

Kara, Engin

Working Paper

Input-output connections between sectors and optimal monetary policy

NBB Working Paper, No. 166

Provided in Cooperation with:

National Bank of Belgium, Brussels

Suggested Citation: Kara, Engin (2009) : Input-output connections between sectors and optimal monetary policy, NBB Working Paper, No. 166, National Bank of Belgium, Brussels

This Version is available at:

<https://hdl.handle.net/10419/144378>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

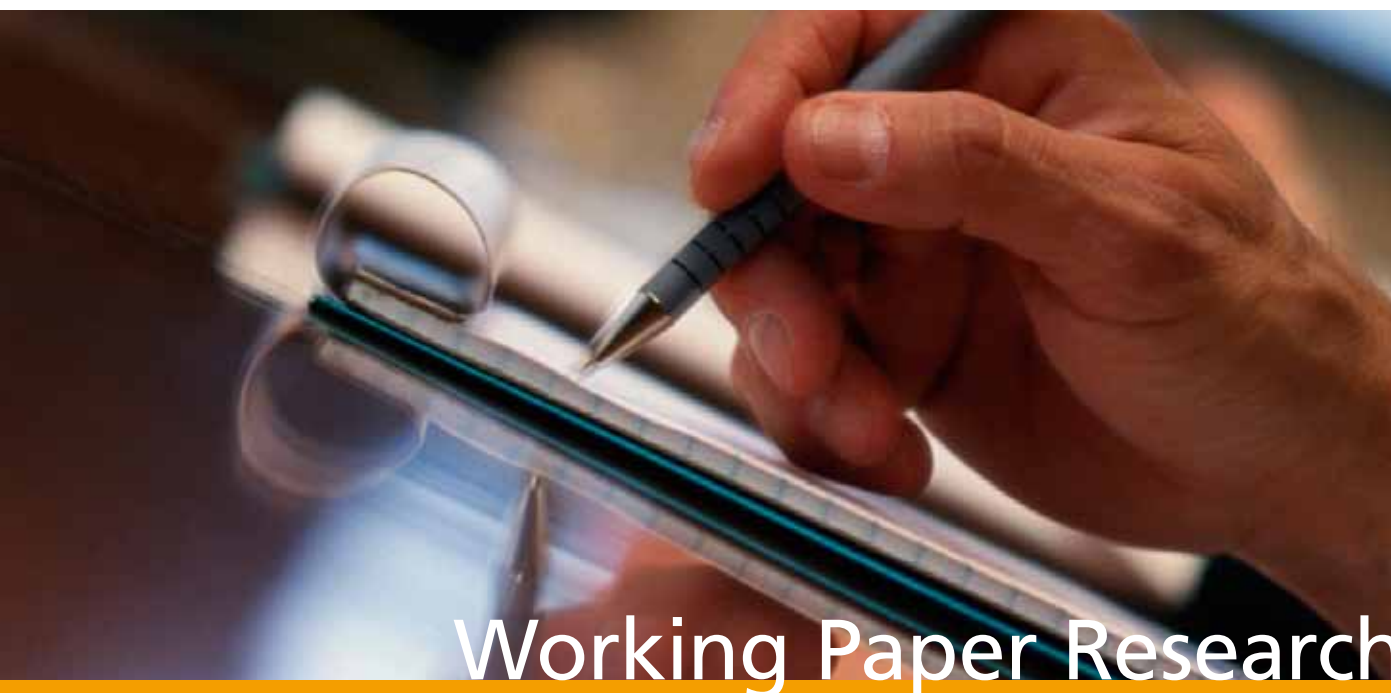
Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.

Input-output connections between sectors and optimal monetary policy



Working Paper Research

by Engin Kara

June 2009 **No 166**

Editorial Director

Jan Smets, Member of the Board of Directors of the National Bank of Belgium

Statement of purpose:

The purpose of these working papers is to promote the circulation of research results (Research Series) and analytical studies (Documents Series) made within the National Bank of Belgium or presented by external economists in seminars, conferences and conventions organised by the Bank. The aim is therefore to provide a platform for discussion. The opinions expressed are strictly those of the authors and do not necessarily reflect the views of the National Bank of Belgium.

Orders

For orders and information on subscriptions and reductions: National Bank of Belgium, Documentation - Publications service, boulevard de Berlaimont 14, 1000 Brussels.

Tel +32 2 221 20 33 - Fax +32 2 21 30 42

The Working Papers are available on the website of the Bank: <http://www.nbb.be>.

© National Bank of Belgium, Brussels

All rights reserved.

Reproduction for educational and non-commercial purposes is permitted provided that the source is acknowledged.

ISSN: 1375-680X (print)

ISSN: 1784-2476 (online)

Abstract

This paper considers the monetary policy implications of a model that features input-output connections between stages of production, so that a distinction between CPI inflation and PPI inflation arises. More specifically, this paper addresses the policy conclusion by K. Huang and Z. Liu [2005, "Inflation targeting: What inflation rate to target", *Journal of Monetary Economics* 52], which states that central banks should use an optimal inflation index that gives substantial weight to stabilising both CPI and PPI. This paper argues that these authors' findings rely on the assumption that producer prices are as sticky as consumer prices and it also shows that, once empirically relevant frequencies of price adjustment are used to calibrate the model, CPI inflation receives substantial weight in the optimal inflation index. Moreover, this rule is remarkably robust to uncertainty regarding the model parameters, whereas the policy rule proposed by Huang and Liu can result in heavy welfare losses.

Key Words: Inflation targeting, Optimal Monetary Policy.

JEL Classification: E32, E52, E58.

Corresponding author:

Engin Kara, NBB Research Department.

e-mail: engin.kara@nbb.be - mail@enginkara.eu

I am grateful to Luc Aucremanne, Pierpaolo Benigno, Huw Dixon, Zheng Liu, Emi Nakamura, Ricardo Reis, Michael Woodford and Raf Wouters for their comments on a previous draft of this paper. I thank participants at presentations at the 2008 CESifo Area conference on Macro, Money & International Finance conference, 2008 Dynare conference, the Central Bank of Cyprus, the European Central Bank and the National Bank of Belgium for helpful comments.

The views expressed in this paper do not necessarily reflect the views of the National Bank of Belgium. Faults remain my own.

TABLE OF CONTENTS

1. Introduction	1
2. The Model	4
2.1. Structure of the Economy.....	4
3.2. Log-linearized Economy.....	5
3. Welfare Function: Woodford's Approximation	7
4. Optimal Monetary Policy	9
5. Monetary Policy Rules	10
6. Choice of Parameters and Computation	11
6.1. Computation.....	12
7. Results	13
7.1. Inflation Targeting Rules.....	13
7.1.1 The Implications of Different Degree of Nominal Rigidity.....	13
7.1.2 An Application to U.S. Data.....	15
7.1.3. Degree of Nominal Rigidity Uncertainty.....	14
7.1.4. Degree of Competition Uncertainty.....	17
7.2 Output Gap Targeting.....	19
6. Summary and Conclusions	20
References.....	22
Tables and figures.....	25
National Bank of Belgium - Working papers series.....	31

1 Introduction

Over the last decade, many central banks have adopted inflation targeting as a framework for monetary policymaking. Most, if not all, inflation targeting central banks use a measure of consumer price inflation or one of its variants as a target. The use of consumer price inflation seems to be the most relevant measure of inflation if one views the ultimate goal of the monetary policy to be the welfare of households, as this measure is the most relevant for calculating the cost of living¹.

This practice raises a question: should the central banks ignore developments in other measures of inflation, such as the producer price index (PPI)? If the target is CPI inflation, this may seem a pointless question. However, it is important for at least one reason. Increases in the prices of intermediate or crude goods may pass through to consumers, resulting in a higher rate of consumer inflation. The greater is the pass through, the more PPI shocks feed into consumer prices in the economy and cause disruption. Therefore, under an inflation targeting regime, the central banks can minimize the disruptive effect of the PPI on consumer prices by also reacting to PPI inflation.

Another question arises: do increased prices of intermediate or crude goods imply a significant increase in inflation risk at the consumer level in reality? According to Ben Bernanke (2004), the answer is "almost certainly not". Ben Bernanke argues that the main reason behind this is that "raw materials costs are a small portion of total cost". A similar view has been expressed by Jean-Claude Trichet (2004).

If we take the Bernanke view and construct an "optimal inflation index" that is an appropriately weighted average of CPI and PPI inflation rates, CPI should then receive substantial weight and the weight on PPI inflation would be small.

Recent work by Huang and Liu (2005) calls this view into question. Using a Dynamic Stochastic General Equilibrium (DSGE) model that features input-output connections between the stages of production, they argue that a simple inflation targeting rule under which the short-term interest rate responds to an "optimal inflation index" results in a welfare level close to the optimum only in cases where the "optimal inflation index" places substantial weight on both CPI inflation and PPI inflation. More specifically, they find

¹This view is consistent with the view taken by Woodford (2003). Woodford (2003) stressed that the maximization of the welfare of a representative household should be the appropriate policy objective in DSGE models.

that with their calibrated parameters, the target weight of PPI should be as high as 46% in such an index. Obviously, this finding stands in sharp contrast to the view taken by Bernanke and Trichet.

However, unfortunately, in arriving at their conclusion, Huang and Liu ignore the possibility that sectors may have different characteristics and make a strong assumption that the sectors are identical in all respects. For example, they assume that the degree of nominal rigidity between the sectors is the same. This assumption, however, is inconsistent with recent microevidence provided by the European Central Bank's Inflation Persistence Network (IPN), which reveals that producer prices adjust more frequently than consumer prices². Nakamura and Steinsson's (2007a) findings indicate the same conclusion for the U.S. economy. In fact, this evidence is consistent with what a model of input-output linkages would predict. As Blanchard (1982) notes, "prices early in the chain of production move more and adjust faster, prices further in the chain move less and adjust more slowly".

This paper aims to answer the question of which inflation index the central banks should target by studying the question in a model that accounts for the asymmetries between the CPI sector and the PPI sector. To be specific, I use Huang and Liu's model to examine the monetary policy implications of alternative assumptions regarding the sectoral differences and explore how to assign weights to different sectors in an optimal inflation index for a central bank to target.

Two asymmetries will be the primary focus of the analysis: differences in the degree of nominal rigidity and in the degree of competition. I first examine the implications of differences in *the degree of nominal rigidity* for the optimal monetary policy design. I present a more realistic numerical example and calibrate the model with the empirically relevant frequencies of price adjustment for each sector for the U.S. economy. Second, I deal with the question of how differences in *the degree of competition* affect the optimal weights that the sector receives in an optimal inflation index. In a recent paper Lombardo (2006) argues that when constructing a price index for a central bank to target, a failure to take into account the possible differences in the degree of competition between the sectors can significantly affect policy evaluations. Unlike the degree of nominal rigidity, however, the de-

²See Dhyne, Alvarez, Bihan, Veronese, Dias, Hoffmann, Jonker, Lunnemann, Rumler and Vilmunen (2005) for a summary of IPN's findings on consumer prices and Vermeulen, Dias, Dossche, Gautier, Hernando, Sabbatini and Stahl (2007) for a summary of IPN's findings on producer prices.

gree of competition between different sectors is an issue surrounded by great uncertainty. First I will gauge the implications of the degree of competition uncertainty by evaluating the extent to which policy conclusions are sensitive to alternative assumptions regarding the degree of competition. I will then investigate the design of optimal monetary policy when the central bank faces uncertainty regarding the degree of competition in different sectors.

The conclusions of the paper are briefly summarised as follows. I find that once the empirically relevant frequencies of price adjustment for each sector are used to calibrate the model, the PPI inflation indeed receives a positive target weight. However, the weight is much less than in the case where the degree of nominal rigidity between sectors is assumed to be the same. The target weight of PPI inflation is around 18%, a little less than half of what it is under a symmetric degree of nominal rigidity³.

The results also suggest that formulating and implementing a rule based on a belief that the degree of nominal rigidity is the same between the sectors results in poor outcomes if the PPI sector actually adjusts more frequently than the CPI sector. In contrast, if the central bank designs and implements monetary policy rule based on the assumption that the degree of nominal rigidity is relatively low in the PPI sector, this rule also performs reasonably well if the degree of nominal rigidity turns out to be the same. This result further strengthens the case for a rule that puts large weight on CPI inflation.

I show that, holding other things constant, an increase in the degree of competition in the PPI sector increases the optimal weight of the PPI inflation. However, when there is uncertainty regarding the degree of competition between sectors, a central bank is concerned with protecting itself against errors should assume a lower degree of competition in the PPI sector compared to the CPI sector and set the target weight of the PPI inflation as 12%. In contrast, welfare losses would be large if the central bank assumes that the degree of competition is higher in the PPI sector than the CPI sector.

Finally, I find that the strict output targeting rules perform very well in this model and give a welfare level close to optimum. This result also is in contrast to the finding of Huang and Liu. However, as is well known, this type of rule is not operational in the sense of McCallum(1999), i.e., the rule requires a measurement of the natural rate of output in the economy, which

³Note that in a case where the degree of nominal rigidity between the sectors is the same, the optimal weight is 38%, not 46%, as argued by Huang and Liu. The difference arises due to a technical error in Huang and Liu's calculations.

is difficult and controversial. In practice central banks may still prefer to choose inflation as their target.

Therefore, this paper suggests that the policy implications of a model with input output connections is in line with the practice of many inflation targeting central banks, that pay close attention to "CPI inflation".

The remainder of the paper is organized as follows: Section 3 outlines the model. Section 4 derives a welfare function for a central bank based on a representative household's utility function. Section 5 characterizes optimal monetary policy. Section 6 looks at the implications of alternative assumptions regarding the sectoral differences for optimal monetary policy design and compares the performance of alternative simple rules. Section 7 summarizes the conclusions.

2 The Model

The model is the same as that in Huang and Liu (2005). The approach of the model is to incorporate intermediate goods into an otherwise standard DSGE model with monopolistic competition and no capital accumulation. The production of consumption goods requires a composite of intermediate goods and labour as inputs, whereas the production of intermediate goods requires labour as the only input. The exposition here aims to outline the basic elements of the model. There are three types of agents in the economy: firms, consumers and the government. First, I describe the behaviour of the households and the government, which are standard. Then, I describe the behaviour of the firms. Huang and Liu (2005) provide a detailed discussion of the underlying assumptions of the model and the derivation of the structural equations; thus, the presentation here is kept brief.

2.1 Structure of the Economy

There is a continuum of identical and infinitely lived households. These households derive utility from consumption and leisure. They buy a continuum of differentiated consumption goods, which they value according to a Dixit-Stiglitz aggregator. The government conducts monetary policy and provides production subsidies to eliminate any distortions in the steady state. The production subsidies are financed by lump-sum taxes.

The production of consumption goods goes through two stages of processing, from intermediate goods to finished goods. In fact, the production side of the economy can be thought of as having two sectors: sector m , in which the intermediate goods are produced and sector f , in which the final consumption goods are produced. Within each sector or each stage of processing, there is a continuum of firms. In each sector, the firms have a monopoly power over a specific product, for which the demand has a constant price elasticity θ_k for $k \in \{f, m\}$. In sector f , firms operate a technology $Y_{ft}(j) = (\bar{Y}_{mt})^\phi (A_{ft}N_{ft}(j))^{1-\phi}$ that transforms a composite of intermediate goods (\bar{Y}_{mt}) , which is a Dixit-Stiglitz aggregate of differentiated intermediate goods, and labour $(N_{ft}(j))$ into output (Y_{ft}) subject to productivity shocks (A_{ft}) . In sector m , firms produce intermediate goods which are required to produce the final consumption goods. Firms in this sector operate a technology $Y_{mt}(i) = A_{mt}N_{mt}(i)$ that transforms labour $(N_{mt}(i))$ into output $(Y_{mt}(i))$ subject to productivity shocks (A_{mt}) . The productivity shocks each follows an $AR(1)$ process with variances of innovations of σ_f and σ_m . Within each sector, firms set prices according to the Calvo process. Therefore, the optimal price in each sector is an effective markup (adjusted for subsidy) over a weighted average of the marginal costs of the future periods, during which the price is expected to remain in effect. The mark-up, μ_k , can capture many possible market structures from standard monopoly $(\mu_k = \frac{\theta_k}{\theta_k - 1})$ to perfect competition $(\mu_k = 1)$. The degree of competition increases in θ_k . The price index of the intermediate goods corresponds roughly to PPI, whereas the price index of the finished goods corresponds to CPI.

2.2 Log-linearized Economy

In this section, I will simply present the log-linearised macroeconomic framework. We define $\tilde{c}_t = c_t - c_t^*$ as the gap between actual output, c_t and the flexible-price equilibrium output level c_t^* . The Euler condition from the representative household's consumption is given by

$$\tilde{c}_t = E_t \tilde{c}_{t+1} - \sigma^{-1}(r_t - E_t \pi_{ft+1} - rr_t^*) \quad (1)$$

where σ denotes the relative risk aversion in consumption, π_{ft} is the inflation rate in the finished goods sector, r_t is the nominal interest rate and $rr_t^* = r_t^* - E_t \pi_{ft+1}^*$ denotes the real interest rate when prices are flexible. r_t^* and π_{ft}^* denote the nominal interest rate and the CPI inflation rate when

prices are flexible, respectively.

In each sector, the dynamics of inflation in terms of real marginal cost is described by an equation analogous to the one associated with a standard one-sector model:

$$\pi_{ft} = \beta\pi_{ft+1} + \kappa_f\tilde{v}_{ft} \quad (2)$$

$$\pi_{mt} = \beta\pi_{mt+1} + \kappa_m\tilde{v}_{mt} \quad (3)$$

with

$$\kappa_k = \frac{(1 - \alpha_k)(1 - \alpha_k\beta)}{\alpha_k} \text{ for } k \in \{f, m\}$$

where β is the discount rate, ϕ is the cost share of intermediate input in final goods production, $(1 - \alpha_f)$ and $(1 - \alpha_m)$ are the Calvo reset probabilities in the finished good sector and the intermediate good sector, respectively. \tilde{v}_{ft} and \tilde{v}_{mt} are the real marginal costs in the finished good sector and in the intermediate goods sector, respectively, and are given by

$$\tilde{v}_{ft} = (1 - \phi)\sigma\tilde{c}_t + \phi\tilde{q}_t \quad (4)$$

$$\tilde{v}_{mt} = \sigma\tilde{c}_t - \tilde{q}_t \quad (5)$$

where $\tilde{q}_t = q_t - q_t^*$ is the relative price gap. $q_t = p_{mt} - p_{ft}$ denotes the relative price of intermediate goods in units of consumption goods and q_t^* denotes the value of this relative price in flexible-price level equilibrium. Note that it is no longer possible to express the real marginal cost entirely as a function of the output gap, as in a one-sector economy. In this economy, in each sector, the real marginal cost depends on the output gap as well as the relative price gap. High aggregate demand increases the real marginal cost and that increases inflationary pressure in both sectors. A high relative price in the intermediate sector reduces the real marginal cost and therefore inflationary pressure in that sector, whereas a high relative price in the finished good sector increases inflationary pressure in that sector.

The relative price gap is given by

$$\tilde{q}_t = \tilde{q}_{t-1} + \pi_{mt} - \pi_{ft} - \Delta q_t^* \quad (6)$$

where Δq_t^* is given by

$$\Delta q_t^* = (1 - \phi) (\Delta a_{ft} - \Delta a_{mt}) \quad (7)$$

where $\Delta a_{kt} = a_{kt} - a_{kt-1}$ is the productivity growth rate in sector $k \in \{f, m\}$.

Finally, the productivity growth rate shocks each follow an $AR(1)$ process. In particular,

$$\Delta a_{kt} = \rho_k \Delta a_{kt-1} + \varepsilon_{kt}, \quad k \in \{f, m\}$$

where ε_{kt} is an $idd(0, \sigma_k^2)$.

3 Welfare Function: Woodford's Approximation

Huang and Liu (2005) follow the procedure described in Woodford (2003) and derive a utility based objective function of a central bank, to provide a benchmark for evaluating the performance of alternative inflation targeting monetary policy rules. In a model that leads to equilibrium conditions (1)-(6), Huang and Liu show that the second order approximation to the welfare of the representative household is given by

$$W_t = E \sum_{t=0}^{\infty} \beta^t U_t = -\frac{U_c(C)C}{2} E \sum_{t=0}^{\infty} \beta^t L_t + t.i.p + O(\|a\|^3) \quad (8)$$

where C is the steady state consumption, $U_c(C)$ is the marginal utility of consumption, $t.i.p$ collects all the terms that are independent of policy and $O(\|a\|^3)$ summarises all terms of the third or higher orders. The normalised quadratic loss function L_t is given by

$$L_t = \frac{\kappa_f \sigma}{\theta_f} \tilde{c}_t^2 + \frac{\kappa_f \phi (1 - \phi)}{\theta_f} (\sigma \tilde{c}_t - \tilde{q}_t)^2 + \pi_{ft}^2 + \phi \frac{\kappa^{gap}}{\theta^{gap}} \pi_{mt}^2 \quad (9)$$

where

$$\theta^{gap} = \frac{\theta_f}{\theta_m}, \quad \kappa^{gap} = \frac{\kappa_f}{\kappa_m}, \quad \kappa_k = \frac{(1 - \alpha_k)(1 - \alpha_k \beta)}{\alpha_k} \text{ for } k \in \{f, m\}$$

where θ_k denotes the elasticity of substitution between the differentiated goods in sector $k \in \{f, m\}$.

This loss function is similar to that obtained in a standard one-sector model, in which the central bank only cares about fluctuations in the output gap and CPI inflation, but involves two additional terms: variances of PPI inflation and the marginal cost gap in the intermediate sector. In fact, when $\phi = 0$, the loss function reduces to the loss function in a standard one-sector model, as in Woodford(2003, p. 400).

When discussing the weight that should be assigned to PPI inflation, Huang and Liu emphasised the role of the share of intermediate goods. However, it is important to note that the weight assigned to the PPI sector in the loss function depends not only on the share of intermediate goods but also on the nominal rigidity gap, $\kappa^{gap} = \frac{\kappa_f}{\kappa_m}$, and the competition gap, $\theta^{gap} = \frac{\theta_f}{\theta_m}$. Thus, the share of intermediate goods, the nominal rigidity gap and the competition gap, taken together, determine how much the central bank should care about the variability of PPI inflation. Even if one considers the case in which the share of intermediate goods gives rise to its greatest concern about fluctuations in the PPI sector, i.e. $\phi = 1$, this does not necessarily mean that the central bank should assign significant weight to the variations in the PPI inflation. Consider, for example, the extreme case in which prices in the CPI sector are sticky, whereas prices in the PPI sector can adjust every period. In this case, for any degree of competition, the weight assigned to the variations in the PPI sector is zero.

What happens more generally? For any degree of competition, if prices in the PPI sector adjust more frequently relative to the prices in the CPI sector, then the variations in the PPI sector become less important, and the weight assigned to the PPI is smaller, compared to the case in which the sectors have the same degree of nominal rigidity. Similarly, for any given degree of nominal rigidity, if the PPI sector is more competitive relative to the CPI sector, then PPI inflation becomes more important and vice versa.

The bottom line, therefore, is that the share of intermediate goods as well as the nominal rigidity gap and the competition gap play crucial role in shaping the central bank's objective. Ignoring any of these factors would result in an objective function that would not be the appropriate objective of policy and may lead to the design of welfare maximizing inflation targeting rules that may not be appropriate for implementation.

4 Optimal Monetary Policy

In the model, as noted by (Huang and Liu (2005)), the Pareto optimal allocation cannot be achieved, so long as $0 < \phi < 1$. As the loss function (equation 9) makes explicit, an equilibrium allocation is Pareto optimal in this model only if the gaps and the inflation rates are zero in every period, that is $\tilde{c}_t = \tilde{q}_t = \pi_{ft} = \pi_{mt} = 0$ for all t . However, it is impossible to satisfy all these stabilization objectives at the same time and therefore Pareto optimal allocation is not attainable. This is most easily seen by considering the case in which $\tilde{c}_t = \tilde{q}_t = 0$. When $\tilde{c}_t = \tilde{q}_t = 0$, it follows from equations (2),(3),(4) and (5) that $\pi_{ft} = \pi_{mt} = 0$. However, equations (6) and (7) imply that $\pi_{ft} - \pi_{mt} = (1 - \phi)(\Delta a_{ft} - \Delta a_{mt})$, which is inconsistent with the requirement that $\pi_{ft} = \pi_{mt} = 0$ unless the shocks are identical ($\Delta a_{ft} - \Delta a_{mt}$).

Given that the first best allocation cannot be achieved, I employ Lagrangian methods to determine the optimal monetary policy. In particular, I compute the optimal policy that can be obtained by maximizing the welfare level defined in (8) subject to the equilibrium conditions (1)- (6). I obtain the first order conditions of this problem by differentiating the Lagrangian with respect to each of the endogenous variables and setting these conditions to zero. The first order conditions are given by

$$\left(\frac{\theta_f}{\kappa_f}\right)\pi_{ft} + \lambda_{ft} - \lambda_{ft-1} - \lambda_{qt} = 0 \quad (10)$$

$$\left(\frac{\theta_m}{\kappa_m}\right)\pi_{mt} + \lambda_{mt} - \lambda_{mt-1} + \lambda_{qt} = 0 \quad (11)$$

$$\sigma\tilde{c}_t + \phi(1 - \phi)(\sigma\tilde{c}_t - \tilde{q}_t)\sigma - \lambda_{ft}(1 - \phi)\kappa_f\sigma - \lambda_{mt}\kappa_m\sigma = 0 \quad (12)$$

$$-\phi(1 - \phi)(\sigma\tilde{c}_t - \tilde{q}_t) - \lambda_{ft}\kappa_f\phi + \lambda_{mt}\kappa_m - \lambda_{qt} + \lambda_{qt+1} = 0 \quad (13)$$

where λ_{ft} , λ_{mt} and λ_{qt} denote the Lagrangian multipliers associated with the constraints. These first order conditions hold for each date $t \geq 1$. They also hold at time zero, if one substitutes the values

$$\lambda_{q,-1} = \lambda_{f,-1} = \lambda_{m,-1} = 0 \quad (14)$$

These conditions at time zero simply reflect the fact that in period zero there is no previous policy commitment that the central bank needs to take into account. Given that each of these first-order conditions hold at each period

t , they should also hold under commitment⁴.

I then use central bank's first order conditions along with the equilibrium conditions for the model to solve and calculate the level of welfare under optimal monetary policy.

While this is a useful reference to evaluate the performance of alternative simple rules, as discussed in Huang and Liu (2005), it is difficult to implement, as it requires the knowledge of leads and lags of the inflation rates and the output gap.

5 Monetary Policy Rules

I consider the performance of simple rules with coefficients chosen to maximize welfare function in equation (8). I examine the performance of alternative inflation targeting rules under which the interest rate reacts to the lagged interest rate, the CPI inflation as well as PPI inflation. In particular, I consider an inflation targeting rule with the following form:

$$r_t = a_r r_{t-1} + a_{\pi_f} \pi_{ft} + a_{\pi_m} \pi_{mt} \quad (15)$$

I also examine the performance of simple rules under which the policy instrument r_t targets the output gap. In this case, the interest rate rule is given by

$$r_t = a_r r_{t-1} + a_y \tilde{c}_t \quad (16)$$

In a two-sector model, Woodford(2003, p. 441-442) shows that strict targeting of the output gap gives welfare outcome nearly identical to that under an optimal policy. Therefore, it would be interesting to see whether Woodford's conclusion holds in a model that features input-output connections between the CPI sector and the PPI sector.

⁴However, as is well-known(e.g. Woodford (2003), p. 473, Wolman (2001) p. 41), this policy is not time-consistent. This is true because if the central bank were allowed to reoptimize in period $t > 0$ to determine the optimal policy commitment from that period onward, the policy chosen would be different from the policy selected in period $t = 0$.

6 Choice of Parameters and Computation

I begin with a calibration of the parameters indicating the degrees of nominal rigidity in the PPI sector, α_m and the CPI sectors α_f . Huang and Liu (2005) assume that the degree of nominal rigidity between the sectors is the same. In particular, they set $\alpha_m = \alpha_f = 0.75$. However, this assumption is inconsistent with recent microeconomic evidence provided by Nakamura and Steinsson (2007a).

Nakamura and Steinsson (2007a) present evidence on the proportion of prices that change in a month for consumer prices across categories and for the intermediate goods across categories of the US economy⁵. The findings reported there suggest that in the U.S. economy, intermediate goods prices adjust more frequently than consumer prices. Nakamura and Steinsson (2007a) note that there is a large amount of heterogeneity across categories both in consumer prices and in the intermediate goods prices and emphasize the median frequency of price changes when summarizing the empirical distribution of price change frequencies. In particular, they find that the median frequency of price changes for consumer prices is 8.7% per month, whereas the corresponding figure for intermediate goods prices is 13.3%⁶. Following Bils and Klenow (2004), I interpret this statistic as a Calvo reset probability. I convert these monthly figures to quarterly figures and use them to calibrate the model for the U.S. economy. I assume that $\alpha_f = 0.73$ and $\alpha_m = 0.60$.

The other two important parameters to calibrate are θ_m and θ_f , which measure the elasticity of substitution between differentiated goods at the two stage of processing. Given the scarcity of disaggregated evidence on these two parameters, following Huang and Liu, I proceed by calibrating $\theta_m = \theta_f = 10$, which corresponds to a steady state markup of 11%. I will then assess the policy and welfare implications of alternative combinations of these parameters.

The rest of the parameter values are taken from Huang and Liu (2005). In

⁵For the US, there is no "entire PPI index". The PPI is represented in a three stage-of-process format (finished goods, intermediate goods and crude materials). These are three separate indexes and are not combined into an aggregate index. See <http://www.bls.gov> for a full discussion.

⁶Note that these numbers exclude sales. This is the approach taken by Golosov and Lucas (2007) and Nakamura and Steinsson (2007b). As Golosov and Lucas (2007) notes when discussing whether sales should be excluded, "To obtain a good match between theory and data, then, sales must either be removed from the data or added to the model...we took the first course"

particular, I assume that the cost-share of intermediate goods in final goods production to $\phi = 0.6$. I use a discount factor β of 0.99 which corresponds to the annual real interest rate in the steady state of 4%. I assume that $\omega = 0$, which implies that the representative household's utility is linear in labour hours. Finally, I set $\rho_k = 0.95$ and the standard deviations of innovations to productivity shocks σ_k to 0.02.

6.1 Computation

I use Dynare to solve the model (see Juillard (1996)). To compute the optimal weights in the optimal inflation index, I numerically minimize the welfare loss with respect to the parameters in the monetary policy rule, a -coefficients, subject to the equilibrium conditions ((1)- (6)). To do so, I use the optimization routine "fminsearch" in Matlab 7.

Note that there is a slight error in Huang and Liu's Matlab code. In their Matlab code, when they define the inverses of κ_f and κ_m , they miss a pair of parentheses. In effect, the inverses of κ_f and κ_m are defined as $d_f^{HL} = \frac{1}{\kappa_f} = \frac{\alpha_f(1-\alpha_f)}{(1-\beta\alpha_f)}$, $d_m^{HL} = \frac{1}{\kappa_m} = \frac{\alpha_m(1-\beta\alpha_m)}{(1-\beta\alpha_m)}$. The correct definitions are $d_f = \frac{1}{\kappa_f} = \frac{\alpha_f}{(1-\beta\alpha_f)(1-\alpha_f)}$, $d_m = \frac{1}{\kappa_m} = \frac{\alpha_m}{(1-\beta\alpha_m)(1-\alpha_m)}$. As discussed in section 3, the price dispersion in each sector in sector $k \in \{f, m\}$ depends on the d_k . Huang and Liu (2005) set $\alpha_f = \alpha_m = 0.75$. When $\alpha_f = \alpha_m = 0.75$, $d_k^{HL} < d_k$. Therefore, the degree of price dispersion in each sector is underestimated in Huang and Liu (2005).

7 Results

The aim of this section is to investigate the effects of the asymmetries between the CPI sector and the PPI sector in optimal monetary policy design. As discussed above, I will first consider the performance of inflation-targeting rules and will then consider the case in which the central bank targets the output gap. Throughout the paper, welfare levels (W) are expressed in terms of the equivalent percentage decline in steady state consumption, which can be obtained by dividing W by $U_c C$ (and multiplied by 100).

7.1 Inflation Targeting Rules

In this subsection, I examine the performance of the inflation-targeting rules with coefficients chosen to maximise welfare in the model. The main goal of this section is to investigate the relationship between the optimal policy parameters a_{π_f} and a_{π_m} , and the difference in the degree of nominal rigidity between the sectors, as well as the difference in the degree of competition. However, before presenting my main results by using the chosen parameter values for α_m , α_f , θ_m and θ_f , it is useful to discuss possible effects of structural asymmetry on optimal monetary policy design.

7.1.1 The Implications of Different Degree of Nominal Rigidity

I begin by looking at the implications of different degrees of nominal rigidity. I let the value of the of Calvo-PPI parameter, α_m , vary from 0.75 to 0. For the sake of comparison, I set the value of the Calvo CPI-sector parameter, α_f , to be 0.75, which is the value of α_f assumed by Huang and Liu, with the other parameters held at baseline values. For each case, I optimise the coefficients of the hybrid rule to maximise welfare in the model, then use the optimised coefficients, construct an optimal inflation index and calculate the weight that the PPI inflation receives in such an index. The optimal weight that the PPI sector receives is given by $a_{\pi_m} / (a_{\pi_f} + a_{\pi_m})$.

The welfare levels under the hybrid rule and the optimal policy are reported in Figure 1. Figure 2 reports the optimal weight, which the PPI sector receives in the optimal index. As Figure 1 shows, the hybrid rule performs very well and gives a welfare outcome close to the optimum. However, the net benefit of switching to the hybrid rule depends on the degree of nominal rigidity in the PPI sector. For example, when the degree of nominal rigidity between the sectors is the same, then the optimal CPI rule incurs a welfare loss of 4%, which is about 1.6 times the loss under the optimal policy⁷. However, as the figure shows, the net gain of using the hybrid rule falls dramatically as the PPI sector becomes more flexible. The question

⁷The scale of welfare losses is in line with that of in Canzoneri, Cumby and Diba (2006). However, the scale is different from that of in Huang and Liu. For example, when the degree of nominal rigidity between the sectors is the same, the findings reported in Huang and Liu suggest that the CPI rule incurs a welfare loss of 0.25%. The difference in scale arises due to the fact that, for the reasons discussed earlier, the price dispersion in each sector is underestimated in Huang and Liu.

then arises: how does the optimal weight of the PPI sector changes as the relative frequency between the sectors change? Five points should be made:

First, as evident from Figure 2, the optimal weight of the PPI sector is highly sensitive to the Calvo parameter in that sector and decreases as the PPI sector adjusts more frequently relative to the consumer prices. This result is closely related to the findings of Benigno (2004), Mankiw and Reis (2003) and Woodford (2003).

Second, if the degree of nominal rigidity between the sectors is the same, which corresponds to the case studied by Huang and Liu, the target weight that the PPI sector receives is as high as 38%. Note that this number is lower than the value reported by Huang and Liu. The corresponding value in Huang and Liu is 46%. The difference from Huang and Liu seems to arise from the error described above.

Third, small differences in the relative frequency can lead to significant decreases in the optimal PPI weight. For example, if the relative frequency between the sectors is only 10%, then the optimal weight should be reduced by 15%, passing from 0.38 to 0.33.

Finally, if the PPI sector has fully flexible prices, then the optimal weight that the PPI sector receives in the optimal index is zero, which is in line with the findings of Aoki (2001).

The main reason for these results is that, as discussed earlier, the central bank should also care about variations in PPI inflation. The reason why PPI inflation enters the loss function is that the production of intermediate goods requires labour as an input. The demand for labour input (\tilde{n}_{mt}) in this sector is given by

$$\tilde{n}_{mt} = - (1 - \phi) \tilde{q}_t + (1 + (1 - \phi) \sigma) \tilde{c}_t + \int_0^1 \left(\frac{P_{ft}(i)}{P_t} \right)^{-\theta} di + \int_0^1 \left(\frac{P_{mt}(i)}{P_t} \right)^{-\theta} di \quad (17)$$

The demand for labour input in the PPI sector depends on the price dispersion $\left(\int_0^1 \left(\frac{P_{mt}(i)}{P_t} \right)^{-\theta} di \right)$ caused by sticky prices in that sector. It is through this channel that PPI inflation turns out to be relevant for welfare. Indeed, as discussed above, the weight assigned to PPI inflation in the loss function decreases as the degree of nominal rigidity in that sector decreases. As a result, variations in PPI inflation becomes less important as the contract duration decreases and, therefore, PPI inflation receives less weight in the

optimal inflation index as the contract duration decreases. In addition to this, the inflation process in the CPI sector is influenced by the price level in the PPI sector. This can be seen easily by rewriting the real marginal cost in the CPI sector in nominal terms. Using equations (4) and (5), one can clearly show that marginal cost in the CPI sector is related to the price level in the PPI sector (p_{mt}) by

$$v_{ft} = \sigma \tilde{c}_t + \phi p_{mt} + (1 - \phi)p_{ft} - \phi q_t^* \quad (18)$$

Thus, there is a spillover effect from the PPI sector to the CPI sector via the marginal cost. As a result, ignoring fluctuations in PPI inflation would be even more disruptive. A policy rule that stabilises fluctuations in PPI inflation would also minimise the disruptive effect of the PPI sector on the CPI sector.

It is important to note that the results are also related to the finding obtained in a model with sticky prices and sticky wages, such as Erceg, Henderson and Levin (2000) in which it is argued that optimal monetary policy can be closely approximated by targeting nominal wages. As noted by Huang and Liu, the main difference between this model and that of Erceg et al. (2000) is that in Erceg et al. (2000) the primary input is labour rather than intermediate goods. However, this difference has important implications on monetary policy design. This is because the nominal rigidity of labour contracts is of a different nature from the nominal rigidity of intermediate goods. If we think of labour as the primary input, the degree of nominal rigidity would probably be much higher than that for intermediate goods. Therefore, as the findings above suggest, if I were to assume that the primary input is labour, then the optimal weight of this sector would have been large.

7.1.2 An Application to U.S. Data

I have thus far established the intuitions on the mechanism through which sectoral asymmetries can affect the policymaker's objective function and the optimal weights that the sectors receive in the optimal inflation index. The findings in the previous section explicitly show that differences in the nominal rigidity between the PPI sector and the CPI sector have significant implications on the design of an optimal monetary policy. The question is then: how much weight should the central banks assign to the PPI and the CPI in reality?

Table 1 provides an answer by applying the model to frequencies of price adjustment for the U.S. economy. Reported here is the target weight of the PPI inflation in the optimal inflation index and the relative degree of stickiness between the sectors.

My conclusion is evident: once the empirically relevant contract lengths for each sector are used to calibrate the model, the PPI inflation indeed receives a positive target weight, but the weight is much less than in the case where it is assumed that both sectors have the same degree of nominal rigidity. In particular, the target weight on the PPI sector is around 18%, roughly half of what it is under a symmetric degree of nominal rigidity.^{8 9}

7.1.3 Degree of Nominal Rigidity Uncertainty

How important is the finding in the previous section? In order to understand the importance of this finding I consider the case in which the central bank formulates its policy by assuming, incorrectly, that sectors are identical in terms of degree of nominal rigidity, when in fact they are not. As empirical evidence surveyed in section 1 reveals, the PPI sector adjusts more frequently than the CPI sector. I then compute the welfare loss under such a policy rule in the true economy.

Table 2 reports the welfare losses under the policymaker's misperceptions about the degree of nominal rigidity between the sectors. The table indicates that if the PPI sector is more flexible than the CPI sector in the true economy, then formulating monetary policy based on the incorrect assumption that the sectors are the same in terms of their contract length would lead to substantial welfare losses.

How robust is this rule which gives substantial weight to the CPI inflation? To assess the robustness of this rule, I consider the case in which the policymaker optimises the parameters of the policy rule based on the assumptions that in the PPI sector the prices adjust more frequently than the prices in the CPI sector. However, in the true economy it turns out that the

⁸I have also used the mean frequencies of adjustment to calibrate the model. Using the mean, instead of the median, does not change the results significantly. In the case of the mean, $\alpha_f = 0.37$ and $\alpha_m = 0.2$ and the optimal PPI weight is 17%.

⁹I have also calibrated the model for the Euro-Area by using the mean frequencies of adjustment. Unfortunately, the median frequencies of adjustment are not available for the Euro-Area. Calibrating the model for the Euro-Area does not change the results significantly. In the case of the Euro-Area, $\alpha_f = 0.55$, $\alpha_m = 0.34$ and the optimal PPI weight is around 15%.

degree of nominal rigidity between the sectors is the same. I again compute the welfare loss under such a policy rule in the true economy.

As Table 2 shows, employing a rule that is optimised under the assumption that the prices in the PPI sector adjust more frequently within a model that assumes the same degree of nominal rigidity between the sectors results in a welfare loss. This level of loss is much less than the case in which the monetary policy is formulated by assuming the same degree of nominal rigidity. More specifically, the increase in the value of loss is roughly half of that under the previous case.

Table 3 shows the reasons for this result. Reported in the table are the standard deviations of the output gap, CPI inflation and PPI inflation under central bank's misperceptions about nominal rigidities. Consider first the case in which the central bank formulates its policy by assuming that prices in the PPI sector adjusts more frequently than prices in the CPI sector, whereas in the true economy the degree of nominal rigidity between the sectors is the same. As noted above, in this case, the target weight on PPI inflation is around 18%, whereas the corresponding number in the true economy is around 38%. Not surprisingly, increased target weight on CPI inflation leads to lower CPI inflation variability but that comes at the cost of greater PPI inflation and output gap variability. On the other hand, if the central bank, when formulating its policy, overestimates the degree of nominal rigidity in the PPI sector, then the more aggressive response to PPI inflation leads to lower PPI inflation variability; however, that then leads to greater CPI inflation and output gap variability. The increase in CPI inflation volatility is more costly in the latter case, since the rise in CPI inflation volatility has more weight in the loss function. Thus, overestimating the degree nominal rigidity in the PPI sector leads to a larger deterioration in social welfare.

7.1.4 Degree of Competition Uncertainty

Evidence concerning the degree of competition between the PPI sector and the CPI sector is scarce. It should be noted that there are some studies that argue that the frequency of price adjustment increases with market concentration (e.g. Carlton (1986) and Powers and Powers (2001)). However, a recent study, Bils and Klenow (2004) finds that market power, as measured by market concentration, is not an accurate predictor of the frequency of price changes. Given this uncertainty, when examining the implications of the relative degree of nominal rigidity on optimal monetary policy, I follow

Huang and Liu to assume that the degree of competition between the sectors is the same. Specifically, I set $\theta_m = \theta_f = 10$. However, before drawing any firm policy conclusions, it is essential to check the sensitivity of policy conclusions to alternative assumptions regarding the degree of competition between the sectors. As pointed out by Lombardo (2006), when constructing an inflation index for a central bank to target in a two sector model, the differences in the degree of competition between the sectors can affect policy conclusions. I now consider the situations in which the degree of competition between the sectors differs.

Figure 3 performs the same exercise as in Table 1 but with alternative assumptions regarding the relative degree of competition between the sectors. As expected, allowing for different degrees of competition between the sectors effects the optimal weights. The optimal weight on PPI decreases as the competition gap, $\theta^{gap} = \frac{\theta_f}{\theta_m}$, increases and vice versa. However, it should be noted that the effect is small expect in cases where there is a significant difference in the degree of competition between sectors. The reason for these results is that price dispersions caused by sticky prices in sector $k \in \{f, m\}$ increases θ_k due to the assumed Dixit-Stiglitz preferences. The higher the θ_k (i.e. the goods are more substitutable); as the price dispersion in the PPI sector increases, the more disruptive it becomes. Therefore, the target weight of the PPI sector increases with increases in θ_k .

Given this finding, a question arises: how should a central bank concerned with protecting against error act when there is uncertainty regarding the degree of competition? To answer this, I investigate the consequences of employing an incorrect combination of values for the parameters which characterise the degrees of competition in the sectors by using the notion of fault tolerance introduced by Levin and Williams (2003). More specifically, I consider variations in θ_m^P , from 2 to 20, which denotes the central bank's perceived value of θ_m , while θ_f and the other parameters are held at the baseline values. For a given value of θ_m^P , I let the central bank find the optimal coefficients in the policy rule based on θ_m^P , which may differ from θ_m , the parameter that characterises the actual degree of competition in the PPI sector. I then compute the welfare loss under such a policy rule with θ_m ¹⁰.

Figure 4 plots the welfare losses under misperceived degree of competition

¹⁰The exercise is similar to the previous study by Walsh (2005) in assessing the consequences of formulating monetary policy under possible misperceptions of the model parameters.

(θ_m^p) relative to that under correct degree of competition (θ_m). The figure shows that the central bank can avoid most of the losses due to competition uncertainty by assuming that the degree of competition in the PPI sector is lower than the CPI sector. In other words, underestimating θ_m^P appears to lead to a more robust policy. Here, a min-max strategy would set $\theta_m^P = 6$, which implies that the target weight of the PPI sector is 12%. When $\theta_m^P = 6$, the average loss is never more than 20% worse than the loss under the correct degree of competition. Note that when $\theta_m^P = 2$, which implies that the target weight of the PPI is 4%, the average loss is no more than 33% worse than the loss under the correct degree of competition; whereas, when $\theta_m^P = 20$, the target weight of the PPI is 30% and the average loss can be more than 270% than the loss under the correct degree of competition.

Thus, a policy rule that does not completely ignore PPI inflation but gives substantial weight to CPI inflation exhibits much greater fault tolerances. In contrast, a policy that gives substantial weight to both CPI inflation and PPI inflation can lead to substantial welfare losses.

7.2 Output Gap Targeting

I now consider the performance of the output gap targeting rule. Figure 5a plots the welfare level under the optimal policy and the output gap targeting when α_m varies from 0 to 1, while fixing the other parameters at the baseline values. Figure 5b performs the same exercise, as in Figure 5a, but it considers variations in θ_m .

As evident from the figures, a simple rule under which the central bank responds to the output gap yields a welfare outcome nearly identical to the optimal policy regardless of the relative frequency of price adjustment and of competition. The reason for this result can be easily seen by simply summing the inflation equations for sectors f and m , which gives

$$\pi_t^a = \beta\pi_{t+1}^a + \sigma\tilde{c}_t \quad (19)$$

where

$$\pi_t^a = \frac{1}{\kappa_f}\pi_{ft} + \phi\frac{1}{\kappa_m}\pi_{mt}$$

It follows from this equation that a policy that targets the output gap can also eliminate fluctuations in π_t^a , which suggests that output gap stabilization

is equivalent to stabilization of inflation in this model.

Given this finding, it can also be concluded that any simple rule (e.g. optimal Taylor rule) under which the coefficients are optimally chosen and includes the output gap as a targeting variable would yield a welfare outcome that is close to optimum. This result contradicts with the finding of Huang and Liu (2005), who argued that the incorporation of the output gap as an additional targeting variable does not affect welfare results. The difference from Huang and Liu seems to arise from the error in Huang and Liu (2005).

Although strictly targeting of the output gap gives outcome close to optimum, as has been pointed out by various authors (see for example Erceg and Levin (2005), Levin, Onatski, Williams and Williams (2005), Woodford (2003)), this type of rule is not operational in the sense of McCallum (1999). That is, this type of rule is demanding concerning the knowledge of the economy. In particular, it requires measurement of the natural rate of output in the economy. However, measurement of the natural rate of output and, therefore, of the output gap is difficult and controversial. Therefore, in practice central banks may still prefer to choose inflation as their target.

8 Summary and Conclusions

I have shown that in a model which features input-output connections between sectors such that a distinction between CPI and PPI arises from the model, a welfare maximizing central bank should use an optimal inflation index that gives substantial weight to CPI inflation. For those familiar with the conclusion of Huang and Liu (2005), this result should be surprising. They argue that the "optimal inflation index" should place substantial weight on both CPI inflation and PPI inflation.

The main difference is in our assumptions regarding the degree of nominal rigidity between sectors. Huang and Liu, in arriving at their conclusion, incorrectly assume that the degree of nominal rigidity between the sectors is the same, when in fact it is not. Microevidence suggests that producer prices adjust more frequently than consumer prices. The degree of nominal rigidity between sectors plays an important role in determining the weights assigned to sectors. The weight on PPI inflation is small if prices in this sector are more flexible, as the prices can adjust more frequently and the disruptive effect of PPI inflation in the economy is small. I apply the model to the U.S. economy and find that the optimal PPI weight is approximately 18%.

The degree of competition between sectors can also affect the optimal weights assigned to sectors. Holding other factors constant, increased competition in the PPI sector increases the target weight of the PPI sector. However, the degree of competition between different sectors is an issue of great uncertainty. I examine how monetary policy should be formulated when the central bank faces uncertainty regarding the degree of competition uncertainty. The results suggest that a central bank concerned with protecting itself against errors should assume that a lower degree of competition in the PPI sector compared to the CPI sector. In this case, the optimal PPI weight is around 12%.

These findings suggest that central banks should use an optimal inflation index that puts large weight on CPI inflation. In fact, a variety of comparisons indicate that if central banks use the inflation index that assigns substantial weight to stabilizing both CPI and PPI, then the welfare loss would be large.

Finally, it may be useful to note that the strict output targeting rules perform very well in this model and give a welfare level close to the optimum. However, it is well known that this type of rule is not easy to implement, as this rule requires measurements of the natural rate of output in the economy, which is difficult and controversial. Therefore, a rule targeting inflation that mainly focuses on CPI inflation represents a sensible approach to policy.

References

- Aoki, K.: 2001, Optimal monetary policy response to relative price changes, *Journal of Monetary Economics* **48**(1), 55–80.
- Benigno, P.: 2004, Optimal monetary policy in a currency area, *Journal of International Economics* **63**(2), 293–320.
- Bernanke, B.: 2004, Monetary policy and the economic outlook: 2004, *The Federal Reserve Board* (<http://www.federalreserve.gov/boarddocs/Speeches/2004/20040104/default.htm>).
- Bils, M. and Klenow, P.: 2004, Some evidence on the importance of sticky prices, *Journal of Political Economy* **112**(5), 947–985.
- Blanchard, O. J.: 1982, Price asynchronization and price level inertia, *NBER working paper no: 900*.
- Canzoneri, M., Cumby, R. and Diba, B.: 2006, *The Cost of Nominal Rigidity in NNS Models*.
- Carlton, D. W.: 1986, The rigidity of prices, *American Economic Review* **76**(4), 637–658.
- Dhyne, E., Alvarez, L. J., Bihan, H. L., Veronese, G., Dias, D., Hoffmann, J., Jonker, N., Lunnemann, P., Rumler, F. and Vilmunen, J.: 2005, Price setting in the euro area: some stylized facts from individual consumer price data, *Working paper series 524*, *European Central Bank*.
- Erceg, C. J., Henderson, D. and Levin, A.: 2000, Optimal monetary policy with staggered wage and price contracts, *Journal of Monetary Economics* **46**(2), 281–313.
- Erceg, C. J. and Levin, A. T.: 2005, Optimal monetary policy with durable consumption goods, *Journal of Monetary Economics* (forthcoming).
- Golosov, M. and Lucas, R. E.: 2007, Menu costs and Phillips curves, *Journal of Political Economy* (115), 171–199.
- Huang, K. X. and Liu, Z.: 2005, Inflation targeting: What inflation rate to target?, *Journal of Monetary Economics* **52**(8), 1435–1462.

- Juillard, M.: 1996, Dynare: A program for the resolution and simulation of dynamic models with forward variables through the use of a relaxation algorithm, *CEPREMAP, Working Paper No. 9602*. (<http://www.cepremap.cnrs.fr/dynare>) .
- Levin, A. T., Onatski, A., Williams, J. C. and Williams, N.: 2005, Monetary policy under uncertainty in micro-founded macroeconomic models, *NBER Working Paper No. 11523* .
- Levin, A. T. and Williams, J. C.: 2003, Robust monetary policy with competing reference models, *Journal of Monetary Economics* **50**(5), 945–975.
- Lombardo, G.: 2006, Inflation targeting rules and welfare in an asymmetric currency area, *Journal of International Economics* **68**(2), 424–442.
- Mankiw, N. G. and Reis, R.: 2003, What measure of inflation should a central bank target?, *Journal of the European Economic Association* **1**(5), 1058–1086.
- McCallum, B. T.: 1999, *Issues in the design of monetary policy rules in: J.B. Taylor and M. Woodford, eds, Handbook of Macroeconomics*, Vol. 1, North-Holland, Amsterdam.
- Nakamura, E. and Steinsson, J.: 2007a, Five facts about prices: A reevaluation of menu cost models, *Quarterly Journal of Economics* (forthcoming).
- Nakamura, E. and Steinsson, J.: 2007b, Monetary non-neutrality in a multi-sector menu cost model, *University of Harvard, mimeo* .
- Powers, E. T. and Powers, N. J.: 2001, The size and frequency of price changes: Evidence from grocery stores, *Review of Industrial Organization* **18**(4), 397–416.
- Trichet, J.-C.: 2004, Press conference by Jean-Claude Trichet, *The European Central Bank*, (<http://www.ecb.eu/press/pressconf/is041202.en.html>) .
- Vermeulen, P., Dias, D., Dossche, M., Gautier, E., Hernando, I., Sabbatini, R. and Stahl, H.: 2007, Price setting in the euro area: some stylised facts from individual producer price data, *Working paper series 727, European Central Bank* .

- Walsh, C.: 2005, Endogenous objectives and the evaluation of targeting rules for monetary policy, *Journal of Monetary Economics* **52**, 889–911.
- Wolman, A. L.: 2001, A primer on optimal monetary policy with staggered price-setting, *Federal Reserve Bank of Richmond Economic Quarterly* (87), 27–52.
- Woodford, M.: 2003, Interest and prices: Foundations of a theory of monetary policy, *Princeton University Press, Princeton, NJ*.

	$\frac{1-\alpha_m}{1-\alpha_f}$	The optimal weight of PPI inflation
The U.S. Economy	1.52	0.18

Table 1: The optimal weight of PPI inflation with empirically relevant frequencies

Actual rigidities	Perceived rigidities	
	$\alpha_f = 0.73, \alpha_m = 0.60$	$\alpha_f = 0.73, \alpha_m = 0.73$
$\alpha_f = 0.73, \alpha_m = 0.60$	1.00	1.28
$\alpha_f = 0.73, \alpha_m = 0.73$	1.18	1.00

Table 2: Welfare Losses when the central bank misperceives the relative degree of nominal rigidity between sectors

Actual rigidities	Perceived rigidities					
	$\alpha_f = 0.73, \alpha_m = 0.60$			$\alpha_f = 0.73, \alpha_m = 0.73$		
	\tilde{c}_t	π_{ft}	π_{mt}	\tilde{c}_t	π_{ft}	π_{mt}
$\alpha_f = 0.73, \alpha_m = 0.60$	0.03	0.65	2.95	0.65	1.36	2.21
$\alpha_f = 0.73, \alpha_m = 0.73$	0.82	0.65	2.94	0.05	1.36	2.21

Table 3: Standard deviations(%) when the central bank misperceives the relative degree of nominal rigidity between sectors

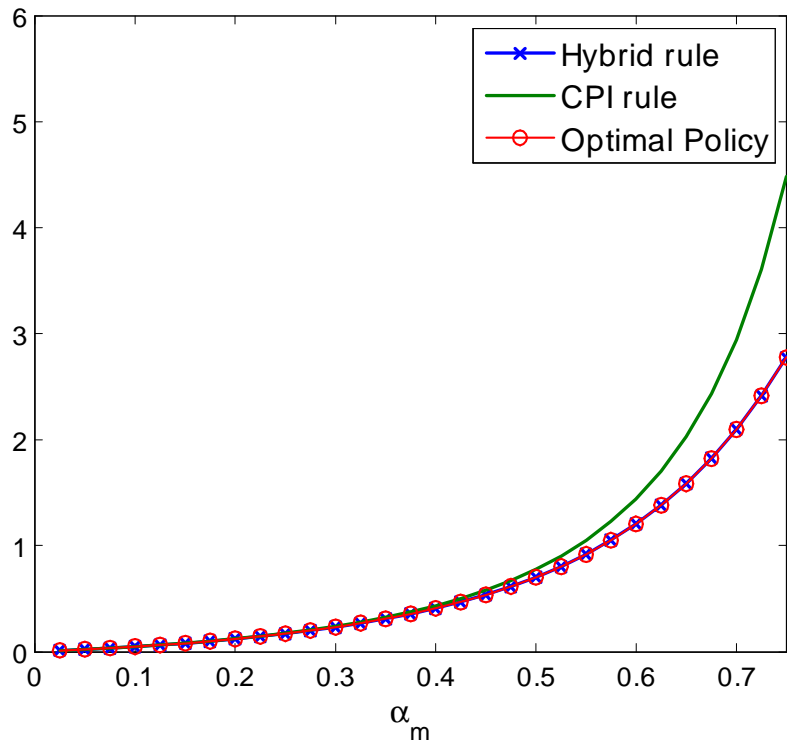


Figure 1: Welfare losses under alternative inflation targeting regimes for different degrees of nominal rigidity in producer prices ($\alpha_f = 0.75$): percent of steady state consumption.

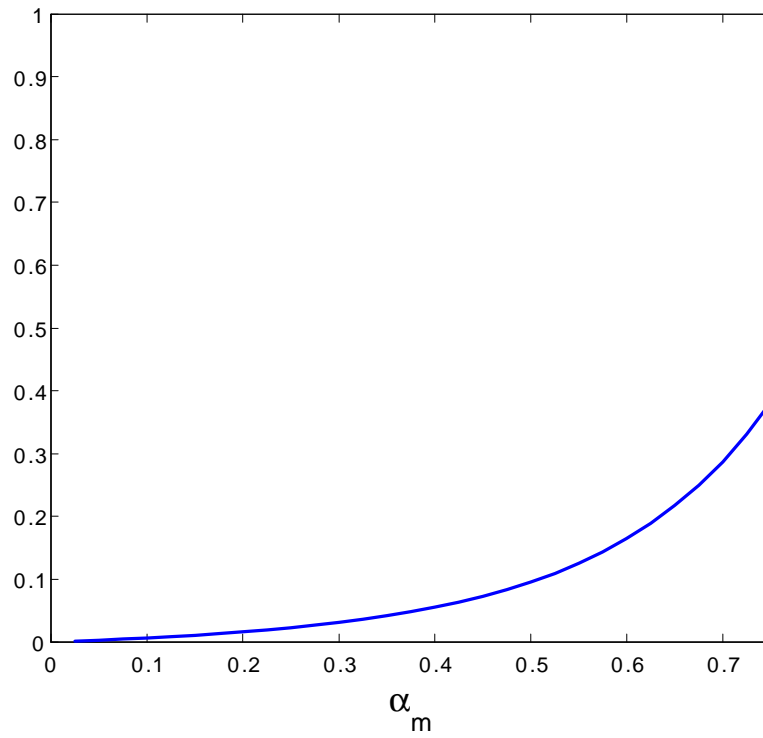


Figure 2: The weight on PPI inflation in the optimal inflation index for different degrees of nominal rigidity in producer prices ($\alpha_f = 0.75$).

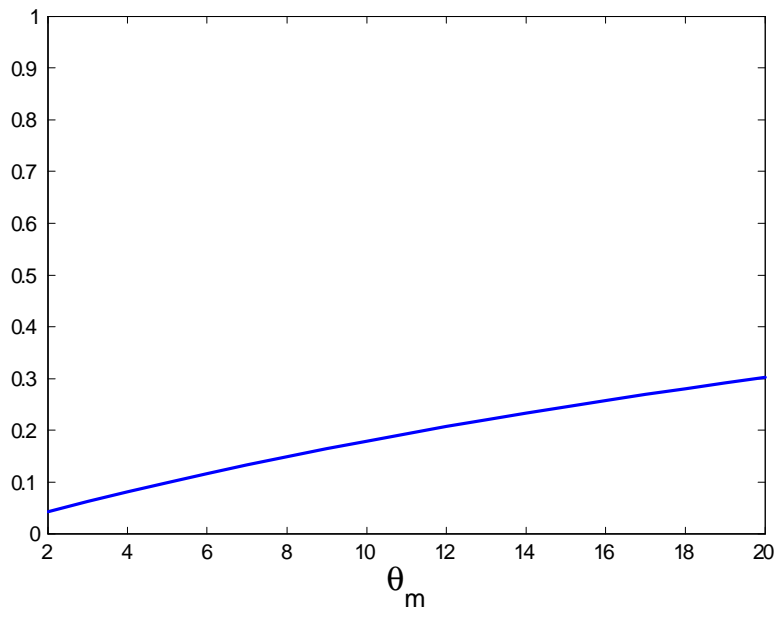


Figure 3: The weight on PPI inflation in the optimal inflation index for different degrees of competition in producer prices ($\theta_f = 10$).

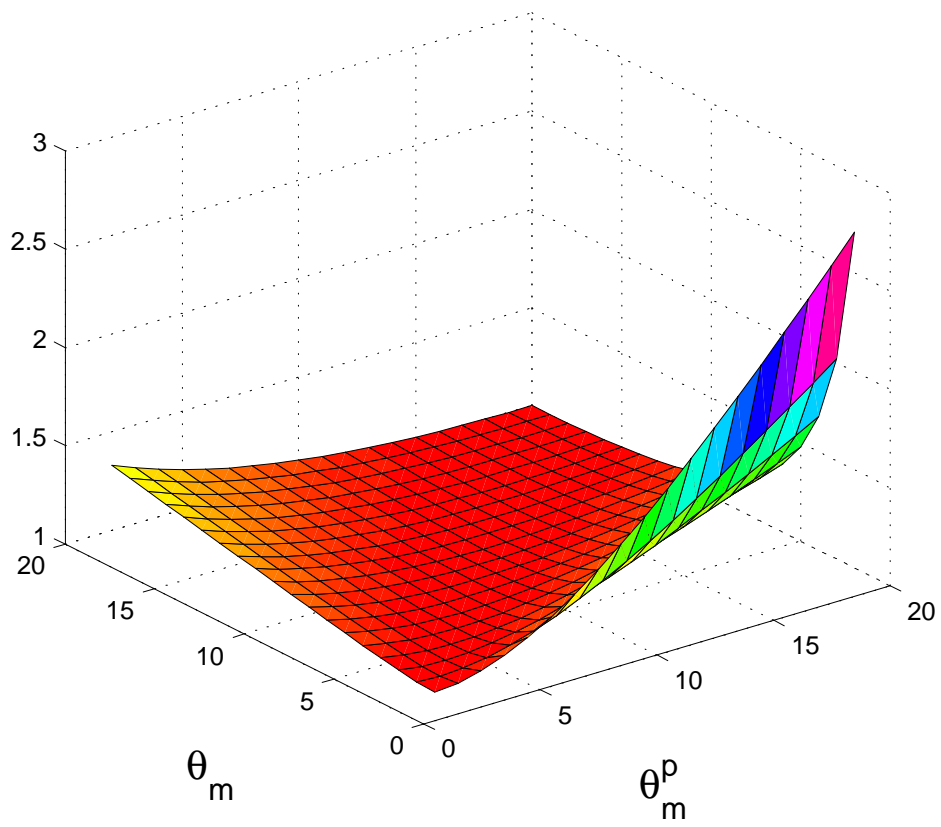


Figure 4: The welfare losses under misperceived degree of competition (θ_m^p) relative to that under correct degree of competition (θ_m)

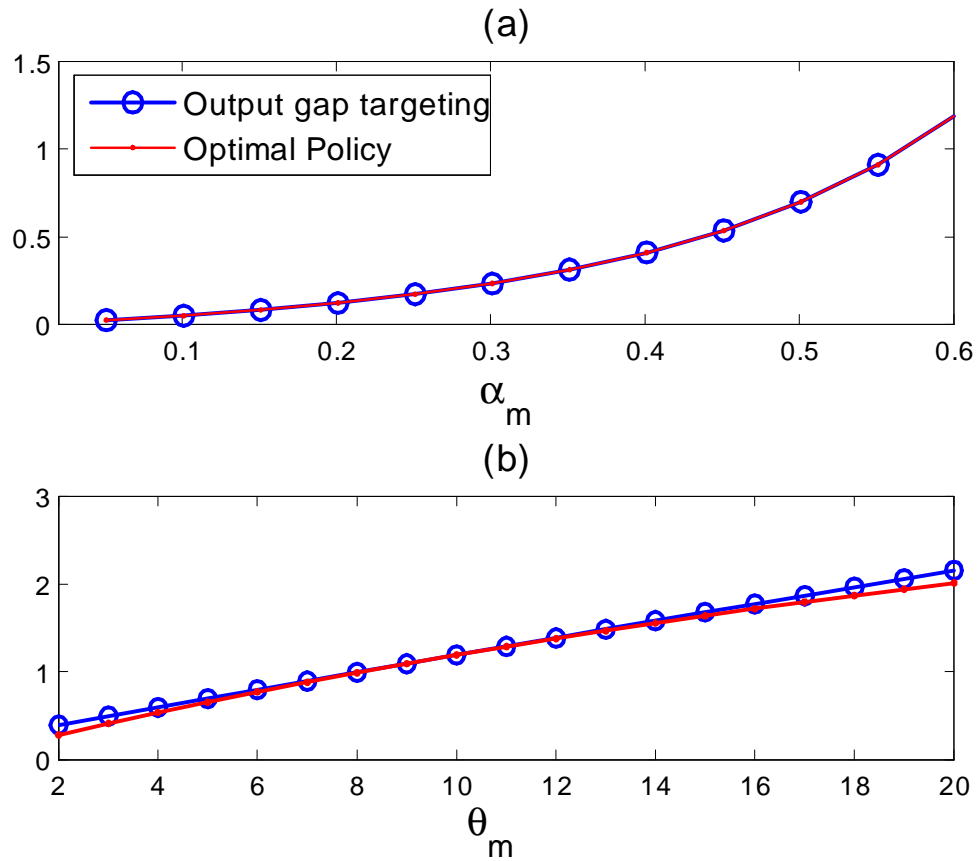


Figure 5: (a). welfare losses under output gap targeting for different degrees of nominal rigidity in producer prices: percent of steady state consumption. (b). welfare losses under output gap targeting for different degrees of competition in producer prices: percent of steady state consumption.

NATIONAL BANK OF BELGIUM - WORKING PAPERS SERIES

1. "Model-based inflation forecasts and monetary policy rules" by M. Dombrecht and R. Wouters, *Research Series*, February 2000.
2. "The use of robust estimators as measures of core inflation" by L. Aucremanne, *Research Series*, February 2000.
3. "Performances économiques des Etats-Unis dans les années nonante" by A. Nyssens, P. Butzen, P. Bisciari, *Document Series*, March 2000.
4. "A model with explicit expectations for Belgium" by P. Jeanfils, *Research Series*, March 2000.
5. "Growth in an open economy: some recent developments" by S. Turnovsky, *Research Series*, May 2000.
6. "Knowledge, technology and economic growth: an OECD perspective" by I. Visco, A. Bassanini, S. Scarpetta, *Research Series*, May 2000.
7. "Fiscal policy and growth in the context of European integration" by P. Masson, *Research Series*, May 2000.
8. "Economic growth and the labour market: Europe's challenge" by C. Wyplosz, *Research Series*, May 2000.
9. "The role of the exchange rate in economic growth: a euro-zone perspective" by R. MacDonald, *Research Series*, May 2000.
10. "Monetary union and economic growth" by J. Vickers, *Research Series*, May 2000.
11. "Politique monétaire et prix des actifs: le cas des Etats-Unis" by Q. Wibaut, *Document Series*, August 2000.
12. "The Belgian industrial confidence indicator: leading indicator of economic activity in the euro area?" by J.-J. Vanhaelen, L. Dresse, J. De Mulder, *Document Series*, November 2000.
13. "Le financement des entreprises par capital-risque" by C. Rigo, *Document Series*, February 2001.
14. "La nouvelle économie" by P. Bisciari, *Document Series*, March 2001.
15. "De kostprijs van bankkredieten" by A. Bruggeman and R. Wouters, *Document Series*, April 2001.
16. "A guided tour of the world of rational expectations models and optimal policies" by Ph. Jeanfils, *Research Series*, May 2001.
17. "Attractive Prices and Euro - Rounding effects on inflation" by L. Aucremanne and D. Cornille, *Documents Series*, November 2001.
18. "The interest rate and credit channels in Belgium: an investigation with micro-level firm data" by P. Butzen, C. Fuss and Ph. Vermeulen, *Research series*, December 2001.
19. "Openness, imperfect exchange rate pass-through and monetary policy" by F. Smets and R. Wouters, *Research series*, March 2002.
20. "Inflation, relative prices and nominal rigidities" by L. Aucremanne, G. Brys, M. Hubert, P. J. Rousseeuw and A. Struyf, *Research series*, April 2002.
21. "Lifting the burden: fundamental tax reform and economic growth" by D. Jorgenson, *Research series*, May 2002.
22. "What do we know about investment under uncertainty?" by L. Trigeorgis, *Research series*, May 2002.
23. "Investment, uncertainty and irreversibility: evidence from Belgian accounting data" by D. Cassimon, P.-J. Engelen, H. Meersman, M. Van Wouwe, *Research series*, May 2002.
24. "The impact of uncertainty on investment plans" by P. Butzen, C. Fuss, Ph. Vermeulen, *Research series*, May 2002.
25. "Investment, protection, ownership, and the cost of capital" by Ch. P. Himmelberg, R. G. Hubbard, I. Love, *Research series*, May 2002.
26. "Finance, uncertainty and investment: assessing the gains and losses of a generalised non-linear structural approach using Belgian panel data", by M. Gérard, F. Verschueren, *Research series*, May 2002.
27. "Capital structure, firm liquidity and growth" by R. Anderson, *Research series*, May 2002.
28. "Structural modelling of investment and financial constraints: where do we stand?" by J.- B. Chatelain, *Research series*, May 2002.
29. "Financing and investment interdependencies in unquoted Belgian companies: the role of venture capital" by S. Manigart, K. Baeyens, I. Verschueren, *Research series*, May 2002.
30. "Development path and capital structure of Belgian biotechnology firms" by V. Bastin, A. Corhay, G. Hübner, P.-A. Michel, *Research series*, May 2002.
31. "Governance as a source of managerial discipline" by J. Franks, *Research series*, May 2002.

32. "Financing constraints, fixed capital and R&D investment decisions of Belgian firms" by M. Cincera, *Research series*, May 2002.
33. "Investment, R&D and liquidity constraints: a corporate governance approach to the Belgian evidence" by P. Van Cayseele, *Research series*, May 2002.
34. "On the Origins of the Franco-German EMU Controversies" by I. Maes, *Research series*, July 2002.
35. "An estimated dynamic stochastic general equilibrium model of the Euro Area", by F. Smets and R. Wouters, *Research series*, October 2002.
36. "The labour market and fiscal impact of labour tax reductions: The case of reduction of employers' social security contributions under a wage norm regime with automatic price indexing of wages", by K. Burggraeve and Ph. Du Caju, *Research series*, March 2003.
37. "Scope of asymmetries in the Euro Area", by S. Ide and Ph. Moës, *Document series*, March 2003.
38. "De autonijverheid in België: Het belang van het toeleveringsnetwerk rond de assemblage van personenauto's", by F. Coppens and G. van Gastel, *Document series*, June 2003.
39. "La consommation privée en Belgique", by B. Eugène, Ph. Jeanfils and B. Robert, *Document series*, June 2003.
40. "The process of European monetary integration: a comparison of the Belgian and Italian approaches", by I. Maes and L. Quaglia, *Research series*, August 2003.
41. "Stock market valuation in the United States", by P. Bisciari, A. Durré and A. Nyssens, *Document series*, November 2003.
42. "Modeling the Term Structure of Interest Rates: Where Do We Stand?", by K. Maes, *Research series*, February 2004.
43. "Interbank Exposures: An Empirical Examination of System Risk in the Belgian Banking System", by H. Degryse and G. Nguyen, *Research series*, March 2004.
44. "How Frequently do Prices change? Evidence Based on the Micro Data Underlying the Belgian CPI", by L. Aucremanne and E. Dhyne, *Research series*, April 2004.
45. "Firms' investment decisions in response to demand and price uncertainty", by C. Fuss and Ph. Vermeulen, *Research series*, April 2004.
46. "SMEs and Bank Lending Relationships: the Impact of Mergers", by H. Degryse, N. Masschelein and J. Mitchell, *Research series*, May 2004.
47. "The Determinants of Pass-Through of Market Conditions to Bank Retail Interest Rates in Belgium", by F. De Graeve, O. De Jonghe and R. Vander Vennet, *Research series*, May 2004.
48. "Sectoral vs. country diversification benefits and downside risk", by M. Emir, *Research series*, May 2004.
49. "How does liquidity react to stress periods in a limit order market?", by H. Beltran, A. Durré and P. Giot, *Research series*, May 2004.
50. "Financial consolidation and liquidity: prudential regulation and/or competition policy?", by P. Van Cayseele, *Research series*, May 2004.
51. "Basel II and Operational Risk: Implications for risk measurement and management in the financial sector", by A. Chapelle, Y. Crama, G. Hübner and J.-P. Peters, *Research series*, May 2004.
52. "The Efficiency and Stability of Banks and Markets", by F. Allen, *Research series*, May 2004.
53. "Does Financial Liberalization Spur Growth?" by G. Bekaert, C.R. Harvey and C. Lundblad, *Research series*, May 2004.
54. "Regulating Financial Conglomerates", by X. Freixas, G. Lóránth, A.D. Morrison and H.S. Shin, *Research series*, May 2004.
55. "Liquidity and Financial Market Stability", by M. O'Hara, *Research series*, May 2004.
56. "Economisch belang van de Vlaamse zeehavens: verslag 2002", by F. Lagneaux, *Document series*, June 2004.
57. "Determinants of Euro Term Structure of Credit Spreads", by A. Van Landschoot, *Research series*, July 2004.
58. "Macroeconomic and Monetary Policy-Making at the European Commission, from the Rome Treaties to the Hague Summit", by I. Maes, *Research series*, July 2004.
59. "Liberalisation of Network Industries: Is Electricity an Exception to the Rule?", by F. Coppens and D. Vivet, *Document series*, September 2004.
60. "Forecasting with a Bayesian DSGE model: an application to the euro area", by F. Smets and R. Wouters, *Research series*, September 2004.
61. "Comparing shocks and frictions in US and Euro Area Business Cycle: a Bayesian DSGE approach", by F. Smets and R. Wouters, *Research series*, October 2004.

62. "Voting on Pensions: A Survey", by G. de Walque, *Research series*, October 2004.
63. "Asymmetric Growth and Inflation Developments in the Acceding Countries: A New Assessment", by S. Ide and P. Moës, *Research series*, October 2004.
64. "Importance économique du Port Autonome de Liège: rapport 2002", by F. Lagneaux, *Document series*, November 2004.
65. "Price-setting behaviour in Belgium: what can be learned from an ad hoc survey", by L. Aucremanne and M. Druant, *Research series*, March 2005.
66. "Time-dependent versus State-dependent Pricing: A Panel Data Approach to the Determinants of Belgian Consumer Price Changes", by L. Aucremanne and E. Dhyne, *Research series*, April 2005.
67. "Indirect effects – A formal definition and degrees of dependency as an alternative to technical coefficients", by F. Coppens, *Research series*, May 2005.
68. "Noname – A new quarterly model for Belgium", by Ph. Jeanfils and K. Burggraeve, *Research series*, May 2005.
69. "Economic importance of the Flemish maritime ports: report 2003", F. Lagneaux, *Document series*, May 2005.
70. "Measuring inflation persistence: a structural time series approach", M. Dossche and G. Everaert, *Research series*, June 2005.
71. "Financial intermediation theory and implications for the sources of value in structured finance markets", J. Mitchell, *Document series*, July 2005.
72. "Liquidity risk in securities settlement", J. Devriese and J. Mitchell, *Research series*, July 2005.
73. "An international analysis of earnings, stock prices and bond yields", A. Durré and P. Giot, *Research series*, September 2005.
74. "Price setting in the euro area: Some stylized facts from Individual Consumer Price Data", E. Dhyne, L. J. Álvarez, H. Le Bihan, G. Veronese, D. Dias, J. Hoffmann, N. Jonker, P. Lünemann, F. Rumlér and J. Vilmunen, *Research series*, September 2005.
75. "Importance économique du Port Autonome de Liège: rapport 2003", by F. Lagneaux, *Document series*, October 2005.
76. "The pricing behaviour of firms in the euro area: new survey evidence, by S. Fabiani, M. Druant, I. Hernando, C. Kwapil, B. Landau, C. Loupias, F. Martins, T. Mathä, R. Sabbatini, H. Stahl and A. Stokman, *Research series*, November 2005.
77. "Income uncertainty and aggregate consumption, by L. Pozzi, *Research series*, November 2005.
78. "Crédits aux particuliers - Analyse des données de la Centrale des Crédits aux Particuliers", by H. De Doncker, *Document series*, January 2006.
79. "Is there a difference between solicited and unsolicited bank ratings and, if so, why?" by P. Van Roy, *Research series*, February 2006.
80. "A generalised dynamic factor model for the Belgian economy - Useful business cycle indicators and GDP growth forecasts", by Ch. Van Nieuwenhuyze, *Research series*, February 2006.
81. "Réduction linéaire de cotisations patronales à la sécurité sociale et financement alternatif" by Ph. Jeanfils, L. Van Meensel, Ph. Du Caju, Y. Saks, K. Buysse and K. Van Cauter, *Document series*, March 2006.
82. "The patterns and determinants of price setting in the Belgian industry" by D. Cornille and M. Dossche, *Research series*, May 2006.
83. "A multi-factor model for the valuation and risk management of demand deposits" by H. Dewachter, M. Lyrio and K. Maes, *Research series*, May 2006.
84. "The single European electricity market: A long road to convergence", by F. Coppens and D. Vivet, *Document series*, May 2006.
85. "Firm-specific production factors in a DSGE model with Taylor price setting", by G. de Walque, F. Smets and R. Wouters, *Research series*, June 2006.
86. "Economic importance of the Belgian ports: Flemish maritime ports and Liège port complex - report 2004", by F. Lagneaux, *Document series*, June 2006.
87. "The response of firms' investment and financing to adverse cash flow shocks: the role of bank relationships", by C. Fuss and Ph. Vermeulen, *Research series*, July 2006.
88. "The term structure of interest rates in a DSGE model", by M. Emiris, *Research series*, July 2006.
89. "The production function approach to the Belgian output gap, Estimation of a Multivariate Structural Time Series Model", by Ph. Moës, *Research series*, September 2006.
90. "Industry Wage Differentials, Unobserved Ability, and Rent-Sharing: Evidence from Matched Worker-Firm Data, 1995-2002", by R. Plasman, F. Rycx and I. Tojerow, *Research series*, October 2006.

91. "The dynamics of trade and competition", by N. Chen, J. Imbs and A. Scott, *Research series*, October 2006.
92. "A New Keynesian Model with Unemployment", by O. Blanchard and J. Gali, *Research series*, October 2006.
93. "Price and Wage Setting in an Integrating Europe: Firm Level Evidence", by F. Abraham, J. Konings and S. Vanormelingen, *Research series*, October 2006.
94. "Simulation, estimation and welfare implications of monetary policies in a 3-country NOEM model", by J. Plasmans, T. Michalak and J. Fornero, *Research series*, October 2006.
95. "Inflation persistence and price-setting behaviour in the euro area: a summary of the Inflation Persistence Network evidence", by F. Altissimo, M. Ehrmann and F. Smets, *Research series*, October 2006.
96. "How Wages Change: Micro Evidence from the International Wage Flexibility Project", by W.T. Dickens, L. Goette, E.L. Goshen, S. Holden, J. Messina, M.E. Schweitzer, J. Turunen and M. Ward, *Research series*, October 2006.
97. "Nominal wage rigidities in a new Keynesian model with frictional unemployment", by V. Bodart, G. de Walque, O. Pierrard, H.R. Sneessens and R. Wouters, *Research series*, October 2006.
98. "Dynamics on monetary policy in a fair wage model of the business cycle", by D. De la Croix, G. de Walque and R. Wouters, *Research series*, October 2006.
99. "The kinked demand curve and price rigidity: evidence from scanner data", by M. Dossche, F. Heylen and D. Van den Poel, *Research series*, October 2006.
100. "Lumpy price adjustments: a microeconomic analysis", by E. Dhyne, C. Fuss, H. Peseran and P. Sevestre, *Research series*, October 2006.
101. "Reasons for wage rigidity in Germany", by W. Franz and F. Pfeiffer, *Research series*, October 2006.
102. "Fiscal sustainability indicators and policy design in the face of ageing", by G. Langenus, *Research series*, October 2006.
103. "Macroeconomic fluctuations and firm entry: theory and evidence", by V. Lewis, *Research series*, October 2006.
104. "Exploring the CDS-Bond Basis" by J. De Wit, *Research series*, November 2006.
105. "Sector Concentration in Loan Portfolios and Economic Capital", by K. Düllmann and N. Masschelein, *Research series*, November 2006.
106. "R&D in the Belgian Pharmaceutical Sector", by H. De Doncker, *Document series*, December 2006.
107. "Importance et évolution des investissements directs en Belgique", by Ch. Piette, *Document series*, January 2007.
108. "Investment-Specific Technology Shocks and Labor Market Frictions", by R. De Bock, *Research series*, February 2007.
109. "Shocks and frictions in US Business cycles: a Bayesian DSGE Approach", by F. Smets and R. Wouters, *Research series*, February 2007.
110. "Economic impact of port activity: a disaggregate analysis. The case of Antwerp", by F. Coppens, F. Lagneaux, H. Meersman, N. Sellekaerts, E. Van de Voorde, G. van Gastel, Th. Vanellander, A. Verhetsel, *Document series*, February 2007.
111. "Price setting in the euro area: some stylised facts from individual producer price data", by Ph. Vermeulen, D. Dias, M. Dossche, E. Gautier, I. Hernando, R. Sabbatini, H. Stahl, *Research series*, March 2007.
112. "Assessing the Gap between Observed and Perceived Inflation in the Euro Area: Is the Credibility of the HICP at Stake?", by L. Aucremanne, M. Collin, Th. Stragier, *Research series*, April 2007.
113. "The spread of Keynesian economics: a comparison of the Belgian and Italian experiences", by I. Maes, *Research series*, April 2007.
114. "Imports and Exports at the Level of the Firm: Evidence from Belgium", by M. Muïls and M. Pisu, *Research series*, May 2007.
115. "Economic importance of the Belgian ports: Flemish maritime ports and Liège port complex - report 2005", by F. Lagneaux, *Document series*, May 2007.
116. "Temporal Distribution of Price Changes: Staggering in the Large and Synchronization in the Small", by E. Dhyne and J. Konieczny, *Research series*, June 2007.
117. "Can excess liquidity signal an asset price boom?", by A. Bruggeman, *Research series*, August 2007.
118. "The performance of credit rating systems in the assessment of collateral used in Eurosystem monetary policy operations", by F. Coppens, F. González and G. Winkler, *Research series*, September 2007.
119. "The determinants of stock and bond return comovements", by L. Baele, G. Bekaert and K. Inghelbrecht, *Research series*, October 2007.

120. "Monitoring pro-cyclicality under the capital requirements directive: preliminary concepts for developing a framework", by N. Masschelein, *Document series*, October 2007.
121. "Dynamic order submission strategies with competition between a dealer market and a crossing network", by H. Degryse, M. Van Achter and G. Wuyts, *Research series*, November 2007.
122. "The gas chain: influence of its specificities on the liberalisation process", by C. Swartenbroekx, *Document series*, November 2007.
123. "Failure prediction models: performance, disagreements, and internal rating systems", by J. Mitchell and P. Van Roy, *Research series*, December 2007.
124. "Downward wage rigidity for different workers and firms: an evaluation for Belgium using the IWF procedure", by Ph. Du Caju, C. Fuss and L. Wintr, *Research series*, December 2007.
125. "Economic importance of Belgian transport logistics", by F. Lagneaux, *Document series*, January 2008.
126. "Some evidence on late bidding in eBay auctions", by L. Wintr, *Research series*, January 2008.
127. "How do firms adjust their wage bill in Belgium? A decomposition along the intensive and extensive margins", by C. Fuss, *Research series*, January 2008.
128. "Exports and productivity – comparable evidence for 14 countries", by The International Study Group on Exports and Productivity, *Research series*, February 2008.
129. "Estimation of monetary policy preferences in a forward-looking model: a Bayesian approach", by P. Ilbas, *Research series*, March 2008.
130. "Job creation, job destruction and firms' international trade involvement", by M. Pisu, *Research series*, March 2008.
131. "Do survey indicators let us see the business cycle? A frequency decomposition", by L. Dresse and Ch. Van Nieuwenhuyze, *Research series*, March 2008.
132. "Searching for additional sources of inflation persistence: the micro-price panel data approach", by R. Raciborski, *Research series*, April 2008.
133. "Short-term forecasting of GDP using large monthly datasets - A pseudo real-time forecast evaluation exercise", by K. Barhoumi, S. Benk, R. Cristadoro, A. Den Reijer, A. Jakaitiene, P. Jelonek, A. Rua, G. Rünstler, K. Ruth and Ch. Van Nieuwenhuyze, *Research series*, June 2008.
134. "Economic importance of the Belgian ports: Flemish maritime ports, Liège port complex and the port of Brussels - report 2006" by S. Vennix, *Document series*, June 2008.
135. "Imperfect exchange rate pass-through: the role of distribution services and variable demand elasticity", by Ph. Jeanfils, *Research series*, August 2008.
136. "Multivariate structural time series models with dual cycles: Implications for measurement of output gap and potential growth", by Ph. Moës, *Research series*, August 2008.
137. "Agency problems in structured finance - a case study of European CLOs", by J. Keller, *Document series*, August 2008.
138. "The efficiency frontier as a method for gauging the performance of public expenditure: a Belgian case study", by B. Eugène, *Research series*, September 2008.
139. "Exporters and credit constraints. A firm-level approach", by M. Muûls, *Research series*, September 2008.
140. "Export destinations and learning-by-exporting: Evidence from Belgium", by M. Pisu, *Research series*, September 2008.
141. "Monetary aggregates and liquidity in a neo-Wicksellian framework", by M. Canzoneri, R. Cumby, B. Diba and D. López-Salido, *Research series*, October 2008.
142. "Liquidity, inflation and asset prices in a time-varying framework for the euro area", by Ch. Baumeister, E. Durinck and G. Peersman, *Research series*, October 2008.
143. "The bond premium in a DSGE model with long-run real and nominal risks", by Glenn D. Rudebusch and Eric T. Swanson, *Research series*, October 2008.
144. "Imperfect information, macroeconomic dynamics and the yield curve: an encompassing macro-finance model", by H. Dewachter, *Research series*, October 2008.
145. "Housing market spillovers: evidence from an estimated DSGE model", by M. Iacoviello and S. Neri, *Research series*, October 2008.
146. "Credit frictions and optimal monetary policy", by V. Cúrdia and M. Woodford, *Research series*, October 2008.
147. "Central Bank misperceptions and the role of money in interest rate rules", by G. Beck and V. Wieland, *Research series*, October 2008.
148. "Financial (in)stability, supervision and liquidity injections: a dynamic general equilibrium approach", by G. de Walque, O. Pierrard and A. Rouabah, *Research series*, October 2008.

149. "Monetary policy, asset prices and macroeconomic conditions: a panel-VAR study", by K. Assenmacher-Wesche and S. Gerlach, *Research series*, October 2008.
150. "Risk premiums and macroeconomic dynamics in a heterogeneous agent model", by F. De Graeve, M. Dossche, M. Emiris, H. Sneessens and R. Wouters, *Research series*, October 2008.
151. "Financial factors in economic fluctuations", by L. J. Christiano, R. Motto and M. Rotagno, *Research series*, to be published.
152. "Rent-sharing under different bargaining regimes: Evidence from linked employer-employee data", by M. Rusinek and F. Rycx, *Research series*, December 2008.
153. "Forecast with judgment and models", by F. Monti, *Research series*, December 2008.
154. "Institutional features of wage bargaining in 23 European countries, the US and Japan", by Ph. Du Caju, E. Gautier, D. Momferatou and M. Ward-Warmedinger, *Research series*, December 2008.
155. "Fiscal sustainability and policy implications for the euro area", by F. Balassone, J. Cunha, G. Langenus, B. Manzke, J. Pavot, D. Prammer and P. Tommasino, *Research series*, January 2009.
156. "Understanding sectoral differences in downward real wage rigidity: workforce composition, institutions, technology and competition", by Ph. Du Caju, C. Fuss and L. Wintr, *Research series*, February 2009.
157. "Sequential bargaining in a New Keynesian model with frictional unemployment and staggered wage negotiation", by G. de Walque, O. Pierrard, H. Sneessens and R. Wouters, *Research series*, February 2009.
158. "Economic Importance of Air Transport and Airport Activities in Belgium", by F. Kupfer and F. Lagneaux, *Document series*, March 2009.
159. "Rigid labour compensation and flexible employment? Firm-Level evidence with regard to productivity for Belgium", by C. Fuss and L. Wintr, *Research series*, March 2009.
160. "The Belgian Iron and Steel Industry in the International Context", by F. Lagneaux and D. Vivet, *Document series*, March 2009.
161. "Trade, wages and productivity", by K. Behrens, G. Mion, Y. Murata and J. Südekum, *Research series*, March 2009.
162. "Labour flows in Belgium", by P. Heuse and Y. Saks, *Research series*, April 2009.
163. "The young Lamfalussy: an empirical and policy-oriented growth theorist", by I. Maes, *Research series*, April 2009.
164. "Inflation dynamics with labour market matching: assessing alternative specifications", by K. Christoffel, J. Costain, G. de Walque, K. Kuester, T. Linzert, S. Millard and O. Pierrard, *Research series*, May 2009.
165. "Understanding inflation dynamics: Where do we stand?", by M. Dossche, *Research series*, June 2009.
166. "Input-output connections between sectors and optimal monetary policy", by E. Kara, *Research series*, June 2009.