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Tradeoffs over Rate Cycles: Activity, Inflation and the Price Level

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Abstract: Central banks often face tradeoffs in how their monetary policy decisions impact economic activity (including employment), inflation and the price level. This paper assesses how these tradeoffs have evolved over time and varied across countries, with a focus on understanding the post-pandemic adjustment. To make these comparisons, we compile a cross-country, historical database of "rate cycles" (i.e., easing and tightening phases for monetary policy) for 24 advanced economies from 1970 through 2024. This allows us to quantify the characteristics of interest rate adjustments and corresponding macroeconomic outcomes and tradeoffs. We also calculate Sacrifice Ratios (output losses per inflation reduction) and document a historically low "sacrifice" during the post-pandemic tightening. This popular measure, however, ignores adjustments in the price level—which increased by more after the pandemic than over the past four decades. A series of regressions and simulations suggest monetary policy (and particularly the timing and aggressiveness of rate hikes) play a meaningful role in explaining these tradeoffs and how adjustments occur during tightening phases. Central bank credibility is the one measure we assess that corresponds to only positive outcomes and no difficult tradeoffs.

Keywords: monetary policy, interest rates, central bank, Sacrifice Ratio, business fluctuations, prices, employment
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I. Introduction

When central banks adjust monetary policy, they can choose between several different strategies, such as when, how quickly, and by how much to adjust the policy interest rate, as well as whether to combine these adjustments with other policy tools. These decisions often involve weighing difficult tradeoffs—such as whether to tighten policy more aggressively in order to bring inflation down to target more quickly, but at the cost of a larger output loss and increase in unemployment. This paper attempts to better understand these tradeoffs and corresponding sacrifices,[1] including how they have evolved over time and varied across economies, and with a focus on understanding the post-pandemic tightening. During this period, advanced economy central banks followed an unusual strategy for adjusting policy rates: a delayed start followed by aggressive tightening. When combined with an initial high level of credibility, this strategy contributed to a historically small "sacrifice" by some traditional measures, but an unusually large cost in terms of the increase in the price level.

An extensive literature analyzes monetary policy tradeoffs using various modeling frameworks and approaches (Clarida, Gali, and Gertler 1999; Adolfson, Laseén, Lindé, and Svenson 2008). A central theme in this literature is the short-run tradeoff between activity and inflation, encapsulated in the Phillips curve and at the core of most central bank DSGE models.[2] Another theme is the relative weight central banks should put on the output (or employment) gap and deviations of inflation from target when setting interest rates, as originally captured in the Taylor rule (Taylor 1993). One simple approach to describing these types of tradeoffs that has captured the attention of the broader public is the "Sacrifice Ratio"—the output losses required per inflation reduction (Ball 1994; Cecchetti et al. 2023; Tetlow 2024). These issues became particularly poignant when inflation spiked around the world in 2021-22, causing central banks to weigh these tradeoffs as they evaluated the appropriate strategy for tightening monetary policy (Tenreyro 2023; Maechler 2024).

Recent research provides various explanations why the tradeoff between activity and inflation can change over time and vary across countries (well summarized in Tetlow 2024). For example, an extensive series of papers focuses on the role of inflation expectations and how the actions taken by central banks can stabilize inflation expectations (and the related wage- and price-setting process) and reinforce central bank commitment to meeting inflation targets (Reis 2022; Afrouzi et al. 2024; Beaudry, Hou and Portier 2024; Romer and Romer 2024).[3] Another line of research emphasizes how the shocks affecting the economy determine the corresponding tradeoffs (Adolfson et al. 2008; Bandera et al. 2023). Other literature discusses how slower-moving

[1] We use the term "tradeoff" to capture when a central bank balances two (often negative) outcomes (e.g., how much adjustment occurs through above-target inflation versus output losses) and the term "sacrifice" to capture a narrower set of situations when a central bank balances a negative outcome in one measure to achieve a positive outcome in another (e.g., the magnitude of output losses to reduce above-target inflation).
[2] This original framework developed in Phillips (1958) focused on the tradeoff between wages and unemployment, but it is now used more broadly to capture the relationships between various measures of activity (including GDP and employment) and different measures of inflation. See McLeay and Tenreyro (2021) for a recent discussion in the NBER Macro Annual.
[3] This links to an extensive body of work on inflation expectations in monetary policy models that depart from full-information rational expectations, as well as to the literature on the responses of inflation and other macro variables to policy shocks, such as Christiano, Eichenbaum, and Evans (2005) and Ramey (2016).

variables, such as globalization and changes in the labor market, reduce the slope of the Phillips curve and therefore affect the relationship between activity and inflation (Jasová, Moessner and Takáts 2018; Ha, Kose and Ohnsorge 2019; Forbes 2020).

One important concept that has received much less attention in this discussion, however, is the aggregate impact of different monetary policy strategies on the price *level*. This is obviously related to the inflation rate, but also takes into consideration the length of time inflation deviates from target combined with the cumulated size of the deviation. Although many central banks viewed the combination of sharp disinflation with fairly robust activity after the pandemic as a success (a view supported by historically low Sacrifice Ratios), recent polls suggest high levels of dissatisfaction with the macroeconomy during this period, partly because of high prices. The period of elevated inflation and its impact on the level of prices appears to have also played a role in recent elections.[4]

A body of research uses survey data on individual preferences to provide further evidence that households care about this increase in the price level, and not just the rate of inflation (Cournède and Moccero 2009; Honkapohja and Mitra 2020). For example, Stantcheva (2024) finds that the "predominant reason for people's aversion to inflation is the widespread belief that it diminishes their buying power" rather than due to an association with unemployment or activity. Other papers document that individuals believe inflation has a negative impact on their personal financial situation and erodes their purchasing power (Coibion et al. 2023; Binetti, Nuzzi, and Stantcheva 2024). This belief that inflation is "unfair" seems to persist even if central banks accomplish their goal of returning inflation to target, and Guerreiro et al. (2024) argues that even if real wages recover, other changes decrease welfare.

Moreover, other research and the post-pandemic experience highlight the nonlinear effects of price shocks. Larger shocks cause firms to adjust prices more frequently (Akarsu, Aktug, and Torun 2024; Khalil and Lewis 2024), reflecting the non-linear effects on workers bargaining for wages that can lead to broader wage-price spirals (Alvarez et al. 2024). Similarly, consumers and businesses pay more attention to inflation after large and longer lasting price shocks, such that inflation expectations may become less firmly anchored (Bums et al. 2021; Beaudry et al. 2024). For all these reasons, even if inflation returns to target after a price shock, larger increases in the price level could correspond to more persistent changes in price setting behavior, wage negotiations, and a greater sensitivity to future inflation shocks, all of which could affect the transmission of monetary policy.

These different strands of research, as well as the post-pandemic experience, suggest that any assessment of the tradeoffs and sacrifices during disinflation episodes should incorporate the duration and cumulative amount by which inflation deviates from target (i.e., the impact on the price level), as well as the traditional focus on activity and returning inflation to target. This does *not* imply that central banks should shift to targeting the price level, which has its own serious shortcomings—including the difficulty in communication (Ambler 2009; Kahn 2009). Such a shift

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[4] New research suggests that inflation surprises "are regularly followed by a substantial increase in vote shares of extremist, anti-system, and populist parties" (Federle, Mohr, and Schularick 2024). This topic has also been covered in media, such as "Voter frustration with rising prices has a major impact on the election" (11/09/24), National Public Radio.

would also imply a major change in strategy away from one that has been largely successful in anchoring inflation expectations over recent decades.

Moreover, in many cases the optimal adjustment to shocks (particularly supply shocks and sectoral shocks) should primarily occur through prices (Afrouzi, Bhattarai, and Wu 2024). Instead, our analysis suggests that central banks should supplement their existing focus on inflation targets (and employment or other measures of activity) with a more explicit assessment of what different strategies imply for the extent and duration of any deviations of inflation from target. This richer discussion of the tradeoffs for monetary policy that includes the impact on the price level could involve a range of approaches, which are discussed in the conclusions.

In order to better understand the tradeoffs in activity, inflation, and the price level facing central banks, Section II draws on the business cycle literature to identify a series of "rate cycles" based on changes in policy interest rates and new balance sheet programs across a sample of 24 advanced economies from 1970 through 2024.[5] This yields a monthly database of tightening and easing phases—together which constitute a "rate cycle"—comparable to how the expansion and recession phases of output together constitute a business cycle. To the best of our knowledge, this is the first cross-country, historical database of rate cycles, and we hope that this will be useful for research on a range of topics in the future—from simply understanding the characteristics of these cycles to documenting regime shifts and non-normalities useful to model and understand rate cycles.[6] Moreover, although the well-known dates for business cycles correspond to the dates of these historical rate cycles in some cases, there are also many periods when business and rate cycles diverge, highlighting the importance of separately identifying the tightening and easing phases for monetary policy in order to better understand the actions of central banks.

Section III provides an initial analysis of the characteristics of these rate cycles, focusing on variables required for the subsequent analysis and building on statistics that are often used to describe business cycles: amplitude (total rate hikes); length of phase; pace (average size of rate adjustments); and initial velocity (rate adjustments over the first six months). We also examine characteristics that are unique to rate cycles—such as the duration for which rates are "on hold" at peak/trough levels before the end of the phase and use of balance sheet policies. This allows us to compare the characteristics of easing and tightening phases across economies and over time, as well as how they correlate to key macroeconomic variables. These statistics on monetary policy strategies will also be central to the analysis of tradeoffs in Section V.

This analysis suggests the post-pandemic tightening phase stands out by several metrics: a very slow start to tightening policy (based on the evolution of macroeconomic variables), followed by aggressive increases in the policy interest rate (measured by the initial velocity, pace and amplitude of rate hikes). This was followed by a much longer period holding rates constant at elevated levels and the start of quantitative tightening in many economies. We also assess the

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[5] An initial version of this database was introduced in Forbes, Ha and Kose (2024), and updated for this paper. The resulting cycle dates and code to calculate these cycles is available at https://mitmgmtfaculty.mit.edu/kjforbes/research/.

[6] For comparison, the classification of business cycles in Burns and Michell (1946) helped launch a body of research to understand patterns over time and the characteristics of these cycles, all of which were then useful to model business cycle dynamics. See the discussion of this paper by Mark Watson for more details.

evolution of activity (GDP and industrial production), the labor market (employment and unemployment), and inflation (for headline and core indices) over tightening phases. This analysis highlights the historically large movements in each variable around the pandemic, after which most variables settled back around levels typical for three years after the start of a tightening phase.

Section IV then focuses on the measurement of key tradeoffs and the corresponding sacrifices for central banks in advanced economies over tightening phases. It begins by calculating relevant statistics for inflation (such as the disinflation accomplished over each phase) and output gaps (using a range of measures). For many of these statistics, the post-pandemic adjustment continues to stand out. For example, the median accumulated output loss during the post-pandemic tightening was only -0.4% of annual GDP, while the median reduction in CPI inflation from its post-pandemic peak was 8.5pp (the largest of any of our long historical sub-periods since 1970).[7]

Next, we combine these measures to calculate Sacrifice Ratios (accumulated negative output gaps relative to the inflation reduction) across economies and tightening phases. The results suggest that the median "sacrifice" during the post-pandemic tightening was lower than any historical period based on a range of measures. This reflects the combination of historically low output losses combined with historically large disinflations. In fact, these Sacrifice Ratios are near zero in several major economies during the post-pandemic tightening phase.

These statistics, however, and the focus on whether inflation returns to target, miss an important consideration: the impact on the price level. During the post-pandemic tightening, price levels increased sharply and remained at elevated levels even as inflation fell. Across our sample, the median increase in the price level (based on the CPI or PCE) was more than 4 percentage points (pp) per year above that which would occur if inflation had remained at 2%. This is the largest annual "excess" increase in the price level since the mid-1980s, and particularly challenging for households and businesses for which inflation expectations were anchored around 2% (or even lower after negative "excess" inflation in the period before the pandemic). A comparison of these accumulated changes in the price level to those for output losses (roughly captured in a simple "Price-Output Tradeoff Ratio") suggests that more of the post-pandemic adjustment occurred through price (level) increases relative to through output (or employment) losses than has historically occurred.

To better understand these tradeoffs for monetary policy, Section V explores why they have changed over time and can vary meaningfully across economies. We begin with regression analysis to assess how a central bank's strategy corresponds to the subsequent macroeconomic adjustments and tradeoffs around inflation, activity and the price level. In order to capture a central bank's strategy, we use the rate cycle characteristics developed in Section II to measure the aggressiveness of tightening phases and timing of the first rate hike. We also control for central bank credibility, labor market flexibility, and the role of oil shocks (as well as a large set of additional variables in sensitivity tests).

[7] As explained in Section III, we analyze rate cycles across five sub-periods: 1970-84, 1985-98, 1999-2007, 2008-19, and 2020-24. Each window includes some type of recession/crisis and recovery period, with the demarcations marking major global events that might have changed the nature of rate cycles.

Our results suggest that the unusual tradeoffs during the post-pandemic period (e.g., the collapse in Sacrifice Ratios, large excess increase in the price level, and bulk of the adjustment occurring through prices rather than output) reflect a combination of: the slow start to tightening monetary policy, the subsequent aggressive path of rate hikes, and the strong prior credibility of the central banks in our sample. A delayed start to raising interest rates corresponds to lower Sacrifice Ratios, but primarily due to significantly larger disinflations after substantially larger increases in the price level. A delayed start does not appear to provide any benefit in terms of reducing output losses (possibly reflecting the more aggressive tightening needed to stabilize inflation) and therefore generates less attractive tradeoffs for monetary policy. A more aggressive path of rate hikes corresponds to significantly larger output losses, only partially balanced by significantly larger disinflations, and thereby higher Sacrifice Ratios and another clear tradeoff for monetary policy. Greater pre-existing central bank credibility is the one institutional feature that does not appear to involve tradeoffs (at least for the measures we consider), as it is associated with better outcomes for each variable (significantly lower Sacrifice Ratios, significantly lower output losses, larger disinflations, and smaller increases in the price level).

These empirical results are simple associations and should only be interpreted as suggestive, however, as they do not control for the full set of risks and uncertainties that play a role in monetary policy decisions. They also do not capture all the variables and interactions that could affect macroeconomic outcomes. Therefore, to better understand these results in the context of a more fully developed framework, we also use the Federal Reserve Board's FRB/US model to simulate the impact of the different central bank strategies analyzed above. More specifically, we simulate how the timing of the first rate hike and subsequent aggressiveness of rate hikes affect inflation, output, and the price level, as well as the Sacrifice Ratio and the share of the adjustment through prices relative to output losses. The results from these illustrative simulations largely support the key findings of our regressions on how different central bank strategies affect macroeconomic variables and the corresponding tradeoffs.

Section VI concludes with several broad lessons from placing the post-pandemic tightening in a historical context. Central banks cannot avoid painful adjustments in response to certain types of shocks. Monetary policy decisions often involve weighing difficult tradeoffs between activity and inflation, and how to assess and balance these tradeoffs will depend on the specific situation and priorities of the central bank. Our analysis of the cross-country and historical evidence, however, suggests that central banks should also consider the price level when weighing these tradeoffs. The results also provide insights on which strategies can mitigate adjustment costs and thereby lead to more favorable tradeoffs during tightening phases in the future.

II. Defining Rate Cycles: Methodology, Data and Dates

This section adapts the methodology used in the extensive business cycle literature to identify cycles in policy interest rates. We also incorporate information on central banks' balance sheet programs involving large-scale asset purchases (QE, quantitative easing) and subsequent asset sales (QT, quantitative tightening). This section begins by introducing the methodology and then describes the data used to identify the rate cycles. It concludes with the resulting dates for easing and tightening phases used in the remainder of the paper.

II.1. Dating Methodology

Our goal is to identify the turning points of rate cycles using a methodology that links to the long-standing literature on business cycles and can be applied consistently over a long period and across countries. Because of the substantial volatility in interest rates early in our sample period and differences in monetary policy frameworks across countries and time, we cannot use an off-the-shelf approach, rely on country-specific analyses, or employ simple rules of thumb as sometimes done for business cycles (such as the two quarters of negative GDP growth popularly used as a shorthand to identify recessions).

Instead, we modify the BBQ algorithm proposed by Bry and Boschan (1971) and then developed in Harding and Pagan (2002).[8] This algorithm evaluates increases and decreases in a series to locate local maxima and minima over specified windows. If an adjacent local peak and trough of policy interest rates meets the censoring criteria set in the algorithm, they define the start of the two phases (easing and tightening) that together constitute a cycle. More specifically, the algorithm identifies a local maxima in the monthly series for interest rates i_t at time *t* if the interest rate increases and does not immediately fall back per the following criteria:

$$\{[(i_t - i_{t-2}) > 0, (i_t - i_{t-1}) > 0] \; and \; [(i_{t+2} - i_t) < 0, (i_{t+1} - i_t) < 0]\}. \qquad (1)$$

Similarly, a local minima occurs in month *t* if:

$$\{[(i_t - i_{t-2}) < 0, (i_t - i_{t-1}) < 0] \; and \; [(i_{t+2} - i_t) > 0, (i_{t+1} - i_t) > 0]\}. \qquad (2)$$

A local maxima is the peak of the interest rate series and can be the start of an easing phase (if it meets the requirements above), while a local minima is the trough of the interest rate series and can be the start of a tightening phase. A full “rate cycle” comprises an easing and a tightening phase, just as a business cycle comprises an expansion and contraction phase. For these local maxima and minima to qualify as the start of an easing or tightening phase, respectively, we set three parameters: (i) a window of at least 18 months on each side of a local maxima and minima; (ii) a window of at least 36 months for a full cycle (including both tightening and easing phases); and (iii) a window of at least 7 months for any individual phase of a cycle (either a tightening or easing phase).

The first two criteria require relatively long windows on each side of a turning point and for the full cycle in order to capture changes in interest rates that are not reversed soon afterward; this allows us to identify and study periods of “premature adjustment”, i.e., when a central bank shifts from raising to lowering interest rates (or vice versa) and then needs to reverse course.[9] These longer windows also avoid classifying changes in interest rates that largely reflect market-driven movements as turning points, an issue earlier in the sample when interest rate data is more volatile and policy rates may not be directly set by central banks. In contrast, the third criterion allows for individual phases in a cycle to be short-lived; brief periods of rate hikes or cuts can potentially qualify as an easing or tightening phase—albeit within the longer parameters for a full cycle. This is

[8] The BBQ algorithm was first proposed by Bry and Boschan (1971), building on the work of Burns and Mitchell (1946) that lays the foundation for identifying US business cycles. See Claessens, Kose, and Terrones (2009, 2012) for details and applications identifying business and financial cycles.
[9] See Forbes, Ha and Kose (2024) for the identification of and analysis of “premature adjustments”.

useful in several cases when a central bank adjusts rates quickly by a large amount and then does not adjust rates again (such as lowering rates to zero in one meeting).

After applying this algorithm, we make several adjustments to the dates identified in order for a month t to qualify as a turning point. These adjustments are mainly to address issues when interest rates are constant for an extended period around the lower bound. First, a month can qualify as the start of an easing (tightening) phase if there is no change in the policy rate but the central bank starts a new QE (QT) program (defined below). Second, if there is not a new balance sheet program, there must be an increase (decrease) in the policy interest rate to qualify as the start of a tightening (easing) phase. Third, any such increase (decrease) in the policy rate must be meaningful and lasting, defined as $|\Delta i_t| \geq 0.50$pp over one month, or at least two rate changes (of any size) occurring over a year, such that the policy rate is at least 30 basis points higher/lower one year after the first rate change.

Finally, if a central bank is in a tightening (easing) phase at the start of 2024, but shifts to easing (tightening) the policy rate in 2024, we classify this change as a turning point indicating the start of the next phase (as long as the rate change was not subsequently reversed). This is required as not enough time has passed for some of these shifts in monetary policy to be identified as turning points according to the mechanical application of the Harding and Pagan (2002) algorithm.[10] Appendix 1 provides more information on the details of the criteria used to identify the cycle dates, the application of each of the additional criteria, and the specific countries and dates affected by each of these criteria.

II. 2. Data: Policy Rates and Balance Sheet Programs

To define rate cycles, we focus on the policy interest rate for several reasons. First, policy interest rates are currently the primary tool used by central banks to affect the monetary policy stance and using market-determined measures would incorporate fluctuations that are not directly under the control of monetary authorities. Second, data for policy interest rates are widely available over a long period, allowing us to analyze their evolution over the past 55 years (1970-2024) for 24 advanced economies. A long panel is particularly important for our empirical decomposition of the factors driving rate cycles and for the identification of precedents for the ongoing rate cycle.

Finally, we focus on nominal policy rates, instead of attempting to estimate more complex measures of the overall stance of monetary policy.[11] Measuring the overall policy stance would require finding a comparable way to measure the impact of adjusting other policy tools (such as the money supply in certain periods) and modelling variables such as the neutral interest rate (which is subject to substantial measurement error). Both of these tasks are extremely challenging for an individual country, and even more so for a cross-section of diverse economies over a long period when economic and financial structures have shifted and the relationships between variables have changed meaningfully. Measuring variables such as the neutral interest rate is also

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[10] This corresponds to the Bank of Japan being defined as shifting from an easing to tightening phase in March 2024 and the other central banks in the sample shifting from tightening to easing phases during 2024 (with the exceptions of the central banks for Australia and Norway, which had not yet lowered rates).

[11] Papers such as Woodford (2003) use alternate approaches to measure the overall monetary policy stance.

particularly difficult in real-time, especially today—which would limit our ability to analyze the current situation and compare it to historical precedents.[12]

While there are multiple reasons to focus on policy interest rates as our main guide to identify cycles in monetary policy, they have several limitations. First, although policy interest rates are currently the key tool for adjusting monetary policy, there are periods when other instruments have also been important (including for different goals)—such as adjusting reserve requirements, the money supply, and the size and composition of the central bank's balance sheet. Given our focus on monetary policy today, we incorporate information on the adoption of new QE and QT programs in our measure of rate cycles. Second, as discussed above, this may not fully capture the overall restrictiveness of monetary policy, especially during periods of high inflation and/or structural change that affects the neutral rate. Similarly, this approach does not capture changes in the restrictiveness of monetary policy from changes in guidance or the market curve, which may precede changes in the policy interest rate. Finally, we do not take into account changes in monetary policy goals, frameworks and targets that occurred over the sample period (such as whether a central bank targets inflation, employment, the money supply, or the exchange rate), although we discuss the likely impact of some of these changes on rate cycles over time.[13]

Our sample includes 24 advanced economies. We select these economies based on several criteria: (i) they are defined as advanced economies in the World Bank's *Global Economic Prospects* report, January 2024 (World Bank 2024); (ii) they are independent countries with GDP of at least $100bn in 2023; (iii) they have data for GDP, inflation and interest rates from at least 1980; and (iv) they have not primarily set interest rates in order to target the exchange rate since 1999.[14] Depending on the analysis, we include individual countries that are currently in the euro area, or consider the euro area as a separate economic entity.

We collect monthly data on the nominal interest rate defined as the policy rate by the central bank from January 1970 through December 2024.[15] Our main source is the BIS, but when data are unavailable or there are gaps, we augment this with information from Haver Analytics, FRED and the OECD. For members of the euro area, we use the policy rate for individual member countries through the end of 1998 and then use the European Central Bank's (ECB's) policy rate starting in January 1999. Also, in many economies the policy rate was substantially more volatile in earlier periods when it was not the central bank's operating target (e.g., in the 1970s and 1980s some central banks allowed their policy rates to adjust frequently as they aimed to meet operating targets for the money supply). This volatility is an important consideration in choosing the appropriate criterion for the identification of the turning points in rate cycles.

[12] See Kiley (2020) for discussions of the challenges associated with using the neutral interest rate to measure the monetary policy stance.
[13] Countries have adjusted their frameworks and targets meaningfully during the sample, but classifying different regimes is not straightforward, especially as some economies had multiple targets and others had substantial discretion in how they adjusted policy (Bernanke and Mishkin 1992; Ball 2011). Section II.3 discusses how these regime changes can explain some of the differences in rate cycles over time.
[14] We include countries in the ERM in the earlier half of our sample, as well as Switzerland when it had a one-sided band on its exchange rate from 2011-15.
[15] The interest rate that the central bank identifies as the policy rate has changed over time in most countries. For details, see the database "Long Series on Central Bank Policy Rates" compiled by the BIS.

Next, we augment this monthly data on policy interest rates with dummy variables indicating if the country announces a new QE or QT program and when such program ends. Incorporating these programs is important to capture changes in the evolution of monetary policy in several parts of the subsequent analysis, particularly when policy rates in several economies were at the lower bound and central banks relied on asset purchase programs to adjust policy. These dummy variables equal one on the announcement date of a new program (even if the program is not implemented until later) and only include programs involving government bonds (i.e., not programs involving only corporate, territory, municipality or agency bonds). The dummy variables only capture the announcement of a new balance sheet program (and not later adjustments to the speed, size or scope of the program). These QE and QT dummies only include programs related to monetary policy, i.e., not programs primarily aimed at providing liquidity or addressing market dysfunction.[16]

II.3. The Dates of the Rate Cycles

Application of our algorithm to the data on nominal policy rates and balance sheet programs yields 223 distinct rate phases (112 of tightening and 111 of easing) from January 1970 through December 2024 for our sample of 24 advanced economies. This includes the phase that each economy is in as of December 2024—even if that phase is not complete. Table 1 lists the identified turning points at the start of tightening and easing phases.

The 24 economies in our sample averaged 5 tightening and 5 easing phases, but some countries have had substantially more rate cycles than others. For example, the United States has had 18 distinct easing and tightening phases, and Canada and Sweden 16, while Ireland and Portugal had only 3 and 4, respectively. The smaller number of cycles for the individual euro area countries, however, reflects their shorter time series—as any cycles after 1998 are included for the euro area and not for the individual countries. Of the countries with data on nominal policy rates from 1970 through the end of the sample, Japan has the fewest turning points, with only 5 tightening and 4 easing phases—half of that for the United States.

To see these cycles in the context of the evolution of the policy rate and any QE or QT announcements for each economy. Figure 1 shows these graphs of policy rates for three major economies: the euro area, Japan, and the United States. Appendix Figures 1a and 1b show the resulting cycles for other economies and the individual euro area countries, respectively. The start of tightening phases is denoted by dashed purple lines and easing phases by dashed red lines. The start of QT and QE programs are in dashed blue and orange lines, respectively.

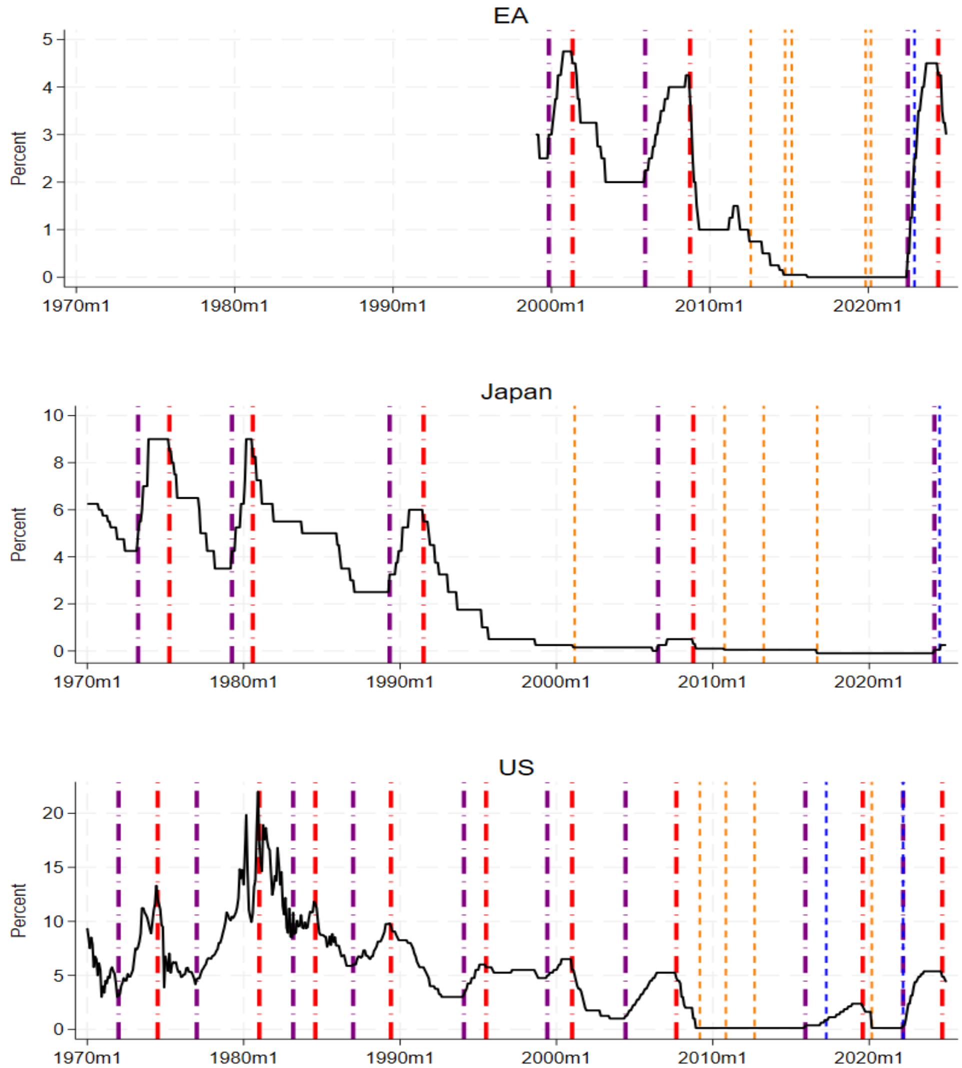
[16] The data used to compile these balance sheet variables are: CGFS (2019) and BIS (2019) for programs before the pandemic, English et al. (2021) and Fratto et al. (2021) for QE programs in response to the pandemic, and Du, Forbes, and Luzzetti (2024) and English et al. (2024) for QT programs since the pandemic.

Table 1: Turning Points—The Start of Monetary Policy Tightening and Easing Phases

	Start of Phase	
	Tightening	Easing
Australia	1973m2	1982m9
	1984m2	1986m1
	1988m2	1989m12
	1994m8	1996m7
	2002m5	2008m9
	2009m10	2011m11
	2022m5	
Canada	1973m4	1976m11
	1978m3	1981m9
	1987m4	1990m6
	1997m6	2001m1
	2004m9	2007m12
	2010m6	2015m1
	2017m7	2020m3
	2022m3	2024m6
Denmark	1973m7	1977m1
	1979m6	1980m9
	1990m3	1992m12
	1999m11	2000m10
	2005m12	2008m11
	2022m7	2024m6
Israel	1993m11	1996m8
	2002m2	2002m12
	2005m9	2006m10
	2009m8	2011m10
	2022m4	2024m1
Japan	1973m4	1975m4
	1979m4	1980m8
	1989m5	1991m7
	2006m7	2008m10
	2024m3	
Korea		1993m5
	1997m12	2001m2
	2005m10	2008m10
	2010m7	2012m7
	2021m8	2024m10
New Zealand	1976m2	1985m4
	1994m1	1998m4
	1999m2	2003m1
	2004m1	2008m7
	2021m10	2024m8
Norway		1982m6
	1986m1	1987m1
	1997m7	1999m1
	2005m7	2008m10
	2009m10	2011m12
	2021m9	
Sweden	1974m4	1978m2
	1979m7	1981m10
	1987m1	1992m11
	1999m11	2002m11
	2006m1	2008m10
	2010m7	2011m12
	2019m1	2020m6
	2022m4	2024m5
Switzerland	1973m1	1975m3
	1979m11	1982m8
	1988m8	1992m9
	2000m1	2001m3
	2004m6	2008m10
	2022m6	2024m3
United Kingdom	1972m6	1976m11
	1977m11	1980m7
	1984m5	1985m3
	1988m6	1990m10
	1994m9	1998m10
	2003m11	2007m12
	2021m12	2024m8
United States	1972m1	1974m7
	1977m1	1981m1
	1983m3	1984m8
	1987m1	1989m6
	1994m2	1995m7
	1999m6	2001m1
	2004m6	2007m9
	2015m12	2019m8
	2022m3	2024m9
EURO AREA	**Tightening**	**Easing**
Euro area	1999m11	2001m5
	2005m12	2008m10
	2022m7	2024m6
Austria		1975m4
	1980m1	1982m9
	1988m7	1992m9
Belgium	1972m11	1981m4
	1983m11	1985m5
	1988m7	1993m9
Finland	1972m11	1974m7
	1976m1	1981m10
	1988m8	1990m1
France	1972m11	1974m7
	1976m1	1981m10
	1988m8	1990m4
Germany	1972m10	1974m10
	1979m1	1980m9
	1983m9	1985m4
	1988m6	1992m9
	1997m10	
Greece		1982m10
	1984m2	1986m7
	1987m10	1994m7
	1997m6	
Ireland		1986m3
	1988m6	1992m12
Italy	1973m9	1977m6
	1979m10	1982m8
	1987m8	1990m5
	1994m8	1996m7
Netherlands	1972m11	1974m10
	1977m11	1980m6
	1983m5	1985m8
	1988m7	1992m9
	1997m3	
Portugal	1977m3	1985m8
	1989m3	1993m5
Spain	1973m7	1983m9
	1988m9	1991m2
	1995m1	1995m12

Sources: Authors' calculations, based on the identification of rate cycles described in Section II, with data from January 1970 through December 2024. **Notes**: Phases for individual countries in the euro area and the euro area as a whole are in the column on the right. Members of the euro area have national cycles through 1998, after which they are reported for the euro area as one entity.

Figure 1: Rate Cycles in the Euro area (EA), Japan, and the United States (US)



Sources: Authors' calculations based on the data and methodology identifying rate cycles described in Section II, with data from January 1970 through December 2024. **Notes:** The solid black line is the policy interest rate. Dashed purple and red lines indicate the start of tightening and easing phases, respectively. Dashed blue and orange lines represent the announcement of new QT and QE programs, respectively for major new programs involving government bonds and aimed at providing monetary stimulus. These QE/QT dates are not turning points that denote the start of an easing or tightening phase unless there is also a red or purple line.

A closer look at the turning points for these three major economies in Figure 1 is useful to better understand how these rate cycles are defined. For example, consider the euro area after the ECB started setting policy rates in January 1999. This methodology identifies: a tightening phase starting in November 1999; followed by an easing phase from May 2001; then another tightening phase starting in December 2005; and an easing phase starting in October 2008 (during the Global Financial Crisis), which subsequently involved several rounds of asset purchases. This later easing phase ended in July 2022, when policy rates began to rise sharply, before the current easing phase began in June 2024. The period in 2011 when the ECB raised interest rates twice by 25bps does not count as the start of a tightening phase, as the ECB unwound these rate hikes within a year, followed by further rate cuts and asset purchase programs.[17] In March 2020 when the ECB announced a new asset purchase program, but did not reduce interest rates, this would have qualified as the start of an easing phase if the ECB was not already in an easing phase.

A useful contrast to these patterns for the ECB is the turning points for Japan (middle of Figure 1). Japan has very few full rate cycles (only four), with policy interest rates hugging zero from the mid-1990s and extended periods when asset purchase programs are the primary tool for monetary policy. Also, in contrast to the above example for the ECB in 2011, Japan's increase in interest rates in July 2006 is identified as the start of a tightening phase—even though (as with the ECB) the Bank of Japan (BoJ) raised rates only twice in 25 bps increments and these hikes were later reversed. This qualifies as a turning point for Japan because the interest rate increases were sustained for over a year; the subsequent easing phase did not begin until over two years after the initial rate hike.

The cycle dates for the US are also a useful contrast to those for the euro area and Japan. The more frequent turning points in the United States, and corresponding larger number of easing and tightening phases, are more typical of other countries in the sample. The dates of the turning points for the US correspond to well-known shifts in monetary policy, as well as to the obvious peaks and troughs in the policy rate data. This is noteworthy given the greater volatility of policy rates earlier in the sample when the Federal Reserve relied on different tools and monetary frameworks (e.g., including more focus on the control of monetary aggregates). Despite these changes in how monetary policy is conducted, the dating algorithm and the additional criteria discussed above (and in Appendix 1) appear to have been successful in identifying the major turning points in policy interest rates that generally correspond to shifts in monetary policy.

While these differences in rate cycles across the euro area, Japan, and the United States are useful to understand the dating algorithm, there are also several fairly consistent patterns across most economies. Policy interest rates tend to be higher and substantially more volatile in the first half of the sample—reflecting higher neutral rates and inflation combined with monetary policy regimes that generally focused less on the level of the policy rate and more on other variables (such as the money supply). In the latter half of the sample, interest rates tend to be lower and much more stable (often flat around the lower bound in the 2010s), with a corresponding shift to more frequent use of balance sheet policy. There are also substantially fewer turning points after 2010, with several countries in a single, lengthy easing phase from around 2008 through 2021/2022. When most countries shifted to a tightening phase after the pandemic, many combined sharp increases in interest rates with the start of QT.

III. Rate Cycles, Activity and Inflation

This section analyzes key characteristics of these rate cycles across economies and over time. It begins by calculating a series of statistics for each economy across all the tightening and easing phases from 1970 through 2024 identified in Section II, and then evaluates how these

[17] Specifically, the ECB increased rates by 25bps in April 2011 and July 2011, and then lowered them by 25bps in November and December 2011, such that the policy rate in January 2012 was the same as in March 2011. Forbes, Ha, and Kose (2024) defines this as a "preliminary adjustment" in an analysis of why some attempts to transition to a new phase are subsequently unwound.

characteristics have changed across shorter windows. The second half of the section evaluates how macroeconomic variables capturing activity, the labor market, and inflation evolve over rate cycles, once again starting with statistics across the full sample period and then examining changes over subperiods. Throughout this section, we evaluate how the tightening episode that began after the COVID-19 pandemic compares to historical episodes. This set of statistics characterizing rate cycles is central to the analysis in Section V (which assesses the tradeoffs for monetary policy), as it provides more detailed information than previously available on the cross-country and time-series variation in central bank strategies during easing and tightening phases.

III.1. Rate Cycles

We begin by computing a set of descriptive statistics on rate cycles inspired by the extensive literature analyzing business cycles, but adjusted in some cases to better apply to the tightening and easing phases for monetary policy. We focus on six statistics:

- *Duration*: The length of the phase (in months), defined from the turning point marking the start of one phase to the turning point marking the start of the subsequent phase, and including any periods when rates are constant at the end of the phase.
- *Amplitude*: The total change in the policy interest rate (in pp) over the entire phase.
- *Number of in-sync rate changes*: The number of times the policy rate is adjusted by more than 0.1 pp in-sync with the phase (i.e., the number of rate increases >0.1 pp during a tightening phase and the number of rate decreases <-0.1pp during an easing phase).[18]
- *Pace*: The average size of policy rate adjustments in-sync with the phase (as described above); this does not include months with no change in rates.
- *Initial Velocity*: The total change in the policy rate (in pp) over the first six months of the phase.
- *Hold Duration*: the number of months when policy is "on hold" at the end of a phase, defined as (i) after the last increase in the policy rate during a tightening phase, or (ii) after the last decrease in the policy rate and after any QE program has ended during an easing phase.[19]

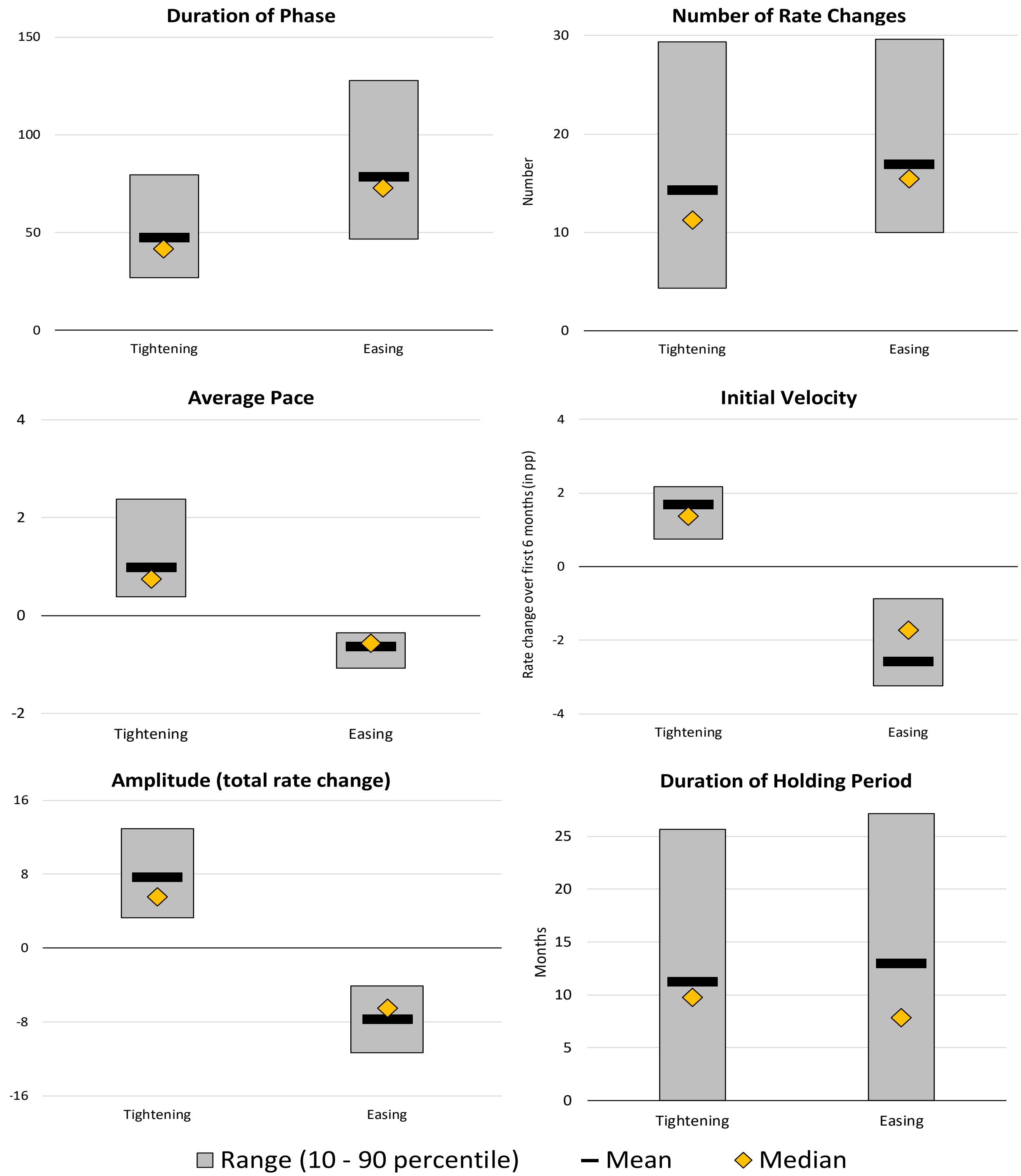
III.1.1. Rate Cycles: 1970–2024

We calculate each of these statistics using monthly data from January 1970 through December 2024 for the tightening and easing phases defined in Section II. Figure 2 summarizes the results and shows large ranges for many of the variables, including substantial skews in some cases (such as for the duration of holding periods during easing phases). Despite these asymmetries, however, the means are close to the medians for most statistics (although the means are usually slightly greater in absolute value), suggesting the skews represent a few outliers and thin tails.

[18] We use the threshold of 0.1pp so that minor movements in market-determined rates are not counted as rate increases or decreases.

[19] We continue to define a change in the policy interest rate as greater than or equal to 0.1pp. We also consider policy "on hold" even if the central bank is continuing QT as this is not the active tool of monetary policy. We have also computed the number of months that policy is "on hold" relative to the total duration of the relevant phase. Results are not reported as they are similar to those for the *Hold Duration*.

Figure 2: Characteristics of Rate Cycles: 1970–2024



Sources: Authors' calculations based on the rate cycles defined in Section II, with data from January 1970 through December 2024.
Notes: Figure shows sample statistics across all tightening or easing phases. The number and pace of rate adjustments only includes "in-sync" rate adjustments, i.e., the rate increases for tightening phases and decreases for easing phases. Initial velocity and amplitude are the total changes in rates (in any direction) over the first six months of the phase or the entire phase, respectively. The duration of the holding period is the number of months after the last rate increase during a tightening phase or the last rate decrease and end of any government QE during an easing phase. Members of the euro area are included as individual countries through 1998, and then the euro area is included as a single entity from 1999.

For a better understanding of the differences across economies, especially given the large variation in each variable, Appendix Table 1 reports the corresponding statistics for the full sample as well as for individual economies.[20] Several patterns are noteworthy. Tightening phases last an average of 47 months, much shorter than the average 79 months of easing phases. During tightening phases policy rates are also adjusted less often and initially more gradually (lower velocity) but are changed by larger increments on average (pace). These differences in the duration, initial velocity, number and pace of rate changes over the phases largely balance out over the full cycle, however, in the sense that the mean amplitude of rate changes is identical across the two phases.

A closer look at the statistics other than the means and medians, as well as individual economy information in Appendix Table 1, provides additional insights on these patterns. Although the durations of the shortest tightening and easing phase are similar (at 24 and 26 months, respectively), the longest easing phase (at 154 months for Japan) is much longer than the longest tightening phase (at 98 months for Spain). There is also substantial heterogeneity across the sample by some measures. For example, in some countries the pace of rate adjustments is substantially greater—whether measured by amplitude, velocity, or the average size of rate changes—although this often reflects a larger share of the respective sample occurring during earlier periods when inflation (and corresponding nominal policy interest rates) was higher.

Some of these differences across easing and tightening phases and across economies can be explained by different shocks triggering the start of certain phases, as well as constraints around the lower bound. Specifically, some easing phases (such as around the 2008 Global Financial Crisis and 2020 COVID-19 pandemic) were triggered by severe shocks that quickly affected many economies, causing central banks to lower interest rates aggressively and contributing to the higher initial velocity of rate adjustments during easing phases.[21] These aggressive rate adjustments during easing phases, however, may not necessarily correspond to similar velocity and pace for tightening phases, as recoveries tend to occur more gradually. The longer average duration of easing phases, however, particularly for some countries with rates around zero, may also partly reflect a limited ability to provide monetary stimulus around the lower bound.

III.1.2. Rate Cycles Over Time

To analyze how rate cycles have changed over time, we calculate the same statistics as above for five sub-periods:

- *1970-84*: the first half of the "pre-ECB" period, including the global recessions of 1975 and 1982, and the first and second oil price shocks of the 1970s.

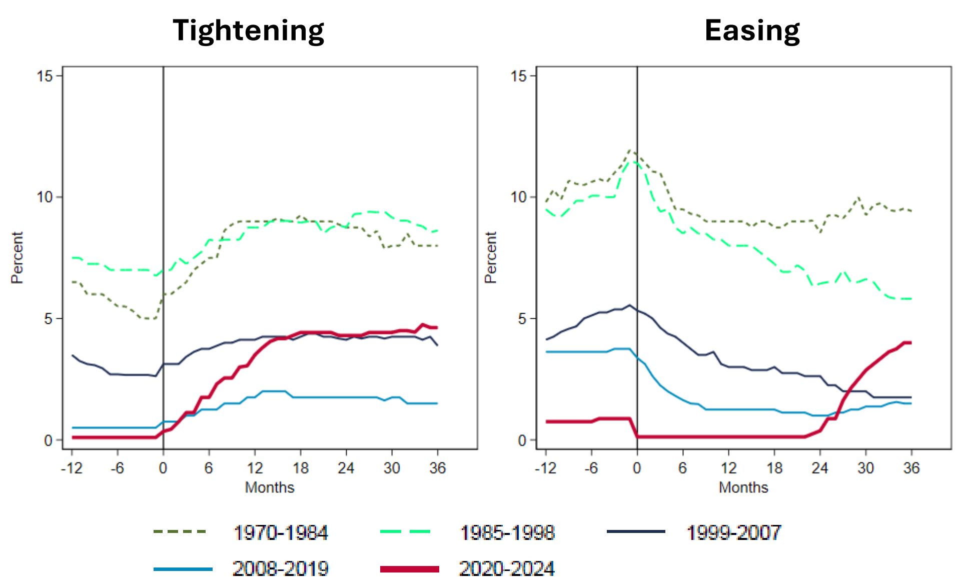
[20] Summary statistics are calculated by first averaging across all relevant phases for each economy, and then calculating the sample statistic (e.g., median) across all the economies with data in the relevant period. This approach gives equal weight to each economy—instead of each easing or tightening phase. This implies that an economy (such as Japan) with a smaller number of long cycles receives more weight than if simply calculating sample statistics across all phases (and not by economy first).

[21] See Forbes, Ha and Kose (2025) for an analysis of the synchronization of rate cycles across economies and detailed analysis of the role of global shocks in explaining rate cycles over time.

- *1985-98*: the latter half of the "pre-ECB" period, including the 1991 global recession, the global downturn in 1997-98 associated with the Asian and Russian financial crises, and a series of debt defaults and emerging market crises.
- *1999-2007*: the start of the ECB setting rates for the euro area, the bursting of the tech bubble, the 2001 global downturn, and the lead up to the 2008 Global Financial Crisis.
- *2008-19*: the Global Financial Crisis and the 2009 global recession, the 2012 global downturn associated with the euro area debt crisis, but ending before the COVID-19 pandemic.
- *2020-24*: the 2020 global recession associated with the COVID-19 pandemic, the post-pandemic spike in inflation, and the Russian invasion of Ukraine in 2022.

Each of these sub-periods includes some type of recession/crisis and recovery period, with the dividing lines between them marking major global events that might have changed the nature of monetary policy cycles. The first two periods (from 1970-1998) also include individual cycles for countries that are currently members of the euro area, but then the later periods (from 1999) include one euro area cycle as the ECB began setting monetary policy for the group. The periods before 1999 are also when central banks used a wider range of monetary policy tools, frameworks, and strategies than in the subsequent periods—with some central banks putting more weight on monetary targets (and interest rates determined partly by markets as well as central bank operations). Over the 1990s and 2000s, however, most central banks transitioned to some form of inflation targeting, albeit this also involved its own evolution of tools and frameworks (such as the greater use of balance sheet policies and forward guidance).

Figure 3: Policy Interest Rates over Tightening and Easing Phases during Different Sub-periods



Sources: Authors' calculations using the turning points for rate cycles listed in Table 1. Data from January 1970 through December 2024.
Notes: Figure shows policy interest rates around the turning points of rate cycles during different sub-periods, with t=0 the start of each phase. Lines are the medians for all phases for which data on the policy rate is available for at least 6 months prior to *t*=0. Phases are defined based on individual euro area countries through 1998, and then for the ECB cycle starting in 1999.

Figure 3 shows median policy interest rates over tightening and easing phases for each of the five periods listed above. It highlights the higher level of policy rates during the pre-1998 cycles, and unusually low level of rates during the 2008-19 cycles. What is most striking, however, are the patterns around the 2020 cycles (in red); rates started the post-pandemic tightening phase at the low levels of the 2008-19 period, but were raised aggressively to reach levels typical of the 1999-2007 tightening phases in about a year. The increases in interest rates during the 2020 easing phase were also unusual—with rates increasing quickly from two years after the start of the easing phase, a much faster shift to tightening than occurred during any of the other windows.

Figure 4 presents median statistics characterizing these rate cycles for the five periods, with the corresponding data in Appendix Table 2. Across tightening phases, there is a striking moderation from the earliest period until the period before the pandemic. Tightening phases had become shorter, involved a slower pace of rate increases, and slower initial velocity. Not surprisingly, this all contributed to a sharp fall in the amplitude of tightening phases over time—with the total change in rates falling by about 80% from 10.3pp in the 1970-84 tightening phases to 2.2pp over 2008-19. Granted, some of this "dampening" reflects lower levels of inflation that reduced the nominal statistics, but these patterns also hold for the duration of tightening phases. Moreover, this moderation did not happen in any one period, but for each of these statistics over each subsequent period. These results are consistent with arguments that more strongly anchored inflation expectations have allowed central banks to stabilize inflation with smaller increases in policy rates (Forbes 2019; Ha, Kose, and Ohnsorge 2019) and lower Sacrifice Ratios (as analysed below).

Equally striking, the post-pandemic tightening breaks this pattern of more moderate cycles over time; it is more aggressive by most measures than tightening phases since 1999.[22] More specifically, in the post-pandemic tightening phase, the sample medians indicate larger rate hikes, a much faster velocity of initial rate hikes, and a larger amplitude in terms of the total increase in interest rates (all relative to the preceding tightening phases over 1999-2007 and 2008-19). For some statistics the most recent tightening phase is closest to the 1985-98 windows. Also striking, rates are on hold at the end of the post-pandemic tightening for longer than any historical period.

In contrast to these patterns for tightening phases, easing phases show less consistent evidence of moderating over time, and less of a break in the characteristics for the most recent cycle.[23] The median duration of easing phases has more than doubled, from 47 months (over 1970-84) to 126 months (over 2008-19). Changes in the patterns of rate adjustments during easing phases also reflect constraints in central banks' ability to lower rates further due to the lower bound—which limits the number of rate reductions, pace, velocity, and amplitude of the phase, potentially leading to longer easing phases as the ability to provide stimulus is more limited.

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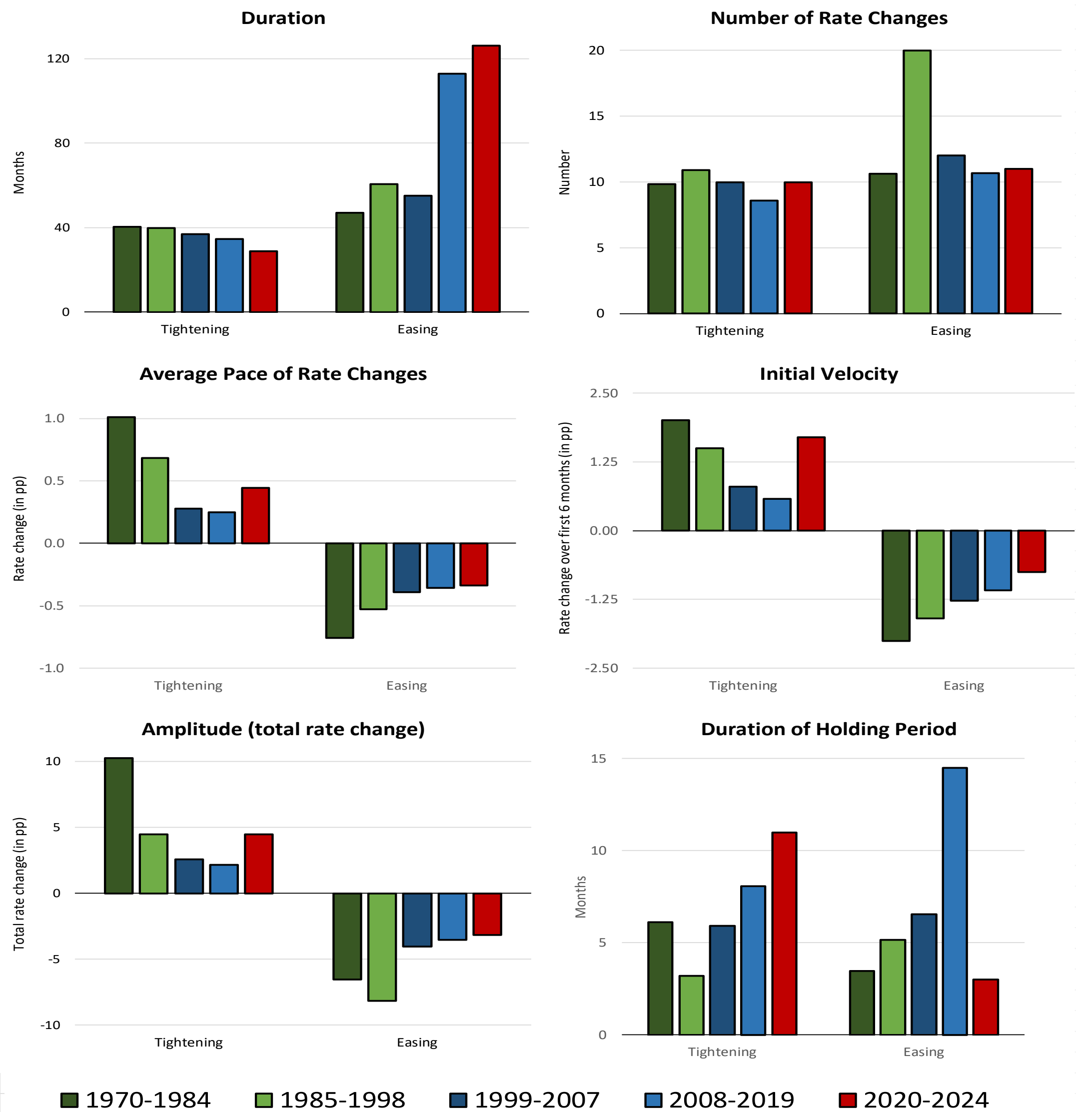
[22] This pattern of tightening phases becoming more moderate over time, and then more aggressive after the pandemic, also applies when assessing each of these statistics based on real policy interest rates (nominal rates divided by CPI inflation) instead of nominal rates. It would also be useful to compare these patterns for a measure of the restrictiveness of monetary policy, i.e., r*, but this is challenging to measure across economies over the long period for this analysis.

[23] It is worth noting that the statistics for the pandemic-related easing over 2020-24 also include the long easing phases that began before 2020 for some economies.

Figure 4: Characteristics of Rate Cycles over Different Sub-periods



Sources: Authors' calculations based on the rate cycles defined in Section II, with data from January 1970 through December 2024.
Notes: Figure shows characteristics of tightening and easing phases within the given time period in 24 advanced economies. The number and pace of rate adjustments only include "in-sync" rate adjustments, i.e., the rate increases for tightening phases and decreases for easing phases. Velocity and amplitude are the total change in rates (in any direction) over the first six months of the phase or the entire phase, respectively. Members of the euro area are included as individual countries through 1998, and then the euro area is included from 1999.

Noteworthy, however, is the abbreviated holding period after the pandemic-related easing—with a median of only 3 months. This was the fastest pivot from actively easing policy to tightening policy of any historical period—and particularly striking when compared to medians for the previous period (over 2008-19). In most cases, a period of actively easing or tightening policy is followed by a period with policy on hold to let the lags from the policy changes take effect. In contrast, central banks shifted to tightening after the pandemic even before the full impact of previous easing would have filtered through the economy.

These patterns on how rate cycles—and particularly tightening phases—have changed over time are consistent with results in the business cycle literature (Ha, Kose, and Ohnsorge 2019) and will form the basis of the discussion of tradeoffs below.

III.2. Activity and Inflation over Rate Cycles

This section examines how the economy typically evolves during rate cycles, analyzing tightening phases as they are the focus of the analysis in the rest of this paper.[24] It follows the standard approach in the business cycle literature of evaluating the evolution of key macroeconomic variables around the cycle's turning points, continuing to use the turning points defined in Section II and listed in Table 1.

In order to assess how the economy evolves in response to increases in policy rates, we study the evolution of six macroeconomic variables that are central to the analysis of monetary policy and which have decent country coverage for the long period on which we focus: GDP growth, industrial production growth, employment growth, changes in the unemployment rate, headline CPI inflation, and core CPI inflation. The first two variables focus on real economic activity, the middle two on the labour market (which we often refer to as activity for simplicity), and the final two on changes in prices. Each variable is measured relative to a year earlier (to eliminate seasonality), with details on sources and definitions in Appendix Table 3A.[25] We focus on the evolution of each of these variables from one year before the turning point of the rate cycle through three years after, with the start of each tightening phase denoted as t=0. For countries in the euro area, we include each member country individually throughout the full sample period (even for any phases beginning after1998 when the ECB began setting monetary policy for the group).[26]

III.2.1. Activity and Inflation over Rate Cycles: 1970–2024

Figure 5 shows the evolution of these macroeconomic variables during tightening phases. The graphs include the mean, median and quartile distribution for the country-phases identified over the full period from January 1970 through December 2024 (or the latest available for most countries). The patterns for economic activity and the labour market closely mirror results from the business cycle literature. Activity is accelerating and the labour market tightening (based on unemployment falling or employment increasing) before the start of tightening phases. After interest rates begin rising, activity and the labour market continue to have positive momentum for roughly 6 months, but then activity begins to slow and the labour market softens, presumably reflecting in part the lagged effects of tightening monetary policy.

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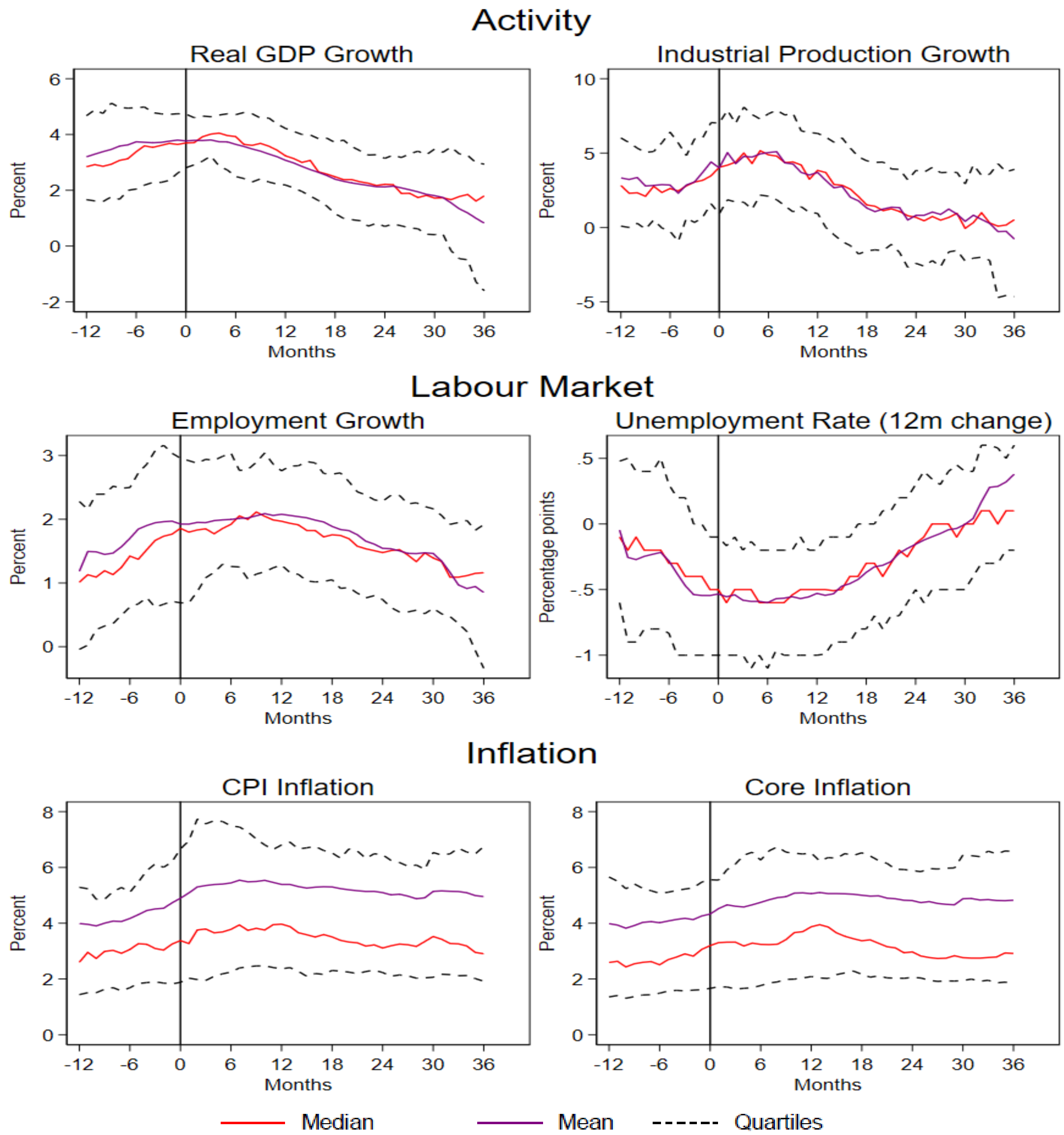
[24] Comparable statistics for easing phases are available in Forbes, Ha and Kose (2024).

[25] All variables are measured as the percent change relative to a year earlier, except the unemployment rate, which is measured as the change. Macroeconomic data was collected on February 1, 2025, and covers the period from January 1970 through late 2024 for most countries. Data for some variables is more limited early in the sample. We only include economies if the relevant data is available for at least six months before t=0.

[26] We have also repeated the analysis with the euro area as one economy starting in 1999 (and excluded individual member countries), with only modest changes in some of the graphs and no impact on the key results discussed below.

Figure 5: Macroeconomic Variables over Tightening Phases



Sources: Authors' calculations using the turning points for rate cycles listed in Table 1. **Notes:** Figures show the evolution of macroeconomic variables around the turning points of interest rate cycles, with *t*=0 the start of the tightening phase. All variables are calculated as % change relative to 12 months earlier, except for the unemployment rate, which is the change relative to 12 months earlier. All statistics calculated across all tightening phases for which the macroeconomic variable is available for at least 6 months prior to *t*=0. Phases include individual euro area countries throughout the sample plus an aggregate euro area economy starting in 1999.

These results are broadly consistent with the forward-looking and counter-cyclical nature of monetary policy, as well as with estimates of the length of transmission lags.[27] The means and medians follow very similar patterns—suggesting any skews in the distribution are roughly balanced between positive and negative outcomes.

[27] See Clarida, Gali, and Gertler (1999), Lane (2022), and Woodford (2003), among many others, for a discussion of these topics. Based on a meta-analysis of 67 studies, Havranek and Rusnak (2013) reports that the average transmission lag of monetary policy to inflation is 29 months (ranging from 18 to 49 months).

The evolution of inflation (both headline and core), however, displays notably different patterns. The pickup in inflation before the start of tightening phases is more muted than occurs for the other macroeconomic variables, and after interest rates are initially increased, mean inflation continues to pick up and only declines very gradually; median inflation barely moves. This weak relationship between starting a tightening phase and inflation is consistent with the "price puzzle" in the monetary VAR literature, as well as with forward-looking monetary policy that targets inflation.[28]

These findings are also consistent with a flat Phillips curve, or a non-linear Phillips curve with the median cycle on the flat section of the curve. For example, when activity is weak and interest rates are low (as typically occur at the start of tightening phases), changes in activity and interest rates may have minimal impact on inflation, but when there is less slack in the economy, changes in activity and interest rates would have a greater impact.[29]

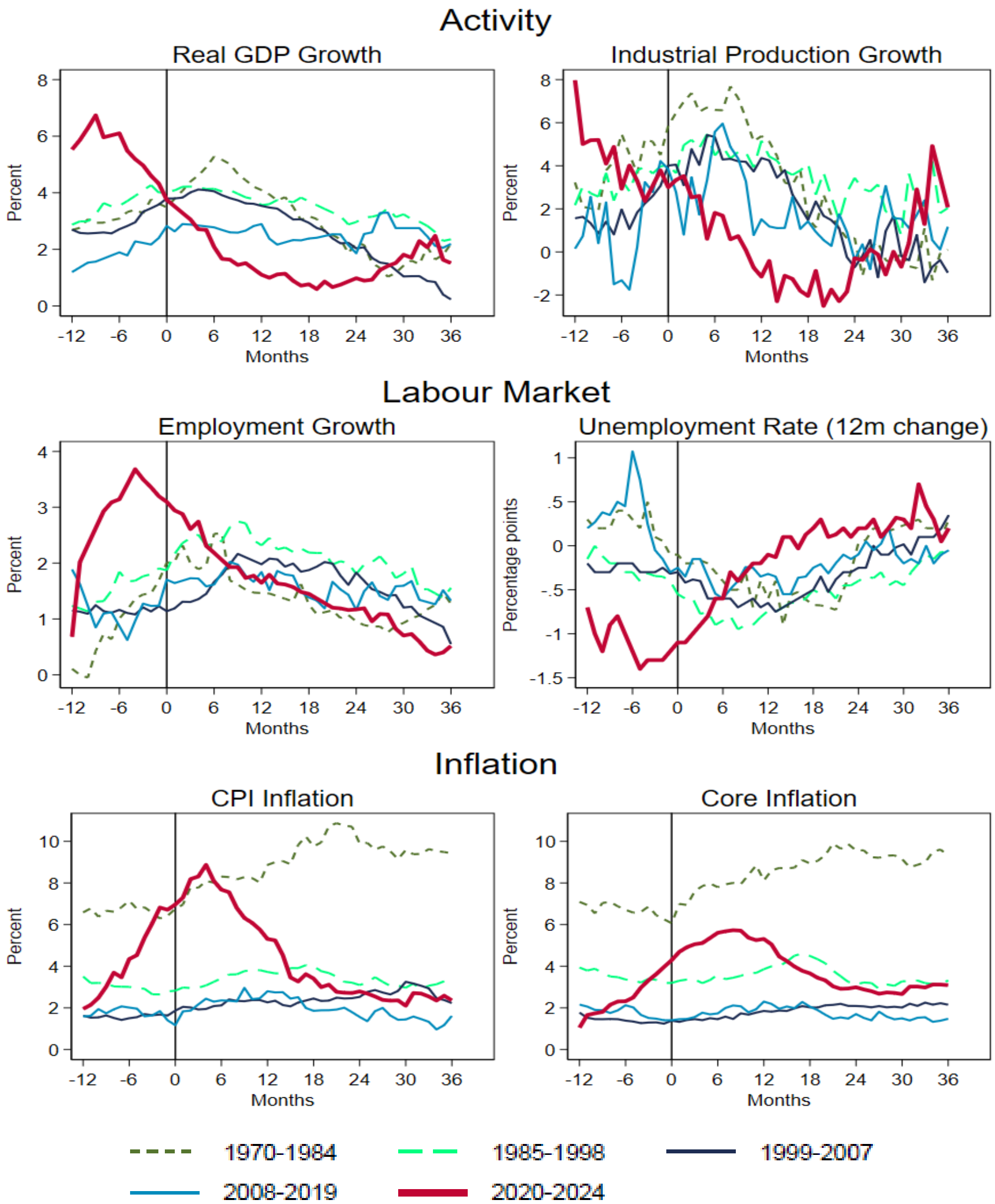
Also, for both headline and core CPI inflation, the mean is substantially higher than the median, indicating an asymmetric skew in the distribution. The dashed lines showing the distribution of inflation outcomes also reflect this skew—with much higher inflation in a small number of economies. As discussed below, these phases with higher inflation largely occur early in the sample when inflation was much higher in most economies—as well as during the post-pandemic period. This highlights the importance of understanding how these rate cycles, and their relationships to economic variables, have evolved over time.

III.2.2. Activity and Inflation across Rate Cycles over Time

To assess how the relationships between tightening phases and macroeconomic variables change over time, Figure 6 repeats this analysis for the five sub-periods used in the last section.[30] Beginning with the measures of activity (including the labor market), the graphs show a fairly similar evolution of GDP, industrial production, employment and unemployment during most tightening phases until 2020. In contrast, the strength in activity before rate increases, as well as the deterioration in activity after rate increases, was much more pronounced during the post-pandemic tightening phase (in red). These patterns are consistent with the post-pandemic tightening starting later in the expansion than has historically occurred based on the macroeconomic variables considered here (and which we show more formally in Section V) and then becoming more aggressive in terms of the path of rate hikes—a pattern consistent with the statistics on how cycle characteristics have changed over time (Figure 4).

[28] More specifically, this muted correlation between the turning points in rate cycles and inflation may reflect that monetary policy reacts to, and prevents, future expected inflation deviations, based partly on central banks' information on future inflation developments (Castelnuovo and Surico 2010; Jarocinsky and Karadi 2020; Ha et al. 2025). In order to assess the direct effects of monetary policy, it would be necessary to use a different analytic approach that controls for the reaction functions of central banks.
[29] See Forbes, Gagnon, and Collins (2022) and Benigno and Eggertsson (2023) for evidence of this nonlinearity in the Phillips curve.
[30] We have also repeated the analysis below to adjust for countries at the effective lower bound for policy interest rates, with no meaningful impact on the results.

Figure 6: Macroeconomic Variables over Tightening Phases during Different Subperiods



Sources: Authors' calculations using the turning points for rate cycles listed in Table 1. **Notes**: See notes to Figure 5.

Three years after the start of the post-pandemic tightening, however, the median measures for activity were comparable to this stage during historical cycles (with IP growth on the stronger end, and employment growth on the softer end—but all near at least one previous cycle). Granted, these graphs only show the medians for the sample and there are important differences for individual economies (and some do not yet have data for the full three years after they started raising interest rates). Overall, however, this implies that even if central banks were slower to start tightening monetary policy after the pandemic given macroeconomic developments (and with the benefit of hindsight), the subsequent aggressive response seems to have caught them up, on average, by these macroeconomic measures for this point in a tightening phase.

The comparable graphs for headline and core CPI inflation during tightening phases (bottom of Figure 6) also suggest that this cycle involved larger movements than have historically occurred, and an unusually slow start to tightening monetary policy, but a recent normalization relative to a comparable stage in historical cycles. Inflation during the post-pandemic period started around the lows typical of historical episodes one year before the start of the tightening phase (excluding the earliest phases when inflation was meaningfully higher), but then picked up much faster than the medians of all earlier tightening phases—such that headline inflation reached the much higher levels typical of the earliest 1970-84 period before central banks began increasing interest rates.

Both measures of inflation have fallen since, such that at the end of the sample, headline inflation is around levels typical at this point in the 1999-2007 tightening phases, although core inflation is still elevated around levels of the 1985-98 phases. Headline inflation peaks at higher levels (as would be expected given the large shocks to food and energy prices), but core inflation was slower to decline (as would be expected given the greater persistence in core inflation). The steep increase and subsequent decline in inflation is a sharp contrast to the flatter inflation paths during earlier episodes, and the most recent data suggests inflation has not fallen back to the low levels typical before the pandemic.

These results are consistent with the previous discussion of the unusual patterns for rate adjustments and holding periods during the pandemic easing and post-pandemic tightening, as well as with new analysis in Stock and Watson (2025) comparing the evolution of a range of macroeconomic variables around the pandemic to prior business cycle recoveries. After easing monetary policy in 2020, unusually rapid recoveries and the sharp acceleration in inflation prompted central banks to transition more quickly than usual from actively easing to tightening policy. Moreover, although the shift from easing to tightening monetary policy occurred later than during historical cycles, the subsequent aggressive path of tightening allowed economies to largely catch up—at least to pre-2008 levels. Noteworthy, however, this "normalization" has occurred with a large increase in the price level (analyzed below) as well as policy rates at much higher levels than since 2008 and closer to levels typical of pre-2008 tightening phases.

IV. Tradeoffs and Sacrifice: Activity, Inflation and the Price Level

This section shifts from analyzing how key macroeconomic variables have evolved over tightening phases to measuring key tradeoffs for central banks over the entire phase. It begins by calculating relevant statistics for inflation, output gaps, and the corresponding Sacrifice Ratio. Then it focuses on a set of statistics that receive less attention—related to changes in the price level—and explains why these measures should be part of the discussion of tradeoffs around tightening phases. Each of these measures can be affected by a range of variables—including the shocks affecting the economy, the structure of each economy (including the slope of the Phillips curve and credibility of the central bank) as well as the endogenous monetary policy response—issues which will be analyzed in the next section.

Throughout these comparisons, the post-pandemic adjustment stands out—with historically low Sacrifice Ratios (on average for the sample) combined with unusually large increases in the price level. The analysis in this section uses the data presented in Section III (with details in Appendix

Table 3) for the period from January 1970 through 2024. We continue to exclude any tightening phases that begin in 2024 (i.e., for Japan) as there has not yet been sufficient time to evaluate the impact on macroeconomic variables.

IV.1. Inflation and Output Gaps

In order to evaluate the tradeoffs facing central banks during tightening phases, we begin by focusing on two macroeconomic variables at the core of monetary policy decisions: inflation and output gaps. For each of the statistics reported below, we begin with the dates for the tightening phases defined in Section II, but also include an additional 12 months after the end of each phase in order to capture any lagged effects of monetary policy (with this extended period referred to as the "tightening window" below).[31] We also calculate each of the statistics reported below for each member of the euro area individually, as well as for the euro area as a whole, in order to be able to understand dynamics and compare tradeoffs across these different entities.[32]

To calculate key statistics for inflation, we use monthly data on the headline or core consumer price index (CPI) for each of the 24 advanced economies in our sample (except for the United States, for which we use the PCE index). We calculate year-over year inflation (π_t) over each month *t* of the window lasting *y* months for the country-phase (*cp*) and then use these statistics to calculate:

Inflation Reduction= $IR_{cp} = \pi_{cp}^{IP} - \pi_{cp}^{IT}$, *(3)*

with *Inflation Peak* = $\pi_{cp}^{IP} = max(\pi_{cp})$,

and *Inflation Trough* = $\pi_{cp}^{IT} = min(\pi_{cp})$ during any month in the window *y* after the π_{cp}^{IP}

The IR_{cp} captures the disinflation that occurs from the inflation peak (π_{cp}^{IP}) to its subsequent trough (π_{cp}^{IT}) over each country-tightening phase (*cp*) and is a key focus of the analysis on tradeoffs below.

Table 2 reports medians for each of these statistics over the five historical windows used throughout the paper. The median disinflation during the post-pandemic window was larger than during any of the historical periods—at 8.5pp for headline and 3.7pp for core inflation. This is noteworthy as peak inflation was meaningfully higher over 1970-84, but did not fall as much, with a trough of only 5.5% for headline inflation over 1970-84 (as compared to 1.5% over 2020-24).[33]

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[31] We focus on a 12-month lag as this is standard in previous work on Sacrifice Ratios (e.g., Ball 1994) and consistent with our analysis in Section III. We also capture longer lags during many cycles when rates are "on hold" before the phase ends. We exclude any lagged effects during the two major global crises in our sample, to avoid interpreting the sharp collapses in activity as resulting from changes in domestic monetary policy. These two exclusion windows are: the Global Financial Crisis (defined as starting in October 2008) and the COVID-19 pandemic (defined as starting in March 2020). Also, we do not include information on phases with less than 6 months of data.

[32] None of the statistics reported below change meaningfully if we exclude the euro area as an individual entity, or if we exclude individual countries and only include the euro area. For the regression analysis below, however, we exclude the euro area as a single entity to avoid double-counting.

[33] The higher trough for inflation during this earlier period reflected a combination of related factors: (1) inflation expectations were not as well anchored; (2) central banks had different monetary policy frameworks that did not involve a 2% inflation target; and (3) in some cases the disinflation process continued over an extended period and is therefore included in subsequent phases.

Table 2: Median Inflation and Disinflation during Tightening Phases

	Headline Inflation			Core Inflation		
	Peak (%)	Trough (%)	Disinflation (pp)	Peak (%)	Trough (%)	Disinflation (pp)
1970-84	13.9	5.5	5.2	12.0	5.6	2.9
1985-98	6.9	2.6	2.3	6.8	3.3	2.2
1999-07	4.0	1.3	1.2	2.9	1.1	0.8
2008-19	3.5	0.6	3.1	2.8	1.1	1.2
2020-24	***9.2***	***1.5***	***8.5***	***6.2***	***2.0***	***3.7***

Notes: Disinflation is calculated from the peak to subsequent trough for each economy, such that the median may not equal the difference between the median peak and trough of the sample. Inflation is calculated based on the CPI and core CPI for each country except the United States, which is based on the PCE (and core PCE) index. Each statistic is calculated over the tightening phases (defined in Section II) plus a 12-month lag.

In addition to closely monitoring inflation, another key set of indicators tracked by central banks is deviations in activity (including the labor market) from "potential". We use several measures of the output gap (OG_t) for each month *t* and then accumulate these measures to calculate the following statistics over each country-phase (*cp*) as defined above (and continuing to include a 12-month lag after the end of each tightening phase):

$$\text{Accumulated Output Gap} = AOG_{cp} = \left(\sum_{t=0}^{y} OG_t\right)/12 \tag{4}$$

$$\text{Accumulated Negative Output Gap} = ANOG_{cp} = \left(\sum_{t=0}^{y} OG_t\right)/12 \quad if\ OG_t < 0. \tag{5}$$

Each measure is divided by 12 so that the accumulated monthly gaps are relative to annual GDP; this makes the measure easier to compare to standard output gap calculations, but smooths sharp but short-lived deviations of output from potential.

Measuring potential output (and the corresponding output gap) is not straightforward, and there are a range of approaches used in the literature.[34] Each approach has its advantages and disadvantages, and there is often substantial variation in the estimates at any point in time. To simplify discussion, we will focus on monthly estimates of the output gap based on the Hodrick-Prescott (HP) filter, but we also report key statistics based on measures of the output gap using alternate filters (Baxter-King and Hamilton), using alternate measures (an OECD measure based on the production method and country-specific sources), and focusing on employment or unemployment rate gaps. We write each measure so that a positive value indicates a strong economy, i.e., output (or employment) above potential and unemployment below its natural rate. The key patterns highlighted below are highly consistent across these alternate measures of the

[34] Estimating output gaps is challenging, particularly as estimates of potential GDP are often substantially revised as more data is available (Orphanides and Norden 2002). This should be less of a concern for our historical comparisons, but may impact estimates of potential GDP over the past few years, and particularly during the post-pandemic period given the large shocks which could affect potential output (Coibion, Gorodnichenko, and Ulate 2018; Ramey 2018). Potential output can also differ in the short and medium term in the presence of supply shocks, leading to different estimates of the corresponding output gap, a distinction used by the ECB. See Hamilton (2018) and Schüler (2024) for information on various filtering methods for time-series data.

output gap, although there are often meaningful differences in the point estimates for any economy at any point in time based on the metric.[35]

Table 3 reports median statistics for our six measures of these gaps over tightening phases for the five historical periods defined earlier in the paper, focusing on the Accumulated Negative Output Gaps (ANOGs) that will be a focus in the analysis below. The post-pandemic period continues to stand out, with the lowest median trough for the output gap of any of the historical windows (at -0.7% of GDP based on the HP filter measures). The ANOGs are the lowest of any historical window when measured using the Baxter-King filter or employment gap, albeit closer to other historical windows based on other measures. These relatively small output losses by most measures are despite the relatively large number of months with negative output gaps (i.e., 12 based on the HP filter), further suggesting that even if output was below potential for much of the post-pandemic tightening, any shortfalls tended to be smaller than during other tightening windows.

It is also worth noting that economies typically "overheat" on average during tightening phases as a whole. Even though activity slows later in the phase as the impact of higher interest rates is transmitted through the economy, the median accumulated output gap (*AOG*) is positive over each historical tightening phase. During the post-pandemic tightening, this "overheating" was the median of the five historical windows.

Table 3: Median Output and Unemployment Gaps during Tightening Phases

	Output gaps (as % of GDP) based on HP filter					ANOG based on alternate gap measures				
	Peak	Trough	AOG	# months of ANOG	ANOG	Hamilton filter	Baxter-King filter	OECD	Employ. Gap	Unemp. Gap
1970-84	2.5	-2.1	0.6	10	-1.6	-5.7	-0.4	-3.1	-1.0	-0.3
1985-98	2.6	-0.8	3.3	8	-0.8	-2.1	-0.3	-1.3	-0.2	-0.2
1999-07	2.4	-1.0	2.5	7	-0.3	-0.4	-0.2	-0.4	-0.4	-0.1
2008-19	1.5	-1.0	0.9	15	-0.8	-1.5	-0.2	-1.1	-0.7	-0.2
2020-24	***1.8***	***-0.7***	***1.0***	***12***	***-0.4***	***-1.6***	***-0.1***	***-2.0***	***-0.1***	***-0.2***

Notes: AOG is the accumulated output gap and ANOG is the accumulated negative output gap. The # months of ANOG is the number of months of negative output gaps. All output gaps are as % of annual GDP, and the unemployment (and employment) gap is relative to the trend unemployment (employment) rate. The window for each statistic is the tightening phase (defined in Section II) plus a 12-month lag. Gaps are positive when output is above potential or unemployment is below the trend rate.

IV.2. Sacrifice Ratios

Next, to better understand the tradeoffs around inflation and output deviations facing central banks—as well as how the decisions made by central banks affect macroeconomic outcomes—it is useful to compare the relative adjustments in these measures over different tightening episodes. To make these comparisons, we draw on an extensive literature to calculate a Sacrifice Ratio—the

[35] To account for the possibility that the variation in output gaps after the pandemic primarily reflects changes in potential output, we conducted additional sensitivity exercises assuming that real (or potential) GDP continued along its pre-pandemic trajectory. Our headline findings regarding output gaps and the sacrifice ratio remain largely unchanged.

output that is “sacrificed” per unit of inflation reduction. This “ratio” has been defined and calculated in more ways than can be summarized here and has been subject to a number of criticisms, but is a popular and easy-to understand measure capturing some of the tradeoffs during disinflation episodes.[36] We build on one of the most common approaches, which uses event studies of disinflation episodes to calculate the Sacrifice Ratio as the accumulated output loss per inflation reduction during each episode (see Ball 1994 and Cecchetti et al. 2023 for prominent examples).

More specifically, we calculate the Sacrifice Ratio for each country-phase (*cp*) as:

$$\textit{Sacrifice Ratio} = SR_{cp} = -\left({ANOG_{cp}}/{IR_{cp}} \right), \tag{6}$$

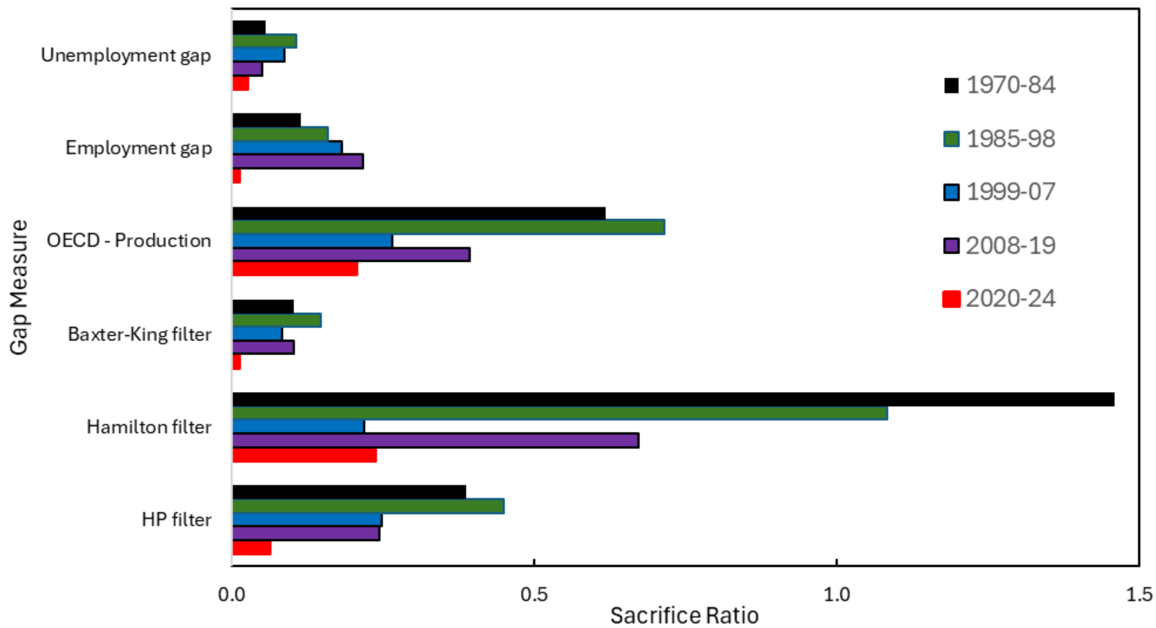
where the Accumulated Negative Output Gap ($ANOG_{cp}$) and peak-to-trough Inflation Reduction (IR_{cp}) over each tightening window are defined above.[37] Our calculation differs from the Sacrifice Ratio used in previous literature by focusing on disinflations over the windows when a central bank is tightening monetary policy (to better link to the tradeoffs facing central banks) rather than over windows determined by inflation peaks and troughs (which often do not correspond to monetary policy cycles) or the recovery/boom periods identified in the business cycle literature.[38] These differences in the windows used for analysis highlight the importance of identifying the rate cycles related to central banks' decisions in Section II. Our estimates—and those across different papers—can also vary due to a number of additional differences in how the individual components of the ratio are measured and calculated.[39]

Figure 7 shows the median Sacrifice Ratios for tightening phases across the five periods used throughout this paper for headline inflation based on the six different gap measures. In each case, the median Sacrifice Ratio is lower during the post-pandemic tightening episodes than during any historical period (except when calculated based on the Hamilton filter, for which it is only marginally above the ratio over the 1999-2007 period). Over the 2020-24 period, the median

[36] Different approaches to measuring the Sacrifice Ratio include: extracting it from estimates of a Phillips curve (Blanco et al. 2024; Benigno and Lopez-Salido 2006), from an aggregate supply curve (Andersen and Wascher 1999), or a time-series model (Cecchetti et al. 2023). See Tetlow (2024) for a survey of estimates using different approaches for the United States. We focus on the event study approach as it is the most common method and therefore easier to compare with previous work. This approach also avoids the need to make assumptions about the underlying model and parameters, instead simply letting the data speak.
[37] Since the ANOG is negative (i.e., output is below potential), we follow the literature by inverting the sign so that the Sacrifice Ratio is a positive number.
[38] In some cases, inflation peaks at or near the end of the tightening window, such that the Inflation Reduction is at or close to zero. In these cases, defined as when the Inflation Peak is within 3 months of the end of the window, we do not calculate a Sacrifice Ratio. There are 22 of these country-phases when headline inflation peaks within 3 months of the end of the tightening window, of which 18 occur during tightening phases that ended around the 2008 Global Financial Crisis (and inflation picked up globally through 2007 and early 2008).
[39] To provide a few examples: (1) we use monthly data, while much of the earlier work uses quarterly or annual data; (2) we scale the ANOG relative to annual GDP, while some earlier work (such as Ball 1994) scales relative to quarterly GDP (which would require multiplying our ratios by roughly four to be comparable); (3) we use direct measures of inflation and output gaps rather than estimating them based on an interpolation of “trend”.

Sacrifice Ratio declines to close to zero by most measures (to 0.01 based on the Baxter-King filter and employment gap, to 0.03 based on the unemployment gap, and 0.06 based on the HP filter). Results are very similar when the Sacrifice Ratio is calculated based on core inflation.[40] The consistent message across all statistics is noteworthy—especially given the substantial variation in the point estimates for different measures of output and employment gaps. For the median advanced economy in our sample, the post-pandemic tightening required a much lower "sacrifice" than during historical tightening phases in terms of the output losses corresponding to the sharp disinflation.

Figure 7: Median Sacrifice Ratios during Tightening Phases



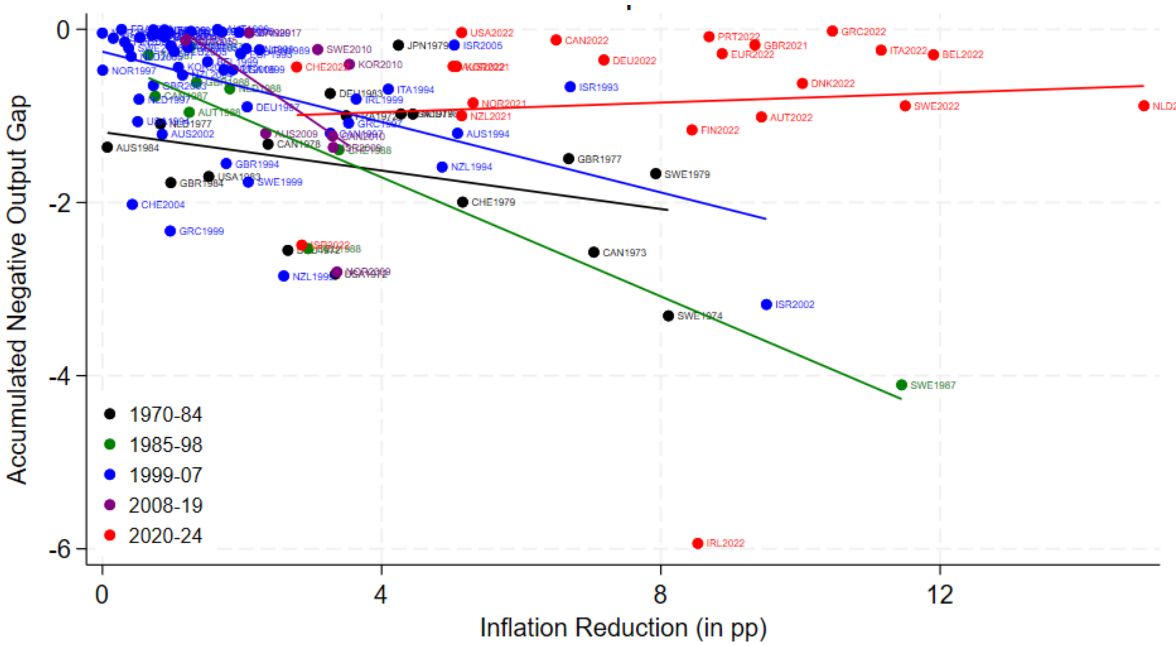
Notes: Sacrifice Ratio is the absolute value of the accumulated negative output gap relative to the reduction in headline inflation from the peak to subsequent trough for each economy over each tightening phase (including a 12-month lag after the tightening phases ends). Headline inflation is the year-over-year change in the monthly CPI price index (or PCE index for the United States). Measures of the output gap are defined in Appendix Table 3. Statistics are medians for the sample of 24 advanced economies.

To better understand this decline in the median Sacrifice Ratio and the underlying tradeoffs, Figure 8 graphs the components of the Sacrifice Ratio for each tightening phase in each economy since 1970 for our baseline measure (using headline inflation and the output gap based on the HP filter). Each data point, and the corresponding fitted lines, are colored to identify the five historical periods—with the post-pandemic tightening in red. The figure highlights how the tradeoffs facing central banks have changed meaningfully over time—and particularly over the most recent tightening phase. The dots for the post-pandemic period are scattered across the top right of the graph—reflecting high levels of disinflation combined with minimal output losses. Some periods with large disinflations (largely over 1970-84) corresponded to large output losses, while other

[40] When these Sacrifice Ratios are calculated based on core inflation, they are also lower during the post-pandemic period than during any historical periods based on all gap measures except the OECD statistic, for which the median Sacrifice Ratio is lower during the 1999-2007 window than the 2020-2024 window.

periods with less disinflation (such as over 1999-2007) corresponded to a range of accumulated negative output gaps. Reflecting these patterns, the slope of the fitted line for the post-pandemic period is much flatter than historical periods—and basically horizontal—indicating no apparent tradeoff between the amount of disinflation and output losses across economies. On average, economies appeared to no longer have to "sacrifice" output in order to accomplish a meaningful reduction in inflation.

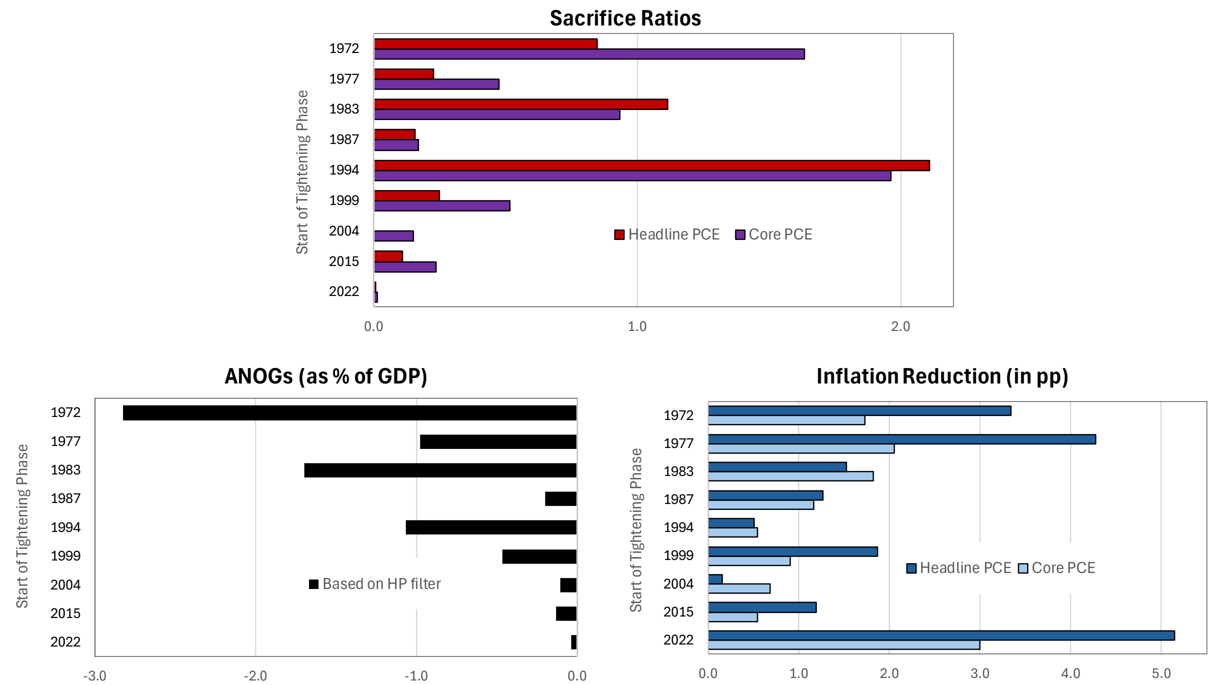
Figure 8: The Components of the Sacrifice Ratio over Time



Notes: Graph shows the components of the Sacrifice Ratio for each country-phase during tightening episodes from 1970 through 2024. The accumulated negative output gap (ANOG) is based on the HP filter and the inflation reduction is based on disinflation of the headline CPI (or PCE for the United States). Lines are fitted based on the observations for the five historical windows defined in the legend.

Figure 8, however, also highlights the substantial variation in these variables across individual economies. To better understand these cross-country differences, Appendix Table 4 reports Sacrifice Ratios and the corresponding components for each of the advanced economies in our sample during the post-pandemic tightening phase (for both headline and core inflation, with the output gap calculated using the HP filter). There is some variation in Sacrifice Ratios across individual economies—ranging from 0.02 or less in several economies (such as Belgium, Canada, Greece, Italy, Portugal, the UK and the US) to highs of 0.7 and 0.9 in Ireland and Israel, respectively. The large values for Ireland and Israel reflect unusual events and the characteristics of these economies (most notably the war in Israel and sharp adjustment in multinational-denominated sectors in Ireland), with the next highest Sacrifice Ratio of 0.2 in New Zealand, Norway and Switzerland. Overall, however, these Sacrifice Ratios are much lower across all the economies (except Israel and Ireland) than historical medians.

Figure 9: US Sacrifice Ratios across Historical Tightening Phases



Notes: Each graph reports the statistics over the nine US tightening phases identified in Section II. The Sacrifice Ratio is the absolute value of the ANOG (2nd graph) relative to Inflation Reduction (3rd graph). See Tables 2 and 3 for detailed definitions.

As a final comparison, and to better understand these patterns over time, Figure 9 shows the Sacrifice Ratio and its components for the United States over each of its nine historical tightening phases (from Table 1). The Sacrifice Ratio is sharply lower during the post pandemic period than during any historical tightening phase since our sample begins in 1970. Moreover, the breakdown of the components of the ratio shows that this reflects a combination of both low accumulated output gaps (the numerator) as well as large inflation reductions (the denominator). In fact, in the United States, the accumulated output loses during the post-pandemic tightening were lower, and the inflation reduction larger, than during any historical tightening phases in our sample.[41]

These results—across advanced economies since 1970 as well as focusing just on the United States—present a consistent message: the post-pandemic tightening involved an unusually low cost when assessed as output losses per inflation reduction.[42] By this traditional measure, central banks faced very little "sacrifice" in reducing inflation sharply from multi-decade highs (combined with achieving maximum employment in some economies).

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[41] These patterns generally apply to measures of the Sacrifice Ratio using other combinations of gaps and inflation measures. The notable exception is when the gap is measured by the unemployment gap, which deteriorated more during the post-pandemic period than tightening phases over 1987-2015. When combined with the large inflation reduction, however, the Sacrifice Ratio based on the unemployment gap is still very close (within 0.004) to the historical low set during another tightening phase.

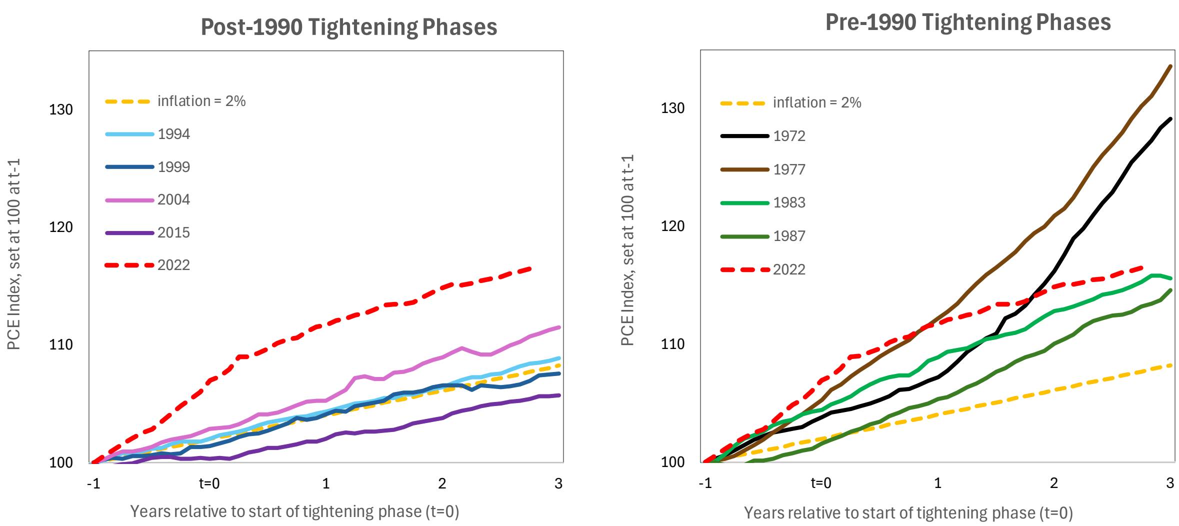
[42] These results are also consistent with Ghirelli, Pérez and Santabárbara (2025), which finds that Sacrifice Ratios in the euro area were lower than expected during the pandemic (reflecting stronger GDP growth and lower-than-expected inflation).

IV.3. The Price Level

The Sacrifice Ratio and its focus on the amount of *disinflation*, however, misses an important factor when assessing the tradeoffs around monetary policy: the impact on the price level. Even if central banks are able to return inflation to target with minimal output losses during tightening phases, this ratio does not incorporate the duration or extent of any deviation of inflation from target. In fact, the Sacrifice Ratio could even be lower for a central bank which allows a larger pickup in inflation above its target, creating the opportunity for a larger disinflation when returning inflation to target than a central bank which attempted to minimize this initial overshoot.

A closer look at the evolution of the price level over historical US tightening phases shows how this adjustment can vary meaningfully across periods. Figure 10 graphs the PCE price index, set at zero one year before the start of each US tightening phase, with tightening phases since 1990 on the left and those from 1970-90 on the right. In each graph, the adjustment in the price level that occurred over the post-pandemic period is in red, and that if inflation was at 2% in yellow. The graphs show that the surge in the price level since 2021 in the United States was well above that for any historical comparison since 1990—and even above that which occurred in the 1980s. The gap relative to what would have occurred if inflation was steady at 2%, which is what households and businesses had grown to expect and become accustomed to, is massive.

Figure 10: The Evolution of the Price Level in the US: Post-Pandemic versus Earlier Tightening Phases and 2% Inflation



Notes: Graphs show the evolution of the US PCE index, which is set to 100 one year prior to the commencement of each US tightening phase. The initial year of each phase is t=0 and the price index is based on monthly data. The yellow line indicates the hypothetical evolution of the price level if annual inflation was 2% over the period.

More specifically, at the end of 2024 and less than 3 years after the start of the post-pandemic tightening, the PCE index was about 13% higher than if inflation was 2% over this period. This is a particularly large adjustment for an economy in which inflation expectations were well anchored around 2% (or even below) before 2021. The only tightening phases during which the price level increased by more than after the pandemic were in the 1970s—a period which required an aggressive tightening in monetary policy under Chair Volcker that corresponded to large output losses and Sacrifice Ratios (Figure 9).

While the mandates of many central banks do not explicitly mention the price level, it is still implicitly incorporated in several ways. For example, the mandates of the US Federal Reserve and Swiss National Bank include a goal of "stable prices". Other central banks include a time by which they are expected to return inflation to target, e.g., two years for the Bank of England in normal circumstances and three years in "exceptional" circumstances.

Moreover (and as discussed in the introduction), recent research highlights that large price shocks can have non-linear effects and impact the transmission of monetary policy—issues which should be central to a discussion of optimal monetary policy. For example, the transmission of price shocks (such as energy supply shocks) into economic conditions is stronger and more persistent following larger shocks and during high-inflation regimes (Bachmeiera and Keen 2023; De Santis and Tornese 2024). Other research suggests that in high inflation regimes, the response of the price level to monetary policy shocks tends to be larger and thus the real effects can be smaller (Ascari and Haber 2022). These results build on the literature documenting that households and businesses care not just about the level of inflation, but also the level of prices (Bernanke 2019; Honkapohja and Mita 2020; Coibion et al. 2023).

In order to analyze this additional consideration for monetary policy, we use the same monthly data on the headline and core price index used above to calculate inflation, except now focus on annualized changes in the level of prices over each country-phase:

$$\textit{Accumulated Excess Price Level Change} = EPLC_{cp} = (PLC_{cp} - PLC_{cp}^{2\%}), \qquad (7)$$

$$\textit{Annualized Accumulated Excess Price Level Change} = EPLC_{cp} * \left(^{12}/_{months_{cp}}\right), \qquad (8)$$

$$\textit{with Price Level Change} = PLC_{cp} = \left(^{CPI_z}/_{CPI_0} - 1\right) * 100,$$

$$\text{and } \textit{PLC if inflation at 2\%} = PLC_{cp}^{2\%} = \left(\left(1.02^{\frac{1}{12}}\right)^{z} - 1\right) * 100$$

The *Annualized Accumulated Excess Price Level Change*—referred to below as the excess increase in the price level for simplicity—captures the accumulated change in the price level per year in excess of what would have occurred if inflation had been 2% over the tightening window. This is a similar concept to the accumulated output gap in the sense that it focuses on the aggregate impact relative to a trend (or target).[43] We annualize this measure in order to capture the amount of time over which the adjustment in the price level occurs, and over which households and business must adjust; a 5pp increase spread over one year would be more challenging than the same increase spread over five years. Also, we measure the change in the price level over a window lasting z months, which includes a 12-month lead before the start of the tightening phase as well as a 12-

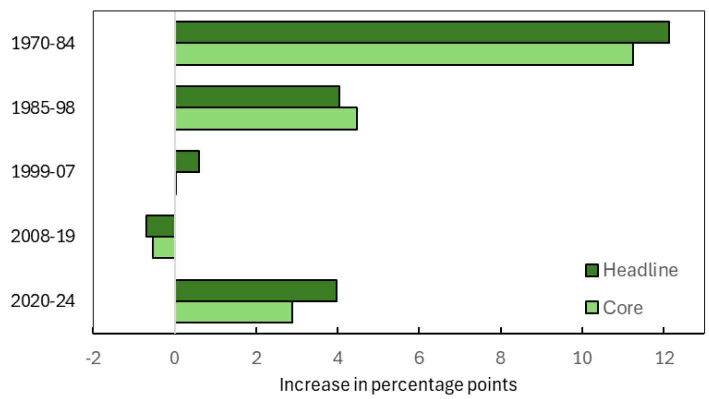
[43] Most economies did not target 2% inflation earlier in the sample, and many have had different targets and frameworks at different points in time (as discussed above). This 2% is still a useful baseline, however, particularly for the inflation targeting period. An alternative approach would be to measure the change in the price level that was a surprise, e.g., relative to inflation expectations, but cross-country data is not available to do this for much of the sample period.

month lag after the phase ends (excluding the periods around the 2008 Global Financial Crisis and 2020 pandemic). Measuring the change in the price level with a lead and lag around the tightening phase allows us to capture any changes in the price level that occur just before the first rate hike (which can be large if the central bank is slow to tighten policy and inflation accelerates before the phase starts)[44] as well as that occur after the phase ends while the effects of the prior rate hikes are still being transmitted to prices.

Figure 11 shows the resulting median excess increase in the price level over tightening phases for our sample of 24 economies over the five historical windows used throughout this paper. The median excess increase in the price level was 4.0pp for the headline CPI (or PCE) index and 2.9pp for the core index. This is meaningfully larger than any historical tightening phases since 1999—and a particularly large adjustment after this measure was negative over 2008-19 (i.e. inflation was less than 2%). This post-pandemic increase in the price level is comparable to that over 1985-98 tightening phases, although it was smaller than over the 1970-1984 window.

Figure 11: Excess Price Level Change during Tightening Phases

(Medians, annualized)



Notes: The Excess Price Level Change is defined as the accumulated increase in the price level over tightening windows in excess of 2% and then annualized. The tightening windows include a 12-month lead before the first rate hike in the phase and a 12-month lag after the tightening phase ends. The headline and core price indices are based on the monthly CPI indices for all economies except the United States (which is based on the PCE indices). Statistics are medians over the historical windows.

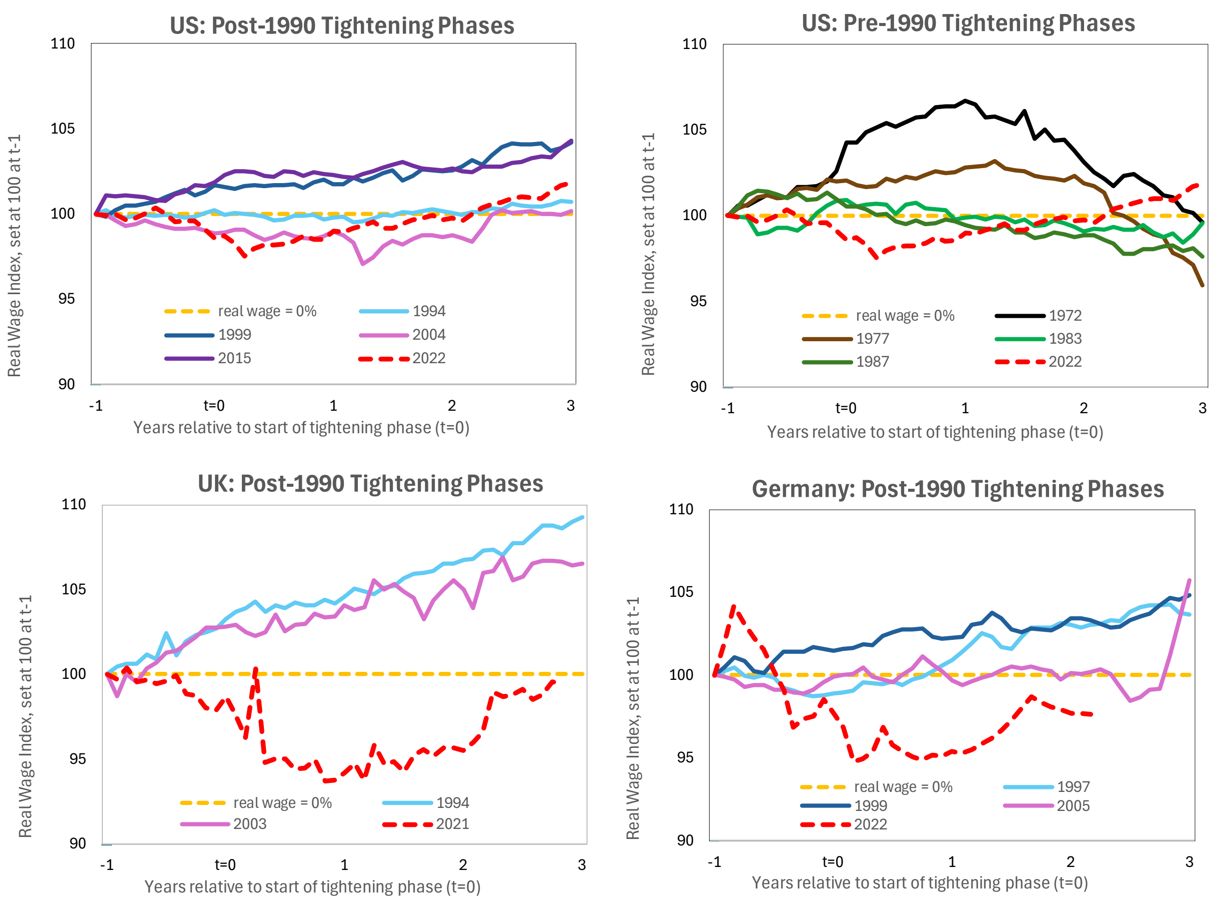
The medians shown in Figure 11, however, mask important differences across individual economies. The right side of Appendix Table 4 reports the corresponding excess price level changes for each of the economies in our sample during their post-pandemic tightening phases. The excess increase in the consumer price index was over 5pp per year in Austria, the Netherlands, Sweden and the UK, as compared to a modest decline (relative to 2% inflation) in Switzerland. The corresponding 3.1pp increase for the US PCE index is smaller than the sample mean and median. The excess price level increases tend to be larger in Europe (albeit with some exceptions, such as Switzerland), likely reflecting the larger role of energy, commodity and other trade shocks to this region after the Russian invasion of Ukraine.[45]

[44] For example, the Federal Reserve started its post-pandemic tightening phase in March 2022, at which time PCE inflation was already 7%.

[45] The larger increase in the price level in Europe may also reflect less concern about the initial increase in the price level as inflation had been well below the 2% target for an extended period in many countries.

In order to assess the impact of changes in the price level on the economy, it is also important to evaluate the impact on real wages (as well as the distribution of wages).[46] If increases in the price level are matched by increases in nominal wages, this would mitigate the impact on real wages, activity and welfare (Guerreiro et al., 2024). Unfortunately, cross-country data on wages is not widely available during the long time series that is the focus of this paper, but a comparison for a smaller group of countries shows substantial variation in how real wages adjust, particularly during the post-pandemic tightening.

Figure 12: The Evolution of Real Wages in the US, UK and Germany: Post-Pandemic versus Earlier Tightening Phases



Notes: Graphs show the evolution of real wages, set to 100 one year prior to the start of each tightening phase. The initial year of each phase is t=0 and real wages are calculated as average hourly earnings (based on OECD data) relative to the CPI price index based on monthly data. The yellow line indicates the hypothetical evolution of the real wages if they remained constant over the period.

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[46] This discussion only considers the impact on average wages, not the distribution of wages, and extending these comparisons to real wage growth for different segments of the population is an important issue for future work. For a discussion of these distributional issues in the Euro area around the pandemic, see Pallotti et al. (2024).

Figure 12 shows the evolution of real wages during the respective tightening phases for the US, UK and Germany (similar to the analysis of the US price level in Figure 10).[47] In each of these countries, real wages fell during the early stages of the post-pandemic tightening (in red) as inflation spiked—and by more than during earlier tightening phases. In the United States, however, real wages began to recover soon after the first rate hike, such that real wages were higher (on average) three years after the start of the tightening phase. In fact, the subsequent recovery in real wages after the pandemic was in the middle of that which has occurred during tightening phases since 1990 (and stronger than during 1970-80 tightening phases). In sharp contrast, real wages did not experience a similar recovery in the UK or Germany after the pandemic, with real wages still below the level from the first post-pandemic rate hike and well below the recovery during all post-1990 tightening periods. A number of factors likely contributed to these patterns, including the stronger fiscal stimulus supporting demand and tight labor market conditions in the US, as well as the larger impact of the energy shock in the UK and Germany.

As a final comparison, and in order to succinctly capture how central banks can face a tradeoff in some circumstances between allowing an adjustment to occur through the price level versus output losses, we also calculate a new Price-Output Tradeoff Ratio:

$$\text{Price-Output Tradeoff Ratio} = {}^{EPLC_{cp}}\!\big/_{-ANOG_{cp}}, \qquad (9)$$

where $EPLC_{cp}$ is the accumulated excess price level change and $ANOG_{cp}$ is the accumulated negative output gap (both defined above) over each country phase (*cp*) during the tightening windows. The $EPLC_{cp}$ is still measured as the "excess" increase in prices resulting from inflation above 2%, but is not annualized in order to be comparable to the denominator (which is over the entire phase). The closest precedent to this ratio that we have been able to find is the "Phillips multiplier" introduced in Barnichon and Mesters (2021) and defined as the expected cumulative change in inflation caused by a monetary shock that lowers expected unemployment by 1pp. Instead of focusing on cumulative output losses in the numerator (as done for the Sacrifice Ratio), our goal (as for Barnichon and Mesters 2021) is to focus on cumulative changes in the price level.[48]

This simple ratio is intended to capture how the macroeconomic adjustment is split between cumulative changes in prices and cumulative losses in output during tightening phases. For example (and shown in more detail in the simulations in Section V), assume an economy is overheating and the central bank can choose rate hikes that are more "gradual" or more "aggressive". In the gradual strategy, cumulative output losses are smaller, but inflation is higher so that the price level increases by more. As a result, the Price-Output Tradeoff Ratio would be higher in the gradual scenario, reflecting more of the adjustment occurring through price level increases and less through output losses. Of course, a number of factors other than the central bank's strategy will affect how much adjustment occurs through prices versus activity (such as the

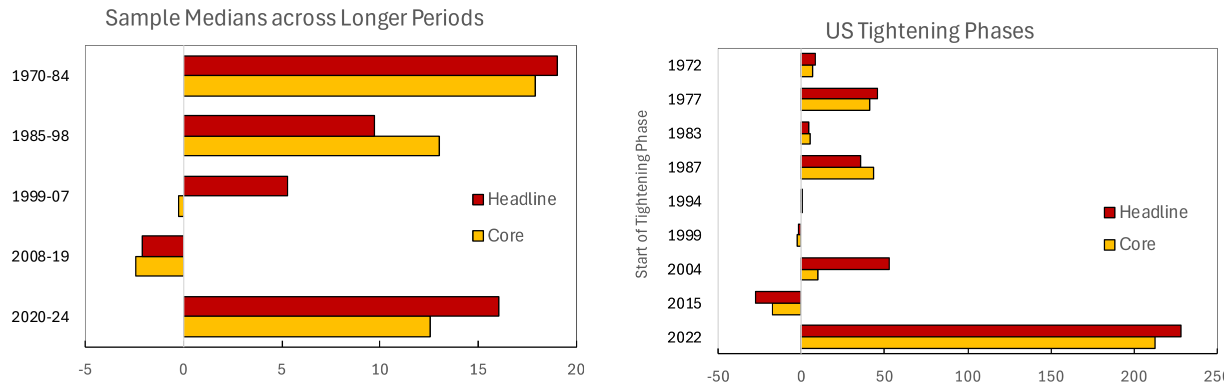
[47] Real wages are calculated as an index of the hourly wage index relative to the CPI price index for each economy (including for the United States). The hourly wage index (2015=100) from the OECD or average hourly earnings from US Bureau of Labor Statistics.

[48] This approach also has analogies to the fiscal literature which evaluates the cumulative multipliers of different policies, often measured as the ratio of integrals to impulse responses, as introduced by Mountford and Uhlig (2009). For a more detailed discussion of the benefits of this approach, see Ramey (2019).

nature of the shocks affecting the economy[49]), just as many other factors affect the relationship between disinflation and output gaps in the Sacrifice Ratio. The central bank's reaction to such shocks over the tightening phase, however, including how much weight it places on stabilizing output versus inflation, could also affect how much of the relative adjustment occurs through these different channels.

Figure 13: Price-Output Tradeoff Ratios during Tightening Phases

(Ratio of Excess Price Level Change to ANOG)



Notes: The Price-Output Tradeoff Ratio is calculated as the ratio of the Excess Price Level Change (relative to that which would occur if inflation was 2%) from Figure 11 to the Accumulated Negative Output Gap (ANOG) over each tightening phase. Output gaps are based on the HP filter. The headline and core price indices are based on the monthly CPI indices for all economies except the United States (which is based on the PCE indices). The left graph shows medians across the sample of advanced economies and the right graph shows the statistics for each of the US tightening phases.

Figure 13 shows the resulting median Price-Output Tradeoff Ratios over tightening phases for our sample of 24 economies over the five historical windows on the left, and then for each of the US tightening phases on the right. For the sample as a whole, this ratio was falling over time (until the pandemic), suggesting that less macroeconomic adjustment was occurring through the price level relative to through output losses. The decline corresponds to the widespread shift to inflation targeting and is consistent with greater attention to maintaining inflation around 2%, even if this strategy involved larger output losses. This Price-Output Tradeoff Ratio jumped during the post-pandemic tightening, however, reflecting the large share of the adjustment that occurred through the price level during this episode. This jump is particularly striking for the United States, where almost all of the adjustment during the post-pandemic tightening occurred through prices rather than through output losses. Although the spike in the ratio overstates the adjustment due to the unusually low cumulative output losses (near zero) in the denominator, it reflects a sharp change in how the adjustment occurred relative to in earlier tightening phases. Appendix Table 4 provides more detail on the components of this ratio.

To summarize, this section highlights the unusual tradeoffs for monetary policy during the post-pandemic period. Inflation spiked to levels not seen since the 1970s and early 1980s in many economies, but then fell quickly towards target levels. This disinflation occurred with fairly small

[49] For example, prices and output generally move in the same direction after a demand shock, but in opposite directions after a supply shock—involving a tradeoff. In the empirical analysis, we control for supply shocks.

output losses in most economies, but large increases in price levels. The Sacrifice Ratios suggest there was historically little "sacrifice" when measured as the output losses per unit of inflation reduction, but this measure misses an important part of this adjustment process: the sharp increase in price levels. Even if the surge in inflation proves to be temporary and inflation settles back at 2%, the price level has increased meaningfully. In other words, and as captured in the Price-Output Tradeoff Ratio, many economies (including the United States) chose to adjust to the post-pandemic shocks largely through adjustments in the price level and with minimal adjustment in output and employment. There were sharp differences across economies, however, with others choosing a more balanced adjustment.

V. Explaining Tradeoffs

This section explores why these tradeoffs and sacrifices for monetary policy vary across economies and over time. It focuses on the role of the central bank's strategy (using the characteristics of rate cycles defined in Section III) during tightening phases (as defined in Section II). It also considers the role of slow-moving country characteristics that have been highlighted in prior work (such as the central bank's credibility and flexibility of the labor market) and the shocks affecting the economy (e.g., the role of oil shocks).

The section begins with a simple regression analysis, focusing on the impact of the central bank's decisions on when to start raising rates and then how aggressively to subsequently tighten policy. The section ends with simulation results from the FRB/US model used by the US Federal Reserve to better understand the empirical findings. A full analysis of the many variables that affect activity, inflation, and the price level is beyond the scope of this study (including a more detailed examination of the additional shocks affecting the economy, such as fiscal policy and supply shocks[50]), as well as a complete model of the endogenous monetary policy response. With this caveat, our regressions and the illustrative simulations provide similar insights on how central bank strategies can impact macroeconomic tradeoffs and how they contributed to the unusual macroeconomic developments during the post-pandemic recovery (shown in Sections III and IV).

V.1. Empirical Assessment

V.1.1. Methodology and Variables

When central banks adjust monetary policy through their primary tool of interest rates (and ignoring decisions around guidance, the balance sheet, etc.), they must make a number of strategic choices. An extensive literature documents how these decisions can affect different macroeconomic variables, the transmission of monetary policy, and corresponding tradeoffs.[51] Much of this literature focuses on how central bank credibility impacts inflation expectations and

[50] For a more detailed analysis of the role of fiscal policy and other "real" factors during the Covid pandemic, see Stock and Watson (2025). For a more detailed analysis of the range of shocks affecting the economy, and a more detailed look at different supply shocks, see Forbes, Ha and Kose (2025). For an analysis of what caused the post-pandemic inflation in eleven economies, see Bernanke and Blanchard (2024).

[51] For details on these strategies and tradeoffs, see Reis (2022); Bandera et al. (2023); Afrouzi, Halac, Rogoff and Yared (2024).

finds that the cost of disinflation can be reduced when monetary authorities have the reputation of implementing credible policies, a commitment to price stability, and a transparent decision-making process (Huang et al. 2019; Magkonis and Zekente 2020; Romer and Romer 2024).

While there is general agreement on the benefits of greater central bank credibility, there are different views and conflicting evidence on the benefits of more aggressive (or "cold turkey") versus "gradual" approaches to adjusting monetary policy (Ball 1994; Mazumder 2014; Tetlow 2024). Some papers find that more aggressive actions by central banks can improve macroeconomic tradeoffs by generating a regime shift that enhances credibility. For example, strategies that reinforce the commitment to an inflation target can better stabilize inflation expectations and reduce second-round effects on wage and price setting so that disinflation is less costly (Kugler 2024). Mann (2022) models how this type of more "activist" approach could even support an earlier shift to easing monetary policy and therefore smaller aggregate output losses than would occur from a longer and more gradual tightening phase.

In contrast, other work argues that more gradual rate adjustments by central banks could lead to more attractive tradeoffs, primarily by minimizing output losses. This could occur if wages and prices exhibit inertia and require time to adjust to monetary tightening. Tenreyro (2023) models how more aggressive rate increase by the Bank of England in response to the post-pandemic inflation could have generated much larger output losses and only moderately lower peak inflation. Other work shows that in the presence of certain types of uncertainty (as initially argued in the seminal work by Brainard 1967) and in order to maintain financial stability (Stein and Sunderam 2018), a slower path of monetary policy tightening could reduce output losses—and in the extreme avoid a financial crisis (and corresponding large output losses).

To test formally if different strategies for monetary policy correspond to different outcomes and tradeoffs, we estimate the simple model below:

$$Tradeoff_{cp} = \alpha + \beta * CB\_Strategy_{cp} + \delta * Country\_Characs_{cp} + \gamma * OilShocks_{cp} + \varepsilon_{cp}, \qquad (10)$$

where *Tradeoff* is one of the: (1) Sacrifice Ratio; (2) Accumulated Negative Output Gap (ANOG); (3) Inflation Reduction (IR); (4) Accumulated Excess Price Level Change (EPLC); or (5) Price-Output Tradeoff Ratio (all defined in Section IV). We focus on the role of the central bank's strategy (*CB_Strategy*), but also control for slower-moving country characteristics (*Country_Characs*) and the role of oil shocks on inflation rates (*OilShocks*).[52] All variables are measured over 1970-2024 for each country-phase (*cp*) identified as a tightening phase in Section II.[53] Standard errors are clustered by country and over the five long periods defined in Section III.

There are many variables that could affect the macroeconomic outcomes in this regression, with an extensive literature providing theoretical and empirical evidence for and against a large number of possible controls. Summarizing this literature and analyzing all of the potential explanatory

[52] As discussed below, in sensitivity tests, we also control for a broader range of shocks (including the contribution of all supply shocks or all global shocks or demand shocks).

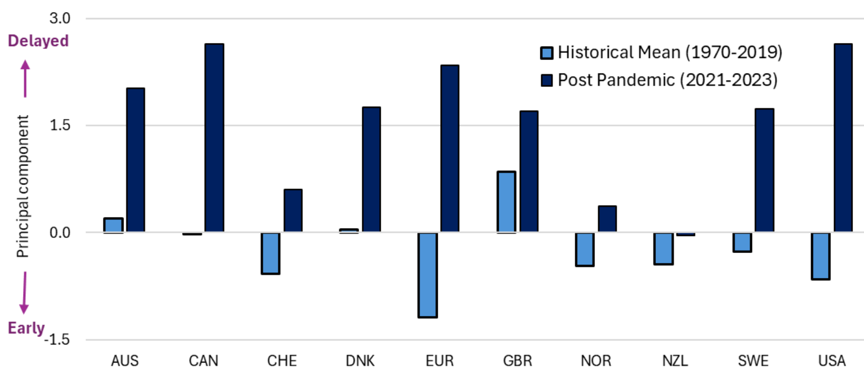
[53] We include each member of the euro area as an individual country (and not the euro area as a separate entity). The countries in the sample are listed in Table 1. For the baseline analysis, we also exclude four extreme outliers (the tightening phases that begin in Spain in 1973, New Zealand in 1976, and Greece in 1987 and 1997). These generally do not impact the empirical results but distort the scale of the graphs.

variables is beyond the scope of this paper; it is also not possible to control for many variables simultaneously in our framework given the limited observations available.[54] Therefore, in the analysis below we focus on the role of central banks—as this draws on our new analysis of rate cycles and the corresponding characteristics—and as this has received less attention in the literature than some other variables (such as labor market flexibility). In our baseline analysis, we focus on two characteristics of the central bank's strategy: the timing of the first rate hike ("liftoff") and the "aggressiveness" of the subsequent rate hikes.

Timing of the first rate hike. To measure the timing of liftoff in each tightening phase relative to the state of the economy, we use the phase definitions and corresponding macroeconomic variables from Sections II and III to estimate a principal component of four variables that are central to setting monetary policy and also widely available across our sample: headline inflation, core inflation, the output gap and unemployment rate gap (both based on the HP filter).[55] We will refer to this variable as *Delayed Start*, as a larger number indicates a later timing of liftoff based on the evolution of the underlying macroeconomic variables.

Figure 14: Timing of First Rate Hike

(Relative to macroeconomic indicators)



Notes: A higher value of the index indicates a slower start to the tightening phase based on the underlying macroeconomic variables. This index is calculated as the principal component of four macroeconomic indicators that can influence the timing of the first rate hike: headline inflation, core inflation, the unemployment gap, and output gap. The output gap is measured using an HP filter; if any of these variables is not available, we calculate a principal component with substitutes (such as using IP growth instead of GDP growth) or with as many variables as available.

To better understand this new variable, Figure 14 graphs this measure during the post pandemic tightening (in dark blue) relative to the average over the 1970-2019 period (in light blue) for a subset of the sample. The large positive values for the post-pandemic period, especially when compared

[54] Although our sample benefits from having a panel of observations for 23 countries over a long period from 1970-2024, the number of observations is still limited by the number of tightening phases and limited availability for some of the macroeconomic variables early in the sample.

[55] In order to maintain as large a sample as possible, if all these variables are not available, we estimate the principal component with substitute measures. More specifically, if the output gap based on the HP filter is not available, we measure the gap using the OECD measure, Hamilton or Baxter-King filter. If GDP growth is not available, we use the growth in industrial production. If the four variables are not available after these substitutions, we estimate the principal component using a smaller set of available measures.

to the slightly negative values for the pre-pandemic window, indicate that all countries were slower to start raising rates based on these macroeconomic developments than has occurred on average during historical tightening phases. As discussed above, this delayed liftoff likely reflected a number of factors: forecasts that missed the inflation surge; caution tightening policy after the prolonged recovery and subpar inflation over the previous decade; uncertainty about the strength of the recovery; belief the Phillips curve was flat; a misunderstanding of the sources and transitory nature of inflation; and constraints switching from easing to tightening policy due to commitments through forward guidance and ongoing asset purchase programs. It is also noteworthy that the United States was the slowest (along with Canada) to start tightening based on its macroeconomic variables, possibly due to the new flexible average inflation targeting (FAIT) framework.[56]

Aggressiveness of rate hikes. As a second measure capturing central bank strategy, we control for the "aggressiveness" of the tightening phase. Section III presents a range of rate cycle characteristics that could each contribute to the aggressiveness of the subsequent rate path in different ways. Rather than taking a stance on which measure better captures aggressiveness, we calculate a principal component of these different cycle characteristics that reflect a form of aggressiveness: (1) the number of rate hikes; (2) the pace of rate hikes (i.e., average size); (3) the amplitude of rate hikes (i.e., total increase); (4) the initial velocity of rate hikes (over the first six months); and (5) the largest rate hike divided by the average rate hike (to capture the use of "supersized" hikes).[57] In the sensitivity tests, we also discuss a subset of results using the individual measures of aggressiveness used to calculate this principal component.

Country characteristics. In addition to these two controls for the central bank's strategy, we also include controls for slower moving country characteristics. In our baseline specification, we focus on two variables that have received the most attention in the literature: central bank credibility (e.g., Goodfriend and King 2005) and labor market flexibility (e.g., Bowdler and Nunziata 2008). In sensitivity tests, we also control for trade openness, financial openness, exchange rate flexibility, and the level of inflation just before the start of the tightening phase. Capturing any effect of these country characteristics is more challenging than for the other factors analyzed above as they tend to be slow moving, so that any relationships are primarily identified through the more limited cross-country variation in the data (and not the additional time dimension incorporated in the phases). Many of these variables are also highly correlated (such as central bank credibility and financial openness) and some have little variation across the sample (such as exchange rate flexibility).

Contributions of shocks. As a final set of variables, we control for the contributions of shocks to the variation in inflation rates during each tightening phase. To measure the underlying shocks, we use estimates from the factor-augmented VAR (FAVAR) model developed in Forbes, Ha and Kose (2024), which estimate the contributions of seven types of shocks to the variation in inflation.[58] In

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[56] See English et al. (2024) for more details on why central banks were slow to start tightening.
[57] Some of these variables are highly correlated, especially nominal variables (such as the pace of rate hikes and total amplitude of rate hikes). Many are also endogenous; for example, if inflation picks up faster than expected midway through the tightening phase, then the central bank is more likely to raise rates more times and for longer (i.e., the phase would involve more rate hikes or a longer duration of the phase).
[58] This framework estimates the contribution of four global shocks (oil prices, supply, demand and monetary policy) and three domestic shocks (supply, demand, and monetary policy) to the variation in domestic inflation (and other macroeconomic variables).

our baseline analysis. we focus on the contribution of oil price shocks (which also includes other commodity shocks, such as gas price shocks, that move similarly to oil prices). In the sensitivity analysis we also control for the role of all supply shocks, of all global shocks, and other combinations of shocks. These are not consistently significant, and do not affect the key results reported below.

The sources and definitions for each of these control variables are provided in Appendix Table 3B. Both *CB_Strategy* and *OilShocks* are measured over each country-phase, while *Country_Characs* is measured in the year before the start of the phase.

V.1.2. Regression Results

To begin, we estimate the regression defined in equation 10 to explain the Sacrifice Ratio, its components, price level increases, and the Price-Output Tradeoff Ratio for tightening phases. Before discussing the results, it is also worth reiterating the important caveat that many of the variables, particularly the monetary policy responses, are endogenously determined with the macroeconomic variables and ratios. For example, central banks are more likely to have an aggressive monetary policy response to a sharper pickup in inflation and the price level (which correspond to a larger disinflation).

With this important caveat, results are shown in Table 4. Starting with the measures capturing the central bank's strategy, the first row of each section shows that a delayed start to tightening corresponds to lower Sacrifice Ratios (with mixed significance), primarily due to significantly larger inflation reduction. This seemingly positive result of a late start, however, masks that this disinflation corresponds to an even larger and significant increase in the price level over the tightening phase. This suggests that the tradeoff from delaying liftoff may not be as attractive as suggested by simply focusing on the Sacrifice Ratio; delaying the first rate hike only appears to lead to a lower "sacrifice" because it allows inflation to surge more before bringing it back down by more—with a long lasting impact on the price level and no apparent improvement in ANOGs. In fact, a delayed start to tightening corresponds to worse output gaps (albeit with mixed significance), likely reflecting additional rate hikes required to disinflate after the higher inflation. Also, the positive and significant coefficient on the Price-Output Tradeoff Ratio suggests tightening phases which start late correspond to a relatively larger share of the subsequent adjustment occurring through prices rather than output losses.

Shifting to the other component of central bank strategy, the second row of each set of results suggests that more aggressive tightening strategies correspond to higher Sacrifice Ratios, driven by significantly worse ANOGs, albeit partly balanced by significantly larger inflation reductions. There is no significant impact on the price level (or Price-Output Tradeoff Ratio) from more aggressive tightening strategies—although this may reflect endogeneity as central banks are likely to tighten more aggressively (and subsequently suffer larger output losses) in the face of larger price increases.

Table 4: Regression Results: Explaining Tradeoffs

	SACRIFICE RATIO (ANOG/IR)					ACCUMULATED NEGATIVE OUTPUT GAP (ANOG)				
Delayed Start	-0.0546*		-0.0782***	-0.0527	-0.0482	-0.304*		-0.130	-0.165*	-0.186*
	(0.0211)		(0.0147)	(0.0309)	(0.0357)	(0.132)		(0.0824)	(0.0651)	(0.0852)
Aggressiveness		0.0361*	0.0788***	0.00539	0.00501		-0.607***	-0.527***	-0.373**	-0.371**
		(0.0139)	(0.0132)	(0.0248)	(0.0256)		(0.0397)	(0.00870)	(0.0957)	(0.0999)
Central Bank Credibility				-0.141**	-0.132**				0.266*	0.226*
				(0.0334)	(0.0394)				(0.115)	(0.0946)
Labor Market Flexiblity					-0.0273					0.121
					(0.0261)					(0.0993)
Oil Shocks					0.00183					-0.00514
					(0.00719)					(0.0254)
Observations	***88***	***88***	***88***	***88***	***88***	***108***	***108***	***108***	***108***	***108***
R-squared	***0.040***	***0.010***	***0.079***	***0.212***	***0.216***	***0.121***	***0.257***	***0.274***	***0.319***	***0.325***

	INFLATION REDUCTION (IR)					EXCESS PRICE LEVEL CHANGE (EPLC)				
Delayed Start	1.704***		1.560***	1.565***	1.476***	2.926*		2.362*	2.328*	2.492**
	(0.136)		(0.120)	(0.0973)	(0.147)	(1.356)		(1.070)	(0.872)	(0.839)
Aggressiveness		1.195*	0.494**	0.586**	0.581**		2.917	1.932	1.372	1.398
		(0.508)	(0.141)	(0.157)	(0.160)		(1.801)	(1.228)	(1.053)	(1.024)
Central Bank Credibility				0.239	0.0697				-1.448	-1.128
				(0.279)	(0.186)				(0.983)	(0.882)
Labor Market Flexiblity					0.532					-0.956
					(0.322)					(0.466)
Oil Shocks					-0.0458					0.0937
					(0.0288)					(0.0462)
Observations	***136***	***137***	***136***	***136***	***135***	***136***	***137***	***136***	***136***	***135***
R-squared	***0.512***	***0.173***	***0.538***	***0.543***	***0.563***	***0.399***	***0.279***	***0.505***	***0.554***	***0.569***

	PRICE-OUTPUT TRADEOFF RATIO (EPLC/ANOG)				
Delayed Start	14.30**		14.82**	14.19**	11.81**
	(4.312)		(4.237)	(3.627)	(2.938)
Aggressiveness		7.631	-1.582	1.150	1.304
		(4.229)	(2.019)	(2.230)	(2.214)
Central Bank Credibility				4.721	0.490
				(3.221)	(3.503)
Labor Market Flexiblity					13.89
					(8.344)
Oil Shocks					-1.006
					(0.570)
Observations	***108***	***108***	***108***	***108***	***108***
R-squared	***0.061***	***0.009***	***0.062***	***0.065***	***0.086***

Notes: Results from estimates of equation (10) of the *Tradeoff* variables on central bank strategies, country characteristics and shocks over tightening phases from 1970-2024 for a sample of 23 advanced economies (including individual countries in the euro area, but not the euro area as a single entity). All variables are defined in Appendix Table 3B. Regressions include a constant (not reported) and robust standard errors clustered by country and time period (for the five long windows defined in Section III).

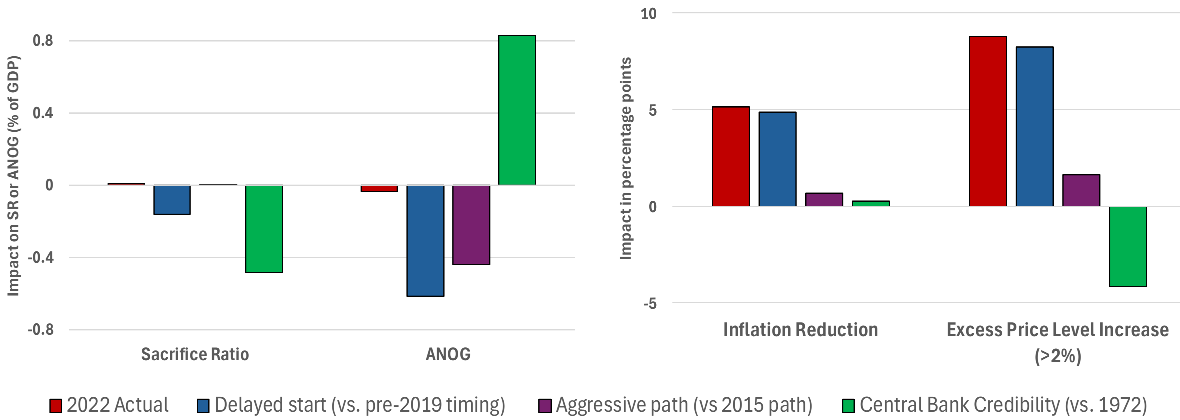
The coefficient estimates for central bank credibility in the third rows also indicate an important role for central banks other than their phase-specific tightening strategy—consistent with results in the literature. Greater central bank credibility is correlated with significantly lower Sacrifice Ratios, and this effect may be more powerful than the phase-specific strategy (as the strategy variables become insignificant in some specifications, including the baseline, when the control for credibility is included). Central bank credibility is also correlated with significantly smaller output losses, larger disinflations, and smaller price level increases—all in the direction expected—albeit the coefficient estimates have mixed significance based on specification and other variables included. This fluctuating significance may also reflect the challenges measuring central bank credibility across countries over this long period. With these caveats, stronger central bank credibility appears to be the one institutional feature with no tradeoff (by our measures)—and only positive outcomes.

The other explanatory variables are usually insignificant, and many of the signs fluctuate across specifications. More flexible labor markets are usually correlated with lower Sacrifice Ratios, smaller output losses, larger disinflations, and smaller price level increases, but the relationships are usually not significant, at least partly reflecting its correlation with the measure of central bank credibility. Oil shocks correspond to larger price level increases (which is sometimes significant at the 10% level) as would be expected if oil price shocks are transitory and monetary policy at least partially looks through these shocks.

Next, in order to help interpret the magnitude of these coefficient estimates and understand the relative importance of different central bank strategies and credibility for macroeconomic outcomes, we use the coefficient estimates from Table 4 to calculate several back-of-the-envelope comparisons for the United States (based on the regressions with the full set of controls in the right-hand side column for each outcome variable). We use these coefficients and characteristics of the post-pandemic US tightening phase to calculate the impact of: (1) the late start to tightening, as compared to if liftoff had occurred at the average timing of before 2019; (2) the more aggressive path of rate hikes (based on the principal component), as compared to the more gradual rate path followed in the 2015 tightening; (3) the greater central bank credibility after the pandemic (based on the principal component), as compared to credibility in 1972. Figure 15 shows the impact of making each of these changes around the recent tightening phase on the Sacrifice Ratio, ANOG, Inflation Reduction, and Excess Price Level Increase, as compared to the actual value of each of these variables.

The graphs show several striking patterns. Improved central bank credibility in 2022, relative to that in 1972, corresponded to a meaningful reduction in the Sacrifice Ratio (by 0.4), an improvement in the output gap (of 0.8% of GDP), and meaningfully smaller increase in the price level (of 4pp) than would have otherwise occurred. The delayed start to liftoff in 2022, as compared to the historical average, corresponded to a slightly smaller Sacrifice Ratio, but this was not a positive outcome as it incorporated worse output gaps (with the ANOG weaker by 0.6%p of GDP) and a much larger increase in the price level (of 8.2pp). The more aggressive tightening path (as compared to the very gradual path in 2015) corresponded to a worse accumulated output gap (by 0.4%p of GDP), but smaller effects on the other outcome variables. Although these calculations are based on rough comparisons, they highlight the risks to the price level from delaying the start to tightening monetary policy, as well as the substantial benefits from greater central bank credibility. If the Federal Reserve had its 1972 level of credibility in 2022, the Sacrifice Ratio would have been meaningfully negative and output losses sharply higher (instead of both being basically zero), and the price level could have increased by an additional 4pp (on top of the already large increase of 9pp).

Figure 15
Impact of Central Bank Strategy and Credibility on Tradeoff Variables for the United States
(Simple calculations for individual policy changes)



Notes: Results from back-of-envelope calculations of three changes on the tradeoff variables based on the coefficient estimates from Table 4 for the full set of controls. The red bars show the actual values for the corresponding outcome variables during the post-pandemic tightening. The other bars show the estimated effects of the delayed first rate hike (relative to pre-2019 tightening phases, blue), the more aggressive rate path (compared to the 2015 rate path, purple) and greater central bank credibility (compared to that in 1972, green). Each estimate assumes all other variables are held constant.

In addition to the main results highlighted above, we also performed an extensive set of sensitivity tests. More specifically, we repeated the baseline analysis with the following changes: (1) added additional controls for the country's characteristics (including inflation before the start of the tightening phase, trade openness, financial openness, and exchange rate flexibility); (2) included country fixed effects and/or period fixed effects (for the five long windows introduced in Section II); (3) used the different measures of output gaps discussed in Section IV.1 (including the unemployment rate and employment rate gaps and output gaps measured by the OECD or using the Baxter-King or Hamilton filters instead of the HP filter; (4) used core (instead of headline) inflation; (5) included each of individual measures of aggressiveness and central bank credibility used in calculating the corresponding principal components (instead of the aggregated measures); and (6) included different measures of shocks affecting inflation (including all supply shocks, all global shocks, or all demand shocks). Appendix Table 5 shows a subset of these results.

The results based on these robustness tests are consistent with the key findings highlighted above, albeit the significance of some variables (particularly those only significant at the 10% level in the baseline) can fluctuate. The coefficients for most of the additional control variables included, however, are not statistically significant. More specifically, throughout these extensions, central bank credibility is consistently and significantly corelated with lower Sacrifice Ratios and smaller output losses (albeit with mixed significance). A delayed start to tightening is consistently and significantly corelated with larger disinflations, but this results from significantly larger price level increases; there is also no evidence that a delayed start reduces output losses (with some evidence it aggravates losses), such that more of the overall adjustment occurs through prices than output. A more aggressive tightening strategy is consistently and significantly correlated with larger output losses and larger disinflations. Most of the country-specific characteristics are insignificant, which is not surprising as many are correlated with measures included in the baseline (such as central bank credibility), but there is some evidence that more openness to trade and capital flows is correlated with smaller price level increases.[59]

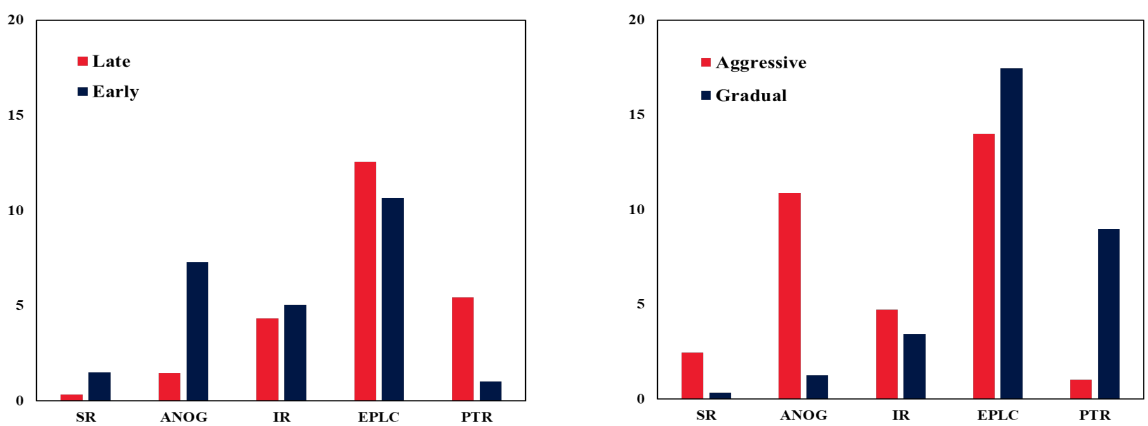
V.2. Illustrative Simulations

To better understand these regression results and assess if they correspond to the predictions of a standard model for how different monetary policy strategies affect the tradeoffs facing central banks, we conduct two illustrative simulations using the FRB/US model, the workhorse model used by the U.S. Federal Reserve. We simulate the impact on the US economy of the choices that are the focus of the empirical analysis above: the timing of the first rate hike and the aggressiveness of the subsequent tightening path.[60] In each simulation, we assume that the economy begins from a position of overheating—similar to the position of the United States before the start of its post-pandemic tightening—with output above potential by 3.0%, unemployment 2.0pp below NAIRU and inflation above target by around 6pp.

First, we simulate the impact of a "late" or "early" start to tightening. In each case, we assume the central bank raises the policy interest rate from 0 to 4.5% over a period of 2 years. In the "early" case, the central bank begins raising rates at t=1, but in the "late" case the central bank waits and begins raising rates one year later. Appendix Figure 2a shows the resulting paths for the policy rate, inflation, price level, output gap, GDP and unemployment rate. A late start corresponds to a longer overshoot of output above potential, higher inflation and a larger increase in the price level.

Figure 16: Simulated Effects of Different Strategies on Tradeoffs

A. Early vs. Late Start | **B. Aggressive vs. Gradual Strategies**



Source: Authors' calculations based on the FRB/US model as explained in Brayton, Laubach, and Reifschneider (2014) and Laforte (2018). See underlying simulations in Appendix Figure 2. **Notes:** The estimates are based on the impulse response functions of US variables following the simulated impacts of a monetary policy tightening of 450 bps. The total increase in interest rates is the same in both scenarios, but has different starting dates for the first rate hike for Panel A and has a different aggressiveness of tightening (i.e., path for the rate hikes) for Panel B. "IR" = Inflation Reduction (in pp), "ANOG" = Accumulated Negative Output Gap (in % of GDP), "EPLC" = Excess Price Level Change (in pp in excess of 2%), "SR" = Sacrifice Ratio (calculated as the ANOG/IR), and "PTR" = Price-Output Tradeoff Ratio (calculated as the EPLC/ANOG).

[59] This is consistent with Razin and Loungani (2005), which models how globalization causes monetary policy to put greater emphasis on reducing inflation than narrowing the output gap.

[60] See Brayton, Laubach, and Reifschneider (2014) and Laforte (2018) for background on the FRB/US model.

Figure 16 shows the corresponding impact on the key macroeconomic variables and tradeoffs that are the focus of this paper: the Sacrifice Ratio and its components, the Excess Price Level Change (above that which would have occurred if inflation was 2%); and the Price-Output Tradeoff Ratio. The central bank's decision on when to start raising rates has clear implications for the corresponding tradeoffs for the economy; a late start corresponds to a lower Sacrifice Ratio (due primarily to meaningfully smaller output losses), but at the cost of a larger increase in the price level. The "late" strategy also corresponds to a meaningfully larger Price-Output Tradeoff Ratio, as a relatively greater share of the adjustment to the initial situation of overheating occurs through the price level than output losses.

These simulations correspond to the results from the regressions analysis in Section V.1 in terms of indicating a later liftoff corresponds to a lower Sacrifice Ratio, larger increase in the price level, and greater share of the adjustment occurred through prices than output gaps. The mechanisms are somewhat different, however, as the regression results indicate that a delayed start corresponds to larger output losses (instead of the smaller losses predicted in the simulations) and more disinflation. The regression results may also capture a secondary effect of a late start on output—that the central bank needs to tighten policy for longer in response to the longer inflation overshoot and higher price level —which is not captured in the simulation.

For a second simulation, we assess the impact of an "aggressive" versus "gradual" path for rate hikes. We begin from the same starting point as above (with the economy overheating) and assume lift off occurs at the same time in each case. In the aggressive case, the policy rate is quickly hiked by 4.75pp in one year and then reduced by 25bp and held steady at 4.5%, while in the "gradual" case, the policy rate is hiked more slowly by 4.5pp over 2 years and then held constant at 4.5%. Appendix Figure 2b shows the resulting paths for the same set of macroeconomic variables. As expected, a more aggressive adjustment corresponds to lower inflation at the end of the window and a smaller increase in the price level, but at the cost of slower GDP growth, larger output losses and a larger increase in unemployment (relative to neutral).

Figure 16 shows that this choice between interest rate paths also has clear implications for the corresponding tradeoffs facing the economy; a more aggressive path corresponds to a much larger Sacrifice Ratio (mainly due to much larger output losses) combined with a smaller increase in the price level. The "aggressive" strategy also implies more adjustment through output losses than prices (and therefore a lower Price-Output Tradeoff Ratio), while the gradual strategy implies more adjustment through prices than activity. These patterns are consistent with the regression results in Section V.I.

It is important to highlight that these illustrative simulations do not answer which strategy is optimal. The optimal choice for monetary policy involves the relative weights given to output losses, unemployment increases, inflation overshoots, and changes in the price level. The simulations do, however, provide more insight into how different central bank strategies affect different macroeconomic variables and the related tradeoffs.

To summarize, these illustrative simulations of the impact of different monetary policy strategies based on the FRB/US model are largely consistent with the regression results in Section V.1., as well as existing literature on Sacrifice Ratios. They also clarify the tradeoffs facing central banks when they choose a strategy for tightening monetary policy. Delaying liftoff corresponds to lower Sacrifice Ratios, but at the cost of a larger increase in the price level, with mixed evidence of the impact on output gaps. A more aggressive tightening path corresponds to smaller increases in the price level, but at the cost of larger output losses and higher Sacrifice Ratios. Interpreting large disinflations as a successful policy is difficult, as this can (at least partially) reflect prior policy choices supporting a larger inflation overshoot. The results also suggest how different monetary policy strategies can affect the channels by which an economy adjusts to overheating; delaying liftoff and raising rates more gradually causes more of the adjustment to occur through prices (instead of output losses), while starting to tighten earlier and/or raising rates more aggressively causes more of the adjustment to occur through output losses.

VI. Conclusions

When central banks adjust monetary policy, they often balance difficult tradeoffs, including how much weight to put on various goals and on different costs, benefits and risks. This evaluation helps determine the direction, magnitude, speed and overall strategy for adjusting interest rates and monetary policy more broadly. This paper explores how these adjustments and the corresponding tradeoffs have changed for 24 advanced economies from 1970 to 2024. We first develop a historical database of rate cycles to explore how strategies for adjusting policy interest rates and corresponding macroeconomic variables have evolved. Then we focus on tightening phases—when the tradeoffs tend to be more challenging—and assess how output losses have corresponded to disinflations and the corresponding Sacrifice Ratios. We also evaluate measures which generally receive less attention: the excess change in the price level (i.e., difference from that assuming 2% inflation) and how much of the adjustment occurs through increases in prices relative to output losses.

These historical and cross-country comparisons highlight the unprecedented tradeoffs in response to the inflation spike after the COVID-19 pandemic. Central banks were relatively slow to start raising interest rates (compared to the evolution of macroeconomic variables) but then raised policy rates more aggressively than during recent tightening phases. Inflation spiked to levels not experienced since the early 1980s, but the spike was largely reversed within three years (on average across our sample). This disinflation corresponded to fairly small output losses and generated historically low Sacrifice Ratios, but also the largest annual increase in the price level (in excess of what would have occurred with inflation at 2%) in over 40 years. A larger share of the macroeconomic adjustment during this period occurred through prices (instead of output losses) than has historically occurred.

Our empirical results (supported by simulations based on the FRB/US model) show how these monetary policy decisions, combined with the pre-existing credibility of the central banks in our sample, contributed to the unusual evolution of macroeconomic variables during the post-pandemic period. The initial delay in starting to hike interest rates lowers the Sacrifice Ratio, but at the cost of a larger increase in the price level. The subsequent more aggressive tightening path reduces inflation more quickly (and mitigates the effects on the price level), but generates larger output losses and a higher Sacrifice Ratio. Stronger central bank credibility, however, mitigates these negative effects of more aggressive rate increases on the Sacrifice Ratio and output losses.

These patterns are broadly consistent with the unusually low Sacrifice Ratios, large disinflations, and large price level increases during the post-pandemic period. The results also highlight that interpreting large disinflations (and the corresponding reduction in the Sacrifice Ratio) as a successful policy is challenging, as this often reflects (at least partly) a prior policy choice contributing to the initial inflation overshoot.

The one aspect of the post-pandemic recovery that is less well explained by the analysis above is the modest output losses that occurred despite the aggressive rate hikes (even after accounting for the mitigating effect of strong pre-existing central bank credibility). There are two potential explanations not incorporated in our analysis. First, the path of rate hikes may not have been as "aggressive" as generally perceived. The analysis of historical rate cycles provides some support for this argument; although recent rate hikes were more aggressive than tightening phases since 1999 by most measures, they were not as aggressive as tightening phases over 1970-1998 by most of the same metrics—periods when inflation was also much higher than over 1999-2019. The path of real interest rates, or a broader measure of the monetary policy stance, may also be important (as compared to the nominal rates that are the focus of this paper) when assessing the aggressiveness of policy and corresponding impact on activity, especially during periods of high inflation or structural change.

Second, and potentially even more important, is the impact of policies other than monetary policy in explaining the relative stability of output during the post-pandemic inflation surge. This includes the substantial fiscal stimulus, policies to limit the impact of energy price increases (including price caps and subsidies), the fairly rapid easing of supply constraints, and other delayed effects of the pandemic (such as the support to consumption from accumulated savings). None of these policies are included in our analysis, but many played critical roles in supporting the economic recovery after the pandemic.

This analysis of the tradeoffs for monetary policy, however, helps explain a disconnect between the views of many central bankers and the public on the success of this post-pandemic adjustment. From the viewpoint of many central bankers, the post-pandemic disinflation was successful; inflation fell sharply and is largely on track to return to target with minimal output loss (at least before any new shocks). From this viewpoint, very little "sacrifice" was required for central banks to meet their mandates, despite inflation spiking to levels not seen since the early 1980s. Opinion polls, however, suggest high levels of dissatisfaction with central banks and governments, and research suggests that this surge in inflation and increase in the price level have contributed meaningfully to election outcomes in recent years (e.g., Federle et al. 2024). Research summarized above shows that households care about the increase in the price level, not just inflation, and that large or prolonged increases in inflation can affect wage and price-setting dynamics, and thereby the transmission of monetary policy throughout the economy. The change in the price level is not captured directly in many central bank frameworks.

A concrete recommendation for how central banks should incorporate changes in the price level into their monetary policy decisions would require a full welfare analysis, a more detailed economic model, and more careful consideration of the additional shocks affecting the economy (including the role of fiscal policy and supply shocks). Our results suggest, however, that in the future central banks may want to place more weight on the length of time and extent to which inflation deviates from target (i.e., changes in the price level) when considering the timing and path of rate adjustments. This does *not*, however, imply that central banks should target the price level or that they should change their formal frameworks.[61] In many cases the optimal adjustment to shocks should involve an adjustment in the price level that deviates from what would have occurred if inflation remained at 2%. In response to certain shocks, the adjustment in interest rates that would be required to target the price level would involve extremely large output losses that are unlikely to be optimal in any reasonable framework.

Nonetheless, there are several ways that central banks could learn from the last few years and place greater weight on adjustments in the price level without constraining their ability to adjust to a range of shocks and situations. First, central banks could be more explicit in their communications about the expected path for the price level when presenting different monetary policy strategies and explain why a potentially large change in the price level is justified given the policy options. Second, when discussing price stability, central banks could clarify that this means stabilizing inflation at target and considering the length and extent of deviations of inflation from target (in both directions). This could include specifying the length of time by which inflation should return to target (such as two years). This is already done in a number of central banks, but for those with no explicit "time target", this could provide an additional incentive to try to limit the duration of any inflation deviations or explain why a longer deviation is optimal in certain circumstances (such as in the presence of longer lasting supply shocks).

Third, central banks could adopt language in their frameworks that commits to a "more forceful" response to inflation deviations from target that are larger and longer lasting; some central banks (such as the ECB) already use this language to address situations when inflation is below target and interest rates are near the lower bound, but this commitment could be made symmetric. Finally, central banks could consider removing any constraints in their frameworks that limit their ability to respond in a timely fashion when inflation is expected to deviate substantially from target (or has already deviated substantially from target), i.e., that relegates price stability to a secondary consideration in order to attain other goals. This does not mean ending dual mandates (such as in the United States) but instead ensuring that a deviation in one part of the mandate will not overly constrain the central bank's ability to respond to large deviations in the other part.[62]

Macroeconomic developments around the pandemic are unlikely to be repeated, and monetary policy frameworks should be designed for a range of scenarios and not overweight the most recent experience. Nonetheless, the lessons from the last few years, particularly when assessed in the longer historical and cross-country context in this paper, suggest that when central banks discuss the many tradeoffs for monetary policy, the corresponding changes in the price level from different strategies should be part of this discussion.

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[61] For discussion of the advantages and disadvantages of price-level targeting, see Ambler (2009) or Bernanke (2019). Another approach could be nominal GDP targeting, as discussed in Woodford (2012) and Binder (2024). While this approach has the benefit of incorporating changes in activity and the price level, it has a number of disadvantages, including challenges communicating to the public and measuring potential GDP.

[62] An example of this type of constraint is the Federal Reserve's FAIT framework, which makes it more difficult to raise interest rates in response to an expected (or ongoing) overshoot of inflation until the economy reaches full employment.

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Appendix 1: Identification of Rate Cycles

Section II discusses the application of the BBQ algorithm in Harding and Pagan (2002) to identify local maxima and minima in policy interest rates and thereby define rate cycles. A simple application of this algorithm to the data on policy interest rates, however, can be problematic due to several characteristics of the interest rate data—particularly long windows when there is no change in i_t. To address this and more accurately identify the turning points of easing and tightening phases consistent with changes in central bank policy stances, we start with the dates identified in the BBQ algorithm, but then make several adjustments and add additional criteria for a month to qualify as a turning point. This appendix describes the process used to identify the easing and tightening phases in more detail.

First, we apply the BBQ algorithm in Harding and Pagan (2002) to the policy rate data, with one adjustment. Early in the sample, when the policy rate is market-determined in some countries, there are occasionally sharp spikes in the rate that appear to primarily reflect shifts in market sentiment, shifts that are quickly reversed. To avoid classifying these temporary market-based fluctuations as turning points in a cycle, we smooth across these spikes by replacing i_t with $(i_{t+1} + i_{t-1})/2$ if the policy rate changes by more than 500 basis points in one month.

Second, we set three parameters for the BBQ algorithm: (1) the window on each side of a local maxima and minima must be at least 18 months; (2) a full cycle (including both tightening and easing phases) must be at least 36 months; and (3) any individual phase of a cycle (either a tightening or easing phase) must last at least 7 months. The first two criteria require relatively long windows on each side of a turning point and for the full cycle in order to capture changes in policy which are not reversed quickly; this also avoids classifying changes in policy rates that largely reflect market movements as turning points in the policy cycle. The shorter window for individual phases in a cycle, however, still allows short periods when central banks adjust policy rates to qualify as an easing or tightening phase (such as a rapid reduction in rates over one month in response to a shock).

Third, we require i_t to increase or decrease for month *t* to qualify as the start of a tightening or easing phase, respectively. This requirement sounds obvious—but is necessary as the dating algorithm incorrectly identifies about 10 false "turning points" during long periods when there is no change in interest rates. This requirement is also needed to correctly date turning points when the exact month identified by the algorithm is slightly off due to substantial volatility in the data or the smoothing around spikes (as mentioned above). Also, if any of these adjustments causes a "false" phase to be dropped, then the subsequent phase must also be dropped as an easing phase must be followed by a tightening phase (and vice versa).[63]

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[63] For example, the algorithm initially identified Switzerland as starting a tightening phase in July 2016 and starting an easing phase in December 2020—despite there being no change in Switzerland's policy rate from January 2015 (when the rate was lowered to -0.75) through May 2022. Therefore, we drop the falsely identified turning point in July 2016, as well as in December 2020, so that Switzerland remains in an easing phase from 2010 (when it started lowering rates) through May 2022 (when its first rate hike since before 2015 meets the criteria to start a tightening phase).

Fourth, we require that the change in the policy rate identified as a turning point must be "meaningful or lasting". To qualify as "meaningful or lasting", we require: (a) either a change in rates of at least 50 basis points over one month, or (b) at least one rate changes (of any size) over a year after the first change such that the policy rate is at least 30 basis points higher/lower one year after the first change in rates. These dual criteria allow for a turning point to occur if there is only one adjustment in the policy rate but the adjustment is sufficiently large.[64]

These criteria also allow for turning points to occur with more modest and gradual rate adjustments. An example is the Federal Reserve's 25bps rate increase in December 2015, which was not followed by another rate increase for a year (and then followed by a series of rate hikes). It is worth highlighting, however, that several periods when rates are adjusted and then reversed within a year will not meet these "meaningful or lasting" criteria and thereby not qualify as a turning point. For example, the ECB increased rates 25bps in April 2011 and July 2011, and then lowered rates by the same amounts in November and December of the same year, such that the policy rate in March 2012 was at the same level as in March 2011. The two, short-lived rate hikes do not qualify as a turning point that starts a tightening phase and are instead classified as a "false start" during a longer easing phase.

Fifth, if a country adopts a new QE program but is not already in an easing phase, or starts a new QT program but is not already in a tightening phase, we allow the announcement of the new balance sheet program to count as a turning point, i.e., the start of a new easing or tightening phase, respectively, even if there is no corresponding change in the policy rate.[65] In practice, this criteria rarely binds as most central banks lower interest rates before starting QE and raise rates before starting QT, but it could be important if a country is near the lower bound and choses to use balance sheet policy to ease monetary policy instead of lowering rates further.[66]

Sixth, we make several adjustments to the start dates of cycles due to challenges using the algorithm at the start of time series or when there is a long period during which rates are not adjusted in both directions. This requires three adjustments: (1) Identify the start of Portugal's initial tightening phase as March 1977, which is immediately after the only rate cut over an

[64] An example is the Bank of Canada 150bps rate cut in March 2020, which was not followed by any subsequent cuts (as rates were at the lower bound).

[65] As discussed in Section II, we only include announcements of new asset purchase programs involving government bonds and primarily intended for monetary policy goals (i.e., not market dysfunction). More specifically, for the US, we include the LSAP for Treasuries (announced March 2009), but do not include the LSAP for agency debt and MBS (announced November 2008). For the Euro area, we include the OMT (announced August 2012) and PSPP (announced January 2015), but do not include the Corporate Bond Purchase Programme (announced October 2011) or Asset-backed Securities Purchase Program (announced September 2014). For the UK, we include the announcement of the start of QT (February 2022), but do not include subsequent announcements adding active bond sales to the ongoing passive QT, or the various announcements about delays and updates start dates for QT around the LDI crisis in 2022. Defining whether an asset purchase program is intended primarily to achieve price stability and support activity (i.e., monetary policy goals) or to provide liquidity and stabilize markets is not always clear, so we include any programs with joint goals in our dummy variables. We do not include programs that are intended to be short-term to provide liquidity, such as the asset purchases announced by the BoE in response to the LDI crisis in 2022.

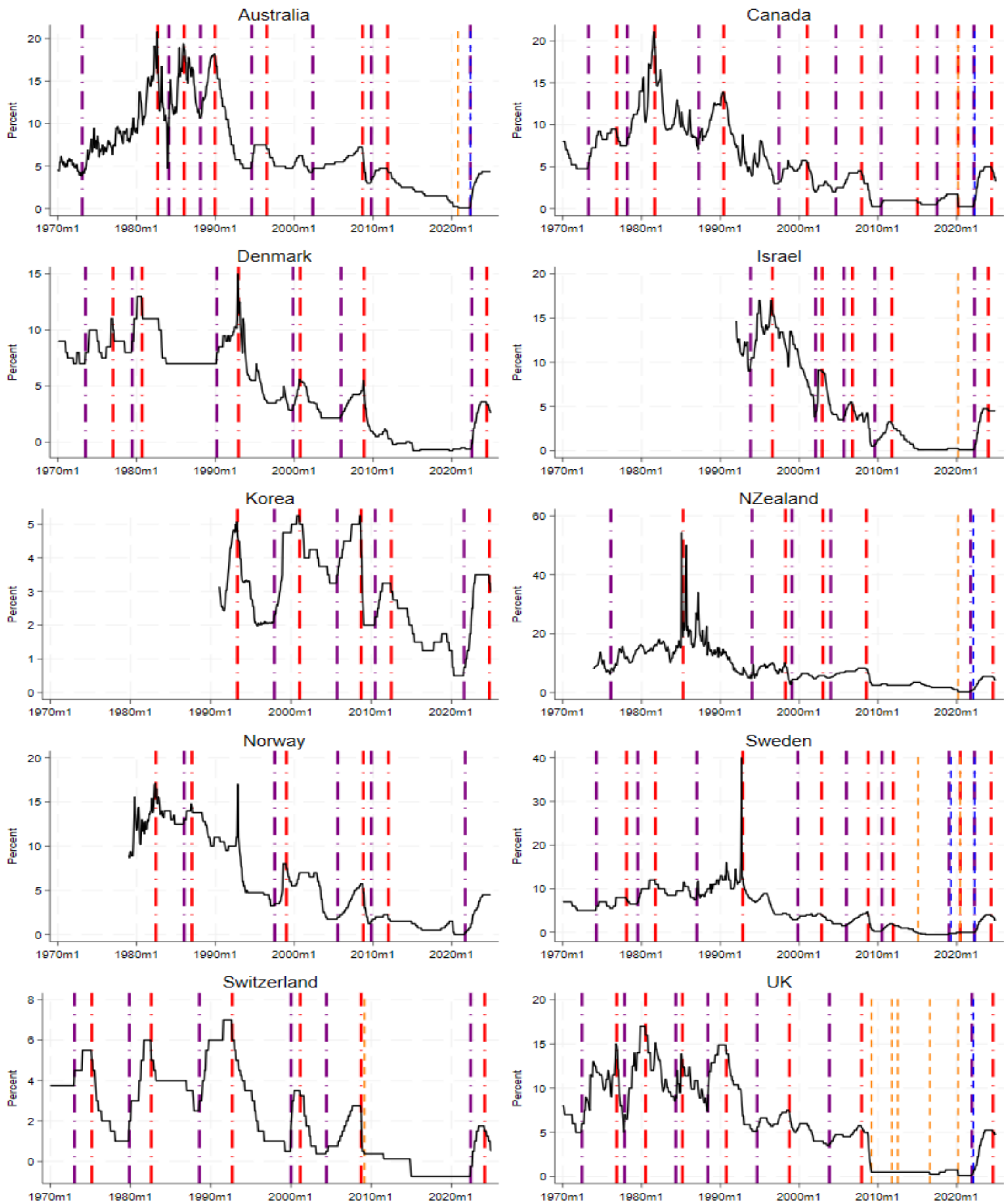
[66] In our sample, there are only two episodes when the announcement of a new balance sheet program qualifies as a turning point to identify a new phase. First is the start of an easing phase in Sweden in March 2020, when the Riksbank announced a new QE program but did not lower interest rates (which were at zero). Second is the start of a tightening phase in Sweden in April 2022, when the Riksbank announced the start of QT but did not start raising the policy rate until May.

extended tightening phase—a phase which does not have a clear enough turning point for the algorithm to define the start of the tightening phase; (2) Identify the start of the ECB's initial tightening phase as November 1999, the date of the first rate increase after the April 1999 rate cut and the beginning of a series of rate hikes—a turning point which the algorithm does not capture with the time series starting in 1999;[67] and (3) identify the start of Denmark's post-pandemic tightening phase as July 2022 (the same as for the ECB), a turning point which is not captured in the algorithm due to the extended prior period with small changes in its negative policy rate.

Finally, our data set currently ends in December 2024. If a central bank adjusts its policy rate near the end of the sample in a way that is likely to become the start of a new easing or tightening phase, enough time may not have elapsed for this policy change to be identified as a turning point according to the mechanical application of the Harding and Pagan (2002) algorithm. This could lead to inaccurate statistics describing the prior phase. For example, the ECB lowered interest rates in June 2024 as the start of an easing phase, and if this does not qualify as a turning point, the second half of 2024 would still be included in statistics for the tightening phase which began in July 2022. To adjust for this, if a central bank is in a tightening (easing) phase at the start of 2024, but shifts to easing (tightening) the policy rate in 2024, we classify this change as a turning point indicating the start of the next phase (as long as the rate change has not subsequently been reversed). This corresponds to the Bank of Japan being defined as shifting from an easing to tightening phase in March 2024 and the other central banks in the sample shifting from a tightening to easing phase at some point in 2024 (with the exceptions of the Reserve Bank of Australia and Norges Bank, who did not reduce interest rates in 2024 and are therefore defined as still being in their post-pandemic tightening phase).

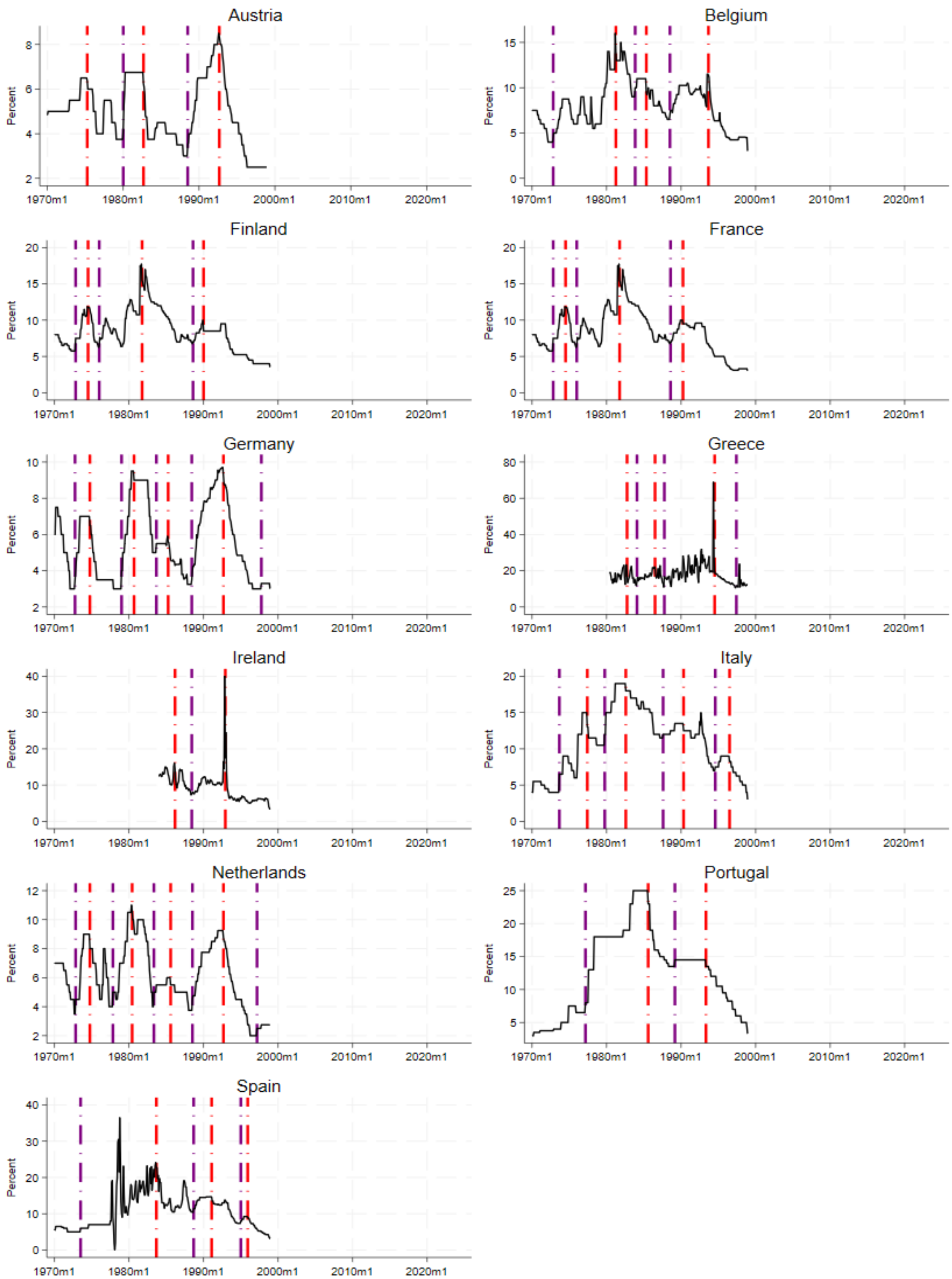
[67] We identify cycles for individual members of the Euro area based on their policy interest rates through end-1998, at which point their easing or tightening phase is defined as ending. Starting in 1999, the Euro area begins its first phase, and the individual member countries no longer have individual phases.

Appendix Figure 1a: Rate Cycles, Other Advanced Economies (non-euro area)



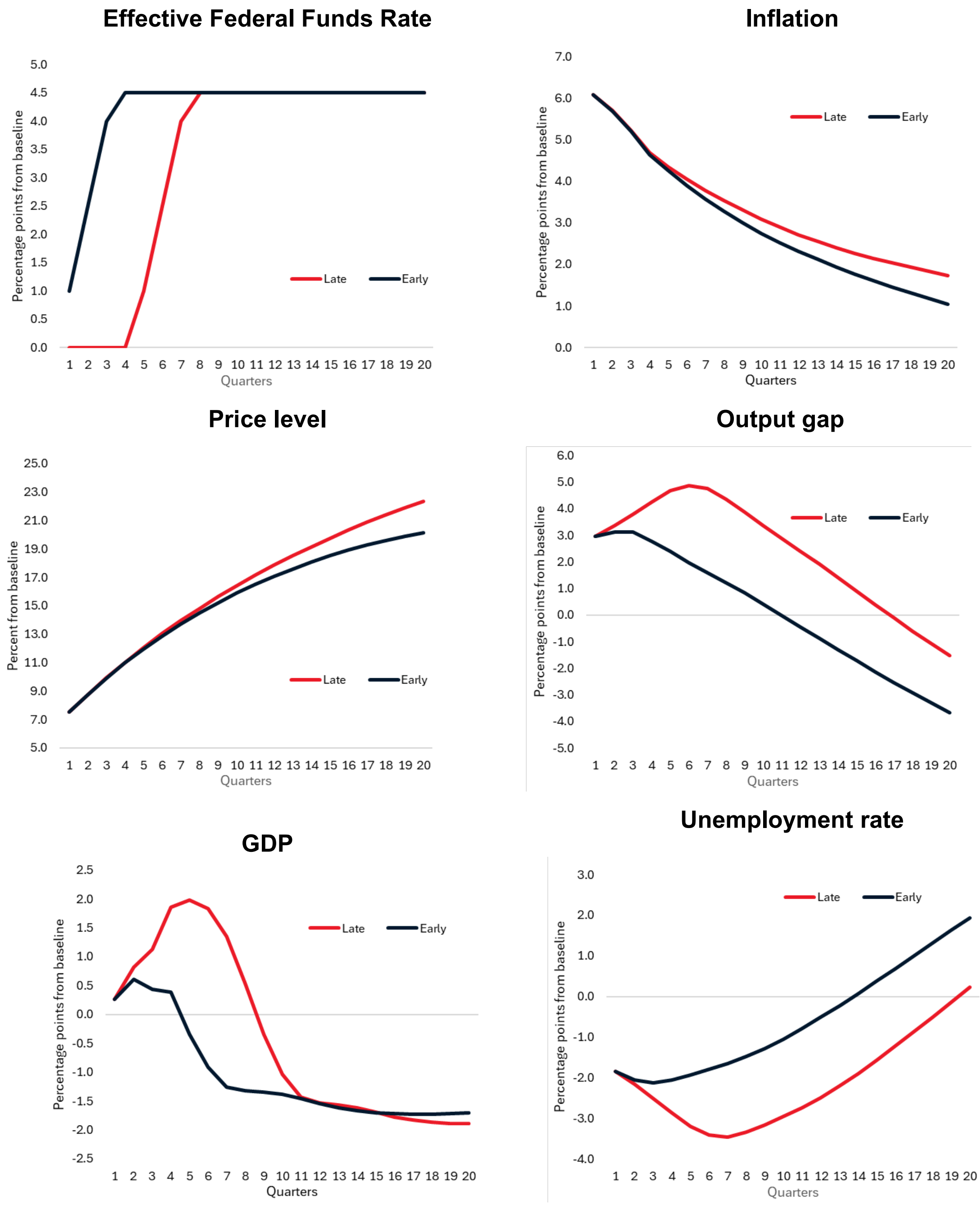
Sources: Authors' calculations based on the data and methodology identifying rate cycles described in Section II, with data from January 1970 through December 2024. **Notes:** The solid black line is the policy interest rate. Dashed purple and red lines indicate the start of tightening and easing phases, respectively. Dashed blue and orange lines represent the announcement of new QT and QE programs, respectively. These QE/QT dates are not turning points that denote the start of an easing or tightening phase unless there is also a red or purple line.

Appendix Figure 1b: Rate Cycles, euro area, pre-ECB



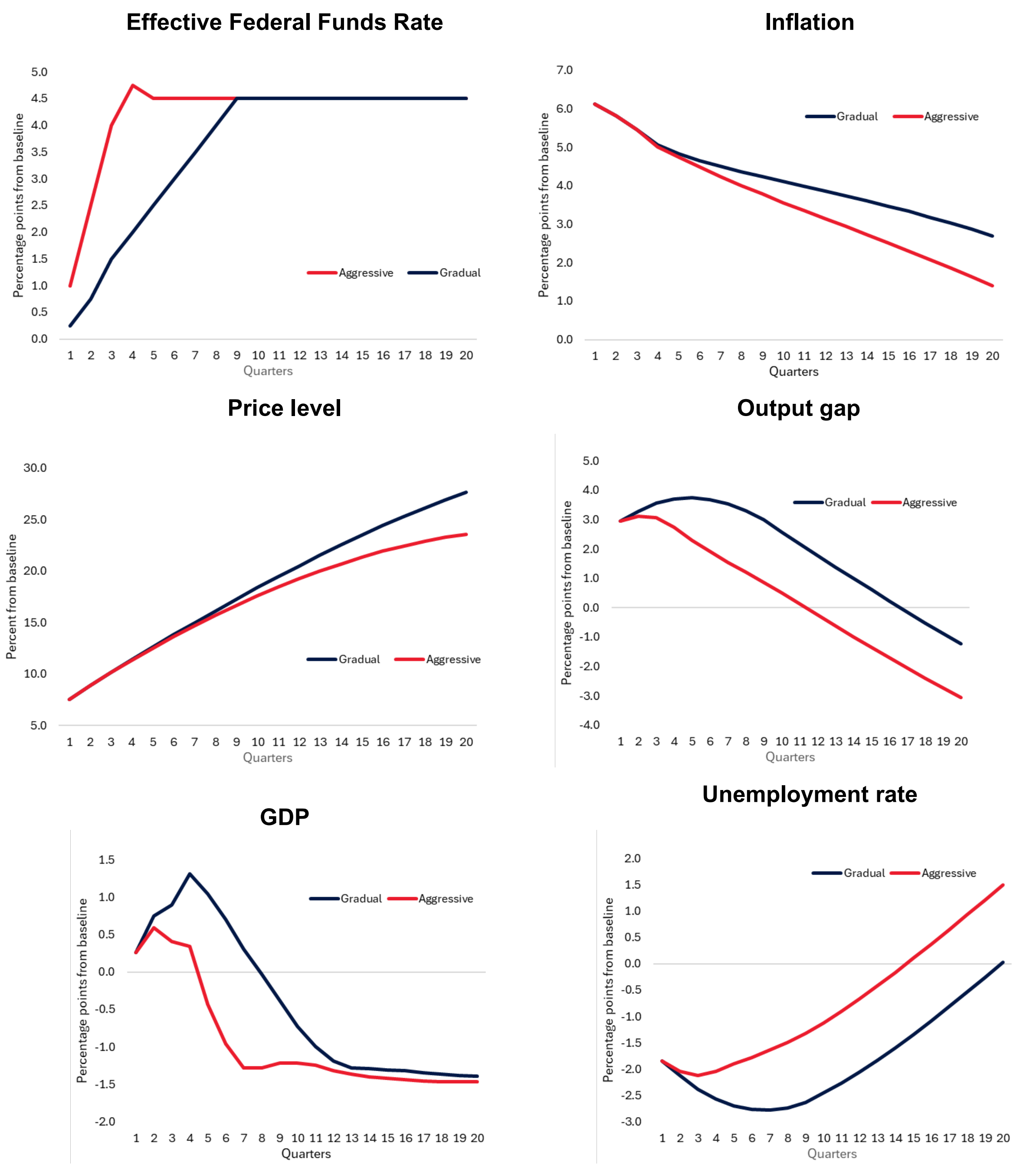
Sources: Authors' calculations based on the data and methodology identifying rate cycles described in Section II, with data from January 1970 through December 2024. **Notes:** See notes to Appendix Figure 1a.

Appendix Figure 2a: FRB/US Simulations of Timing of First Rate Hike



Source: Authors' calculations based on the FRB/US model as explained in Brayton, Laubach, and Reifschneider (2014) and Laforte (2018). **Notes:** The estimates are the simulated trajectory of US variables following a hypothetical monetary policy tightening that involves increasing the policy rate by 450 bps in total for both scenarios. In the "Late" scenario, this increase in rates begins 4 quarters later than in the "Early" scenario.

Appendix Figure 2b: FRB/US Simulations of Aggressiveness of Tightening Phase



Source: Authors' calculations based on the FRB/US model as explained in Brayton, Laubach, and Reifschneider (2014) and Laforte (2018). **Notes:** The estimates are simulated trajectory of US variables following a hypothetical monetary policy tightening that involves an increase in the policy rate of 450 bps by the end of the sample both scenarios. In the "Gradual" or "Aggressive" scenario, the policy rate is increased more gradually and there are no additional rate hikes after reaching 450bps, while in the "Aggressive" scenario rates are increase more rapidly to 475 bps before being reduced to 450bps.

Appendix Table 1: Characteristics of Rate Cycles: 1970-2024

	Duration (in months)		Amplitude (total change, pp)		Velocity (pp/first 6 months)		Rates "In Sync" with Phase				Hold Duration (months)	
							# Changes		Pace (pp)			
	Tightening	Easing	Tightening	Easing	Tightening	Easing	Tightening	Easing	Tightening	Easing	Tightening	Easing
Australia	70	81	8.9	-6.6	1.3	-2.0	29	15	0.6	-0.6	12.8	7.3
Austria	43	69	4.5	-4.3	1.8	-1.2	12	16	0.5	-0.3	26.1	23.3
Belgium	79	49	8.6	-7.0	1.2	-3.0	17	18	0.9	-0.5	12.3	2.8
Canada	41	55	4.6	-7.6	1.4	-2.5	11	25	0.4	-0.6	31.7	13.9
Denmark	31	114	4.7	-6.6	1.7	-3.1	8	19	0.9	-0.6	5.5	52.4
Euro area	27	138	2.9	-3.9	1.3	-2.3	9	12	0.3	-0.3	6.5	27.1
Finland	51	90	9.2	-8.2	1.4	-1.2	16	23	0.9	-0.5	0.0	0.0
France	51	88	9.0	-8.5	1.4	-0.7	15	30	0.9	-0.3	1.8	0.0
Germany	32	49	4.4	-4.7	1.3	-1.3	11	13	0.5	-0.5	12.0	10.1
Greece	60	26	12.9	-14.3	6.2	-6.5	28	19	3.4	-1.6	0.5	0.0
Ireland	54	61	32.7	-29.2	0.8	-25.1	28	30	1.5	-1.3	0.0	0.0
Israel	24	87	5.0	-6.3	1.7	-1.4	10	20	0.6	-0.4	5.0	4.7
Italy	36	47	6.6	-6.4	2.2	-1.5	4	10	1.7	-0.9	13.1	8.2
Japan	24	154	3.3	-4.1	1.4	-1.2	4	8	0.7	-0.4	14.6	19.3
Korea	35	77	2.5	-2.7	0.6	-0.9	9	10	0.3	-0.3	15.0	19.6
New Zealand	71	128	8.3	-10.9	1.6	8.4	31	30	0.8	-1.1	10.7	4.4
Netherlands	34	42	4.5	-5.6	1.1	-1.4	7	13	0.7	-0.6	9.9	6.9
Norway	32	100	3.5	-6.5	0.6	-1.3	11	17	0.4	-0.6	7.6	12.8
Portugal	84	58	12.7	-11.3	4.7	-3.2	4	11	2.4	-1.1	40.7	7.4
Spain	98	50	15.3	-9.7	1.4	-2.9	34	21	2.4	-0.8	6.4	2.3
Sweden	42	63	3.4	-4.6	1.1	-1.7	11	13	1.0	-0.4	8.8	12.0
Switzerland	38	106	3.3	-4.2	1.3	-1.7	6	8	0.6	-0.5	10.9	61.3
UK	42	102	6.2	-6.5	2.0	-1.8	10	14	0.9	-0.6	8.3	3.3
US	34	56	6.7	-5.7	1.1	-2.6	16	12	0.5	-0.6	9.6	11.1
Full Sample												
Mean	***47***	***79***	***7.7***	***-7.7***	***1.7***	***-2.6***	***14***	***17***	***1.0***	***-0.6***	***11.2***	***12.9***
Median	***42***	***73***	***5.6***	***-6.5***	***1.4***	***-1.7***	***11***	***15***	***0.7***	***-0.6***	***9.7***	***7.8***
St. Dev.	***20***	***33***	***6.3***	***5.3***	***1.2***	***5.4***	***9***	***7***	***0.8***	***0.3***	***9.7***	***15.5***
Min	***24***	***26***	***2.5***	***-2.7***	***0.6***	***8.4***	***4***	***8***	***0.3***	***-0.3***	***0.0***	***61.3***
Max	***98***	***154***	***32.7***	***-29.2***	***6.2***	***-25.1***	***34***	***30***	***3.4***	***-1.6***	***40.7***	***0.0***

Sources: Authors' calculations based on the rate cycles described in Sections II and III.
Notes: Duration is the length of the phase in months (including any period at the end of the phase when rates are on hold). Amplitude is the sum of rate changes in percentage points (pp) over the entire phase (including any rate changes in either direction). Velocity is the total change in the policy rate in pp over the first six months of the phase. Rates in-sync with phase is the mean number or mean size in pp of rate changes in "in-sync" with the phase, i.e., rate increases for a tightening phase and rate decreases for an easing phase. A holding period is the number of months after the last rate increase during a tightening phase, or after the last rate decrease <u>and</u> end of any government QE programs during an easing phase. Means are calculated as the average for each economy across all easing or tightening phases. EA is the euro area, with policy rate data starting in January 1999. Individual members of the euro area only include policy rate data through December 1998. Otherwise, policy rate data covers a period from January 1970 through December 2024, with a later start for some economies due to data limitations.

Appendix Table 2: Characteristics of Rate Cycles over Time

	Duration		Number of Rate Changes		Pace (pp/change)		Velocity (first 6 months)		Amplitude (in pp)		Hold Duration (in months)	
	Tightening	Easing	Tightening	Easing	Tightening	Easing	Tightening	Easing	Tightening	Easing	Tightening	Easing
Full Period	41.5	72.6	11.2	15.5	0.7	-0.6	1.4	-1.7	5.6	-6.5	9.7	7.8
Pre-ECB: 1970-1998	41.4	60.6	13.0	16.1	0.9	-0.6	1.4	-2.5	7.7	-8.2	6.4	7.4
Post-ECB: 1999-2024	35.7	105.3	8.8	10.9	0.3	-0.3	1.0	-1.2	3.1	-3.9	9.7	13.1
1970-1984	40.3	46.9	9.8	10.6	1.0	-0.8	2.0	-2.0	10.3	-6.5	6.1	3.5
1985-1998	39.7	60.6	10.9	20.0	0.7	-0.5	1.5	-1.6	4.5	-8.2	3.2	5.1
1999-2007	37.0	55.0	10.0	12.0	0.3	-0.4	0.8	-1.3	2.6	-4.0	5.9	6.5
2008-2019	34.5	112.8	8.6	10.7	0.3	-0.4	0.6	-1.1	2.2	-3.5	8.1	14.5
2020-2024	28.7	126.0	10.0	11.0	0.4	-0.3	1.7	-0.8	4.5	-3.2	11.0	3.0
Change or percent change from 1970-84 period to 2008-19 period												
Change	***-5.8***	***65.9***	***-1.2***	***0.0***	***-0.8***	***0.4***	***-1.4***	***0.9***	***-8.1***	***3.0***	***1.9***	***11.0***
% Change	***-14%***	***140%***	***-13%***	***0%***	***-75%***	***-53%***	***-71%***	***-46%***	***-79%***	***-46%***	***32%***	***319%***

Sources: Authors' calculations using the turning points for rate cycles listed in Table 1 and data ending in December 2024.
Notes: This table shows medians across all tightening or easing phases within the given period, See notes to Appendix Table 1 for details.

Appendix Table 3: Data Appendix

A. Variables Measuring Cycle Characteristics

Variable	Variable Description (unit)	Source
Policy rate	Nominal monetary policy interest rates by central banks (in %).	BIS, Haver Analytics, OECD
Headline CPI	Headline Consumer Price Index for all economies except the United States, which is based on the Headline Personal Consumption Expenditures (PCE) index. Inflation rates are calculated using monthly data as the % change in the price index relative to 12 months earlier.	OECD, Haver Analytics, Ha, Kose, Ohnsorge (2023)
Core CPI	Core Consumer Price Index, following OECD classification: Headline CPI excluding food and energy components for all economies except the United States, which is based on the core PCE index. Inflation rates are calculated using monthly data as the % change in the price index relative to 12 months earlier.	OECD, Ha, Kose, Ohnsorge (2023), Haver Analytics
Output	Real gross domestic product index based on chain-linked volume (in local currencies). The reference year is 2015.	OECD, Haver Analytics
Output gap	% deviation of real GDP from trend (potential) GDP. For our baseline measure, we use the output gap based on HP-filter. In other specifications, we also use alternative methods of calculating the output gap, including using a trend based on the Baxter-King filter and Hamilton filter, or OECD estimates of the output gap based on production function approach. We also calculate the employment gap using the long-term trends (OECD) and unemployment gap based on HP-filter.	OECD, Haver Analytics
Industrial Production	The industrial production index covers the volume of production in sectors such as mining, manufacturing, electricity, gas, steam, and air conditioning. The reference year is 2015 (OECD) unless specified otherwise.	OECD, Haver Analytics
Unemployment rate	Unemployment rate (in %): unemployment/labour market participation	OECD
Employment	Number of persons employed with age 15 and over (in thousands)	OECD, IFS, ILO, FRED
Oil price	Nominal oil prices (average of Dubai, WTI, and Brent oil prices).	World Bank (Pink sheet database)

Notes: Sample period is from January 1970 through December 2024, albeit some data for the end of the sample period was not available when the data was collected (February 4, 2025). Economies included are: Australia, Austria, Belgium, Canada, euro area, Germany, Denmark, Spain, Finland, France, Greece, Ireland, Israel, Italy, Japan, Korea, Netherlands, New Zealand, Norway, Portugal, Sweden, Switzerland, the United Kingdome, and the United States.

B. Variables Used in Baseline Regression Analysis

Category	Indicator	Variable Description	Source
Tradeoffs (dependent variables)	Sacrifice Ratio (SR)	The negative of the ratio of ANOG to Inflation Reduction, with both components defined below, over the tightening window (the tightening phase plus a lag of 12 months).	Authors' calculations
	Accumulated Negative Output Gap (ANOG)	Sum of negative output gaps over the tightening window. Output gaps are % deviations of real GDP from trend (potential) GDP. For our baseline measure, we use the output gap based on the HP-filter. In sensitivity tests we use the other measures of the output gap listed in Appendix Table 3A.	Authors' calculations
	Inflation Reduction (IR)	Reduction in headline inflation from peak to subsequent trough during the tightening window. For our baseline measure we use headline CPI inflation (or PCE inflation for the US), and in sensitivity tests we use core CPI inflation.	Authors' calculations
	Excess Price Level Change (EPLC)	The increase in the headline price index from 12 months before the start of the tightening phase through 12 months afterwards in excess of the increase in the price level that would have occurred if inflation stayed at 2%. In sensitivity tests we also use the price changes in core price index.	Authors' calculations
	Price-Output Tradeoff Ratio (PTR)	The ratio of the Excess Price Level Change (EPLC) to ANOG, with both components defined above, over the tightening window.	Authors' calculations
Central Bank Strategy	Delayed Start	A principal component calculated such that a higher value indicates a later "liftoff" (first rate hike during a tightening phase) relative to underlying macroeconomic conditions. The four macro variables used to calculate the principal component are: headline inflation, core inflation, the output gap (based on the HP filter) and unemployment gap, all defined in Appendix Table 3A.	Authors' calculations
	Aggressiveness	A principal component calculated such that a higher value indicates a more aggressive path for interest rates during a tightening phase. The variables used to calculate the principal component are: (1) the number of rate hikes; (2) the pace of rate hikes (i.e., average size); (3) the amplitude of rate hikes (i.e., total increase); (4) the initial velocity of rate hikes (over the first six months); and (5) the largest rate hike divided by the average rate hike (to capture the use of "supersized" hikes). See Section III for more details on the calculations of each of these variables.	Authors' calculations
Country Characteristics	Central Bank Credibility	A principal component of 5 measures of central bank credibility, with a higher value indicating greater credibility. The 5 measures are: three central bank transparency indices, one from Dincer and Eichenbaum (2014) and two from Garriga (2025); a measure of central bank turnover from Dreher, Sturm, de Haan (2010) and a central bank independence index from Romelli (2024). The first measure is not available for individual euro area countries, so we calculate the principal component without these measures through 1999 and then use the value for the ECB from 1999.	Authors' calculations
	Labor Market Flexibility	A principal component of 2 measures of labor market flexibility, with a higher value indicating more flexibility. The 2 variables are: (1) An index of labor market flexibility from the Fraser Institute Economic Freedom and (2) a measure of the degree of regulation on hiring and firing practices from the OECD.	Authors' calculations
Shocks	Oil Price Shocks	The variance contribution of oil price shocks to the total variation in inflation as estimated in a factor-augmented VAR with 7 global and domestic shocks, as explained in Forbes, Ha, and Kose (2024).	Authors' calculations

C. Variables Used in Sensitivity Tests for Regression Analysis

Category	Indicator	Variable Description	Source
Country Characteristics	Initial inflation rate	Headline CPI (or PCE for the US) inflation rate one month before the start of the tightening phase.	OECD, Haver Analytics, Ha, Kose, Ohnsorge (2023)
	Exchange rate flexibility	A principal component of two measures indicating the flexibility of a country's exchange rate, with higher values indicating more flexibility. The two variables are: (1) A classification of the country's de jure regime from Ilzetzki, Reinhart, and Rogoff (2019); and (2) a classification of the country's de facto regime from Shambaugh (2019).	Authors' calculations
	Financial openness	A principal component of three measures of capital account openness, with a higher value indicating more openness. The three variables are: (1) a country's degree of capital openness from Chinn and Ito (2006); the ratio of international assets and liabilities to GDP from Lane and Milesi-Ferretti (2007); and (3) a country's degree of capital account openness from Quinn and Toyoda (2008).	Authors' calculations
	Trade openness	A principal component of three measures of trade openness, with a higher value indicating more openness. The three variables are: (1) trade to GDP from Ha, Kose and Ohnsorge (2019); (2) imports to GDP from the World Bank; (3) the average rate of effectively applied tariffs weighted by import shares for each partner from WITS.	Authors' calculations
Shocks	Global shocks	The total variance contribution of global shocks (including global demand, global supply, oil prices, and global monetary policy shocks) to the variation in inflation as estimated in a FAVAR model in Forbes, Ha and Kose (2024).	Authors' calculations
	Supply shocks	The total variance contribution of all supply shocks (including global supply, oil prices, and domestic supply shocks) to the variation in inflation as estimated in a FAVAR model in Forbes, Ha and Kose (2024).	Authors' calculations
	Demand shocks	The total variance contribution of all demand shocks (including global demand and domestic demand) to the variation in inflation as estimated in a FAVAR model in Forbes, Ha and Kose (2024).	Authors' calculations

Appendix Table 4:
Sacrifice Ratios and Tradeoffs during the Post-Pandemic Tightening Phase: By Economy

	ANOG (% of GDP)	Inflation Reduction		Sacrifice Ratio		Excess Δ in Price Level		Price-Output Tradeoff
		Headline	Core	Headline	Core	Headline	Core	
Australia	-0.4	5.0	3.3	0.1	0.1	4.5	4.3	24.4
Austria	-1.0	9.4	6.1	0.1	0.2	5.9	5.1	14.6
Belgium	-0.3	11.9	4.5	0.0	0.1	4.6	3.9	39.5
Canada	-0.1	6.5	3.7	0.0	0.0	2.7	2.3	63.0
Denmark	-0.6	10.0	4.9	0.1	0.1	2.2	1.1	8.8
Euro area	-0.3	8.9	3.0	0.0	0.1	4.4	2.5	39.4
Finland	-1.2	8.4	6.1	0.1	0.2	3.5	3.1	7.6
France		5.2	2.3			2.3	0.7	
Germany	-0.4	7.2	3.4	0.0	0.1	4.0	2.5	28.1
Greece	0.0	10.5	3.9	0.0	0.0	4.8	3.5	581.9
Ireland	-5.9	8.5	4.7	0.7	1.3	4.8	3.5	2.0
Israel	-2.5	2.9	3.5	0.9	0.7	2.3	1.9	2.5
Italy	-0.2	11.2	3.3	0.0	0.1	3.4	1.0	35.4
Netherlands	-0.9	14.9	4.0	0.1	0.2	5.2	3.4	14.8
New Zealand	-1.0	5.1	3.6	0.2	0.3	4.2	3.9	13.3
Norway	-0.9	5.3	3.7	0.2	0.2	3.2	2.0	12.5
Portugal	-0.1	8.7	5.3	0.0	0.0	3.9	3.2	114.1
South Korea	-0.4	5.1	2.4	0.1	0.2	1.7	0.7	13.3
Spain		9.3	2.8			4.1	2.5	
Sweden	-0.9	11.5	10.1	0.1	0.1	5.2	5.1	16.0
Switzerland	-0.4	2.8	1.3	0.2	0.3	-0.2	-1.1	-1.3
UK	-0.2	9.3	4.0	0.0	0.0	5.2	3.9	88.6
US	0.0	5.1	3.0	0.0	0.0	3.1	2.9	228.4
Median	***-0.4***	***8.5***	***3.7***	***0.1***	***0.1***	***4.0***	***2.9***	***16.0***
Mean	***-0.8***	***7.9***	***4.0***	***0.1***	***0.2***	***3.7***	***2.7***	***64.1***
St. Dev	***1.3***	***3.1***	***1.7***	***0.2***	***0.3***	***1.4***	***1.5***	***129.7***
Min	***-5.9***	***2.8***	***1.3***	***0.0***	***0.0***	***-0.2***	***-1.1***	***-1.3***
Max	***0.0***	***14.9***	***10.1***	***0.9***	***1.3***	***5.9***	***5.1***	***581.9***

Notes: The window to calculate each statistic is the economy's post-pandemic tightening phase plus a lag of 12 months though end-2024 if data is available (and a lead of 12 months for price-level indices). ANOG is the accumulated negative output gap based on monthly output gaps calculated using the HP filter. Inflation Reduction is the peak to trough decline based on the monthly CPI headline or core index for all economies except the United States (which is based on the PCE indices). The Sacrifice Ratio is the absolute value of the ANOG relative to Inflation Reduction. The Excess Δ in the Price Level is the increase in the price level over 2%, annualized. The Price-Output Tradeoff is the ratio of the Excess Δ in the Price Level (not annualized) relative to ANOG. There are no statistics for Japan as its post-pandemic tightening phase only began in March 2024. Ratios based on Inflation Reduction are not calculated if inflation is not falling from its peak at the end of the tightening window (i.e., France and Spain in the table above).

Appendix Table 5: Explaining Tradeoffs: Sensitivity Tests

	SACRIFICE RATIO (ANOG/IR)								
	Additional controls					+ country +	Other measures of output gap		
	Baseline	Inflation at t= -1	Trade openness	Financial open & ER	+ period dummies	period dummies	Baxter-King filter	OECD measure	Unemp. gap
Delayed Start	-0.0482	-0.0125	-0.0486	-0.0439	-0.0657	-0.0734	-0.0211**	-0.0878	-0.0202**
	(0.0357)	(0.0773)	(0.0348)	(0.0287)	(0.0568)	(0.0365)	(0.00587)	(0.0534)	(0.00524)
Aggressiveness	0.00501	0.0114	0.00619	0.0312	0.0306	0.0537	0.00838	0.0658	0.0110
	(0.0256)	(0.0243)	(0.0276)	(0.0394)	(0.0236)	(0.0370)	(0.00502)	(0.0427)	(0.00603)
Central Bank Credibility	-0.132**	-0.136**	-0.134**	-0.191***	-0.184**	-0.267*	-0.0348**	-0.255*	-0.0161*
	(0.0394)	(0.0325)	(0.0302)	(0.0349)	(0.0624)	(0.0985)	(0.00906)	(0.119)	(0.00602)
Labor Market Flexiblity	-0.0273	-0.0250	-0.0293	-0.0648*	-0.0571*	-0.0938*	0.00147	0.0871	-0.0124
	(0.0261)	(0.0237)	(0.0305)	(0.0263)	(0.0216)	(0.0400)	(0.0132)	(0.0682)	(0.00790)
Oil Shocks	0.00183	0.00204	0.00187	0.00331	0.00249	-0.00570	0.000970	0.0239***	0.000396
	(0.00719)	(0.00738)	(0.00725)	(0.00783)	(0.00828)	(0.00916)	(0.00171)	(0.00333)	(0.00195)
Additional Controls		-0.0207	0.00428	0.101					
		(0.0274)	(0.0156)	(0.0549)					
				-0.00584					
				(0.0343)					
Observations	***88***	***88***	***88***	***88***	***88***	***88***	***96***	***87***	***89***
R-squared	***0.216***	***0.220***	***0.216***	***0.240***	***0.236***	***0.433***	***0.214***	***0.135***	***0.192***

	ACCUMULATED NEGATIVE OUTPUT GAP (ANOG)								
	Additional controls					+ country +	Other measures of output gap		
	Baseline	Inflation at t= -1	Trade openness	Financial open & ER	+ period dummies	period dummies	Baxter-King filter	OECD measure	Unemp. gap
Delayed Start	-0.186*	-0.544**	-0.193*	-0.192*	-0.261*	-0.273	-0.00806	-0.804*	-0.0118
	(0.0852)	(0.181)	(0.0855)	(0.0874)	(0.120)	(0.224)	(0.0300)	(0.333)	(0.0319)
Aggressiveness	-0.371**	-0.439***	-0.349**	-0.316***	-0.467***	-0.453**	-0.147**	-0.686**	-0.103***
	(0.0999)	(0.0693)	(0.104)	(0.0628)	(0.0786)	(0.145)	(0.0488)	(0.243)	(0.0222)
Central Bank Credibility	0.226*	0.262*	0.180	0.215	0.318*	0.328	0.0415	0.594	0.0285
	(0.0946)	(0.0963)	(0.125)	(0.143)	(0.115)	(0.173)	(0.0312)	(0.364)	(0.0325)
Labor Market Flexiblity	0.121	0.102	0.0854	0.106	0.119	0.0631	0.0145	0.0293	0.0122
	(0.0993)	(0.0671)	(0.131)	(0.134)	(0.0943)	(0.0682)	(0.0395)	(0.276)	(0.0175)
Oil Shocks	-0.00514	-0.00863	-0.00502	2.83e-05	0.00106	-0.00400	0.000530	-0.0436	-0.000863
	(0.0254)	(0.0256)	(0.0249)	(0.0215)	(0.0269)	(0.0310)	(0.00494)	(0.0275)	(0.00332)
Additional Controls		0.212*	0.0780	0.0704					
		(0.0795)	(0.130)	(0.147)					
				0.180					
				(0.179)					
Observations	***108***	***108***	***108***	***108***	***108***	***108***	***117***	***101***	***108***
R-squared	***0.325***	***0.367***	***0.327***	***0.340***	***0.370***	***0.524***	***0.342***	***0.355***	***0.281***

Appendix Table 5 (cont.): Explaining Tradeoffs: Sensitivity Tests

	INFLATION REDUCTION (IR)						
		Additional controls					
	Baseline	Inflation at t= -1	Trade openness	Financial open & ER	+ period dummies	+ country + period dummies	Core Inflation
Delayed Start	1.476***	0.404	1.466***	1.479***	1.254**	1.197***	1.358**
	(0.147)	(0.239)	(0.170)	(0.168)	(0.298)	(0.250)	(0.445)
Aggressiveness	0.581**	0.406*	0.618**	0.490	0.646**	0.825*	0.783**
	(0.160)	(0.153)	(0.202)	(0.237)	(0.187)	(0.310)	(0.275)
Central Bank	0.0697	0.235	-0.0830	0.135	-0.173	0.0467	-0.233
Credibility	(0.186)	(0.215)	(0.130)	(0.314)	(0.0954)	(0.234)	(0.247)
Labor Market	0.532	0.556**	0.420	0.582	0.249	0.337	-0.278
Flexiblity	(0.322)	(0.183)	(0.412)	(0.323)	(0.530)	(0.549)	(0.140)
Oil Shocks	-0.0458	-0.0562*	-0.0456	-0.0584	-0.0602	-0.0374	-0.0295
	(0.0288)	(0.0263)	(0.0249)	(0.0396)	(0.0408)	(0.0360)	(0.0511)
Additional		0.530***	0.239	-0.256			
Controls		(0.0996)	(0.340)	(0.367)			
				-0.510**			
				(0.151)			
Observations	***135***	***135***	***135***	***135***	***135***	***135***	***135***
R-squared	***0.563***	***0.627***	***0.564***	***0.582***	***0.592***	***0.662***	***0.459***

	EXCESS PRICE LEVEL CHANGE (EPLC)						
		Additional controls					
	Baseline	Inflation at t= -1	Trade openness	Financial open & ER	+ period dummies	+ country + period dummies	Core inflation
Delayed Start	2.492**	-1.861***	2.555**	2.331**	2.679**	2.162**	2.462**
	(0.839)	(0.303)	(0.812)	(0.730)	(0.881)	(0.652)	(0.821)
Aggressiveness	1.398	0.686	1.166	1.066	1.240	1.356	1.260
	(1.024)	(0.610)	(0.940)	(0.996)	(0.979)	(1.165)	(0.899)
Central Bank	-1.128	-0.457	-0.153	0.174	0.141	0.287	-1.338
Credibility	(0.882)	(0.285)	(0.400)	(0.405)	(0.710)	(0.469)	(0.873)
Labor Market	-0.956	-0.858	-0.240	-0.127	-0.0210	-0.120	-1.065
Flexiblity	(0.466)	(0.457)	(0.476)	(0.435)	(0.297)	(0.559)	(0.508)
Oil Shocks	0.0937	0.0513	0.0923*	0.0719	0.0133	0.0594	0.0780
	(0.0462)	(0.0421)	(0.0413)	(0.0358)	(0.0377)	(0.101)	(0.0475)
Additional		2.155***	-1.527*	-2.113***			
Controls		(0.207)	(0.606)	(0.397)			
				0.0470			
				(0.337)			
Observations	***135***	***135***	***135***	***135***	***135***	***135***	***135***
R-squared	***0.569***	***0.851***	***0.589***	***0.611***	***0.656***	***0.721***	***0.607***

Notes: Results from estimates of equation (10). See notes to Table 4 for details. All variables are defined in Appendix Table 3. “Financial open & ER” indicates two additional control variables for *Financial Openness* and *Exchange Rate Flexibility*.