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Inflation Reports and Models: How Well Do Central Banks Really Write?

Aleš Bulíř, Jaromír Hurník, and Kateřina Šmídková*

Abstract

We offer a novel methodology for assessing the quality of inflation reports. In contrast to the existing literature, which mostly evaluates the formal quality of these reports, we evaluate their economic content by comparing inflation factors reported by the central banks with ex-post model-identified factors. Regarding the former, we use verbal analysis and coding of inflation reports to describe inflation factors communicated by central banks in real time. Regarding the latter, we use reduced-form, new Keynesian models and revised data to approximate the true inflation factors. Positive correlations indicate that the reported inflation factors were similar to the true, model-identified ones and hence mark high-quality inflation reports. Although central bank reports on average identify inflation factors correctly, the degree of forward-looking reporting varies across factors, time, and countries.

JEL Codes: E17, E31, E32, E37.

Keywords: Inflation targeting, Kalman filter, modeling, monetary policy communication.

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Nontechnical Summary

Transparent and credible central banks publish well-written, insightful inflation reports and, hence, anchor inflation expectations efficiently. Researchers have repeatedly tried to define attributes of high-quality inflation reports and to measure their quality in order to contribute to the discussion about transparency benchmarks.

This paper contributes to this discussion by proposing a novel methodology for measuring the quality of inflation reports. Previous studies have focused mainly on the formal quality of the text, the volume of information disclosed, or the consistency of inflation reports with other communication tools. We propose that it is equally important to assess inflation reports' analytical power, since reports can be both voluminous and coherent, yet may not reflect the "true" state of the world. While fulfilling the above formal definitions of high-quality inflation reports, such reports would be unlikely to anchor the public's expectations. Moreover, such incorrectly labeled reports may bias empirical studies of transparency and credibility toward finding low or insignificant effects of transparency.

We compare how well the inflation factors declared in inflation reports correspond to the true inflation factors, that is, the factors obtained from a new Keynesian model. To obtain the reported factors, we manually code inflation reports, transforming the factors identified in each document for the current inflation forecast into numerical variables. Our coded variables therefore reflect real-time data communicated at the time of publication of the inflation report. For the sake of simplicity, we aggregate them into three groups: demand, supply, and exchange rate factors. To approximate the true inflation factors, we estimate the model-identified inflation factors, taking a reduced-form, calibrated new Keynesian model for each country to the data using the method of Kalman filtration. These factors – labeled again as demand, supply, and exchange rate – correspond reasonably well to the reported inflation factors.

Inflation reports have significant analytical power, in other words, they are high-quality reports, if the forward-looking reported inflation factors correlate with the model-identified ones. We acknowledge that not every insignificant or negative correlation indicates an analytical and forecasting failure of the inflation reports. For example, negative correlations may reflect opportunistic disinflations, major unforeseen shocks, large data revisions, or, indeed, a failure of our model to identify the true inflation factors.

We apply our methodology to eight central banks – in alphabetical order: Chile, the Czech Republic, the European Central Bank, Hungary, Poland, Thailand, Sweden, and the United Kingdom. The sample consists of both developed and emerging economies, and pure inflation targeters as well as one price stability targeter.

Our sample findings indicate that inflation reports are generally of good quality, even though most central banks struggled during certain periods to communicate the true inflation factors. Most of the sample central banks identified the overall balance of inflation factors in a forward-looking manner, usually with a 2–4 quarter lead. To put it simply, the net balance of the reported pro- and counter-inflationary factors was a good predictor of the net balance of the ex-post, model-identified factors. Hence, the public could link the thrust of the verbal assessments with the ex-post analysis of the data.

Two points are worth noting and could be subjects for further research. First, the subcategories of reported and model-identified factors did not correlate very well in all countries. Perhaps the sample central banks emphasized the overall balance of inflation factors at the expense of a detailed decomposition, as the latter is less important for monetary policy setting. Second, the correlation between the reported inflation factors and the model-identified ones varied spatially and over time. It appears that no national forecasting system was able to match all the true (model-identified) factors. The decomposition of the model-identified factors in our model may have been off during certain periods. It would be interesting to check the link between the type of forecasting apparatus and the ex-post analysis.

To conclude, we argue that when assessing the link between transparency and monetary policy one should take into account the analytical power of inflation reports. Focusing only on the quality of the text and the volume of information is unlikely to suffice.

1. Introduction

One of the professed benefits of monetary policy transparency is enhanced credibility, which allows central banks to manage and anchor medium- and long-term expectations. To this end, central bank communication should be clear, consistent, and verifiable against a set of publicly available "stylized facts." Communication that is corroborated ex post by empirical analyses is more likely to anchor the public's expectations than communication that contradicted such analyses (Bernanke, and Woodford, 1997). In this paper we assess the quality of communication by comparing inflation factors reported in inflation reports with ex-post model-identified factors. We interpret positive correlations between the reported and model-identified factors as signaling high-quality inflation reports.

The literature suggests various approaches to evaluating the quality of inflation and monetary policy reports.[1] While some authors focus on the formal quality of the text, others measure the volume of information disclosed, or consistency with other communication tools. Nevertheless, these approaches only proxy inflation reports' analytical power. The reports can be both voluminous and coherent, but if they do not reflect the "true" state of the world they are unlikely to anchor the public's expectations.

We propose a novel methodology for assessing whether central bank communication helps the public to understand the true state of the world and compile a unique database for this purpose. First, the policymaker communicates factors that are expected to affect inflation in the foreseeable future.[2] The *reported inflation factors* are identified in each document for the current inflation forecast or projection.[3] We manually code the inflation reports, transforming the factors into numerical variables and aggregating them into three groups: demand, supply, and exchange rate factors. The reported factors reflect the real-time data available at the time of publication of the inflation report.

Second, we estimate the *model-identified inflation factors* using a reduced-form, calibrated new Keynesian model for each country as proposed by Berg, Karam, and Laxton (2006). These factors (demand, supply, and exchange rate) are defined to correspond as much as possible to the reported inflation factors, but they are not identical. Given that the model-identified factors reflect ex-post data and a realistic model description of the economy, these factors represent the "true" state of the world. For each sample country we take the model to the data and estimate the inflation factors, quantifying the effect of each factor on inflation. The observed inflation rate is then decomposed into the contributions of each factor using the inflation accounting of Smets and Wouters (2007).

Third, we compare the forward-looking reported inflation factors with the model-identified ones, interpreting a positive correlation between them as a measure of the quality of inflation reports. The precise lead with which the inflation reports identify each factor is unknown and we thus compare the current-period model-identified factors with lagged reported factors. To test the alternative hypothesis

[1] Although the names of the various monetary policy documents differ across countries, we call them all "inflation reports" in this paper. See Appendix 1 for the names of these documents for our sample countries.

[2] The "policymaker" is a collective body with heterogeneous views and we use the singular for simplicity only.

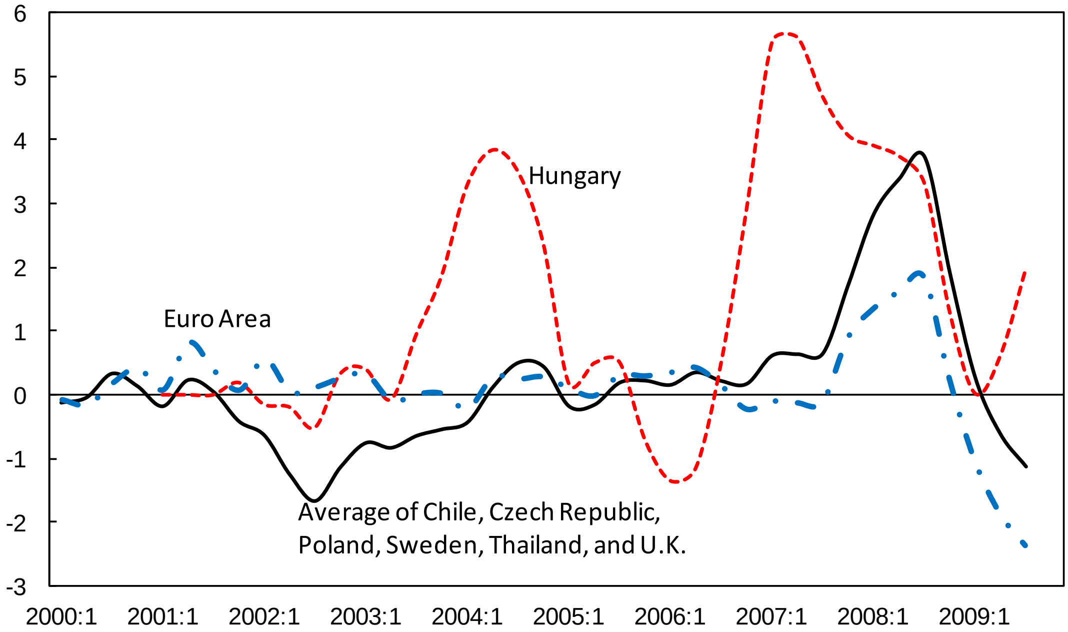
[3] While some central banks identify their predictions of inflation as forecasts, based on an economic model with a policy reaction function, others identify them as projections, conditional on explicit assumptions vis-à-vis the interest rate (see Appendix 1).

that the inflation reports are backward-looking, we also let the model-identified factors lead the reported ones. We hasten to say that not every insignificant or negative correlation indicates an analytical and forecasting failure of the inflation reports – some of these results can be attributed to other developments. For example, negative correlations can reflect opportunistic disinflations, major unforeseen shocks, or large data revisions. Our model may also misrepresent the true state of the world, and with a better model one may obtain positive correlations. We leave the problem of model uncertainty open for further research.

We apply our methodology to eight central banks, calling their policy objectives "inflation targets" (Appendix 1, Table A.1.1). Sweden and the UK represent industrial countries, while Banco Central de Chile, the Czech National Bank, Magyar Nemzeti Bank, the National Bank of Poland, and the Bank of Thailand represent emerging market countries. The European Central Bank is not formally an inflation targeting institution, but its communication strategy makes it comparable to the rest of the sample. Despite different institutional and forecasting frameworks, inflation performance in most countries deviated from the targets in a rather similar manner during our sample period (Figure 1 and Figure A.1.1). While most countries undershot their targets on average during 2001–2003, with the exception of Hungary and the Euro Area, the 2007–2008 global commodity price shock resulted in target overshooting.

Figure 1: Deviations from the Inflation Target

(In percentage points)



Source: International Financial Statistics for inflation; central bank websites for inflation targets; authors' calculations.

Our findings indicate that inflation reports broadly met their objectives, even though most central banks struggled during certain periods. First, most of the sample central banks identified the overall balance of inflation factors in a forward-looking manner, usually with a 2–4 quarter lead. Hence, the public could link the thrust of the verbal assessments with the ex-post analysis of the data. Second, the identification of the subcategories of reported and model-identified factors was much less precise:

the correlation coefficients for subcategories of factors were both lower and less stable compared to the overall aggregate balance of factors. Perhaps the banks emphasized the overall balance of inflation factors at the expense of a detailed decomposition, as the latter is less important for monetary policy setting. Third, the correlation between the reported inflation factors and the model-identified ones varied spatially and over time. It appears that no national forecasting system was able to match all the true (model-identified) factors. We leave it to future research to check the link between the type of forecasting apparatus and the ex-post analysis. Fourth, periods of mostly pro- and counter-inflationary factors were correlated across the sample, with the exception of the UK.

The remainder of the paper is organized as follows. First, we review the relevant literature. Second, we formulate a set of testable hypotheses, explain our methodology, and present the model. Third, we discuss the results. The final section concludes.

2. Literature Review

The consensus among central bankers is "that transparency is not only an obligation for a public entity, but also a real benefit to the institution and its policies" (Issing, 2005). According to the literature, central bankers have the ability to move the markets with their analyses (Blinder and others, 2008), even though it is difficult to explain the reasons for this ability. Various approaches have been offered to assess how well central banks write. One possibility is to look at the formal quality of central bank writing. Some banks write better than others (Fracasso, Genberg, and Wyplosz, 2003) and well-written texts have a better chance of being understood as intended by the policymaker (Jansen, 2011). Another possibility is to measure the volume of information disclosed (Geraats, 2009). Finally, others have looked at consistency among various communication tools (Bulíř, Čihák, and Šmídková, 2012; Bulíř Šmídková, Kotlán, and Navrátil, 2008). In general, banks with a well-developed forecasting and policy analysis systems write better, that is, more clearly.

The problem with the above methods is that nothing precludes central bank communication from being nicely worded, voluminous, and coherent, and yet failing to anchor expectations due to its weak analytical power. The analytical power may be weakened for multiple reasons. First, the policymakers' objectives can differ from those stated officially. For example, central banks pursuing opportunistic disinflation (Orphanides and Wilcox, 2002) may communicate positive output gaps or forthcoming fiscal impulses, thus justifying the need for a monetary stance that is tighter than implied by the inflation target and the state of the world (Ireland, 2007). Second, obsessively transparent central banks may decide to communicate all information, even that which they understand imperfectly, with "noise" crowding out the correct part of the message (Dale, Orphanides, and Österholm, 2008). Also, some central bankers may be excessively talkative, sending signals that are either inconsistent or contradictory to the official views, or both (Rozkrut and others, 2007). Third, the forecasting and policy analysis framework may be genuinely weak, producing systematically biased assessments of the economic environment. Fourth, in some periods, central banks may simply be unlucky, owing to unusual measurement errors. For example, major data revisions can completely change the views about the true state of the world ex post (Orphanides, 2001).

In practice, the four reasons are difficult to distinguish empirically (see, Šmídková, Bulíř, and Čihák, 2008b). However, they are likely to have similar consequences for communication. For example, a doctored inflation report in a period of opportunistic disinflation may be as bad as a bona fide wrong analysis of inflation. They both violate the key underpinning of efficient monetary policy communication: transparency. Poor analysis and an unpublicized objective both complicate anchoring of the public's expectations.

3. The Methodology: Are "Reports" Validated by "Models"?

3.1 Correlations

We test whether the real-time inflation reports are validated by ex-post model-identified inflation factors, in turn anchoring inflation expectations. The technique is based on testing whether the reported inflation factors, constructed from real-time verbal assessments (α), are correlated with the ex-post, model-identified inflation factors (ξ). We interpret ξs as "true" inflation factors, both because to obtain them we employ the new Keynesian class of models used by many central banks and because we use revised data. To compare the comovement of verbal and model-based inflation factors, we compute the Pearson (product-moment) and Spearman (rank) correlation coefficients between the two set of factors. Both correlation coefficients can be interpreted as the strength of the relationship (linear and non-parametric, respectively).

There are two possible outturns for the correlation coefficient (r) between the reported and model-identified inflation factors. On the one hand, the correlation coefficient can be positive ($\kappa < r(\alpha,\xi)$ <1), where κ corresponds to a "sufficiently strong" value of the coefficient, the threshold value of which we will discuss later. For $\kappa < r$ we argue that the central bank identified and communicated the "true" inflation factors, thus gaining credibility and anchoring inflation expectations. On the other hand, the correlation coefficient can be either not statistically different from zero or even negative ($r(\alpha,\xi) < \kappa$). In such a case, the central bank failed to identify the "true" inflation factors, presumably failing to anchor inflation expectations. A negative correlation implies that the report misjudged the direction of the inflation factors, for example, announcing an expansionary aggregate demand conditions when these were contractionary.

3.2 Selecting the Threshold Value for Our Correlations

The noise introduced by the four effects above complicates our choice of the threshold value for the correlation coefficient, κ. If we set the threshold value too high, we will make too many Type I errors, rejecting the null hypothesis of models validating the reports, when accord was acceptable. If we set the threshold value too low, we will fail to reject the null hypothesis of no accord when we should (Type II error).

We consider several features of inflation forecasts that are likely to bias our correlations downward. While the first three represent various forms of measurement errors, the fourth captures deliberate misreporting. First, the new Keynesian framework may not generate the "true" inflation factors: our sample spans an initial disinflation period for some countries, the Great Moderation and Great Recession, and occasional regime switches from crawling pegs to floats or from conditional to unconditional inflation forecasts. Moreover, the mapping from subcategories of reported factors (demand, supply, and exchange rate) to identically-named model-identified factors may not be accurate and the overall balance of inflation factors is a possibly more relevant measure than the factor subcategories.

Second, the economist drafting the inflation report has at her disposal only preliminary estimates, nowcasts, or forecasts for the relevant variables. Empirical analyses are sensitive to the exact vintages of the data and, hence, a lack of correlation between the reported and model-identified factors may partly reflect the subsequent revisions (Croushore and Stark, 2003). Moreover, some forecasts may be prepared by other institutions under a different set of assumptions. For example, the fiscal forecast may be based on the government's stump promises as opposed to the most probable outcome. Rather than measuring the quality of the inflation reports we may be observing noise in the real-time data. Third, the coding of reported factors is subject to human error to the extent that we may have miscoded an otherwise correct assessment. To minimize such risk, each entry was vetted by two of the co-authors.[4] While we do not underestimate the measurement error problem, it should not be a major issue: if we have misinterpreted some of the reported factors, so would the public. Indeed, the less clear is the inflation report – measured using a readability index such as the Flesch-Kincaid grade level – the more likely it is to be misinterpreted (Bulíř, Čihák, and Jansen, 2013).

Fourth and perhaps most dangerously, the communication may knowingly report inflation factors different from those observable in the real-time data. The monetary policy committee may have its own political agenda or be simply more risk averse vis-à-vis interest rate hikes, putting rather a spin on the observed data (Romer and Romer, 2008; Ellison and Sargent, 2012). One example is reporting unexpected supply-side or external shocks, such as higher world oil prices or poor harvests, while in reality the central bank allowed the economy to overheat. Another example is warning about expansionary fiscal policy when the fiscal stance was neutral ("crying wolf"). Empirically, examples of such bias are difficult to spot from the data – our sample countries reported roughly similar shares of demand, supply, and external factors.

Given the various measurement errors and the short sample, we are more concerned about the Type I error than about the Type II error. To this end, we set the threshold value for the correlation coefficient, κ, at 0.2. It turns out that this value corresponds in our sample to about the 20 percent significance level. While our chosen κ is somewhat lower than what is recommended in the literature as "medium strength correlation" (Table 1), Cohen (1988) argued that these criteria are arbitrary and need not be observed too strictly. To summarize, our interpretation of the values of the Pearson correlation coefficient above 0.2 and statistically significant values of the Spearman rank coefficient is as follows: the reported inflation factors correctly matched the true inflation factors identified by the new Keynesian model ($r > \kappa$). In contrast, values of r below 0.2 and statistically insignificant rank correlation coefficients imply that the reports failed to identify the true inflation factors.

[4] The quality of our coding for the ECB can be compared against the KOF Monetary Policy Communicator (MPC) published by the Swiss Federal Institute of Technology and the Rosa Verga (2007) index of ECB President announcements. Our summary index is highly correlated with these indexes, at 0.77 and 0.82, respectively. The correlation coefficient between the KOF MPC and Rosa Verga was 0.76 (see Bulíř, Čihák, and Šmídková, 2012).

Table 1: Guidelines for the Interpretation of a Correlation Coefficient

Correlation Strength	Absolute Value of the Correlation Coefficient
None	0.00 to 0.09
Small	0.10 to 0.29
Medium	0.30 to 0.49
Strong	0.50 to 1.00

Source: Cohen (1988).

3.3 Leads and Lags in Reporting of Inflation Factors

The above methodology presents one particular challenge, namely that of timing the reported factors relative to the model-identified factors. When the inflation report points to an inflation factor, has that factor already impacted inflation or will it do so in the future? Intuitively, central banks are forward-looking institutions and spend a lot of resources on macroeconomic forecasts so that they may identify and report factors before these can be observed in the data, thus leading the model-identified factors. If this is so, how long is the lead? Are the leads identical for all types of inflation factors, given that some of them are likely to be more predictable than the others? Do these reporting leads and lags differ across individual central banks and over time as the banks' forecasting systems evolve?

At first glance, the distinction between backward and forward-looking factors should be straightforward: ever since Fracasso, Genberg, and Wyplosz (2003) established the benchmark for a well-written inflation report, inflation reports contain a backward-looking chapter, typically named "Past inflation developments," and a comparable forward-looking chapter, such as "Prospects for inflation." In practice, such distinction is anything but straightforward. For example, business cycle factors tend to be long-lasting, making it difficult to distinguish the past from the future. Furthermore, institutions with underdeveloped forecasting systems are more likely to classify contemporaneous events as forward-looking factors, and so on.

Let us consider the lags or leads of the inflation factors more systematically. On the one hand, the model-identified factors are recorded when they are observed in the data: a hike in the VAT rate is identified in the same-quarter increase in the overall CPI. On the other hand, the central bank may foresee the increase in the CPI – the government mulled the VAT hike for some time – and report the expected impact before it occurred. Thus, the reported factor leads the model-identified factor. Such a scenario may or may not be realistic for all factors: some factors may not be identifiable ex ante or the policymaker may decide against communicating them with a lead. For example, following past erratic executions of pre-announced administrative price adjustments, the central bank may hesitate to incorporate these factors into its inflation forecasts with longer leads.

We consider other limitations to forward-looking reported factors. First, central banks seem to possess knowledge about the overall balance of inflation risks rather than about the individual inflation factors (Ehrmann and Fratzscher, 2007; Bulíř, Šmídková, and Čihák, 2013). Hence, one would expect to find higher correlation coefficients computed for the combined inflation factors than for their subcomponents, say, demand- or supply-side factors. Second, institutions facing a more volatile macroeconomic environment should have difficulty disentangling the factors. However, Bulíř, Čihák, and Jansen (2013) failed to find support for this hypothesis. Finally, financial crises make communication difficult (Bulíř, Čihák, and Jansen, 2013).

To this end, we construct the correlation coefficients of the reported and model-identified inflation factors over reasonable leads (from zero to four quarters) and lags (two quarters). Such time span should ensure that we cover most inflation factors: on the one hand, it is unlikely that the report would identify a factor with a lead of more than one year, and on the other hand, a two-quarter lag ought to be sufficient to capture data collection lags.

3.4 Data Transformation

To test our null hypothesis of verbal assessments corresponding to the model-identified inflation factors, we use datasets of the Czech Republic, Chile, the Euro Area, Hungary, Poland, Sweden, Thailand, and the United Kingdom. While the ECB is technically not an inflation targeting central bank, its communication strategy (declaration of the price stability objective, publication of forecasts and detailed reports, and so on) makes it comparable to the rest of the sample. The sample period for the reported inflation factors is from 1999Q1 to 2007Q4 for the ECB and from 2000Q1 to 2009Q4 for the rest (except the National Bank of Hungary, which began publishing its inflation reports in 2001Q3). The sample period for the model-identified factors is determined by the availability of consistent data (see Appendix 1 for a description of the sample).

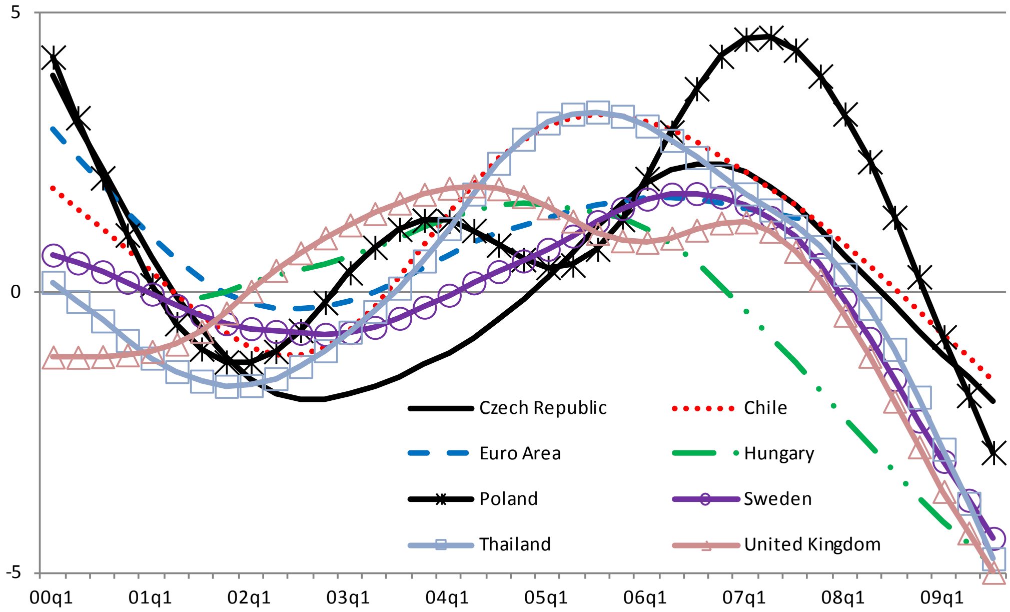
Reported Inflation Factors

We quantify the reported factors using the content analysis proposed by Guthrie and Wright (2000) and used recently by Bulíř, Šmídková, and Čihák (2013). To this end we build a unique new database based on inflation reports. Each reported factor is catalogued into a supply, demand, or foreign exchange factor and classified as pushing the rate of inflation either higher (+1), lower (-1), or neither (0). The observations are aggregated to obtain the "stock of communication" of the inflation factors reported in any given quarter (Ehrmann and Fratzscher, 2007; Conrad and Lamla, 2010). We gave each inflation factor an equal weight in the summary index, because the reports do not provide information on the factors' quantitative importance and we wanted to avoid subjective judgments of the type made by Rosa and Verga (2007). The obvious limitation of content analysis is that the reported factors contain real time uncertainty about the data or the underlying framework that generates the macroeconomic forecast (Šmídková, 2005).

The reported inflation factors were both autocorrelated and spatially correlated (see Figure 2, Table 2, and Appendix 1 for a description of the coding procedure and individual country inflation factors). Only two countries seem to stand apart from the rest: Hungary and the United Kingdom. For example, the inflation factors identified by Magyar Nemzeti Bank were only loosely correlated with those identified by the ECB and the other two banks in the region, the CNB and NBP. The negative correlation between the factors reported by the Bank of England and the ECB is driven by the first four years in our sample, when these banks identified opposite inflation factors.

Figure 2: Trends in Reported Factors

(All factors, the Hodrick-Prescott filter)



Source: Authors' calculations.

Table 2: Trends in Reported Factors

(Correlation coefficients of the Hodrick-Prescott filtered inflation factors)

	Chile	Euro Area	Hungary	Poland	Sweden	Thailand	United Kingdom
Czech Rep.	0.72	0.95	**0.15**	0.79	0.70	0.54	**0.11**
Chile		0.80	0.54	0.64	0.82	0.94	0.56
Euro Area			**0.06**	0.73	0.80	0.58	**-0.21**
Hungary				**0.16**	0.73	0.72	0.92
Poland					0.70	0.60	**0.39**
Sweden						0.88	0.76
Thailand							0.78

Note: Correlation coefficients of less than 0.5 (in bold) indicate that the central bank reported different overall assessment of inflation factors than the other sample banks.

Source: Authors' calculations.

Model-identified Inflation Factors

To obtain the model-identified inflation factors, we build a reduced-form new Keynesian model for each country. Such a model has several advantages over alternative frameworks. First, some central banks relied at least partly on a more complex version of this general equilibrium model during the period under consideration. In particular, the Bank of England, the Riksbank, Banco Central de Chile, and the Czech National Bank initially employed this type of model, while the rest employed either older-generation large-scale models (the National Bank of Poland and the Bank of Thailand) or utilized more eclectic frameworks for their inflation forecasts (the ECB and Magyar Nemzeti Bank). In the second half of the 2000s, however, some of the banks switched their core forecasting apparatus to richer micro-founded models (the ECB, the Riksbank, the Czech National Bank, the Bank of England, and so on). Second, the properties of the reduced-form model are well understood, the model is easy to calibrate, and it is known to predict inflation as well as micro-founded general equilibrium models or estimated empirical models such as VARs (Berg, Karam, and Laxton, 2006).

We start with the estimation of directly unobserved economic shocks, employing the model, the information contained in the observed variables, and the method of Kalman filtration. The link between the observed and unobserved variables is represented by the model itself. The estimated shocks then determine the corresponding model-identified inflation factors. Each factor captures the impact of the particular sequence of shocks on inflation, while the model structure defines the transmission mechanism from the sequence of shocks to inflation. When the impacts of all the estimated shocks are accounted for, we get the decomposition of inflation as in Smets and Wouters (2007). The decomposition of model-identified factors corresponds to the reported factors – demand, supply, and exchange rate – although the mapping is not identical.

Each country model draws on nine observable series (Table 3): the domestic and foreign consumer price index (p and p^*); the domestic and foreign inflation target (π^T and π^{*T}), domestic and foreign gross domestic product (y and y^*), the domestic and foreign 3-month interbank interest rate (i and i^*), and the nominal exchange rate (s). The CPI, GDP, interest rate, and exchange rate data are from the IMF's *International Financial Statistics* database, and the inflation target data are from the national central bank websites.

3.5 The Model

The model employed for the estimation of economic shocks and subsequent identification of inflation factors consists of four behavioral equations (aggregate demand, aggregate supply, the uncovered interest rate parity condition, and the policy-reaction function) and several identities (see Appendix 2 for a detailed description of the model). The model structure encompasses both nominal and real deterministic trends so as to avoid any ad hoc pre-detrending of the time series. The nominal trend is unique and is determined by the inflation target in the domestic and foreign economies. Four different real trends are used to replicate the observed data: real GDP growth, the real exchange rate, and domestic and foreign real interest rates. The trend changes in the real exchange rate and in domestic and foreign real interest rates are bound via the real version of the uncovered interest rate parity. Real trends, shocks to these trends, and the business cycle are jointly estimated as unobserved variables.

The canonical model is calibrated to capture the country-specific features along the lines of Berg, Karam, and Laxton (2006) and Bulíř and Hurník (2006), following the so-called minimal econometric approach suggested by Geweke (1999). Table A2.1 summarizes the parameter calibrations for our sample countries, comparing them to the all-purpose calibration values suggested by Berg, Karam, and Laxton (2006) and to their calibration for Canada. In our calibrations, we rely on the analysis of (i) impulse responses, (ii) the forecast error variance decomposition, and (iii) the recursive forecasts (Appendix 3).

Table 3: The List of Variables

Model variable	Source
Domestic prices	Consumer price index (CPI)
Foreign prices	CPI in Euro Area (Czech Republic, Hungary, Poland, and Sweden) or the U.S. (Chile, Thailand, and Euro Area)
Inflation target	(i) midpoints of official target ranges; (ii) missing intra-year target observations were intrapolated; (iii) Euro Area price stability objective of “close to, but below 2 percent”
Domestic demand	Full-model Kalman filter applied to real GDP
Foreign demand	Asymmetric Christiano-Fitzgerald filter applied to Euro Area GDP for Czech Republic, Hungary, Poland, and Sweden, and U.S. GDP for Chile, Thailand, and Euro Area
Nominal exchange rate	Spot exchange rate in domestic currency terms vis-à-vis euro (Czech Republic, Hungary, Poland, and Sweden) and U.S. dollar (Chile, Thailand, and Euro Area)
Nominal short-term interest rates	3-month interbank rate
Foreign nominal short-term interest rates	3-month interbank rate in Euro Area (Czech Republic, Hungary, Poland, and Sweden) and U.S. (Chile, Thailand, and Euro Area)

The country-specific models predict inflation reasonably well, with adequate contributions of past inflation, the output gap, the exchange rate, and so on as shown in the sample mean square errors (Table A3.1), which are comparable to the out-of-sample errors from the same-variable vector autoregressive (VAR) model (Table A3.2).[5] The model forecasts predict the majority of the turning points in inflation and those missed can be traced back to supply shocks that our nine-variable model does not capture, such as indirect tax changes and administrative price adjustments described in the reports (Figure A3.1). The forecast error variance decomposition charts summarize the various stylized facts, such as a negligible exchange rate transmission channel for the Euro Area, a limited role of domestic interest rates in countries that shadow the ECB (Hungary and Sweden) relative to countries with independent monetary policy (such as the Czech Republic and Thailand), unanchored inflation expectations in Hungary, and so on (Figure A3.2).

Estimation of Unobserved Variables and Inflation Accounting

We solve the model for its reduced form, substituting non-predetermined forward-looking variables with a linear combination of past shocks. The reduced-form of the model then serves as a starting point for the estimation of economic shocks using the Kalman filter. The multivariate filter extends the reduced form of the model to measurement equations that map observed variables to the unobserved one:

[5] The VAR models have four endogenous variables (domestic inflation, output, the interest rate, and the exchange rate) and three exogenous variables (foreign inflation, output, and the interest rate). The data are in first differences, with the exception of interest rates. VAR models are tested for stability, normality of residuals, and so on, and lags are chosen according to standard information criteria. The out-of-sample performance is tested on the 2002–2010 sample.

$$y_t = Zx_t + \varepsilon_t \tag{1}$$

$$x_t = Tx_{t-1} + \nu_t, \tag{2}$$

where x denotes the vector of unobserved state variables, y is the vector of observed (measurement) variables, ε is the process noise, and ν is the measurement noise. It assumes that the distributions of the ε and ν vectors as well as that of the initial state ($t=0$) of the state vector x are Gaussian. Conditional on the state form of the model and the observed variables, the Kalman filter identifies all unobserved variables and shocks. For linear systems the Kalman filter represents an optimum estimate in terms of the least squares criterion (Hamilton, 1994). As some variables are nonstationary, without finite value variances, we employ the diffuse Kalman filter (De Jong, 1991). Finally, we employ the smoothing step of the filter using the complete information (Harvey, 1989).

The Kalman filter identifies the unobserved state variables and economic shocks. The estimated realizations of various shocks are then used for historical simulations of the model, quantifying their exact time-varying effects on inflation (Smets and Wouters, 2007). Deviations of inflation from its target are due to six unobserved components, each defined as a deviation from its steady-state value: aggregate demand; aggregate supply; the exchange rate; foreign variables, such as foreign aggregate demand, the interest rate, and inflation; trends; and monetary policy. To this end we recursively simulate the model using the estimated state variables, while adding only one particular sequence of estimated shocks. Inflation deviations from the target caused in the model simulation by one sequence of shocks are what we call model-identified inflation factors. Hence, each inflation factor captures the interaction of the individual shocks and the transmission mechanism that propagates such shocks. The recursive simulations are repeated for all sequences of shocks, providing us with estimates of the impact of demand, supply, exchange rate, and other shocks on the deviation of inflation from its target. We denote these as the model-identified inflation factors, and by summing up all the inflation factors we recover the actual inflation rate.

4. The Results

In general, our findings confirm that communication by central banks through their flagship documents is mostly forward looking and that the reported inflation factors can be validated ex post. On average, it appears that the sample central banks reported the overall balance of inflation risks with a lead of 2–4 quarters (see Table 4 for weighted averages of the all-country results). As expected, the correlations for subcategories of inflation factors were both lower and less stable. The exchange rate factors also appeared to be identified with a two-quarter lead. In contrast, both demand and supply factors were reported in the same quarter in which they could be identified by the model. The panel data hide substantial differences across countries, however, and we summarize the country-specific results in Table 5 and include individual country charts in Figure A1.2 in Appendix 1. As robustness checks – available on demand – we (i) split the full sample into the 2000–2004 and 2005–2009 subsamples and (ii) exclude the end-sample crisis period (dating its beginning either at mid-2008 or early 2009). Neither modification alters the thrust of our results noticeably.

Table 4: All Countries: Correlation Between Reported and Model-Identified Inflation Factors, 2000–2009

	Correlation coefficient	All factors	Aggregate demand	Aggregate supply	Exchange rate
Contemporaneous	Pearson	0.13	0.19	0.24	0.09
	Spearman's ρ (prob. >|t|)	0.32	0.20	0.26	0.24
Two Leads	Pearson	0.31	0.11	0.02	0.22
	Spearman's ρ	0.16	0.29	0.39	0.30
Four Leads	Pearson	0.29	0.01	-0.17	0.08
	Spearman's ρ	0.17	0.31	0.39	0.42
Two Lags	Pearson	-0.12	0.10	0.14	-0.20
	Spearman's ρ	0.46	0.41	0.25	0.27

Note: In this table we evaluate the 16-quarter rolling window correlation coefficients between the reported and model-identified inflation factors for all sample countries. The averages are weighted by the number of observations per country. We use the Pearson (product-moment) and Spearman (rank) correlation coefficients, recording for the latter the significance level at which the null hypothesis of independence of reported and model-identified factors can be rejected.

Source: Authors' calculations; detailed data for individual countries are available on request.

4.1 Overall Balance of Inflation Factors

The main finding is that all central banks – with the exception of Hungary – identified on average the overall balance of inflation factors and did so in a forward-looking manner (see Table 5).[6] Most leads were 2–4 quarters, implying that the reports identified the overall inflationary pressures well ahead. Within the sample the correlation coefficients varied substantially, as the individual inflation reports periodically struggled to identify the factors (see the individual countries in Figure A1.2 in Appendix 1).

[6] Magyar Nemzeti Bank seems to be aware of this problem and a recent paper by Szilágyi and others (2013) attributed its failure to identify the relevant inflation factors to the exchange rate band that remained in place until 2008, mismeasurement of the real-time cyclical position of the economy, and inaccurate judgment about the disinflationary forces.

Table 5: Correlation Between Reported and Model-Identified Inflation Factors, 2000–2009

		All factors	Demand	Supply	Exchange rate
Czech Republic	Is $r > 0.2$?	Yes	No	Yes	Yes
	Is it stable?	Yes	No	Yes	Yes
	Is it FL or BL?	Mostly FL (2q;4q)	--	BL(–2q)	FL (2;4q)
Chile	Is $r > 0.2$?	Yes	Yes	Yes	Yes
	Is it stable?	Yes	Yes	Yes	No
	Is it FL or BL?	FL (4q)	FL (0q;2q)	Mixed (0q;–2q)	FL (2q;4q)
Euro Area	Is $r > 0.2$?	Yes	No	Yes	Yes
	Is it stable?	Yes	No	Yes	No
	Is it FL or BL?	FL (0q;2q)	--	FL (0q;2q)	Mixed
Hungary	Is $r > 0.2$?	No	No	Yes	Yes
	Is it stable?	No	No	No	Yes
	Is it FL or BL?	--	--	FL (2q)	FL (2q)
Poland	Is $r > 0.2$?	Yes	No	Yes	Yes
	Is it stable?	Yes	No	No	Yes
	Is it FL or BL?	Mixed (0q;2q;4q)	--	BL (–2q)	Mixed (0q;2q;4q)
Sweden	Is $r > 0.2$?	Yes	Yes	Yes	No
	Is it stable?	Yes	Yes	Yes	No
	Is it FL or BL?	FL (2q)	FL (0q;2q;4q)	FL (0q)	--
Thailand	Is $r > 0.2$?	Yes	Yes	Yes	Yes
	Is it stable?	Yes	Yes	No	Yes
	Is it FL or BL?	FL (0q;2q)	FL (0q)	FL (0q)	FL (0q)
United Kingdom	Is $r > 0.2$?	Yes	Yes	Yes	Yes
	Is it stable?	No	Yes	No	Yes
	Is it FL or BL?	FL (4q)	FL (0q;2q;4q)	FL (0q)	FL (2q)

Note: In this table we evaluate the 16-quarter rolling window correlation coefficients between the reported and model-identified inflation factors for all sample countries. Specifically, we ask whether the full-sample estimates (i) exceeded the threshold of 0.2; (ii) were stable during the sample period, that is, if $r > 0.2$ in the full sample and the 2000–2004 and 2005–2009 subsamples; and (iii) whether the reported factors were mostly forward-looking, that is, leading the model-identified factors (FL), backward-looking (BL), or both. In brackets we indicate the number of quarters; negative signs indicate lags of reported factors; contemporaneous correlations are denoted as forward-looking.

Source: Authors' calculations; detailed data for individual countries are available on request.

4.2 Subcategories of Inflation Factors

The sample countries identified on average one-half of the "true" subcategories of inflation factors at or above the chosen threshold level, with most misses being in the aggregate demand category. Moreover, in some countries and/or during certain periods the accord between the reported and model-identified factors was tenuous at best. Somewhat surprisingly, the most consistently forward-looking results were found for the Banco Central de Chile, however, the reporting leads varied across the subcategories. The track record of the Riksbank was impressive for most factors, except for the exchange rate factors.

Aggregate Demand Factors

Only about one-half of our sample countries reported demand factors in line with the model-identified ones (Chile, Sweden, Thailand, and the UK). Industrial country central banks (Sweden and the UK) reported demand inflation factors with longer leads than emerging market banks (Chile and Thailand). In other countries, the estimated coefficients were either lower than the threshold, or unstable, or both. Somewhat surprisingly, the rolling correlation coefficients declined precipitously in some countries in the second half of the 2000s (Chile, the Czech Republic, the Euro Area, and Hungary), presumably reflecting the difficulty of measuring the business cycle during the Great Recession. While in the Czech Republic the forward-looking correlation coefficients increased after 2002, when the CNB replaced its expert-based inflation forecast with a model-based one, the reported factors became mostly backward-looking in the second half of the decade. Similarly, the ECB's track record deteriorated in the mid-2000s, only to improve again in the second half of the 2000s. The temporary loss of accord seem to be linked to the measurement of the fiscal stance: while the ECB's Economic Bulletins repeatedly mentioned an expansionary fiscal stance, the model identified slack in the economy. Poland's results are puzzling – the forward-looking correlations are consistently negative. They can be pinpointed to two particular periods: first, in 2002–2004 the central bank worried about expansionary fiscal policies when the economy was apparently operating below its potential; second, the small negative model-identified output gap during 2006–2007 is opposite to what the bank reported (see Figure A1.1).

Aggregate Supply Factors

The full-sample correlations were high for all countries. However, they were unstable in Hungary, Poland, Thailand, and the UK. Only the Euro Area and Hungary appeared to report supply-side factors with a lead of 2 quarters; in the rest these were reported either contemporaneously (Sweden) or with a 2-quarter lag (Chile, the Czech Republic, and Poland). Thailand's inflation reports attributed the inflation spike in 2004–2006 to a large extent to various supply-side (mostly food) factors, while the model identified the supply-side factors as pushing inflation downward. Given that the supply-side factors in emerging market countries are largely driven by administrative price and indirect tax changes, these correlations may simply reflect the practice of not reporting policy-driven price moves in a forward-looking manner. Although such changes are typically subject to approval in either the parliament or the government with a long lead, their implementations have often been postponed or watered down and central banks may prefer to incorporate this information contemporaneously.

Exchange Rate Factors

In emerging market countries these factors were identified in a forward-looking manner, typically with a 2- or 4-quarter lead. The correlations were unstable for Chile and the Euro Area and either insignificant or negative for Sweden. These differences presumably reflect central banks' communication strategy and uncertainty about transmission. The Bank of Thailand did not make any forward-looking statements about exchange rates during the sample period, whereas the ECB made mostly forward-looking statements at the beginning of the sample period and put more stress on the contemporaneous component toward the end of the sample. In the three Central European countries –

the Czech Republic, Hungary, and Poland – the exchange rate factors are the most consistently identified factors, reflecting the strength of the exchange rate channel in emerging market economies.

4.3 Policy Implications: Glass Half Full or Half Empty?

While all but one sample central bank correctly identified the thrust of the inflation factors during the period under consideration, the occasional identification failures – across subcategories, countries, and time – are a reason to remain alert. The analytical power of inflation reports cannot be taken for granted and ought to be regularly evaluated, both internally and by external assessors. The goal of such periodic reviews would be to identify past errors and learn from them. Most central banks are subject to such reviews, although they take different forms. In Sweden, the parliamentary Committee on Finance conducts an annual evaluation of the monetary policy conducted over the last three years, and external evaluations are conducted every four years (Svensson, 2009). The annual "ECB Watchers' Conference" organized by the Center for Financial Studies in Frankfurt, fulfills a similar objective for the Euro Area (http://www.ifk-cfs.de).

The reviews should focus on both sets of reasons that lead to identification failures. First, there may be broadly defined measurement errors, such as forecasting errors or erroneous central bank communication. Regarding the former, the new Keynesian framework employed by inflation targeting central banks may not generate the "true" inflation factors in every instance. Regarding the latter, the public may find it challenging to understand reports that fail the test of clarity of communication. Second, and more dangerously, policymakers may knowingly report inflation factors different from those observable in the real-time data owing to their own political agenda or risk aversion. For example, the reports may attribute inflation to supply-side factors when the economy was allowed to overheat.

5. Conclusions

We assessed the quality of monetary policy communication by comparing inflation factors reported in inflation reports with ex-post model-identified factors, interpreting positive correlations between the reported and model-identified factors as signaling high-quality inflation reports. We were motivated by the Bernanke-Woodford argument that inflation report communication that is consistent with other communication tools and empirical analyses is more likely to anchor the public's expectations than communication that contradicted such analyses. In other words, we use report-to-model accord as a measure of inflation report quality. We used the new Keynesian reduced-form model to generate model-identified inflation factors for a sample of eight central banks with clearly defined inflation objectives and transparent communication.

Our results confirm that inflation reports identified on average the same inflation factors as the new Keynesian model, generally with a lead of two quarters. Demand and supply factors were mostly identified contemporaneously, however. Sample countries identified on average one-half of the "true" subcategories of inflation factors at or above the chosen threshold level, with most misses being in the aggregate demand category. In some countries and/or during some periods the accord between the reported and model-identified factors was tenuous at best. We relate these occasional communication breakdowns to measurement errors, both in our modeling framework and in our de-coding of central banks' verbal communication, and to central banks knowingly reporting inflation factors different from those observable in the real-time data owing to the policymakers' own political agenda. The policy implication of our findings is clear: the analytical power of inflation reports cannot be taken for granted and needs to be periodically evaluated.

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Appendix 1: Coding the Inflation Reports

Our research assistants extracted all verbal assessments and noted the presumed direction of all these effects on inflation. Their entries were then reviewed and checked by two co-authors to ensure consistency and limit subjectivity. Less than 10 percent of the initial codes required vetting by the co-authors. The ternary coding of inflation factors, (–1, 0, +1), required several steps. First, each verbal comment was catalogued into a major category and several subcategories: *demand* (fiscal, domestic cycle pressure, wages, external demand, domestic asset price bubbles, other), *supply* (weather and similar shocks, oil/gas prices, agricultural prices, capacity utilization, labor supply, regulated prices, structural changes, retail competition, indirect taxes, other), or *external* (exchange rates, global financial shocks, other). Second, factors putting upward/downward pressure on inflation were denoted as +1/–1 and neutral factors were denoted as 0.

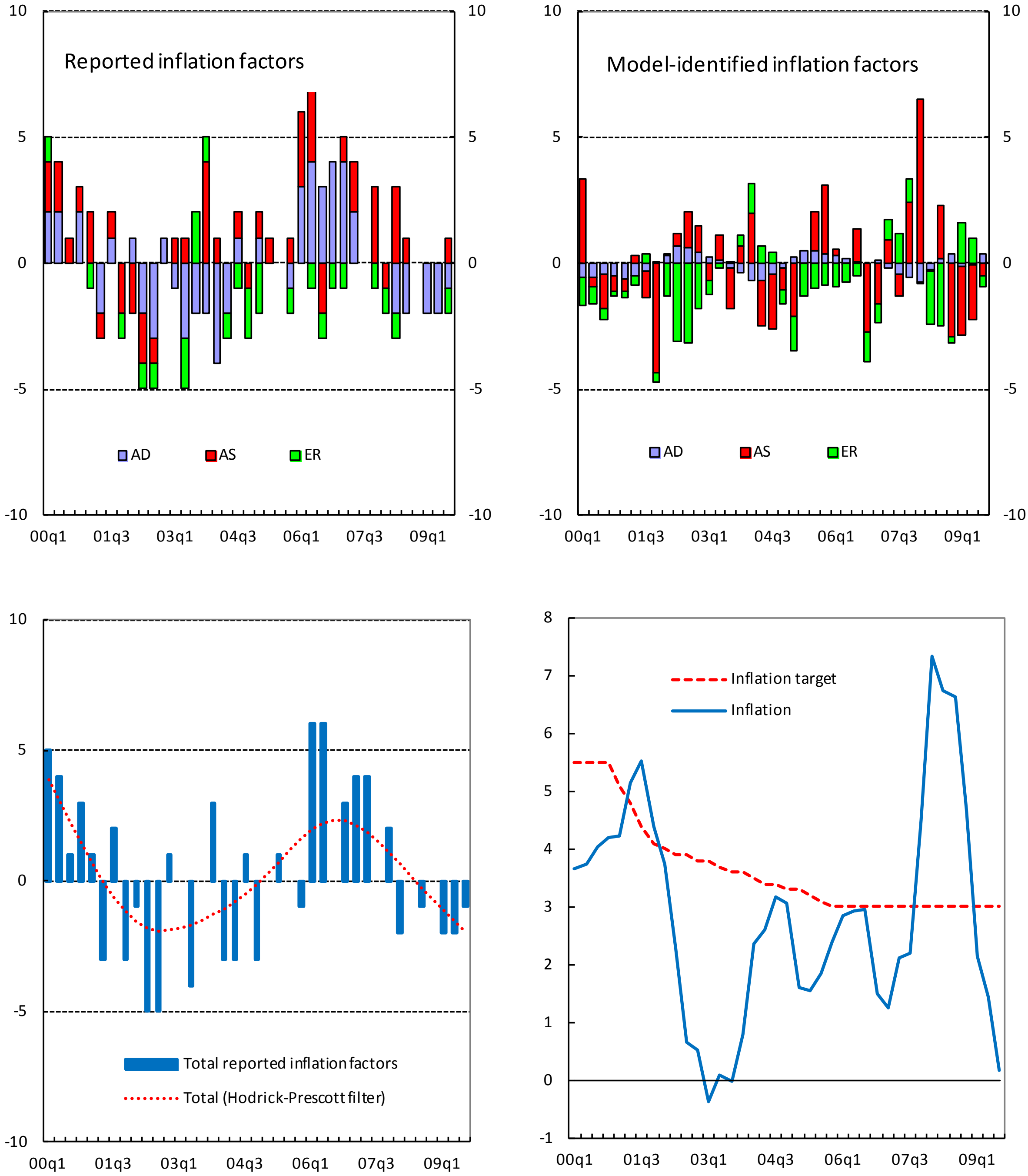
Below are some typical examples of our coding. The January and March 2003 *ECB Monthly Bulletins* contained the following sentences: "the current subdued pace of economic growth should contain inflationary pressures" and "the moderate pace of economic growth should also reduce inflationary pressures," respectively, and these were coded as −1 in the demand category. The January 2003 bulletin noted "various increases in administered prices," and was coded as +1 in the supply category.

Table A.1.1: Sample Country Characteristics

Country	Inflation targeting introduced	Name, frequency, and availability of reports	Sample period for model simulations
Chile	1991	Monetary Policy Report, three times a year; http://www.bcentral.cl	1994–2011
Czech Republic	1998	Inflation Report, four times a year; www.cnb.cz	1996–2011
Euro Area	Not an inflation targeting central bank	Monthly Bulletin, 12 times a year; http://www.ecb.int	1996–2011
Hungary	2001	Quarterly Report on Inflation, four times a year; www.mnb.hu	1995–2011
Poland	1999	Inflation Report, Three-to-four times a year; www.nbp.pl	1995–2011
Sweden	1993	Monetary Policy Report, three times a year; www.riksbank.com	1994–2011
Thailand	2000	Monetary Policy Report, four times a year; www.bot.or.th	2000–2011
United Kingdom	1992	Inflation Report, four times a year; http://www.bankofengland.co.uk	1999–2011

Source: National central bank websites; World Economic Outlook.

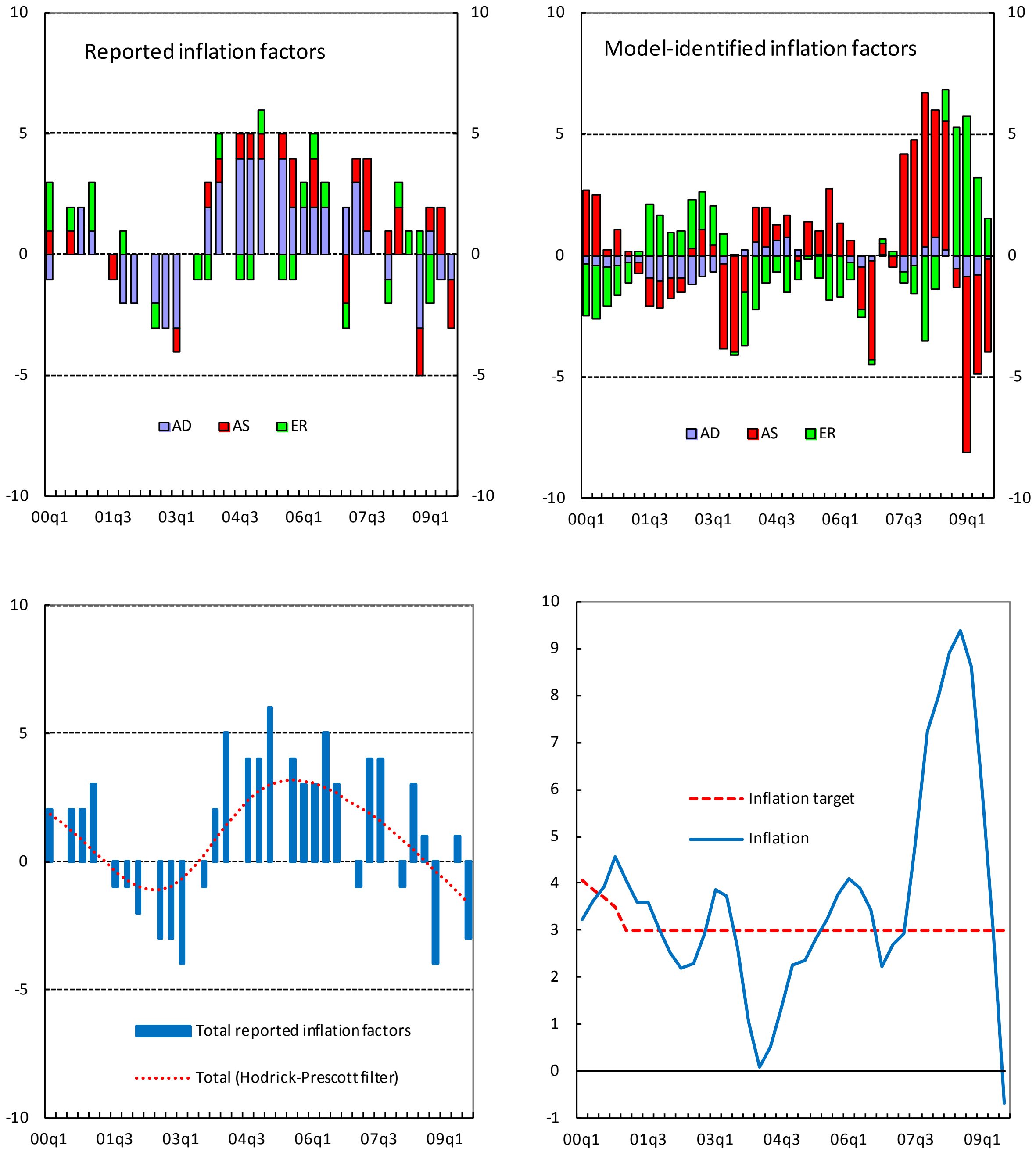
Figure A1.1: Czech Republic: Reported Inflation Factors and Inflation, 2000–2009



Note: The upper left panel shows the gross count of the disaggregated reported inflation factors and the lower left panel provides the net sum of all reported factors and the Hodrick-Prescott trend thereof (λ=100); the upper right panel shows the values of the model-identified factors (the sum of all factors adds up to the difference between actual inflation and the inflation target; the lower right panel displays headline inflation (in percent) and the official inflation target/objective (if defined as a range, we report the midpoint of the target range).

Source: Czech National Bank; authors' calculations.

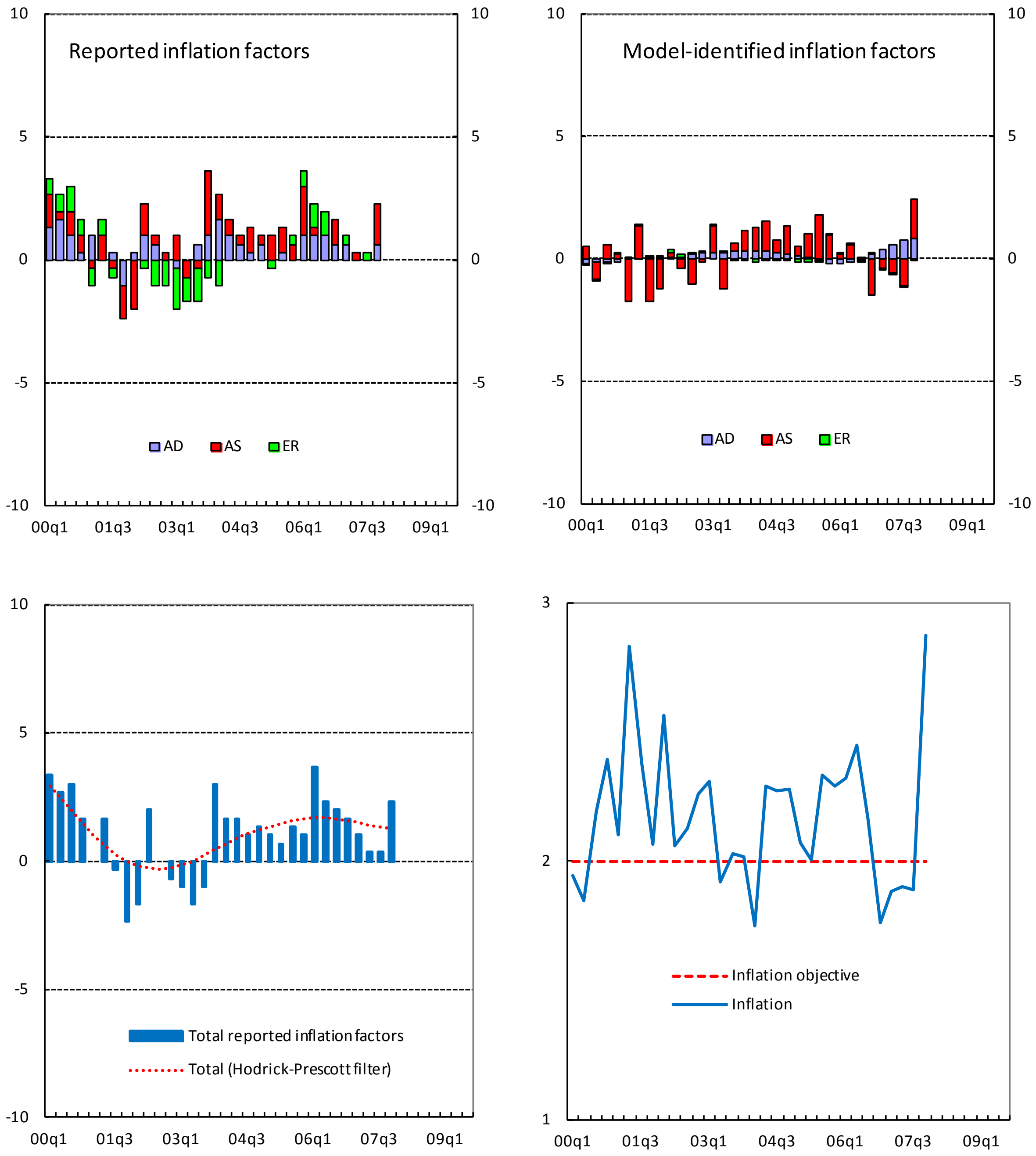
Figure A1.1: Chile: Reported Inflation Factors and Inflation, 2000–2009 (continued)



Note: The upper left panel shows the gross count of the disaggregated reported inflation factors and the lower left panel provides the net sum of all reported factors and the Hodrick-Prescott trend thereof (λ=100); the upper right panel shows the values of the model-identified factors (the sum of all factors adds up to the difference between actual inflation and the inflation target; the lower right panel displays headline inflation (in percent) and the official inflation target/objective (if defined as a range, we report the midpoint of the target range).

Source: Banco Central de Chile; authors' calculations.

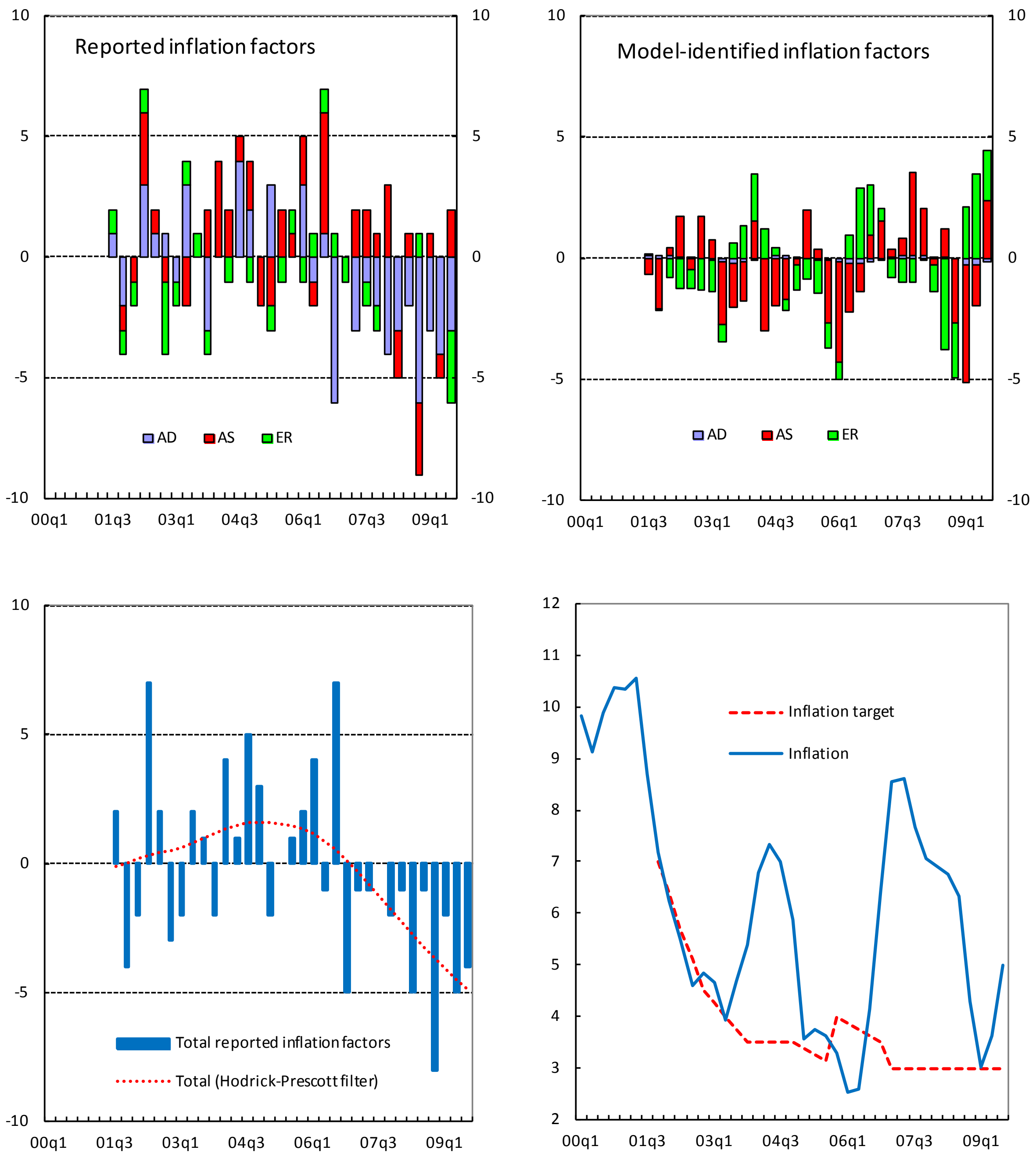
Figure A1.1: Euro Area: Reported Inflation Factors and Inflation, 2000–2007 (continued)



Note: The upper left panel shows the gross count of the disaggregated reported inflation factors and the lower left panel provides the net sum of all reported factors and the Hodrick-Prescott trend thereof (λ=100); the upper right panel shows the values of the model-identified factors (the sum of all factors adds up to the difference between actual inflation and the inflation target; the lower right panel displays headline inflation (in percent) and the official inflation target/objective (if defined as a range, we report the midpoint of the target range).

Source: European Central Bank; authors' calculations.

Figure A1.1: Hungary: Reported Inflation Factors and Inflation, 2001–2009 (continued)



Note: The upper left panel shows the gross count of the disaggregated reported inflation factors and the lower left panel provides the net sum of all reported factors and the Hodrick-Prescott trend thereof (λ=100); the upper right panel shows the values of the model-identified factors (the sum of all factors adds up to the difference between actual inflation and the inflation target; the lower right panel displays headline inflation (in percent) and the official inflation target/objective (if defined as a range, we report the midpoint of the target range).

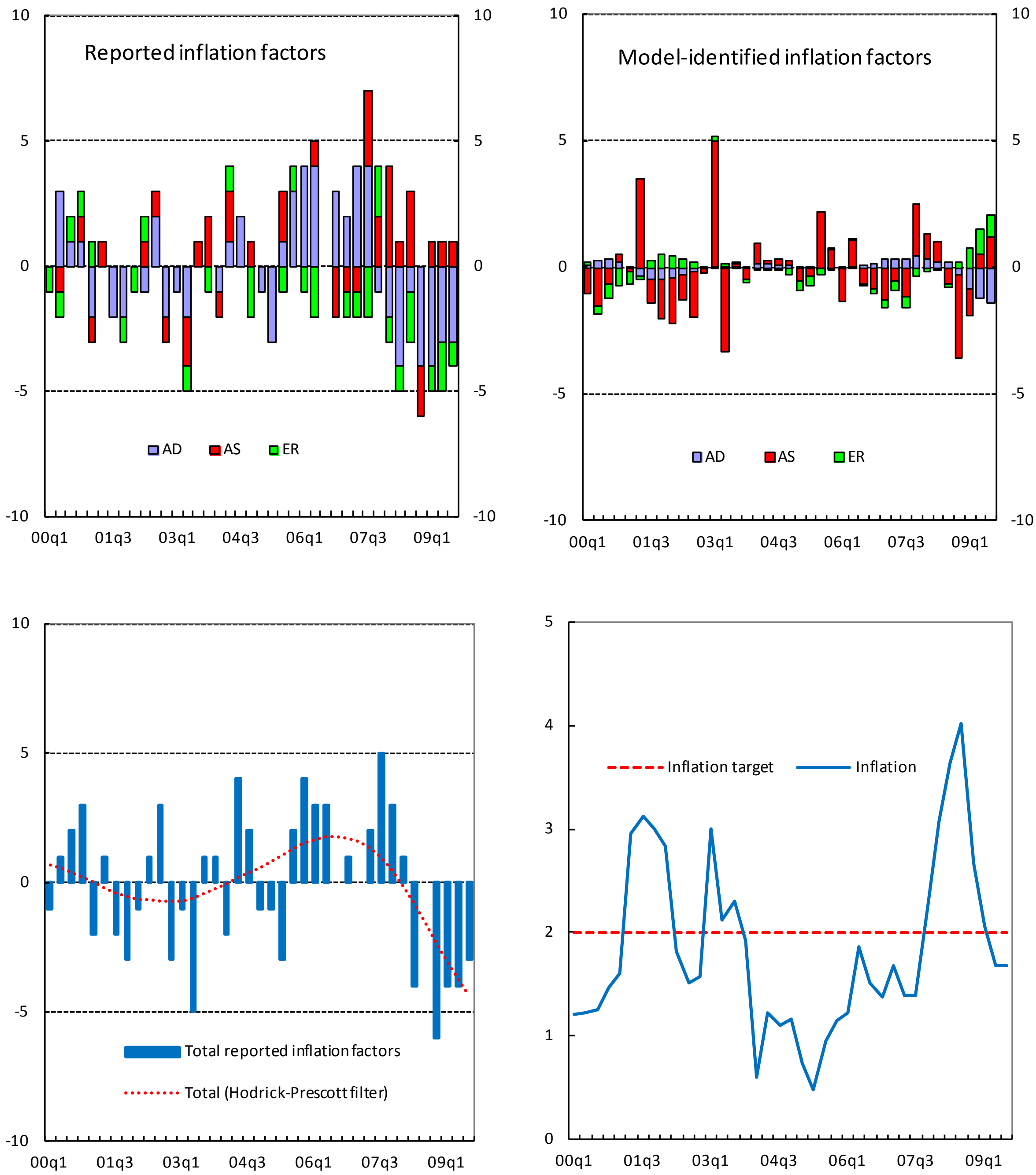
Source: Magyar Nemzeti Bank; authors' calculations.

Figure A1.1: Poland: Reported Inflation Factors and Inflation, 2000–2009 (continued)

Note: The upper left panel shows the gross count of the disaggregated reported inflation factors and the lower left panel provides the net sum of all reported factors and the Hodrick-Prescott trend thereof (λ=100); the upper right panel shows the values of the model-identified factors (the sum of all factors adds up to the difference between actual inflation and the inflation target; the lower right panel displays headline inflation (in percent) and the official inflation target/objective (if defined as a range, we report the midpoint of the target range).

Source: National Bank of Poland; authors' calculations.

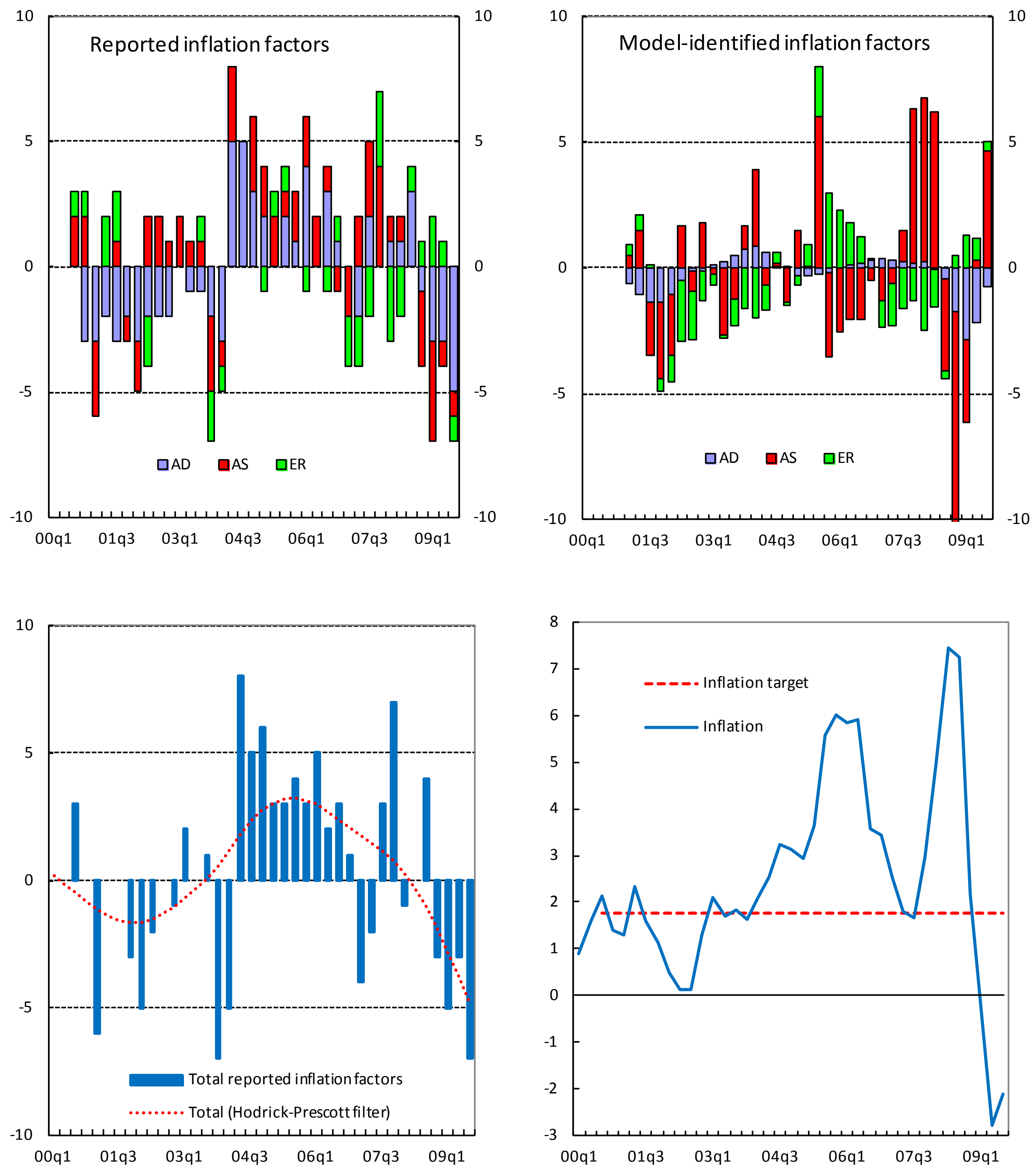
Figure A1.1: Sweden: Reported Inflation Factors and Inflation, 2000–2009 (continued)



Note: The upper left panel shows the gross count of the disaggregated reported inflation factors and the lower left panel provides the net sum of all reported factors and the Hodrick-Prescott trend thereof (λ=100); the upper right panel shows the values of the model-identified factors (the sum of all factors adds up to the difference between actual inflation and the inflation target; the lower right panel displays headline inflation (in percent) and the official inflation target/objective (if defined as a range, we report the midpoint of the target range).

Source: Riksbank; authors' calculations.

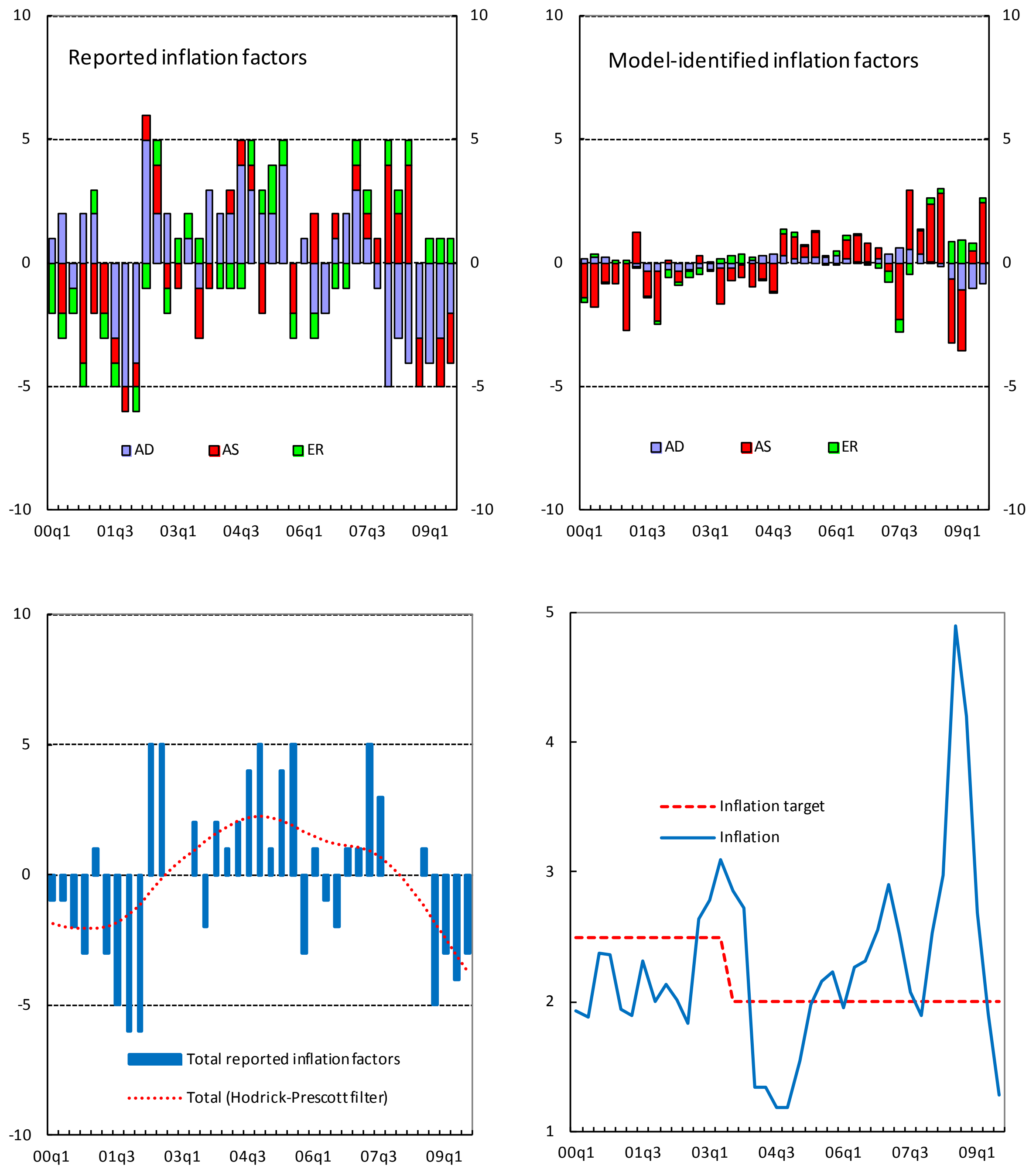
Figure A1.1: Thailand: Reported Inflation Factors and Inflation, 2000–2009 (continued)



Note: The upper left panel shows the gross count of the disaggregated reported inflation factors and the lower left panel provides the net sum of all reported factors and the Hodrick-Prescott trend thereof (λ=100); the upper right panel shows the values of the model-identified factors (the sum of all factors adds up to the difference between actual inflation and the inflation target; the lower right panel displays headline inflation (in percent) and the official inflation target/objective (if defined as a range, we report the midpoint of the target range).

Source: Bank of Thailand; authors' calculations.

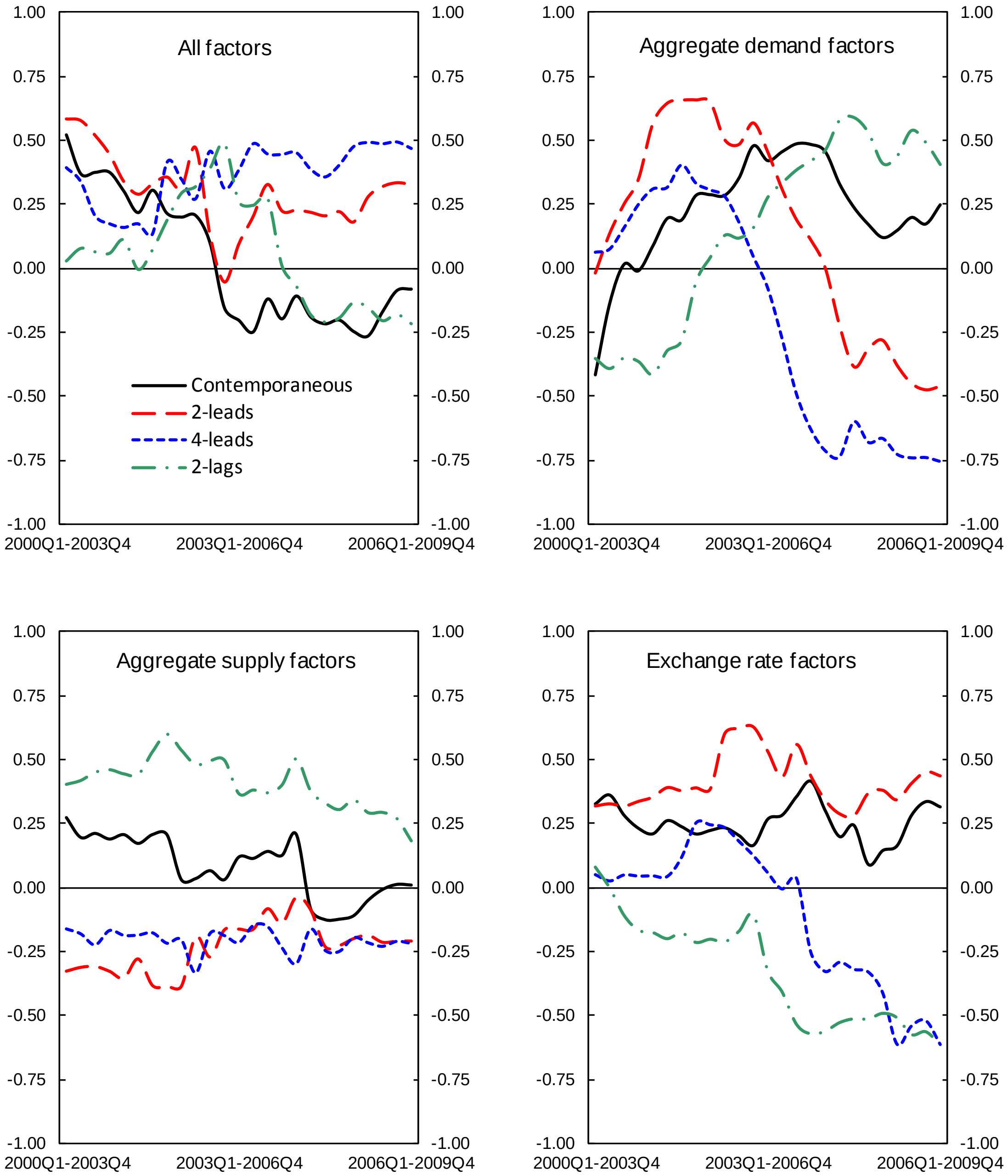
Figure A1.1: United Kingdom: Reported Inflation Factors and Inflation, 2000–2009 (concluded)



Note: The upper left panel shows the gross count of the disaggregated reported inflation factors and the lower left panel provides the net sum of all reported factors and the Hodrick-Prescott trend thereof (λ=100); the upper right panel shows the values of the model-identified factors (the sum of all factors adds up to the difference between actual inflation and the inflation target; the lower right panel displays headline inflation (in percent) and the official inflation target/objective (if defined as a range, we report the midpoint of the target range).

Source: Bank of England; authors' calculations.

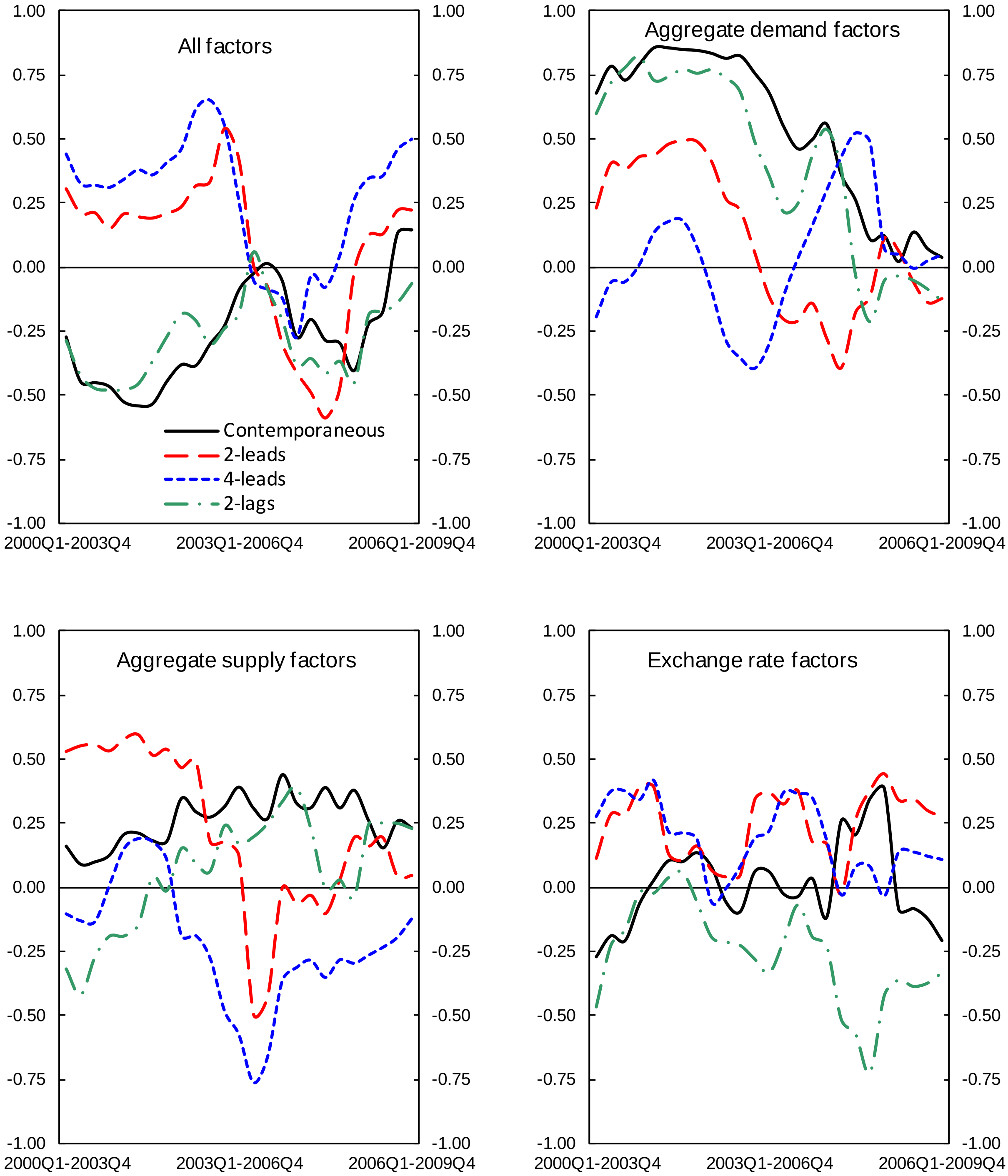
Figure A1.2: Czech Republic: Reported and Model-Identified Inflation Factors, 2000–2009



Note: Rolling correlation coefficients (Pearson), 16-quarter window. The reported factors are derived from inflation reports; model-identified factors are based on the Kalman filter decomposition of the new Keynesian model. "2 leads" implies that we compare model-identified factors with reported factors from earlier quarters, that is, the reports lead by 2 quarters.

Source: Authors' calculations.

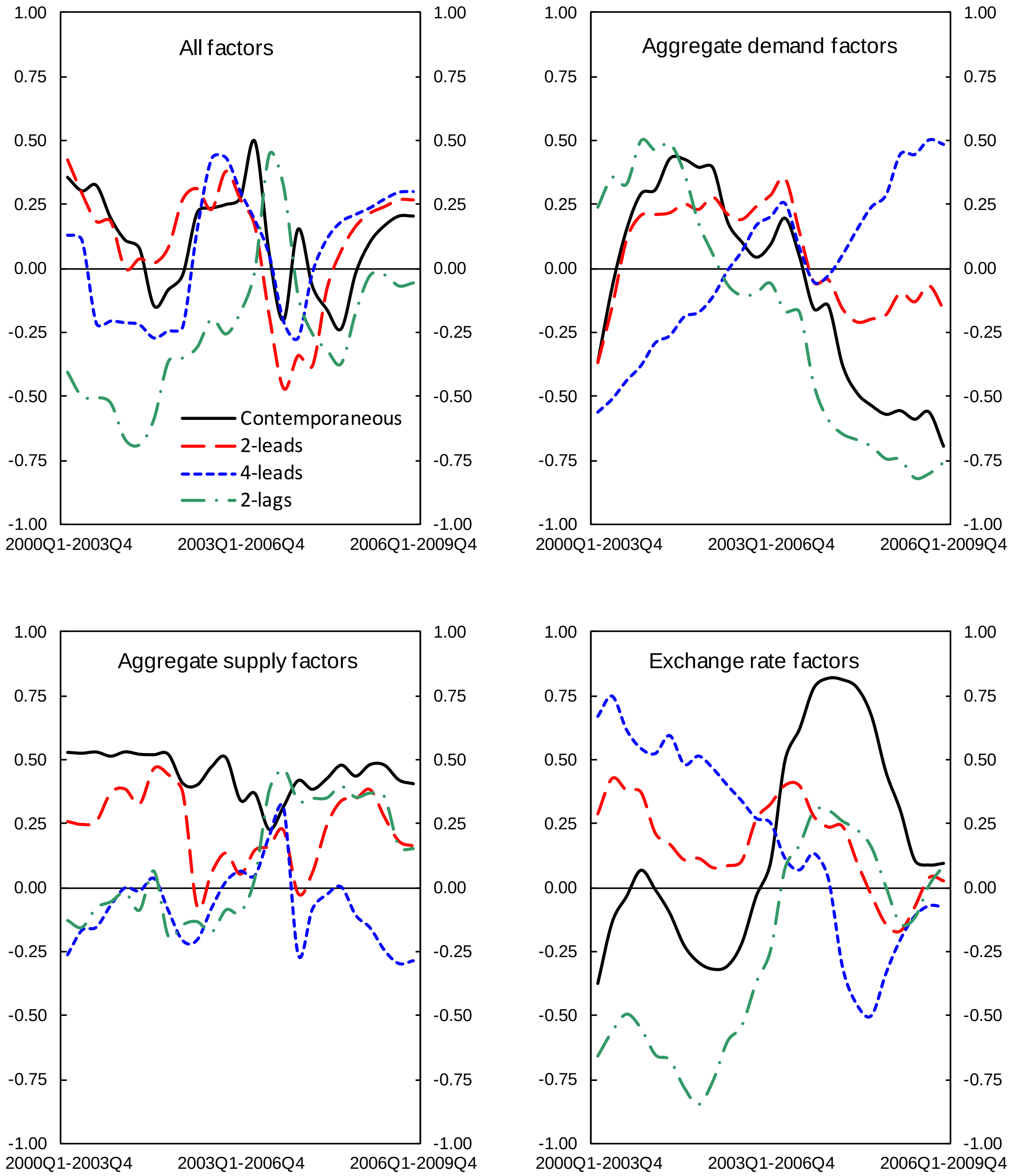
Figure A1.2: Chile: Reported and Model-Identified Inflation Factors, 2000–2009 (continued)



Note: Rolling correlation coefficients (Pearson), 16-quarter window. The reported factors are derived from inflation reports; model-identified factors are based on the Kalman filter decomposition of the new Keynesian model. "2 leads" implies that we compare model-identified factors with reported factors from earlier quarters, that is, the reports lead by 2 quarters.

Source: Authors' calculations.

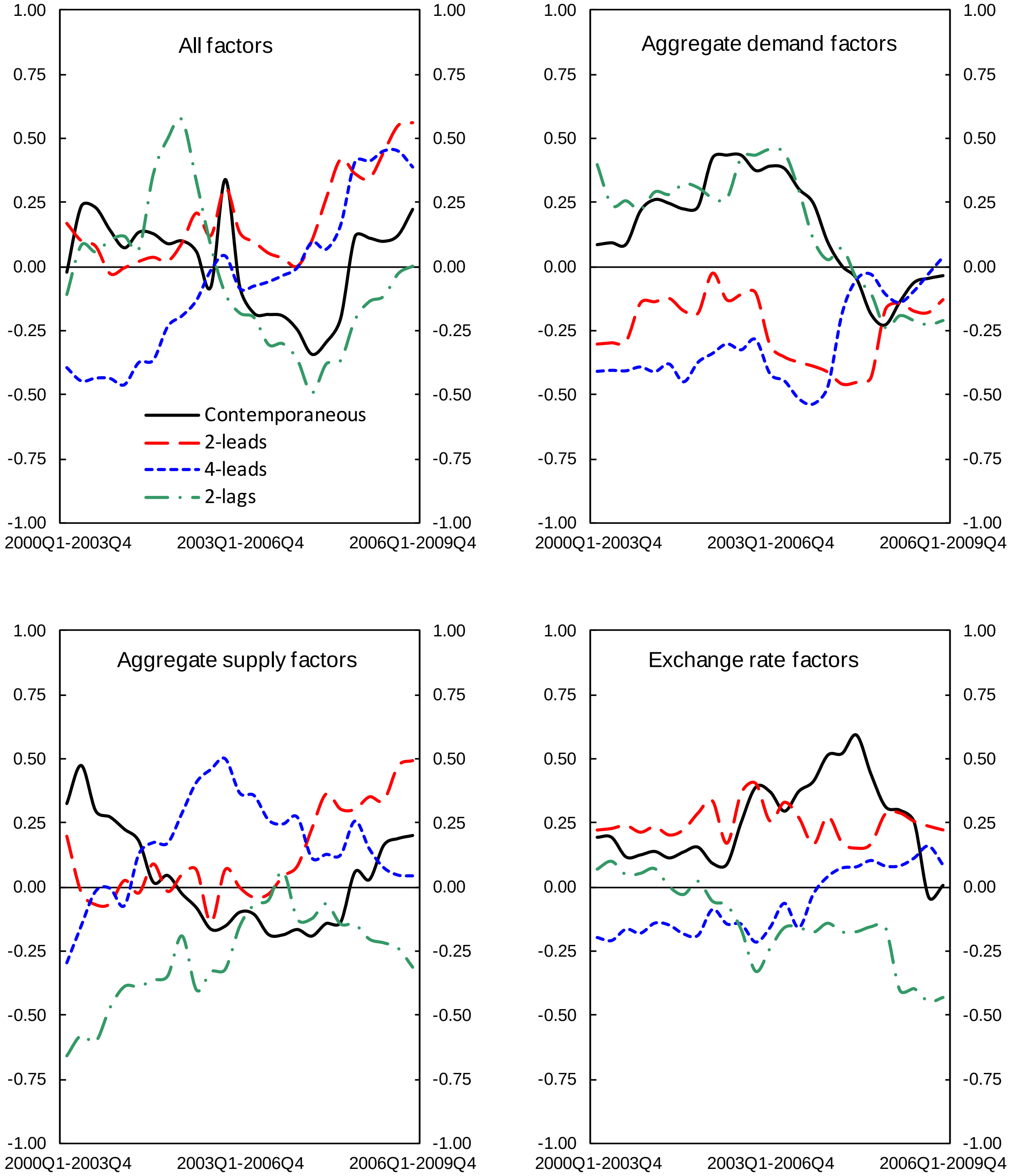
Figure A1.2: Euro Area: Reported and Model-Identified Inflation Factors, 2000–2007 (continued)



Note: Rolling correlation coefficients (Pearson), 16-quarter window. The reported factors are derived from inflation reports; model-identified factors are based on the Kalman filter decomposition of the new Keynesian model. "2 leads" implies that we compare model-identified factors with reported factors from earlier quarters, that is, the reports lead by 2 quarters.

Source: Authors' calculations.

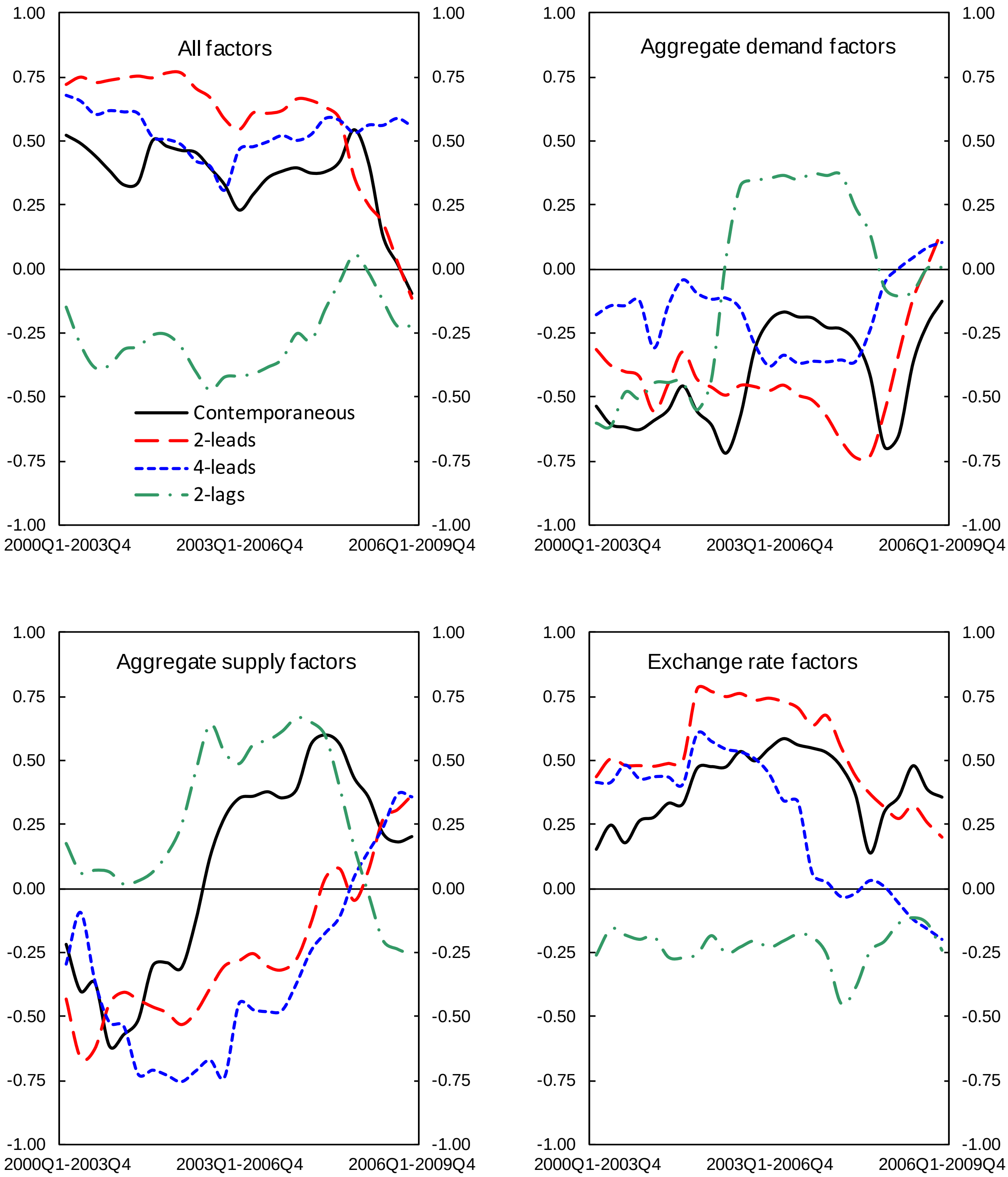
Figure A1.2: Hungary: Reported and Model-Identified Inflation Factors, 2000–2009 (continued)



Note: Rolling correlation coefficients (Pearson), 16-quarter window. The reported factors are derived from inflation reports; model-identified factors are based on the Kalman filter decomposition of the new Keynesian model. "2 leads" implies that we compare model-identified factors with reported factors from earlier quarters, that is, the reports lead by 2 quarters.

Source: Authors' calculations.

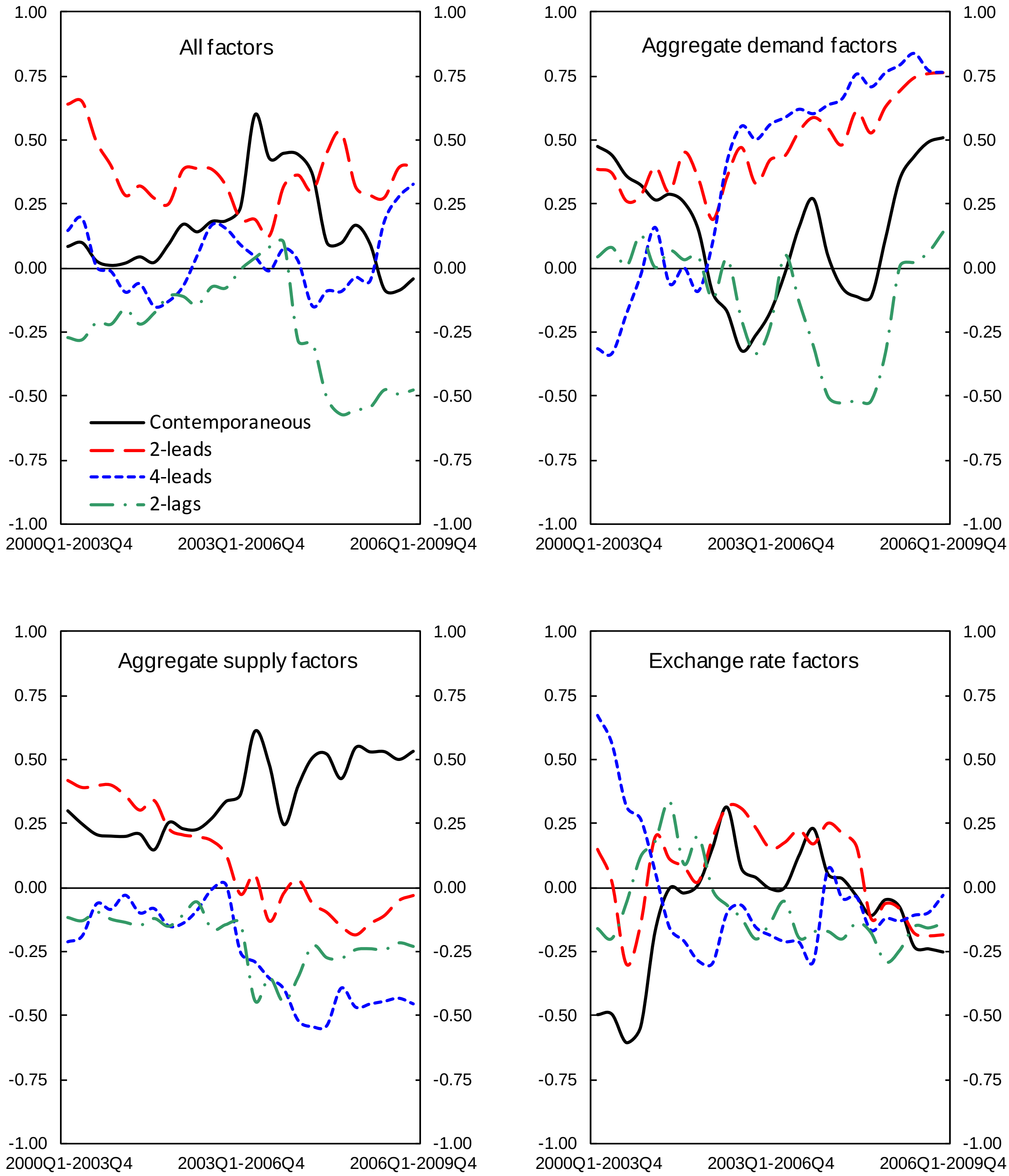
Figure A1.2: Poland: Reported and Model-Identified Inflation Factors, 2000–2009 (continued)



Note: Rolling correlation coefficients (Pearson), 16-quarter window. The reported factors are derived from inflation reports; model-identified factors are based on the Kalman filter decomposition of the new Keynesian model. "2 leads" implies that we compare model-identified factors with reported factors from earlier quarters, that is, the reports lead by 2 quarters.

Source: Authors' calculations

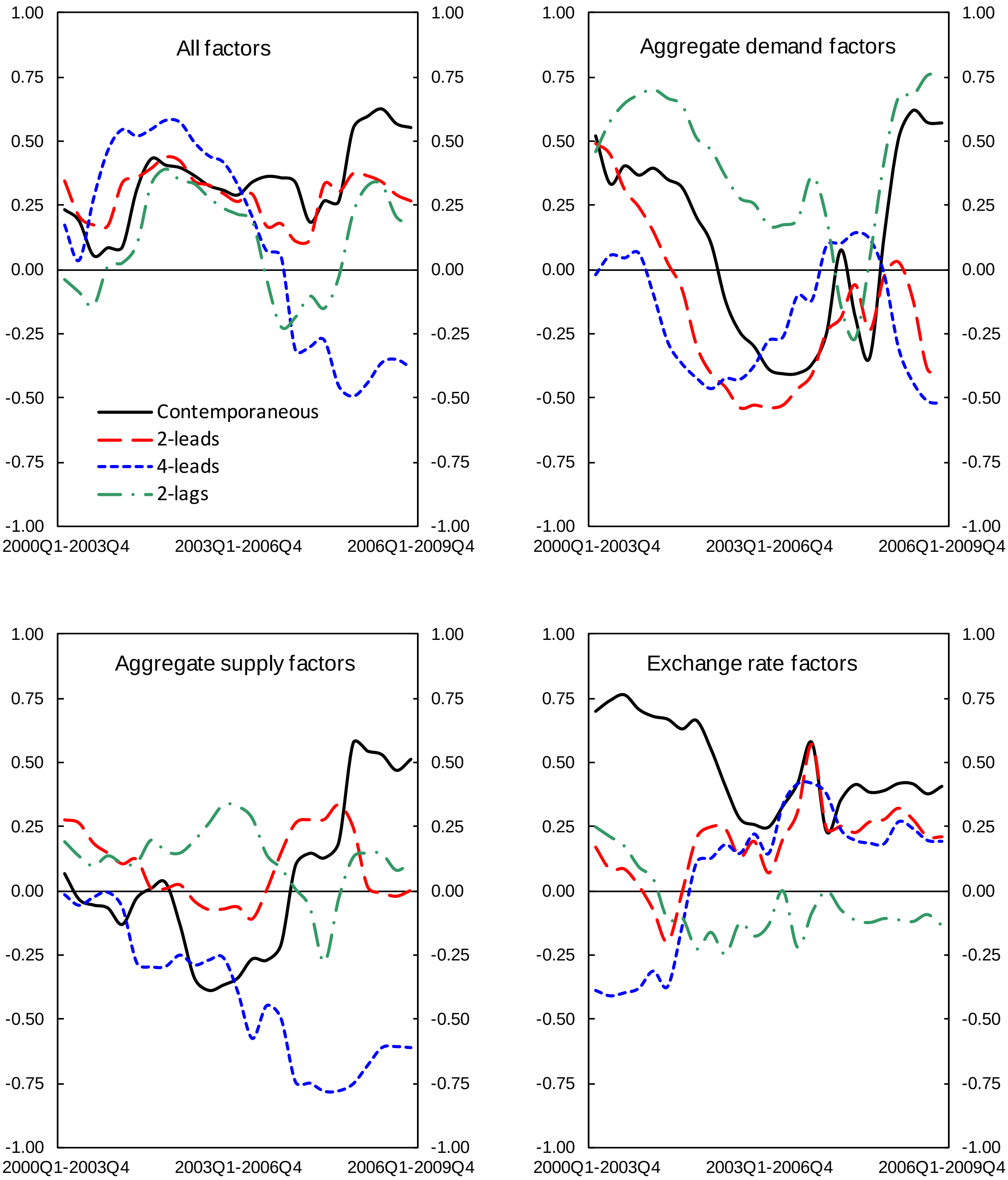
Figure A1.2: Sweden: Reported and Model-Identified Inflation Factors, 2000–2009 (continued)



Note: Rolling correlation coefficients (Pearson), 16-quarter window. The reported factors are derived from inflation reports; model-identified factors are based on the Kalman filter decomposition of the new Keynesian model. "2 leads" implies that we compare model-identified factors with reported factors from earlier quarters, that is, the reports lead by 2 quarters.

Source: Authors' calculations

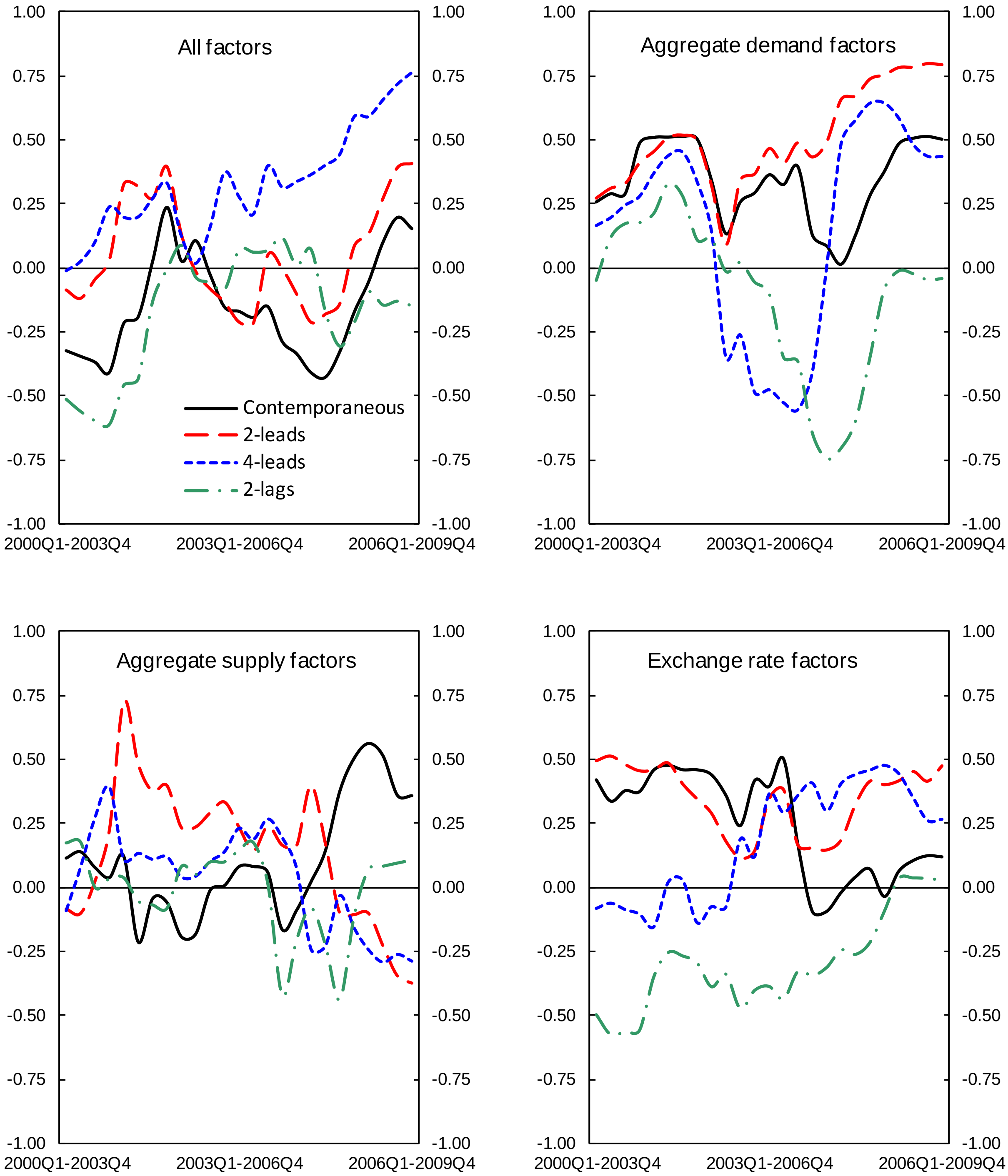
Figure A1.2: Thailand: Reported and Model-Identified Inflation Factors, 2000–2009 (continued)



Note: Rolling correlation coefficients (Pearson), 16-quarter window. The reported factors are derived from inflation reports; model-identified factors are based on the Kalman filter decomposition of the new Keynesian model. "2 leads" implies that we compare model-identified factors with reported factors from earlier quarters, that is, the reports lead by 2 quarters.

Source: Authors' calculations

Figure A1.2: United Kingdom: Reported and Model-Identified Inflation Factors, 2000–2009 (concluded)



Note: Rolling correlation coefficients (Pearson), 16-quarter window. The reported factors are derived from inflation reports; model-identified factors are based on the Kalman filter decomposition of the new Keynesian model. "2 leads" implies that we compare model-identified factors with reported factors from earlier quarters, that is, the reports lead by 2 quarters.

Source: Authors' calculations

Appendix 2: The Model and Its Calibration

We employ a four-equation open-economy model to estimate the inflation factors. The aggregate demand (IS) and supply (Phillips curve) equations take the following form:

$$\hat{y} = a_1 \hat{y}_{t-1} - a_2 \hat{r}_t + a_3 \hat{z}_t + a_4 \hat{y}_t^* + \varepsilon_t^y \tag{1}$$

$$\pi_t = b_1 \pi_{t+1}^e + (1-b_1)\pi_{t-1} + b_2 \hat{z}_t + b_3 \hat{y}_t + \varepsilon_t^\pi \tag{2}$$

where $\hat{y}_t$, $\hat{r}_t$, $\hat{z}_t$, and $\hat{y}_t^*$ represent the deviations of real output, the real interest and exchange rates, and foreign real output from their respective noninflationary (natural) levels; π_t and π_{t+1}^e represent domestic and expected (model-consistent) inflation. Shocks are denoted by ε^i. All variables are in logs, except for the interest rates.

The uncovered interest rate parity equation takes the form:

$$s_t = s_{t+1}^E + (i_t^* - i_t + prem_t)/4 + \varepsilon_t^S \tag{3}$$

where s_t and s_{t+1}^E are the nominal exchange rate and its expectation, respectively; i_t and i_t^* are the domestic and foreign nominal short-term interest rates, respectively; and *prem* is the premium required by investors for holding domestic securities. The interest rate differential between the domestic and foreign short-term nominal interest rates is quoted in annual terms. To avoid the excessively fast adjustment of the exchange rate under the pure version of the uncovered interest rate parity (3), the term s_{t+1}^E does not represent model-consistent expectations of the exchange rate, but instead it is derived as a weighted average of the model-consistent expectations and a backward-looking element based on the relative version of the purchasing power parity framework:

$$s_{t+1}^E = c_1 s_{t+1}^e + (1-c_1)(s_{t-1} + 2/4(\pi_t^T - \bar{\pi}_t^* + \Delta z_t))$$

where s_{t+1}^e is model-consistent expectations of the nominal exchange rate, $\bar{\pi}_t^*$ is foreign long-run inflation defined as the inflation target, and $\Delta \bar{z}_t$ is the change in the trend real exchange rate. This specification was proposed by Berg, Karam, and Laxton (2006) and analyzed by Beneš, Hurník, and Vávra (2008).

Finally, the forward-looking policy rule is as follows:

$$i_t = d_1 i_{t-1} + (1-d_1)(\bar{r}_t + \pi_{t+1}^e + d_2(\pi_{t+4}^e - \pi_{t+4}^T) + d_3 \hat{y}_t) + \varepsilon_t^i \tag{4}$$

where i_t represents the policy (and market) short-term rate, $\bar{r}_t$ is the trend short-term real interest rate, and π_t^T is the inflation target.

The model further contains the following equations and identities:

$$r_t = i_t - \pi_{t+1}^e$$

$$\hat{r}_t = r_t - \bar{r}_t$$

$$\bar{r}_t = \bar{r}_t^* - \Delta\bar{z}_t + prem_t$$

$$\Delta z_t = \Delta s_t + \pi_t - \pi_t^*$$

$$\hat{z}_t = z_t - \bar{z}_t$$

$$i_t^* = \bar{r}_t^* + \pi_{t+1}^{e*}$$

$$z_t = z_{t-1} + \Delta z_t / 4$$

$$\bar{z}_t = \bar{z}_{t-1} + \Delta\bar{z}_t / 4 ,$$

where r_t is the short-term real interest rate, $\bar{r}_t^*$ is the foreign trend real interest rate, and Δz_t is the change in the real exchange rate. In our notation, bars denote potentially exogenous trend values of model variables with the property that $\lim_{t\to\infty} \bar{x}_t = \lim_{t\to\infty} x_{t,} \forall x$. For instance, $\bar{z}$ is an exogenous trend in the real exchange rate, implying that $\bar{z} = z$ in the steady state.

The calibration of the model parameters is summarized in Table A2.1. It includes the Berg, Karam, and Laxton (2006) calibration for Canada, which serves as a benchmark. The parameters *a*, *b*, *c*, and *d* correspond to aggregate demand, aggregate supply, the uncovered interest parity condition, and the policy rule, respectively. With the exception of Sweden and the eurozone, the parameter values differ from those for Canada to better reflect the stylized facts of emerging market economies.

First, the exchange rate channel (parameter a_3) is stronger in emerging economies than that in Sweden (or Canada) and may even exceed the interest rate channel (a_2). These calibrations reflect the relatively underdeveloped financial markets and dollarization (euroization) in emerging market economies, which tend to reduce the relative strength of the interest rate channel. Second, the output gap in emerging market economies is more dependent on external demand than that in industrial countries (parameters a_4). Third, the exchange rate pass-through, b_2, is stronger and faster in emerging economies. Fourth, the slope of the Phillips curve, b_3, appears to be higher in emerging economies, owing to limited indexation of wage contracts. The Euro Area calibration exhibits closed-economy features: parameters a_3, a_4, and especially b_2 are low compared to the sample small open economies, while the exchange rate is more persistent (c_1).

Table A2.1: Parameter Calibration

Parameter	Chile	Czech Republic	Euro Area	Hungary	Poland	Sweden	Thailand	Canada[1]	All-purpose[1]
a_1	0.8	0.8	0.7	0.7	0.7	0.5	0.8	0.85	0.50–0.90
a_2	0.2	0.2	0.15	0.15	0.2	0.1	0.2	0.10	-
a_3	0.4	0.1	0.05	0.15	0.1	0.05	0.6	0.05	-
a_4	0.6	0.6	0.2	0.5	0.4	0.4	0.3	0.25	-
b_1	0.7	0.7	0.8	0.7	0.7	0.8	0.7	0.80	> 0.50
b_2	0.2	0.2	0.01	0.15	0.1	0.05	0.4	0.10	-
b_3	0.7	0.2	0.1	0.15	0.2	0.15	0.6	0.30	-
c_1	0.5	0.5	0.6	0.5	0.5	0.5	0.5	-	-
d_1	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.50	0.50–1.00
d_2	1.5	2.0	1.5	1.0	2.0	1.5	1.5	2.00	-
d_3	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.50	-

[1] See Berg, Karam, and Laxton (2006).

Appendix 3: Tests of Predictive Power

Table A3.1: Mean Square Error of Inflation Forecasts

Forecast period	Chile	Czech Republic	Euro Area	Hungary	Poland	Sweden	Thailand
T+1	0.77	0.80	0.28	1.39	0.79	0.73	1.65
T+2	1.70	1.83	0.46	3.02	1.50	1.21	2.20
T+3	2.70	2.79	0.89	3.52	2.94	1.79	2.76
T+4	2.69	3.13	0.75	3.95	3.71	1.72	2.38
T+5	2.19	3.49	0.65	4.36	4.24	1.28	1.45
T+6	1.72	3.54	0.65	4.48	4.71	0.81	1.39

Source: Authors' calculations.

Table A3.2: Mean Square Error of VAR Out-of-Sample Forecasts

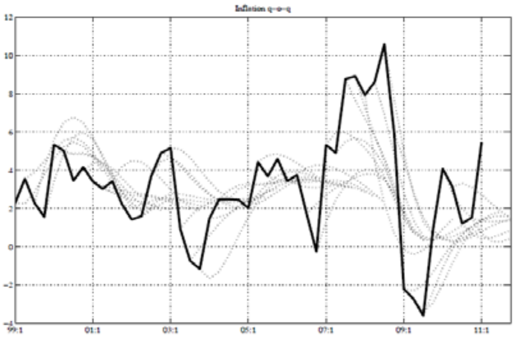
Forecast period	Chile	Czech Republic	Euro Area	Hungary	Poland	Sweden	Thailand
T+1	1.61	1.87	0.91	1.49	1.55	1.03	2.40
T+2	1.82	2.11	0.80	1.81	1.77	0.98	2.39
T+3	1.87	2.02	0.81	1.99	1.87	1.14	2.42
T+4	1.95	2.01	0.97	1.96	1.80	1.01	2.28
T+5	2.51	2.52	1.03	2.59	2.31	1.26	3.61
T+6	2.77	3.34	0.95	3.13	3.19	1.28	3.38

Source: Authors' calculations.

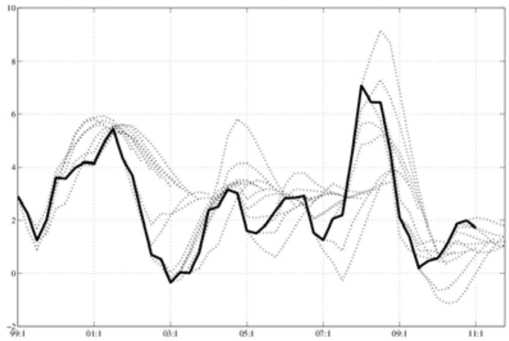
Figure A3.1: In-Sample Inflation Forecasts

(Year-on-year, in percent)

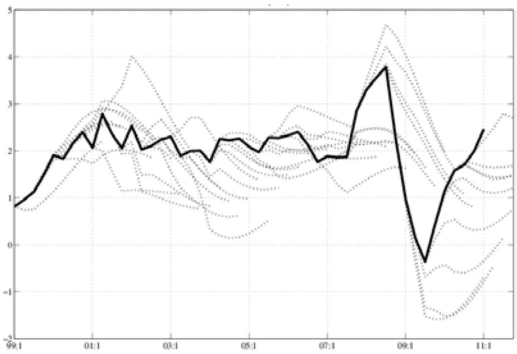
Chile



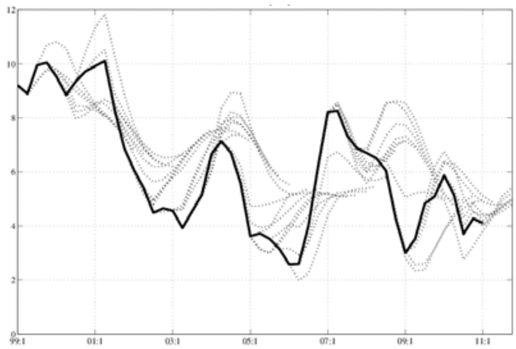
Czech Republic



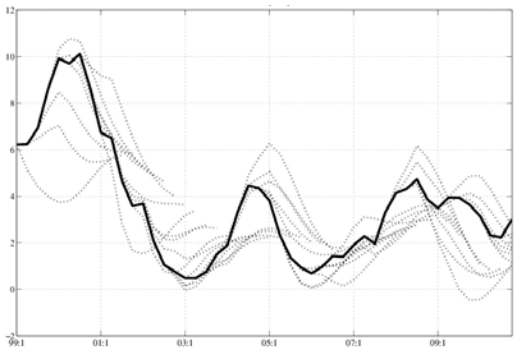
Euro Area



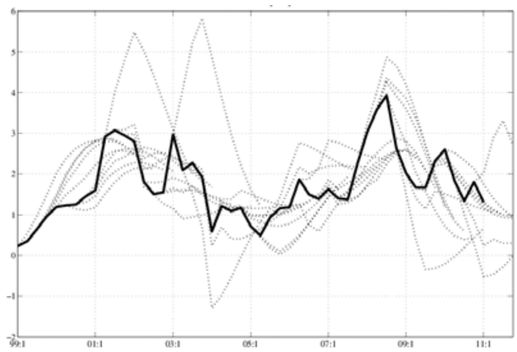
Hungary



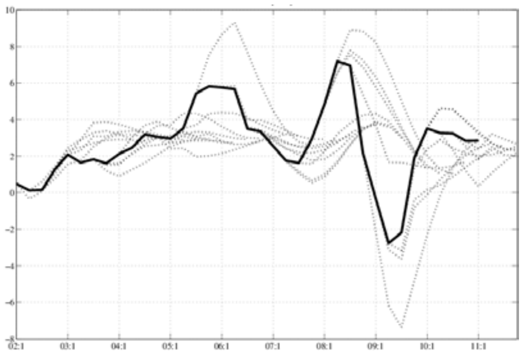
Poland



Sweden



Thailand



United Kingdom

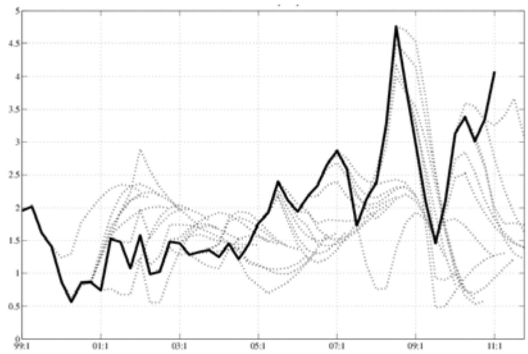
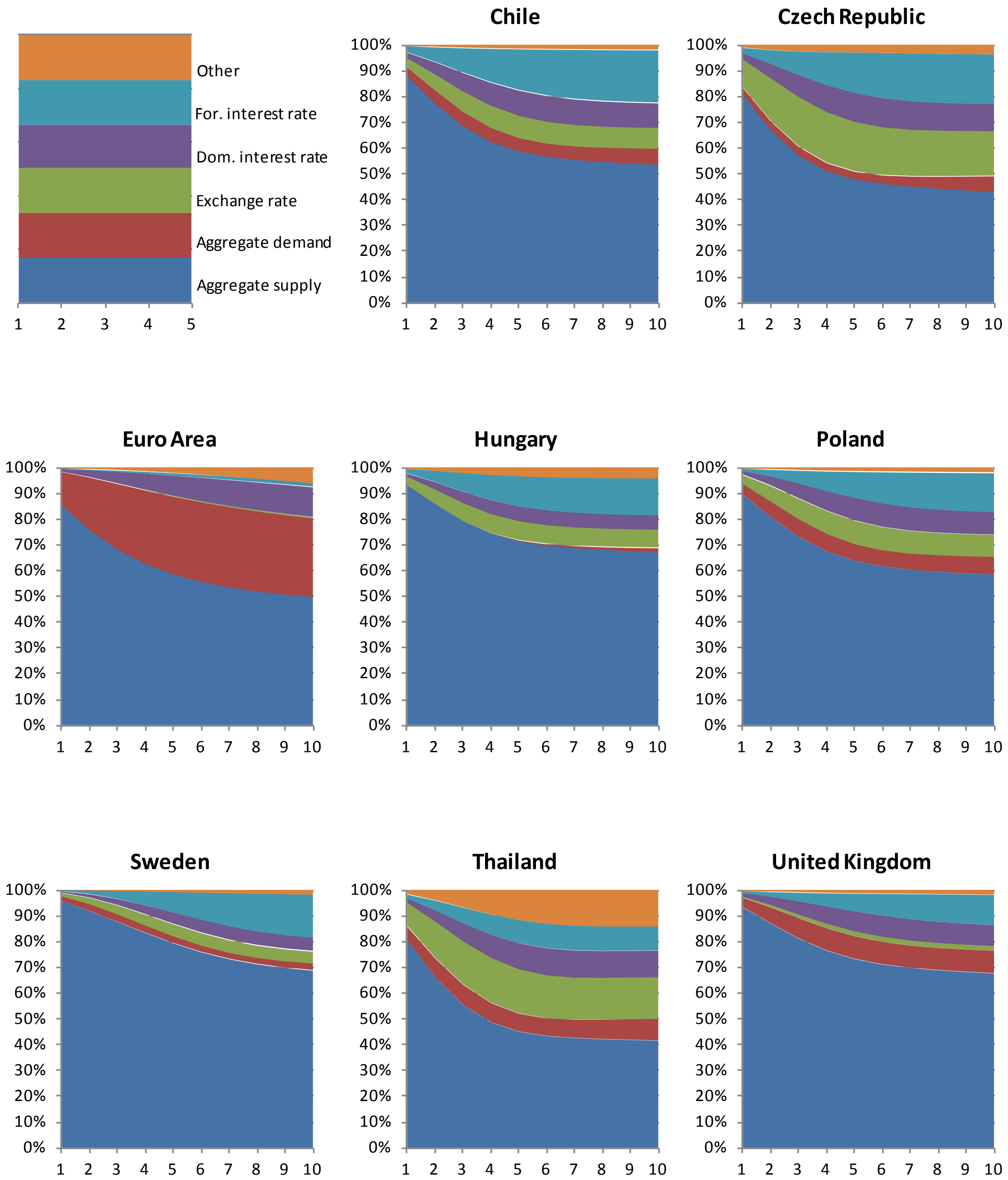


Figure A3.2: Model-Implied Forecast Error Variance Decomposition for Inflation



Notes: The chart decomposes the variance of the model-implied inflation forecast over the next ten periods into five major factors and lumps the rest. For example, aggregate supply corresponds to shocks to the Phillips curve; aggregate demand lumps the impact of the domestic and foreign output gap; and so on.

Source: Own calculations.

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