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NORWAY

Selected Issues

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Approved by the European Department

May 13, 2005

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I. INFLATION DYNAMICS IN NORWAY[1]

1. Despite a significant easing of monetary conditions, the core inflation rate in Norway has been well below the 2½ percent targeted by Norges Bank since end-2002. This chapter analyzes inflation in Norway with a view to shedding light on this surprising development and the possible near-term course of inflation, using statistical and econometric analyses. The results suggest that the inflation rate will start increasing in the near term as the main factors which reduced it in 2003–04 are either reversing or waning. Moreover, the target rate of inflation may be overshot in the medium term if growth proves more robust than now projected. The first section reviews recent developments of monetary policy and inflation in Norway; the second section applies statistical and econometric tools to identify factors influencing inflation; and the third section concludes by spelling out the implications of the analysis for policymaking.

A. Introduction

From exchange targeting to inflation targeting

2. **Before Norway adopted its current inflation targeting framework, monetary policy stabilized the exchange rate.** From 1994 to 1999, Norway used a managed float to maintain stability against European currencies. Accordingly, interest rate movements in Norway were largely determined by those in Germany. This framework worked well during the recovery from the crisis in the early 1990s. Under it, fiscal policy was given the main role in stabilizing the economy, while the centralized wage bargaining system was supposed to help achieve full employment with low inflation. Monetary policy under such systems tends to be procyclical.

3. **In the late 1990s, however, the strain of using monetary policy to achieve both the exchange rate and inflation targets became evident.** In 1997, for example, Norwegian interest rates were lowered to curb the appreciation of the krone when the economy was experiencing excess demand pressures. This situation changed dramatically in August 1998. When the krone came under strong pressure in the exchange market as world commodity prices declined, Norges Bank raised short-term interest rates by 425 basis points.[2] It became apparent that it is difficult for a commodity-exporting country such as Norway to maintain a fixed exchange rate without significant output volatility. Moreover, the decision to phase in the spending of some petroleum revenue, which is embodied in the 2001 fiscal guidelines, implied a slightly expansionary fiscal policy, interfering with its role in macroeconomic stabilization

[1] Prepared by Etibar Jafarov

[2] See IMF (1999).

4. **An inflation targeting framework was implicitly adopted in 1999. Norges Bank innovatively interpreted the fixed-exchange rate instructions from the government as implying the target would be met only in the long run.** In addition, Norges Bank stated that the best way to achieve this target was to aim for an inflation rate similar to that of the euro zone (Svensson and others, 2002). The inflation targeting framework reduced the procyclical tendency of a fixed-exchange rate regime, thereby allowing monetary policy to help with macroeconomic stabilization.

5. **The current inflation targeting framework was formally adopted in March 2001.** Originally, the framework aimed at achieving 2½ percent core inflation in a two-year time horizon.[3] By setting the inflation target at a slightly higher level than that of trading partners (at about 2 percent), the government indicated its preference for the expected real appreciation (related to large oil revenues) to occur in the form of a slightly higher inflation rate rather than a nominal appreciation (J. Soikkeli, 2002). In addition to the inflation target, the new monetary guidelines aim to help stabilize output and employment. Thus, Norway has a flexible inflation targeting framework.

Recent inflation developments

6. **Three underlying factors seem important in considering Norwegian inflation developments**. First, since the mid-1990s, wages have increased considerably faster than the consumer price index. Although under the centralized wage bargaining system, social partners used exchange rates and wage growth abroad as anchors for wage settlements, during 1998–2002 wage growth in Norway outpaced that of other countries. Since productivity growth in Norway has not been much higher than elsewhere, unit labor costs also rose more rapidly, putting upward pressure on inflation relative to other countries and resulting in a real exchange rate appreciation (Table I-1). Second, as in other small open economies, import prices in Norway are important.[4] Declines in import prices, which have also occurred in other Nordic countries, have helped to hold inflation down. Third, changes in administered prices as well as in taxes and import tariffs also have a significant impact on prices. For example, the reduction in the value-added tax (VAT) on food by 12 percent in July 2001 reduced headline inflation, whereas a 1 percent increase in the VAT at the beginning of 2005 is expected to increase headline inflation significantly.

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[3] When the inflation targeting framework was adopted, this time horizon was deemed to be long enough to avoid unnecessary output costs of returning inflation to the target in too short a period of time. Even so, Norges Bank reserved the option to extend the time horizon beyond two years if necessary. In mid-2004, with the aim of reducing variability in interest rates and output, Norwegian authorities changed the time horizon for achieving the inflation goal from 2 years to 1–3 years.

[4] For example, Norges Bank estimates the share of import prices in the consumer price index (CPI) at more than one-fourth. Moreover, import prices influence CPI indirectly through prices for domestic goods with significant imported inputs and components.

Table I-1. Inflation and its Determinants in Selected Countries
(Percentage change)

Inflation Rate 1/

	1998	1999	2000	2001	2002	2003	2004	2005
Trading partners 2/	1.1	1.3	2.0	2.4	1.9	1.8	1.5	1.8
Denmark	1.8	2.5	2.9	2.4	2.3	2.1	1.2	1.5
Finland	1.4	1.3	3.0	2.7	2.0	1.3	0.1	1.2
Sweden	1.0	0.6	1.3	2.7	2.0	2.3	1.1	0.6
Euro area	1.1	1.1	2.1	2.4	2.3	2.1	2.2	1.8
US	1.5	2.2	3.4	2.8	1.6	2.3	2.7	2.7
UK	1.6	1.4	0.8	1.2	1.3	1.4	1.3	1.8
Norway								
CPI	2.3	2.3	3.1	3.0	1.3	2.5	0.5	1.2
CPI-ATE 3/	…	…	…	2.6	2.3	1.1	0.3	1.0

Sources: Norwegian authorities, WEO, and April Consensus Forecasts.

1/ Unless otherwise specified, actual numbers are from WEO, and projections are from the Consensus.
2/ Norges Bank's estimates. Numbers are from the IR 3/04.
3/ Norges Bank's estimates. Numbers are from the IR 1/05.

Wage Increases

	1998	1999	2000	2001	2002	2003	2004	1998 -2002
Denmark	3.6	2.3	4.2	4.6	3.2	3.6	3.3	3.6
Finland	4.4	2.2	3.7	4.6	1.9	3.3	4.1	3.4
Sweden	2.6	1.4	7.4	4.5	2.7	2.3	3.4	3.7
Germany	1.1	1.2	2.1	1.6	1.5	1.6	0.1	1.5
Euro area	0.8	2.8	2.6	2.9	2.7	2.6	2.2	2.3
US	4.9	4.2	5.7	2.4	3.2	4.0	4.2	4.1
UK	5.6	4.4	5.6	5.3	4.5	4.1	5.2	5.1
Norway	7.1	5.7	4.9	6.1	4.8	4.2	4.0	5.7

Source: The European Commission's Annual Macroeconomic Database (AMECO).

Import Prices

	1998	1999	2000	2001	2002	2003	1998 -2002
Denmark	1.0	0.4	7.8	0.9	-1.4	-0.1	2.7
Finland	-3.8	2.5	18.2	0.7	-1.0	-2.8	4.6
Sweden	-3.3	1.5	4.6	6.0	3.3	1.6	1.9
Germany	-3.1	-1.5	10.1	-0.1	-4.8	-2.4	1.7
US	-6.0	0.1	4.8	-2.9	-1.7	3.1	-1.6
UK	-7.3	-1.0	3.3	-0.7	-2.5	-0.7	-2.6
Norway	1.4	-7.4	3.5	0.2	-6.8	-3.2	-0.7

Source: OECD International Trade and Competitiveness Indicators.

7. **From May 2000 to January 2003, the krone appreciated significantly, as Norges Bank maintained higher interest rates than in Norway's trading partners.** The interest rate differential widened in 2002 when Norway's main trading partners reduced their interest rates to stimulate growth while Norges Bank increased its key interest rate in the wake of higher-than-expected wage pressures. High oil prices and conflicts in the Middle East also contributed to the strength of the krone, as investors considered the krone as a "safe-haven currency."

8. **These tight monetary conditions, the strong currency, and sluggish world economic activity caused declines in mainland GDP in Norway in late 2002 and early 2003, leading to negative output gaps and reduced inflationary pressure.** In response, Norges Bank cut its key interest rate ten times from 7 percent in December 2002 to 1.75 percent in March 2004, well below levels considered cyclically neutral. This led to a 16 percent depreciation of the krone in nominal effective terms from January 2003 to February 2004, although this appreciation has since been in part reversed. Though growth resumed in the second half of 2003 on the back of very loose monetary conditions and improving economic activities worldwide, inflation has remained very low.

B. Empirical Analysis

9. **The dynamics of core inflation are analyzed using a mark-up model for prices, with some elements relating to the Phillips curve.** The central idea is that inflation is associated with costs of production and the business cycle. Accordingly, inflation is modeled as a mark-up over total unit costs, including unit labor costs and import prices.[5] The output gap is also included as an explanatory variable, to capture the effects of economic activity on changes in the mark-up. This can be expressed as:

$$P = f\,(ULC, IP, OG), \tag{1}$$

where *P* stands for prices, *ULC* for unit labor costs, *IP* for import prices, and *OG* for output gap. This model implicitly embeds the hypothesis of purchasing power parity by including import prices among costs of production.

10. **The CPI-ATE, which measures headline inflation adjusted for the direct effects on consumer prices of changes in taxes and energy prices, is examined because this is Norges Bank's policy target.** The headline measure is subject to strong transitory effects, notably electricity prices (Figure I-1).[6] Data for the CPI were kindly provided by Norges Bank. Import prices are from the OECD. Using data from Statistics Norway, unit labor costs are calculated as the difference between wages and productivity, and the output gap is

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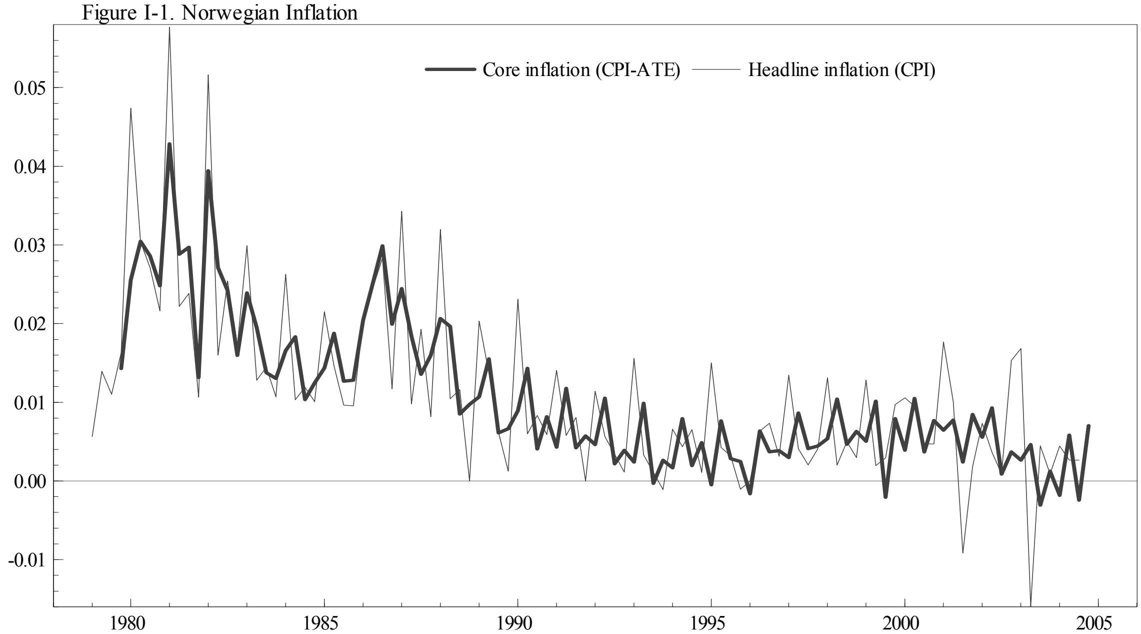
[5] Energy prices are not included as this paper models core inflation, which excludes energy prices.

[6] Henceforth, CPI means CPI-ATE and inflation means core inflation, unless otherwise noted.

calculated as the difference between mainland GDP (at 2001 prices) and trend GDP. The latter is estimated using a Hodrick-Prescott filter. All data are quarterly, spanning 1979:Q3 to 2004:Q2. A dummy variable is used to capture the impact of the formal introduction of the inflation targeting framework in 2001. Allowing for lags and transformations, the estimation period is 1982:Q1 to 2004:Q2.

Figure I-1. Norwegian Inflation



11. **Graphs of import prices, unit labor costs, and the output gap are revealing** (Figure I-2). Over the sample as a whole, import prices fell relative to the CPI, perhaps reflecting high productivity growth in the tradable-goods sector worldwide. This trend intensified in 2002–03, in part because of the appreciation of the krone in 2002. Unit labor costs decreased relative to the CPI from the late 1980s to early 1990s, but have risen significantly since then. Mainland GDP recorded wide deviations from its trend until the late 1980s, after which the amplitude of cycles appears to have fallen substantially. As mentioned, since the fourth quarter of 2002, the output gap has been negative. These stylized facts suggest that the low inflation rate since 2002 is related to the low rate of increase in prices for imported goods and the slowdown in economic activity. It is also worth noting that the difference between prices for imported consumer goods (CPI-IP) and import prices (IP) is positively correlated with the output gap (Figure I-3).[7] Furthermore, prices for imported consumer goods that face competition from locally made goods fell significantly more than prices for goods without competition from locally made goods (Table I-2).

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[7] Strictly, CPI-IP (provided by Norges Bank) and IP (from the OECD) are not fully comparable. The former excludes the impact of taxes and tariffs while the latter does not; and the latter includes, in addition to consumer goods, imports not sold directly to consumers.

Figure I-2. Real Import Prices, Real Unit Labor Costs, and Output Gap

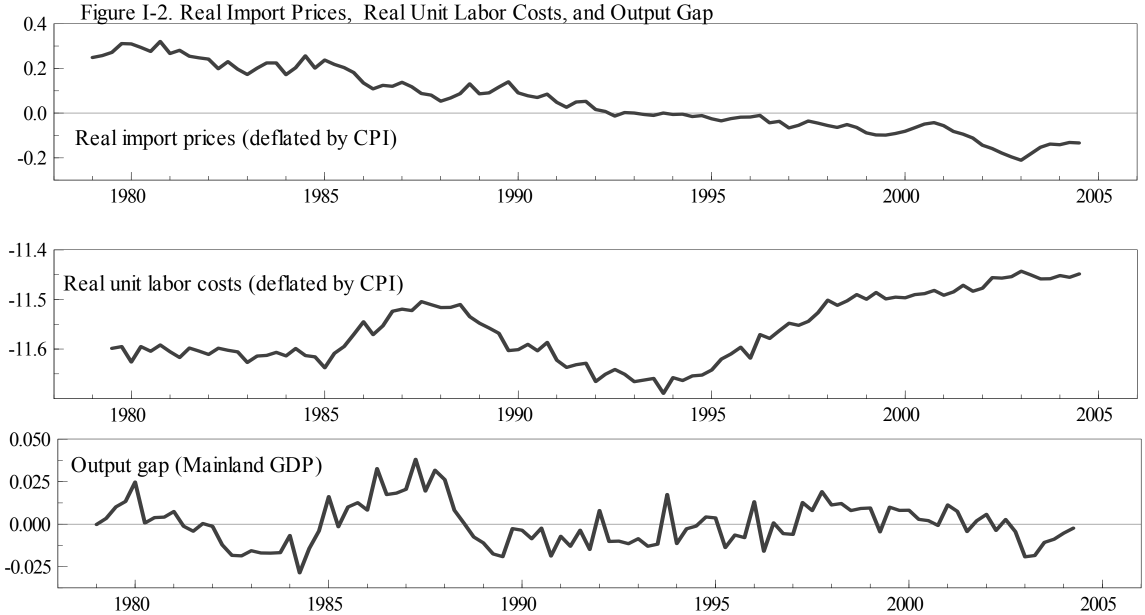


Figure I-3. Import Prices, Difference between Consumer Prices and Import Prices, and Output Gap

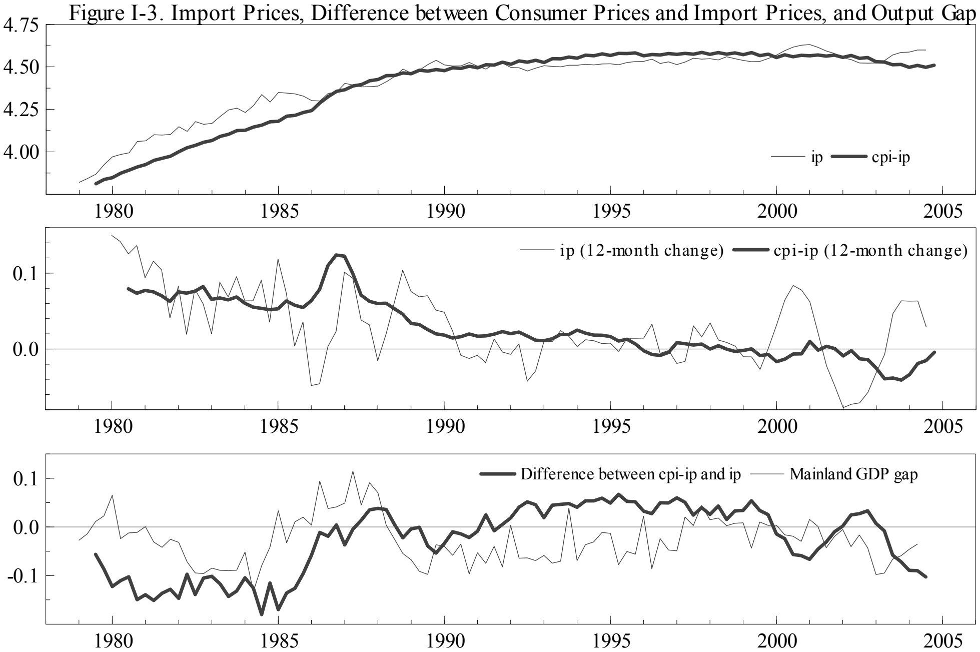


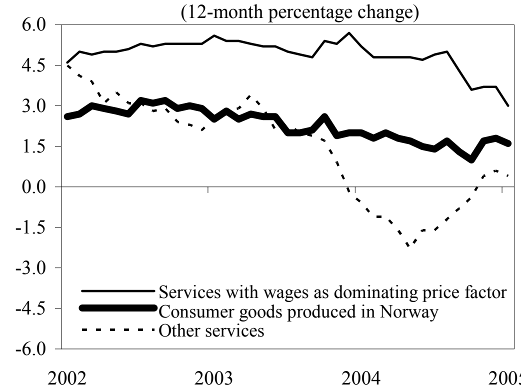
Table I-2. Norway: Consumer Price Index for Imported Goods
(In percent)

	All goods		Goods without competition from Norwegian made goods		Goods facing competition from Norwegian made goods	
	1998=100	Change since 2000	1998=100	Change since 2000	1998=100	Change since 2000
2004	92.7	-6.1	97.9	-2.0	82.2	-14.5
2003	94.2	-4.6	98.4	-1.5	85.5	-11.0
2002	97.8	-0.9	100.4	0.5	91.9	-4.4
2001	99.3	0.6	101.1	1.2	95.2	-0.9
2005						
January	91.0	-7.8	97.9	-2.0	77.6	-22.3
2004						
December	93.1	-5.7	98.1	-1.8	82.9	-17.0
November	93.5	-5.3	98.2	-1.7	83.6	-16.3
October	93.4	-5.4	98.2	-1.7	83.5	-16.4
September	92.9	-5.9	97.7	-2.2	82.8	-17.1
August	91.2	-7.6	97.4	-2.5	78.9	-21.0
July	92.2	-6.6	97.8	-2.1	81.0	-18.9
June	93.0	-5.8	98.0	-1.9	82.9	-17.0
May	93.3	-5.5	98.0	-1.9	83.6	-16.3
April	93.3	-5.5	98.0	-1.9	83.5	-16.4
March	92.8	-6.0	97.9	-2.0	82.5	-17.4
February	92.1	-6.7	97.6	-2.3	81.0	-18.9
January	91.7	-7.1	97.6	-2.3	79.9	-20.0
2003						
December	93.3	-5.5	97.5	-2.4	84.5	-15.4
November	93.6	-5.2	97.7	-2.2	84.9	-15.0
October	93.7	-5.1	97.9	-2.0	85.0	-14.9
September	93.6	-5.2	97.9	-2.0	84.5	-15.4
August	93.0	-5.8	97.9	-2.0	83.0	-16.9
July	93.5	-5.3	98.2	-1.7	83.8	-16.1
June	94.4	-4.4	98.3	-1.6	86.2	-13.7
May	95.1	-3.6	98.7	-1.2	87.4	-12.5
April	95.1	-3.6	98.7	-1.2	87.4	-12.5
March	95.2	-3.5	98.9	-1.0	87.4	-12.5
February	95.2	-3.5	99.3	-0.6	86.5	-13.4
January	94.9	-3.9	99.4	-0.5	85.7	-14.2

Source: Statistics Norway

12. **Increased domestic competition also appears to have contributed to low inflation.** The entry of a new company into the air transportation market caused large declines in airfares from the second half of 2003 to the first half of 2004. Increased competition also led to declines in prices for telecommunication services. As a result, prices for "other services" fell significantly. Moreover, entry of foreign chain stores into the Norwegian retail market

CPI Components
(12-month percentage change)



Source: Norges Bank.

may have increased competition in this sector.[8] These factors, however, are not taken into account in the following empirical analysis because an index of competition is unavailable.

13. **Turning to the empirical results, most variables appear to have unit roots** (Table I-3). CPI and unit labor costs seem to be I(2) based on the Dickey-Fuller statistics alone. However, the estimated roots for *dp* and *dulc* are 0.75 (=1-0.25) and 0.43 (=1-0.57), respectively, which are well below unity. Therefore, both variables are treated as I(1), while recognizing that some caveats may apply.[9] The output gap seems to be I(0), which accords with intuition (Figure I-4).

Table I-3. Augmented Dickey-Fuller (ADF) Statistics for Testing a Unit Root 1/ 2/

(Sample period is 1980 Q1-2004 Q2)

	In levels 3/			In changes		
	Coefficient of the first lag 4/	ADF statistics		Coefficient of the first lag 4/	ADF statistics	
Consumer price index (cpi)	-0.02	-3.11		-0.25	-2.78	
Unit labor costs (ulc)	-0.04	-1.98		-0.57	-2.60	
Import prices (imp)	-0.07	-2.61		-0.77	-3.76	**
Mainland GDP gap (og)	-0.27	-2.97	*	-1.57	-4.51	**

1/ Using seasonality dummy variables.
2/ * indicates rejection of the null hypothesis at 5 percent level, and ** at 1 percent level.
3/ Including a constant for all variables; and a trend for cpi, ulc, and imp.
4/ Under a null order of I(1), the coefficent of the first lag should be zero.

[8] See Norges Bank Inflation Report 1/05.

[9] See Johansen (1992) for an analysis of the cointegrating properties of I(2) series.

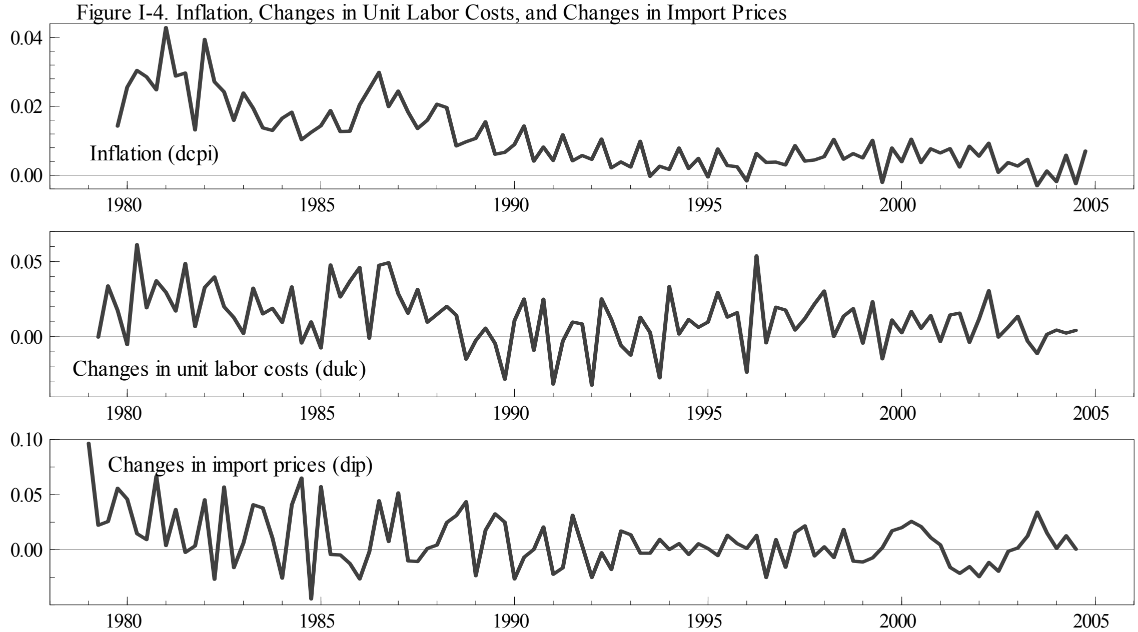
14. **No meaningful cointegrating relationship is found among the above variables in levels.** Regressions are therefore run using *og*, which is an I(0) variable, and differences of the I(1) variables.[10] Using a general-to-specific procedure yields the following model:[11]

$$\Delta p_t = 0.001 + 0.28\Delta p_{t-1} - 0.23\Delta p_{t-3} + 0.56\Delta p_{t-4} + 0.16\Delta p_{t-7} +$$

$$+ 0.09\Delta ulc_t + 0.03\Delta ulc_{t-2} - 0.06\Delta ulc_{t-6} + 0.11\mathrm{og} +$$

$$+ 0.03\Delta \mathrm{ip}_t + 0.03\Delta \mathrm{ip}_{t-6} + 0.02\Delta \mathrm{ip}_{t-8} + \text{Seasonality Dummies} + \varepsilon_t, \qquad (6)$$

Figure I-4. Inflation, Changes in Unit Labor Costs, and Changes in Import Prices



[10] If there is, in fact, a cointegrating relationship among these variables, excluding the error-correction term derived from the cointegrating relationship, would introduce inefficiency and bias (see Banerjee, Dolado, Galbraith, and Hendry, 1993). Such bias, however, may not be very large if feedback from long-run relationships among explanatory variables to short-term relationships is slow.

[11] The procedure began with 10 lags of the relevant variables, then non-significant variables, based on *F*-tests, were dropped.

15. **The results can be summarized as follows.** The output gap as well as changes in unit labor costs and import prices seem to be very important determinants of inflation. The inflation targeting dummy had the expected negative sign, but was not statistically significant and was therefore dropped.[12]

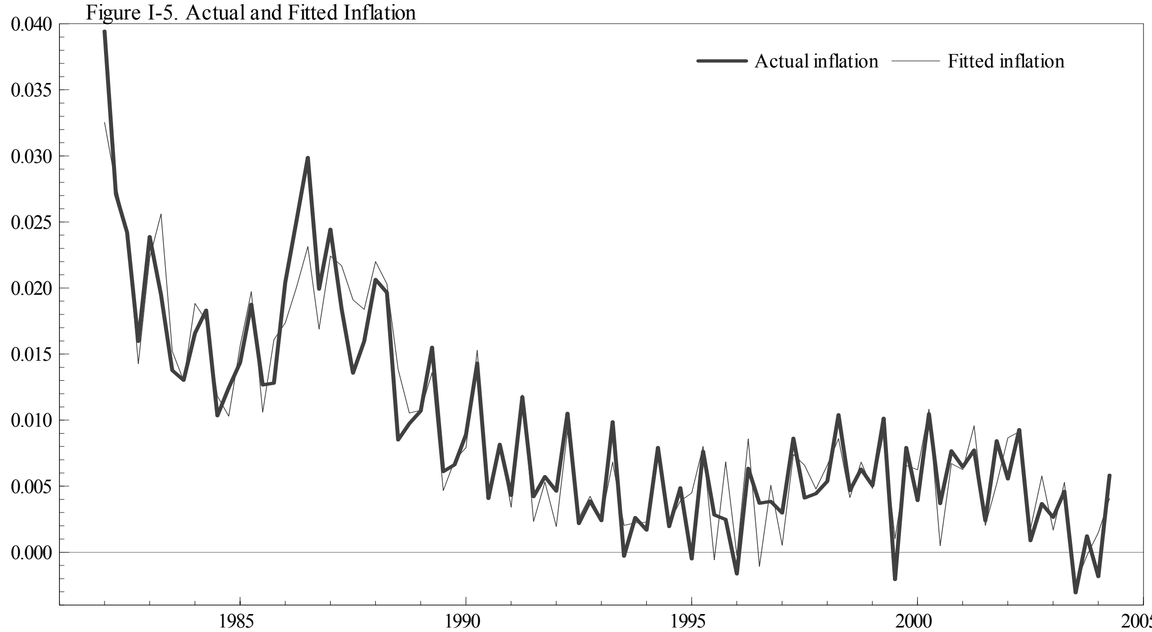
16. **The estimated model performs by and large satisfactorily in terms of diagnostic tests.** The adjusted R^2 is over 90 percent. Tests for autoregression, normality, and heterogeneity do not reveal any serious problems. The RESET test suggests that there is some possibility of omitted variables (Table I-4 and Figure I-5). However, this result is not surprising given that many other factors also affect inflation, such as forces of domestic competition. Iterative estimations of the model suggest that the model parameters are largely stable.

Table I-4. Diagnostic Staistics

R^2		=	0.91
AR 1-5 test:	F(5,70)	=	0.61 [0.69]
ARCH 1-4 test:	F(4,67)	=	1.31 [0.28]
Normality test:	Chi^2(2)	=	4.72 [0.09]
hetero test:	F(25,49)	=	1.65 [0.07]
RESET test:	F(1,74)	=	6.11 [0.02]*

Source: Author's calculations

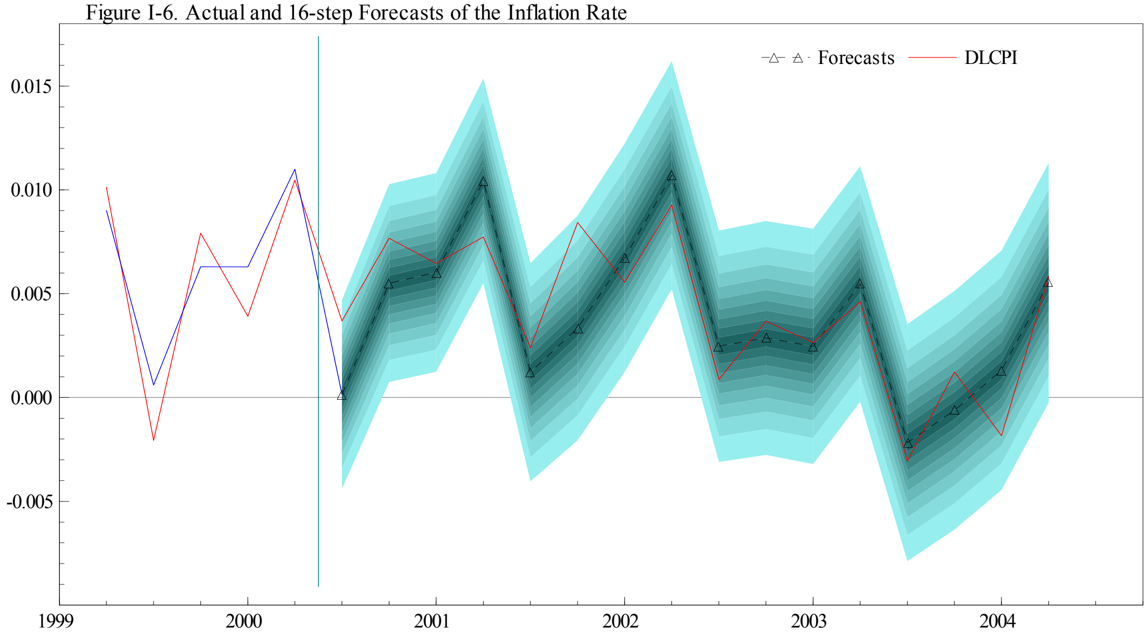
Figure I-5. Actual and Fitted Inflation



[12] This lack of significance of the inflation targeting dummy indicates that the underlying relationship between headline inflation and explanatory variables did not significantly change with the formal introduction of inflation targeting. However, both the mean and standard deviation of headline inflation have declined since 1999, suggesting that the de facto introduction of the inflation targeting framework may have affected inflation through its impact on explanatory variables in equation (6). See Chapter 2 of this selected issues paper, which closely examines the central bank reaction function.

17. **The model forecasts inflation well.** Graphs of the 1-step forecasts for 16-quarter shows that the fit for inflation is quite close and that the forecasts lie within their 95 percent confidence intervals (shown by error fans). Moreover, forecast errors seem to be unbiased and reverting toward zero (Figure I-6).

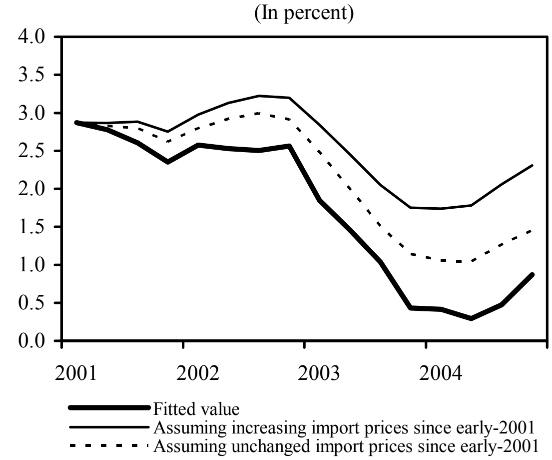
Figure I-6. Actual and 16-step Forecasts of the Inflation Rate



C. Implications for Policymaking

18. **The main factors behind the low inflation since end-2002 seem to be the slowdown in economic activity in late 2002 and early 2003, declines in import prices, and increased competition domestically.** Simulations of the estimated model (equation (6)), assuming no output gap during the 2003–04 period, suggest that the excess capacity in the economy reduced inflation during this period by about 0.8 percentage points each year. Similarly, simulations assuming unchanged import prices since early 2001 suggest that declining import prices reduced inflation by more than 0.6 percentage points. Inflation would have been by more than 1 percentage point higher had import prices increased during this period at a rate prevailing in the two years prior to 2001.

Inflation Estimations Using Equation (6)
(In percent)

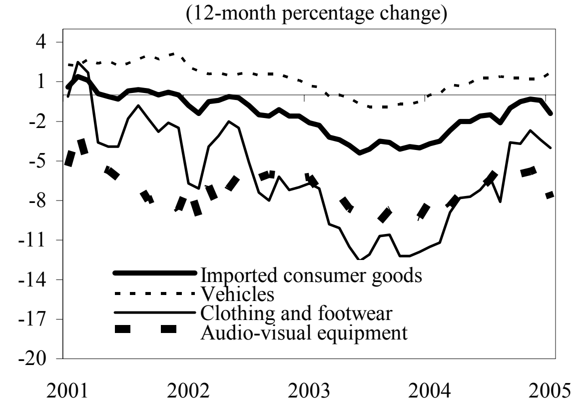


Source: The author's estimations.

19. **Declines in import prices and increased competition domestically can be considered one-off factors that lower the price level, but have no long-run effect on inflation.**[13] The declines in import prices can be attributed to four factors: (i) a strong appreciation of the krone in 2002; (ii) a shift in imports from high-cost countries such as Europe and the U.S. to low-cost countries such as China and India; and (iii) lower trade barriers. While it is difficult to predict how long such factors might persist, they are expected to wind down eventually. Similarly, market entry and regulatory changes can enhance domestic competitive forces, but margins can only be cut so far. Indeed, evidence suggests that these import and domestic price declines are coming to an end.

Prices for Imported Consumer Goods

(12-month percentage change)

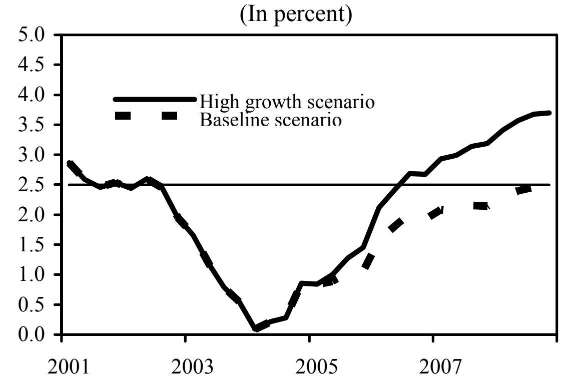


Source: Norges Bank.

20. **The strong pickup in domestic activity and the waning of the so-called structural factors are thus likely to herald rising inflation.** The authorities and staff project a sizable positive output gap in 2005–07 and tighter labor markets. Inflationary pressure is thus likely to rise. Forecasts using the estimated model, assuming that import prices stabilize and start increasing in 2006, suggest that the inflation target would be achieved in 2006-08, depending on the evolution of the output gap. To illustrate the sensitivity of inflation to the gap, simulations are performed under two scenarios: (i) the baseline, which assumes growth consistent with staff projections (which include, among other things, a gradual rise in interest rates toward cyclically neutral levels), involving about 0.9 percent output gap during 2005–08; and (ii) a high growth scenario (which could be consistent with continued low interest rates), involving a 2.9 percent output gap during 2005–08. Under the baseline scenario, the model predicts that the targeted rate of 2.5 percent would be achieved in 2008. Under the high growth scenario, the model predicts that the targeted rate of 2.5 percent would be overshot by about 1 percentage point in 2008.

12-month Inflation Forecasts

(In percent)



Source: The author's estimations

[13] The authorities refer to these factors as structural factors.

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II. Implicit and Explicit Targets in Small Open Economies[14]

A. Motivation and Overview

1. **In Norway—like in other industrialized open economies—the inflation targeting regime has been instrumental in taming inflation and stabilizing the economy, and appears to have gained considerable credibility over time.**[15] Since March 2001, Norges Bank has operated a flexible inflation targeting regime, taking into consideration both variability in output and employment, and variability in inflation. The operational target of monetary policy is annual consumer price inflation—adjusted for tax changes and excluding energy products—of "approximately 2½ percent" over a "reasonable" time horizon, lately redefined as 1–3 years. According to survey evidence, Norway's medium-term inflationary expectations remain anchored at 2½ percent. Recent measures have further improved the transparency and the flexibility of the Norwegian monetary policy framework, while enhancing guidance to the markets.[16]

2. **An unsettled issue in inflation-targeting open economies such as Norway remains whether deviations of the real exchange rate from equilibrium should be taken into account in formulating monetary policy.** Under a flexible inflation targeting regime, should policymakers focus solely on domestic variables and avoid any reaction to movements in the foreign exchange market? Or is it correct to claim that "a substantial appreciation of the real exchange rate [...] furnishes a *prima facie* case for relaxing monetary policy," as argued by Obsteld and Rogoff (1995)? The primacy of inflation targeting entails that, as soon as macroeconomic indicators suggest that inflationary pressures are beginning to surface, the monetary authority should start a gradual policy tightening. Indeed, delays in rising interest rates might undermine the credibility of the inflation targeting framework itself. In practice, however, the room for maneuvering of small open economies' (SOEs) policymakers is likely to be constrained by the need to avoid an exchange rate appreciation that would damage the traded goods sector. Should this prospect make a case against an immediate policy tightening?

3. **Using data for six advanced small open economies explicitly targeting inflation, this chapter examines empirically whether deviations of the exchange rate from their**

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[14] Prepared by Silvia Sgherri.

[15] Over the 1990's, New Zealand, Canada, the United Kingdom, Sweden, and Australia all changed the institutional framework under which monetary policy was conducted, by shifting to an inflation targeting regime. Norway and Iceland followed suit in 2001. The literature on the institutional aspects of inflation targeting in industrial countries is vast. For a recent review, see Bernanke and Woodford (2005) and references therein.

[16] On recently introduced measures enhancing the transparency of Norway's monetary framework and related discussion, see the staff report.

equilibrium levels systematically affect the conduct of monetary policy. The basic test is to see if such deviations enter the monetary policy reaction function, modeled as a forward-looking interest rate rule, and thus whether they enter as a separate argument in the interest rate rule.

4. **This chapter finds that most of the inflation targeters examined do not respond to output deviations and, if they target core inflation, not to the exchange rate.** In three out of six cases (Canada, Australia, and New Zealand) where the available measure of core inflation closely resembles headline CPI inflation, the real exchange rate does appear to enter the monetary policy reaction function independently. Estimates from rolling regressions also indicate that monetary policy responses in inflation-targeting open economies have varied significantly over time. As the institutional framework for the conduct of monetary policy has evolved over recent years, the parameterization of interest rate reaction functions has changed accordingly. Interestingly, rolling regressions imply that confidence in inflation targeting has increased over time in all six economies.

5. **Norway, in particular, now appears to be targeting the inflation rate, but not, independently, output or the exchange rate**. The use of an explicit target for core inflation, and a greater use of the expectation channel of monetary policy appear to be key features behind this result. In this respect, time-varying estimates of the monetary policy responses suggest that the credibility of the framework has increased over time and is now well established. At the same time, putting private sector perceptions about the stability of monetary policies at center stage highlights the importance of central bank communication.

6. **The chapter is organized as follows.** Section B briefly reviews the standard framework of analysis of forward-looking monetary reaction functions. The model is generalized to an interest rate rule explicitly allowing for real exchange rates to act both as information variables and as monetary policy targets. *Inter alia,* alternative targets for inflation and a range of proxies for the output gap are here examined. Section C reports the main empirical results from estimating standard forward-looking rules as well as augmented forward-looking Taylor rules, which allow for possible exchange rate targeting. For each country, the actual and the implied value of the policy interest rate under the standard and the augmented monetary reaction function are shown. Finally, changes in central banks' behavior over time are analyzed by presenting results from rolling regressions, in which parameter estimates are reported over successive forty-quarter windows. The results are open to several interpretations, which are discussed in the concluding section.

B. Theoretical Background

7. **Extensive academic work on monetary policy tends to characterize conduct in terms of interest rate rules and consequences in stylized models embedding these rules.**[17] According to this framework, short-term money market rates are set to stabilize

[17] See, among others, Clarida, Galí, and Gertler (1999), Taylor (1993, 2000), and Woodford (2001).

domestic variables—such as price inflation and real output—around their equilibrium path. Several contributions within the so-called New Keynesian synthesis have shown that—under quite general conditions—a simple, inward-looking, interest rate rule can be regarded as an optimal policy response for a *closed* economy.[18] Less attention has been paid to the choice of monetary policy objectives in a *small open economy* context, given that an open economy is isomorphic to a closed economy whenever the exchange rate pass-through to import prices is complete.[19] In other words, under *complete exchange rate flexibility*, SOE's policymakers should also focus solely on domestic targets. Unfortunately, there is extensive evidence that—in reality—departures from the law of one price for traded goods prices are large and pervasive. Under these circumstances, policy choices are hardly independent of exchange rate dynamics and monetary conduct is liable to focus on more than just domestic stabilization.[20] Indeed, recent empirical studies provide evidence that exchange rates are statistically significant in interest rate rules depicting the reaction function of major economies.[21]

8. **Following a widespread approach in the literature of flexible inflation targeting, this chapter assumes that central banks face a quadratic loss function over inflation and output**.[22] Under standard conditions, this implies that in each period the monetary authority has a target for the nominal money market interest rate i_t^*, which is a function of the gaps between expected inflation and output from their respective targets:

$$i_t^* = i^* + \beta\left[E\left(\pi_{t+k^\pi} \middle| \Omega_t\right) - \pi^*\right] + \gamma\left[E\left(y_{t+k^y} \middle| \Omega_t\right)\right], \tag{1}$$

where i^* is the desired nominal rate of interest when both inflation and output are at their target levels; $E\left(\pi_{t+k^\pi} \middle| \Omega_t\right)$ denotes the expectations of inflation at time $t+k^\pi$; and $E\left(y_{t+k^y} \middle| \Omega_t\right)$ denotes corresponding expectations of the output gap at time $t+k^y$. π^* is the level of inflation implicitly or explicitly targeted by the central bank, whereas the output gap, y, is defined as the difference between the level of real output and its trend. The coefficients β and γ measure the strength of policy responses to deviations from the target variables. A parameter γ=0 implies monetary policy is uniquely concerned about price stability and does

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[18] See, for example, Taylor (1999) and references therein.

[19] On this point, see Galí and Monacelli (2002).

[20] Corsetti and Pesenti (2002) and Monacelli (2003) show that, with incomplete pass-through, optimal monetary policy is not purely inward looking.

[21] See, for example, Clarida, Galí, and Gertler (1998) and Chadha, Sarno, and Valente (2004).

[22] See, among others, Bernanke and Woodford (1997) and Svensson (1997).

not aim at stabilizing business cycle fluctuations. If β<1, policy is attempting to accommodate inflationary shocks, which—over the long run—will lead to instability as real rates respond perversely to inflationary disturbances.[23]

9. **However, central banks are likely to react gradually to expected deviations from targets, by smoothing their policy rate adjustments over several periods**.[24] To account for this behavior, the interest rate rule is modified by allowing for a second-order partial adjustment to the target rate, namely:

$$i_t = \rho(L) i_{t-s} + \left[1-\rho(L)\right] i_t^* + v_t, \tag{2}$$

where $\rho(L)$ is a second-order polinomial, L is the lag operator, i_t^* is the target rate whose behavior is described by equation, and v_t is a zero-mean interest rate shock. Combining equations (1) and (2) yields an expression for the standard forward-looking Taylor rule, e.g.,

$$i_t = \rho(L) i_{t-s} + \left[1-\rho(L)\right]\left\{\alpha + \beta\left[E\left(\pi_{t+k^{\pi}} \left|\Omega_t\right.\right)\right] + \gamma\left[E\left(y_{t+k^{y}} \left|\Omega_t\right.\right)\right]\right\} + v_t, \tag{3}$$

which, in turn, allows direct inference of the policy responses, β and γ, and derivation of the implied (ex-ante) equilibrium real interest rate, $r^* = \alpha - \left(1-\beta\right)\pi^*$, if the inflation target is known. So far, the only innovation in this policy rule specification regards the inclusion of two lagged terms (rather than one) in the interest rate. This more flexible dynamic structure provides a better description of some of the changes in monetary responses over time.

10. **It is under debate whether and how exchange rates (and asset prices, in general) should be taken into account in formulating monetary policy**.[25] While it is unanimously recognized that exchange rates are useful indicators of inflationary pressures in the economy (because changes in the exchange rate feed through into domestic prices and affect aggregate demand), central bankers have often been explicit that exchange-rate stabilization is not a direct target of policy. To assess whether this is really how they act, the interest rate rule (3) is further generalized to allow for policymakers' responses to exchange rate disequilibria:

$$i_t = \rho(L) i_{t-s} + \left[1-\rho(L)\right]\left\{\tilde{\alpha} + \tilde{\beta}\left[E\left(\pi_{t+k^{\pi}} \left|\Omega_t\right.\right)\right] + \tilde{\gamma}\left[E\left(y_{t+k^{y}} \left|\Omega_t\right.\right)\right] + \delta\left[E\left(e_{t+k^{e}} \left|\Omega_t\right.\right)\right]\right\} + \varepsilon_t, \tag{4}$$

[23] Christiano and Gust (2000) emphasize that a high inflation expectations trap may arise if policy accommodates inflation.

[24] Sack and Wieland (2000) provide an in depth discussion of interest rate smoothing. On the issue of gradualism as optimal response to uncertainty, see Brainard (1967) as canonical reference on the theory side, Woodford (1999) for a recent application, and Walsh (2003) for an exhaustive review.

[25] See Taylor (2001) and Goodhart (2001).

where e_{t+k^e} denotes the forward-looking real exchange rate. In line with recent empirical literature, purchasing power parity (PPP) is assumed to hold in the long run, so that the real exchange rate follows a persistent, albeit stationary, process. The equilibrium real exchange rate can thus be captured by a constant included in the intercept term $\tilde{\alpha}$ of the "augmented interest rate rule" (4), implying that central banks attempt to correct expected misalignments from PPP. If the real exchange rate is expressed as the domestic price of foreign currency, the resulting monetary rule will stabilize it if $\delta > 0$, as an appreciation of the real exchange rate will require a cut in the short-term interest rate. Under the augmented specification, the implied (ex-ante) equilibrium real interest rate will hence be identified only if both the inflation target *and* the equilibrium real exchange rate are known: $r^* = \tilde{\alpha} - \left(1-\tilde{\beta}\right)\pi^* + \delta e^*$.

11. **Under rational expectations, central banks form their forecasts of future inflation, output gap, and real exchange rate using *all* relevant information available at the time the interest rate is set.** Let z_t denote the vector of indicators comprising the central bank's information set at that time (i.e., $\mathbf{z}_t \in \Omega_t$). If the monetary authority adjusts the interest rate according to the augmented interest rate rule (4), while forming expectations of future variables in a fully rational manner, then there must exist a set of parameters $\left\{\hat{\tilde{\rho}}_1, \hat{\tilde{\rho}}_2, \hat{\tilde{\alpha}}, \hat{\tilde{\beta}}, \hat{\tilde{\gamma}}, \hat{\delta}\right\}$ such that the residuals obtained from the estimation of equations (4) are orthogonal to the information set available, z_t. Formally, $E\left[\varepsilon_t \middle| \mathbf{z}_t\right] = 0$. This set of orthogonality conditions forms the basis of the estimates, using the Generalized Method of Moments (GMM). In addition, the validity of the set of instruments used can be tested by means of over identifying restrictions, provided the number of instruments in z_t is greater than the number of parameters to be estimated.

12. **The dataset comprises quarterly data from January 1984 to June 2004 for six inflation targeting countries: Norway, Sweden, United Kingdom, Canada, Australia, and New Zealand.** The baseline inflation measure is the annual core inflation rate (π^{CORE}), as reported by national monetary authorities. Because this measure is generally available only over recent periods, the series were extended backwards using the fourth differences in the log of CPI, as reported by the IFS database. Results are, however, also described using fourth differences in the log of CPI series (π^{CPI}) throughout the sample. Figure II-1 plots the instrument interest rate (that is, the rate used by the central bank as a policy instrument) for each of the six countries against measures of underlying and headline inflation. As for the output gap, the preferred indicator is the *growth* gap (y^{DGAP}), given recent findings on the optimal policy response to potential output uncertainty (Orphanides and van Norden, 2002). Results are also reported for two alternative measures of the output gap: the Hodrick-Prescott filter for the level of real output (y^{HP}), and the real unit labor cost after adjusting for wage markup (y^{ARMC}), constructed as documented in Galí, Gertler, and López-Salido (2001).

Figure II-1: Interest Rate, Core, and Headline Inflation

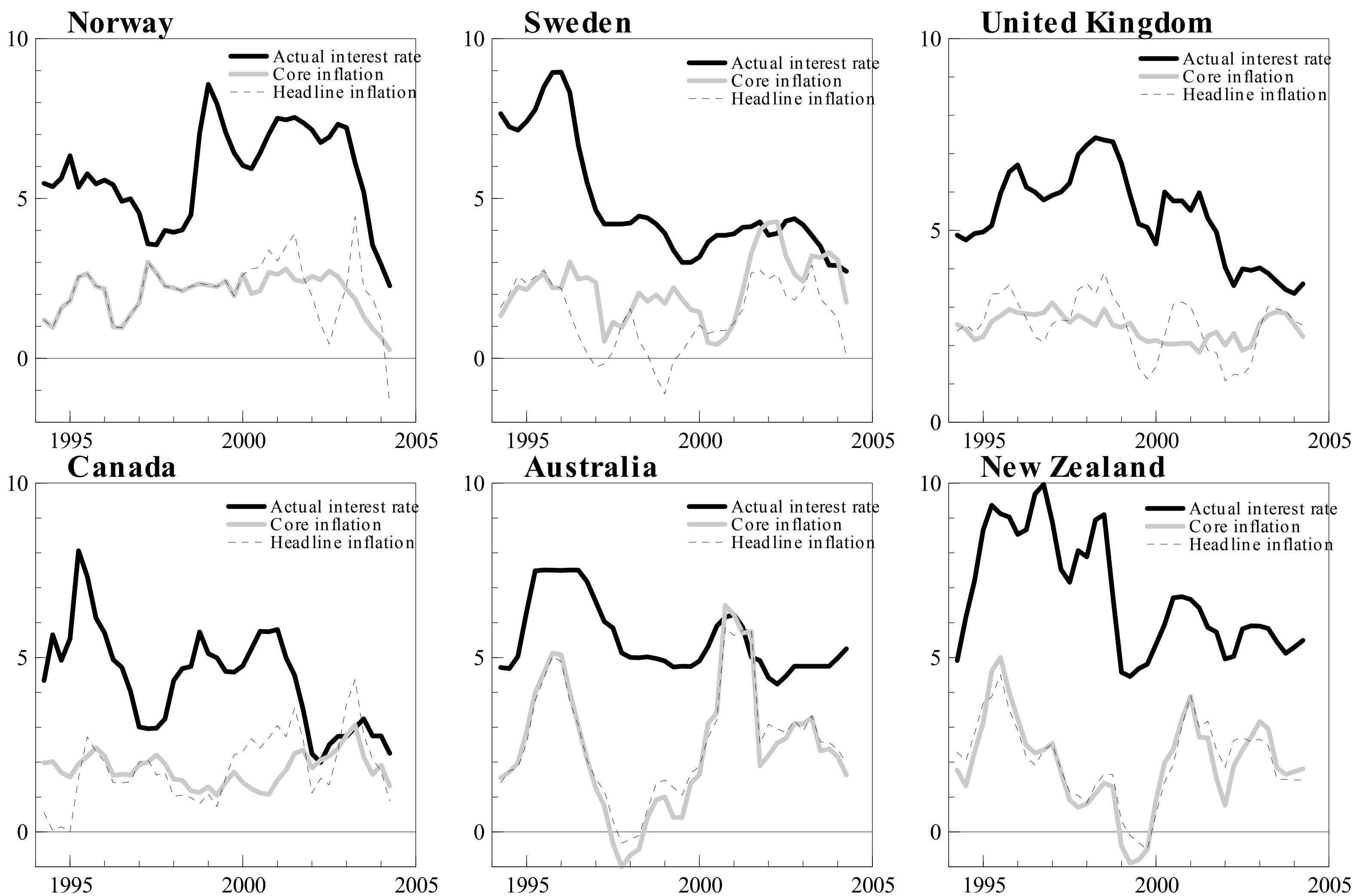

Figure II-2 seems to confirm that the three output gap series are positively correlated but not identical.[26] Finally, for all countries, misalignments from PPP are proxied by the logs of de-meaned real effective exchange rates based on CPI, given that real effective exchange rates series based on unit labor costs were not available for all countries.

C. Empirical Results

13. **Table II-1 reports GMM estimates of the parameters $\left\{\hat{\rho}_1, \hat{\rho}_2, \hat{\beta}, \hat{\gamma}\right\}$ in the standard forward-looking Taylor rule (3), where only expected inflation and expected output gap are considered as explanatory variables.** The target horizon is assumed to be one quarter for both inflation and the output gap (i.e. $k^{\pi} = k^{y} = 1$), although results are qualitatively unaffected by this choice (not reported). The instrument set, $\mathbf{z}_t$, includes a constant, a world commodity price index, and four lags of the policy rate, inflation, and the output gap. In estimating the model for Norway and Sweden, the 1993Q1 and the 1992Q4 interest rate observations, respectively, are dummied out as extreme and unsystematic monetary tightening episodes dealing with the ERM crisis.

14. **Estimation results yield parameter values broadly consistent with previous findings reported by the literature for inflation targeting countries**. In particular, for Norway, for each of the specifications considered the estimate of β is always correctly signed, strongly significant, and greater than unity, while the estimate of γ is not statistically different from zero at conventional significance levels. This implies that Norges Bank has responded only to deviations of the expected inflation from target, not to the expected output gap. The same conclusion can be drawn for Sweden, United Kingdom, and New Zealand, whose parameter estimates look very much alike in size and statistical significance.[27] As for Australia, the estimate of β is strongly significant and greater than unity, but there is also some evidence that monetary policy stabilizes expected business cycle fluctuations. The evident outlier is Canada, for which monetary policy responses to both inflation and output gap are much stronger than in other countries, though the parameters are estimated with far less precision. For all specifications and for each country, the over-identifying restrictions cannot be rejected, with the Hansen test supports the validity of the instrument set used. Standard deviations of the countries' policy rates are estimated in the order of 1 percent, with the exception of New Zealand, where the volatility is slightly higher (around 1.3 percent).

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[26] In the case of Norway, all pairwise correlations between the three output gap measures are statistically significant, ranging between 0.24 (between y^{HP} and y^{ARMC}) and 0.58 (between y^{HP} and y^{DGAP}). For all countries, the adjusted real unit labor cost exhibits the least synchronized behavior.

[27] For the United Kingdom, this holds true in five out of six specifications, while the estimate of γ becomes significant when the output gap is proxied by the HP filter and price changes are measured by core inflation. The same exception remains valid in Table II-2, when deviations from PPP are also allowed for.

Figure II-2: Output Gap Measures

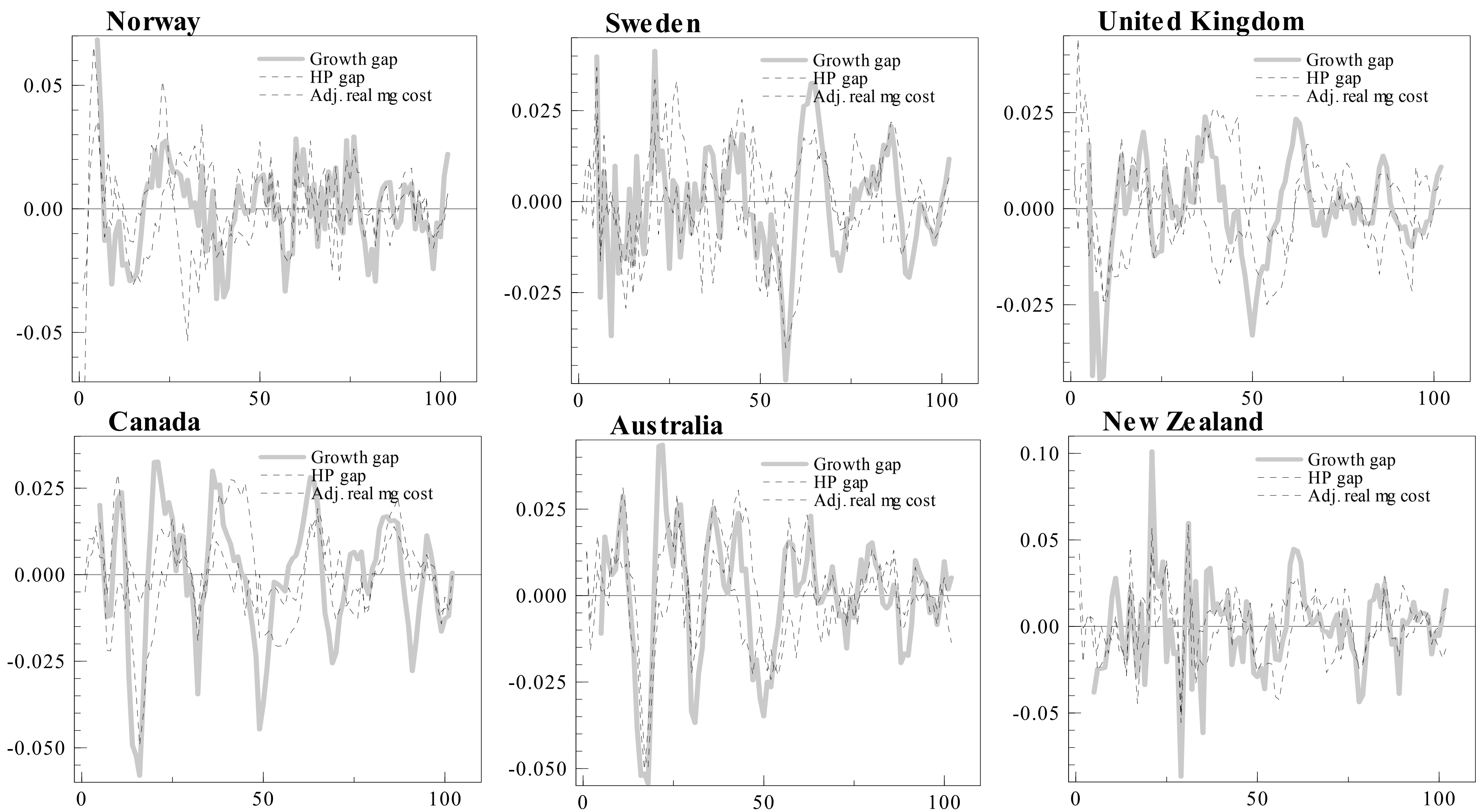


Table II-1: Forward-Looking Taylor Rule

Norway	ρ_1	ρ_2	β	γ	*j-test*	*see*
$y=y^{DGAP}$; $\pi=\pi^{CORE}$						
	0.585	0.062	**1.731**	0.002	0.884	1.010
	(0.111)	(0.058)	**(0.099)**	(0.175)		
$y=y^{HP}$; $\pi=\pi^{CORE}$						
	0.555	0.085	**1.788**	0.007	0.904	1.031
	(0.138)	(0.066)	**(0.107)**	(0.291)		
$y=y^{ARMC}$; $\pi=\pi^{CORE}$						
	0.613	0.064	**1.739**	0.504	0.873	1.003
	(0.109)	(0.057)	**(0.188)**	(0.586)		
$y=y^{DGAP}$; $\pi=\pi^{CPI}$						
	0.685	0.042	**1.780**	0.206	0.657	1.051
	(0.116)	(0.073)	**(0.162)**	(0.311)		
$y=y^{HP}$; $\pi=\pi^{CPI}$						
	0.699	0.060	**1.738**	0.671	0.614	1.051
	(0.134)	(0.076)	**(0.183)**	(0.669)		
$y=y^{ARMC}$; $\pi=\pi^{CPI}$						
	0.695	0.066	**1.845**	0.974	0.790	1.111
	(0.115)	(0.073)	**(0.259)**	(0.740)		
Sweden	ρ_1	ρ_2	β	γ	*j-test*	*see*
$y=y^{DGAP}$; $\pi=\pi^{CORE}$						
	0.824	**-0.055**	**1.951**	0.321	0.573	0.974
	(0.054)	**(0.014)**	**(0.178)**	(0.344)		
$y=y^{HP}$; $\pi=\pi^{CORE}$						
	0.901	**-0.063**	**1.900**	0.917	0.704	0.925
	(0.080)	**(0.025)**	**(0.223)**	(0.618)		
$y=y^{ARMC}$; $\pi=\pi^{CORE}$						
	0.823	**-0.064**	**1.916**	-0.394	0.580	1.003
	(0.054)	**(0.014)**	**(0.167)**	(0.448)		
$y=y^{DGAP}$; $\pi=\pi^{CPI}$						
	0.936	**-0.094**	**1.458**	0.285	0.657	1.051
	(0.045)	**(0.014)**	**(0.157)**	(0.414)		
$y=y^{HP}$; $\pi=\pi^{CPI}$						
	0.960	**-0.081**	**1.406**	**1.594**	0.614	1.051
	(0.053)	**(0.025)**	**(0.196)**	**(0.804)**		
$y=y^{ARMC}$; $\pi=\pi^{CPI}$						
	0.949	**-0.105**	**1.518**	-0.830	0.790	1.111
	(0.049)	**(0.013)**	**(0.190)**	(0.659)		

(continued)

Table II-1: *(continued)*

United Kingdom	ρ_1	ρ_2	β	γ	*j-test*	*see*
$y=y^{DGAP}$; $\pi=\pi^{CORE}$						
	0.771	0.013	**1.838**	0.732	0.570	0.980
	(0.127)	(0.082)	**(0.327)**	(0.773)		
$y=y^{HP}$; $\pi=\pi^{CORE}$						
	0.591	**0.124**	**1.900**	**1.416**	0.665	0.968
	(0.108)	**(0.067)**	**(0.243)**	**(0.470)**		
$y=y^{ARMC}$; $\pi=\pi^{CORE}$						
	0.777	0.029	**1.799**	0.667	0.585	0.987
	(0.125)	(0.087)	**(0.361)**	(0.982)		
$y=y^{DGAP}$; $\pi=\pi^{CPI}$						
	0.604	0.166	**1.724**	0.144	0.763	0.872
	(0.080)	(0.064)	**(0.203)**	(0.391)		
$y=y^{HP}$; $\pi=\pi^{CPI}$						
	0.642	**0.181**	**1.522**	0.872	0.838	0.899
	(0.085)	**(0.061)**	**(0.320)**	(0.901)		
$y=y^{ARMC}$; $\pi=\pi^{CPI}$						
	0.611	0.163	**1.759**	0.294	0.743	0.872
	(0.084)	(0.069)	**(0.217)**	(0.377)		

Canada	ρ_1	ρ_2	β	γ	*j-test*	*see*
$y=y^{DGAP}$; $\pi=\pi^{CORE}$						
	0.835	0.129	5.755	9.318	0.732	1.006
	(0.094)	(0.072)	(6.372)	(15.161)		
$y=y^{HP}$; $\pi=\pi^{CORE}$						
	0.717	**0.150**	**2.427**	**2.762**	0.800	0.998
	(0.071)	**(0.050)**	**(0.548)**	**(0.940)**		
$y=y^{ARMC}$; $\pi=\pi^{CORE}$						
	0.788	0.051	**3.165**	**3.942**	0.757	1.072
	(0.094)	(0.057)	**(0.790)**	**(1.641)**		
$y=y^{DGAP}$; $\pi=\pi^{CPI}$						
	0.786	0.153	**3.328**	6.563	0.669	0.988
	(0.106)	(0.075)	**(1.710)**	(5.222)		
$y=y^{HP}$; $\pi=\pi^{CPI}$						
	0.779	**0.148**	0.190	**5.379**	0.562	0.934
	(0.082)	**(0.061)**	(0.946)	**(2.806)**		
$y=y^{ARMC}$; $\pi=\pi^{CPI}$						
	0.831	0.084	**1.980**	8.500	0.508	1.047
	(0.111)	(0.081)	**(0.920)**	(5.261)		

(continued)

Table II-1: *(concluded)*

Australia	ρ_1	ρ_2	β	γ	*j-test*	*see*
$y=y^{DGAP}$; $\pi=\pi^{CORE}$						
	1.031	-0.104	**1.524**	**3.723**	0.767	1.018
	(0.083)	(0.080)	**(0.341)**	**(1.018)**		
$y=y^{HP}$; $\pi=\pi^{CORE}$						
	1.062	-0.141	**0.715**	**3.046**	0.865	1.060
	(0.083)	(0.081)	**(0.360)**	**(1.454)**		
$y=y^{ARMC}$; $\pi=\pi^{CORE}$						
	1.118	**-0.191**	**1.083**	2.705	0.818	1.079
	(0.099)	**(0.090)**	**(0.490)**	(1.772)		
$y=y^{DGAP}$; $\pi=\pi^{CPI}$						
	1.012	-0.093	**1.771**	**3.441**	0.723	0.991
	(0.081)	(0.079)	**(0.355)**	**(0.970)**		
$y=y^{HP}$; $\pi=\pi^{CPI}$						
	1.048	-0.136	**0.936**	2.573	0.837	1.037
	(0.081)	(0.080)	**(0.335)**	(1.461)		
$y=y^{ARMC}$; $\pi=\pi^{CPI}$						
	1.094	**-0.181**	**1.331**	1.959	0.809	1.049
	(0.101)	**(0.089)**	**(0.420)**	(1.647)		
New Zealand	ρ_1	ρ_2	β	γ	*j-test*	*see*
$y=y^{DGAP}$; $\pi=\pi^{CORE}$						
	0.746	-0.100	**1.341**	-0.520	0.680	1.388
	(0.120)	(0.099)	**(0.066)**	(0.211)		
$y=y^{HP}$; $\pi=\pi^{CORE}$						
	0.876	**-0.196**	**1.349**	-0.081	0.490	1.214
	(0.082)	**(0.069)**	**(0.072)**	(0.267)		
$y=y^{ARMC}$; $\pi=\pi^{CORE}$						
	0.860	**-0.192**	**1.353**	-0.117	0.479	1.230
	(0.089)	**(0.074)**	**(0.095)**	(0.304)		
$y=y^{DGAP}$; $\pi=\pi^{CPI}$						
	0.751	-0.107	**1.328**	-0.517	0.725	1.417
	(0.124)	(0.104)	**(0.059)**	(0.210)		
$y=y^{HP}$; $\pi=\pi^{CPI}$						
	0.864	**-0.196**	**1.336**	-0.078	0.540	1.228
	(0.079)	**(0.067)**	**(0.061)**	(0.273)		
$y=y^{ARMC}$; $\pi=\pi^{CPI}$						
	0.873	**-0.198**	**1.369**	0.060	0.530	1.345
	(0.088)	**(0.074)**	**(0.098)**	(0.410)		

15. **Next, the parameters $\left\{\hat{\hat{\rho}}_1, \hat{\hat{\rho}}_2, \hat{\hat{\beta}}, \hat{\hat{\gamma}}, \hat{\delta}\right\}$ for the six countries are estimated using an augmented interest rate rule (4)**. The target horizon for the three forward-looking variables—inflation, output gap, and real exchange rate—is still assumed to be one (i.e. $k^{\pi} = k^{y} = k^{e} = 1$). The results of the GMM estimation are reported in Table II-2, using alternative measures of inflation and output gap. In all countries except the United Kingdom, there is some evidence that—over the sample—real exchange rate movements have direct explanatory power in characterizing interest rate changes. In Norway and in Sweden, this is true *only if* the monetary authority is assumed to target *headline* rather than core inflation (recall that Norway targets core inflation). In three out of six cases (Canada, Australia, and New Zealand)—where, ex post, the available measure of core inflation closely resembles headline CPI inflation—the real exchange rate yields significant (and correctly signed) parameter estimates, even when the central bank is assumed to target core inflation.

16. **Overall, the inclusion of exchange rate disequilibria does not seem to affect appreciably the model's interest rate predictions.** To aid interpretation of the results, Figure II-3 juxtaposes, for each country, the actual interest rate to the estimated interest rate implied (i) by the baseline standard forward-looking Taylor rule (Table II-1), and (ii) by the augmented interest rule allowing for exchange rate responses (Table II-2). The interest rates implied by the estimated rules characterize well the behavior of the actual rates. Indeed, both specifications of the reaction function satisfactorily trace the dynamics of the interest rates. The simple visual inspection of the models' predictions suggests that the contribution of real exchange rate disequilibria is not sufficient to distinguish between the two models. Even for Australia and New Zealand—where deviations from PPP play a slightly greater role in explaining interest rate movement, given our preferences for measuring inflation and output gap—the standard Taylor rule that provides a better fit over the latest quarters of the sample.

Table II-2: Augmented Forward-Looking Taylor Rule

Norway	$\tilde{\rho}_1$	$\tilde{\rho}_2$	$\tilde{\beta}$	$\tilde{\gamma}$	δ	*j-test*	*see*
$y=y^{ARMC}$; $\pi=\pi^{CORE}$							
	0.608	0.061	**1.760**	0.643	0.006	0.917	1.051
	(0.120)	(0.055)	**(0.205)**	(0.514)	(0.119)		
$y=y^{HP}$; $\pi=\pi^{CORE}$							
	0.571	0.051	**1.718**	0.198	0.060	0.874	1.028
	(0.147)	(0.063)	**(0.266)**	(0.339)	(0.109)		
$y=y^{DGAP}$; $\pi=\pi^{CORE}$							
	0.577	0.040	**1.716**	0.100	0.050	0.848	1.018
	(0.122)	(0.055)	**(0.214)**	(0.184)	(0.098)		
$y=y^{ARMC}$; $\pi=\pi^{CPI}$							
	0.658	0.080	**1.714**	0.895	0.067	0.715	1.101
	(0.116)	(0.072)	**(0.250)**	(0.645)	(0.114)		
$y=y^{HP}$; $\pi=\pi^{CPI}$							
	0.667	0.050	**1.435**	0.919	0.219	0.517	1.048
	(0.139)	(0.069)	**(0.301)**	(0.644)	(0.125)		
$y=y^{DGAP}$; $\pi=\pi^{CPI}$							
	0.655	0.031	**1.533**	0.228	**0.173**	0.574	1.035
	(0.119)	(0.069)	**(0.202)**	(0.279)	**(0.084)**		
Sweden	$\tilde{\rho}_1$	$\tilde{\rho}_2$	$\tilde{\beta}$	$\tilde{\gamma}$	δ	*j-test*	*see*
$y=y^{ARMC}$; $\pi=\pi^{CORE}$							
	0.839	**-0.067**	**1.668**	0.076	0.075	0.538	0.952
	(0.067)	**(0.019)**	**(0.267)**	(0.656)	(0.070)		
$y=y^{HP}$; $\pi=\pi^{CORE}$							
	0.923	**-0.065**	**2.086**	1.371	-0.063	0.638	0.937
	(0.094)	**(0.025)**	**(0.564)**	(1.475)	(0.171)		
$y=y^{DGAP}$; $\pi=\pi^{CORE}$							
	0.847	**-0.058**	**1.721**	0.412	0.075	0.591	0.945
	(0.064)	**(0.020)**	**(0.229)**	(0.391)	(0.053)		
$y=y^{ARMC}$; $\pi=\pi^{CPI}$							
	0.914	**-0.097**	**1.202**	-0.018	0.117	0.663	0.926
	(0.050)	**(0.013)**	**(0.226)**	(0.729)	(0.076)		
$y=y^{HP}$; $\pi=\pi^{CPI}$							
	0.962	**-0.081**	**1.424**	1.668	-0.009	0.705	0.914
	(0.061)	**(0.025)**	**(0.343)**	(1.417)	(0.134)		
$y=y^{DGAP}$; $\pi=\pi^{CPI}$							
	0.892	**-0.082**	**1.165**	0.313	**0.109**	0.609	0.914
	(0.043)	**(0.015)**	**(0.159)**	(0.357)	**(0.045)**		

(continued)

Table II-2: *(continued)*

United Kingdom	$\tilde{\rho}_1$	$\tilde{\rho}_2$	$\tilde{\beta}$	$\tilde{\gamma}$	δ	*j-test*	*see*
$y=y^{ARMC}$; $\pi=\pi^{CORE}$							
	0.778	0.031	**1.760**	0.470	-0.016	0.489	0.989
	(0.121)	(0.083)	**(0.403)**	(1.315)	(0.072)		
$y=y^{HP}$; $\pi=\pi^{CORE}$							
	0.615	0.123	**1.829**	**1.502**	-0.015	0.561	0.966
	(0.108)	(0.067)	**(0.271)**	**(0.567)**	(0.035)		
$y=y^{DGAP}$; $\pi=\pi^{CORE}$							
	0.801	0.008	**1.740**	0.689	-0.010	0.515	0.993
	(0.128)	(0.083)	**(0.383)**	(0.974)	(0.062)		
$y=y^{ARMC}$; $\pi=\pi^{CPI}$							
	0.608	**0.165**	**1.657**	-0.174	-0.033	0.630	0.874
	(0.094)	**(0.062)**	**(0.217)**	(0.682)	(0.044)		
$y=y^{HP}$; $\pi=\pi^{CPI}$							
	0.657	**0.180**	**1.443**	1.142	-0.032	0.791	0.908
	(0.097)	**(0.061)**	**(0.346)**	(1.118)	(0.037)		
$y=y^{DGAP}$; $\pi=\pi^{CPI}$							
	0.650	**0.140**	**1.655**	0.092	-0.022	0.634	0.886
	(0.117)	**(0.070)**	**(0.213)**	(0.737)	(0.045)		

Canada	$\tilde{\rho}_1$	$\tilde{\rho}_2$	$\tilde{\beta}$	$\tilde{\gamma}$	δ	*j-test*	*see*
$y=y^{ARMC}$; $\pi=\pi^{CORE}$							
	0.730	0.012	**1.223**	**3.459**	**0.178**	0.805	1.121
	(0.104)	(0.074)	**(0.491)**	**(0.868)**	**(0.071)**		
$y=y^{HP}$; $\pi=\pi^{CORE}$							
	0.640	**0.133**	0.681	**2.141**	**0.180**	0.845	1.018
	(0.087)	**(0.053)**	(0.373)	**(0.502)**	**(0.040)**		
$y=y^{DGAP}$; $\pi=\pi^{CORE}$							
	0.835	0.126	5.339	8.744	0.023	0.648	1.013
	(0.094)	(0.074)	(6.752)	(13.724)	(0.390)		
$y=y^{ARMC}$; $\pi=\pi^{CPI}$							
	0.709	0.029	0.427	**3.825**	**0.254**	0.958	1.175
	(0.120)	(0.100)	(0.415)	**(1.076)**	**(0.065)**		
$y=y^{HP}$; $\pi=\pi^{CPI}$							
	0.666	0.118	-0.292	**2.257**	**0.251**	0.772	0.944
	(0.096)	(0.063)	(0.407)	**(0.422)**	**(0.047)**		
$y=y^{DGAP}$; $\pi=\pi^{CPI}$							
	0.785	0.145	2.835	5.621	0.049	0.579	0.993
	(0.106)	(0.077)	(1.600)	(4.212)	(0.134)		

(continued)

Table II-2: *(concluded)*

Australia	$\tilde{\rho}_1$	$\tilde{\rho}_2$	$\tilde{\beta}$	$\tilde{\gamma}$	δ	*j-test*	*see*
$y=y^{ARMC}$; $\pi=\pi^{CORE}$							
	0.902	**-0.149**	**1.054**	-0.381	**0.269**	0.570	0.948
	(0.069)	**(0.066)**	**(0.135)**	(0.322)	**(0.035)**		
$y=y^{HP}$; $\pi=\pi^{CORE}$							
	0.911	-0.120	**1.082**	0.307	**0.277**	0.485	0.902
	(0.072)	(0.072)	**(0.158)**	(0.381)	**(0.039)**		
$y=y^{DGAP}$; $\pi=\pi^{CORE}$							
	0.996	**-0.169**	**1.108**	0.980	**0.251**	0.749	0.913
	(0.083)	**(0.075)**	**(0.182)**	(0.545)	**(0.043)**		
$y=y^{ARMC}$; $\pi=\pi^{CPI}$							
	0.827	-0.099	**1.171**	-0.596	**0.242**	0.517	0.923
	(0.072)	(0.060)	**(0.129)**	(0.369)	**(0.032)**		
$y=y^{HP}$; $\pi=\pi^{CPI}$							
	0.880	-0.104	**1.231**	0.305	**0.261**	0.454	0.865
	(0.069)	(0.067)	**(0.157)**	(0.372)	**(0.036)**		
$y=y^{DGAP}$; $\pi=\pi^{CPI}$							
	0.951	**-0.142**	**1.287**	0.786	**0.245**	0.607	0.868
	(0.080)	**(0.070)**	**(0.173)**	(0.465)	**(0.038)**		

New Zealand	$\tilde{\rho}_1$	$\tilde{\rho}_2$	$\tilde{\beta}$	$\tilde{\gamma}$	δ	*j-test*	*see*
$y=y^{ARMC}$; $\pi=\pi^{CORE}$							
	0.855	**-0.214**	**1.434**	0.552	**0.150**	0.468	1.301
	(0.077)	**(0.078)**	**(0.100)**	(0.336)	**(0.047)**		
$y=y^{HP}$; $\pi=\pi^{CORE}$							
	0.819	**-0.219**	**1.341**	-0.187	**0.123**	0.430	1.265
	(0.086)	**(0.078)**	**(0.058)**	(0.242)	**(0.044)**		
$y=y^{DGAP}$; $\pi=\pi^{CORE}$							
	0.748	-0.149	**1.355**	-0.369	**0.102**	0.581	1.359
	(0.106)	(0.098)	**(0.060)**	(0.215)	**(0.046)**		
$y=y^{ARMC}$; $\pi=\pi^{CPI}$							
	0.902	**-0.224**	**1.475**	0.929	**0.158**	0.600	1.474
	(0.084)	**(0.078)**	**(0.110)**	(0.500)	**(0.054)**		
$y=y^{HP}$; $\pi=\pi^{CPI}$							
	0.833	**-0.225**	**1.343**	-0.124	**0.113**	0.390	1.251
	(0.091)	**(0.082)**	**(0.062)**	(0.274)	**(0.044)**		
$y=y^{DGAP}$; $\pi=\pi^{CPI}$							
	0.743	-0.142	**1.356**	-0.375	**0.097**	0.545	1.335
	(0.121)	(0.108)	**(0.063)**	(0.212)	**(0.044)**		

17. **A more flexible approach to inflation targeting implies that central banks can decide to apply a somewhat longer period for bringing inflation back to target.** The horizon for achieving the inflation target implicitly provides some indication of how much weight the central bank gives to stability in the real economy. Considerable emphasis on stability in the real economy—at the expense of somewhat greater and more persistent deviations from the inflation target—implies a relatively long horizon.

18. **A precondition for a longer monetary policy horizon is that financial market participants are confident that inflation will be low and stable over time.** Financial market confidence in the inflation target provides central banks with greater scope for promoting stability in the real economy. This scope tends to increase as the inflation target is incorporated as an anchor for the formation of inflation expectations, in general, and wage formation, in particular. This creates a role for regular central bank communication to help financial markets filter macroeconomic news. However, in situations where there is a risk that confidence in monetary policy is in jeopardy, a rapid and pronounced change in the interest rate may be needed.

19. **The results confirm the view that central banks tend to smooth the adjustment of interest rates over several quarters, thereby increasing the predictability of monetary policy conduct.** However, the extent to which central banks rely on smoothing appears to differ across countries and over time. In particular, for Sweden, Australia, and New Zealand, the coefficient on the first lag appears to be close to one, while the second lag displays a significant corrective behavior, signaling more elongated and predictable interest rate movements in response to changes in the macroeconomic environment and, hence, a greater use of the expectation channel of monetary policy. Previous work in this area indicates that the strength of the expectation channel relates to the degree of forward-looking behavior in the rest of the economy, which—in turn—can be seen as the policymakers' reward for ensuring monetary stability (Bayoumi and Sgherri, 2004a, 2004b). Figure II-4—plotting parameter estimates from rolling regressions over successive forty-quarter windows—shows that, in this respect, Norges Bank (and, to a lesser extent, the Swedish Riksbank) has enjoyed the greatest confidence gains over recent times, possibly in connection with its latest switch to a longer adjustment horizon. At the other end of the spectrum is Canada (and, to a lesser extent, the United Kingdom), which respond the quickest to macroeconomic misalignments.

20. **Central banks' response to real exchange rate misalignments have varied over time**. Rolling-window estimates of the exchange rate responses (Figure II-5) suggest that, even if the level of the implied instrument rate is very similar to the one implied by the standard forward-looking Taylor rule, central banks in each of the six countries have effectively targeted exchange rates at some point over the sample. Norway (and Sweden) appear to have been concerned about exchange rate misalignments until the first half of the 1990s. Over the past decade, however, the interest rate response to deviations of exchange rates from target has become statistically insignificant.

Figure II-3: Interest Rate: Actual versus Implied

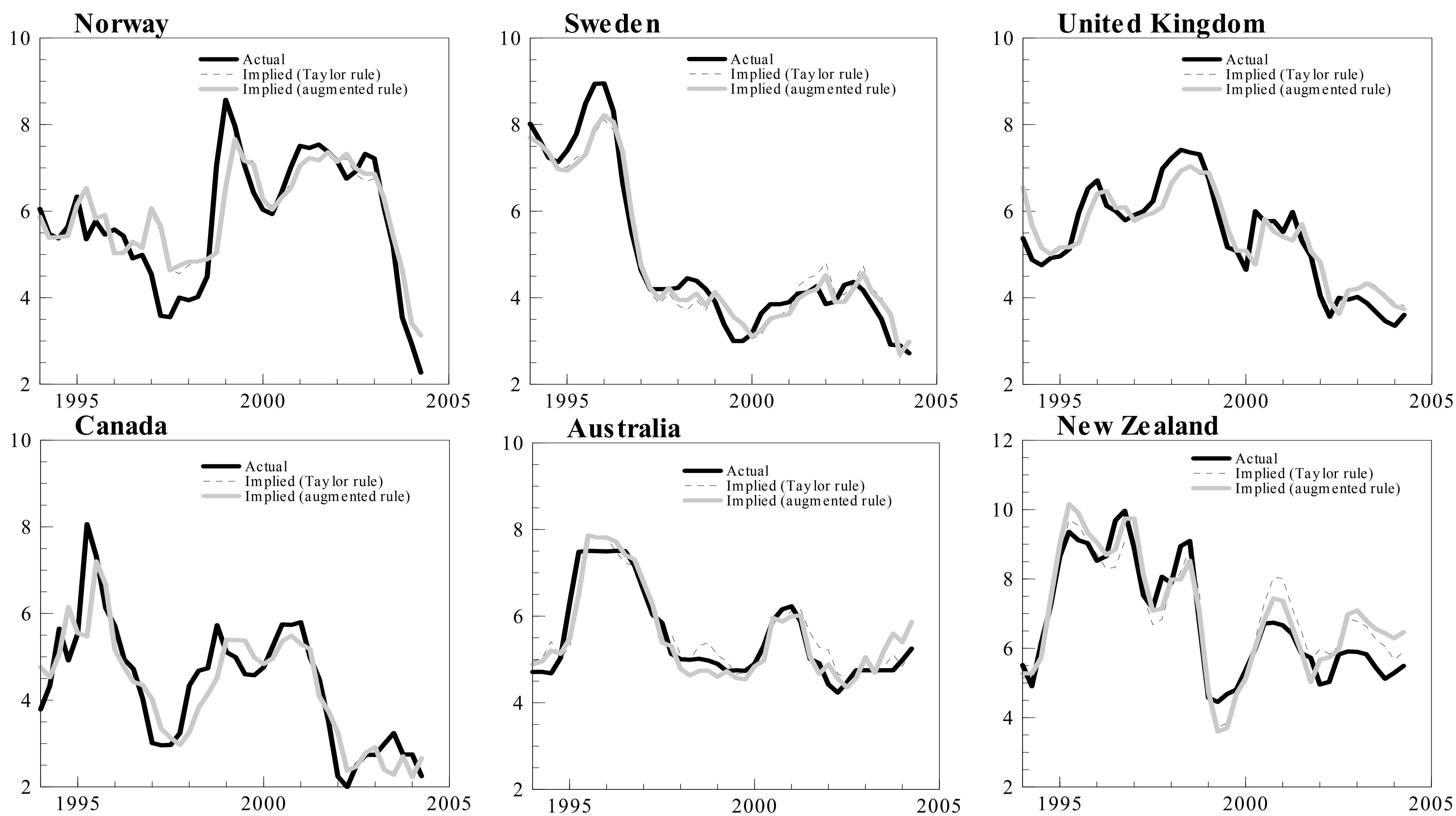
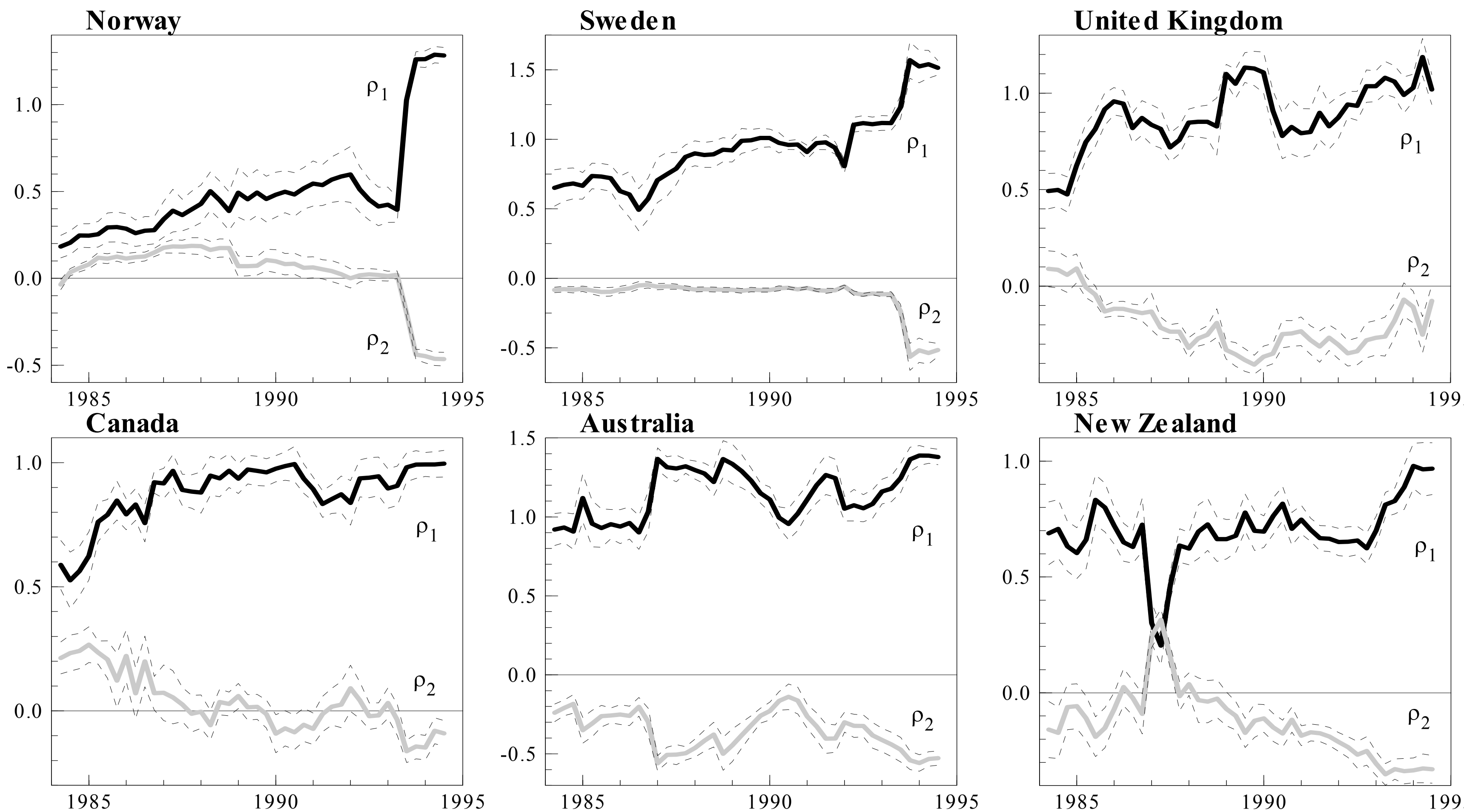
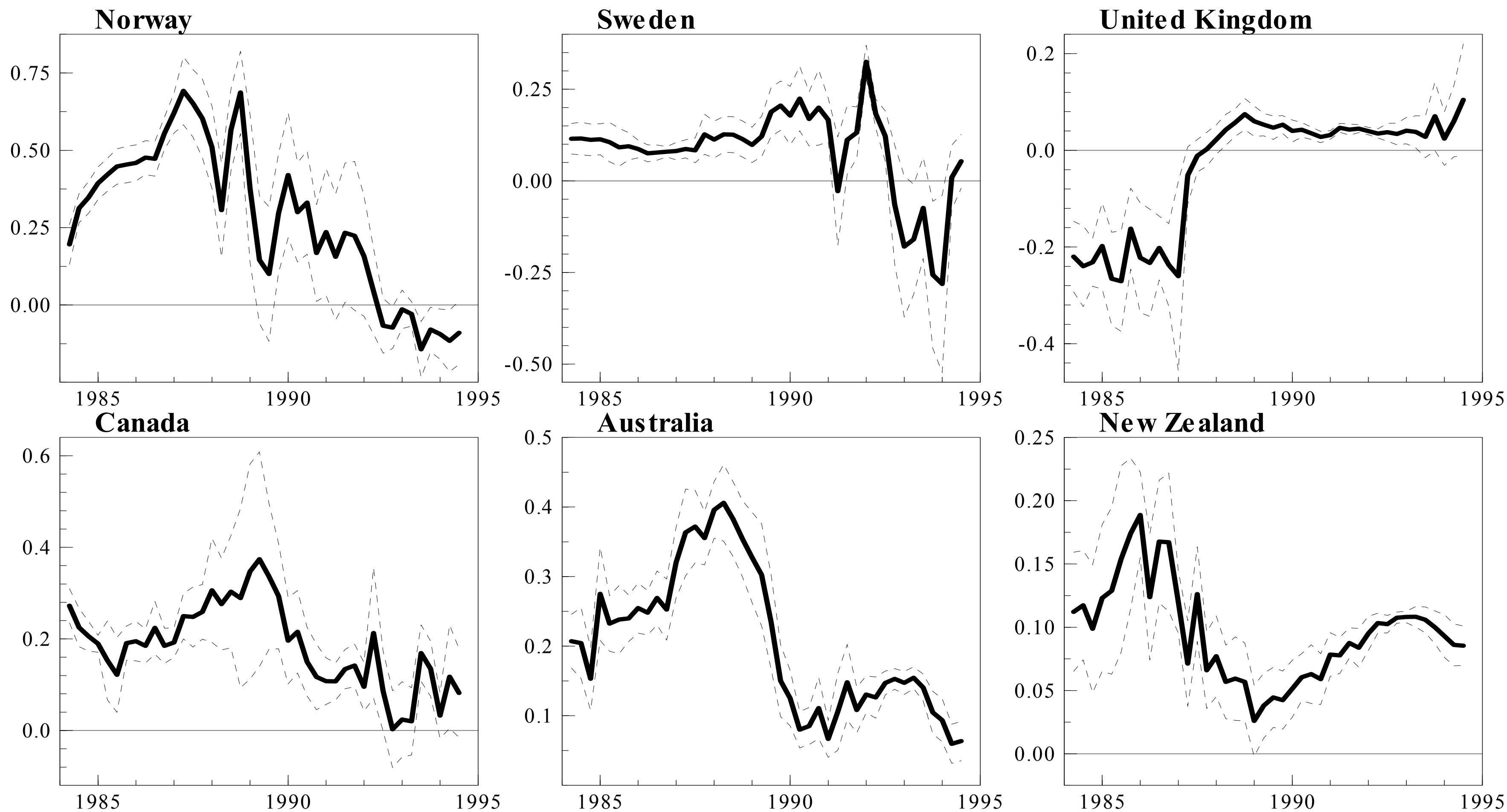


Figure II-4: Interest Rate Smoothing[1]



[1] Rolling GMM estimates over successive forty-quarter periods. Dates displayed on the horizontal axes indicate the initial period of the 10-year window.

Figure II-5: Long-term Response to the Real Exchange Rate[1]



[1] Rolling GMM estimates over successive forty-quarter periods. Dates displayed on the horizontal axes indicate the initial period of the 10-year window.

D. Discussion

21. **Inflation targeting is now a well established framework for the conduct of monetary policy.** Norway's experience, like that of other countries, has been that the period of inflation targeting has delivered favorable economic outcomes. According to surveys, medium-term inflationary expectations in the country remain anchored at 2.5 percent, thus contributing to stabilizing inflation around the target and amplifying the effects of monetary policy itself. Expectations concerning inflation and economic stability are indeed of crucial importance for both wage-price formation and the stability of the foreign exchange market.

22. **Inflation targeting has evolved over time across a number of dimensions, notably the degree of flexibility and the approach to communication.** The chapter's results show that in Norway the regime has recently become much more flexible, allowing greater scope for inflation to vary around the target and, as a result, for broader macroeconomic goals to be taken into account. As the central bank has started to smooth the adjustment of interest rates over a longer horizon, the predictability of monetary policy conduct has also increased. In addition, the monetary authority has recently become more transparent, improving the scope of its communication and delivering it in more varied forms.

23. **Although with some significant differences across countries**, **exchange rates are generally *not* key for systematic monetary responses in inflation targeting small open economies.** More precisely, if a country attempts to target core (rather than headline) inflation, the exchange rate does not seem to enter as a separate argument in the interest rate rule. At the same time, however, exchange rates are found to be valuable inputs into the monetary policy decision-making process, as information variables. Nonetheless, this finding may be consistent with the view that, while committed to a flexible inflation targeting regime, central banks may act in response to exchange rates *on occasions* when there is a need to smooth out high volatility in foreign exchange markets that could destabilize domestic inflation.[28] Indeed, to detect *unsystematic* interest rate responses to abrupt corrections in asset prices, a non-linear framework of analysis could be more helpful than a standard linear framework like the one used in this chapter.

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[28] The debate on the significance of monetary responses to changes in asset prices remains open. While some authors claim that including asset prices in the central bank's policy rule may be optimal (Cecchetti and others, 2000; Bordo and Jeanne, 2002) and that central banks react significantly to stock market movements by changing the short-term interest rate (Rigobon and Sack, 2003), other studies argue that central banks should not respond directly to asset prices (Bernanke and Gertler, 2001). Allowing for nonlinearity in the monetary reaction function could help to shed some light on this empirical issue.

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III. THE NORWEGIAN GOVERNMENT PETROLEUM FUND AND THE DUTCH DISEASE[29]

"The current cost level in the Norwegian business sector is adapted to an expansion of the petroleum sector and a steady phasing-in of petroleum revenues into the mainland economy. Costs rose sharply from the mid-1960s to the mid-1970s and reached a very high level. In subsequent years, costs have varied around this level. After a period, we will be able to cover a smaller share of our imports using current petroleum revenues and drawings on the Petroleum Fund. Competitiveness must then have to be improved. It may have to be brought back to around the level prevailing at the end of the 1960s prior to Norway's emergence as an oil nation."

—— Svein Gjedrem, Norges Bank Governor

1. **Norway's strategy regarding the transformation of its large petroleum wealth into other assets will be key to its long-term prospects.** Norwegian policymakers face a set of interrelated issues: insulating the budget from changes in petroleum prices and extraction rates; intergenerational equity in the use of petroleum wealth; the fiscal pressures of population aging, which are expected to mount significantly in the coming decades; and the potential crowding out effects that rapid spending of oil wealth might bring. This last issue—the so-called Dutch disease problem—is examined in this chapter.

2. **In general, the Dutch disease can manifest itself via three channels: the factor-moving effect, the spillover-loss effect, and the spending effect** (Box III-1). This chapter focuses on the last of these—the spending effect—because fiscal policy can potentially mitigate it by saving petroleum revenue rather than spending it, whereas the others are structural in nature (Davis and others, 2003). In the spending effect, the use of the income from natural resource sales boosts domestic demand and crowds out traded-goods industries, notably manufacturing. The result may be lower immediate welfare, but also a permanent reduction in the industrial base, even after the resources have all been extracted, because of the loss of human capital, for example.

3. **The chapter is organized as follows**. Section I describes Norway's policy response to rising petroleum revenues; Section II briefly reviews the indicators of the Dutch disease in Norway; and Section III analyzes empirically whether Norway might suffer from the Dutch disease and, by implication, whether the fiscal policy response has helped. In summary, Section II finds mixed evidence of Dutch disease effects. Section III finds some empirical evidence of these effects, and consistent with a policy of mitigating the Dutch disease, that fiscal policy does not respond to oil booms.

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[29] Prepared by Etibar Jafarov and Kenji Moriyama.

Box III-1. Effects of Resource Wealth: Factor Moving, Spending, and Spillover-Loss Effect

Corden (1984) used a three-sector (the booming sector, the tradable sector, and the non-traded sector) small economy model to explain the factor moving and spending effects of resource wealth:

Factor-Moving Effect. On the supply-side, labor shifts to the booming sector from the other sectors after an exogenous increase in the value of the booming sector's (oil-producing sector) output raises the marginal product of labor in that sector. This shift causes a contraction of the tradable sector. In addition, this factor movement leads to an increase in the price of non-traded sector because, given other conditions, the supply of non-tradable goods declines. Since the prices of tradables are exogenously determined in the world markets, the rise in the prices of non-tradables is equivalent to a real appreciation, which puts further pressure on the tradable sector. This effect generally depends on the elasticity of substitution in the production technologies in each sector and the smoothness of labor shifts across different sectors.

Spending Effect. On the demand side, the resource boom increases income in the country and stimulates demand for all goods via the income effect. Since the price of tradables is set in the world markets, this additional demand raises the relative price of non-tradables to tradables. This is equivalent to a real appreciation, which again leads to labor shifts from the tradable to the non-tradable sector. As a result, the output level of the non-booming tradable sector contracts.

In addition, the literature has identified a *spillover-loss effect*. This results when the crowding-out of the non-resource tradables sector reduces total productivity, because learning by doing (know-how) benefits are higher in the tradables sector than in the non-tradable sector (Van Wijnbergen, 1984; Krugman, 1987; Sachs and Warner, 1995, Gylfason and others, 1997; and Torvik, 2001).

A. Norway's Strategy for Managing Oil Wealth

4. **Norway's petroleum production and exports have increased rapidly.** The country started oil production in the North Sea in 1971, but petroleum operations did not create cash flows to the state until 1975. Production and exports of oil and gas then picked up, and Norway is now the third largest oil exporter in the world. Although oil production has recently declined slightly, rising gas production has offset this. The 2005 national budget predicts that the production of oil and gas will peak around 2010 and decline gradually after that.

5. **Oil revenues have contributed to Norway's large fiscal and current account surpluses since the late 1970s.** Driven by oil revenues, the general government budget recorded large surpluses for most of the 1980–2004 period, whereas the non-oil budget was mostly in deficit (Figure III-1).[30] In the 2005 budget, revenues from petroleum activities are expected to amount to about 20 percent of the mainland GDP. Oil exports have averaged 13 percent of GDP since 1978, ensuring large current account surpluses even though the non-oil current account has been in deficit.

6. **The Norwegian authorities established the Government Petroleum Fund (GPF) in 1990.** The GPF, which is formally a government account at Norges Bank, receives most of the petroleum revenue and invests it in financial assets abroad. It, therefore, can insulate the budget from changes in petroleum income and preserve the assets for use by future generations (Skancke, 2003). One such use is to finance growing old-age pensions, and this year the government proposed to link the GPF formally to old-age pensions.[31] No transfers to the GPF took place until 1995 because of low net oil income and large oil-related expenditures. Since then, however, assets of the GPF have increased rapidly, as oil production and prices picked up and the government's oil related investment declined. In the beginning of 2005, the market value of the GPF was estimated at Nkr1,016 billion or 78 percent of mainland GDP. The 2005 budget projects that the market value of the fund will reach NOK 2,103 billion or 128 percent of the mainland GDP in 2010 (Figure III-1).

7. **In 2001 (effective for the 2002 budget) the policy of saving petroleum revenue for the future was formalized in the fiscal guidelines.** Within these guidelines, the key rule sets the non-oil central government structural deficit to the long-run real return on the GPF, assumed to be 4 percent. The guidelines allow temporary deviations from the rule over the business cycle and in the event of extraordinary changes in the value of the GPF. The guidelines were meant to serve a number of purposes: the capital of the GPF is preserved for

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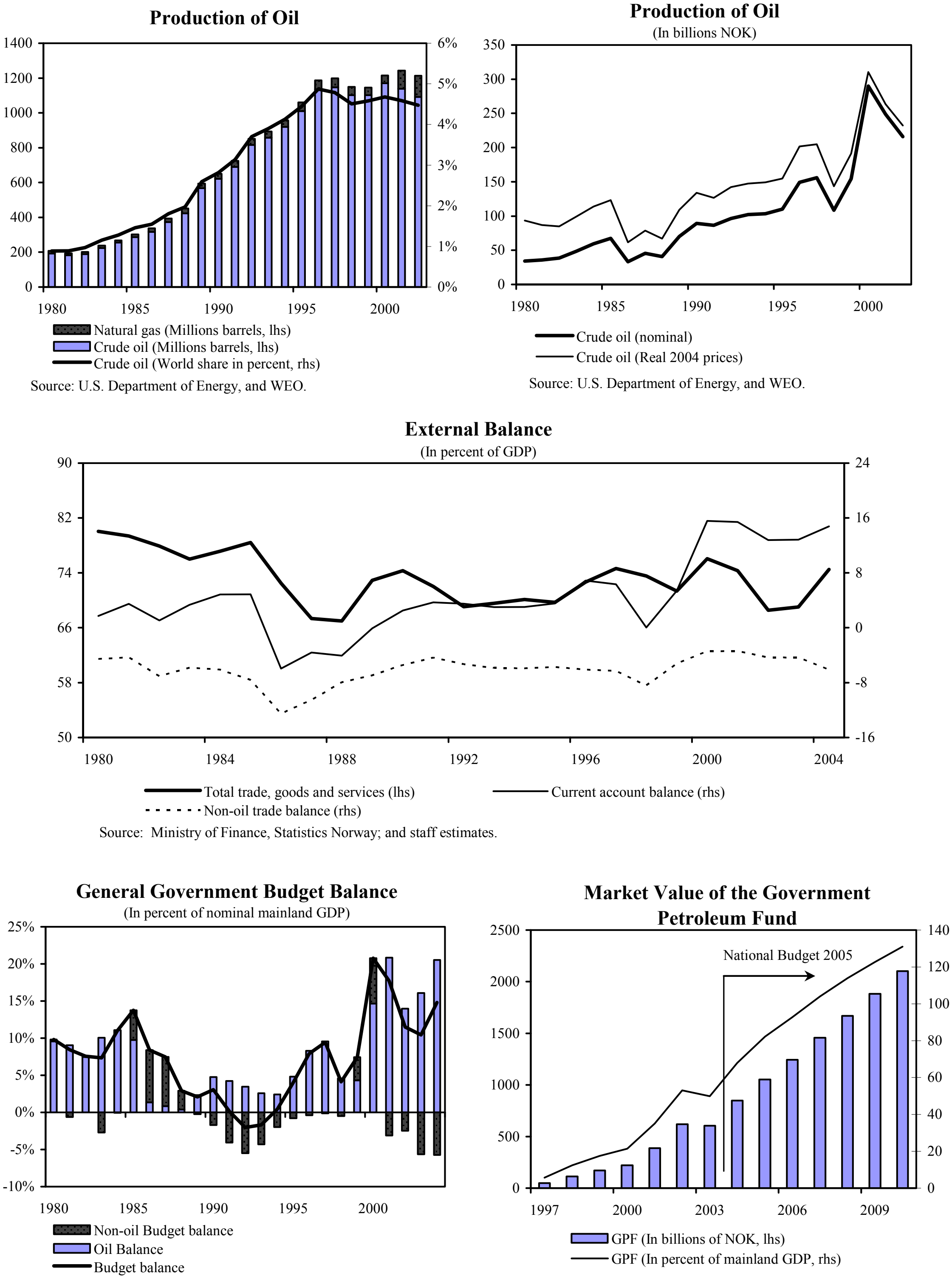
[30] The state receives revenues from oil enterprises through taxes and royalties, fees, its direct financial interest in the petroleum sector (SDFI), and dividends from state shares Statoil and Norsk Hydro (see IMF 2001).

[31] The GPF is widely admired and the authorities of several other oil producing countries, in designing their own oil funds, extensively studied Norway's experience (Tsalik 2003).

Figure III-1. Norway: Petroleum Production, Exports and Revenues.



Source: U.S. Department of Energy, and WEO.

Source: U.S. Department of Energy, and WEO.

Source: Ministry of Finance, Statistics Norway; and staff estimates.

Source: WEO, Ministry of Finance, Norway and Staff estimation.

Source: Annual report of the government petroleum fund, 2003.

future generations; some petroleum revenue is currently being spent; and the budget is insulated against sharp changes in petroleum revenues.

B. Indications of Dutch Disease in Norway

8. **The indicators of the Dutch disease in Norway are mixed, perhaps reflecting the success of the GPF/fiscal rule policy approach** (Figure III-2). A number of indicators suggest the absence of an effect. The CPI-based real effective exchange rate (REER) of the krone has been broadly stable since the late 1970s. Norway's non-oil exports, as percent of mainland GDP, have also been broadly stable. While the share of the manufacturing valued added in GDP has fallen substantially, this decline has been no more marked than that typically found in other developed economies over the same period. Set against these benign indicators, however, are large increases in the unit-labor-cost-based REER of the krone since 1994 and a relatively low export-to-output ratio in manufacturing, both suggesting a loss of competitiveness. Finally, the traded-goods sector faced severe difficulties when the currency appreciated substantially in both real and nominal terms in 2002, indicating the sector is sensitive to real exchange rate movements.

9. **Empirical results have also been mixed.** Brunstad and Drystad (1997) found that labor which is regionally and occupationally close to the booming petroleum sector, experienced nominal wage increases relative to other types of labor, suggesting that oil wealth had a factor-moving effect. Regarding the spending effect, Hutchison (1994) concluded that the energy boom had no long-run influence, while Larsen (2004) suggested that Norway might have had some symptoms of Dutch disease in the late 1990s.

C. Empirical Analysis

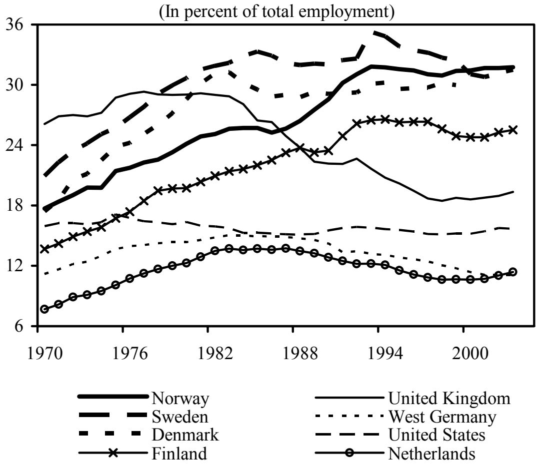
10. **Rather than measuring the Dutch disease effect directly, the empirical approach taken here considers, from two different angles, the potential for a Dutch disease effect**. The first angle is to estimate cointegration vectors to capture the long-run effects of oil prices and government spending on manufacturing and manufacturing exports. High oil prices that translate into lower manufacturing activity would suggest a classic Dutch disease problem. The second is to estimate a vector autoregression model to examine whether oil prices raise government expenditures, a key channel of the spending effect of the Dutch disease.

11. **Before undertaking these exercises, it is worth considering whether Norwegian households are Ricardian**. If they were, then fiscal policies, including Norway's fiscal guidelines and the GPF, would be offset by household saving behavior. By the same taken, Ricardian households would also take into account the relevant intertemporal effects of petroleum spending, weakening the justification for the GPF. Econometric analysis, provided in Appendix III-I, suggests that Norwegian households are partly but not fully Ricardian, implying that the GPF is potentially an effective and useful policy instrument.

Figure III-2. Selected Indicators

Public Employment

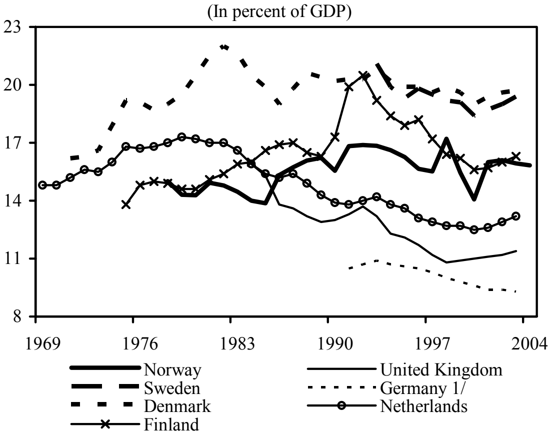
(In percent of total employment)



Sources: OECD.

General Government Value Added

(In percent of GDP)

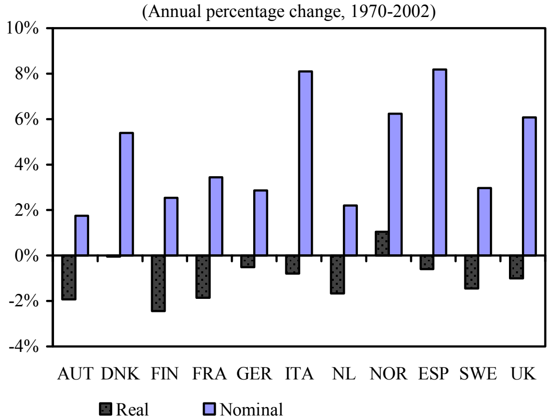


Sources: Eurostat.

1/ Including ex-GDR from 1991.

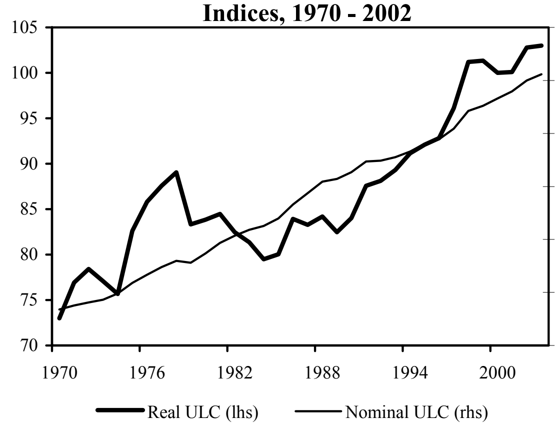
Manufacturing Unit Labor Costs

(Annual percentage change, 1970-2002)



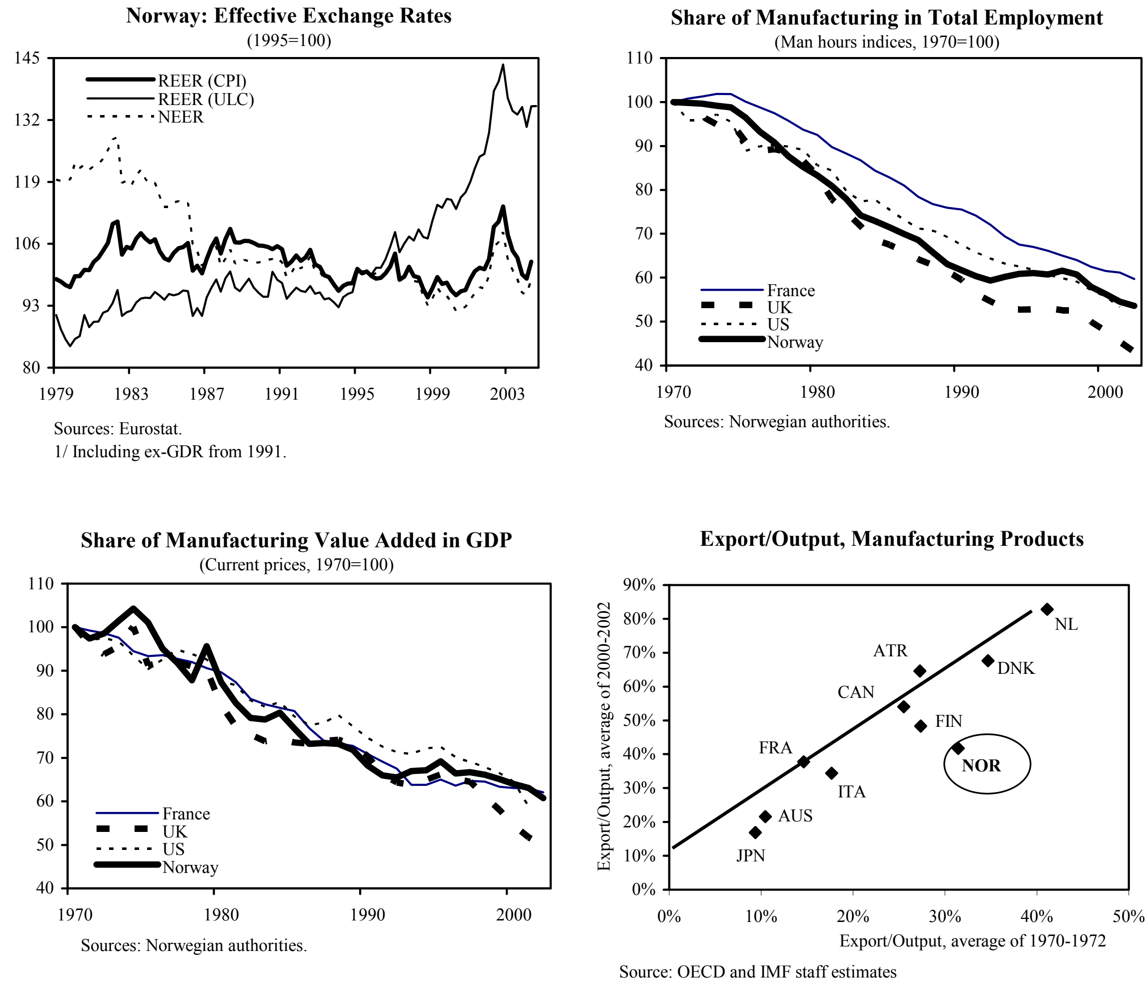
Sources: OECD, IMF and author's computation.

Norway: Manufacturing Unit Labor Cost Indices, 1970 - 2002



Sources: OECD, IMF and staff computation.

Figure III-2. Selected Indicators (cont.)



Cointegration analysis

12. **The Dutch disease arises, via the spending effect, when domestic spending, stimulated by an oil boom, causes a real appreciation and a contraction of the exposed sector**. This sub-section estimates cointegration vectors to analyze the long-run effects of an oil boom (proxied by oil prices, p^{oil}) on the exposed sector (proxied by value-added of the manufacturing sector, y^m). After much experimentation, other relevant variables affecting manufacturing output are found to be aggregate Norwegian economic activity (real mainland GDP, y, and the GDP deflator, *Def*), and foreign demand (European real GDP, y^{EU}, and the European GDP deflator, Def^{EU}, translated through real Norwegian manufacturing exports, m^{EX}). The model can thus be written as follows:

$$A(L)z_t = \alpha + e_t \tag{1}$$

where $z_t = (y_t^m, y_t, m_t^{EX}, Def_t, g_t, Def_t^{EU}, y_t^{EU}, p_t^{Oil})'$.[32]

13. **Quarterly data from OECD spanning the 1978–2004 period are used, in logarithms and seasonally adjusted.** Unit root test shows that all variables are I (1), and the results of the co-integration test suggests that there are four co-integrating vectors, suggesting the following relationships (Table III-1).[33] Higher oil prices are indeed associated with a decline in manufacturing value added (with an elasticity of 0.04), indicating the Dutch disease effect, although they are also related to higher overall mainland GDP (vector 1). Higher oil prices are also associated with lower EU GDP, which reduces Norwegian manufacturing exports (vectors 2 and 3). Finally, higher oil prices raise Norwegian inflation as well (vector 4). However, this last vector also suggests that higher oil prices are associated with lower government expenditure. This, in turn, would imply that the government sector is not the transmission mechanism for the Dutch disease.[34] This result could reflect the prudent fiscal policy followed over the years by the Norwegian authorities: that is, such a policy has effectively cut off this transmission mechanism. To explore this issue further, the short-run dynamics of oil prices and government expenditure are estimated.

Table III-1. Co-integration Vectors

Co-integration vector	y^m	y	m^{EX}	Def	g	Def^{EU}	y^{EU}	p^{Oil}	*Trend*
(1)	1.000	-1.074						0.042	0.006
(t-stat)		(-16.971)						(5.647)	
(2)						-0.263	1.000	0.017	-0.003
(t-stat)						(-5.814)		(1.460)	
(3)			1.000	1.167		-1.167	-1.113		-0.007
(t-stat)				-7.745		(-7.746)	(-3.593)		
(4)				1.000	-2.998			-0.153	0.010
(t-stat)					(-2.950)			(-2.366)	

VAR analysis

14. **To measure the effect of oil prices on government expenditures, a VAR model using the same variables as in equation (1), but in differences, is estimated assuming the following structural relationships among its error terms:**

$$e^{y^m} = \alpha_1 u^{y^m} + \alpha_2 u^{y} + \alpha_3 u^{m^{EX}} + \alpha_4 u^{Def} + \alpha_5 u^{g} + \alpha_6 u^{Def^{EU}} + \alpha_7 u^{y^{EU}} + \alpha_8 u^{p^{Oil}}$$

[32] Different order of the elements in vector z was also computed, but the main conclusions do not change.

[33] Based on the Schwarz criterion, three lags of the variables were used.

[34] This does not, of course, rule out the possibility that household consumption or business investment increase in reaction to the oil boom to produce a Dutch disease effect. While this mechanism is beyond the scope of this chapter, recall that Appendix III-1 found Norwegian consumers to be partly Ricardian, implying some such response.

$$e^{y} = \alpha_9 u^{y} + \alpha_{10} u^{m^{EX}} + \alpha_{11} u^{Def} + \alpha_{12} u^{g} + \alpha_{13} u^{Def^{EU}} + \alpha_{14} u^{y^{EU}} + \alpha_{15} u^{p^{Oil}}$$

$$e^{m^{EX}} = \alpha_{16} u^{m^{EX}} + \alpha_{17} u^{Def} + \alpha_{18} u^{g} + \alpha_{19} u^{Def^{EU}} + \alpha_{20} u^{y^{EU}} + \alpha_{21} u^{p^{Oil}}$$

$$e^{Def} = \alpha_{22} u^{Def} + \alpha_{23} u^{g} + \alpha_{24} u^{Def^{EU}} + \alpha_{25} u^{y^{EU}} + \alpha_{26} u^{p^{Oil}} \qquad (2)$$

$$e^{g} = \alpha_{27} u^{g} + \alpha_{28} u^{Def^{EU}} + \alpha_{29} u^{y^{EU}} + \gamma u^{p^{Oil}}$$

$$e^{Def^{EU}} = \alpha_{30} u^{Def^{EU}} + \alpha_{31} u^{y^{EU}} + \alpha_{32} u^{p^{Oil}}$$

$$e^{y^{EU}} = \alpha_{33} u^{y^{EU}} + \alpha_{34} u^{p^{Oil}}$$

$$e^{p^{Oil}} = \alpha_{35} u^{p^{Oil}}$$

where u stands for actual shocks to the system (which are not contemporaneously correlated and have unit variance), which are translated to observed shocks e in equation (2). The equations can be re-written compactly:

$$e_t = \begin{bmatrix} \alpha_1 & \alpha_2 & \alpha_3 & \alpha_4 & \alpha_5 & \alpha_6 & \alpha_7 & \alpha_8 \\ 0 & \alpha_9 & \alpha_{10} & \alpha_{11} & \alpha_{12} & \alpha_{13} & \alpha_{14} & \alpha_{15} \\ 0 & 0 & \alpha_{16} & \alpha_{17} & \alpha_{18} & \alpha_{19} & \alpha_{20} & \alpha_{21} \\ 0 & 0 & 0 & \alpha_{22} & \alpha_{23} & \alpha_{24} & \alpha_{25} & \alpha_{26} \\ 0 & 0 & 0 & 0 & \alpha_{27} & \alpha_{28} & \alpha_{29} & \gamma \\ 0 & 0 & 0 & 0 & 0 & \alpha_{30} & \alpha_{31} & \alpha_{32} \\ 0 & 0 & 0 & 0 & 0 & 0 & \alpha_{33} & \alpha_{34} \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & \alpha_{35} \end{bmatrix} u_t$$

This structure assumes that: a shock to real oil prices is exogenous; the price level and output level in foreign countries are exogenous to Norway; a shock to the mainland GDP deflator depends on government expenditure among other factors; exports of manufacturing depends on real exchange rate and foreign demand; and mainland GDP depends on all factors other than manufacturing output. Estimating the covariance matrix of e by the vector autoregressive system yields the estimator of the elements of the matrix in equation (2).

15. **The most important parameter in equations (2), γ, which measures the response of the error term of government expenditure to that of real oil prices, is not statistically significant.**[35] In other words, the estimates are consistent with the view that government expenditure does not react to an energy boom. This result suggests that the objectives of insulating the budget from oil revenue fluctuations and the economy from fiscally induced Dutch disease effects have been met.

[35] The estimated coefficient for γ is -0.0002, standard deviation is 0.0017, and t-stat is -0.1057, nearly zero. Full results are reported in Appendix II.

RICARDIAN EQUIVALENCE

1. **The test of Ricardian Equivalence uses the indirect Euler equation approach**. Using the model developed by Himarios (1995), aggregate consumption responses, taking account of the possibility of a finite horizon and of liquidity constraints of households, leads to the following consumption function:

$$C_t = \alpha\left[(1+r)A_{t-1} + \sum_{j=0}^{\infty}\left(\frac{1-\mu}{1+r}\right)^j E_t Y_{t-j}\right] \tag{A-1}$$

where A_{t-1} is the stock of real assets outstanding at the end of period $t-1$, r is the constant real return on these assets, μ is the constant probability of dying of each cohort, Y_t is the real after-tax labor income and E_t is the expectation operator conditional on information known in period t, α is the propensity of consumption out of total wealth. The aggregate budget constraint is:

$$A_t = (1+r)A_{t-1} + Y_t - C_t \tag{A-2}$$

when a fraction (λ) of income goes to liquidity-constrained households, the consumption functions expressed by the observable variables are (Himarios 1995):[36]

$$C_t = \left(\frac{1+r}{1-\mu}\right)(1-\alpha)C_{t-1} - \alpha\mu\left(\frac{1+r}{1-\mu}\right)A_{t-1} + \lambda Y_t - \lambda\left(\frac{1+r}{1-\mu}\right)(1-\alpha)Y_{t-1} + u_t \tag{A-3}$$

$$C_t = \left(\frac{1+r}{1-\mu}\right)[1-\alpha(1-\mu)]C_{t-1} - \alpha\mu\frac{(1+r)^2}{1-\mu}A_{t-2} + \lambda Y_t - \left(\frac{1+r}{1-\mu}\right)[\lambda - \alpha(\lambda-\mu)]Y_{t-1} + u_t \tag{A-4}$$

The null hypothesis (Ricardian equivalence) is that households have infinite time horizon and do not face liquidity constraints: that is $\mu = \lambda = 0$.

2. **Annual SNA data from 1960 to 2003 are used.** Private final consumption expenditure is used as a measure of consumption. (Real) after-tax disposable income, including social transfers, instead of after-tax labor incomes in other empirical studies, is used. This choice requires adjustments to equations (A-3) and (A-4) because after-tax disposable income includes capital income. All variables are deflated by the non-oil GDP deflator and normalized to per capita terms. The sum of gross government financial liabilities (including monetary base) and capital stock in the private sector, computed based on the permanent inventory method, is used as a proxy for real assets. Since data on gross government liabilities are available only after 1970, the series is iteratively extended to 1960 using net lending/borrowing data.[37] In addition, dummy variables capture the introduction

[36] See Romer (1996) for the review of literature on the liquidity-constraint hypothesis.

[37] Using financial assets omitting government debt does not change the main results.

Appendix Box III-1. Empirical Literature on the Ricardian Equivalence

Since Barro's (1974) classic paper, there has been a huge and growing body of literature on Ricardian equivalence following two types of testing strategies, the indirect test and the direct test. The result is still inconclusive (Bernheim 1987, Seater, 1993, and Elmendorf and Mankiw, 1998). The indirect test focused on testing the validity of such critical assumptions of Ricardian equivalence as the permanent income hypothesis, intergenerational redistribution of wealth (bequest motive), liquidity constraints, distributional effects, and distortionary taxation. The direct test examined the impact of fiscal variables (taxes, social security contributions and government debt) on the rest of the economy (consumption, saving, exchange rate, and interest rates).

The results of the indirect test throw doubt on the validity of critical assumptions of the Ricardian equivalence hypothesis. Most studies of the permanent income hypothesis confirm that consumption to some extent depends on current income. Many individuals are widely considered to face liquidity constraints, which limit consumption smoothing.

The results of the direct test are "ultimately inconclusive" (Elmendorf and Mankiw 1998). Bernheim (1987) concluded the hypothesis does not hold, but Seater (1993) concluded it holds "approximately." Lucke (1999) examining Germany, concluded that there is hardly any evidence against the Ricardian proposition whereas the theoretical model that implies Ricardian equivalence is strongly rejected. Giorgioni and Holden (2001) found that for six countries (Israel, Italy, Korea, Singapore, Tanzania, and the United Kingdom) deficits would not have a positive effect upon private consumption, providing some support in favor of Ricardian equivalence. Marinheiro (2001) got ambiguous results for the Portuguese economy. Doménech, and others (2000) reported that Ricardian equivalence did not work in 18 OECD countries, since private saving compensated for only a small fraction of the budget deficit, and Drakos (2001) found the same result for Greece.

Mixed or inconclusive results of the direct test are in part caused by problems in methodology in econometric tests, as noted by Elmendorf and Mankiw (1998) and Seater (1993). These papers pointed out the following four problems in the literature of the direct test for Ricardian equivalence: the treatment of expectation, simultaneity, multi-collininarity, and limited power of the test.

- **Expectations**. The behavior of forward-looking households depends on expectations of fiscal policy, not just the measures of current fiscal policy that are included in the regressions. If government actually follows the tax-smoothing hypothesis, the current level of taxation is the best prediction of the tax policies in the future. However, in this case, a significant negative coefficient on current taxes in consumption does not necessarily contradict Ricardian equivalence because higher current taxes indicates higher future taxes too.
- **Simultaneity**. Some studies estimate the consumption function with ordinary least squares. However, this strategy is valid only when the shocks to consumption do not affect fiscal policy or other right hand side variables. Other studies use instrumental variables to avoid this problem, but finding persuasive instruments is generally very difficult.
- **Multi-collininarity**. This makes the estimates unstable because of large standard deviations. One remedy to this problem is to use a longer estimation period, but this strategy may face the risk of structural changes of an economy.
- **Little power to distinguish between the Ricardian and conventional views of fiscal policy**. As highlighted by Poterba and Summers (1987), using a life-cycle model with plausible structural parameters suggests individuals live long enough to make the assumption of infinite horizon a good approximation for analyzing short-run saving effects. Hence, it may be statistically quite difficult to measure propensities of consumption for a change in government tax policy, even though the difference between a small and zero marginal propensity of consumption is economically critical in the long run, since a short-run drop in savings can accumulate to a large long-run decline in the capital stock.

Appendix Box III-1. Empirical Literature on the Ricardian Equivalence
(continued)

There are two possible ways to mitigate these problems: the Euler equation approach and the aggregate consumption function approach with instrumental variables. The Euler equation approach is collapsed to the test of the permanent income htypothesis, an indirect test. The instrumental variables approach is used to estimate regressions in the direct approach. Although it is generally very difficult to find good instruments, Cardia (1997) proposed productivity be used as an instrument for output. This was based on tests of ssssimulated data, where she found that distorting taxes reduced labor supply and output (an effect unrelated to the issue of Ricardian equivalence), which biased the estimate of the Ricardian effect of taxes on consumption.

and changes in the VAT tax rates (1969, 1970, 2002 and 2003), as these create wedges between the marginal rate of substitution between different periods, the banking crisis during 1988-92, and earlier financial liberalization (1985–87). All variables are I(1), according to standard tests.

18. **2SLS is used to avoid endogeneity problems caused by contemporaneous values of the right side variables.** After-tax disposable income in period t is instrumented by GDP developments in EU (including lag), real oil productions (including lag), and real assets at period $t-2$. The results of the first stage regression clearly show no signs of the problem of weak instruments. Exogeneity of instrumental variables is also checked by the over-identification test, which confirms that the choice of instrumental variables is appropriate.

19. **Ricardian equivalence is rejected.** The coefficients of after-tax disposable income in the current period are significantly positive in both estimated equations: a one krone increase in disposable income due to changes in taxes or transfers raises consumption by about 0.4 krone. Second, the joint null hypothesis of no liquidity constraints and infinite time horizon is rejected ("p-value" in Appendix I-1). However, examination of the underlying structural parameters (Appendix I-2), while implying a substantial fraction of households face liquidity constraints and confirming the rejection of the joint null, also suggest an implausibly high (though barely significant) probability of death and a low marginal propensity to consume. While these results are common,[38] they may also suggest measurement error (Marinheiro, 2001).

[38] Himarios (1995), using US data, reported the estimates $(\alpha,\mu,\lambda)=(0.054,0.145,0.449)$ for equation (3) and $(\alpha,\mu,\lambda)=(0.056,0.159,0.419)$ for equation (4), where all estimated coefficients were statistically significant. Marinheiro (2001) estimated the three parameters for Portugal as $(\alpha,\mu,\lambda)=(0.793,0.018,0.337)$ but such high propensity to consume out of total wealth is economically implausible. Lucke (1999) reported a fraction of household income facing liquidity constraints to be around 0.1.

Appendix I-1. Results of the Model

Equation	*C (t-1)*	*A(t-1)*	*A(t-2)*	*Y (t)*	*Y (t-1)*	*p-value for H_0*
(A-3)	0.881	-0.020		0.440	-0.340	0.014
(t-stat)	(5.56)	(-1.14)		(2.52)	(-1.65)	
(A-4)	0.831		-0.018	0.398	-0.276	0.014
(t-stat)	(6.32)		(-1.12)	(2.48)	(-1.49)	

Appendix I-2. Estimated Parameters

Equation	α	μ	λ	*p-value for $\lambda = \mu = 0$*
(A-3)	0.197	0.093	0.440	0.039
(t-stat)	(2.34)	(1.05)	(2.52)	
(A-4)	0.241	0.071	0.398	0.037
(t-stat)	(2.64)	(1.15)	(2.48)	

Appendix II-1. Relevant Statistics from the Estimation of the VAR Model with Restrictions Imposed as in Equations 2 and 3.

Estimated Matrix:

0.0274	0.0000	0.0105	-0.0061	0.0066	-0.0014	0.0098	0.0059
0	0.0134	0.0171	-0.0041	0.0009	-0.0023	0.0035	0.0029
0	0	0.0135	-0.0049	0.0036	-0.0013	0.0052	0.0017
0	0	0	0.0100	0.0003	0.0002	0.0022	-0.0005
0	0	0	0	0.0172	0.0001	0.0028	-0.0002
0	0	0	0	0	0.0018	0.0000	-0.0004
0	0	0	0	0	0	0.0038	-0.0001
0	0	0	0	0	0	0	0.1105

Standard Errors

0.0019	0.0027	0.0028	0.0029	0.0030	0.0030	0.0031	0.0032
	0.0009	0.0018	0.0022	0.0022	0.0022	0.0022	0.0022
		0.0009	0.0014	0.0015	0.0015	0.0015	0.0016
			0.0007	0.0010	0.0010	0.0010	0.0010
				0.0012	0.0017	0.0017	0.0017
					0.0001	0.0002	0.0002
						0.0003	0.0004
							0.0077

z-Statistic

14.283	0.012	3.737	-2.089	2.191	-0.469	3.148	1.819
	14.283	9.568	-1.876	0.431	-1.037	1.569	1.303
		14.283	-3.567	2.499	-0.902	3.403	1.103
			14.283	0.259	0.168	2.211	-0.518
				14.283	0.043	1.661	-0.106
					14.283	-0.118	-2.116
						14.283	-0.325
							14.283

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