

SVERIGES RIKSBANK  
WORKING PAPER SERIES

178



# Some Further Evidence on Interest-Rate Smoothing: The Role of Measurement Errors in the Output Gap

*Mikael Apel and Per Jansson*

MARCH 2005

WORKING PAPERS ARE OBTAINABLE FROM

Sveriges Riksbank • Information Riksbank • SE-103 37 Stockholm  
Fax international: +46 8 787 05 26  
Telephone international: +46 8 787 01 00  
E-mail: [info@riksbank.se](mailto:info@riksbank.se)

The Working Paper series presents reports on matters in the sphere of activities of the Riksbank that are considered to be of interest to a wider public.

The papers are to be regarded as reports on ongoing studies and the authors will be pleased to receive comments.

The views expressed in Working Papers are solely the responsibility of the authors and should not be interpreted as reflecting the views of the Executive Board of Sveriges Riksbank.

Some further evidence on interest-rate smoothing:

The role of measurement errors in the output gap

Mikael Apel, Per Jansson\*

Sveriges Riksbank Working Paper Series

No. 178

March 2005

---

**Abstract**

It has been suggested that interest-rate smoothing may be partly explained by an omitted variable that relates to conditions in financial markets. We propose an alternative interpretation that suggests that it relates to measurement errors in the output gap.

*Keywords:* Interest-rate smoothing; Measurement errors; Output gap

*JEL classification:* E43; E44; E52

---

---

\*Sveriges Riksbank, SE-103 37 Stockholm, Sweden. Email: [mikael.apel@riksbank.se](mailto:mikael.apel@riksbank.se); [per.jansson@riksbank.se](mailto:per.jansson@riksbank.se). The views expressed in this paper are solely the responsibility of the authors and should not be interpreted as reflecting the views of the Executive Board of Sveriges Riksbank.

## **1. Introduction**

It is a stylised fact that the empirical fit of an estimated monetary policy reaction function improves considerably when a lagged interest rate is included. There is less agreement on how this finding should be interpreted, however. The traditional explanation is that it reflects policy inertia, i.e. that the central bank for one reason or another chooses only to gradually adjust the interest rate towards the desired level (given by the original Taylor rule).

This view has been challenged in recent years, notably by Rudebusch (2002), who argues that the large and significant coefficient on the lagged interest rate is the result of a misspecified representation of monetary policy. More specifically, he proposes that the reason why the Fed chooses to smooth interest rates is that it reacts to some serially correlated variable(s) that is incorrectly omitted from the reaction function. The significance of the lagged interest rate might therefore be spurious and should not be regarded as support for policy inertia.

The relative importance of policy inertia and omitted variables has been investigated in a number of recent studies (e.g., Castelnuovo, 2003, English et al., 2003, Gerlach-Kristen, 2004), most of which conclude that both mechanisms are at play simultaneously. However, relatively few papers have so far tried to investigate empirically what the omitted variable actually represents. A notable exception is Gerlach-Kristen (2004) (hereafter GK), who estimates the omitted variable as an unobserved component within a model that nests the two hypotheses. Since the estimated series turns out to be rather closely related to a risk premium on corporate bonds, GK concludes that interest-rate smoothing, in part, is likely to be a result of concerns for financial market conditions.

In this paper we propose an alternative, equally plausible interpretation of the omitted variable, namely as a “measurement error” in the output gap. The measurement error arises

because the Fed's real-time assessment of the output gap differs from the gap that is obtained from official sources.<sup>1</sup>

## 2. Empirical analysis

We use quarterly US data on the federal funds rate ( $i$ ), inflation ( $\pi$ ), and the output gap ( $y$ ) covering the time period 1987:4–2004:4. The output gap is constructed as the (log) difference between real GDP and the CBO estimate of potential GDP. All variables are from the FRED II database, Federal Reserve Bank of St Louis.

The model analysed by GK is:

$$i_t = (1 - \rho)(\alpha\pi_t + \beta y_t + \gamma z_t) + \rho i_{t-1} + \eta_t, \quad (1)$$

$$z_t = \varphi z_{t-1} + u_t, \quad (2)$$

where  $z$  is an unobserved component, and  $\eta$  and  $u$  mutually and serially uncorrelated white noise error terms. If  $\varphi = 0$ , then the unobserved  $z$  variable is white noise and (1) becomes observationally equivalent to the so-called policy inertia model. If, on the other hand,  $\rho = 0$  and  $\sigma_\eta^2 = 0$ , then the lagged interest rate does not enter (1) and we end up with the so-called unobserved variable model.<sup>2</sup> Of course, if none of the restrictions hold, then both models are valid and monetary policy is characterised by both inertia and concerns for the unobserved  $z$  variable.

GK estimates (1)–(2) over the period 1987:4–2003:3 using maximum likelihood and the Kalman filter (subject to the normalisation  $\gamma = 1$ ). The first column in Table 1 re-estimates

---

<sup>1</sup>For a normative rather than positive analysis of the importance for monetary policy of measurement errors in the output gap, see Smets (2002).

<sup>2</sup>Without the restriction on the variance of  $\eta$  the policy shocks would follow an MA(1) process and thus not be white noise.

her model using our updated data. As can be seen, the estimates of  $\rho$ ,  $\varphi$ , and the variance of  $\eta$  are all significant at the 1% test level, implying that both policy inertia and an omitted variable are important in explaining interest-rate smoothing. Interestingly, the estimate of  $\rho$  is lower than in the case of OLS estimation of (1) subject to  $\gamma = 0$ , in which case the estimate is 0.811.<sup>3</sup> Perhaps the most interesting finding is that the estimates of the unobservable  $z$  turn out to be rather closely related to a risk spread that measures the difference between the yields on a safe and risky bond (Fig. 1).<sup>4</sup> From this, GK concludes that interest-rate smoothing, in part, is likely to be a result of concerns for financial market conditions.

In this paper we propose an alternative, equally plausible interpretation of the unobservable  $z$  variable. We consider the following generalised unobserved-components (UC) model:

$$i_t = (1 - \rho)(\alpha\pi_t + \beta\tilde{y}_t) + \rho i_{t-1} + \eta_t, \quad (3)$$

$$z_t = \varphi z_{t-1} + u_t, \quad (4)$$

$$y_t = \tilde{y}_t + z_t, \quad (5)$$

$$\tilde{y}_t = \gamma_1 \tilde{y}_{t-1} + \gamma_2 \tilde{y}_{t-2} + \varepsilon_t, \quad (6)$$

where we have introduced a new latent variable,  $\tilde{y}$ , that represents the output gap as perceived by the Fed. The idea is that the CBO output gap measures the Fed's (implicit) real-time estimate of the gap with a "measurement error", perhaps because real-time and final GDP releases are different or because the Fed's assessment of potential GDP differs from the CBO's. As can be seen, our UC model is a straightforward generalisation of model (1)–(2), obtained by imposing the restriction  $\beta = -\gamma$  and adding Eq. (6). The main advantage of this

---

<sup>3</sup>The two estimates are however not significantly different. A Wald test accepts the restriction that  $\rho$  equals 0.81 in the GK model with a  $p$  value of approximately 28%.

<sup>4</sup>All estimates of unobservables are two-sided in this paper.

formulation is that  $z$  becomes explicitly interpretable, namely as a measurement error of the output gap estimated by the CBO.

The estimates of the UC model (3)–(6) appear in the second column of Table 1. All parameter estimates are highly significant and economically reasonable. It is interesting to note that the estimate of  $\rho$  is lower than in the GK model.<sup>5</sup> Also, the  $R^2$  associated with the prediction errors of the federal funds rate is slightly higher for system (3)–(6) than for system (1)–(2) (0.824 compared to 0.809).

The evidence in Table 2 further strengthens the case for our generalised UC model. This table shows that the adjusted output gap  $\tilde{y}$  has a higher (and statistically more precise) correlation with inflation than the standard CBO gap measure. Adjusting  $y$  for  $z$  thus seems to generate a measure of resource utilisation that better reflects actual capacity constraints in the economy.

Another piece of evidence may be the real-time statements made by the Fed. Of course, the Fed does not base its policy on any explicit measure of the output gap and the evidence therefore is anecdotal. Nevertheless, in periods when the two output gap estimates are qualitatively different, it may be possible to find some evidence in the minutes of the FOMC that allows us to judge whether one estimate is preferable to the other. In our sample, such a period occurs during 1994–1997, where the adjusted output gap  $\tilde{y}$  is positive while the CBO gap is negative (Fig. 2). The following two quotations are from the minutes of the FOMC in 1996:

“More generally, resource utilization was expected to remain high [in 1996] and greater pressures could emerge in labor and product markets.” (January 30–31, page 15.)

---

<sup>5</sup>For the UC model, the Wald test rejects the restriction that  $\rho$  equals 0.81 at the 5% test level. The  $p$  value for this test is slightly below 4%.

“Nonetheless, broad measures of price inflation [...] did not exhibit any uptrend despite [...] high levels of resource use.” (August 20, page 5.)

Obviously, such statements square better with an output gap that is positive rather than negative.

Finally, Fig. 3 documents the differences between the estimates of  $z$  from models (3)–(6) and (1)–(2). Evidently, the policy implications of the two estimates are occasionally quite different.

### **3. Conclusion**

In this paper we present empirical evidence that suggests that interest-rate smoothing is due in part to measurement errors in the output gap. The measurement error arises because the Fed’s real-time assessment of the output gap differs from the gap that is obtained from official sources.



## References

- Castelnuovo, E. 2003. Taylor rules, omitted variables, and interest rate smoothing in the US. *Economics Letters* 81, 55–59.
- English, W.B., Nelson, W.R., Sack, B.P. 2003. Interpreting the significance of the lagged interest rate in estimated monetary policy rules. *Contributions to Macroeconomics* 3.
- Gerlach-Kristen, P. 2004. Interest-rate smoothing: Monetary policy inertia or unobserved variables? *Contributions to Macroeconomics* 4.
- Rudebusch, G.D. 2002. Term structure evidence on interest rate smoothing and monetary policy inertia. *Journal of Monetary Economics* 49, 1161–1187.
- Smets, F. 2002. Output gap uncertainty: Does it matter for the Taylor rule? *Empirical Economics* 27, 113–129.

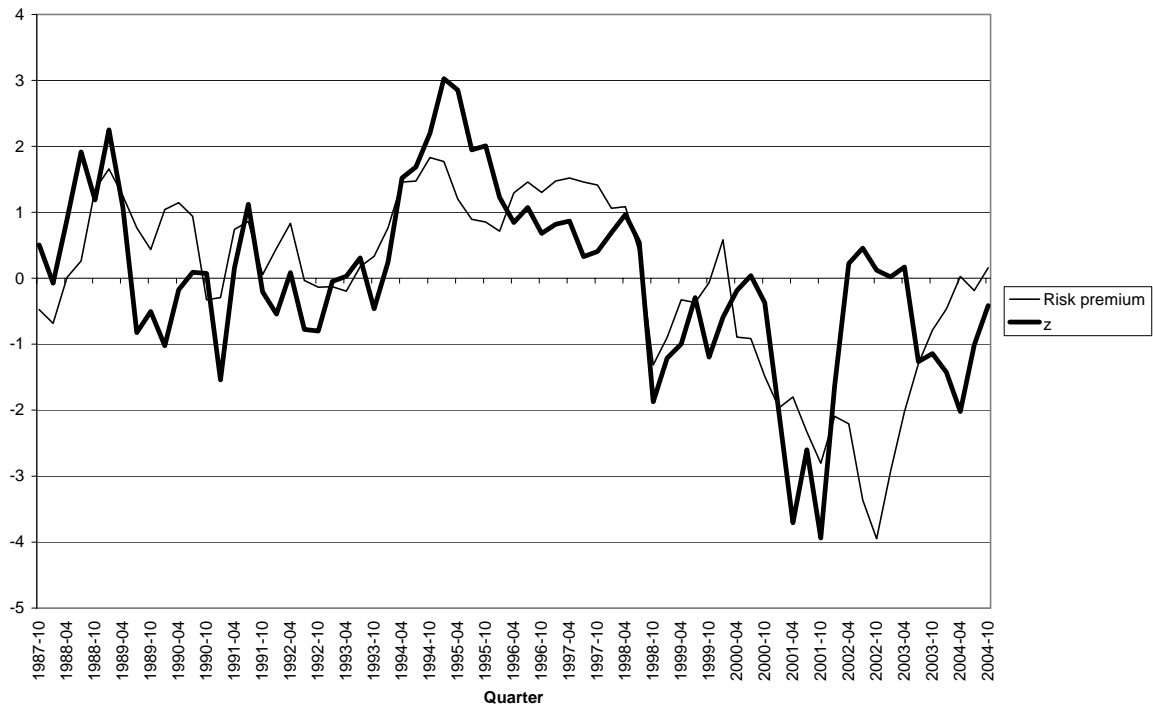


Fig. 1. Paths of  $z$  and risk premium on corporate bonds in Gerlach-Kristen model. The risk spread has been normalised so that it has the same mean and variance as  $z$ . The variable is constructed as the difference between a ten-year US Treasury note yield and Moody's Baa corporate bond yield. Both yield series are from the FRED II database, Federal Reserve Bank of St Louis.



Fig. 2. Paths of output gaps according to CBO and UC model.

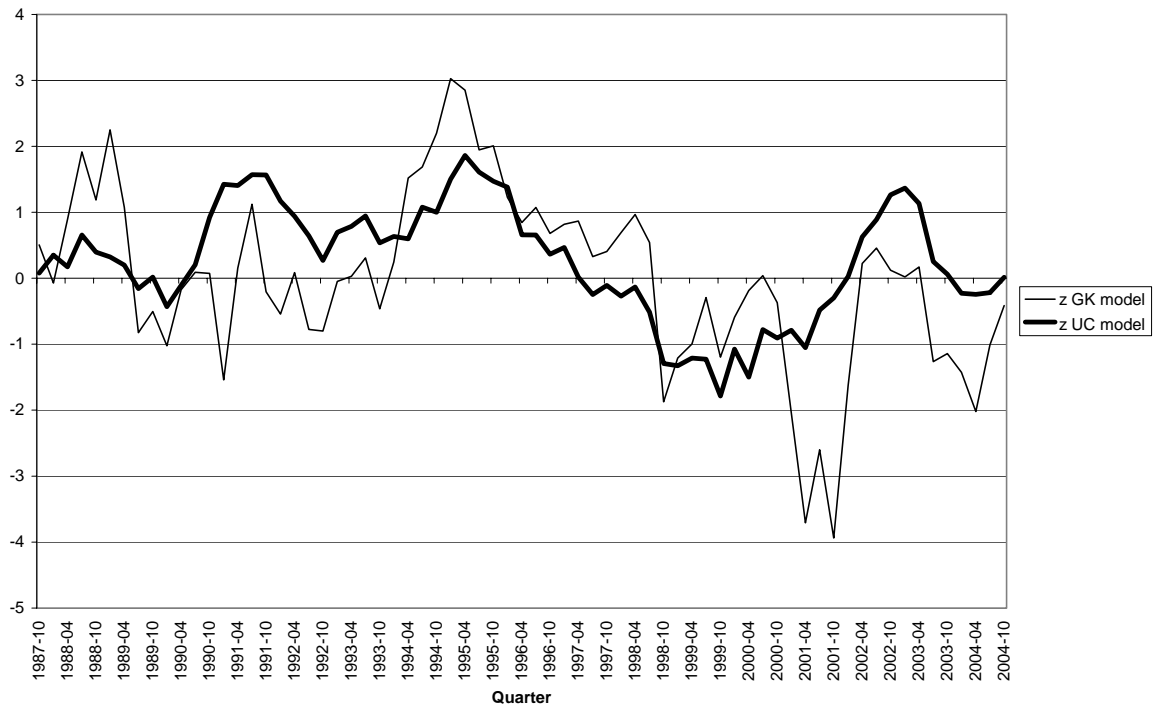


Fig. 3. Paths of  $z$  according to Gerlach-Kristen model and UC model. To ease comparisons the  $z$  variable from the UC model has been multiplied by  $-1$ .

Table 1

Estimation results

| Parameter              | Gerlach-Kristen model | UC model   |
|------------------------|-----------------------|------------|
| Constant               | 0.4587                | 0.8123*    |
| $\alpha$               | 1.5964***             | 1.3285***  |
| $\beta$                | 1.1204***             | 1.7688***  |
| $\rho$                 | 0.7220***             | 0.6366***  |
| $\varphi$              | 0.7185***             | 0.8978***  |
| $\gamma_1$             | –                     | 1.5243***  |
| $\gamma_2$             | –                     | –0.5878*** |
| $\sigma_\eta^2$        | 0.0129***             | 0.0404***  |
| $\sigma_u^2$           | 0.9091                | 0.1466***  |
| $\sigma_\varepsilon^2$ | –                     | 0.0741***  |

\* Significant at 10% level.

\*\* Significant at 5% level.

\*\*\* Significant at 1% level.

Table 2

Correlations between output gaps and inflation

|                 | Output gap, CBO | Output gap, UC  | Inflation |
|-----------------|-----------------|-----------------|-----------|
| Output gap, CBO | 1.0000          |                 |           |
| Output gap, UC  | 0.8693 (0.0000) | 1.0000          |           |
| Inflation       | 0.2159 (0.0818) | 0.2845 (0.0220) | 1.0000    |

The output gaps are lagged four quarters. Numbers within parentheses are approximate  $p$  values associated with the null of two uncorrelated time series.

# Earlier Working Papers:

For a complete list of Working Papers published by Sveriges Riksbank, see [www.riksbank.se](http://www.riksbank.se)

|   |          |
|---|----------|
| An Alternative Explanation of the Price Puzzle by <i>Paolo Giordani</i> .....   | 2001:125 |
| Interoperability and Network Externalities in Electronic Payments by <i>Gabriela Guibourg</i> .....   | 2001:126 |
| Monetary Policy with Incomplete Exchange Rate Pass-Through by <i>Malin Adolfson</i> .....   | 2001:127 |
| Micro Foundations of Macroeconomic Price Adjustment: Survey Evidence from Swedish Firms by <i>Mikael Apel, Richard Friberg and Kerstin Hallsten</i> .....               | 2001:128 |
| Estimating New-Keynesian Phillips Curves on Data with Measurement Errors: A Full Information Maximum Likelihood Approach by <i>Jesper Lindé</i> .....                   | 2001:129 |
| The Empirical Relevance of Simple Forward- and Backward-looking Models: A View from a Dynamic General Equilibrium Model by <i>Jesper Lindé</i> .....                    | 2001:130 |
| Diversification and Delegation in Firms by <i>Vittoria Cerasi and Sonja Daltung</i> .....   | 2001:131 |
| Monetary Policy Signaling and Movements in the Swedish Term Structure of Interest Rates by <i>Malin Andersson, Hans Dillén and Peter Sellin</i> .....                   | 2001:132 |
| Evaluation of exchange rate forecasts for the krona's nominal effective exchange rate by <i>Henrik Degré, Jan Hansen and Peter Sellin</i> .....                         | 2001:133 |
| Identifying the Effects of Monetary Policy Shocks in an Open Economy by <i>Tor Jacobsson, Per Jansson, Anders Vredin and Anders Warne</i> .....                         | 2002:134 |
| Implications of Exchange Rate Objectives under Incomplete Exchange Rate Pass-Through by <i>Malin Adolfson</i> .....   | 2002:135 |
| Incomplete Exchange Pass-Through and Simple Monetary Policy Rules by <i>Malin Adolfson</i> .....  | 2002:136 |
| Financial Instability and Monetary Policy: The Swedish Evidence by <i>U. Michael Bergman and Jan Hansen</i> .....   | 2002:137 |
| Finding Good Predictors for Inflation: A Bayesian Model Averaging Approach by <i>Tor Jacobson and Sune Karlsson</i> .....   | 2002:138 |
| How Important Is Precommitment for Monetary Policy? by <i>Richard Dennis and Ulf Söderström</i> .....   | 2002:139 |
| Can a Calibrated New-Keynesian Model of Monetary Policy Fit the Facts? by <i>Ulf Söderström, Paul Söderlind and Anders Vredin</i> .....                                 | 2002:140 |
| Inflation Targeting and the Dynamics of the Transmission Mechanism by <i>Hans Dillén</i> .....  | 2002:141 |
| Capital Charges under Basel II: Corporate Credit Risk Modelling and the Macro Economy by <i>Kenneth Carling, Tor Jacobson, Jesper Lindé and Kasper Roszbach</i> .....   | 2002:142 |
| Capital Adjustment Patterns in Swedish Manufacturing Firms: What Model Do They Suggest? by <i>Mikael Carlsson and Stefan Laséen</i> .....                               | 2002:143 |
| Bank Lending, Geographical Distance, and Credit risk: An Empirical Assessment of the Church Tower Principle by <i>Kenneth Carling and Sofia Lundberg</i> .....          | 2002:144 |
| Inflation, Exchange Rates and PPP in a Multivariate Panel Cointegration Model by <i>Tor Jacobson, Johan Lyhagen, Rolf Larsson and Marianne Nessén</i> .....             | 2002:145 |
| Evaluating Implied RNDs by some New Confidence Interval Estimation Techniques by <i>Magnus Andersson and Magnus Lomakka</i> .....                                       | 2003:146 |
| Taylor Rules and the Predictability of Interest Rates by <i>Paul Söderlind, Ulf Söderström and Anders Vredin</i> .....  | 2003:147 |
| Inflation, Markups and Monetary Policy by <i>Magnus Jonsson and Stefan Palmqvist</i> .....  | 2003:148 |
| Financial Cycles and Bankruptcies in the Nordic Countries by <i>Jan Hansen</i> .....  | 2003:149 |
| Bayes Estimators of the Cointegration Space by <i>Mattias Villani</i> .....   | 2003:150 |
| Business Survey Data: Do They Help in Forecasting the Macro Economy? by <i>Jesper Hansson, Per Jansson and Mårten Löf</i> .....   | 2003:151 |
| The Equilibrium Rate of Unemployment and the Real Exchange Rate: An Unobserved Components System Approach by <i>Hans Lindblad and Peter Sellin</i> .....                | 2003:152 |
| Monetary Policy Shocks and Business Cycle Fluctuations in a Small Open Economy: Sweden 1986-2002 by <i>Jesper Lindé</i> .....   | 2003:153 |
| Bank Lending Policy, Credit Scoring and the Survival of Loans by <i>Kasper Roszbach</i> .....   | 2003:154 |
| Internal Ratings Systems, Implied Credit Risk and the Consistency of Banks' Risk Classification Policies by <i>Tor Jacobson, Jesper Lindé and Kasper Roszbach</i> ..... | 2003:155 |
| Monetary Policy Analysis in a Small Open Economy using Bayesian Cointegrated Structural VARs by <i>Mattias Villani and Anders Warne</i> .....                           | 2003:156 |
| Indicator Accuracy and Monetary Policy: Is Ignorance Bliss? by <i>Kristoffer P. Nimark</i> .....  | 2003:157 |
| Intersectoral Wage Linkages in Sweden by <i>Kent Friberg</i> .....  | 2003:158 |

|   |          |
|---|----------|
| Do Higher Wages Cause Inflation? by <i>Magnus Jonsson</i> and <i>Stefan Palmqvist</i> .....   | 2004:159 |
| Why Are Long Rates Sensitive to Monetary Policy by <i>Tore Ellingsen</i> and <i>Ulf Söderström</i> .....  | 2004:160 |
| The Effects of Permanent Technology Shocks on Labor Productivity<br>and Hours in the RBC model by <i>Jesper Lindé</i> .....   | 2004:161 |
| Credit Risk versus Capital Requirements under Basel II: Are SME Loans and Retail<br>Credit Really Different? by <i>Tor Jacobson</i> , <i>Jesper Lindé</i> and <i>Kasper Roszbach</i> .....      | 2004:162 |
| Exchange Rate Puzzles: A Tale of Switching Attractors<br>by <i>Paul De Grauwe</i> and <i>Marianna Grimaldi</i> .....  | 2004:163 |
| Bubbles and Crashes in a Behavioural Finance Model<br>by <i>Paul De Grauwe</i> and <i>Marianna Grimaldi</i> .....   | 2004:164 |
| Multiple-Bank Lending: Diversification and Free-Riding in Monitoring<br>by <i>Elena Carletti</i> , <i>Vittoria Cerasi</i> and <i>Sonja Daltung</i> .....  | 2004:165 |
| Populism by <i>Lars Frisell</i> .....   | 2004:166 |
| Monetary Policy in an Estimated Open-Economy Model with Imperfect Pass-Through<br>by <i>Jesper Lindé</i> , <i>Marianne Nessén</i> and <i>Ulf Söderström</i> .....                               | 2004:167 |
| Is Firm Interdependence within Industries Important for Portfolio Credit Risk?<br>by <i>Kenneth Carling</i> , <i>Lars Rönnegård</i> and <i>Kasper Roszbach</i> .....                            | 2004:168 |
| How Useful are Simple Rules for Monetary Policy? The Swedish Experience<br>by <i>Claes Berg</i> , <i>Per Jansson</i> and <i>Anders Vredin</i> .....   | 2004:169 |
| The Welfare Cost of Imperfect Competition and Distortionary Taxation<br>by <i>Magnus Jonsson</i> .....  | 2004:170 |
| A Bayesian Approach to Modelling Graphical Vector Autoregressions<br>by <i>Jukka Corander</i> and <i>Mattias Villani</i> .....  | 2004:171 |
| Do Prices Reflect Costs? A study of the price- and cost structure of retail payment<br>services in the Swedish banking sector 2002 by <i>Gabriela Guibourg</i> and <i>Björn Segendorf</i> ..... | 2004:172 |
| Excess Sensitivity and Volatility of Long Interest Rates: The Role of Limited<br>Information in Bond Markets by <i>Meredith Beechey</i> .....   | 2004:173 |
| State Dependent Pricing and Exchange Rate Pass-Through<br>by <i>Martin Flodén</i> and <i>Fredrik Wilander</i> .....   | 2004:174 |
| The Multivariate Split Normal Distribution and Asymmetric Principal<br>Components Analysis by <i>Mattias Villani</i> and <i>Rolf Larsson</i> .....  | 2004:175 |
| Firm-Specific Capital, Nominal Rigidities and the Business Cycle<br>by <i>David Altig</i> , <i>Lawrence Christiano</i> , <i>Martin Eichenbaum</i> and <i>Jesper Lindé</i> .....                 | 2004:176 |
| Estimation of an Adaptive Stock Market Model with Heterogeneous Agents by <i>Henrik Amilon</i> .....  | 2005:177 |





Sveriges Riksbank

Visiting address: Brunkebergs torg 11

Mail address: se-103 37 Stockholm

Website: [www.riksbank.se](http://www.riksbank.se)

Telephone: +46 8 787 00 00, Fax: +46 8 21 05 31

E-mail: [registratorn@riksbank.se](mailto:registratorn@riksbank.se)