ESSAYS ON DISCRETIONARY INFLATION

by

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Abstract

The focus of the following three essays rests on the Kydland-Prescott (1977) and Barro-Gordon (1983) model of time inconsistent discretionary monetary policy. The first essay derives a model in which the costs and benefits to inflation are tied to the underlying features of the economy. The benefit to inflation arises due to monopolistic competition among firms and the cost is due to a staggered timing structure for nominal money. The benefit of this approach is that it can be shown that factors that increase the monetary authority’s incentive to inflate may also increase the costs to inflation, and therefore do not necessarily result in a worsened inflation bias. In particular, the model shows that discretionary inflation in the economy is nonmonotonically related to the distortion. The model also indicates that changes in the real interest rate affect the monetary authority’s incentives and hence the discretionary rate of inflation. An increase in the labor share raises the discretionary rate. Lastly, lack of commitment, costs to inflation, and the presence of a distortion are crucial for discretionary inflation to be biased above the Friedman (1969) rule. The second essay builds on the first, extending the model to an open economy environment. The extended model indicates several channels through which openness affects the monetary authority’s incentives. Most significantly, the model cannot replicate the Romer (1993) and Lane (1995) result that openness reduces the discretionary rate of inflation. Again, the model relates the underlying features of the economy on the discretionary rate, and an economy’s foreign asset position. Strategic incentives are also important for determining whether an open economy’s rate of inflation
is less than that of a comparable closed economy. The last essay analyzes empirically the relationship between the overall degree of competition among firms, as measured by the markup, and the average rate of inflation for the OECD group of countries. In line with the time-consistency argument, results indicate a positive relationship between markups and inflation. This finding is robust to the inclusion of several explanatory variables, such as terms of trade effects, and central bank independence. The evidence is weak, however, in the presence of per capita GDP.
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To my parents.
1 Introduction

A central concern in economics is the issue of inflation determination. One of the main views held by economists for explaining what determines inflation in industrial economies is the dynamic inconsistency argument put forth by Kydland and Prescott (1977) and formalized by Barro and Gordon (1983a). The argument is based on the idea that, in a sticky price environment, governments see themselves as able to set inflation above expectations in an effort to raise output above its socially inefficient full employment level. Knowing the incentives of the monetary authority, private agents raise their expectations so that, in equilibrium, inflation matches expectations and output remains at its full employment level. The outcome is similar to the prisoners’ dilemma: given that inflation is costly, and that in equilibrium output remains at its full employment level, everyone would be better off if the monetary authority could commit to a lower rate of inflation at the outset.

Three key issues underlie the dynamic inconsistency argument described above: lack of commitment on the part of the monetary authority to a pre-announced rate of inflation, as reflected by the fact that the monetary authority chooses inflation taking expected inflation as given; the existence of costs to inflation that ultimately dampen the monetary authority’s desire to continue raising inflation above expectations; and benefits to inflation that provide the monetary authority with an incentive to inflate, embedded in the assumption that full employment is below its socially efficient level. As an explanation of inefficiently high inflation, the dynamic inconsistency problem has led to several
theoretical models, policy prescriptions and empirical analyses, each of which focusses on one of the three elements of the basic argument.

With regard to the issue of commitment, several changes in the institutional structure governing the monetary authority, such as establishing a money growth rate rule or creating an independent central bank, have been advocated in response to the time consistency problem of discretionary monetary policy. The idea that the monetary authority should commit to a specific growth rate of the money supply is not new to the dynamic inconsistency argument. Perhaps the most famous early advocate of such a rule is Friedman (1968). His justification for constraining the monetary authority to follow "rules rather than discretion" differs from that provided by the dynamic inconsistency argument: Friedman believed that although monetary policy has real effects in the short term, these effects occur with what he describes as "long and variable lags", in which case the economy may already be recovering on its own when the monetary policy takes effect, causing it to be destabilizing. Furthermore, money growth in the long run merely contributes to inflation, doing nothing to raise the level output above its full employment level. For these reasons he believed that the monetary authority should relinquish its discretionary powers and follow a money growth rule consistent with the long run growth of the economy. The time consistency argument served to strengthened the appeal of rules in that it illustrated the inflationary bias inherent in discretionary policies. The main critique of following a money growth rule, has been and still is, that by doing so the monetary authority is unable to respond to real shocks to the economy (see, for example,

\[1\] For a recent textbook treatment, see Obstfeld and Rogoff (1996).
An alternative way of overcoming the inflationary bias without resorting to strict rules was put forth by Rogoff (1985a). In an influential paper, he suggests that the government appoint a conservative central banker whose preferences differ from those of the private sector. Such a central banker would weight the cost of inflation more heavily than the private sector, but still care about fluctuations in output. In other words, such a central banker would be able to overcome some of the time consistency problems without giving up the ability to smooth fluctuations in output resulting from real shocks to the economy. The argument for appointing a conservative central banker, or creating an independent central bank, is appealing and it has been shown that central bank independence and inflation are inversely related among industrial countries (see Alesina (1989), Grilli, Masiandaro, and Tabellini (1991), Cukierman, Webb, and Neyapti (1992)). However, a more comprehensive study of the determinants of inflation by Miron and Campillo (1996) finds that central bank independence is insignificant in determining inflation outcomes.

Rogoff's (1985a) model indicates a role for the government in influencing monetary policy through its choice of central banker. A related issue is addressed in a paper by Walsh (1995), in which the government designs a contract between itself and the central bank so as to induce the central banker to follow the optimal inflation policy without relinquishing his ability to respond to shocks to the economy. Walsh shows that there exists a contract that can eliminate the inflation bias and simultaneously allow for

\footnote{For extensions on the basic model, see for example, Lohmann (1992), Waller (1992), and Walsh and Waller (1996).}
discretionary response to real shocks. However, Herrendorf and Lockwood (1997) show that appointing a conservative central banker may still be optimal if wage contracts are renegotiated more often than the contract between the government and the central bank.

Early in the debate over how best to overcome the problem of time consistency, Barro and Gordon (1983b) suggested that reputational concerns enable the monetary authority to overcome the problem of inflation bias without having to establish central bank independence. They argued that if the monetary authority is engaged in a repeated game with the private sector, there exist trigger strategy equilibria in which the monetary authority builds a reputation over time by continually setting inflation at a low level, since any deviation would entail a punishment by the private sector. But it is difficult to follow a strategy in which agents punish the monetary authority for deviating from the low, "ideal" inflation policy since this requires the private sector and the monetary authority to have access to the same information. As Canzoneri (1985) points out, if there is asymmetric information, then this type of reputation story unravels. This is because agents will not know if higher inflation this period is a result of the monetary authority counteracting a negative shock according to the ideal policy, or just pursuing an inflationary policy.

An alternative theory to dealing with problems of commitment through reputation, based on a model by Kreps and Wilson (1982), was raised most notably by Barro (1986) and Backus and Driffill (1985). The idea is that agents in the economy are confused as to the central banker’s type. If the central banker is a low inflation type, then he will choose
low inflation. If the central banker is not a low inflation type, then it may still be in his
interest to follow a low inflation policy to make people think he is a low inflation type
since by revealing his true type today he will have to accept higher inflation at the same
level of output in the future. Therefore, uncertainty as to the central banker's type, along
with the fact that central bankers do not completely discount future periods, enables the
monetary authority to follow a low inflation policy and overcome the time consistency
problem without having to resort to legal restrictions on the central bank's discretionary
powers. Rogoff (1987) argues against relying too heavily on reputation, emphasizing that
there are too many unanswered modelling issues to conclude that reputational concerns
can significantly reduce the inflation bias. For example, in the reputation model described
above, the results are sensitive to the public's priors regarding the central banker's type,
but these are taken as being determined outside the model.

In addition to problems of commitment, the dynamic inconsistency argument rests on
the assumption that the monetary authority has an incentive to raise output above its full
employment level. The reason given for this assumption is that full employment is below
its socially efficient level, perhaps due to the distortionary effects of taxation, unemploy-
ment insurance, or imperfect competition (see Barro and Gordon (1983a)). As Rogoff
(1985b) points out, the first best solution for overcoming the dynamic inconsistency
problem is to remove the distortion creating the incentive for the monetary authority to
inflate. For this reason, there has been an effort to understand the effect of changes in the
underlying structure of an economy on inflation. In particular, the effect of a country's
openness to trade and its subsequent impact on the relationship between openness and inflation through the terms of trade was first addressed by Romer (1993). Romer argued that because open economies suffer from a terms of trade deterioration (see Rogoff (1985b)) in addition to the more general costs, such as income redistribution, associated with unanticipated inflation, more open economies should have lower average rates of inflation. Lane (1995) builds on the argument put forth by Romer, showing that openness can reduce an economy's rate of inflation even if that country is too small to affect its terms of trade. The explanation for this finding is as follows: more open economies have, by definition, a smaller non-traded goods sector, which is assumed to be monopolistically competitive. Therefore, the smaller the source of the monetary authority's incentive to inflate (eg the more open an economy), the lower is inflation. This story is very much related to the "dynamic" gains from trade argument, namely increased competition among domestic firms resulting from exposure to foreign competition is an additional benefit to trade (see, for example, Markusen(1981) and Venables (1985)). What is interesting about the time-consistency argument, is that it can potentially explain the repercussions of such changes in response to trade policy on an economy's average rate of inflation.

The idea that firm structure affects a monetary authority's incentive to inflate can be related to several other issues not directly linked to the time consistency argument. For example, attempts have been made to understand the link between a country's level of development and inflation. Empirical evidence indicates that more developed economies have a greater degree of competition among firms (see Gali (1995)). Some
economists have taken this a step further and suggested that structural reforms, such as de-monopolization, must precede any attempts by transition economies to reduce inflation on their path towards greater development (see Fischer, Sahay, and Végh (1996)). Their argument may be attributed to the idea that many formerly communist countries cannot feasibly reduce their rates of inflation without first seeking privatization of state monopolies. This is because, without privatization, the government is responsible for financing these industries which, in the face of a dwindling tax base, it can only achieve by printing money. The alternative, of course, is to allow these state owned monopolies to fail, leading to an increase in unemployment. Politically, this alternative may not be feasible, in which case these economies are stuck in a trap of high inflation and a socially inefficient level of output unless structural reforms aimed at increasing competition are pursued.

Finally, the time consistency argument crucially depends on the assumption that inflation is costly. This assumption is generally attributed to the existence of menu and shoe-leather costs, income redistribution, or for political reasons. However, such costs are often difficult to model from microfoundations (see Calvo and Guidotti (1993)). For example, it is necessary to adopt a model with heterogeneous agents if one wants to incorporate distributional effects or develop a more complicated theory to include menu costs that is consistent with profit maximization. For these reasons, costs to inflation are typically incorporated in an ad hoc fashion, but by considering only how benefits change, and assuming that the costs of inflation are independent of the structure of the economy,
results in partial equilibrium conclusions as to the effect of changes in the underlying fundamentals of an economy on inflation.

In line with the recent trend of focusing on the effect of underlying structural changes on discretionary inflation, the following three essays share the feature that full employment is suboptimal due to the presence of monopolistic competition among firms. The implication is that the monetary authority would like to raise output to its socially optimal level using the one tool it has at its disposal, namely monetary policy. In addition, the costs to inflation are derived explicitly by assuming a staggered timing structure for the acquisition of nominal balances, as first suggested by Persson, Persson, and Svensson (1989). This is a critical feature of the first two chapters and highlights the fact that the cost, as well as the benefit, to inflation is tied to the structure of the economy. The focus of the first essay is on creating a structural model in which the costs and benefits to inflation are derived explicitly. This structural model is then expanded to analyze the impact of openness on discretionary inflation. The last essay analyzes empirically one of the main predictions of the basic model, namely that economies in which firms lack competition can suffer from higher average inflation. A brief introduction to each of the following three essays is given below.

Chapter 2 extends the Barro and Gordon (1983a) model to a general equilibrium framework in which the costs and benefits to surprise inflation reflect the preferences, technology, and market structure of the economy. The benefit of such an approach is that we can relate the underlying features of the economy to the size of the inflation bias.
In particular, it can be shown that an increase in the source of the monetary authority's incentive to inflate does not necessarily result in a worsened inflation bias due to offsetting changes in the cost of inflation. Furthermore, changes in the real interest rate affect the monetary authority's incentives and hence the discretionary level of inflation. Lastly, we can show that an increase in the labor share of national income worsens the inflation bias. The model also indicates the importance of a nominal rigidity, lack of policy precommitment, and a distortion for optimal monetary policy to be characterized by a level of discretionary inflation that exceeds the Friedman (1969) rule.

Chapter 3 examines the effect of openness on the discretionary rate of inflation. The model builds on the one presented in the first chapter by allowing international borrowing and lending. We find that the cost and benefits to inflation fall into two broad classes, which are referred to as a fundamentals effect and a strategic effect on the monetary authority's choice of inflation. Firstly, the model provides insight into how an economy's ability to engage in international borrowing and lending affects the fundamentals of the monetary authority's incentives and so the discretionary level of inflation. Unlike earlier models, the fundamental's portion of discretionary inflation is not necessarily lower for an open economy and will depend on the underlying structure of the economy. In particular, economies in which firms have a relatively large degree of monopoly power will find that a move to openness will on impact reduce the incentives of the monetary authority to inflate, but that economies in which firms are highly competitive, such a move may worsen the average rate of inflation. The model also addresses the issue of how an economy's net
foreign asset position affects the fundamentals of the monetary authority's incentives. Because the direct cost of inflation is itself a function of a country's net foreign asset position, it is no longer necessarily the case that as a country becomes a net borrower that inflation is expected to rise. Lastly, the model shows that strategic effects are important in determining whether an open economy's overall rate of discretionary inflation will be higher or lower than that of a comparable closed economy.

The last chapter examines empirically the relationship between markups and inflation over the 1973-88 period for OECD countries. Markups, which are interpreted as representing the distortion in the economy responsible for reducing the full employment level relative to perfect competition, provide the monetary authority with an incentive to inflate in a sticky price environment. The prediction therefore is that higher markups increase the monetary authority's incentive to raise output, thereby leading to higher equilibrium rates of inflation. The empirical results support the hypothesis that markups and inflation are positively related for OECD countries. In addition, this finding is robust to the inclusion of several explanatory variables such as central bank independence, which we find to be insignificant. We also find that markups are significant if we include an interaction variable to capture terms of trade effects. Lastly, per capita GDP appears to play a significant role in determining average inflation rates, although its effects are difficult to interpret.
Chapter 2: Discretionary Inflation in a Closed Economy General Equilibrium Model

2.1 Introduction

One of the most widely accepted theories of inflation is that of Barro and Gordon (1983a). In that paper, the authors look at the trade-off between the costs and benefits to surprise inflation in a game between the monetary authority and the private sector. They argue that the presence of distortions in the economy provide the monetary authority with an incentive to raise output above its full employment level through surprise inflation. Costs to inflation, however, ultimately dampen the desire to continue to seek to raise output. In a rational expectations equilibrium, where inflation is predicted correctly, output remains at its full employment level, but inflation is higher than it would have been had the monetary authority been able to precommit.  

This chapter re-examines the monetary authority’s choice of inflation in a general equilibrium environment in which the costs and benefits to surprise inflation are modelled explicitly to reflect the underlying preferences, technology, and market structure of the economy. The desire of the monetary authority to raise output above its market clearing level arises due to the existence of monopolistic competition among producers of goods. Blanchard and Kiyotaki (1987) show that the existence of monopoly power  

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3 Following Kydland and Prescott (1977), this paper focusses on a particular equilibrium in which the monetary authority chooses inflation sequentially. The equilibrium solution is time-consistent, but we do not attempt to solve for all the time-consistent equilibria.  
4 Note that the benefits of surprise inflation in this environment differs from that in the public finance
among firms generates an aggregate demand externality that reduces the level of output relative to an environment of perfect competition. The assumption of monopolistic competition, therefore, provides a natural way to model suboptimal full employment in a general equilibrium model. In the standard model of excessive time-consistent inflation, distortions are generally attributed to unemployment insurance, income taxation, or imperfect competition. While these distortions manifest themselves in an undesirably low level of full employment, which the policy authority attempts to surmount through surprise inflation, the precise channel through which the distortion causes output to be inefficiently low remains unexplored.

In addition to the presence of a distortion in the economy, models of excessive discretionary inflation require that there be costs to unanticipated inflation. This is necessary for the existence of a finite level of inflation that solves both the policy authority's maximization problem and is an equilibrium. Persson, Persson, and Svensson (1989) suggest literature in which the focus is on the component of seignorage revenue in the optimal tax structure in the absence of lump sum transfers. See for example Kimbrough (1986), Faig (1988), and Chari, Christiano, and Kehoe (1995).

5See Romer (1993, 1996). Note that an alternative approach would have been to model monopolistic competition in the labor market. See Blanchard and Kiyotaki (1987) for more details on the impact of monopolistic competition in the labor market on output and employment.

6Note that excessive discretionary inflation is anything above that rate that would prevail had the monetary authority the ability to precommit. The use of "excessive" as a description of optimal discretionary inflation in the present context is taken from Kydland and Prescott (1977).

7See for example Barro and Gordon (1983a), Backus and Drifill (1985), Rogoff (1985), and Obstfeld (1994).

8As Friedman (1968) pointed out, the term full employment should not imply that it is "immutable and unchangeable": the full-employment level is influenced by market structure and policy, and as such is often lower than it otherwise might be.

9Chari, Christiano, and Eichenbaum (1996) develop a general equilibrium model similar to the one presented here. The main difference is in the way costs to unexpected inflation enter the model. In the present paper, the costs, as they appear in the monetary authority's objective function, are directly linked to the preferences of the representative agent. In Chari, Christiano, and Eichenbaum, there are no costs to surprise inflation and therefore an upper bound on the monetary growth rate is imposed to characterize the set of sustainable outcomes. Their paper is viewed as complementary to the one
a way to introduce costs to unanticipated inflation in a representative agent framework by altering the timing structure such that agents choose period $t$ nominal money in $t-1$. Therefore, unanticipated inflation erodes the value of period $t$ real balances, directly reducing the welfare of money holders. A staggered timing structure for the acquisition of nominal money is adopted in the present framework, providing a theoretical basis for the typically invoked argument that for political reasons, the existence of menu and shoe-leather costs, and income redistribution, the inclusion of inflation as a cost in the policymaker’s objective function is reasonable.

One of the advantages to modelling the costs and benefits of surprise inflation from micro-foundations is that we can examine the channels through which the monetary authority has an incentive to inflate. In particular, there are three areas in which our model provides additional insights into the sources of inflation.

Firstly, we can identify a more precise relationship between markups and inflation. The distortion introduced by monopolistic competition has two competing effects on the incentive to inflate. For example, if firms have a relatively high degree of monopoly power, equilibrium employment, output and consumption are low, so there is a big incentive on the part of the monetary authority to inflate and raise output and hence consumption. At the same time, however, the equilibrium demand for real balances is also low, making it quite costly to surprise inflate in that such action further reduces current real balances. These counterbalancing effects lead to a nonmonotonic relationship between the discretionary level of inflation and the size of the distortion. This result contrasts with that presented here.
of previous models of excessive discretionary inflation, which find that an increase in the source of the monetary authority's incentive to over-inflate worsens the inflation bias.\textsuperscript{10} In the present model, however, this need not be the case. If the degree of monopoly power among firms is sufficiently large, an increase in the degree of competition among firms and hence a reduction in the source of the monetary authority's incentive to inflate will lead to a higher discretionary rate of inflation, since the cost of surprise inflation has been correspondingly reduced.

Secondly, we are able to show that the discretionary level of inflation is increasing in the labor share of national income. An increase in the labor share of national income increases the elasticity of output with respect to labor, thereby raising the benefit to surprise inflation and hence the discretionary rate of inflation.

Thirdly, the model shows that the discretionary level of inflation is negatively related to the underlying real interest rate. As a consequence, nominal interest rates do not reflect changes in inflation one-for-one in response to changes in the real interest rate. An observer might then conclude that inflation affects the real interest rate, in violation of the Fisher effect, although the causation is actually reversed.

Finally, the model presented here provides a unified, general equilibrium framework that ties the optimal quantity of money result, as given by the Friedman (1969) rule, to that of optimal inflation under discretion, as given by Barro-Gordon-type models. The model indicates which qualities are necessary for an economy to possess in order that optimal monetary policy be characterized by excessive inflation: if the monetary

\textsuperscript{10}See Barro and Gordon (1983a).
authority lacks precommitment capabilities, if nominal wages are sticky, or if firms are
not perfectly competitive, then the optimal level of discretionary inflation is greater than
the Friedman rule.

The chapter is organized as follows: Section 2.2 lays out the details of the model;
Section 2.3 analyzes the flexible wage equilibrium; the sticky wage equilibrium, the mon­
etary authority’s choice problem, and the effects of the parameters of the economy on
the inflation bias are examined in Section 2.4; Section 2.5 concludes. Section 2.6 gives
an appendix detailing the derivation of the monetary authority’s objective function.

2.2 The Model

This section describes the setup of the model. Goods are produced by monopolistically
competitive firms that face a fixed nominal wage. Leisure and money enter the util­
ity function directly. Following Kydland and Prescott (1977), and Barro and Gordon
(1983a), the monetary authority is assumed to have no precommitment capabilities. It
maximizes a social welfare function that coincides with the utility function of the repre­
sentative agent by choosing the price level, taking expectations, the nominal wage, and
nominal money holdings in the current period as given. In this framework, surprise in­
flation has real effects in the short run. Consequently, the monetary authority sees itself
as able to raise employment and output above its market clearing level through surprise
inflation, by eroding the real value of the fixed nominal wage at a cost of reduced cur­
rent real balances. Wage setters understand this and set a higher nominal wage ex ante
to reflect this incentive. Equilibrium obtains when the monetary authority, taking the
expected rate of inflation as given, optimally chooses to set the actual rate of inflation
equal to the expected rate of inflation.

The economy is inhabited by a unit measure of infinitely lived representative agents
that derive utility from a composite consumption good, leisure, and real balances. Agents
can supply at most one unit of labor. There is a unit measure of firms, each of which has
a degree of monopoly power over its good. A monetary authority provides agents with
nominal money. Firm profits and government seignorage are then transferred back lump
sum to the agent. We now turn to the details of the model.

2.2.1 Households

The representative agent maximizes

$$\max_{C_t, l_t, M_t+1} \sum_{t=0}^{\infty} \beta^t \left[ \ln C_t + \eta \ln (1 - l_t) + \frac{\gamma}{1 - \epsilon} \left( \frac{M_t}{P_t} \right)^{1 - \epsilon} \right],$$

(1)

where it is assumed that $\epsilon, \eta > 1$, and $0 < \beta < 1$.\textsuperscript{11} $C_t$ is a composite consumption
good, $l_t$ denotes employment and is restricted to lie in the interval $(0, 1)$, and $M_t$ denotes
nominal money holdings. The composite consumption good, $C_t$, is defined as

$$C_t = \left[ \int_0^1 c(i)^{\rho} di \right]^{\frac{1}{\rho}},$$

(2)

\textsuperscript{11} $\gamma$ is a free parameter that is assumed to be equal to $(\xi \times \sigma)$, where $\sigma = (\frac{1}{\epsilon})^{1 - \epsilon}$. The parameter
$\sigma$ acts as a scaling device such that changes in productivity (given by the parameter $A$ found in the
representative firm's production function) have no effect on the discretionary level of inflation. The
assumption of $\epsilon > 1$ guarantees that the solution to the monetary authority's choice problem given by
equation (26) is always a global maximum.
where \( c(i) \) is the consumption of good \( i \) within a continuum of differentiated consumption goods and \( \frac{1}{1-\rho} \) is the elasticity of substitution between any two varieties of consumption goods. The parameter \( \rho \) is restricted to lie in the interval \((0, 1)\) so as to ensure that a monopolist cannot charge an infinite price. Given the above consumption bundle, the price index is defined as
\[
P_t = \left[ \int_0^1 p(i)^{\frac{-\rho}{1-\rho}} \, di \right]^{\frac{1}{\rho}}. \tag{3}
\]
The agent maximizes lifetime utility subject to the following series of budget constraints
\[
P_tC_t + M_{t+1} + B_{t+1} = w_t l_t + M_t + \tau_t + \theta_t + R_t B_t, \quad t = 0, 1, ..., \infty \tag{4}
\]
where \( M_t \) is chosen in time \( t - 1 \) and \( M_0 > 0 \) is given. An implication of the timing structure for nominal money acquisition is that unanticipated inflation is costly. This is a key assumption for the results in Section 4 to hold.

\( B_t \) is the period \( t \) holdings of 1 period nominal domestic bonds which pay off nominal interest rate \( R_t \). \( B_0 = 0 \) is taken as given. In equilibrium, a zero net asset position is imposed, since there is no borrowing or lending in the model.\(^\text{12}\) \( \tau_t \) denotes lump sum transfers paid to the representative agent by the monetary authority, and \( \theta_t \) denotes the profit of all firms. The representative agent takes government transfers and firm profits as given when making its optimal consumption, leisure, and money demand choices.

\(^{12}\)Since Ricardian Equivalence holds in this model, the absence of government debt is irrelevant.
2.2.2 Monetary Authority

The monetary authority’s budget constraint is

\[ M_{t+1} - M_t = \tau_t. \]  

(5)

The monetary authority chooses \( M_{t+1} \) in time \( t \). Equilibrium in the money market then determines \( P_t \).\(^{13}\)

2.2.3 Firms

There is a continuum of individual, monopolistically competitive firms, indexed \( i \in [0, 1] \), each of which produces a single good.\(^{14}\) Given the agents’ preferences, each firm \( i \) faces a downward sloping demand schedule for its good

\[ y(i) = C \left( \frac{p(i)}{P} \right)^{\frac{1}{1-\rho}}. \]  

(6)

It is assumed that the number of firms is large enough so that the price level and the composite consumption good are taken as given by the \( i \)th firm. Goods are produced according to a decreasing returns to scale production technology

\[ y(i) = Al(i)^{\alpha}, \quad 0 < \alpha < 1 \]  

(7)

where \( A \) is a productivity parameter and \( \alpha \) is the share of labor in national income. Each firm \( i \) solves the following profit maximization problem

\[ \max_{l(i)} p(i)y(i) - w\ l(i), \]  

(8)

\(^{13}\)The monetary authority sets the supply of money, which in turn determines the price level. For exposition purposes, however, it is easier to proceed as if the monetary authority were choosing the current inflation rate, denoted \( \pi = \frac{P_t - P_{t-1}}{P_{t-1}} \), directly.

\(^{14}\)The way in which monopolistic competition is introduced here is taken directly from Farmer (1993).
taking into account the demand for its good and its production technology. The labor demand condition for firm \( i \) is therefore

\[
\alpha \rho A \ell(i) = \frac{w}{p(i)}.
\]

(9)

### 2.3 Equilibrium Under Flexible Wages

We now describe the production and consumption decisions of firms and the representative household, respectively. We begin with the assumption of flexible wages and introduce nominal wage stickiness later on. The first order conditions for the representative agent's maximization problem are:

\[
P_{t+1}C_{t+1} = \beta R_{t+1}P_tC_t
\]

(10)

\[
\frac{\eta C_t}{1 - l_t} = \frac{w_t}{P_t}
\]

(11)

\[
\frac{M_{t+1}}{P_t} = \left( \frac{P_t}{P_{t+1}} \right)^{\frac{\epsilon - \delta}{\epsilon}} \left( \frac{\gamma \beta C_t}{1 - \frac{1}{R_{t+1}}} \right)^{\frac{1}{\epsilon}}
\]

(12)

Equation (10) is the standard Euler equation linking present and future consumption. This condition states that the individual must be indifferent between consuming an additional unit of output in time \( t \), and saving it at a gross return of \( R_{t+1} \) to be used for consumption in time \( t + 1 \). The second equation is an implicit labor supply condition. The agent supplies labor such that he is just indifferent between consuming one more unit of leisure in time \( t \) and supplying an additional unit of labor whose earnings can then be used for period \( t \) consumption. The third expression is a money demand equation. The agent faces a tradeoff between devoting an additional unit of output to acquiring \( M_{t+1} \).
versus immediate consumption. The money demand equation states that the agent must be just indifferent between the two alternatives. An additional unit of $M_{t+1}$ will affect the utility function directly as well as relax the $t + 1$ budget constraint, allowing for higher period $t + 1$ consumption. These effects are discounted back to period $t$. The staggered timing structure changes the relationship slightly in that the tradeoff is between period $t$ consumption and period $t + 1$ demand for nominal money balances. The money demand equation satisfies the standard properties in that it is decreasing in the nominal interest rate and increasing in consumption.

Equation (9) at the end of the last section indicates the optimal labor demand choice for firms. This choice determines the output of firm $i$ and, in turn, the price of good $i$. Since firms are assumed to be identical, we focus on a symmetric equilibrium. This implies that employment, output, and prices will be the same across firms. The optimality condition for firms therefore becomes

$$\rho \alpha A_l^{p-1} = \frac{w_i}{P_t},$$

where $\frac{1}{\rho}$ is interpreted as the markup of price over marginal cost, and reflects a firm's degree of monopoly power.

In equilibrium, the following market clearing condition and government budget constraint must be satisfied:

$$C_t = y_t,$$  \hspace{1cm} (14)

$$M_{t+1} = M_t + \tau_t.$$  \hspace{1cm} (15)

20
Furthermore, assume that money growth is constant such that $\tau_t = \mu M_t$.\(^{15}\) Combining these conditions with equations (10, 11, 12, and 13) yields equilibrium employment, consumption, and money demand:

\[
\bar{l} = \frac{\alpha \rho}{\eta + \alpha \rho},
\]

\[
C_t = A(\bar{l})^\alpha,
\]

\[
\frac{M_{t+1}}{P_t} = (1 + \mu) \left( \frac{\beta \gamma A(\bar{l})^\alpha}{1 + \mu - \beta} \right)^t.
\]

The market clearing level of employment, denoted $\bar{l}$, is less than the socially efficient level of $\frac{\alpha}{\eta + \alpha}$ that would prevail if firms were perfectly competitive. It is due to this inefficiency that the monetary authority will have an incentive to over inflate in the sticky wage environment. In the case of flexible wages, however, the monetary authority cannot affect output, which will remain at its market clearing level, regardless of its choice of inflation. Therefore the optimal choice of the monetary authority will be to set inflation according to the Friedman rule (e.g. $\pi = \beta - 1$).\(^{16}\)

### 2.4 Equilibrium Under Sticky Wages

Now assume that nominal wages are set at the beginning of each period, before the current price level is known. Given the expected price, the nominal wage is set so as to clear the labor market. Therefore, the agent sets the nominal wage such that the expected real wage is equal to the marginal productivity of labor at the market clearing

\(^{15}\)In the discretionary equilibrium examined below, this will always be the case.

\(^{16}\)This will be discussed more fully in Section 4.2.
level of employment, $\bar{l}$, times the inverse of the markup

$$\bar{w}_t = P^e_t \alpha \rho A(\bar{l})^{\alpha-1},$$

(19)

where $P^e_t$ denotes the expected price. The above may be rewritten in the following way,

$$\frac{\bar{w}_t}{P_t} = \left(\frac{1 + \pi^e}{1 + \pi}\right) \alpha \rho A(\bar{l})^{\alpha-1},$$

(20)

where $\pi^e = \frac{P^e_t - P_{t-1}}{P_{t-1}}$. This formulation illustrates that by setting the current price level above the expected price level (and therefore current inflation above expected inflation), the monetary authority succeeds in eroding the real wage of the agent. Ex post employment is then determined by firms, who choose employment along their labor demand curve. Employment is then given by

$$l_t = \left(\frac{1 + \pi}{1 + \pi^e}\right)^{1-\alpha} \bar{l}.$$  

(21)

Goods market clearing yields the equilibrium level of consumption

$$C_t = \left(\frac{1 + \pi}{1 + \pi^e}\right)^{1-\alpha} \bar{y},$$

(22)

where

$$\bar{y} = A(\bar{l})^\alpha.$$  

(23)

Notice that when $\pi = \pi^e$ equilibrium labor and consumption found here correspond to those found under the assumption of flexible wages. If $\pi > \pi^e$, however, surprise inflation raises employment and hence output and consumption by reducing the real wage.

The nominal interest rate can be found by combining the Euler equation and the equilibrium level of consumption, taking into account that from time $t + 1$ onwards it is
taken as given that future inflation, employment, and consumption are determined in a Nash equilibrium of the future stage game. Therefore,

\[ R_{t+1} = (1 + \mu) \frac{1}{\beta} \left( \frac{1 + \pi}{1 + \pi^c} \right)^{\frac{\alpha}{1 - \alpha}}, \]

(24)

where \( \mu = \frac{P_{t+1} - P_t}{P_t} \) now denotes the future discretionary rate of inflation. With surprise inflation, the real interest rate as well as the nominal interest rate must fall (see Figure 1) so as to induce the agent to consume all the extra output produced within the period that the surprise inflation occurred.

Finally, the solution to consumption, labor, and nominal interest rates yield equilibrium real balances, which are given by

\[ \frac{M_{t+1}}{P_t} = (1 + \mu) \left( \frac{\beta \gamma A \left( \frac{1 + \pi}{1 + \pi^c} \right)^{\frac{\alpha}{1 - \alpha}} \tau^c}{1 + \mu - \beta \left( \frac{1 + \pi}{1 + \pi^c} \right)^{\frac{\alpha}{1 - \alpha}}} \right)^{\frac{1}{\gamma}}. \]

(25)

This equation will pin down the supply of \( M_{t+1} \) given the monetary authority's choice of inflation. We now turn to this choice.

### 2.4.1 The Monetary Authority's Choice Problem Under Sticky Wages

Following Kydland and Prescott (1977) and Barro and Gordon (1983a), the monetary authority is assumed to lack precommitment capabilities. It chooses \( \pi^c \), given \( \pi^e \), the nominal wage, and period \( t \) nominal money, to maximize an objective function that conforms with the representative agent's preferences, taking as given that the future rate of inflation, employment, and output will be determined in a Nash equilibrium of the future
stage game.\textsuperscript{17} Since all periods are alike, and because there is no physical state variable to link periods, the future level of discretionary inflation is perfectly anticipated and constant regardless of the present choice of inflation. Therefore, the objective function reduces to a one period problem of selecting the current rate of inflation to maximize the period \( t \) sub-utility function. An explicit derivation of the monetary authority's objective function is given in the appendix (see Section 2.6). The monetary authority solves the following problem:

\[
\max_{\pi} \ln \left[ \left( \frac{1 + \pi}{1 + \pi^e} \right)^{1 - \alpha} \bar{y} \right] + \eta \ln \left[ 1 - \left( \frac{1 + \pi}{1 + \pi^e} \right)^{1 - \alpha} \right] \\
+ \frac{\gamma}{1 - \epsilon} \left( \frac{M_t \alpha \rho A c^{\alpha-1}}{\bar{w}_t} \right)^{1 - \epsilon} \left( \frac{1 + \pi^e}{1 + \pi} \right)^{1 - \epsilon} \\
+ \frac{\beta}{1 - \beta} \ln \bar{y} + \eta \ln \left( 1 - \bar{L} \right) + \frac{\gamma}{1 - \epsilon} \left( \frac{\beta \gamma \bar{y}}{1 + \mu - \beta} \right)^{1 - \epsilon}. \tag{26}
\]

The above objective function illustrates how the staggered timing structure for the acquisition of nominal money introduces a cost to unanticipated inflation: for a given \( \bar{M}_t \), the higher \( \bar{w}_t \) the more costly it becomes for the monetary authority to raise \( \pi \) above \( \pi^e \). Since \( \bar{w}_t \) is monotonically related to \( \pi^e \) (i.e. see equation (20)), the cost of inflation surprises are higher the higher the average rate of inflation. Note that the timing structure is such that the choice of \( \bar{M}_t \) is prior to the choice of \( \bar{w}_t \) since \( M_t \) is chosen in \( t - 1 \) and \( \bar{w}_t \) is chosen at the beginning of time \( t \), before the monetary authority has chosen \( \pi \). If this were not the case, then there would be no costs to unanticipated inflation, and thus no finite rate of inflation that solves both the monetary authority’s maximization

\textsuperscript{17}Note that by imposing this equilibrium concept we have ruled out non-stationary strategies. Unlike recent work by Chang (1996), in which methods are employed to characterize the set of all time-consistent outcomes, the focus here is on a stationary, non-cooperative equilibrium.
problem and is an equilibrium. Costly unanticipated inflation will ultimately curb the monetary authority's desire to continue raising $\pi$ above $\pi^e$ in an attempt to raise output. In the standard Barro-Gordon-type model, this is accomplished by defining the monetary authority's loss function to be quadratic in inflation.

The solution to the above maximization problem yields the following government reaction function

$$0 = \frac{\alpha}{1 - \alpha} - \left[ \frac{l_t}{1 - l_t} \left( \frac{\eta}{1 - \alpha} \right) \right] - \gamma \left[ \frac{\beta \gamma \bar{y}}{1 + \mu - \beta} \right] \frac{1 - \epsilon}{\epsilon} \left(1 + \mu\right)^{1 - \epsilon}, \quad (27)$$

where the following has been substituted into the first order condition:

$$\bar{w}_t = P_t \left( 1 + \frac{\pi^e}{1 + \pi} \right) \frac{\alpha p \bar{y}}{l}, \quad (28)$$

$$\frac{M_t}{P_t} = \left( 1 + \mu \right) \left( 1 + \frac{\beta \gamma \bar{y}}{1 + \mu - \beta} \right)^{1/2}, \quad (29)$$

and $l_t$ is given by equation (21). Before analyzing the reaction function in greater detail, we turn to the rational expectations equilibrium.

### 2.4.2 Rational Expectations Equilibrium

At the start of period $t$, the representative agent forms $\pi^e$ taking into account the anticipated action of the monetary authority. The policymaker then chooses $\pi$, given a fixed value of $\pi^e$. Since the private agent understands the incentives of the monetary authority when formulating $\pi^e$, equilibrium will obtain when $\pi^e$ is sufficiently high so that $\pi = \pi^e$ is the monetary authority's best choice given the value of $\pi^e$. To find the fixed point, set $\pi = \pi^e = \mu$. This yields a level of discretionary inflation that is a stationary, Nash
equilibrium. The equilibrium discretionary rate of inflation, denoted $\pi^d$, is given by

$$\pi^d = \frac{1}{\beta - 1} + \frac{2}{\alpha (1 - \rho)} \left( \frac{\beta}{\xi (1 - \alpha)} \right) \beta \xi \tilde{y},$$

where,

$$\tilde{y} = (\bar{I})^\alpha$$

There are two components that make up $\pi^d$. The first component is Friedman's rule for optimal inflation, whereby the cost of holding money across periods is eliminated by setting the inflation rate equal to the negative of the real interest rate. If the monetary authority had precommitment capabilities, nominal wages were flexible (as in the preceding section), or markets were perfectly competitive, then the discretionary level of inflation would be set according to the Friedman rule. Output and employment would be at their market clearing levels, and the marginal utility of real balances would equal zero.

The second component of $\pi^d$ is interpreted as the inflation bias. Due to the presence of monopolistic competition (e.g. $0 < \rho < 1$) in an environment of sticky wages and no commitment on the part of the monetary authority, $\pi^d$ will not be set according to the Friedman rule, rather it will be biased upwards, as this last expression in $\pi^d$ is always positive. The size of the inflation bias depends on the parameters of the model. The effect of these parameters on the discretionary rate of inflation is discussed in the next section.

To facilitate interpretation, the first order condition of the monetary authority's max-
imization problem when \( \pi = \pi^e \) may be rewritten in the following way:

\[
\frac{\alpha}{1 - \alpha} = \frac{\alpha \rho}{1 - \alpha} + \xi \left[ 1 + \frac{\pi^d - \beta}{\beta \xi \bar{y}} \right]^{\frac{\epsilon - 1}{\epsilon}}. \tag{32}
\]

The expression on the left hand side of equation (32) is the marginal benefit, in utility terms, of inflation through its effect on output. In a Nash equilibrium, where \( \pi = \pi^e \), this expression is constant reflecting the fact that in equilibrium inflation has no effect on output. The first term on the right hand side is the marginal cost, in utility terms, of inflation through its effect on leisure. It is also constant when \( \pi = \pi^e \), indicating that inflation has no effect on leisure in equilibrium either. Notice that if firms were perfectly competitive (e.g. \( \rho = 1 \)) then the benefit to inflating is exactly offset by the cost of inflating through its effect on leisure, and hence the monetary authority would set the inflation rate according to the Friedman rule.\(^{18}\) As Rogoff (1985) points out, if there is no reason for the monetary authority to systematically over-inflate, then discretionary monetary policy is at its optimal precommitment level. In the present framework, the source of systematic over-inflation is due to the presence of monopolistic competition in the goods market. If \( 0 < \rho < 1 \) then the benefit to inflation outweighs the cost through its effect on leisure and the monetary authority has an incentive to raise inflation above the Friedman rule level, so that the marginal cost of inflation through its effect on real balances is positive. This is reflected in the last expression of the above equation. It is a function of inflation indicating that, in equilibrium, a higher level of discretionary inflation raises the marginal cost of inflating.

\(^{18}\)The parameter restriction \( \epsilon > 1 \) ensures that in equilibrium the marginal cost to inflating is increasing in the discretionary level of inflation.
2.4.3 Determinants of Discretionary Inflation

This section looks at the effect of underlying parameters in the economy on the discretionary rate of inflation, and in particular, on the inflation bias.

Consider the effect of the distortion introduced by monopolistic competition on the discretionary rate of inflation. Recall that the distortion is given by the parameter \( \rho \), which may be interpreted as the inverse of the markup. If \( \rho \) is close to 1, then firms do not have much monopoly power. Goods are close substitutes, leading to greater competition, and hence output, among firms. The distortion, therefore, is said to be low. On the other hand, if \( \rho \) is close to 0, firms have a relatively large degree of monopoly power, goods are not highly substitutable in consumption, and competition and output are correspondingly low. A change in the size of the distortion in the economy has two competing effects on the equilibrium rate of inflation. The first effect is referred to as the leisure effect. For example, an increase in the size of the distortion causes the marginal cost of inflation in utility terms, through its effect on leisure, to fall. Alternatively, we can think of an increase in the size of the distortion as an increase in the source of the monetary authority's incentive to systematically over-inflate, causing the discretionary level of inflation to increase further above the Friedman rule level. This effect dominates when the distortion is relatively low.

The second effect is interpreted as the real balances effect. The marginal cost of inflation, through its effect on real balances, is decreasing and convex in real balances. This means that the lower are real balances, the higher the cost of inflation through
its effect on real balances. As the distortion increases, the market clearing level of employment falls and, for a given rate of inflation, the equilibrium demand for real balances falls as well. The monetary authority will reduce the discretionary rate of inflation accordingly to reflect and offset this increased marginal cost. Thus, an increase in the distortion, by reducing money demand, will lead to a lower inflation rate through the real balances effect. This effect dominates when the distortion is relatively large.

Which of the two effects on the discretionary level of inflation dominates will depend on the relative size of the distortion. The relationship between the discretionary level of inflation and the size of the distortion is illustrated in Figure 2. The effect of the distortion on equilibrium real balances generates the result of nonmonotonicity between discretionary inflation and the distortion in the present framework. This finding contrasts with that found in Barro and Gordon (1983a). In their paper, as the distortion increases, so does inflation. This is because there are no counter-balancing effects of the distortion. Only the benefit to inflation is a function of the distortion, and so an increase in the benefit always leads to an increase in the discretionary level of inflation. If we ignore the real balances effect and focus on the leisure effect, we can generate the standard result that an increase in the source of the monetary authority's incentive to inflate raises the discretionary level of inflation. This is illustrated in Figure 3. In general, however, we have shown that both the costs and the benefits to surprise inflation are affected by the distortion.

Parameter values used to generate Figure 2 are the following: \( \beta = 0.9, \eta = 2.1, \epsilon = 4, A = 1, \xi = 0.01, \) and \( \alpha = 0.5. \) For a level of \( \rho = 0.8, \) this yields a level of \( \pi^d = 9.54\%. \)
The parameter $\alpha$ measures the share of labor in income. The effect of a change in $\alpha$ works through the marginal gain of inflation, in utility terms, through its effect on output, as well as the marginal cost of inflation through its effect on leisure and real balances. As $\alpha$ increases, a given increase in $P_t$ over $P^*_t$ raises output by more since output has become more elastic with respect to labor. This can be interpreted as an increase in the benefit to surprise inflation. At the same time, an increase in $\alpha$ raises the equilibrium demand for real balances, thereby reducing the costs of inflating. In addition, an increase in $\alpha$ raises the marginal cost to inflating through its effect on leisure. But this latter effect is dominated by the change in output due to the distortion, so that on the whole, inflation will rise with an increase in the labor share of income.

The discount factor in this economy is equal to the inverse of one plus the real interest rate. A rise in the real interest rate, or equivalently a fall in the discount factor, reduces the discretionary rate of inflation. This occurs for two reasons. Firstly, the Friedman rule portion of discretionary inflation (given by equation (30)) falls. Secondly, a rise in the real interest rate reduces the equilibrium value of real balances at any nominal interest rate (see the right hand side of equation (18)). This latter effect raises the marginal cost of surprise inflation, thus further reducing the discretionary level of inflation. Overall, therefore, inflation is negatively related to the real interest rate. This raises an interesting question of inference from observations of inflation. The fact that changes in the real interest rate affect the discretionary rate of inflation might lead an observer to conclude that the Fisher equation, which asserts that changes in the inflation rate do not affect
the real interest rate and are therefore reflected one for one in the nominal interest rate, has been violated. In the present context, however, the causation runs the other way: a change in the real interest rate effects the monetary authority’s incentives and hence the optimal level of discretionary inflation.

Other affects of underlying parameters of the economy on the discretionary rate of inflation include the parameter $\xi$, which reflects the agent’s preference for real balances relative to consumption and leisure. It may be interpreted as the utility cost of inflation. If $\xi$ is small, then inflation is not very costly. As in Barro and Gordon (1983a), if inflation is not very costly then the inflation bias is large. Even though a decrease in $\xi$ reduces the demand for real balances, this is more than offset by the direct effect, which reduces the impact of a change in real balances on utility, thereby making it less costly to inflate.

The parameter $\eta$ represents the intensity of the representative agent’s preference for leisure relative to consumption and real balances. The larger $\eta$, the more costly in utility terms it becomes to raise labor above its market clearing level. Therefore, the monetary authority has less of an incentive to inflate and $\pi_d^d < 0$. Finally, the smaller the consumption elasticity of money demand (denoted by the inverse of the parameter $c$), the lower discretionary inflation ($\pi_d^c < 0$).

2.5 Conclusion

This chapter has extended the celebrated Barro and Gordon (1983a) model of discretionary inflation to a general equilibrium framework in which preferences, technology,
and market structure are modelled explicitly. The key difference between this approach and that of Barro-Gordon-type models is that both the costs and benefits of surprise inflation are related to these underlying features of the economy. We show that the absence of a commitment technology on the part of the monetary authority, coupled with a nominal rigidity and a distortion arising from monopolistic competition in the economy, leads the monetary authority to set inflation above the Friedman rule optimum rate. The main determinants of the size of the inflation bias are the degree of monopoly power among firms, the share of labor in national income, and the real interest rate. An important finding of this analysis is that the discretionary rate of inflation is non-monotonically related to the source of the monetary authority’s incentive to inflate, reflected in the relative size of the price markup distortion.
2.6 Appendix

In this section we derive the monetary authority’s objective function under sticky wages as described in section 4.1. Recall that in the text, it was noted that the monetary authority is assumed to be a benevolent social planner, and as such has preferences that correspond to that of the representative agent. When choosing the rate of inflation, the monetary authority takes into account that consumption is determined according to equation (22), employment according to equation (21), and period t nominal money and the nominal wage are taken as given at the outset. All that remains to be shown, then, is the agent’s choice of future real balances $\frac{M_{t+i}}{P_{t+i}}$, $i = 0, 1, ..., \infty$.

Recall from equation (18) that, in a rational expectations equilibrium with constant money growth $\mu$, $M_{t+1}$ is given by

$$M_{t+1} = \phi P_t,$$

where

$$\phi = (1 + \mu) \left( \frac{\beta \gamma y}{1 + \mu - \beta} \right)^{\frac{1}{2}}.$$

If it is taken as given that period $t + 2$ will be characterized by a Nash equilibrium, then

$$M_{t+2} = \phi P_{t+1}$$

as well. Now, the Nash equilibria of all future period’s are identical due to the lack of a state variable tying periods together. Therefore, $\mu$ denotes not only next period’s discretionary rate of inflation, but all future discretionary rates. We can therefore divide and multiply $M_{t+2}$ by $M_{t+1}$ and use the fact that in a rational expectations equilibrium
$M_{t+1+i}$ and $P_{t+i}, \ i = 0, 1, \ldots, \infty$ grow at the same rate so that \( \frac{M_{t+2}}{M_{t+1}} = 1 + \mu \). Rearranging we find

\[
\frac{M_{t+1}}{P_{t+1}} = \frac{\phi}{1 + \mu},
\]

which is out of the control of the period $t$ monetary authority, since neither $\mu$ nor $\phi$ depend on $\pi$. The implication is that the period $t$ monetary authority may take $t + 1 + i, \ i = 0, 1, \ldots, \infty$ real balances as given. In addition, future employment and future consumption will be given by $\bar{l}$ and $\bar{y}$, respectively. Using all of the above in the representative agent's utility function yields the monetary authority's objective function as given by equation (26) in the text.
3 Chapter 3: Discretionary Inflation in an Open Economy General Equilibrium Model

3.1 Introduction

Recent work by Romer (1993) and Lane (1995) provides evidence that a country’s openness to trade reduces the monetary authority’s incentive to inflate and so reduces the discretionary level of inflation. Romer (1993) addresses the issue of openness and inflation within a static Barro and Gordon (1983a) framework. He argues that the underlying explanation for the empirical finding that openness and inflation are negatively correlated is that surprise inflation causes a deterioration in a large open economy’s terms of trade, reducing the monetary authority’s incentive to inflate, and so leading to a reduction in the discretionary level of inflation in open relative to closed economies. Openness therefore provides an additional cost to inflation above and beyond the typically assumed costs of income redistribution, menu costs and the like that warrant the inclusion of inflation as a cost in the policy maker’s objective function. A more recent paper by Lane (1995) argues that more open economies have, by definition, smaller monopolistically competitive non-traded goods sectors. The lack of perfect competition in the non-traded goods sector provides the monetary authority with an incentive to raise inflation in an effort to boost output in that sector. Therefore, the smaller the relative size of the nontraded goods sector, that is to say, the more open an economy, the less of an incentive the monetary authority has to inflate. Lane argues that this fact may account for the observed negative
relationship between openness and inflation, even for countries too small to affect their terms of trade.

This chapter re-evaluates the effect of openness on the time consistent rate of discretionary inflation in a simple general equilibrium, small open economy model in which the costs and benefits to inflation are modelled explicitly. Openness is defined as the ability to trade intertemporally in a homogeneous good with the rest of the world. This structure abstracts from any possible effects on the terms of trade in response to inflation. A monopolistically competitive non-traded goods sector, the size of which is assumed to be fixed, provides the monetary authority with an incentive to raise output above its full employment level.\(^{20}\) Such action is costly in that it erodes real balances, which appear in the agent’s objective function, given the staggered timing structure for the acquisition of nominal money.\(^{21}\)

A result of the model is that openness affects the monetary authority’s incentive to inflate through a number of channels, each of which may be isolated. These effects fall into two broad classes, which we refer to as a fundamentals effect and a strategic effect. First, if we focus on the effect of fundamentals on inflation, we do not find that discretionary inflation in an open economy is always lower than that of a comparable closed economy. The source of ambiguity stems from the fact that openness provides conflicting effects on the monetary authority’s incentive to inflate. On the one hand, surprise inflation today has the effect of raising consumption in all future periods due to


the agent's desire to smooth consumption over time. This is accomplished by increased foreign lending. The resulting income effect imposes an additional cost of inflation not present in the closed economy version of the model in that agents will choose to increase their future consumption of leisure accordingly, thereby reducing future domestic output, consumption, and money demand. On the other hand, the direct effect of inflation on raising future consumption leads to a higher demand for real balances, which increases the utility of the agent. Which of these two effects dominates will depend on the underlying structure of the economy. In particular, countries in which the consumption elasticity of money demand is small, or in which firms have a relatively large degree of monopoly power will find that a move to openness reduces the fundamentals portion of the discretionary rate of inflation.

Secondly, the model illustrates how changes in the state of the economy, represented by changes in a country's foreign asset position, affect the monetary authority's incentives and hence the discretionary level of inflation when evaluated at an initial position of zero foreign asset holdings. An increase in the level of foreign indebtedness has two competing effects on the fundamentals portion of discretionary inflation. Hence it will not necessarily be the case that as a country increases its foreign borrowing that inflationary expectations are expected to rise. This is because although the benefits of unanticipated inflation are high in such an environment, the corresponding costs are as well since heavy borrowing means holdings of real balances will be relatively small. Therefore, unanticipated inflation may be too costly since its effect is to further reduce current real balances.
Finally, numerical techniques are employed to analyze the strategic effect on the discretionary rate of inflation. We find that for a set of parameter values, multiple solutions for the open economy discretionary rate of inflation can be found, each of which may be higher or lower than the corresponding discretionary rate of inflation for a closed economy. Therefore, this model cannot replicate the Romer (1993) and Lane (1995) finding that openness reduces the discretionary rate of inflation relative to a closed economy, as this will depend on the overall effect of openness, operating through a number of channels, on the monetary authority's incentives.

3.2 The Model

Consider a two-sector small open economy model. The nontraded, intermediate goods sector is assumed to be monopolistically competitive and faces a fixed nominal wage for its labor input. The traded, final goods sector is perfectly competitive and uses monopolistically competitive goods as inputs in production. The economy is inhabited by a group of infinitely lived agents who set the nominal wage at the beginning of each period such that it clears the labor market in an expected sense. In an environment of no commitment, the monetary authority sees itself as able to fool agents for their own good through surprise inflation, which reduces the real wage, thereby prompting the intermediate goods sector to hire more labor and expand output. It is assumed that agents understand the incentives of the monetary authority, and set the nominal wage.

Note that throughout this chapter, the monetary authority is actually choosing $M_{t+1}$, which in turn determines $P_t$. We can therefore think of the monetary authority as choosing $P_t$ directly. This choice is rewritten in terms of the rate of inflation, which is denoted $\pi_t = \frac{P_t - P_{t-1}}{P_{t-1}}$, where $P_{t-1}$ is given.
wage higher ex ante. This process continues until the best response for the monetary authority is to set actual inflation equal to expected inflation. In a rational expectations equilibrium, whereby inflation is predicted correctly, output remains at its competitive, market clearing level, but inflation is higher than it would have been had the monetary authority been able to commit to a level of inflation at the outset. Thus, the model captures the essence of the time consistency problem within the context of a general equilibrium model. We now turn to the specifics of the model.

3.2.1 Firms

Final Goods Sector:

The final goods sector serves as an aggregator function for the intermediate, monopolistically competitive goods sector. Intertemporal trade between the domestic and foreign economy takes place only in the final good. The assumption of perfect competition in the export sector allows us to abstract from modelling the rest of the world in any great detail.

The final goods sector is subject to a constant returns to scale technology and has the following production function:

\[ y_t = \left[ \int_0^1 y_t^\lambda d\lambda \right]^{\frac{1}{\lambda}}. \]  \hspace{1cm} (33)

The production of final goods requires intermediate goods, denoted \( y_{it} \), as inputs, which are assumed to enter the production function symmetrically. In order to ensure sub-

\(^{23}\)The structure of monopolistic competition adopted here is taken from Farmer (1993). See also Krugman and Helpman (1985) for more details on modelling monopolistic competition in this way.

\(^{24}\)See Dixon (1994) for more details.
stitution between intermediate inputs is less than perfect, ϱ is restricted to lie in the interval (0, 1). The elasticity of substitution in production, given by \( \frac{1}{1-\lambda} \), is assumed to be the same across all intermediate inputs. If ϱ is close to 1, then intermediate goods are highly substitutable in production of the final good, and intermediate firms have very little monopoly power.

The final goods sector solves the following maximization problem

\[
\max_{y_{it}} P_t y_t - \int_0^1 p_i y_{it} di, \tag{34}
\]

subject to its production function given by Eq. (33). The solution to this problem yields an inverse demand function for each intermediate input \( i \):

\[
p_{it} = \left[ \frac{y_t}{y_{it}} \right]^{1-\lambda} P_t. \tag{35}
\]

Intermediate Goods Sector:

There is a continuum of individual, monopolistically competitive firms in the intermediate goods sector, indexed \( i \in (0, 1) \). Each firm \( i \) faces an inverse demand function for its good as given by Eq. (35) and is assumed to operate under decreasing returns to labor with a production technology given by: \( 25 \)

\[
y_{it} = (l_{it})^v, \quad 0 < v < 1. \tag{36}
\]

Firm \( i \) maximizes profits subject to its production function and the demand for its good:

\[
\zeta_{it} = \max_{l_{it}} \left( P_t \left( \frac{y_{it}}{y_t} \right)^{\lambda-1} y_{it} - w_l l_{it} \right). \tag{37}
\]

\( ^{25} \)The assumption of decreasing returns to scale ensures that firms will move down their labor demand curve in the face of surprise inflation in an environment of sticky wages.
Each firm $i$ therefore chooses labor according to

$$\lambda v(l_{it})^{v-1} = \frac{\omega_t}{p_{it}}.$$  \hspace{1cm} (38)

The parameter $\lambda$ in Eq. (38) creates a wedge between price and marginal cost: output will be low from a social efficiency standpoint, thereby providing the monetary authority with an incentive to create surprise inflation.

3.2.2 Monetary Authority

The monetary authority’s period budget constraint is

$$M_{t+1} - M_t = r_t.$$ \hspace{1cm} (39)

Only domestic agents are assumed to hold domestic money. Seignorage revenues are transferred back to agents in the form of a lump sum transfer. However, due to the staggered timing structure adopted in the present framework, these transfer payments cannot be accessed in period $t$ to alter the agent’s choice of period $t$ nominal money. This means that period $t$ real balances will be eroded as a consequence of inflation, thereby making surprise inflation costly ex post.

3.2.3 Households

The representative agent is assumed to have an infinite horizon utility function that depends on consumption of the final good, leisure, and real balances

$$W = \sum_{t=0}^{\infty} \beta^t \left[ \ln C_t + \eta \ln (1 - l_t) + \frac{\gamma}{1 - \epsilon} \left( \frac{M_t}{P_t} \right)^{1-\epsilon} \right].$$ \hspace{1cm} (40)
where it is assumed that $\epsilon$ and $\eta > 1$, and $0 < \beta < 1$. The agent maximizes lifetime utility subject to the following sequence of budget constraints

$$
P_tC_t + M_{t+1} + P_tF_{t+1} + B_{t+1} = w_t l_t + M_t + \tau_t + \zeta_t + P_t R^*_t F_t + R_t B_t \forall \ t \geq 0, \quad (41)
$$

where $M_t$ is assumed to be chosen in time $t-1$, and $F_t$ is the period $t$ domestic holdings of net foreign claims. These are denominated in 1 period foreign currency real bonds which payoff $P_t R^*_t$. $B_t$ is the period $t$ holding of one period nominal domestic bonds which payoff nominal interest rate $R_t$, $\tau_t$ denotes transfers from the government in nominal amount per period, and $\zeta_t$ is the profit of all firms in the intermediate goods sector. The foreign nominal interest rate $R^*_t$ is assumed to be equal to $\frac{1}{\beta}$. This assumption implies that foreign inflation is zero, and that the foreign and domestic discount factor are the same. Given that trade takes place in a single, perfectly substitutable good, purchasing power parity holds at every point in time:

$$
P_t = e_t P^*_t. \quad (42)
$$

### 3.3 Equilibrium Under Flexible Wages

This section describes equilibrium under flexible nominal wages. In an environment of no nominal rigidities the monetary authority cannot affect employment and hence output. As we shall see below, even though output is below its socially efficient level due to the presence of monopolistic competition in the intermediate goods sector, there is no way that surprise inflation can increase output. Therefore, discretionary inflation will be
given by the Friedman money growth rule that corresponds to the case of commitment on the part of the monetary authority.

The representative agent maximizes its utility function (Eq. (40)) subject to its budget constraint (Eq. (41)) to arrive at its optimal choice of \( C_t, l_t, \) and \( M_{t+1} \). Optimality requires that the following conditions are satisfied:

\[
P_{t+1} C_{t+1} = \beta R_{t+1} P_t C_t, \tag{43}
\]

\[
\frac{\eta C_t}{1 - l_t} = \frac{w_t}{P_t}, \tag{44}
\]

\[
\frac{M_{t+1}}{P_t} = \left( \frac{P_t}{P_{t+1}} \right)^{1 - \frac{\gamma}{\epsilon}} \left( \frac{\gamma \beta C_t}{1 - \frac{1}{R_{t+1}}} \right)^{\frac{1}{\epsilon}}, \tag{45}
\]

\[
R_{t+1} = \frac{P_{t+1}}{P_t} R^*_t. \tag{46}
\]

Equations (43), (44), (45) and (46) are the Euler equation, the implicit labor supply condition, the money demand equation, and the uncovered interest rate parity condition, respectively. Equation (46) arises from allowing for international capital mobility. It links the domestic economy to the foreign economy via the interest rate by requiring that in equilibrium the return on deposits of any two currencies are equal when measured in the same currency. The Euler equation, together with the uncovered interest rate parity condition and the assumption that \( R^* = \frac{1}{\beta} \), indicates that the agent wishes to perfectly smooth consumption across periods.
Imposing symmetry across all firms in the intermediate goods sector and a zero profit condition for the final goods sector yields the optimal markup under flexible wages:

$$\lambda v(l_t)^{v-1} = \frac{w_t}{P_t}, \tag{47}$$

where $\frac{1}{\lambda}$ may be interpreted as the markup of price over marginal cost.

Impose the following market clearing conditions:

$$C_t = y_t, \tag{48}$$

and

$$M_{t+1} = M_t + \tau_t. \tag{49}$$

Note that $C_t = y_t$ occurs in this case because in equilibrium $y_t = A(l)^v$ $\forall$ $t$ and is therefore the same in every period.\(^\text{26}\) In a flexible wage equilibrium, employment remains at its market clearing, competitive level in every period.

Combine the market clearing conditions with the optimality conditions given in equations (43), (44), (45), (46) and (47) to obtain the following equilibrium conditions:

$$\bar{l} = \frac{\lambda v}{\eta + \lambda v} \tag{50}$$

$$C_t = \bar{y} = (\bar{l})^v \tag{51}$$

$$\frac{M_{t+1}}{P_t} = (1 + \pi) \left( \frac{\beta \gamma \bar{l}^v}{1 + \pi - \beta} \right)^{\frac{1}{\varepsilon}} \tag{52}$$

$$F_{t+1} = 0 \tag{53}$$

\(^\text{26}\)Note that it is being assumed that the initial level of inherited foreign credit is zero.
In the flexible wage equilibrium, we can see that \( \bar{l} \) is less than the socially efficient level of \( \frac{w}{\eta + \nu} \), which would obtain if firms were perfectly competitive. The wedge created by monopolistic competition in the intermediate goods sector manifests itself by causing consumption to be socially inefficiently low, and leisure inefficiently high. The agent supplies less labor in this environment because real wages are reduced by the presence of monopoly power. That is to say, prices are too high. Therefore, there is an incentive on the part of the monetary authority to raise consumption and reduce leisure to their socially efficient levels. In the flexible wage environment, however, the monetary authority cannot achieve this goal.

3.4 Equilibrium Under Sticky Wages

We now examine the monetary authority's incentives to inflate in a sticky wage environment. Equilibrium is derived for the general case, such that foreign asset holdings, denoted \( F_t \), for this small open economy may be non-zero. The nominal wage is assumed to be pre-set at the beginning of the period. Given the expected price, the agent sets the nominal wage in advance so as to clear the labor market,

\[
\frac{\bar{w}_t}{P_t} = \frac{1 + \pi^e_t}{1 + \pi^e_t} \frac{\bar{y}(F_t)}{\bar{l}(F_t)},
\]

where \( \pi^e_t \) denotes the expected rate of inflation,\(^{27} \) and \( \bar{l}(F_t) \) solves

\[
\frac{\eta \left( \bar{l}(F_t)^{\nu} + \frac{1-\beta}{\beta} F_t \right)}{1 - \bar{l}(F_t)} = \nu \lambda \bar{l}(F_t)^{\nu-1},
\]

\(^{27}\text{Precisely, } \pi^e_t = \frac{P_t - P_{t-1}}{P_{t-1}}.\)
which is just the labor market clearing condition in the case of \( \pi_t = \pi^e_t \). Employment is then chosen optimally by firms according to:

\[
l_t = \left( \frac{1 + \pi_t}{1 + \pi^e_t} \right)^{\frac{1}{1-v}} \bar{I}(F_t).
\]

Agents agree to supply labor as demanded by firms for the pre-agreed nominal wage of \( \bar{w}_t \). A rate of actual inflation that exceeds expected inflation entails a movement down the firm's demand curve due to the corresponding reduction in the real wage. Output is then given by:

\[
y_t = \left( \frac{1 + \pi_t}{1 + \pi^e_t} \right)^{\frac{1}{1-v}} \bar{I}(F_t)^v.
\]

Notice that if \( \pi_t > \pi^e_t \), the monetary authority is able to increase employment and hence output, indicating that in this environment, unanticipated inflation has real effects.

Goods market clearing is found by solving for the present value budget constraint:

\[
\sum_{i=0}^{\infty} \beta^i C_{t+i} = \sum_{i=0}^{\infty} \beta^i y_{t+i} + \frac{1}{\beta} F_t,
\]

where it has been assumed that the following terminal condition holds:

\[
\lim_{j \to \infty} \beta^j F_{t+1+j} = 0.
\]

Note that in deriving the present value budget constraint, the monetary authority's period budget constraint, given by Eq. (49), and intermediate firm profits, given by \( \zeta_{t+i} = P_{t+i} y_{t+i} - w_{t+i} l_{t+i} \forall i \geq 0 \), have been imposed.

In the case of sticky nominal wages, we must allow for the possibility of unanticipated inflation (e.g. \( \pi_t > \pi^e_t \)) at time \( t \). From \( t + 1 \) onwards, however, it is assumed that a

\[\text{Notice that if } F_t = 0 \text{ then } \bar{I}(F_t) = \bar{I} = \frac{m\lambda}{\pi^e_t + \lambda}.\]
rational expectations equilibrium holds such that \( y_{t+i} = \bar{y}(F_{t+i}) \quad \forall \ i \geq 1 \). Combining the present value budget constraint with the Euler equation linking present and future consumption yields:

\[
C_t = \bar{y}(F_{t+1}) + (1 - \beta)(y_t - \bar{y}(F_{t+1})) + \frac{1 - \beta}{\beta}F_t, \tag{60}
\]

\[
F_{t+1} = \beta(y_t - \bar{y}(F_{t+1})) + F_t, \tag{61}
\]

where

\[
\bar{y}(F_{t+1}) = \bar{l}(F_{t+1})^\nu. \tag{62}
\]

If there is no unanticipated inflation at time \( t \) or any previous periods, then in equilibrium \( C_t = \bar{y} \) and \( F_{t+1} = 0 \). But if there is unanticipated inflation in the present period, Eq. (60) indicates that \( C_t \) increases relative to past consumption, but not by the full amount of the increase in output, as would be the case if the economy were closed. The reason for this is due to the fact that the representative agent desires to smooth consumption across periods. This is accomplished in the presence of unanticipated inflation by an increase in current consumption by a fraction of the increase in output. The remaining portion is then lent out to foreigners so that in future periods consumption may be higher as well, since the representative agent is able to use the interest payment on its period \( t \) loan to consume above the future market clearing level of output (see Fig. 4). For example, if in the past inflation has been higher than anticipated, the economy can finance a trade balance deficit using the interest on previously acquired foreign credit. To illustrate, impose market clearing on the representative agent’s period budget constraint,
given by Eq. (41):

\[ F_{t+1} - F_t = y_t - c_t + \frac{1 - \beta}{\beta} F_t, \]

(63)

where the left hand side represents the capital account and the right hand side represents the current account (e.g. the trade balance plus interest earnings on previously acquired foreign assets). Unanticipated inflation will lead to a capital account deficit and a current account surplus in the current period. If inflation is perfectly anticipated, then the capital account and the current account are in balance, but the economy may run a trade balance deficit or surplus depending on whether inflation has been perfectly anticipated in the past.

Demand for real balances is given by:

\[ \frac{M_{t+1}}{P_t} = (1 + \pi_{t+1}) \left( \frac{\beta \gamma \left( \bar{y} (F_{t+1}) + (1 - \beta)(y_t - \bar{y} (F_{t+1})) + \frac{1 - \beta}{\beta} F_t \right)}{1 + \pi_{t+1} - \beta} \right)^{\frac{1}{\varepsilon}}, \]

(64)

which is the same as in the flexible wage case, except for that here we allow for the possibility that \( C_t \neq y_t \). The implication is that future real balances cannot be taken as given by the monetary authority when choosing the inflation rate at time \( t \). The argument is as follows. If it is assumed that in \( t + 1 \) and onwards a rational expectations equilibrium holds, then \( t + 2 \) money balances are given by:

\[ \frac{M_{t+2}}{P_{t+1}} = (1 + \pi_{t+2}) \left( \frac{\beta \gamma \left( \bar{y} (F_{t+1}) + \frac{1 - \beta}{\beta} F_{t+1} \right)}{1 + \pi_{t+2} - \beta} \right)^{\frac{1}{\varepsilon}}. \]

(65)

Multiply and divide the left hand side of the above equation by \( M_{t+1} \) and use the
condition that
\[ \frac{M_{t+2}}{M_{t+1}} = (1 + \pi_{t+2}), \]  
(66)

Furthermore, since it has been assumed at the outset that a rational expectations equilibrium holds in all future periods, all future rates of discretionary inflation will be the same. Therefore,
\[ \pi_{t+2} = \pi_{t+1}, \]  
(67)
and
\[ \frac{M_{t+1}}{P_{t+1}} = \left( \frac{\beta \gamma (\bar{y}(F_{t+1}) + \frac{1-\beta}{\beta} F_{t+1})}{1 + \pi_{t+1} - \beta} \right)^{\frac{1}{2}}. \]  
(68)

Indeed, the above defines all future real balances such that
\[ \frac{M_{t+1+i}}{P_{t+1+i}} = \left( \frac{\beta \gamma (\bar{y}(F_{t+1}) + \frac{1-\beta}{\beta} F_{t+1})}{1 + \pi_{t+1} - \beta} \right)^{\frac{1}{2}} \quad \forall \ i \geq 0. \]  
(69)

The equation illustrates that for the open economy, future real balances cannot be taken as given since \( F_{t+1} \) is a function of \( \pi_t \). That is to say, inflation today effects the level of foreign asset holdings, which in turn will affect future labor supply, output, consumption, and money demand.

### 3.5 The Monetary Authority's Choice Problem Under Sticky Wages

At time \( t \), the monetary authority chooses \( \pi_t \), given \( \pi_t^{\epsilon}, \bar{w}_t, \) and \( \bar{M}_t \) to maximize an objective function that corresponds with the preferences of the representative agent, taking it as given that the future price level, expected price level, and output will be
determined in a Nash equilibrium of the future stage game. This particular equilibrium concept is imposed in order to restrict the strategy of the monetary authority to be stationary. The future level of inflation is therefore perfectly anticipated, but cannot be taken as given.

The problem facing the monetary authority is:

\[
\max_{\pi_t} \frac{1}{1-\beta} \ln \left[ \bar{y}(F_{t+1}) + (1-\beta)(y_t - \bar{y}(F_{t+1})) + \frac{1-\beta}{\beta} F_t \right] + \eta \ln \left[ 1 - \bar{I} \right] 
+ \frac{\gamma}{1-\epsilon} \left[ \frac{\bar{M}_t v \lambda \bar{I}(F_t)^v}{\bar{w}_t} \right]^{1-\epsilon} \left( \frac{1+\pi_t^e}{1+\pi_t} \right)^{1-\epsilon} + \frac{\beta}{1-\beta} \eta \ln \left[ 1 - \bar{I}(F_{t+1}) \right] 
+ \frac{\beta}{1-\beta} \gamma \left[ \beta \gamma \left( \bar{y}(F_{t+1}) + (1-\beta)(y_t - \bar{y}(F_{t+1})) + \frac{1-\beta}{\beta} F_t \right) \right]^{1-\epsilon \gamma},
\]

subject to Eq. (61).

The solution to the above problem yields the government reaction function which may be expressed, in its general form, as being made up of three distinct parts:

\[ 0 = \]

\[
\frac{\partial W}{\partial \pi_t} \text{ direct effect} 
+ \frac{\partial W}{\partial F_{t+1}} \frac{\partial F_{t+1}}{\partial \pi_t} \text{ income effect} 
+ \frac{dW}{d\pi_{t+1}} \frac{dF_{t+1}}{d\pi_t} \text{ strategic effect} 
+ \frac{dW}{d\pi_{t+1}} \frac{dF_{t+1}}{d\pi_t} \frac{dF_{t+1}}{d\pi_t}
\]

The impact of a change in the current period rate of inflation on utility is made up of a direct effect and an income effect which we refer to in sum as the effect of fundamentals.
on the monetary authority's incentive to inflate. In addition, the lack of precommitment on the part of the monetary authority, as well as the existence of a state variable in the form of inherited credit, introduces a strategic effect. This latter effect captures the monetary authority's strategic incentive to alter $\pi_t$ in order to influence $\pi_{t+1}$. The monetary authority understands that the future choice of inflation will depend on the present choice of inflation according to some function $\pi_{t+1}(F_{t+1})$. It will therefore take this relationship into account when choosing its present action. The monetary authority's reaction function is given by:

$$0 = \left[ \begin{array}{l}
\frac{v}{1-v} \left( \frac{y_t}{C(F_{t+1})} \right) - \frac{\eta}{1-v} \left( \frac{l_t}{1-\beta} \right) + \frac{\gamma \beta}{\epsilon} \frac{v}{1-v} \left( \frac{y_t}{C(F_{t+1})} \right) \left( \frac{\beta \gamma C(F_{t+1})}{1+\pi_{t+1} - \beta} \right) \\
\frac{v}{1-v} \left( \frac{y_t}{C(F_{t+1})} \right) - \frac{\eta}{1-v} \left( \frac{l_t}{1-\beta} \right) + \frac{\gamma \beta}{\epsilon} \frac{v}{1-v} \left( \frac{y_t}{C(F_{t+1})} \right) \left( \frac{\beta \gamma C(F_{t+1})}{1+\pi_{t+1} - \beta} \right) \\
\frac{v}{1-v} \left( \frac{y_t}{C(F_{t+1})} \right) - \frac{\eta}{1-v} \left( \frac{l_t}{1-\beta} \right) + \frac{\gamma \beta}{\epsilon} \frac{v}{1-v} \left( \frac{y_t}{C(F_{t+1})} \right) \left( \frac{\beta \gamma C(F_{t+1})}{1+\pi_{t+1} - \beta} \right)
\end{array} \right] \left( \frac{\theta(F_{t+1}) + \eta v (1 - \beta)}{\theta(F_{t+1})} \right),$$

where

$$\theta(F_{t+1}) = (\eta \beta + \nu \lambda) v + \frac{v \lambda (1 - v)}{l(F_{t+1})}. \quad (71)$$

The monetary authority will choose a level of inflation that equates the marginal benefit to the marginal cost, in utility terms, of increased inflation. The first order condition is made up of 6 parts, each of which may be interpreted as a marginal benefit or cost of higher inflation in the present period. The first term in the above equation may be interpreted as the marginal benefit of higher inflation on present output through its
effect on consumption in the present period and all subsequent periods. The second
effect is the marginal cost from decreased leisure in the present period. In equilibrium,
these two effects would exactly offset each other if the intermediate sector were perfectly
competitive, leading the monetary authority to choose the Friedman money growth rule.
Due to the presence of monopolistic competition, however, the monetary authority will
choose a rate of inflation that exceeds the Friedman rule and in the process bear the
costs of doing so. The third term is the marginal benefit from increased real balances in
all subsequent periods due to an increase in future consumption from increased present
output. This effect does not arise in the closed economy case, since the benefits to
unanticipated inflation are contained within the period that it has occurred. The fourth
effect is the marginal cost from decreased real balances in the present period. This effect
arises because agents are assumed to choose period $t$ nominal money holdings in $t - 1$.
Therefore, anticipated inflation, which is reflected in a higher pre-set nominal wage, will
erode the value of period $t$ money balances. The fifth effect is the income effect of
inflation today on future consumption, leisure, and real money balances. Overall, the
income effect imposes an additional cost in that an increase in foreign asset holdings
reduces future labor supply, output, and money demand. The last effect is the marginal
benefit or cost (depending on the sign of $\frac{\partial \pi}{\partial F}$) of inflation today through its effect on
future discretionary inflation. This effect ties the present incentives of the monetary
authority to future incentives, even though the monetary authority is assumed to have
no precommitment capabilities.
Now consider a rational expectations equilibrium whereby inflation is perfectly anticipated. Set \( \pi_t = \pi_t^* \), and \( \pi_t = \pi_{t+1} \) to find the fixed point as a function of the state variable.\(^{29}\) Period \( t \) equilibrium discretionary inflation, denoted \( \pi_t^d \), is given by:

\[
\pi_t^d = \beta - 1 + \left[ \frac{\gamma(1-\lambda)}{\gamma(1-v)} \frac{\partial \bar{y}(F_t)}{\partial (1-\gamma)} \left( 1 - \frac{\beta \nu}{\gamma(1-\nu)} \right) \right] \bar{y}(F_t) \\
\beta \gamma \bar{C}(F_t)
\]

where

\[
\bar{C}(F_t) = \bar{y}(F_t) + \left( 1 - \frac{\beta}{\gamma} \right) F_t.
\]

In order to proceed with the analysis, it is necessary to gain some insight into the term \( \frac{\partial \pi_t^*}{\partial F_t} \). This is done in the next section by employing a numerical technique. But first, let us ignore the strategic effect and consider the role of fundamentals on the discretionary level of inflation. In addition, impose the condition that there has been no past unanticipated inflation such that the trade balance is zero (e.g. \( F_t = 0 \)). In this case, \( \bar{l}(F_t) = \bar{l} \) and \( \bar{y}(F_t) = \bar{y} \), and the discretionary rate of inflation is given by:

\[
\pi^d = \beta - 1 + \left( \frac{\nu(1-\lambda)}{\gamma(1-v)} \right) \frac{\bar{y}}{\bar{y}} \beta \gamma \bar{y}
\]

where

\(^{29}\)Recall that it has been assumed that the future price level will be determined in a Nash equilibrium of the future stage game. This means that \( F_t = F_{t+1} \) \( \forall \ i \) and so \( \pi_t = \pi_{t+1} \) \( \forall \ i \). This assumption allows us to solve for the period \( t \) level of discretionary inflation.
If $\Phi$ is equal to 1, then the discretionary rate of inflation corresponds to the closed economy case. However, openness provides two competing effects on the monetary authority’s incentives. First, there is an added benefit in that unanticipated inflation in an open economy means that consumption and hence money demand will be higher in all future periods since openness provides consumers with a way of smoothing consumption across periods by running a capital account deficit in the period in which the unanticipated inflation occurred. The downside is that the ability to lend in the current period in order to finance future trade deficits is costly because the resulting income effect will cause workers to choose more leisure in the future, thereby worsening the distortion created by the presence of monopolistic competition in the intermediate goods sector. Which of these effects dominates will depend on the underlying structure of the economy. For example, if the consumption elasticity of money demand (given by $\frac{1}{\eta}$) is large then the effect of increased money demand in response to increased consumption will be large, and so we would expect the benefits of openness to outweigh the costs, resulting in an open economy discretionary level of inflation that is greater than that of a closed economy. This is illustrated in Fig. 5. We would also expect inflation for an open economy to exceed the closed economy rate if firms in the intermediate goods sector are relatively competitive. Fig. 6 compares the "fundamentals" open economy discretionary rate of inflation to the closed economy rate over a range of varying degrees of monopoly power. If

\[
\Phi = \left( \frac{1}{\eta (1-\epsilon) + \nu \lambda + \eta \nu \delta} \right)^{-\frac{1}{1-\epsilon}}.
\]
firms have little monopoly power ($\lambda$ close to 1), increased future leisure arising from an income effect would not be very costly in the face of an already small distortion in the intermediate goods sector. Alternatively, if firms in the intermediate goods sector had a large degree of monopoly power ($\lambda$ close to 0), the cost of increased future leisure would be relatively high in the face of an already large distortion. Thus we would expect the open economy level of discretionary inflation to be less than that of a closed economy. This fact may provide insight into the empirical regularity that more open economies tend to have lower rates of inflation. Closed economies, due to the lack of foreign competition, might be expected to have sectors in which firms have a large degree of monopoly power. Therefore, a move to open up these economies would see a reduction in the average rate of inflation. Furthermore, the analysis shows that, beyond some critical level, inflation falls as firms become more competitive. If openness then exposes domestic firms to foreign competition, thereby reducing the overall degree of monopolistic competition in the economy, as suggested by Lane, then these findings indicate that openness may have more than one channel through which it effects the incentives of the monetary authority.

Relating the previous findings to those of Romer illustrates that if we were to consider an additional cost to inflation arising from a deterioration in the terms of trade, it would still not be possible to make a definitive statement about the fundamentals portion of discretionary inflation in an open economy vis-à-vis a closed economy. This is because we still have a benefit arising from openness, namely that consumption and therefore money demand increases in all future periods due to the ability to borrow and lend on
international capital markets in the face of unanticipated inflation.

Now consider the "fundamentals" response of discretionary inflation to an increase in an economy's foreign asset holdings, evaluated at an initial position of zero foreign asset holdings. Again there are two competing effects at work.

First, as the trade deficit increases (e.g., the country is a net lender) there is less of an incentive to inflate because consumption and money demand are already high even in the presence of the distortion created by monopolistic competition since interest earnings on past lending can be used to buy and consume foreign produced goods above and beyond domestic production. In addition, with consumption already high a slight reduction in future consumption via the income effect in response to unanticipated inflation is relatively less costly. The former effect dominates the latter, leaving inflation lower for larger trade deficits. This result is consistent with the argument that inflation expectations are high when a country is a net borrower because the monetary authority has an incentive to inflate so as to erode the nominal value of its debt. In this model, debt is real but if a country is a net debtor then the monetary authority has an incentive nevertheless to raise inflation above expectations in order to boost output and reduce its foreign debt.

However, the model indicates that the story does not end here. An additional effect of the trade balance on money demand must also be taken into consideration when thinking about the relationship between a country's foreign asset position and inflation. When real balances are low, as would be the case if the economy were a net debtor, then inflation would be relatively costly in that its effect would be to further reduce real balances.
If the economy were a net creditor then real balances would be high and the cost of
inflating correspondingly low. So we can see that even if we ignore the strategic effects,
an unambiguous relationship between a country’s foreign asset position and inflation,
evaluated from an initial position of zero foreign asset holdings, cannot be found, the
difference being that in this model the direct cost as well as the benefits of inflation is a
function of a country’s foreign asset position.

3.6 Numerical Analysis

We now turn to a numerical analysis of the monetary authority’s first order condition
that takes into account the strategic effect of the current level of inflation on the future
incentive to inflate.\textsuperscript{30} A polynomial is employed to approximate the relationship between
inflation and inherited credit.\textsuperscript{31} The estimation is then run over a grid of inherited
credit and updated parameters of the polynomial are chosen according to a Taylor series
expansion of the weighted sum of squared residuals of the first order condition around
the old parameter values. In Eq. (72), the monetary authority’s decision rule is assumed
to have the following form:

$$\pi = a_0 + \sum_{i=1}^{n} a_i F^i$$  \hspace{1cm} (76)

and,

$$\frac{\partial \pi}{\partial F} = \sum_{i=1}^{n} i a_i F^{i-1}.$$  \hspace{1cm} (77)

\textsuperscript{30}I thank Christian Sigouin for providing programming help.
\textsuperscript{31}See Lancaster and Salkauskas (1986) and Goldfeld, Quandt, and Trotter (1966) for more details
regarding the particular method employed here.
The following parameter values are used: \( \beta = .97 \), \( \nu = .5 \), \( \eta = 2.1 \), \( \gamma = .01 \), \( \epsilon = 4 \), and \( \lambda = .8 \).

Numerical simulations of a quadratic polynomial relating inflation to inherited credit yield the following two Markov stationary equilibria for the discretionary level of inflation:

\[
\pi^{1d}_{\text{open}} = 0.05 + 0.01F - 0.001F^2
\]
\[
\pi^{2d}_{\text{open}} = 0.26 - 0.03F + 0.002F^2
\]

To compare the discretionary level of inflation found in the open economy case to that of the closed, let \( F = 0 \). Let \( \pi^{d}_{\text{closed}} \) denote the discretionary level of inflation that would obtain in the case of a comparable closed economy\(^{32}\) and \( \pi^{FR} \) denote the Friedman rule level of inflation.\(^{33}\) The above solutions indicate the following ranking:

\( \pi^{FR} < \pi^{1d}_{\text{open}} < \pi^{d}_{\text{closed}} < \pi^{2d}_{\text{open}} \), where \( \pi^{FR} = -0.03 \), \( \pi^{1d}_{\text{open}} = 0.05 \), \( \pi^{d}_{\text{closed}} = 0.18 \), and \( \pi^{2d}_{\text{open}} = 0.26 \).

The multiple solutions arise due to the strategic effect. If \( \frac{\partial \pi}{\partial F} > 0 \) at \( F = 0 \), then unanticipated inflation today has an additional cost of raising the future incentive to inflate. On the other hand, if \( \frac{\partial \pi}{\partial F} < 0 \) when \( F = 0 \), then unanticipated inflation today has the added benefit of reducing the future incentive to inflate. In the low inflation solution \((\pi^{1d}_{\text{open}})\), the overall marginal cost outweighs the marginal benefit at \( \pi^{d}_{\text{closed}} \) and so inflation is lower. In the high inflation solution \((\pi^{2d}_{\text{open}})\), the overall marginal benefit outweighs the cost at \( \pi^{d}_{\text{closed}} \) and so inflation is higher. Furthermore, the cost to inflation is not constant over time and depends on the size of inherited credit. In the first equilibrium the marginal

\(^{32}\)To obtain the closed economy value for \( \pi^{d}_{\text{closed}} \), set \( \Phi = 1 \) in Eq. (74) and plug in the parameter values given in the text.
\(^{33}\)The Friedman rule level of inflation is given by \( \pi^{FR} = \beta - 1 \).
cost falls by more than the marginal benefit and so inflation increases overall as inherited credit increases. In the second equilibrium, the marginal benefit falls by more than marginal cost, and so inflation falls with a rise in inherited credit. What the solutions here indicate is that for a set of parameter values, two solutions are possible, each of which may be higher or lower than the corresponding discretionary rate of inflation for a closed economy depending on the monetary authority’s strategic incentive. Therefore, this model cannot replicate the result found by Romer and Lane that openness reduces inflation. Such a result will depend on the relative sizes of the costs and benefits to inflation, working through a number of channels.

3.7 Conclusion

This chapter has extended the general equilibrium model in Chapter 1 to an open economy environment. The approach indicates various competing channels through which openness affects the monetary authority’s incentive to inflate, and so cannot replicate the Romer (1993) and Lane (1995) result that openness reduces inflation. The main points are threefold. Firstly, the fundamentals portion of discretionary inflation may or may not be less than the corresponding closed economy rate, and depends on the underlying structure of the economy. Similarly, the fundamentals response to a change in the economy’s foreign asset position, starting from an initial position of zero foreign asset holdings, cannot be pinned down. This arises from the fact that the cost of inflation, in the form of nominal money, is itself a function of a country’s level of indebtedness.
Therefore, even though the benefit to inflation has increased in an environment in which the economy has borrowed heavily from foreigners in the past, the costs have risen as well, in which case it may be that discretionary inflation is lower. The last point relates to the overall discretionary rate of inflation, taking into account the strategic incentive on the part of the current monetary authority to alter the incentives faced by the future monetary authority through its effect on the economy's foreign asset position. Numerical techniques indicate multiple solutions for the open economy discretionary rate of inflation, each of which may be higher or lower than the corresponding closed economy rate of discretionary inflation depending on the monetary authority's strategic incentive.
4 Chapter 4: Evidence of Markups and Inflation for OECD Countries

4.1 Introduction

In response to the models developed by Kydland and Prescott (1977) and Barro and Gordon (1983a), several empirical papers have examined time-consistency issues as they relate to inflation determination. Initially, the focus has been on central bank independence and inflation, the idea being that greater central bank independence enables the monetary authority to commit to an inflation policy and so reduces inflation (see Alesina (1989), Grilli, Masciandaro, and Tabellini (1991), Cukierman, Webb, and Neyapti (1992), and Alesina and Summers (1993)). The argument is intuitively appealing: low inflation in Germany is often attributed to the independence of the Bundesbank, for example. However, a recent comprehensive study by Miron and Campillo (1996) finds that central bank independence does not appear to be significant in explaining differences in average rates of inflation across countries.

More recently, the shift has been toward examining the effect of changes in the underlying structure of the economy on inflation. In particular, the effect of a country's openness to trade and its subsequent impact on the relationship between openness and inflation through the terms of trade was first addressed by Romer (1993). His idea is based on Rogoff's (1985b) finding that inflation causes a terms of trade deterioration. Therefore, open economies face an additional cost to inflation relative to closed economies.
and should, accordingly, have a lower rate of inflation.

Not directly related to the time-consistency argument is the issue raised by Fischer, Sahay, and Végh (1996). They find that in transition economies, structural reforms, such as de-monopolization, play a role in reducing inflation, perhaps indicating that as firms become more competitive, output rises and the monetary authority’s incentive to inflate is reduced. This hypothesis is supported by Gali’s (1995) finding that more developed economies tend to have a greater degree of competition among firms.

Underlying the above attempts at evaluating the effect of time-consistency on inflation is the assumption that the greater the gap between the socially optimal level of output and full employment, the greater the monetary authority’s desire to raise output above its full employment level, leading to higher equilibrium rates of inflation in the absence of commitment. Several papers have tried to relate the distortion in the economy to inflation. Lane (1995) argues that the distortion created by monopolistic competition in the non-traded goods sector is by definition smaller for more open economies. This story is very much related to the "dynamic" gains from trade argument, namely increased competition among domestic firms resulting from exposure to foreign competition is an additional benefit to trade (see, for example, Markusen(1981) and Venables (1985)). What is interesting about the time-consistency argument, is that it can potentially explain the repercussions of such changes in response to trade policy on an economy’s average rate of inflation. If openness reduces the distortion in the economy, then open economies should have lower rates of inflation. In support of this, Lane finds
that openness is significant for the OECD sample of countries once country size is controlled for. The drawback to this approach is the difficulty in interpreting the effect of openness on inflation. Does openness capture terms of trade effects or the effect of foreign competition on domestic firms? A more recent paper by Miron and Campillo (1996) tries to assess the impact of the difference between full employment and the socially optimal rate of employment on inflation directly by regressing inflation on unemployment for a subset of countries. Although they find that the effect of unemployment on inflation is positive for richer countries, the link is weak.

The focus of this chapter is to re-evaluate the contribution of economic fundamentals by examining on the relationship between markups and inflation for OECD countries. \(^34\) The hypothesis is that higher markups, by increasing the distortion in the economy and providing the monetary authority with an incentive to inflate, worsen the discretionary rate. The method employed here is similar to that of earlier papers. We regress average inflation for the OECD sample of countries on markups and other country specific characteristics. The difficulty of this approach is in obtaining a measure of markups. \(^35\) Following Gali (1995), we do this using the inverse of the observed share of labor in national income as a measure of markups. Several interesting results emerge.

Firstly, empirical findings indicate a positive relationship between markups and infla-

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\(^{34}\)Regression results for a much larger set of countries are not reported here. Our measure of markups did not enter significantly in those regressions, indicating that time-consistency issues are not important in explaining differences in average rates of inflation for developing countries (see Romer (1996)). This is in line with previous findings (see Romer (1993), Miron and Campillo (1996)).

\(^{35}\)Another possible measure of imperfect competition is the degree of unionization. Data for 17 OECD countries on the rate of unionization as reported by Bruno and Sachs (1985) was used in place of our measure of markups. The rate of unionization was found to be insignificant.
tion, which is consistent with the time consistency argument that the distortion worsens the inflation bias. This result is robust to the inclusion of several explanatory variables. For comparison purposes, we initially examine the impact of including markups to the base Romer (1993) and Lane (1995) regressions and find that the inclusion of markups improves the fit of those regressions substantially. Secondly, markups remain robust to the inclusion of an interaction variable between openness and country size, which we interpret as the terms of trade effect. For this specification, terms of trade effects appear to play a small but significant role in determining inflation. This result is consistent with Lane’s (1995). Lastly, central bank independence has an insignificant effect on inflation. Overall, the results support the Miron and Campillo (1996) finding that economic fundamentals rather than institutional arrangements, such as central bank independence, play a bigger role in explaining observed differences in cross-country rates of inflation.

The chapter is organized as follows: Section 4.2 describes the empirical analysis and data; Section 4.3 reports the regression results; Section 4.4 evaluates the robustness of our findings; and Section 4.5 concludes.

4.2 Empirical Analysis

4.2.1 Markups

In order to directly assess the effect of the overall degree of competition among firms in an economy on average inflation rates across countries, it is first necessary to obtain a measure of the economy-wide markup of price over marginal cost. The procedure
employed here is taken directly from Hall (1988) and Gali (1995). To obtain a measure of
the markup we exploit the fact that a profit maximizing firm equates marginal revenue
with marginal cost \((x)\). For a monopolistically competitive firm, however, marginal
revenue no longer equals price, since increases in output must be accompanied by a
reduction in price. More specifically, marginal revenue \((m_r)\) may be expressed as:

\[
m_r = p(1 - \frac{1}{\epsilon}),
\]

(78)

where, \(\epsilon\) denotes the price elasticity of demand faced by firms and \(p\) denotes price. The
markup, denoted \(\mu\), is therefore given by the inverse of \((1 - \frac{1}{\epsilon})\), reflecting the ratio of
price over marginal cost:

\[
\mu = \frac{p}{x}.
\]

(79)

The marginal cost of producing one more unit of output is defined as the ratio of the
factor price \((w)\) to its marginal productivity \((mpl)\). Substituting in for the definition
of marginal cost, and dividing and multiplying the above equation through by the factor
input \((l)\) and output \((y)\) yields:

\[
\mu = \frac{mpl}{yl}.
\]

(80)

The above may then be rewritten as:

\[
\mu = \frac{\alpha}{s},
\]

(81)

where \(s\) denotes labor's observed share in total income, and \(\alpha\) denotes the elasticity of
output with respect to labor input.

\[\text{Note that it has been assumed that firms take the wage as given.}\]
Following Gali (1995), $s$ is calculated as the ratio of compensation of employees to GDP. For the present purpose it is assumed that $\frac{1}{s}$ is sufficient as a measure of markups. This simplification is based on the assumption that the elasticity of output with respect to labor input, which represents technology, is the same across countries. The implication is that we do not expect the available technology to differ across countries to the extent that it can explain observed differences in average rates of inflation. Consequently, by dropping $\alpha$ and simply using $\frac{1}{s}$ as a measure of markups, the regression will not suffer from a missing variables bias.

To provide some evidence that the above described measure of markups captures the overall degree of competition among firms in an economy, we compare the ranking of competitiveness based on our measure of markups to the ranking of competitiveness prepared by the Institute for Management Development. The Institute for Management Development establishes an index of world competitiveness based on 244 different indicators. The sample rank correlation between the two rankings is approximately 0.73. A scatter plot of the two rankings is illustrated in Fig. 7.

### 4.2.2 Other Determinants of Inflation

This paper should be viewed as an extension of the work done by Romer (1993), Lane (1995), and Miron and Campillo (1996). As such, we do not claim that markups alone account for differences in average inflation rates across countries. In particular, open-

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37 The 1993 ranking of world competitiveness is used here for 22 countries. Due to data availability, Iceland and Luxembourg are excluded from the ranking.

38 These indicators are grouped in the following way: domestic economy, internationalization, government, finance, infrastructure, management, science and technology, and people.
ness and country size are included to capture the terms of trade effect. In the Romer regression, openness is interpreted as capturing the terms of trade effect. The idea is that inflation, which leads to a terms of trade deterioration, will have a greater adverse effect the more open is an economy. Therefore, we should find that the more open an economy, the lower its average rate of inflation. Except for the OECD subsample, Romer finds that this relationship is supported empirically in cross country regressions. In the Lane regression, country size is interpreted as capturing the terms of trade effect, whereas openness is a proxy for the degree of imperfect competition (eg markups). Lane expanded on the work done by Romer, arguing that in examining the relationship between openness and inflation it is necessary to control for country size. The theoretical reasoning is as follows: an open economy is defined as having a small non-traded goods sector, which is assumed to be monopolistically competitive. Monopolistic competition in the non-traded goods sector is the distortion that provides the monetary authority with an incentive to inflate in a sticky price environment, leading to higher equilibrium inflation. Therefore, the smaller the source of the monetary authority's incentive to inflate (eg the more open an economy), the lower is inflation. Openness should therefore be negatively related to inflation even for countries too small to affect their terms of trade. Empirically, this relationship is borne out. In addition, Lane finds that once country size is controlled for, openness has a negative and significant effect on inflation for the OECD subsample of countries.

Both Lane and Romer's findings are confirmed in a more recent paper by Miron and
Campillo (1996) for an enlarged data set, leading to the conclusion that trade, which leads to changes in the underlying structure of an economy, can help a country reduce its rate of inflation. However, the interpretation of the openness and country size variables in a regression including markups differs from previous regressions. Neither variable can, on its own, convincingly capture the terms of trade effect. A country that is open but too small to affect the world price will not suffer from a terms of trade deterioration resulting from inflation. Similarly, a country that is large but closed to trade will not be concerned with a terms of trade deterioration since the terms of trade has no impact on domestic agents. The terms of trade will affect a country's rate of inflation only if that country is a large open economy. Therefore, the interaction between openness and country size is the relevant variable for capturing terms of trade effects. In the following regressions, however, we first include markups in the Romer and Lane regressions for comparison purposes before dropping country size and openness in favor of an interaction term, which we refer to as the terms of trade.

In addition to the terms of trade, the effect of institutional arrangements on inflation is included. The hypothesis is that institutional arrangements enable the monetary authority to surmount the time consistency problem by shifting preferences away from employment towards price-stability considerations. This is captured by a measure of central bank independence: Greater central bank independence reduces inflation. Therefore, the expectation is that the sign of the coefficient on central bank independence is negative. The average annual rate of turnover of the central bank governor is used in
addition to an index of legal central bank independence. The expectation is that higher turnover rates are associated with higher rates of inflation.

Lastly, the log of per capita GDP is included as a general measure of development. Inclusion of the log of per capita GDP serves as a proxy for the optimal inflation tax, which is assumed to be lower in high income countries since high income countries are more likely to have sophisticated tax systems (see Lane (1995)). In addition, per capita GDP is assumed to capture a country's distaste for inflation: richer countries are more able to establish a means of overcoming costs to inflation and therefore are more able to adapt to inflation (see Miron and Campillo (1996)). Note that both of these effects imply opposite signs on the coefficient of per capita GDP on inflation.

The basic regression, therefore, is:

\[ \log(\pi_i) = \beta_0 + \beta_1 \log(\mu_i) + \beta_2 Z_i + e_i, \]  \hspace{1cm} (82)

where \( Z_i \) includes the terms of trade, central bank independence, governor turnover rates, and the log of per capita GDP.\(^{39}\)

4.2.3 Data Source

The data set used here is comparable to the Romer/Lane data set.\(^{40}\) We use a cross-section of data over the period 1973-88 for 24 OECD countries. This procedure is adopted

\(^{39}\)In the regression the log of inflation and the log of markups are used. This is consistent with earlier work and is done so that outliers are given a smaller weight. Results are not sensitive to the use of log markups rather than markups as an explanatory variable.

\(^{40}\)I would like to thank Philip Lane for generously providing me with his data set.
so that the effect of markups on the inflation bias can be evaluated. In this case it is best to use the average inflation rate over a period, since we do not claim that markups explain annual fluctuations in inflation rates. As in the Romer/Lane data set, inflation (denoted INF) is measured as the annual change in the log GDP (or GNP) deflator using *International Financial Statistics* data. The markup variable is calculated as the inverse of the ratio of compensation of employees to gross domestic product. The data source for the construction of markups is the *United Nations National Accounts Statistics: Main Aggregates and Detailed Tables*.

The terms of trade effect is constructed as an interaction between openness, as measured by the ratio of imports to GDP, and country size, which is given by GDP in 1985 international prices.\(^{41}\) The interaction between country size and openness is captured by the terms of trade, denoted TOT, where \(TOT = (\log(GDP)^{1/2} + OPEN^{1/2})^2\). This formulation has the property that the correlation between the terms of trade and country size as well as between the terms of trade and openness are positive (see Table 2).

A measure of central bank independence and turnover rates of the central bank governor are taken from Cukierman, Neyapti, and Webb (1992). The index of central bank independence lies on the interval \([0, 1]\), where values close to 1 indicate a greater degree of central bank independence.\(^{42}\) Average annual turnover rates of the chief executive of

\(^{41}\)An average over the period is constructed for GDP using data in 1985 international prices (chain index) obtained from the Summers and Heston Penn world tables: Mark 5. For consistency purposes, an average per capita GDP measure over the 1973-88 period is also used.

\(^{42}\)The legal central bank independence index developed by Cukierman, Neyapti, and Webb (1992) is based on four categories: governor of central bank terms of office, appointment, and dismissal; central bank objectives; degree of allowable public sector lending; conflict resolution between the central bank and the executive branch.
the central bank (denoted TRN) over the period 1972-89 are used in place of the TRN measure used in Lane, which looks at the average annual governor turnover rate for the period 1950-89. Cukierman, Webb, and Neyapti (1992) argue that, for industrial countries, turnover rates do not reveal much about variations in independence. However, they base this on the fact that none of the average rates for the period 1950-89 exceed 0.2 (i.e. none of the countries have an average tenure of less than 5 years). Given the sample used here, seven countries have turnover rates exceeding 0.2 for the 1972-89 period.\textsuperscript{43} For this reason, the variable TRN is included as an explanatory variable.

Summary statistics on inflation and the explanatory variables are reported in Table 1.\textsuperscript{44} The variation in markups across countries is illustrated in Figure 8, with Greece and Turkey as outliers (countries are in alphabetic order).\textsuperscript{45} Simple correlations between inflation and all the explanatory variables are reported in Table 2. The very high correlation between inflation and markups reported in Table 2 is illustrated in the scatterplot of Figure 9.

The high correlations between markups, per capita GDP, and governor turnover indicates the need to watch for problems of multicollinearity in our regressions. Consistent with the underlying assumption of the Lane regression, markups and openness are negatively correlated, indicating that more open economies tend to also be more competitive.

\textsuperscript{43}The seven countries for which average turnover rates exceed 0.2 are Greece, France, Japan, New Zealand, Portugal, Sweden, and Turkey.

\textsuperscript{44}Note that in Table 1 the variable labelled markup is actually the inverse of labor's observed share in total income.

\textsuperscript{45}All of the following regressions were re-run excluding Turkey from the sample. The basic results do not change.
Table 1: Summary Statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Standard Deviation</th>
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<tbody>
<tr>
<td>Inflation</td>
<td>10.9</td>
<td>8</td>
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<tr>
<td>Openness</td>
<td>32.4</td>
<td>16</td>
</tr>
<tr>
<td>Markup</td>
<td>2.03</td>
<td>0.78</td>
</tr>
<tr>
<td>GDP (millions)</td>
<td>380</td>
<td>747</td>
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<tr>
<td>Terms of Trade</td>
<td>23.7</td>
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</tr>
<tr>
<td>Per Cap GDP (thousands)</td>
<td>10,504</td>
<td>2,981</td>
</tr>
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<td>Bank</td>
<td>0.375</td>
<td>0.15</td>
</tr>
<tr>
<td>Turnover</td>
<td>0.16</td>
<td>0.09</td>
</tr>
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</table>
Table 2: Correlation Matrix

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<th></th>
<th>L(INF)</th>
<th>OPEN</th>
<th>L(Mrkup)</th>
<th>L(PCGDP)</th>
<th>L(GDP)</th>
<th>TOT</th>
<th>BANK</th>
<th>TRN</th>
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<td>L(INF)</td>
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<td>L(Mrkup)</td>
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<tr>
<td>L(PCGDP)</td>
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4.3 Regression Results

The simple correlations of the previous section highlight the fact that, with the exception of per capita GDP, past variables that have been studied for their impact on inflation are much less correlated with inflation than markups. In this section we first compare the inclusion of markups to the base Romer and Lane regressions and report robustness checks.\(^46\) An interaction variable between openness and country size is then included along with markups to capture terms of trade effects.

A comparison of Columns I and II in Table 3 indicates the superiority of markups over openness in explaining inflation differences. Markups alone are significant and account for nearly 40% of inflation, whereas openness has no explanatory power.\(^47\) Furthermore, running openness and markups jointly on inflation shows a reduction in explanatory power. However, the inclusion of markups to the base Romer regression does not change the result that openness is insignificant for the OECD sample. The base regressions also show that markups enter with the correct sign and have a large impact on inflation. For example, an economy in which firms are perfectly competitive (ie a markup of 1) will have an average rate of inflation of 3%. If the markup is 2, then inflation increases to 5%. Countries with a low degree of competition among firms with a markup of 5 will have an average rate of inflation of 9.5%. This result contrasts with the findings of Miron and Campillo (1996). Their addition of the average level of unemployment generates a positive, but weak, relationship between unemployment and inflation for the rich country

\(^{46}\)Some of the following regressions were re-run using a weighted least squares method in which smaller countries were given less weight. No significant differences in the results were found.

\(^{47}\)The * denotes significant variables at the 5% level.
We now examine the effect of including markups in the base Lane regression. The results are reported in Table 4. The base Lane regression in column I confirms the result that openness becomes significant once we control for country size. This result holds with the inclusion of markups, the addition of which improves the fit of the regression substantially. The marginal contribution of markups as an explanatory variable in the basic Lane regression is significant at the 5% level. The inclusion of markups, however, reduces the effect of openness on inflation, as well as the significance of the coefficient, considerably. This is consistent with the dynamic gains from trade argument that trade exposes domestic firms to foreign competition, leading to greater efficiency. Therefore, we would expect that a regression excluding markups would tend to overestimate the
Table 4: Markups in the Lane Regression

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<td></td>
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<td>(0.7)</td>
<td>(0.58)</td>
<td></td>
</tr>
<tr>
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<td>-0.25*</td>
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<td>-0.26*</td>
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<tr>
<td></td>
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<td>(0.08)</td>
<td></td>
<td>(0.07)</td>
</tr>
<tr>
<td>Log(PCGDP)</td>
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<td>-0.7</td>
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</tr>
<tr>
<td></td>
<td></td>
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<td>(0.35)</td>
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</tr>
<tr>
<td>$R^2$</td>
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<td>0.56</td>
<td>0.38</td>
<td>0.62</td>
</tr>
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negative effect of openness on inflation.\textsuperscript{48}

Column III of Table 4 includes markups as an explanatory variable in the basic Romer regression including PCGDP. Romer argued that PCGDP serves as a general measure of development and therefore may capture a variety of factors that influence average rates of inflation. Lane and Miron and Campillo include PCGDP to capture optimal inflation tax considerations or a country's taste for inflation. However, Gali's (1995) finding of a significant negative relationship between markups and PCGDP, and the high negative correlation between markups and PCGDP indicate a problem of multicollinearity between PCGDP and the log of markups. Although markups and per capita GDP are individually insignificant, the joint significance of the log of markups and the log of PCGDP shows the difficulty in interpreting the effect of PCGDP on inflation, since it seems to serve as a "catch-all" variable encompassing many different effects, each of which is difficult to identify separately. In addition, a comparison of Columns II and IV shows that the inclusion of PCGDP raises the adjusted $R^2$ of the regression considerably, in support of the hypothesis that PCGDP captures effects other than markups.

To further check the robustness of markups, Table 5 reports regressions including the BANK variable measuring central bank independence, the TRN measure, as well as the log of PCGDP. The regression results show that the significance of markups is robust to the inclusion of variables measuring central bank independence and governor

\textsuperscript{48}There is no evidence of a significant negative relationship between openness and markups for the OECD sample. The following regression was run to see if there was evidence of a negative relationship between openness and markups: $\log(\text{markups}) = \alpha + \beta_{\text{open}}$ where the following estimates were obtained: $\hat{\beta} = -0.47$ with a standard deviation of 0.3, and $\hat{R}^2 = 0.05$. 
Table 5: Markups and Inflation

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<td>(3.9)</td>
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<td>-1.94*</td>
<td>-1.97*</td>
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<td>(0.47)</td>
<td>(0.44)</td>
<td>(0.51)</td>
</tr>
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<td>-0.25*</td>
<td>-0.25*</td>
<td>-0.24*</td>
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<td>(0.06)</td>
</tr>
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<tr>
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<td>(1.2)</td>
<td>(1.1)</td>
<td>(1.13)</td>
<td></td>
</tr>
<tr>
<td>Log(PCGDP)</td>
<td></td>
<td></td>
<td></td>
<td>-0.99*</td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td>(0.36)</td>
</tr>
<tr>
<td>$\bar{R}^2$</td>
<td>0.62</td>
<td>0.54</td>
<td>0.6</td>
<td>0.71</td>
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turnover. Central bank independence as well as governor turnover enter insignificantly. The result that central bank independence is insignificant is consistent with the findings of Miron and Campillo that institutional arrangements do not appear to be important in determining inflation. However, the overall fit of the regression improves somewhat with the inclusion of central bank independence. The insignificance of governor turnover, a proxy for political stability, supports the conclusion of Cukierman, Webb, and Neyapti (1992) that political stability does not account for observed differences in inflation across industrialized countries.

The results reported in column IV highlight the difficulty in separating out the effects between political stability, as captured by the variables TRN, BANK, the log of PCGDP, and the log of markups. This is consistent with the argument brought forth by Miron and Campillo that political stability captures the effect of divergences of the full employment rate of output from its socially optimal rate. A comparison of Columns III and IV again indicates the importance of including PCGDP as well as its apparent superiority over markups as an explanatory variable. However, this finding is not interpreted as evidence against markups, rather it is interpreted as reflecting the fact that PCGDP captures not only the effect of markups on inflation but other effects as well.

The above regressions indicate the significance of markups in the Romer and Lane regressions. In addition, markups are significant to the inclusion of several explanatory variables that have been studied in the literature. However, the inclusion of markups in the regressions presents a problem of interpretation. How do we interpret the coefficient
on openness and country size, and how do these relate to the terms of trade effect? Large open economies will be concerned with terms of trade effects. Therefore it seems natural to use an interaction between openness and country size as a variable, rather than including the variables separately in the regression.\(^{49}\)

The results for regressions using an interaction term are reported in Table 6. The results of the above regressions are similar to the previous regressions: markups and the terms of trade effect are significant.\(^{50}\) Markups remain significant when BANK and TRN are included, but not if we add the log of PCGDP. The results of column V again indicate the problem of distinguishing the effects of political stability and markups. All variables have the expected sign. The finding by Miron and Campillo that central bank independence is not important is borne out here as well. In further support of their findings, the regression results here indicate that the most important determinants of inflation are related to the underlying structure of the domestic economy. Economies that lack competition among firms have lower levels of output, which in turn creates an incentive to inflate in the hopes of raising output. In addition, terms of trade effects are small but significant.

\(^{49}\)In all of the following regressions, the inclusion of OPEN and LGDP does not improve the fit, nor do any of the results change. Furthermore, including TOT, OPEN, and LGDP simultaneously renders all three of the variables insignificant, indicating the presence of multicollinearity.

\(^{50}\)These regressions were re-run for a sub-sample of countries using the Lee (1993) measure of openness. Terms of trade effects were found to be insignificant. This arises because Australia, Iceland, and Luxembourg have been dropped from the sample, not because of the alternative measure of openness. Furthermore, the finding is consistent with the results reported in Lane (1995). In the OECD regressions using the Lee (1993) measure of openness, country size is not significant when PCGDP, central bank independence, or governor turnover rates are included.
Table 6: Markups, the Terms of Trade and Inflation

<table>
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<td>10.31</td>
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<td>(1.8)</td>
<td>(1.73)</td>
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<td>-0.23*</td>
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<td>(0.52)</td>
<td>(0.47)</td>
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<tr>
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<tr>
<td>$R^2$</td>
<td>0.57</td>
<td>0.62</td>
<td>0.55</td>
<td>0.60</td>
<td>0.68</td>
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4.4 Robustness Checks

In addition to the problem that the effect of markups on inflation is eliminated in a regression including PCGDP, it may be argued that the markup is itself an endogenous variable and determined in part by the average inflation rate. The idea is that in an economy where inflation is relatively high, the ability of prices to carry information is reduced. Therefore, firms are able to hide real price increases for their product behind the cover of nominal price changes. This, in turn, may reduce competition among firms, and so raise the markup.

This section reports regression results in which the Institute for Management Development’s world competitiveness ranking is used in place of our measure of markups. As a check on the robustness of the finding that markups are positively related to average inflation, and to provide evidence that inflation and markups are not jointly determined, we regress the log of inflation on the IMD ranking of international competitiveness as well as other explanatory variables discussed above. The ranking is from most (a rank of 1) to least (a rank of 22) competitive. Therefore the hypothesis is that the coefficient on the IMD ranking is positive: a higher IMD ranking is associated with a higher average rate of inflation. Recall that the ranking of world competitiveness and our measure of markups are highly correlated. Therefore, the IMD ranking provides us with a good proxy for markups. In addition, since the ranking is based on 244 different indicators, it may be considered an exogenous measure of competitiveness and as such can help reject the endogeneity argument that inflation affects markups. Ideally, the IMD ranking will
also enable us to separate the effects of per capita GDP and markups on inflation. The results from regressions using the IMD ranking of world competitiveness in place of the log of the markup as an explanatory variable are reported in Table 7.

All estimates have the expected sign. Results indicate that competitiveness is an important determinant of average inflation, and remains so in the presence of per capita GDP. The results also provide support for the argument that markups affect inflation. Finally, central bank independence, governor turnover rates, and the terms of trade appear to be insignificant.

4.5 Conclusion

The empirical evidence presented in this chapter provides support for the hypothesis that markups are an important determinant in cross country average inflation rates. This is consistent with the recent finding by Miron and Campillo (1996) that economic fundamentals appear to play a greater role than institutional arrangements, such as central bank independence, in overcoming the time-consistency problem. The inclusion of markups changes the interpretation of the parameter on openness and country size in the Romer and Lane regression. In order to take into account that large open economies are concerned with terms of trade effects, an interaction variable between openness and country size is included as an explanatory variable. As a consequence, the effect of the terms of trade on inflation becomes ambiguous, although more parsimonious regressions indicate that terms of trade effects are significant.
Table 7: IMD Ranking and Inflation

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<td>0.76</td>
<td>0.7</td>
<td>0.73</td>
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The main difficulty lies in the fact that per cap GDP is highly correlated with markups. When this variable is included, the fit of the regression improves substantially, but we are unable to separate out the effects of political stability, taste for inflation, optimal tax considerations and markups on inflation. However, once we realize that markups are very highly correlated with PCGDP, the importance of PCGDP in earlier regressions might indicate the impact that domestic competition among firms has on inflation, rather than optimal tax considerations or political stability. A robustness check using the Institute for Management Development ranking of international competitiveness supports the result that markups play a role in explaining differences in average inflation experiences across OECD countries. Most importantly, this finding is not weakened by the presence of PCGDP.
References


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