Inflation Aversion and the Real Effects of Monetary Policy Shocks

by

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Abstract

I extend a standard monetary business cycles model with flexible prices along three dimensions: market share competition as proposed by Phelps and Winter (1970), search efforts and switching costs in the goods market and the assumption that overall inflation has a direct negative effect on agents' utility. The implied relationship between optimal search efforts and the rate of inflation creates a new transmission channel by which monetary policy can affect the real economy. Although nominal prices and wages are fully flexible they do not completely absorb the effects of nominal disturbances. As a result, for a broad range of parameter values consistent with the empirical evidence, the model is able to account for the substantial and persistent real effects of nominal disturbances. Furthermore, the model generates highly persistent responses to technology shocks even when the the level of technology has a coefficient of autocorrelation equal to zero and thus provides an endogenous explanation of the persistence in observable business cycles in the industrialized world.

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1 Introduction

There is substantial empirical evidence indicating that average markups are countercyclical, that there is a high degree of rigidity in nominal goods prices and probably as a consequence of that rigidity, monetary shocks induce highly persistent dynamic responses of inflation, output, consumption and investment.

Most sticky price models imply counterfactual reactions of markups to favorable technology shocks and thus in most cases a counterfactual positive correlation between markups and output. In an interview in the *Economic Dynamics Forum* given in 2004 Patrick Kehoe sharply criticizes existing sticky price models and points out their inability to account for the persistence observable in the data. He argues that the persistence generated by that models is due solely to the exogenously imposed unrealistically high degree of price stickiness, not consistent with the empirical observations. Kehoe summarizes his critique as follows:

"...Currently I see a large number of economists writing papers that take the existing sticky price models as they stand and tries to use them to address a number of issues, especially policy issues. I think that this is not a productive use of time. A better use of time for the sticky price enthusiasts is to go back to the drawing board and dream up another version of the model that has a chance at generating the patterns observed in the Great Depression. Doing so may be difficult, but the payoff is worth it."

In the light of this critique as well as the empirical evidence, I take up the challenge formulated by Patrick Kehoe and take a first step in developing *"another version of the model"* which provides an endogenous explanation of the incomplete or rigid response of nominal prices to monetary and interest rate shocks, the cyclical pattern of markups and the persistent reactions of most macroeconomic variables to demand and supply side disturbances. To achieve these three goals, I extend a standard monetary business cycles model with monopolistic competition in the goods market along several dimensions.

First, based on the empirical evidence accumulated in research areas closely related to psychology and dramatically deviating from any tradition in the real and monetary business cycles theory I assume that agents' behavior is characterized by *inflation aversion* - current inflation has a direct negative effect on utility. By intensifying search and switching efforts in the goods market and thus switching from more expensive to cheaper products an individual household is able to reduce the direct disutility caused by inflation. The emerging positive relationship between search efforts and inflation crates a new channel by which nominal disturbances can be transmitted into the real economy. If an increase in search activity caused by an upward pressure on current inflation forces firms to pass through to prices only a fraction of the increase in nominal marginal costs, markups will tend to fall and thus real wages, hours and output will tend to increase. To ensure such an outcome the structure of the goods market should be altered in some way. I propose the following extensions of the *static* monopolistic competition framework.

First, I assume that firms do not only engage in price competition but also in *dynamic market share competition* as proposed by Phelps and Winter (1970) in their *customer market model*. Second, I assume that the law of motion of the individual market share is governed by a *matching function* depending on the pricing behavior of the firm and the intensity of the search and switching activities households engage in. How does each individual assumption as well as the combination of them alter the characteristics and the implications of the model?

Under dynamic market share competition the price set in the current period by a monopolistically competitive firm does not only affect its current profits but also its next-period market share and thus the expected present value of its future profits. Consequently, the monopolistically competitive firm faces a trade-off between charging the price that maximizes its current profits but will probably induce a decline in its next-period market share and charging a lower price, which does not maximize current profits, but leads to an increase in next-period market share and thus to higher future profits. As a result of this trade-off, if there is an unexpected increase in current marginal costs, firms won't pass through to prices the whole amount of the marginal cost increase as they would do if there were no market share competition. Hence, markups will tend to be countercyclical. There is also a further channel by which dynamic market share competition tends to make markups countercyclical: An increase in current consumption demand caused by a positive monetary or technology shock leads to higher *stochastic discount factors* and thus lower interest rates. The lower in absolute value the intertemporal elasticity of substitution, the higher the rise in the expected present value of future profits caused by the higher discount factor and thus the stronger the incentive for firms to make additional *"investments"* in future market shares by choosing lower current markups.

Further, I extend the law of motion of market share defined by Phelps and Winter (1970) and used by Rotemberg and Woodford (1993) by assuming that the function describing the growth factor of the firm-specific market share does not only depend on the firm's pricing decision but also on the intensity of search and switching efforts chosen by consumers. This function can be interpreted as a matching mechanism in the goods market assigning customers to suppliers and has the following key implication: If an individual firm charges a lower (higher) price relative to the overall price level, a higher search activity by households will induce a stronger increase (decrease) of that firm's customer stock. Therefore, in times of high search activity firms will tend to charge lower prices and thus choose lower markups. In other words, a higher overall search activity implies that households reallocate their demand more *aggressively* as a reaction to price differences, therefore firms with relatively high current prices suffer more severe losses in future market share. From the point of view of an individual household the intensification of her search for cheaper suppliers as well as the efforts aimed at the redistribution of her demand by adjusting the weights attached to the individual goods within the consumption bundle, the representative household is able to respond in a utility maximizing way to changes in relative goods prices. The costs induced by search activity are measured in real terms and reduce directly the resources available for consumption.

The assumption that households' behavior is characterized by *inflation aversion* and that by spending more resources on search and switching activities the disutility caused by inflation is reduced creates a new link between the real and the monetary side of the economy which is the crucial new feature of the model. As I show below, search activity depends positively on current inflation. The latter implies that nominal shocks will not be fully absorbed by changes in nominal prices: A monetary expansion will induce two opposing effects on current inflation - the usual positive one *via* the positive income effect on current demand and a *new* negative one *via* the positive effect on search and switching activity. The higher search activity then forces firms to choose lower current prices and thus lower markups than they would do if search were independent of inflation. As a consequence, on the one hand overall inflation rises by less than if there were no dependence between search and inflation and on the other real wages, hours and output rise. If search efforts were independent on current inflation, the positive and negative pressures on current markups induced by a monetary disturbance will exactly offset each other. As a consequence, markups and therefore real wages, hours and output will remain unchanged and the increase in inflation will be exactly sufficient to offset the income effect of the monetary shock. In other words, the *neutrality of money* will hold.

The main findings of the paper can be summarized as follows. After extending the standard monetary business cycles model along the three dimensions described above it becomes able to generate endogenous countercyclical markups which react negatively to monetary as well as technology shocks, and endogenous sluggishness in nominal prices. Furthermore, the model provides an endogenous explanation of the persistence in actual business cycles. Hence, the model of this paper should be considered a useful alternative to the *New Keynesian Model* for analyzing and evaluating monetary and interest rate policy.

The paper is organized as follows. Section 2 provides a review of the literature and motivates the main assumption of the model. Section 3 presents the model and section 4 concludes.

2 Review of the Literature

2.1 Empirical Evidence on the Cyclical Behavior of Markups and Nominal Prices

In a comprehensive survey of the empirical studies on the cyclical behavior of prices and marginal costs Rotemberg and Woodford (1999) emphasized the great importance of markups for output fluctuations at business cycle frequencies. According to their results, the output fluctuations attributable to variations of markups, which are orthogonal to fluctuations induced by shifts in the marginal cost curve, account for about 90% of the variance of output growth in the short run.[1] In addition, it can be easily shown that endogenous markup

[1]Rotemberg and Woodford (1999) decompose output into two components. The fluctuations of the first result solely from shifts in the marginal cost curve for a constant markup

variation on the aggregate level has the potential to substantially magnify (or dampen) business cycles or make them more (or less) persistent.[2] Consider for example a positive supply side shock, e.g. a favorable technology disturbance, in a symmetric equilibrium. If markups remain constant the shock will have a positive effect on output through shifting the marginal cost curve downwards. But if the disturbance generates strong enough an incentive for firms to lower (raise) markups then the output reaction will become stronger (weaker) than in the constant-markups case. A demand side shock which doesn't shift the marginal cost curve will have no impact on aggregate output if firms are unable or unwilling to change markups. But if firms do lower (rise) markups in response to the demand shock output will rise (fall).

The bulk of the empirical evidence on the cyclical properties of markups indicate that they are *countercyclical* and respond *negatively* to demand and supply side shocks. As marginal costs as well as markups are not directly observable, various proxies of these variables were proposed in the literature. Depending on the proxy constructed and the estimation technique employed the estimates of the correlation between markups and output on the aggregate level range between -0.188 and slightly above -1.[3]

Also related to the short run fluctuations of marginal costs and markups is the VAR evidence provided by Christiano *et al.* (1996, 2005). They show that an expansionary monetary shock induces an increase in employment[4] and real

while the second component responds only to deviations of markups from their steady state values, and hence represents movements along the marginal cost curve. Rotemberg and Woodford (1999) use the *predicted declines of output* as measure of the cyclical component of output and compare it with the two components of output growth they identify.

[2] Rotemberg and Woodford (1999) provide a simple example.

[3] Examples of such empirical studies are Rotemberg and Woodford (1999), Boldrin and Horvath (1996), Gomme and Greenwood (1995), Ambler and Clarida (1996), Bils (1987), Basu (1995), Bils and Kahn (1996), Comin and Gertler (2003).

[4] In fact, Christiano *et al.* (1996, 2005) estimate the impulse responses of output to

wages. But if capital is fixed in the short run and there is diminishing marginal product of labor the positive response of employment can be associated with higher real wages only if markups fall. Hence, the impulse responses estimated by Christiano *et al.* can be seen as evidence supporting the hypothesis of countercyclical markups.

It should be noted that there is much less empirical evidence indicating that markups are procyclical. For example Domowitz *et al.* (1986), Ramey (1991) and Kollman (1996) reach the conclusion that the correlation between markups and output is positive.[5]

Nominal goods prices and inflation are directly observable. As a consequence a huge stock of empirical investigations of the short run properties of prices and inflation has been accumulated over the past three decades. Perhaps two of the most important questions, these studies try to answer, are, whether nominal prices are sticky or not and how important are nominal rigidities for the cyclical behavior of real aggregates and welfare. Most of them come to the conclusion that there is significant stickiness in goods prices. Examples of such studies are the already cited papers by Christiano *et al.* (1996, 2005), Rotemberg (1982), Benabou (1992), Biovin *et al.* (2007), Eichenbaum and Fisher (2004) and many others. Most macroeconomic theories developed in the last twenty years attribute the real effects of monetary shocks to the presence of some kind of price rigidity.

The VAR-evidence provided by Christano *et al.* also indicates that there are delayed, hump-shaped dynamic responses of output, consumption and investment to monetary disturbances, characterized by a substantial degree of

monetary shocks. But, as capital is a predetermined state variable, increases in output can occur only if hours increase.

[5]Domowitz *et al.* (1986) is an example of a cross-sectional study of the behavior of marginal costs. Ramey (1991) and Kollman (1996) use inventory data to construct their measures of marginal costs.

persistence with all three variables remaining above their respective initial values for about twelve quarters. To at least partly reproduce the shape and persistence of these impulse responses is of major concern to modern monetary economics.

2.2 Review of Existing Theoretical Studies

As there is a large number of existing models generating endogenous markup fluctuations, in this section I only review the studies most closely related to the current paper.

Real Business Cycles Models of Endogenous Markups:
In the already cited study by Phelps and Winter (1970) markups are endogenized by the assumption of a particular form of dynamic market share competition in continuous time. The discrete time version of that structure is used in the model presented below. In a series of real business cycles models based on the partial equilibrium model proposed by Rotemberg and Saloner (1986), Rotemberg and Woodford[6] show that countercyclical markups may arise if firms are able to collude implicitly. In their models, markups respond negatively to demand side as well as to supply side shocks. Ravn *et al.* (2006, 2007) are able to generate countercyclical markups by introducing good-specific habit formation, the so called *deep habits*, into a standard RBC-model with a monopolistically competitive goods market. Froot and Klemperer (1989), Klemperer (1987, 1995) and Kleshchelski and Vincent (2007) develop static models of the goods market in which customers face fixed costs of switching suppliers. All these models have in common the implication that firm's current pricing behavior has an influence on its future profits. Since the studies just mentioned neglect the money market, they do not provide any implications about the reactions of key aggregates as well as markups to monetary shocks.

[6]Rotemberg and Woodford (1992), (1995), (1996)

Monetary Business Cycles Models with Sticky Prices: In general, sticky price models generate endogenous markups responding negatively to monetary and positively to technology shocks. Since, according to most estimation results, technology shocks are much more persistent than monetary are, average markups in these models tend to be positively correlated with output. In most of these models price stickiness is *exogenously* given. Examples of such studies are: Yun (1996), McCallum and Nelson (1999), Rotemberg and Woodford (1997), Sbordone (2002), Gali *et al.* (2001), Christiano *et al.* (2005) and many others. Models in which there is a Calvo-type price setting are often referred to as *New Keynesian*. There are also theories in which price stickiness is induced by the assumption that each firm faces exogenously given costs of price adjustment. Examples of such models are: Ball and Romer (1991), Caplin and Spulber (1993), Akerlof and Yellen (1985) and many others.

Unfortunately most standard sticky price models are not able to reproduce the persistence of the economic reactions induced by nominal shocks found in the data . To close this gap, many theorists extend primarily the *New Keynesian Model* by including further components, such as non-rational behavior of part of the firms, matching frictions in the labor market, nominal wage contracts, variable utilization of the factors of production as well as more exotic ones, such as different kinds of habit formation or adjustment costs of capital and labor. Examples of such studies are the already cited Christiano *et al.* (2005), Walsh (2005), Trigari (2004) and many others. However, in an interview in the *Economics Dynamic Forum* given in 2004 and already cited in the introduction of this paper Patrick Kehoe argued that all these models are only able to generate some persistence because of the extremely high degree of price stickiness assumed, implying an average time between price changes much longer than that observed in the data.[7] Kehoe also argued that if one modifies a typical sticky price model by assuming a more realistic frequency of price changes the model will generate much less persistence than empirically observed, even when one incorporates the whole battery of *real rigidities* mentioned above.[8]

The model developed by Haubrich and King (1991) is the only one to my knowledge providing endogenous explanation of price stickiness. In that model firms are able to insure against idiosyncratic monetary shocks by signing nominal contracts.

2.3 Inflation Aversion

According to most economic theories and the view of many economists inflation affects only indirectly the well-being. Either by reducing the real value of the wealth and income components denominated in nominal terms or by exacerbating already existing inefficiencies and therefore leading to a suboptimal distribution of private expenditure.[9] Absent these valuation or expenditure

[7]Bils and Klenow (2003) and Klenow and Krystov(2003) provide evidence that the average time between price changes is about 4 months.

[8]See Chari *et al.* (2000, 2002).

[9]In the *New Keynesian Models* with Calvo-type price setting, for example, higher inflation induces a larger dispersion of prices for the individual goods produced (and consumed) in the economy. The latter results in an inefficient dispersion of output and demand among the individual goods. As there is diminishing marginal utility of consumption of every individual good, the utility derived from consuming more of the cheaper goods is less than the utility loss from consuming less of the more expensive ones. If there is increasing marginal disutility of producing an individual good, the utility loss from producing more of the cheaper goods will be higher than the gain in utility from producing less of the more expensive ones. In these models it is often assumed that the central bank designs monetary or interest rate policy so as to minimize a quadratic loss function depending on some measure of the output gap and the inflation rate. As the loss function is just an approximation of the utility function of the representative agent in the economy, the presence of the inflation rate stems

distribution effects, inflation would be of no relevance for the private economy and therefore of no relevance for policy makers and of no interest for economic theory. There is a similar consensus about how households' and firms' behavior depends on the variability of the inflation rate - in a purely indirect manner: A higher volatility of the inflation rate in most cases makes many income components more variable. As a consequence consumption tends to fluctuate more and hence reduces utility if agents are risk averse.

In contrast to this traditional or mainstream way of thinking about inflation the empirical evidence accumulated in some research areas closely related to psychology indicates that consumption (or income) is by no means the only variable directly affecting people's subjective well-being.[10] Other variables such as the overall rate of inflation, the personal unemployment status, the general unemployment rate as well as the institutional and political framework seem to have highly significant direct effects on people's life satisfaction. Frey and Stutzer (2002) provide an exhaustive survey of *Happiness Research*, a discipline directly stemming from psychology. Some of the papers reviewed by the authors provide stylized facts on the correlation between income and happiness. According to the results, despite the sharp increase of per capita income in all industrial countries after World War II, in most of them average subjective well-being has remained unchanged or has even declined. The more elaborate econometric studies on this issue cited by Frey and Stutzer (2002) go

from the indirect effects on utility just described. (See Woodford (2003), pp. 383-405 and Walsh (2003) pp. 517-558 on this and related issues.)

[10]Frey and Stutzer (2002) define *subjective well-being* as follows: It is the scientific term in psychology for individual's evaluation of her experienced *positive and negative affect*, *happiness* or *satisfaction with life*. In psychology they are separable constructs, whereas, to my knowledge, in modern macroeconomics only the abstract concept of *agent's utility* is used. The latter is a cardinal measure summerizing all three psychological concepts, allowing no precise distinction between them. Therefore the terms *subjective well-being*, *happiness* and *life satisfaction* are used interchangeably, as synonyms of *utility*.

beyond the purely descriptive analysis by controlling for individual characteristics of households as well as the effects of inflation, unemployment, institutional and other factors. They all come to the conclusion that the income level has no, or in rare cases a very limited explanatory power with respect to private agents' happiness.[11] At the same time inflation tends to have significant direct effects on life satisfaction. Di Tella *et. al.*, also cited by Frey and Stutzer (2002), show that after controlling for individual socioeconomic characteristics and the unemployment rate, an increase of inflation by five percentage points reduces average happiness by 0.05 *"units of satisfaction"* which is equivalent to a shift of five percent of the population from one life-satisfaction level to the next lower one.[12] Walton (1979) provides evidence based on a sample taken by the American Council of Life Insurance (AICL)[13] that consumers are often *"disturbed"*, *"frustrated"* and *"angry"* when confronted with higher prices for particular products or a higher overall price level.

In a study inspired by the question wether Okun's *Economic Discomfort Index*[14] can be regarded as a good measure of agents' *disutility* Lovell and Tien (1999) come to the conclusion that current inflation has greater influence on people's well-being than current unemployment does, as measured by the elas-

[11]As many studies show, the *income* variable that does have a significant positive effect on subjective well-being is the *relative* rather than the *absolute* income level. The *relative* income of a person is defined as the quotient of his own income and a weighted average over all households. There is also for people in richer countries to be happier.

[12]In Di Tella *et. al.* (2001) satisfaction is measured by a 4-point scale ranging from *"not at all satisfied"* through *"very satisfied"*. To transform the ordinal scale into a cardinal one the numbers 1,2,3 and 4 are attached to the levels *"not at all satisfied"*,... and *"very satisfied"* respectively.

[13]To take a sample of people's opinion about inflation, ACLI placed advertisements in major newspapers and news magazines urging Americans to express their views on the subject in letters addressed to the author.

[14]Okun's *Economic Discomfort Index* is simply defined as the sum of the inflation and the unemployment rate.

ticities of these two variables with respect to the *Index of Consumer Sentiment (ICS)*.[15] Furthermore, once the *change* in the unemployment rate and/or the growth rate of GDP are included in the regression equation the coefficient of the rate of unemployment tends to get insignificant. The latter indicates that by the inclusion of current unemployment in the *disutility index* one just approximates the effect of the cyclical component of income on agents' happiness. The relative strength of this effect compared with that of inflation is consistent with the findings in the papers reviewed by Frey and Stutzer (2002).

Much in line with the evidence provided by Lovell and Tien (1999) as well as that cited by Frey and Stutzer (2002) are the results in Hymans (1970). He also examines the dependence of the *Index of Consumer Sentiment (ICS)* on income, stock price changes and inflation. His results indicate that all three variables have highly significant direct effects on consumer sentiment. Since the long run trend as well as recent changes of stock prices provide a fairly good approximation of the changes in the value of households' wealth, it is less surprising that these variables have explanatory power with respect to consumer sentiment. Much more surprising is the role of inflation as an independent determinant of ICS. The fact that income is not the sole determinant of consumer sentiment explains why the latter usually has a significant coefficient in demand regressions in which income was already included. In a more recent empirical study Franses (2006) also provides evidence supporting the existence of substantial direct effects of inflation on consumer confidence.

The empirical studies discussed so far examine the relationship between subjective well-being and the *current* values of income, inflation, unemployment and other variables. But as most agents are to some extent forward looking, it can not be ruled out on *a priori* grounds that average happiness

[15] Lovell and Tien (1999) use the *Index of Consumer Sentiment* as an approximation of consumers' subjective well-being.

depends on expected rather than current inflation. Smyth *et. al.* (1994) apply a battery of *non-nested* tests in order to give an answer to the question wether agents are on average *forward* or *backward looking* when deciding on how satisfied they are with the current economic situation. According to their results, the hypothesis that agents' satisfaction with the current economic situation depends on expected future inflation and unemployment is rejected in favor of the one that current inflation and unemployment are the only significant determinants of people's subjective well-being.[16]

The empirical findings on the determinants of agents' well-being can be summarized as follows: The current inflation rate has significant direct effects on utility and is at least as important as real income. Based on these results, I assume that the utility function of the representative agent depends directly on the overall rate of inflation. The pain caused by inflation can be reduced by spending some part of the currently available resources on search and switching efforts aimed at the reallocation of demand from suppliers charging relatively high to suppliers charging relatively low prices. As documented by Frey and Stutzer (2002), the other factors mentioned above e.g. the political situation and many institutional factors also have greater importance for individual well-being than income has. As none of them is explicitly taken into account in the model presented below, I do not reproduce the empirical findings on the effects of these variables on happiness.

Why does utility depend directly on inflation? It is the job of psychologists to give answer to this question and I do not provide any suggestions or even speculations about the possible reasons for the direct link between inflation and subjective well-being. In much the same way, as many economic models assume that agents are *risk averse* without providing any explanation of the possible

[16] Agents' satisfaction with current economic conditions is approximated by the Gallup's *Index of Presidential Popularity.*

reasons for *risk aversion*, in the model described below I simply assume that households' behavior is characterized by a property called *inflation aversion.*

3 The Model

I refer to this model as the *"Benchmark Model"* or the *"CM-Model"*.[17]

3.1 Theoretical Framework

3.1.1 Firms

There are n product varieties, each produced by a profit maximizing monopolistic firm according to the linear production function

$$Y_{i,t} = Z_t N_{i,t},$$

where $N_{i,t}$ denotes labor input of firm i. Z_t denotes the total factor productivity which follows a stochastic process given by:

$$\ln(Z_t) = \rho_z \ln(Z_{t-1}) + \epsilon_t,$$

where ϵ_t follows a *White Noise Process* with variance σ_ϵ^2.

The demand function faced by the producer of variety i is given by

$$C_{i,t} = x_{i,t} \cdot \left(\frac{P_{i,t}}{P_t}\right)^{-\theta} \cdot \frac{D_t}{n}, \qquad \theta > 0, \tag{1}$$

where $x_{i,t}$ is a measure of firm i's market share. $x_{i,t}$ can be also interpreted as a measure of the subjective relative weight within the consumption bundle attached by households to product variety i. More precisely, $x_{i,t}$ is the fraction of aggregate demand firm i would face if all firms were to choose the same

[17] CM - Customer Market.

price. D_t and P_t denote, respectively, aggregate demand and the aggregate price level.[18]

Firm-specific market share evolves according to

$$x_{i,t+1} = g\left(\frac{P_{i,t}}{P_t}, s_t\right) \cdot x_{i,t} \tag{2}$$

where s_t are aggregate households' search and switching efforts. Each firm treats s_t as an exogenous variable. I assume that the function $g(.,.)$ governing the law of motion of market share has the following properties:

$$g(1, s_t) = 1, \qquad \frac{\partial g\left(\frac{P_{i,t}}{P_t}, s_t\right)}{\partial P_{i,t}/P_t} = g_1\left(\frac{P_{i,t}}{P_t}, s_t\right) < 0,$$

$$\frac{\partial g\left(\frac{P_{i,t}}{P_t}, s_t\right)}{\partial s_t} = g_2\left(\frac{P_{i,t}}{P_t}, s_t\right) < 0 (> 0) \quad \text{for} \quad \frac{P_{i,t}}{P_t} > 1 (< 1).$$

According to these assumptions, higher search activity today leads to a fall (rise) in next-period market share if the price the firm charges is higher (lower) than the overall price level. Market shares are bounded by 0 from below and by 1, n or some other positive value from above. Generally, to ensure that x_i remains $\forall t$ within these bounds, one should try to find a reasonable normalization of x_i. This issue will be one of the most important in models with heterogeneous firms but it does not arise here, since in equilibrium all firms charge the same price.[19] I assume the following functional form of $g(.,.)$:

$$g\left(\frac{P_{i,t}}{P_t}, s_t\right) = \exp\left(\left(1 - \frac{P_{i,t}}{P_t}\right) \cdot s_t\right).$$

[18] The demand function in (1) is very similar to that proposed by Phelps and Winters (1970). Rotemberg and Woodford (1993) apply the discrete time version of the *"Customer Market Model"* used here to the analysis of the effects of government spending on private consumption and investment. The authors are unable to derive the used demand function from utility maximization problem. Therefore they just impose it. As I show below, it is easy to specify a utility function consistent with (1).

[19] See below.

The dependence of the market share in $t+1$ on past pricing behavior introduces a dynamic aspect into the profit maximization problem of the individual firm. Each firm maximizes

$$\max_{P_{i,t}} \left\{ x_{i,t} \left(\frac{P_{i,t}}{P_t} \right)^{-\theta} \frac{D_t}{n} \left(\frac{P_{i,t}}{P_t} - \mu_t \right) + \right.$$
$$\left. + E_t \left\{ \sum_{j=1}^{\infty} \beta^j \frac{\Lambda_{t+j}}{\Lambda_t} x_{i,t+j} \left(\frac{P_{i,t+j}}{P_{t+j}} - \mu_{t+j} \right) \left(\frac{P_{i,t+j}}{P_{t+j}} \right)^{-\theta} D_{t+j} \right\} \right.$$

s. t.

$$x_{i,t+1} = g\left(\frac{P_{i,t}}{P_t}, s_t \right) x_{i,t},$$

where $E_t \left\{ \beta^j \frac{\Lambda_{t+j}}{\Lambda_t} \right\}$ denotes the stochastic discount factor between periods t and $t+j$ which is given to the firm. μ_t denotes marginal costs. The corresponding first order condition reads:

$$\left(\frac{P_{i,t}}{P_t} \right)^{-\theta} x_{i,t} D_t - \theta \left(\frac{P_{i,t}}{P_t} - \mu_t \right) \left(\frac{P_{i,t}}{P_t} \right)^{-\theta-1} x_{i,t} D_t + \frac{g_1\left(\frac{P_{i,t}}{P_t}, s_t \right)}{g\left(\frac{P_{i,t}}{P_t}, s_t \right)} \Omega_t = 0,$$

where

$$\Omega_t = E_t \left\{ \sum_{j=1}^{\infty} \beta^j \frac{\Lambda_{t+j}}{\Lambda_t} x_{i,t+j} \left(\frac{P_{i,t+j}}{P_{t+j}} - \mu_{t+j} \right) \left(\frac{P_{i,t+j}}{P_{t+j}} \right)^{-\theta} D_{t+j} \right\} =$$

$$= E_t \left\{ \beta \frac{\Lambda_{t+1}}{\Lambda_t} x_{i,t+1} \left(\frac{P_{i,t+1}}{P_{t+1}} - \mu_{t+1} \right) \left(\frac{P_{i,t+1}}{P_{t+1}} \right)^{-\theta} D_{t+1} \right\} + E_t \left\{ \beta \frac{\Lambda_{t+1}}{\Lambda_t} \Omega_{t+1} \right\}.$$

Defining the markup over marginal costs as

$$mu_{i,t} = \frac{P_{i,t}}{P_t \mu_t}, \qquad mu_t = \frac{1}{\mu_t},$$

one can write the FOC, evaluated at the symmetric equilibrium, as

$$mu_t = \frac{-\theta}{1 - \theta + g_1(1, s_t) \frac{\Omega_t}{D_t}} \tag{3}$$

In a symmetric intertemporal equilibrium in each period each firm sets the same price as all other firms. The most important implication regarding market shares is that $x_{i,t}$ equals one for all t and all i. According to equation (3) the equilibrium markup depends positively on current demand and negatively on current search efforts as well as the present value of future profits. In the static monopolistic competition model markups are given by

$$mu_t = \frac{\theta}{\theta - 1} \tag{4}$$

implying that at any point in time and in any given state of the economy pass-through of marginal cost changes to prices is complete. Unlike that model, in an environment characterized by market share competition markups will be generally time varying. Wether pass-through of marginal costs to prices will turn to be greater, lower or equal to one depends on the relative strength of the reactions of D_t, Ω_t and s_t to exogenous shocks. For example, consider a positive exogenous shock which increases current consumption. The temporary (or even an one time) increase in current consumption will have a positive *direct* effect on markups through the induced increase in aggregate demand D_t. Based on this result, many microeconomic models assuming a constant discount factor reach the conclusion that markups are procyclical. In the present model, however, the discount factor is endogenous and strongly linked to current consumption - as shown below the Lagrange-multiplier Λ_t is given by

$$\Lambda_t = C_t^{-\eta}.$$

Other things equal, if η is sufficiently large an increase in current consumption will cause larger an increase in Ω_t *via* the rise in the discount factor. As a consequence, the markup will tend to be countercyclical. Further, if search activity depends positively on consumption, as is the case in this model,[20]

[20] See below.

consumption will also have a second indirect negative effect on markups *via* s_t. Further, equation (3) implies that markups in this model are always lower than they would be if there were static monopolistic competition in the goods market.

3.1.2 Households

Let agents in this economy have preferences over consumption, real balances, working hours, search activity and overall inflation given by

$$U = E_t \left\{ \sum_{t=0}^{\infty} \beta^t \left(\frac{C_t^{1-\eta}}{1-\eta} + \phi \frac{(M_t/P_t)^{1-\chi}}{1-\chi} - \frac{b}{2} N_t^2 - \frac{\varrho}{\alpha} \frac{\pi_t^{\delta}}{s_t^{\alpha}} \right) \right\}, \qquad \phi, b, \varrho, \delta, \eta, \chi > 0, \quad \beta \in (0,1),$$

where M_t/P_t, N_t and π_t denote real balances, working hours and the gross rate of overall inflation respectively. In the above expression C_t is a composite good that includes all varieties:

$$C_t = \left\{ \frac{1}{n} \sum_{i=1}^{n} x_{i,t}^{\frac{1}{\theta}} C_{i,t}^{\frac{\theta-1}{\theta}} \right\}^{\frac{\theta}{\theta-1}},$$

$$s_t = \left\{ \frac{1}{n} \sum_{i=1}^{n} x_{i,t}^{\frac{1}{\theta}} s_{i,t}^{\frac{\theta-1}{\theta}} \right\}^{\frac{\theta}{\theta-1}}. \tag{5}$$

$x_{i,t}$ evolves according to (2). The corresponding utility-based price index is given by:

$$P_t = \left\{ \frac{1}{n} \sum_{i=1}^{n} x_{i,t} P_{i,t}^{1-\theta} \right\}^{\frac{1}{1-\theta}}.$$

The budget restriction of the representative household is given by:

$$C_t + s_t + m_{t+1} - \frac{m_t}{\pi_t} = \frac{W_t}{P_t} N_t + \Pi_t + \frac{T_t}{P_t},$$

where W_t, Π_t, T_t and $m_t = \frac{M_t}{P_{t-1}}$ denote the nominal wage, real profits, nominal net transfers form the government and real balances respectively.

3.1.3 Some Reinterpretations of the Model

An Interpretation of $x_{i,t}$ as subjective weights: Let $x_{i,t}$ be a measure of the subjective weight within the consumption bundle an agent assigns to good i. According to equation (1) this subjective weight affects the demand for good i for any given level of the relative price $P_{i,t}/P_t$ and household's total demand D_t. A higher s_t enables the household to respond stronger to relative price differences between individual suppliers - the next-period weight of firms with relatively high (low) prices in the current period are reduced (increased) by a higher amount. This is a kind of gradual switching from suppliers with high current prices to suppliers charging lower current prices. It does not take place immediately, but with a one period lag. In other words, firms are punished (rewarded) in the next period for choosing relatively high (low) prices today. To be able to undertake such a switch, the household has to reduce the resources available for consumption. The costs in terms of real resources and the time lag are an approximation of the fact that it is (or may be) costly, time consuming and even painful to switch between goods or suppliers. In many cases it is not immediately obvious whether two goods are perfect substitutes or to what extent the one can be substituted for the other. For example many services such es consulting, banking as well as educational services contain components which are not directly observable. That makes comparisons between individual products costly, as they usually involve the time and resource consuming process of analyzing, tasting, testing and trying different products. Often it is not an easy task to find the firm supplying the desired product. The service sector again, provides a vast number of examples. Habits, too, play an important role in this context, since the switch from one good or supplier to another one may require a painful break of some habits. I assume further, that since search activity usually leads to a reduction (rise) of demand for relatively expensive (cheap) goods, a positive psychological effect arises which takes the form of a reduction of the subjective negative effect on household's well-being induced by inflation. Since the same frictions which make switching between products costly, are also among the most important determinants making search efforts in the goods market necessary, s_t can be interpreted as search activity as well.

An Interpretation of $x_{i,t}$ and $g\left(\frac{P_{i,t}}{P_t}, s_t\right)$ as a measure of probability and a matching function respectively: Assume that at the beginning of each period t each household is *randomly* matched with one of the n firms and remains a customer of that firm until the end of the period. At the beginning of the next period a new round of assigning households to firms takes place with the result that the household either remains a customer of the same firm, or is matched with another supplier and so on. Each household faces a probability equal to $x_{i,t}$ to become a customer of firm i at the beginning of period t. Assume that this probability is independent of the firm she was matched to in the previous period. By intensifying search and switching efforts s_t the household increases the probability to become a next-period customer of a firm with a relatively low price in the current period. Accordingly, a higher s_t reduces the probability to be attached to the next-period customer base of a producer charging a relatively high price in t. In other words, firms are punished (rewarded) with a one period lag for choosing relatively high (low) prices. To be able to increase s_t, the household has to reduce the resources available for consumption in the same period. Given the distribution of prices and other properties of the products supplied, a higher search activity enables the household to achieve a more desirable allocation of her resources to individual goods. Under this interpretation of the model each of the two composite goods C_t and s_t represents a nonlinear risk aggregator as suggested by Chew and Dekel for valuating state dependent consumption. To avoid any heterogeneity across households, it can be assumed that there are complete

Arrow-Debreu-markets allowing each household to insure against idiosyncratic consumption risk. Since there is a continuum of identical households, the law of large numbers implies that the probability for a household to be matched with firm i, $x_{i,t}$, is identical with the fraction of households actually becoming customers of firm i in period t. Alternatively, one can assume that each household is a family consisting of a large number of members. Each period each member receives the same amount of resources for purchasing goods as well as engaging in search as any other. The goods purchased are then pooled and distributed equally among members by the head of the family.

3.1.4 First Order Conditions

The first order conditions of the representative household evaluated at the symmetric equilibrium read:

$$C_t^{-\eta} = \Lambda_t, \tag{6}$$

$$bN_t = \Lambda_t \frac{W_t}{P_t}, \tag{7}$$

$$\varrho s_t = \pi_t^{\frac{\delta}{1+\alpha}} C_t^{\frac{\eta}{1+\alpha}}, \tag{8}$$

$$\beta \phi m_{t+1}^{-\chi} E_t \{\pi_{t+1}^{\chi-1}\} = \Lambda_t - \beta E_t \left\{ \frac{\Lambda_{t+1}}{\pi_{t+1}} \right\}, \tag{9}$$

$$C_t + s_t + m_{t+1} - \frac{m_t}{\pi_t} = \frac{W_t}{P_t} N_t + \Pi_t + \frac{T_t}{P_t}. \tag{10}$$

Note that the optimality condition with respect to search activity will take exactly the same form as in (8) even when there were price dispersion in equilibrium. (8) states that at the optimum the marginal utility of consumption should be equal to the marginal utility of search. The latter is given by $\varrho \pi_t^{\delta} s_t^{-(1+\alpha)}$. For a given rate of inflation, an increase in consumption lowers its marginal utility and so, makes a lower marginal utility of search and thus a higher s_t and a stronger reduction of the disutility of inflation desirable. For a given consumption level a higher overall inflation increases the marginal utility of search. As a consequence households find it optimal to intensify search and switching efforts s_t. Although there is a vast number of game theoretic partial equilibrium models assuming costly search or switching in the goods market in order to explain equilibrium price dispersion, to the best of my knowledge, there are no empirical investigations of the cyclical properties of households' search and switching efforts in the goods market. Therefor I am not able to tell if the predictions of the model are consistent with the patterns of households' search efforts in actual economies.

3.1.5 Government

The central bank finances its lump-sum transfers to the public by changes in the nominal quantity of money:

$$M_{t+1} - M_t = T_t.$$

It is further assumed that in each period transfers constitute a fraction of current money supply:

$$T_t = (\tau_t - 1)M_t,$$

where the percentage deviation of τ_t from its steady state $\hat{\tau}_t$ follows a first order autoregressive process

$$\hat{\tau}_t = \rho_\tau \hat{\tau}_{t-1} + u_t, \qquad \rho_\tau \in [0, 1).$$

u_t is assumed to be a *White Noise Process* with variance σ_u^2.

3.1.6 Equilibrium

In equilibrium, real wages and profits are given by

$$\frac{W_t}{P_t} = \frac{Z_t}{mu_t} \qquad \text{and} \qquad \Pi_t = \left(\frac{mu_t - 1}{mu_t}\right) Z_t N_t$$

respectively. These two results, together with the households first order conditions, (6) through (10), the firm's first order condition (3) evaluated at the symmetric equilibrium and the definition of Ω_t, describe the evolution of the economy.

The inclusion of search activity s_t as an argument of the function describing the evolution of firm-specific market share introduces an externality from the point of view of the individual firm, since s_t depends on overall inflation and consumption.

3.2 Calibration

In models featuring static monopolistic competition the short run price elasticity of demand for an individual θ good is restricted to be greater than unity in order to ensure that the markup of prices over marginal costs is grater than one and thus profits are positive. Usually θ is set to a value between 6 and 8 since empirically observable average markups are relatively low - according to most estimations they are smaller than 1.6. In contrast to the static monopolistic competition model in the economy described above one don't need to impose the restriction $\theta > 1$ since θ is not the sole determinant of the steady state markup mu^*. In fact, as I show below, any value of θ smaller than $\frac{mu^*}{mu^*-1}$ is consistent with $mu^* > 1$ and a negative first derivative of the function $g\left(\frac{P_{i,t}}{P_t}, s_t\right)$ with respect to its first argument. A large part of the empirical evidence suggests that the short run price elasticity of demand for nondurables is well below one. Carrasco *et al.* (2005) provide panel estimates of the price elasticities of the demand for *food*, *transport* and *services* in Spain which take the values -0.85, -0.78 and -0.82 respectively. According to the results in Bryant and Wang (1990) based on aggregate US time series the price elasticity of *total demand for nondurables* is equal to -0.2078. Blanciforti *et al.* (1986) estimate an *Almost Ideal Demand System (AIDS)* based on aggregate US time series. Their results with respect to the own-price elasticities of nondurables can be summarized as follows: *food* - between -0.21 and -0.51; *alcohol and tobacco* - between -0.8 and -0.25; *utilities* - between -0.20 and -0.67; *transportation* - between -0.38 and -0.66; *medical care* - between -0.57 and -0.70; *other nondurable goods* - between -0.29 and -1.26; *other services* - between -0.20 and -0.36. There is also evidence supporting a short run price elasticity of demand greater than one. For example, using Finish time series Mellin and Viren (1982) come to the conclusion that the own-price elasticity of nondurables takes a value slightly below -5. However, their estimates should be interpreted with caution, since they are most likely subject to a simultaneity bias. In a more recent paper Tellis (1988) surveys the estimates of the price elasticity of demand in the marketing literature. He provides a skewed distribution of the results found in that literature with mean, mode and standard deviation equal to -1.76, -1.5 and 1.74 respectively. The bulk of the estimated elasticities take values in the range [-2,0]. In light of the empirical evidence it appears more reasonable to set θ at a value lower than one. However, for the sake of completeness and better comparability with models featuring static monopolistic competition, I decide to carry out a sensitivity analysis with respect to θ by simulating the model for several values of θ below and several values above one.

Most authors set the steady state markup at a value in the range suggested by Rotemberg and Woodford (1993) - between 1.2 and 1.4. The same is done in the current paper - $mu^* = 1.2$ is chosen as a baseline value. However, since there is also empirical evidence[21] supporting lower as well as much higher

[21] See Rotemberg and Woodford (1990, 1993) for a brief survey.

steady state markups, ranging from 1 to 2, I perform simulations with three alternative values of $mu^* = \{1.1, 1.3, 1.4\}$.

Table 1 shows the parameters set at their so called *standard values*, usually found in the business cycles literature.

Table 1: Calibration

Households/Preferences	Firms/Technology	Central Bank
$\eta = 2$	$Z^* = 1$	$\tau^* = 1$
$\chi = 2$	$\rho_z = \{0, 0.95\}$	$\rho_\tau = 0$
$\beta = 0.991$	$\sigma_\epsilon = 0.0061$	$\sigma_u = 0.0173$
$\theta \in (0, 2)$	$mu^* \in [1.1; 1.6]$	
$N^* = 0.24$		

The second part of the calibration involves finding the parameter values of b, ϱ and δ as well as the steady state values s^*, C^* and π^* satisfying the economy's nonstochastic stationary equilibrium.

$\tau^* = 1$ implies that the steady state value of the gross rate of inflation is equal to one. To be able to determine the value of search and switching efforts in the stationary equilibrium, s^*, one needs to compute $\frac{\Omega^*}{D^*}$ first. To find the value of Ω^* just observe that the steady state is characterized by the following relationships $\Lambda_{t+1} = \Lambda_t$, $\left(\frac{P_i}{P}\right)^* = 1$, $x_i^* = 1$ and $\frac{P_i}{P} - \mu^* = \frac{mu^*-1}{mu^*}$, and then insert them into the definition of Ω_t. After some algebraic manipulations one arrives at

$$\frac{\Omega^*}{D^*} = \frac{\beta}{1-\beta}\frac{mu^* - 1}{mu^*}.$$

s^* can then be derived from (3) evaluated at the steady state. This equation is reproduced here for convenience:

$$mu^* = \frac{-\theta}{1 - \theta - s^* \frac{\Omega^*}{D^*}}.$$

For s^* to be positive θ should be smaller than $\frac{mu^*}{mu^*-1}$ which in the case $mu^* = 1.2$ is equivalent to the restriction $\theta < 6$. Next, C^* can be derived from the goods market equilibrium condition

$$Y^* = N^* = s^* + C^*.$$

The last step involves solving equation (8) evaluated at the steady state

$$\varrho s^* = (C^*)^{\frac{\eta}{1+\alpha}}$$

with respect to the parameter ϱ for a given α.

Unfortunately, there is neither empirical evidence with respect to the values of δ and α nor there is enough model information to determine these parameters. Therefore I set δ at one and investigate the implications of the model for different values of α.

3.3 Results

3.3.1 Monetary Shocks

The effects of θ: Figures 1 through 7 in Appendix A illustrate the impact of a positive monetary shock without serial correlation, $\rho_\tau = 0$ for different choices of θ. mu^* and α are equal to 1.2 and 0.5 respectively. t denotes the time index of the period in which the shock occurs. $t+1$ is the time index of the period after the shock. For a given price level the rise in the nominal money supply induces a positive income effect encouraging households to increase consumption, money demand and search activity and reduce labor supply. These reactions generate an upward pressure on current nominal wages and prices as well as expected inflation. Since all nominal variables are fully flexible, they will rise. The increase in inflation weakens the positive income effect of the monetary impulse. But whether hours, output and consumption will actually rise, fall or remain constant depends on how do firms react to the increase in nominal wages and the changes in current consumption and search efforts. First, note that an increase in current consumption does not only have a positive effect on current demand and current profits but also on the discount factor. A higher discount factor in turn generates a stronger incentive for firms to invest more in future market share. Thus for any given level of current demand and households' search efforts firms will set lower prices than they would do if the discount factor remained constant. Second, if all firms rise their prices current inflation will rise. Assume for simplicity that the resulting equilibrium is symmetric. The higher inflation will induce households to intensify search and switching efforts. From the point of view of an individual firm the higher search activity creates an incentive to choose a lower than average price. Since all firms will do the same, the average price level and the resulting overall inflation will be lower than they would be in an environment in which search does not depend on π_t. In other words, if there is an upward pressure on inflation the externality arising from the positive relationship between s_t and π_t lowers pass-through and leads to a lower equilibrium inflation.

For the reasons just described, firms pass through to prices only a fraction of the increase in nominal marginal costs. As a consequence, markups fall and real wages rise. As figures 1 through 7 show the increase in real wages $\left(\widehat{\frac{W_t}{P_t}}\right)$ is sufficient to induce working hours to rise, despite the increase in consumption. The higher output makes it possible to rise both, C_t and s_t.

It is important to note, that the key mechanism, making it possible for nominal disturbances to have real effects, is the direct link between search efforts and current inflation, which is due to the assumed form of inflation aversion. To understand that, assume that before search could be adjusted the rise in inflation induced by a monetary shock is just sufficient to force consumption and hours to remain constant. Is the situation just described an equilibrium allocation? No, it isn't for the following reason: Since inflation is above average search efforts will be above average too. Therefore firms will have an incentive to lower their prices and so equilibrium inflation will fall. As a result markups will deviate negatively and real wages, hours and output positively from their respective steady state levels. Absent the dependence between s_t and π_t, the positive pressures put on consumption C_t, expected future profits Ω_t and search s_t by the monetary shock will exactly offset each other and the increase in inflation will be sufficient to offset the income effect of the monetary disturbance. In that case money will be *neutral.* [22]

The impulse responses indicate that lower values of θ make the reactions to a one time monetary disturbance more pronounced in the period of the shock on the one hand and more persistent on the other. What is the intuition behind the stronger reactions when θ takes a relatively low value? The higher the value of θ, the higher in absolute value the slope of the *current profit function* with respect to mu_t at the symmetric equilibrium. Therefore, if θ is relatively high, firms will need a smaller adjustment of mu_t as a reaction to changes in the term $\frac{g(1,s_t)\Omega_t}{D_t}$, in order to ensure that their respective optimality conditions remain satisfied.[23] The stronger deviations of markups for low values of θ then imply more pronounced reactions of real wages and thus hours and output. The higher output makes it possible to increase consumption which in turn has a positive effect on search activity. In fact, the initial reaction of s_t is virtually the same for all values of θ. For higher values of θ the rise in search is induced by the healthy increase of inflation, whereas for lower values of θ it results from the relatively strong positive reaction of consumption. Hence, pass-through in the low-θ-case is further decreased relative to that in the high-θ-case by the larger increase of the discount factor in the former.

Where does the higher persistence come from? Since it is optimal for house-

[22] An Appendix with detailed derivations is available upon request.

[23] I provide a detailed derivation of this result in an appendix available upon request.

holds to smooth consumption over the entire future, the higher consumption in the period of the shock will force them to increase their investment in real balances. Since the positive deviation of real balances in $t+1$ is larger than that of inflation, the term $\frac{m_{t+1}}{\pi_{t+1}}$ increases. Hence, at the beginning of $t+1$ households start with above average real value of wealth, or in other words, are subject to a positive wealth effect. The latter induces qualitatively the same reactions as did the positive monetary shock in the previous period. The lower the value of θ, the higher the increase in the real value of wealth $\frac{m_{t+1}}{\pi_{t+1}}$, and thus the stronger the induced positive wealth effect in the period after the shock, $t+1$. As a result, the increase in $t+1$-consumption in the low-θ-economy will be larger than that in the high-θ-economy. The higher the increase in $t+1$-consumption relative to its average future level, the stronger the additional investment in money balances[24] m_{t+2} and therefore, the stronger the positive wealth effect in $t+2$ and so on.

The effects of mu^*: Figures 8 through 12 depict the impulse responses to the same monetary shock for different values of mu^*. θ and α are set to 1 and 0.5 respectively. It can be shown that there is a positive relationship between the absolute value of the slope of the *current profit function* evaluated at the symmetric equilibrium and the steady state markup mu^*. Therefore, if mu^* is relatively high, firms will need a larger adjustment of mu_t as a reaction to changes in the term $\frac{g(1,s_t)\Omega_t}{D_t}$, in order to ensure that their respective optimality conditions remain satisfied.[25] The impulse responses displayed in figure 8 confirm that: A higher steady state markup implies a lower pass-through of marginal costs to prices and leads to more pronounced and more persistent impulse responses in the same way as low values of θ do.

[24]Because of consumption smoothing.

[25]I provide a detailed derivation of this result in an appendix available upon request.

The effects of α: Figures 13 through 15 illustrate the impulse responses of markups, output and inflation to a one time monetary shock for different values of α. θ and μ are set to 1 and 1.2 respectively. As can be seen, lower values of α induce stronger and more persistent responses to monetary shocks. The reason is that lower values of α imply stronger positive reactions of search activity to changes in inflation and thus a tendency for firms to choose a lower (higher) pass-through as a reaction to a positive (negative) monetary disturbance. If α takes a very high value money is almost *neutral* in this model.

A comparison with the New Keynesian Model: The *New Keynesian Model* is the most used theoretical model for analyzing and evaluating monetary policy. It assumes *Calvo*-type price stickiness by which in each period the firms that are allowed to adjust their prices are randomly selected. A fraction $1-\varphi$ of all firms adjust their prices while the remaining fraction φ do not. For the purpose of comparison I assume that technology and monetary policy are identical with that in the benchmark model. Further, in the *New Keynesian Model* there are no market share competition and no search or switching activity. The consumption aggregator is modified as follows:

$$C_t = \left\{ \frac{1}{n} \sum_{i=1}^{n} C_{i,t}^{\frac{\theta-1}{\theta}} \right\}^{\frac{\theta}{\theta-1}},$$

and the utility function reads:

$$U = E_t \left\{ \sum_{t=0}^{\infty} \beta^t \left(\frac{C_t^{1-\eta}}{1-\eta} + \phi \frac{(M_t/P_t)^{1-\chi}}{1-\chi} - \frac{b}{2} N_t^2 \right) \right\}, \qquad \phi, b, \eta, \chi > 0, \quad \beta \in (0,1).$$

The pricing decisions of individual firms can then be aggregated to the following log-linear, forward looking *Phillips Curve*:

$$\hat{\pi}_t = \beta E_t(\hat{\pi}_{t+1}) + \frac{(1-\varphi)(1-\beta\varphi)}{\varphi} \hat{\mu}_t,$$

where μ_t denotes marginal costs. The model is parameterized as follows: $\beta = 0.991$, $N^* = 0.24$, $\eta = 2$, $\chi = 2$, $\rho_\tau = 0$, $\sigma_u = 0.0173$, $\rho_z = 0$ or $\rho_z = 0.95$,

$\sigma_\epsilon = 0.0061$, $\varphi = 0.75$ and $mu^* = 1.4$. Note, that in this model the choice of mu^* affects only the impulse responses of profits. Figure 16 depicts the impulse responses to a purely temporary monetary shock in the third quarter. As can be seen, the effect of the shock is largest on impact, dies out gradually and disappears completely after about 11 quarters. Markups and profits respond negatively to the monetary impulse. Since, according to the empirical evidence, steady state markups in range between 1.2 and 1.4 as well as values of θ lower than one are economically plausible and at the same time there is no *a priory* reason to disregard the choice $\delta = 1$ as implausible, for a fairly large range of parameter values the benchmark model presented in section 3 implies stronger and more persistent responses to monetary shocks than the *New Keynesian Model* does. Thus, firstly, the benchmark model provides an alternative explanation of the observable real effects of nominal disturbances and secondly, for a broad range of parameter values it matches better the empirical evidence provided by Christiano *et al.* (2005) with respect to the magnitude and persistence of the responses to nominal shocks than the *New Keynesian Model* does.

It is also important to note that the *New Keynesian Model* implies some persistence of the impulse responses only for relatively high levels of price rigidity (high values of φ). For instance $\varphi = 0.5$ ($\varphi = 0.3$) imply that the effects of the monetary shock completely disappear after 5 (2) quarters.

3.3.2 Technology Shocks

Figures 17 through 20 depict the impulse responses to a non-autocorrelated technology shock $\rho_z = 0$. Combinations of relatively low values of θ, $\theta \leq 1$ and a relatively high steady state markup, $\mu^* \geq 1.2$ imply highly persistent reactions to a one time increase of total factor productivity. According to these results, the benchmark model of section 3 provides an endogenous explanation of the persistence of *technolgy-shock-driven* business cycles, since it does not impose the exogenous assumption that the coefficient of serial correlation of total factor productivity ρ_z is greater than zero. In other words, large scale real- or monetary business cycle models incorporating a complex combination of assumptions e.g. *high degree of wage and price rigidity, and adjustment costs of capital, and matching frictions in the labor market, and habit persistence, and...* or simpler models assuming $\rho_z \in (0.99, 1)$ are not the only theories able to account for the observed duration of business cycles. There are also much simpler models, like the one presented in section 3, which are able to do that. For instance, the parameter combination $\theta = 0.7(1.2)$, $\delta = 1$, $\alpha = 0.5$ and $\mu^* = 1.4(1.2)$ imply the following first-order autocorrelations, $corr(x_t, x_{t-1})$: output: 0.68 (0.42), consumption: 0.67 (0.31), hours: 0.63 (0.24), real wages: 0.69 (0.42), markups: 0.67 (0.41).

Note, that the original version of the customer market model proposed by Phelps and Winter (1970) does not generate persistent responses to one-time technology shocks! The discrete time version of that model is presented in an appendix available upon request.

A comparison with the New Keynesian Model: Figure 21 displays the impulse responses to a technology shock without serial correlation implied by the *New Keynesian Moedl*. There is no such thing as persistence in the responses of hours and markups and the reactions of output and consumption are almost indiscernible. The implied increase in markups is at odds with the results in Rotemberg and Woodford (1996). In contrast, the benchmark model predicts a decline of markups.[26]

[26]See figure 17 and 19.

4 Conclusion

The model presented in sections 3 through 3.3 extends the standard monetary business cycles model along three dimensions: market share competition, search and switching activity in the goods market and inflation aversion. The interplay of these new features of the model with the old ones enables it to account for the cyclical properties of markups and the significant and persistent real effects of monetary impulses. Furthermore, the theory provides an endogenous explanation of the empirically observable persistent reactions to technology shocks without resorting to the assumption that total factor productivity follows an autoregressive process with a coefficient of autocorrelation near one.

An important challenge for future empirical research will be the attempt to quantify the cyclical properties of s_t and to estimate α. From theoretical point of view, the model provides many dimensions along which it can be extended. For example by taking an explicit account of capital accumulation or labor market frictions.

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A Benchmark Model

Figure 1: Benchmark model *(CM-model)*. Impulse responses to a monetary shock, $mu = 1.2$, $\alpha = 0.5$, $\rho_\tau = 0$.

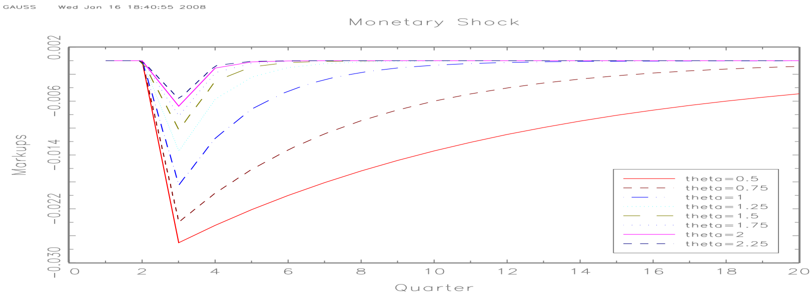


Figure 2: Benchmark model *(CM-model)*. Impulse responses to a monetary shock, $mu = 1.2$, $\alpha = 0.5$, $\rho_\tau = 0$.

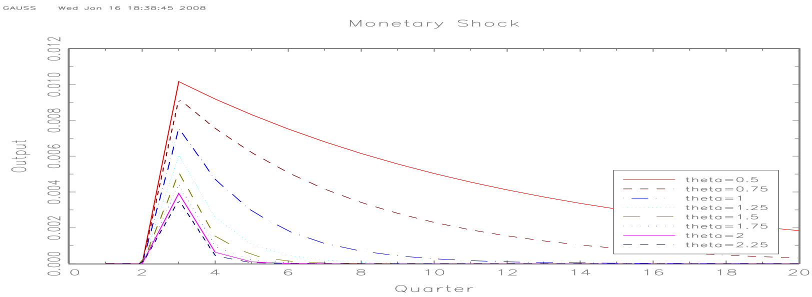


Figure 3: Benchmark model *(CM-model)*. Impulse responses to a monetary shock, $mu = 1.2$, $\alpha = 0.5$, $\rho_\tau = 0$.

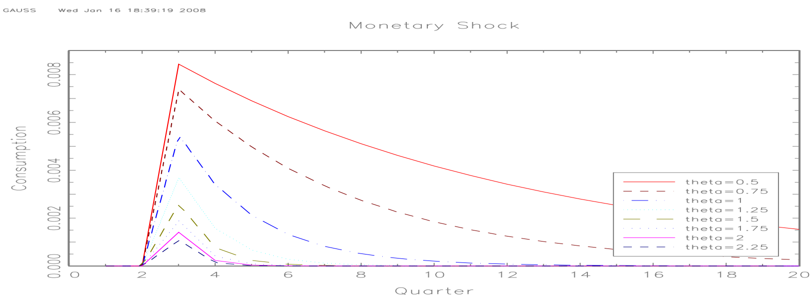


Figure 4: Benchmark model *(CM-model)*. Impulse responses to a monetary shock, $mu = 1.2$, $\alpha = 0.5$, $\rho_\tau = 0$.

Figure 5: Benchmark model *(CM-model)*. Impulse responses to a monetary shock, $mu = 1.2$, $\alpha = 0.5$, $\rho_\tau = 0$.

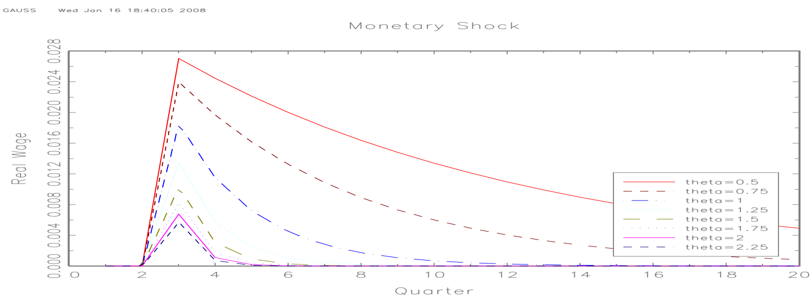


Figure 6: Benchmark model *(CM-model)*. Impulse responses to a monetary shock, $mu = 1.2$, $\alpha = 0.5$, $\rho_\tau = 0$.

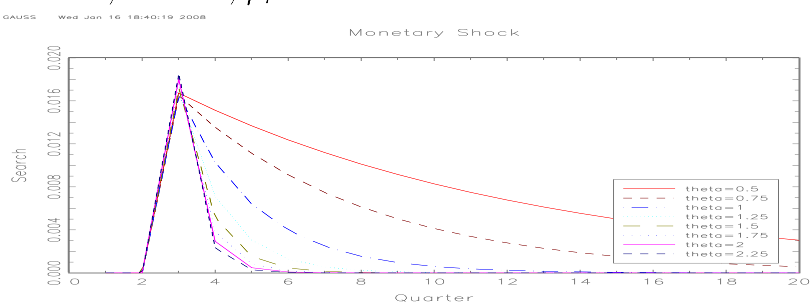


Figure 7: Benchmark model *(CM-model)*. Impulse responses to a monetary shock, $mu = 1.2$, $\alpha = 0.5$, $\rho_\tau = 0$.

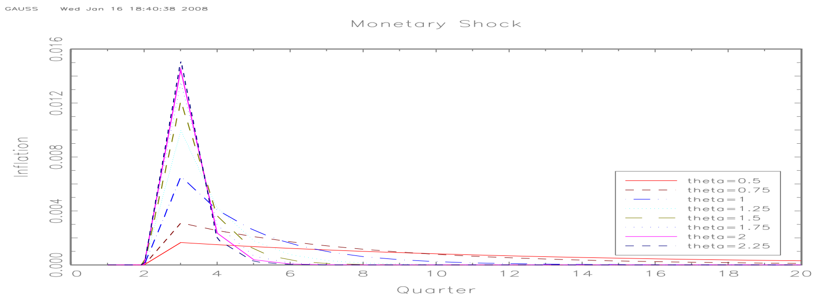


Figure 8: Benchmark model *(CM-model)*. Impulse responses to a monetary shock, $\theta = 1$, $\alpha = 0.5$, $\rho_\tau = 0$.

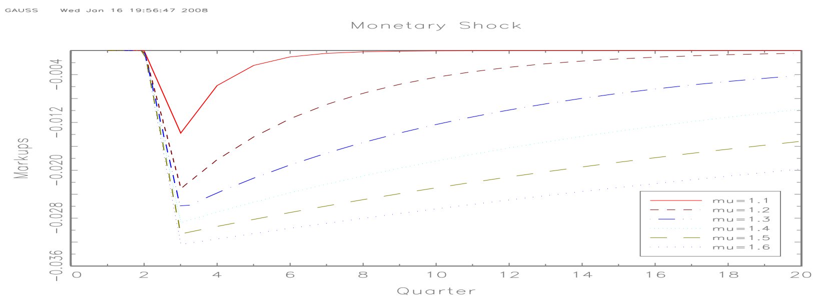


Figure 9: Benchmark model *(CM-model)*. Impulse responses to a monetary shock, $\theta = 1$, $\alpha = 0.5$, $\rho_\tau = 0$.

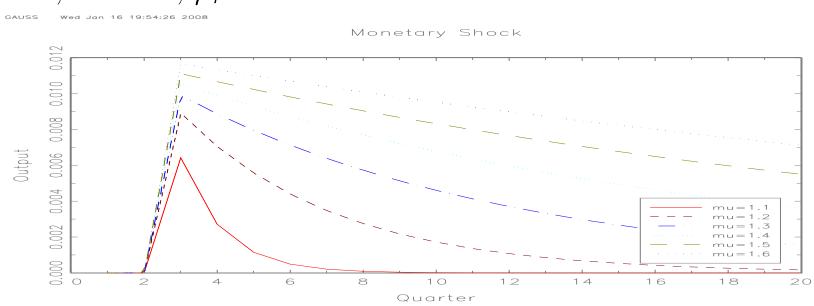


Figure 10: Benchmark model *(CM-model)*. Impulse responses to a monetary shock, $\theta = 1$, $\alpha = 0.5$, $\rho_\tau = 0$.

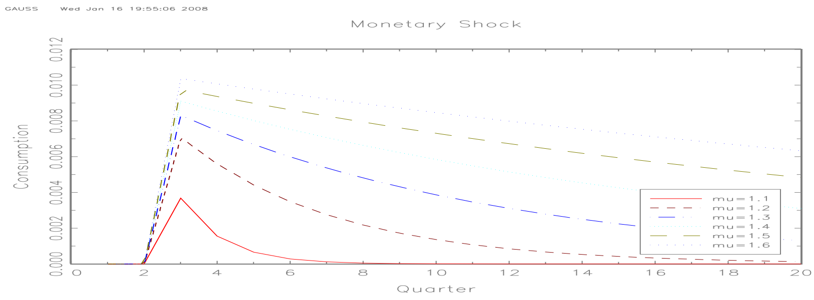


Figure 11: Benchmark model *(CM-model)*. Impulse responses to a monetary shock, $\theta = 1$, $\alpha = 0.5$, $\rho_\tau = 0$.

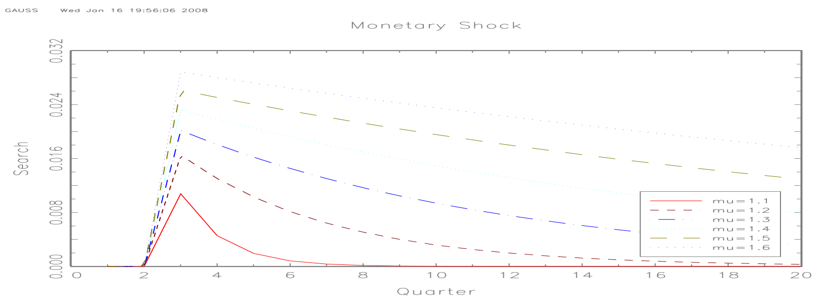


Figure 12: Benchmark model *(CM-model)*. Impulse responses to a monetary shock, $\theta = 1$, $\alpha = 0.5$, $\rho_\tau = 0$.

Figure 13: Benchmark model *(CM-model)*. Impulse responses to a monetary shock, $\theta = 1$, $mu^* = 1.2$, $\rho_\tau = 0$.

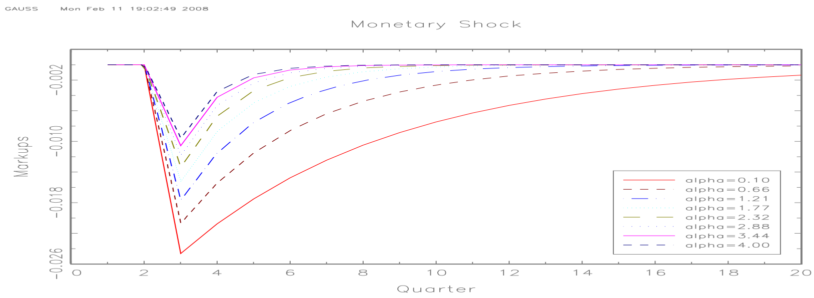


Figure 14: Benchmark model *(CM-model)*. Impulse responses to a monetary shock, $\theta = 1$, $mu^* = 1.2$, $\rho_\tau = 0$.

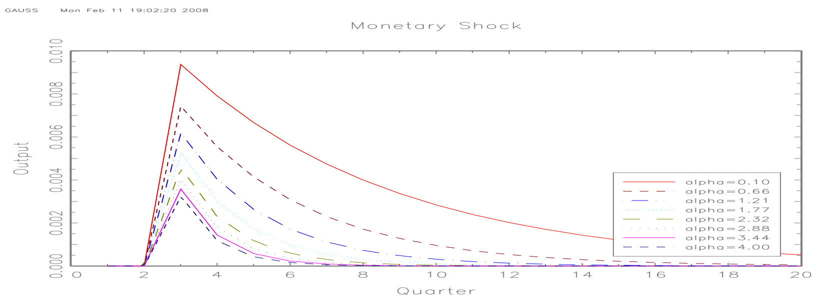
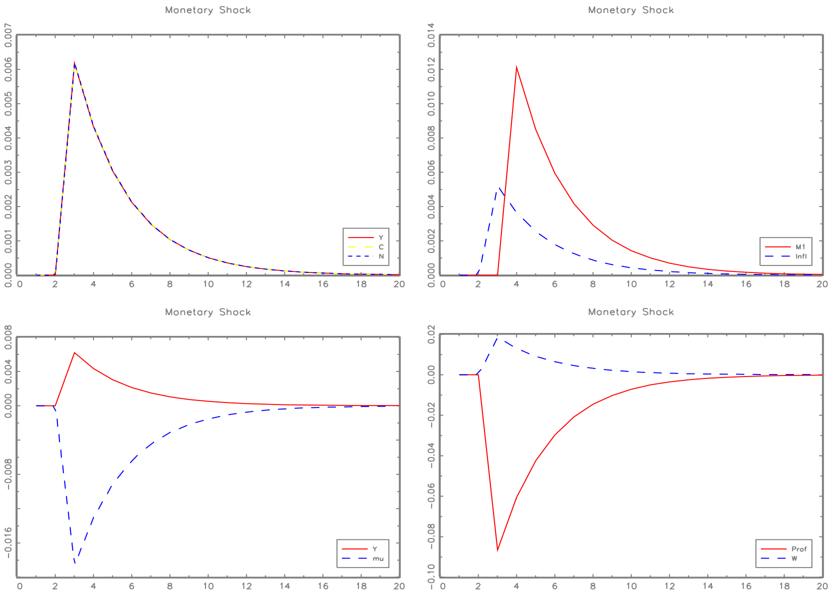


Figure 15: Benchmark model *(CM-model)*. Impulse responses to a monetary shock, $\theta = 1$, $mu^* = 1.2$, $\rho_\tau = 0$.

Figure 16: New Keynesian Model. Impulse responses to a monetary shock, $mu^{*} = 1.2$, $\rho_{\tau} = 0$, $\varphi = 0.75$.



Percentage deviations from the long run mean. Y-Output, C-Consumption, N-Hours, W-Real Wage, S-Search Effort, M_1-Real Balances, $Infl$-Inflation, $Prof$-Profits.

Figure 17: Benchmark model *(CM-model)*. Impulse responses to a technology shock, $mu = 1.2$, $\alpha = 0.5$, $\rho_z = 0$.

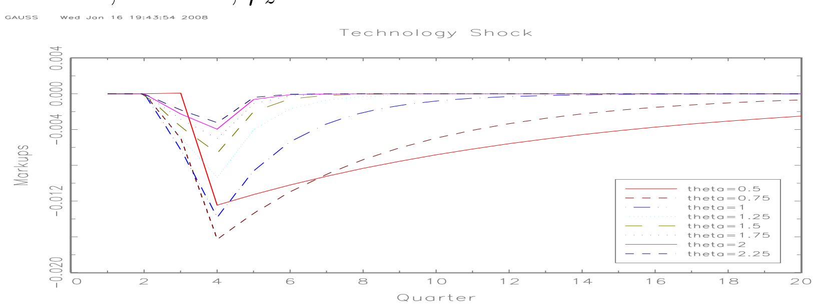


Figure 18: Benchmark model *(CM-model)*. Impulse responses to a technology shock, $mu = 1.2$, $\alpha = 0.5$, $\rho_z = 0$.

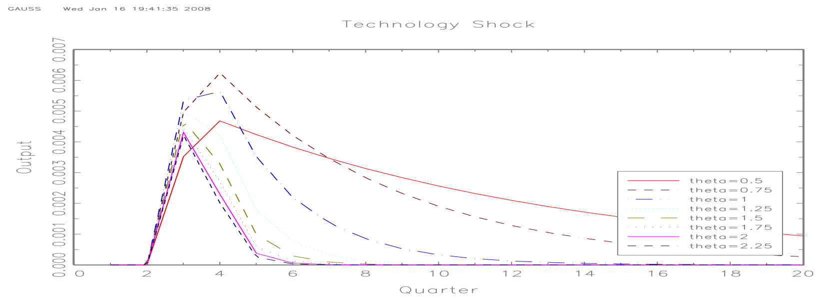


Figure 19: Benchmark model *(CM-model)*. Impulse responses to a technology shock, $\theta = 1$, $\alpha = 0.5$, $\rho_z = 0$.

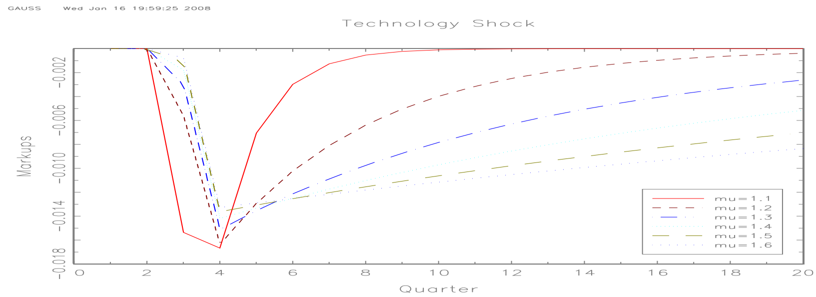


Figure 20: Benchmark model *(CM-model)*. Impulse responses to a technology shock, $\theta = 1$, $\alpha = 0.5$, $\rho_z = 0$.

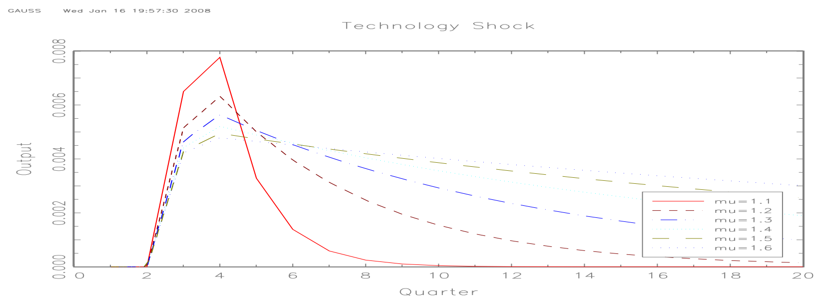
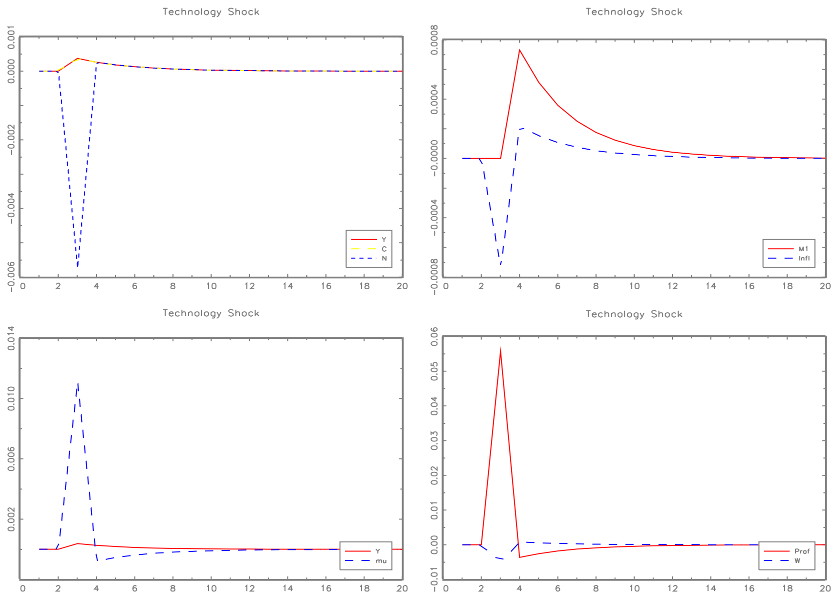


Figure 21: New Keynesian Model. Impulse responses to a technology shock, $mu^{*} = 1.2$, $\rho_z = 0$, $\varphi = 0.75$.



Percentage deviations from the long run mean. Y-Output, C-Consumption, N-Hours, W-Real Wage, S-Search Effort, M_1-Real Balances, $Infl$-Inflation, $Prof$-Profits.