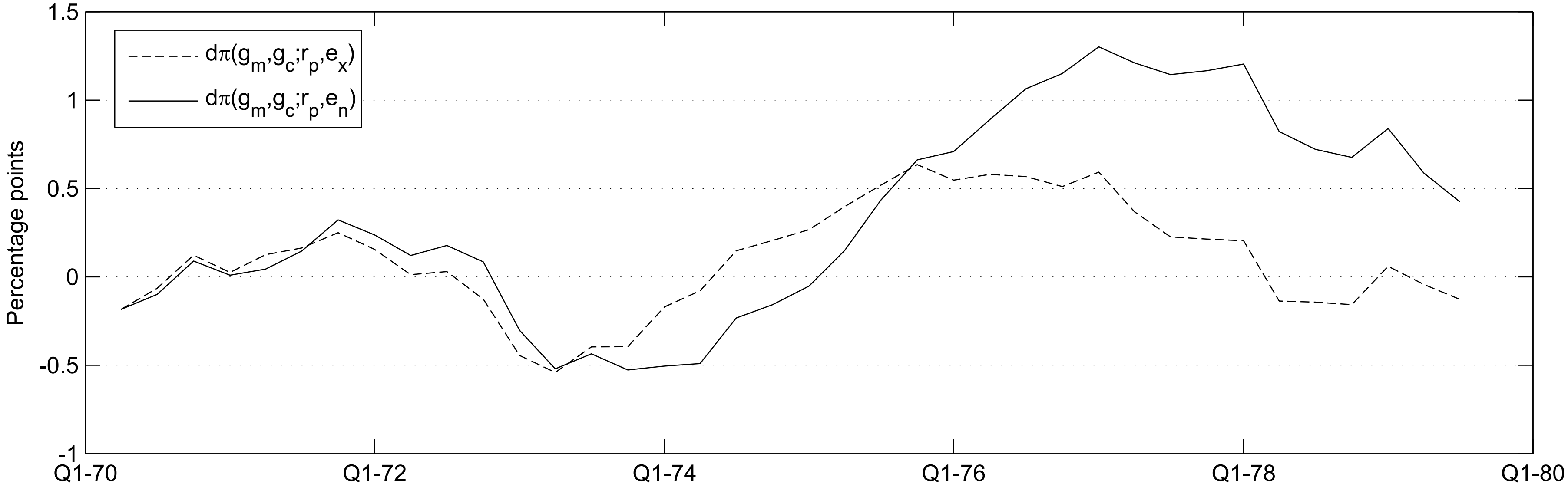

Figure 15a: Marginal impacts of RAP on Fed funds rate (given GM) for exogenous and for endogenous inflationary expectations

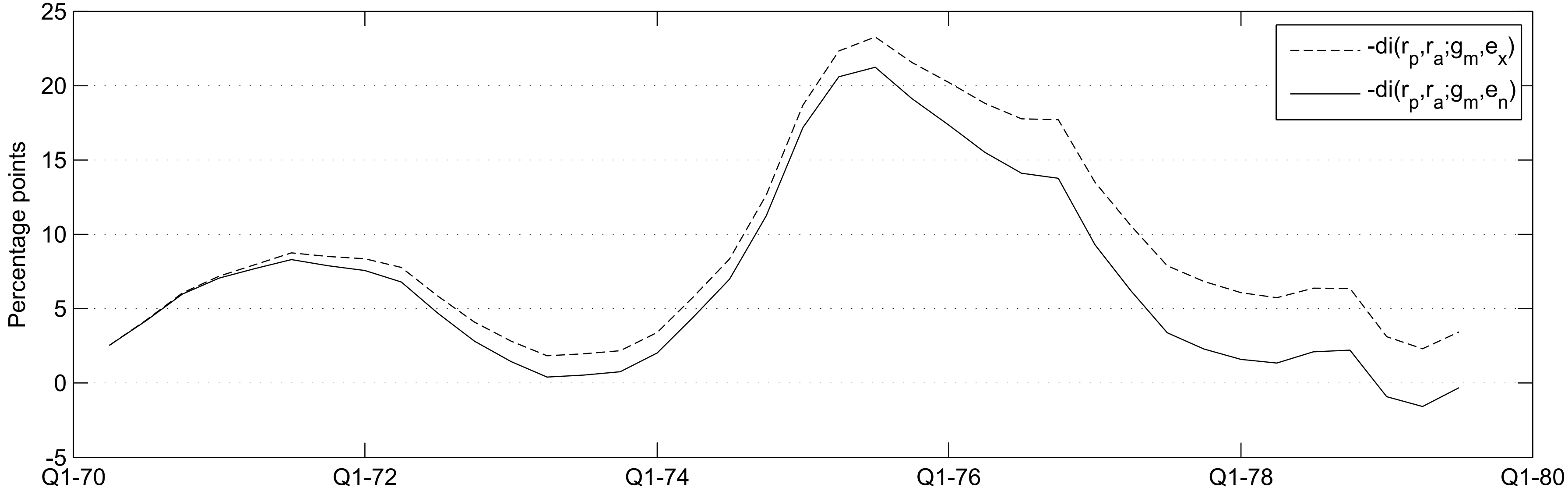

Figure 15b: Marginal impacts of GM on Fed funds rate (given RAP) for exogenous and for endogenous inflationary expectations

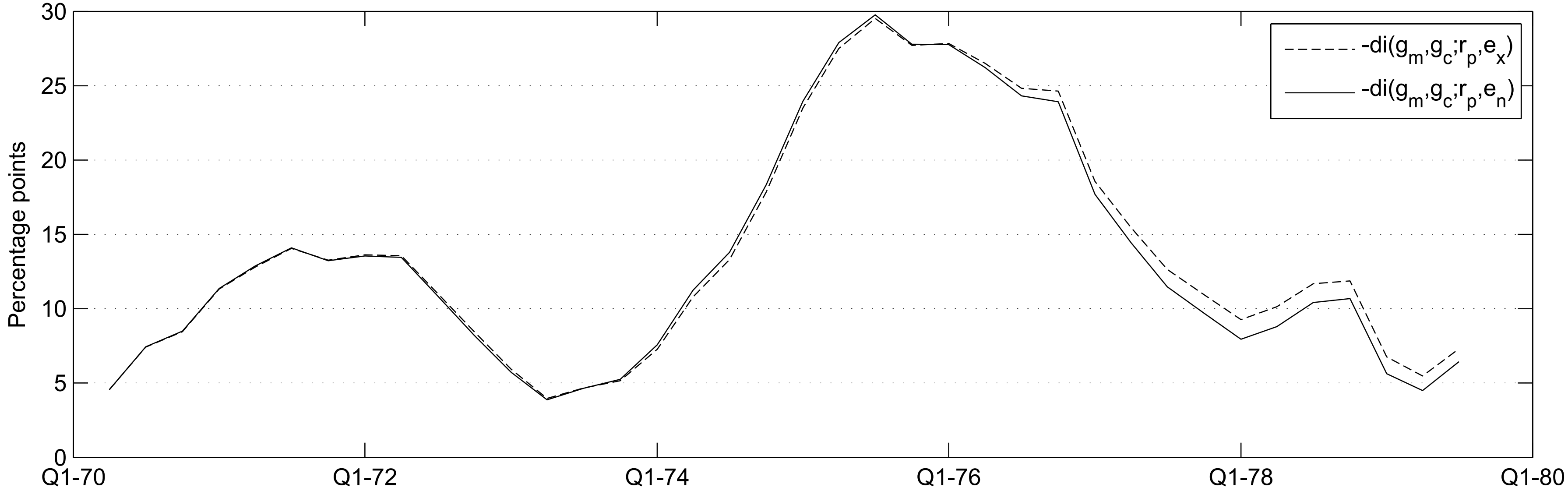

Figure 16a: Marginal impacts of RAP on output gap (given GM) for exogenous and for endogenous inflationary expectations

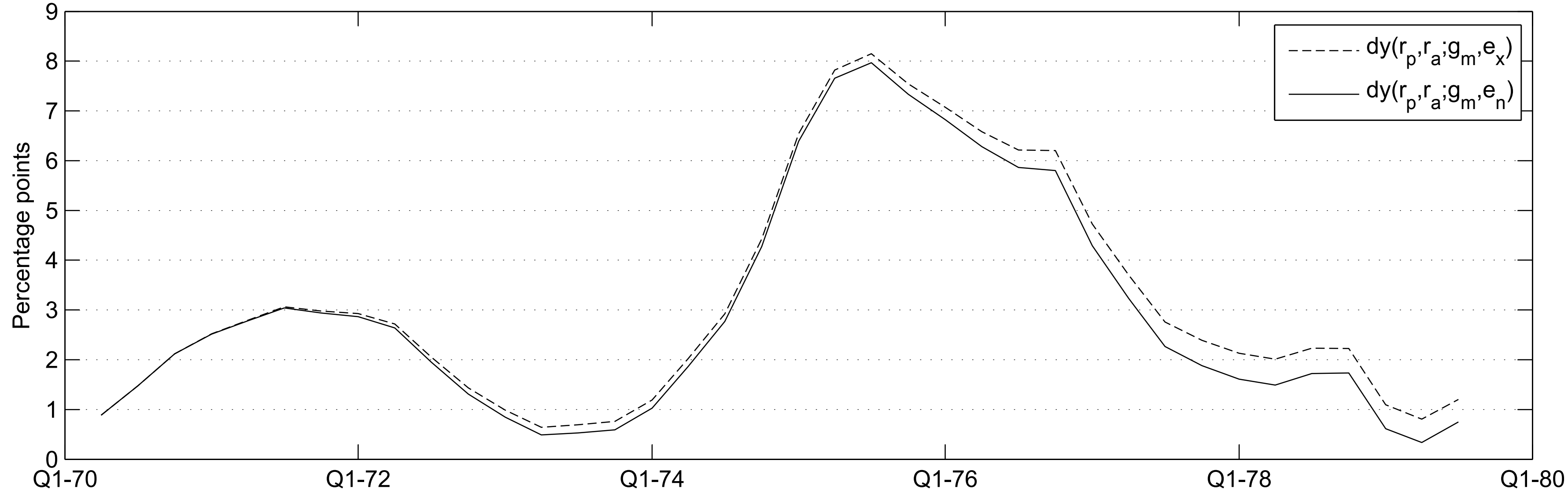

Figure 16b: Marginal impacts of GM on output gap (given RAP) for exogenous and for endogenous inflationary expectations

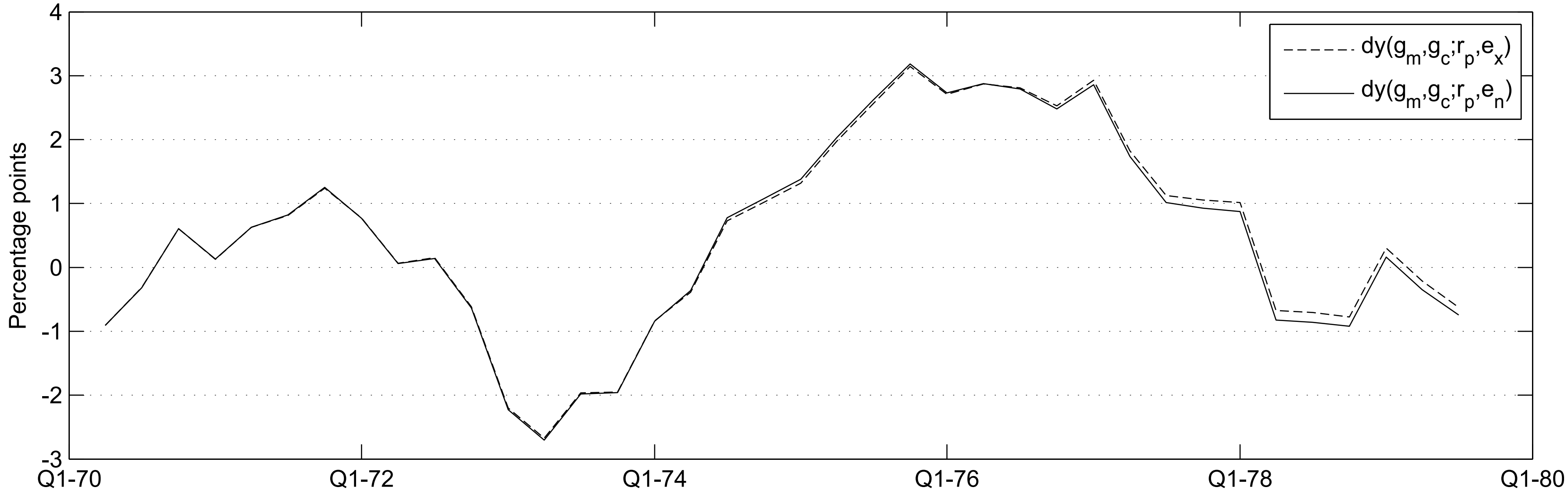

Figure 17a: Marginal impact of RAP on endogenously simulated inflationary expectations (given GM)

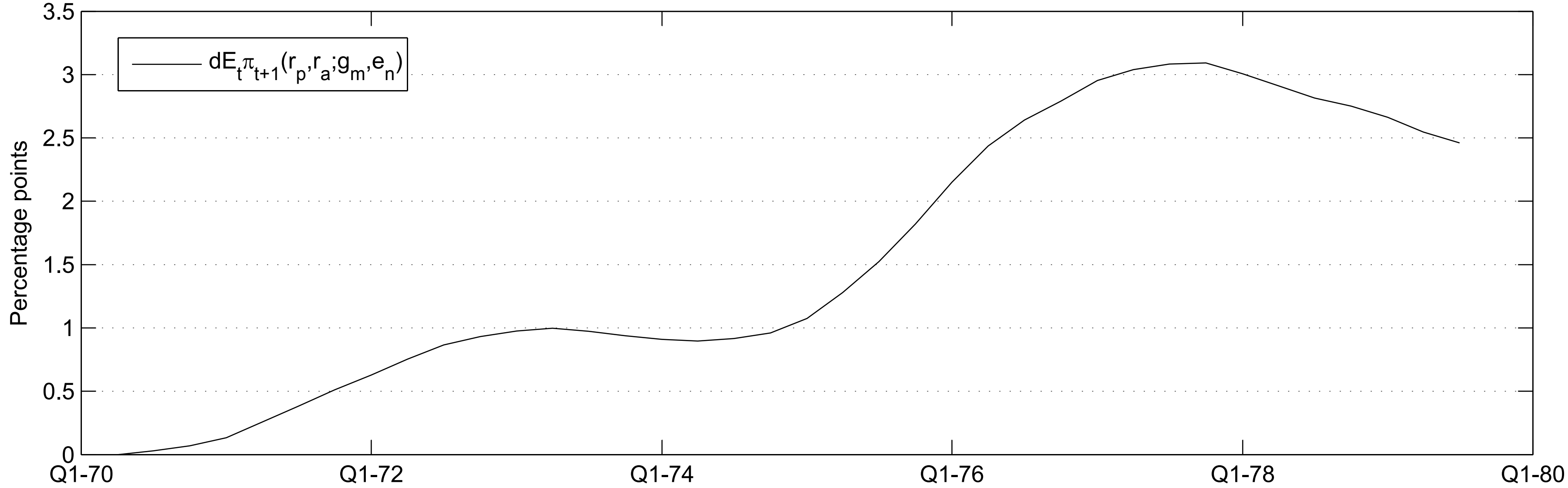

Figure 17b: Marginal impact of GM on endogenously simulated inflationary expectations (given RAP)

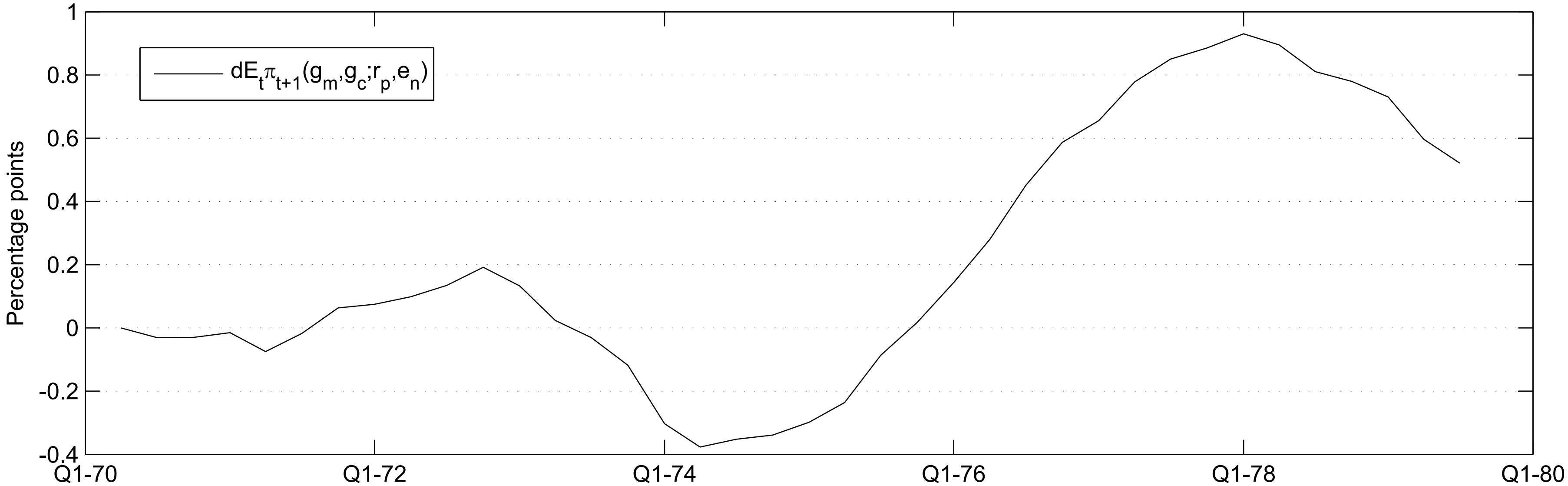

Figure 18a: Combined impact of RAP and GM on inflation and on endogenously simulated inflationary expectations

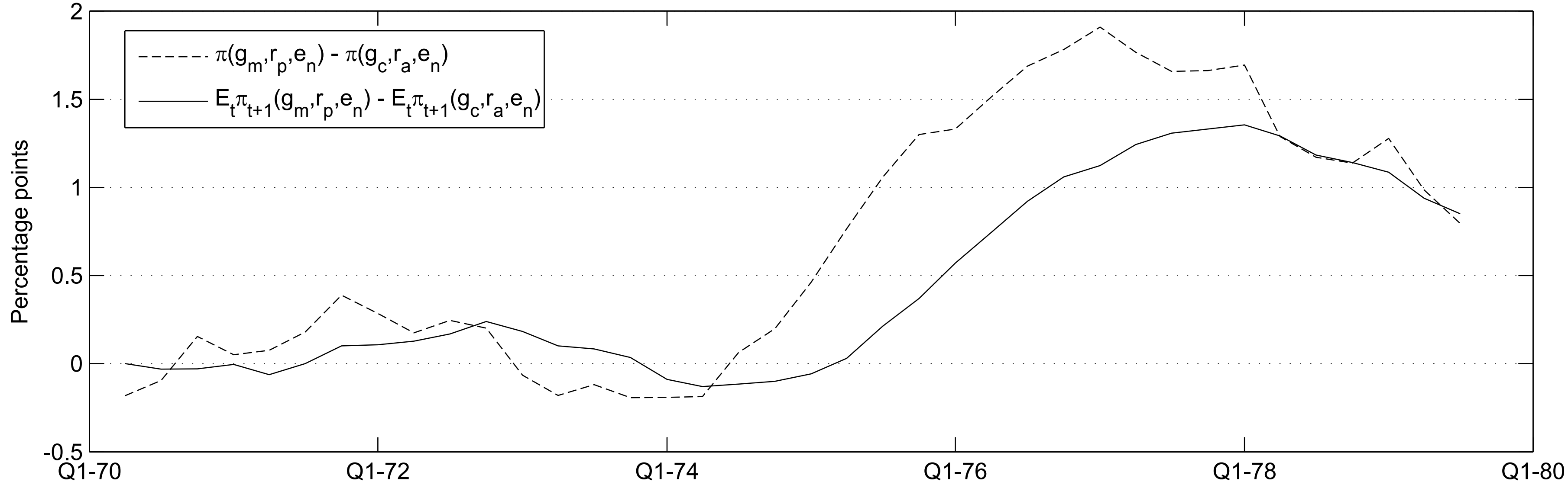

Figure 18b: Combined impact of RAP and GM on Fed funds rate and on the output gap (given endogenous expectations)