CHAPTER 2

Understanding Global Inflation Synchronization

Inflation movements have become increasingly synchronized internationally over time: a common global factor accounts for about 22 percent of changes in national annual inflation rates in the period since 2001. Inflation synchronization has also become more broad-based: while it was previously much more pronounced among advanced economies than among emerging market and developing economies, it has become substantial in both groups over the past two decades. In addition, inflation synchronization has become significant across all inflation measures since 2001, whereas it was previously prominent only for inflation measures that included mostly tradable goods. Greater inflation synchronization over time has coincided with improvements in economic policy institutions in many countries, stronger global trade linkages, and greater similarity of monetary policy frameworks that trigger similar policy responses.

Introduction

Inflation has recently appeared to move in tandem among countries around the globe. As documented in the previous chapter, inflation and inflation volatility have trended downward in advanced economies since the mid-1980s and in emerging market and developing economies (EMDEs) since the mid-1990s, regardless of the price index examined. A wide range of structural factors have contributed to declining inflation in recent decades. These factors appear to have depressed inflation and changed the responsiveness of inflation to global and domestic shocks.

This chapter expands on this analysis by exploring the extent to which global and group-specific factors have driven movements in national inflation rates. A growing number of studies provide evidence on highly synchronized national inflation rates (Hakkio 2009; Cicarelli and Mojon 2010; Auer, Levchenko, and Sauré 2017). Some of these also examine the extent of synchronization in other real and nominal variables, in addition to inflation (Mumtaz, Simonelli, and Surico 2011).

In theory, a wide range of factors could be responsible for the global synchronization of inflation, such as common shocks, similar policy responses, and structural features of economies, including openness to international trade and financial flows. Early studies often highlighted the contribution of

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Note: This chapter was prepared by Jongrim Ha, M. Ayhan Kose, Franziska Ohnsorge, and Filiz Unsal.

synchronized or coordinated monetary policies as a major source of inflation comovement, especially among advanced economies (Clarida, Gali, and Gertler 2002; Rogoff 2003). More recent work has emphasized the roles of international spillovers of technology and increased trade integration through global value chains (Henriksen, Kydland, and Šustek 2013; Auer, Borio, and Filardo 2017).

This chapter expands empirical research on the topic by addressing the following questions:

- How has inflation synchronization among countries evolved over the past four to five decades?
- Which goods and price indexes have been associated with greater inflation synchronization?
- What country characteristics have been associated with greater inflation synchronization?

To answer these questions, the chapter examines synchronization in inflation using a dynamic factor model that allows the estimation of latent global and group-specific factors. In a unified framework, these factors capture commonalities in multiple measures of inflation in a large, balanced sample of countries (25 advanced economies and 74 EMDEs) over a long period (1970-2017). The chapter makes four unique contributions to the literature.

First, it systematically explores the evolution of inflation synchronization among many countries and over time. It identifies a truly global inflation factor that captures common movements in inflation in a large sample of countries, including many EMDEs. This contrasts with earlier studies that typically included only advanced economies (Box 2.1). In this global sample, the evidence of increased global inflation synchronization since 2001 is unambiguous, whereas some earlier studies based on advanced economy samples have found no such increase.

Second, in recognition of differences in economic structures and policy frameworks between EMDEs and advanced economies, the model explicitly allows for the role of an EMDE inflation factor that is distinct from an advanced economy factor; the focus in the literature thus far has been on global factors.

Third, the chapter examines commonalities and differences in inflation synchronization among a wide range of inflation measures. By choosing price indexes that differ in their tradables content, this allows for a more precise interpretation of the global factor and broadens the evidence for increased inflation synchronization since 2001.

BOX 2.1 Global inflation synchronization: A review

This box summarizes the evidence in the literature that inflation has become highly synchronized internationally over time. Global inflation synchronization depends on the frequency of common shocks; the strength of cross-border inflation spillovers, especially from major economies; the openness of economies to international trade and financial flows; and the extent to which there are similar policy frameworks among countries, generating similar policy responses. It is therefore not surprising that there is evidence of an increase in inflation synchronization in recent decades, since this has been a period of strengthening global economic linkages, increasingly developed and internationally integrated financial markets, and a growing prevalence of monetary policy frameworks focused on the objective of low and stable inflation.

Using a wide range of methodologies, a large literature has studied various aspects of inflation synchronization across countries and its evolution over time. This box provides a brief summary of what this literature says on the following questions:

- How has global inflation synchronization evolved over time?
- Which factors have contributed to global inflation synchronization?

How has global inflation synchronization evolved?

Many studies have documented the high degree of inflation synchronization in recent decades, mostly, but not exclusively, in advanced economies.[1] Some of these studies also report that the degree of synchronization has increased over the past three decades.

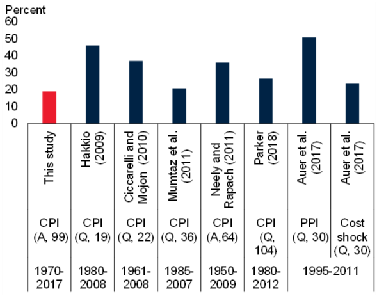
Existence of a global inflation factor. Several studies have documented that a global factor has accounted for a substantial proportion—ranging from 20 to 51 percent—of inflation variation among various groups of advanced economies, with the estimated contribution differing somewhat by inflation measure, time period, methodology, and sample composition (Table A.2.1.1 in Annex 2.1). In a well-known study, Ciccarelli and Mojon (2010) extract a common global factor from the consumer price index (CPI) inflation of 22 Organisation for Economic Co-operation and Development (OECD) countries over 1960-2008. They find that the global factor accounts for almost 37 percent of the variance of national

[1] The majority of studies on inflation synchronization employ variants of dynamic factor models developed by Stock and Watson (1999); Forni et al. (2005); and Kose, Otrok, and Whiteman (2003).

BOX 2.1 Global inflation synchronization: A review *(continued)*

FIGURE 2.1.1 Contribution of the global factor to inflation: Literature

The estimates of the contribution of the global factor presented in this chapter are in the range of those reported elsewhere in the literature, although at the lower end of the range.



Source: Hakkio 2009; Ciccarelli and Mojon 2010; Mumtaz, Simonelli, and Surico 2011; Neely and Rapach 2011; Auer, Levchenko, and Sauré 2017; Parker 2018.

Note: Numbers in parentheses indicate the number of countries included. The figures for "This study," for consistency with other studies, shows the average contribution of the global factor to inflation variation. A = annual data set; CPI = consumer price index; PPI = producer price index; Q = quarterly data set.

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inflation rates.[2] Ferroni and Mojon (2014) update this analysis through 2013, confirming a strong role for global factors among advanced economies.

Hakkio (2009) extracts a global factor from 19 OECD countries' inflation rates for 1960-2008 but adds a regional factor and expands the set of inflation measures to include overall CPI inflation, cyclical CPI inflation, core CPI inflation, and cyclical core CPI inflation. He finds that the global factor explains, on average, 41 percent of cyclical inflation variation. Auer, Levchenko, and Sauré (2017) estimate a global inflation factor using a sample of 30 countries and find that the global factor accounts for 51 percent of inflation variation, half of which reflects common cost shocks propagated through input-output linkages (see also Auer and Mehrotra 2014).

These studies use considerably smaller and more homogeneous country samples than the sample used in this chapter. This helps to explain why, in their studies, the global factors account for larger shares of inflation variation (Figure 2.1.1). Nevertheless, the shares presented in this chapter are within the range—although toward the low end—of those reported in the literature.

[2] Although they do not explicitly quantify the contribution of global factors to inflation variation, Cecchetti et al. (2007) document coincident inflation developments around the world, such as the widespread start of the Great Inflation in the late 1960s and synchronized inflation stabilization in the mid-1980s.

BOX 2.1 Global inflation synchronization: A review *(continued)*

Other studies estimate, typically in a Phillips curve framework, the impact of specific global variables on domestic inflation—with mixed success. For example, Eickmeier and Pijnenburg (2013), using data for 24 OECD countries during 1980-2007, estimate a Phillips curve model of domestic inflation using the global and idiosyncratic factors of output gaps and changes in unit labor costs. They find that the global factor of changes in unit labor costs has a notable impact on domestic inflation. Lodge and Mikolajun (2016) also find that global commodity prices were important determinants of inflation in 19 advanced economies, although other global variables were not.

In related work, Borio and Filardo (2007) and Auer, Borio, and Filardo (2017) show that global inflation and the foreign output gap add explanatory power to conventional Phillips curve models of domestic inflation for several OECD countries. However, Gerlach et al. (2008) find that this result is not robust to the measurement of the global output gap, controlling for additional variables, or the estimation period. Ihrig et al. (2010) find that in estimates of the Phillips curve for 11 countries, the globalization hypothesis has little support. Kabukçuoğlu and Martínez-García (2018) model inflation expectations for 14 advanced economies in a Phillips curve framework augmented by the global output gap and global inflation. Their results for global output gaps are mixed—which they attribute to measurement error—but the results still indicate a strong role for global inflation in domestic inflation.

Evolution of global inflation synchronization over time. Neely and Rapach (2011) extract a global factor and seven regional factors from CPI inflation in 64 mostly advanced economies during 1950-2009. They find that the global factor, on average, accounted for 35 percent of inflation variance, and the regional factors accounted for 16 percent—and these shares have risen substantially since the 1980s. Neely and Rapach (2011) document that the regional (world) factor has increased in importance for several North American and European (Latin American and Asian) countries since 1980. Mumtaz and Surico (2012) estimate global and regional factors from 164 inflation indicators for 13 OECD economies during 1961-2004. They find that, in most countries, the degree of inflation synchronization has strengthened since the 1980s. Mumtaz, Simonelli, and Surico (2011) focus on an unbalanced panel of 36 countries

BOX 2.1 Global inflation synchronization: A review *(continued)*

between 1860 and 2007. They show that the share of inflation variation due to the global factor has grown since 1985.[3]

Which factors have contributed to global inflation synchronization?

Several studies document strong economic policy institutions, trade openness, and financial development as factors associated with a higher degree of cross-country inflation synchronization. Two types of approaches have been employed. First, the country characteristics associated with a greater share of inflation explained by the global factor are analyzed. Second, sectoral, goods, or subnational factor decompositions are used to identify more granular patterns in inflation synchronization.

Country characteristics. Neely and Rapach (2011), in their sample of 64 mostly advanced economies during 1950-2009, correlate the share of CPI inflation variance accounted for by the global factor with country characteristics. They find that the share is higher in advanced economies with stronger economic policy institutions, more developed financial markets, lower inflation, and more independent central banks. Parker (2018) shows that energy prices appear to be less synchronized with global inflation factors in less developed economies. Ciccarelli and Mojon (2010) document that the impact of a global inflation factor on domestic inflation is stronger in countries with lower inflation. In a Phillips curve framework, Auer, Levchenko, and Sauré (2017) present evidence that cross-border trade in intermediate goods and services is the main channel through which global economic slack influences domestic CPI inflation; cost shocks propagated through input-output linkages account for about one-quarter of inflation variability.

Sectoral decompositions. Monacelli and Sala (2009) estimate the contributions of a global factor to inflation variance in a large cross-section of sectoral price data (948 CPI products) for four OECD countries during 1991-2004. They find that, on average, the global factor explains 15-30 percent of the variation in disaggregated consumer price inflation, the share being higher in sectors with greater trade openness. Förster and Tillmann (2014) extract global, sectoral, and regional factors from CPI inflation in

[3] Using wavelet analysis, Bhanja et al. (2013) and Bhanja, Dar, and Tiwari (2016) document that inflation synchronization among Group of Seven and Euro Area countries has increased over time.

BOX 2.1 Global inflation synchronization: A review *(continued)*

40 mostly OECD countries for 1996-2011.[4] They find that about two-thirds of overall inflation volatility is due to country-specific determinants. For CPI inflation net of food and energy, the global factor and the CPI basket-specific factor account for less than 20 percent of inflation variation. Only energy price inflation in advanced economies is dominated by common factors.

Parker (2018) extends Förster and Tillmann's (2014) analysis to 223 countries and territories over 1980-2012. He finds that the global factor explains around two-thirds of the variance of advanced economies' inflation but only about one-fifth for middle-income countries and one-tenth for low-income countries. Regardless of the country group, common factors account for a larger share of variability in energy and food price inflation than housing price inflation or, more broadly, headline CPI inflation.

Subnational decompositions. Beck, Hubrich, and Marcellino (2009) extract Euro Area, national, and subnational factors from subnational inflation rates in six Euro Area countries. They find that the Euro Area factor accounted for about half the inflation variation, and national and regional components accounted for 32 and 18 percent, respectively.

Goods decompositions. Auer, Levchenko, and Sauré (2017) show, for disaggregated producer price index (PPI) inflation for 30 mostly OECD countries and 17 sectors during 1995 to 2011, that the global factor explains nearly half the fluctuations in PPI inflation in the average economy. They argue that this PPI synchronization across countries is driven primarily by common sectoral shocks and amplified by input-output linkages.

Conclusion

The literature has documented that inflation is highly synchronized internationally, but that the degree of inflation synchronization varies with country characteristics and other factors, including the measure of inflation used. Findings have typically been restricted to headline CPI inflation, largely disregarding sectoral differences in inflation synchronization.

[4] Their novel dynamic hierarchical factor model allows a decomposition into a global factor, a factor specific to a given subcomponent of the CPI (energy price inflation, food price inflation, and CPI inflation net of food and energy items), a country-group factor driving the particular CPI basket in industrial or emerging economies, and a country-specific component.

Fourth, the chapter studies a wide range of country characteristics that are conducive to high inflation synchronization; the literature often confines itself to only a few characteristics.

The chapter's principal conclusions are as follows:

- In the median country, the global inflation factor accounted for one-eighth (12 percent) of total variation in national inflation rates over 1970-2017. Its contribution was much more pronounced in the median advanced economy (24 percent) than in the median EMDE (10 percent) and negligible in the median low-income country (LIC).

- The global factor's contribution to inflation variation was greater between 1970 and 1985—a period of two global oil price spikes and two global recessions—than between 1986 and 2000. Partly as a result of the 2008-09 global financial crisis and the 2014-16 oil price plunge, global inflation synchronization strengthened significantly in 2001-17. During this last period, the global factor explained 22 percent of national inflation in the full sample. It accounted for 18 percent of inflation variation in the median EMDE and 27 percent in the median advanced economy, compared with 7 and 22 percent, respectively, during 1986-2000. In LICs as well, the global factor's contribution increased to 17 percent in 2001-17 from a 3-4 percent previously.

- In addition to global synchronization, group-specific inflation synchronization has emerged among advanced economies and EMDEs. Like global inflation synchronization, group-specific inflation synchronization increased after 2000. Since 2001, the group-specific inflation factors have accounted for 8 percent of inflation variation in the median EMDE, one-third more than during 1986-2000, and for 21 percent in the median advanced economy, one-sixth more than during 1986-2000.

- Global inflation synchronization has broadened across different measures of inflation. In 1970-85, the extent of inflation synchronization was pronounced only for inflation measures with a large portion of tradable goods and services (import prices and producer prices); it has more recently become sizable across all inflation measures. During 1970-2017, it was most pronounced for the inflation measures with the largest share of tradables: it was highest for import prices (54 percent), followed by the producer price index (PPI), headline consumer price index (CPI), gross domestic product (GDP) deflator, and core CPI (5 percent). Since 2001, it has grown to one-third even for core CPI inflation and growth of the GDP deflator.

- Inflation synchronization has tended to be greater among countries with higher trade openness, greater commodity-import intensity, and lower trade concentration. Among EMDEs, the share of the global factor was particularly high in East Asia and Pacific, Latin America and the Caribbean, and South Asia. Since 2001, however, systematic differences in the role of the global factor among countries with different characteristics have faded.

The next section documents the evolution of global and group-specific factors that have driven the increased synchronization of inflation rates. The subsequent section explores the synchronization across different measures of inflation, including headline and core consumer price inflation, and measures based on producer prices and import prices. The penultimate section examines the main factors that explain the global synchronization of inflation. The final section concludes with a brief summary, discussion of policy implications, and future research directions.

Evolution of inflation synchronization

Using results from estimates of a dynamic factor model, this section documents that global inflation synchronization has increased, in degree and breadth.

Data and methodology

The analysis is based on annual inflation data for 25 advanced economies and 74 EMDEs (including 16 LICs) for 1970-2017. In the benchmark estimation, inflation is measured as annual headline CPI inflation. To analyze the extent of synchronization in multiple measures of inflation, the database is augmented with core CPI inflation, PPI inflation, import price inflation, and GDP deflator growth for a subset of 38 countries (of which 13 are EMDEs) (Table A.2.1.2, Annex 2.1).

A dynamic factor model is employed to decompose inflation in each country into *a global inflation fact*or that is shared across all countries, an advanced economy or EMDE factor that is shared within the respective groups (that is, two *group-specific inflation factors*), and an *idiosyncratic inflation factor* that is unique to each individual country (see Annex 2.1 for details about the model and estimation).[1] Dynamic factor models are designed to extract a few unobservable common elements from a large number of (observable) variables. Thus, the model allows a parsimonious representation of the data in terms of the unobservable common elements, which are typically referred to as factors. The degree of global inflation synchronization is simply measured by the share of the variance of national inflation attributable to the global factor. In a similar

[1] These types of models are used extensively to analyze global business and financial cycles (Kose, Otrok, and Whiteman 2008; Kose, Otrok, and Prasad 2012; Ha et al. 2017; Neely and Rapach 2011; Mumtaz and Surico 2012).

fashion, the extent of inflation synchronization within each country group is measured by the fraction of variance that is explained by the group-specific factor.[2]

Inflation synchronization: Global and group factors

Behavior of the global and group-specific factors. The model identifies a global inflation factor that, as expected, registers sharp movements around oil price spikes and global recessions (Figure 2.1). Within a year of an average global recession (such recessions having occurred in 1975, 1982, 1991, and 2009) and during the average oil price plunge (these having occurred in 1986, 1990-91, 1997-98, 2001, 2008, and 2014-16), annual global inflation fell by 0.5 and 0.2 percentage point, respectively, below its long-term trend. Conversely, in the average year preceding a global recession, global inflation was almost 2 percentage points above trend. The global factor moved in tandem with median inflation across countries.[3] The advanced economy and EMDE factors also exhibited common (although more muted) movements with their respective group-specific median inflation rates.

Importance of the global inflation factor. During 1970-2017, the global inflation factor accounted for a sizable share of within-country inflation variance in advanced economies and EMDEs (Figure 2.2; Table 2.1). In the median country, the global factor accounted for 12 percent of inflation variation, but its role varied widely across and within country groups (from near zero to 70 percent). For example, for the full sample period, the contribution of the global inflation factor was much greater in the median advanced economy (24 percent) than in the median EMDE (10 percent).

Importance of group-specific inflation factors. The group-specific factors have also played an important role in driving inflation. For example, in the median advanced economy, the group-specific factor accounted for 8 percent of inflation variation during 1970-2017.

The contributions of the global inflation factor to inflation variation reported in this chapter are consistent with, but at the low end of, the range of estimates

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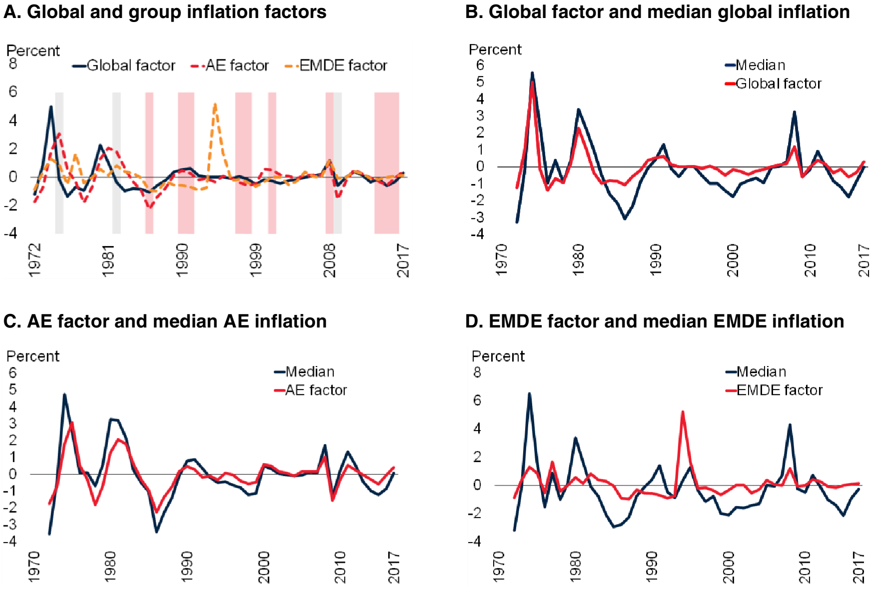
[2] The results are qualitatively robust to different detrending methods (for example, the Hodrick-Prescott or Butterworth filter), the use of a three-factor model (including country-specific factors), and the use of quarterly data.

[3] For 90 percent of the countries in the sample, the factor loadings on the global factor (coefficients associated with the global factor in the model) are positive (and statistically significant within 90 percent confidence intervals), indicating that national inflation rates generally move in tandem with the global factor. The remaining 10 percent of the countries are mostly, although not exclusively, in Sub-Saharan Africa (Algeria, Cameroon, Central African Republic, Democratic Republic of Congo, Gabon, Gambia, Mali, Niger, Saudi Arabia, and Senegal). In these countries, the factor loadings on the global factor are not statistically significantly different from zero.

FIGURE 2.1 Global and group inflation factors

The global factor troughs around global recessions and oil price plunges. The global factor and, especially, the advanced-economy factor move in tandem with median inflation across countries.



Source: World Bank.

Note: The global and group inflation factors are estimated with the baseline dynamic factor model (two-factor model with a global and a group-specific factor) for 1970-2017 (Annex 2.1). The sample includes 99 countries (25 AEs and 74 EMDEs, including 16 low-income countries). "Median" denotes cross-country median headline inflation. AE = advanced economy; EMDE = emerging market and developing economies.

A. Grey shades indicate periods of global recessions (1975, 1982, 1991, and 2009) and slowdowns (1998 and 2001); red shades indicate periods of oil price plunges (1986, 1990-91, 1997-98, 2001, 2008, and 2014-16) (Kose and Terrones 2015; Baffes et al. 2015). Identification of these global events is explained in more detail in Chapter 3.

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reported in other studies (see Box 2.1). Earlier studies have reported that the global inflation factor has contributed 20-50 percent to the variation in national inflation rates, with estimates differing depending on the methodology, sample periods, country groups, and data transformations. The differences in the estimates presented here may reflect the more extensive inclusion of EMDEs in the country sample in this study than in earlier work.

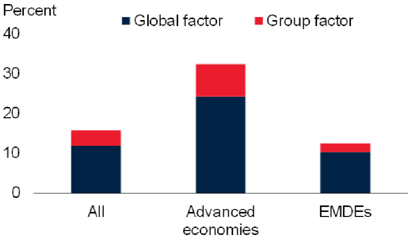
Evolution of inflation synchronization

Increasing synchronization over time. Global inflation synchronization has risen over the past four to five decades (Figure 2.2; Table 2.2). This is illustrated by estimates of the model for three approximately equal subperiods: 1970-85, 1986-2000, and 2001-17. The first period, 1970-85, overlaps with the Great Inflation of 1965-84 (Annex 1.4 in Chapter 1); the second, 1986-2000, was a

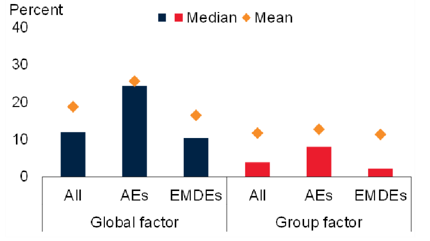
FIGURE 2.2 Contributions of global and group factors to inflation

In the full sample period, 1970-2017, the global and group-specific inflation factors together explain around 16 percent of the variation in inflation rates, but more in the median advanced economy (32 percent) than in the median EMDE (13 percent). The share of inflation variance explained by the global factor declined after 1985 but rose again after 2000. Since 2001, the global inflation factor has accounted for a larger share of inflation variation in a greater number of countries than in the 1970s and 1980s.

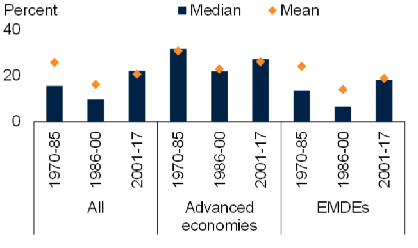
A. All, advanced economies, and EMDEs



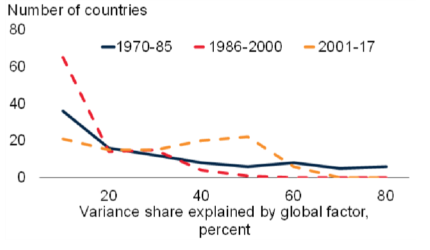
B. Contributions of global and group factors



C. Contribution of global factor, 1980-85, 1986-2000, and 2001-17



D. Contribution of global factor, by number of countries



Source: World Bank.

Note: The contribution of global and group factors to inflation variance is estimated with the dynamic factor model over 1970-2017 and three subsample periods (Annex 2.1). The sample includes 99 countries (25 AEs and 74 EMDEs, including 16 low-income countries). AEs = advanced economies; EMDEs = emerging market and developing economies.

B.C. Unweighted means or medians.

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TABLE 2.1 Variance decompositions: Headline CPI , 1970-2017 (percent)

Factor	All countries	Advanced economies	EMDEs
Global	11.9	24.3	10.4
	(18.8, 2.9 - 29.4)	(25.6, 10.4 - 35.2)	(16.4, 2.2 - 21.8)
Group	3.9	8.1	2.1
	(11.6, 0.7 - 16.6)	(12.7, 4.2 - 18.4)	(11.3, 0.5 - 12.7)
Global + Group	27.2	37.2	21.4
	(30.4, 14.0 - 44.2)	(38.3, 30.6 - 49.6)	(27.8, 11.5 - 41.8)

Note: All numbers indicate percent contributions of global and group-specific factors to the variance of headline CPI inflation during 1970-2017. The contributions of global and group-specific inflation factors are estimated using the dynamic factor model described in Annex 2.1. The data set includes 99 countries (25 advanced economies and 74 EMDEs). In each pair of rows, the numbers in the first row indicate medians across countries. The first number in the second row (in parentheses) is the unweighted mean across countries. The second and third numbers in the second row (in parentheses) indicate the interquartile range (25th and 75th percentiles). CPI = consumer price index; EMDEs = emerging market and developing economies.

period of widespread disinflation; and the third, 2001-17, was a period of low but typically stable inflation (Chapter 1).

The *global* factor's contribution to inflation variation was sizable—16 percent for the median country in the full sample—in 1970-85, when economies were considerably more energy-intensive than more recently and oil price spikes lifted inflation globally (Baffes et al. 2015). Then, the global factor's contribution dipped to 10 percent during 1986-2000, as many countries implemented policies to rein in inflation. But in 2001-17, it rose beyond its level in 1970-85, to 22 percent for the median economy in the full sample and 18 percent for the median EMDE; for the median advanced economy it rose to 27 percent but remained below its level in 1970-85. Similarly, the contribution of the *group* factor to inflation variation has grown since the 1970s and 1980s, to 21 percent in the median advanced economy in 2001-17 (from 18 percent in 1970-85) and 8 percent in the median EMDE (from 6 percent).

Increasingly broad-based inflation synchronization. Global inflation synchronization has become more broad-based over time. During 1986-2000, for example, the global factor contributed more than 10 percent to inflation variation in around one-third of the countries in the sample (compared with half the countries in 1970-85), and during 2001-17, this was the case in two-thirds of the countries. The distribution of the contribution of the *global* factor has clearly shifted to the right between 1970-85 and 2001-17 for all country groups (Figure 2.2). The distribution of the contribution of the *group* factor to inflation variation only shifted to the right for advanced economies: for EMDEs, the distribution in 2001-17 resembled that in 1970-85.[4]

Inflation synchronization in LICs. Until 2000, the contribution of the global factor to inflation variation in LICs was negligible (3-4 percent in the median LIC). Since 2001, however, the global factor's contribution has quintupled to 17 percent in the median LIC, a level broadly in line with the median EMDE. The share of LICs with a contribution of the global factor to inflation variation in excess of 10 percent has risen from one-quarter before 2000 to two-thirds since 2001. In addition to the growing contribution of the common global factor to short-term inflation movements, global factors have also contributed considerably to long-term inflation movements. Chapter 6 documents that a benign external environment was the main reason for the decline in trend inflation in LICs over the past two

[4] These trends are robust to estimating the dynamic factor model by subsample periods of 15-year rolling windows. The combined importance of global and group-specific factors declined until 2006, but it has since increased again. The share of variance due to the global factor was often higher for rolling samples that overlapped with the post-2007 period, reflecting the highly synchronized movements in inflation across countries following the global financial crisis.

TABLE 2.2 Variance decompositions, over time: Headline CPI (percent)

	1970-2017	1970-85	1986-2000	2001-17
Factor	**All countries**			
Global	11.9	15.5	9.9	22.1
	(18.8, 2.9 - 29.4)	(25.8, 4.1 - 40.1)	(16.2, 1.5 - 29.0)	(20.7, 8.6 - 30.9)
Group	3.9	7.9	6.7	9.0
	(11.6, 0.7 - 16.6)	(12.2, 2.3 - 18.2)	(19.4, 2.8 - 22.0)	(13.7, 3.8 -19.5)
Global + Group	27.2	31.0	34.8	33.6
	(30.4, 14.0 - 44.2)	(38.0, 18.3 - 59.5)	(35.6, 16.1 - 48.7)	(34.4, 19.0 - 49.3)
Factor	**Advanced economies**			
Global	24.3	31.6	22.0	27.3
	(25.6, 10.4 - 35.2)	(30.8, 10.8 - 39.7)	(22.9, 9.9 - 35.5)	(26.1, 21.6 - 32.9)
Group	8.1	18.0	15.7	20.5
	(12.7, 4.2 - 18.4)	(18.1, 7.3 - 24.0)	(21.0, 4.9 - 33.6)	(22.7, 9.4 - 34.8)
Global + Group	37.2	47.2	45.0	50.7
	(38.3, 30.6 - 49.6)	(48.8, 36.3 - 64.6)	(43.9, 26.9 - 55.4)	(48.8, 39.1 - 62.8)
Factor	**EMDEs**			
Global	10.4	13.6	6.6	18.1
	(16.4, 2.2 - 21.8)	(24.1, 2.9 - 38.9)	(14.0, 0.7 - 26.7)	(18.9, 5.8 - 30.3)
Group	2.1	6.3	6.4	7.8
	(11.3, 0.5 - 12.7)	(10.3, 1.9 - 15.1)	(18.9, 2.7 - 19.0)	(10.7, 3.2 - 16.9)
Global + Group	21.4	25.8	27.4	28.9
	(27.8, 11.5 - 41.7)	(34.4, 13.8 - 52.3)	(32.9, 13.0 - 43.8)	(29.6, 17.2 - 39.4)

Note: All numbers indicate percentage contributions of the global and group-specific factors to the variance of headline CPI inflation. The contributions of global and group-specific inflation factors are estimated using the dynamic factor model described in Annex 2.1. The data set includes 99 countries (25 advanced economies and 74 EMDEs). In each pair of rows, the numbers in the first row indicate medians across countries. The first number in the second row (in parentheses) is the unweighted mean across countries. The second and third numbers in the second row (in parentheses) indicate the interquartile range (25th and 75th percentiles). CPI = consumer price index; EMDEs = emerging market and developing economies.

decades. Growing synchronization coincided with LICs' rapid integration into global trade networks as well as a shift toward greater exchange rate flexibility (Box 1.2, Chapter 1).

Extent of synchronization: Inflation and output

How high is the degree of global inflation synchronization reported here relative to the synchronization of other, comparable economic variables? To answer this question, it is useful to compare the extent of inflation synchronization with that of business cycles. A large literature reports that there is a global business cycle, evidenced by a high degree of synchronization of various measures of national economic activity, including output growth.

Inflation tends to exhibit stronger global synchronization than output growth (Box 2.2). For the full sample of countries over 1970-2017, the median contributions of the global factor to variations in inflation and output growth were 12 and 5 percent, respectively. The difference was somewhat more pronounced for EMDEs than for advanced economies. The global factor accounted for 10 percent of inflation variation in the median EMDE but only 3 percent of output growth variation. In the median advanced economy, the contribution of the global factor was also more sizable for variations in inflation (24 percent) than in output growth (19 percent). Since 2001, the median contributions of the global factor to variation in inflation and output growth have increased significantly, to 22 and 12 percent, respectively, for the full sample of countries.

Synchronization across different measures of inflation

The inflation synchronization discussed thus far refers to headline CPI inflation. However, the degree of inflation synchronization differs across various measures of inflation. To analyze these differences, a dynamic factor model is estimated using five measures of inflation with varying tradables content (headline CPI, core CPI, PPI, GDP deflator, and import prices).[5] Separately, a common factor to represent nontradables inflation is extracted from the three measures with below-average tradables content (core CPI, headline CPI, and GDP deflator), and a common factor to represent tradables inflation is extracted from the three measures with above-average tradables content (import prices, headline CPI, and PPI). Global and group-specific factors for each inflation measure are estimated separately for annual data for 38 countries (25 advanced economies and 13 EMDEs) over 1970-2016.

Inflation synchronization: Different measures

Behavior of global inflation measures. Global factors were typically more volatile for inflation measures with greater tradables content.

- Global factors for *PPI* and *import price* inflation tended to move together over the past four to five decades, but with considerably greater variability in the global factor for import price inflation—as may be expected for goods

[5] In price indexes for the United States, for example, the share of tradable goods and services is greatest for the PPI (54 percent), followed by headline CPI (53 percent), GDP deflator (26 percent), and core CPI (15 percent), according to the U.S. Bureau of Labor Statistics. The classification of sectors into tradables and nontradables here follows the earlier literature: agriculture, hunting, forestry and fishing, mining and quarrying, and manufacturing are classified as tradable sectors and the rest as nontradable (Knight and Johnson 1997).

BOX 2.2 Global synchronization of inflation and output growth

International synchronization of inflation has tended to be higher than that of output growth over the past four to five decades. This result is mainly driven by the much higher degree of inflation synchronization during 1970-85, which witnessed multiple common shocks. Over the past three decades, the degree of synchronization of output growth has increased to become comparable to that of inflation. The differences in the degree of synchronization in inflation and output growth over time may reflect changes in the nature and frequency of global shocks and structural factors, including the evolution of policy frameworks.

Relative to what is the degree of international inflation synchronization reported in this chapter "high"? A comparison with the extent of business cycle synchronization offers a possible standard of reference for this question. A large literature reports the degree of international synchronization of various measures of business cycles, including output growth. This box examines the evidence on the relative degrees of synchronization of inflation and output growth to address the following questions:

- How does the degree of synchronization of inflation compare with that of output growth?
- What are the major factors that could explain the difference between the extent of synchronization of inflation and output growth?

Inflation versus output synchronization

Full sample comparison. To examine the relative degrees of synchronization in output growth and inflation, global factors for the two variables were separately estimated using the baseline two-factor model for 99 countries over 1970-2017. Inflation movements tended to exhibit a stronger degree of synchronization than output growth (Figure 2.2.1).[1] Specifically, the median contributions of the global factors to variation in inflation and output growth for the full country sample in this period are

[1] This is consistent with the findings in earlier theoretical and empirical studies (Henriksen, Kydland, and Šustek 2013; Mumtaz, Simonelli, and Surico 2011; Wang and Wen 2007). For instance, Wang and Wen (2007) offer sticky-price and sticky-information New Keynesian models to explain inflation synchronization that is high and well in excess of output synchronization; neither model can account for the phenomenon. They conclude that neither nominal rigidities nor monetary shocks are likely sources of inflation synchronization.

BOX 2.2 Global synchronization of inflation and output growth *(continued)*

12 and 5 percent, respectively. The difference reflects weak output growth synchronization in advanced economies and emerging market and developing economies (EMDEs): the global factor accounted for 10 percent of inflation variation in the median EMDE but only 3 percent of output growth variation. In contrast, in the median advanced economy, the contribution of the global factor was sizable for variations in inflation (24 percent) and output growth (19 percent). These results are consistent with findings in earlier studies.[2]

Inflation and output synchronization over time. Over the past three decades, the degree of synchronization of output growth has grown to become comparable to that for inflation (Figure 2.2.1). During 1970-85, inflation synchronization (with a median variance contribution of the global factor of 16 percent) was stronger than output growth synchronization (5 percent). During 1986-2000, however, the median share of the global factor in the variance of inflation declined to 10 percent, and the share of the global output growth factor remained low (6 percent), with wide differences across countries. Since 2001, the median contribution of the global factor to variation in output growth and inflation have increased significantly, to 12 and 22 percent, respectively. For the median advanced economy, the share is now greater for output growth (34 percent) than for inflation (27 percent). For the median EMDE, the global factor still contributed more to inflation variation (18 percent) than to output growth variation (7 percent).

The trends in the relative importance of global and group-specific factors over time were similar for output growth and inflation. Output growth and inflation were explained more by global factors than group-specific factors during 1970-85, but the relative importance of the group-specific factors increased during 1986-2000.[3] However, since 2001, the global factors have again become more important than the group-specific factors for output growth and inflation. Although these trends were similar in direction, they were more pronounced for inflation than for output growth.

[2] For example, among 60 mostly advanced economies, the global factor accounts for 25-50 percent of the variance of output growth (Kose, Otrok, and Whiteman 2003).

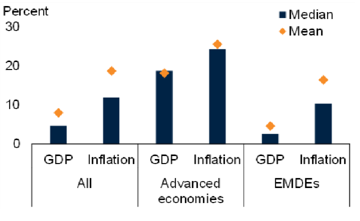
[3] This is consistent with the findings on the "decoupling of macroeconomic variables between advanced economies and EMDEs" reported by Kose, Otrok, and Prasad (2012).

BOX 2.2 Global synchronization of inflation and output growth (*continued*)

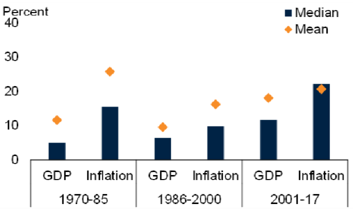
FIGURE 2.2.1 Synchronization in output growth and inflation

Global inflation synchronization has been stronger than global synchronization of output growth, especially in EMDEs. In advanced economies, inflation synchronization has been comparable to, or lower than, output growth synchronization since the mid-1980s.

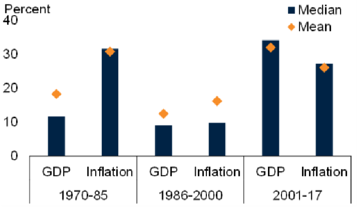
A. Contribution of the global factor to output growth and inflation variation, 1970-2017



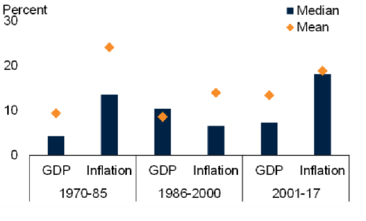
B. Contribution of the global factor to output growth and inflation variation, over time



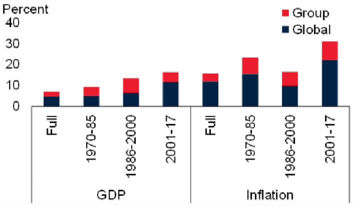
C. Contribution of the global factor to output growth and inflation variation: Advanced economies



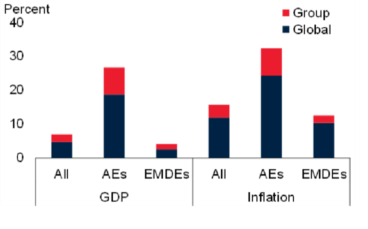
D. Contribution of the global factor to output growth and inflation variation: EMDEs



E. Contribution of global and group factors to output and inflation variation, over time



F. Contribution of global and group factors to output and inflation variation, by country group



Source: World Bank.

Note: Contribution of global and group factors to the variance of real output growth and inflation in 99 economies (25 AEs and 74 EMDEs, including 16 low-income countries), based on a two-factor dynamic factor model (Annex 2.1). AEs = advanced economies; EMDEs = emerging market and developing economies; GDP = gross domestic product.

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BOX 2.2 Global synchronization of inflation and output growth *(continued)*

Evolution of global factors for output growth and inflation. Around the global oil price spikes in the 1970s and the oil price plunge in the mid-2010s, global (and group-specific) factors for output growth and inflation moved in opposite directions, possibly indicating a major role of global supply shocks as the main drivers of global business and inflation cycles during these episodes. However, around global recessions and slowdowns, especially around the global financial crisis in 2008-09, the two global factors moved in tandem, probably due to demand shocks. This time-varying correlation between the two global factors is clearly observed for EMDE-specific factors (Figure 2.2.2).

Reasons for differences in inflation and output growth synchronization

Henriksen, Kydland, and Šustek (2013) examine this question in an international business cycle model with common technology shocks as well as cross-border technology spillovers. In their model, central banks' policy rules are combined with a no-arbitrage condition between domestic and foreign interest rates to render *current* prices (and interest rates) a function of expected *future* output. This results in a stronger cross-country correlation in prices than in output.

Alternatively, the difference in the degrees of synchronization may reflect the nature of global shocks or differential impacts of cross-border spillovers of shocks on inflation and output. If movements in the prices of internationally traded goods, such as swings in commodity prices, play an important role as global shocks, their impact on inflation could be greater and more immediate than their impact on output. Indeed, the degree of inflation synchronization is much higher than that of output growth during 1970-85, a period that witnessed multiple global shocks associated with sharp movements in oil prices.

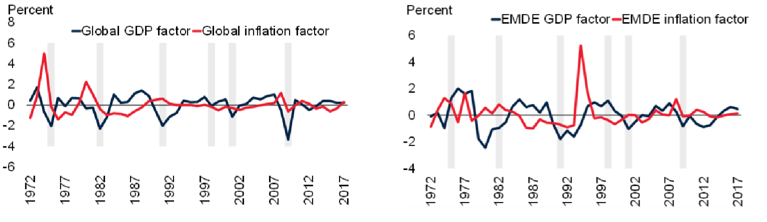
Considering that cross-border spillovers of shocks can drive global synchronization in inflation and output, structural changes can also influence real and nominal linkages across countries. For instance, the strong degree of output synchronization among advanced economies during 2001-17, which was slightly more pronounced than inflation synchronization during the same period, might partly reflect widespread and major economic disruptions during the global financial crisis.

BOX 2.2 Global synchronization of inflation and output growth *(continued)*

FIGURE 2.2.2 Global inflation and output growth factors

Around global recessions and slowdowns, especially around the global financial crisis in 2008-09, global inflation and output growth factors moved in tandem, probably due to demand shocks.

A. Global factors for output growth and inflation **B. EMDE factors for output growth and inflation**



Source: World Bank.

Note: The global and group inflation and output growth factors are estimated with the baseline dynamic factor model (two-factor model with a global and a group-specific factor) for 1970-2017 (Annex 2.1). The sample includes 99 countries (25 advanced economies and 74 EMDEs, including 16 low-income countries). Grey shades indicate the periods of global recessions and slowdowns (Kose and Terrones 2015). EMDEs = emerging market and developing economies; GDP = gross domestic product.

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Conclusion

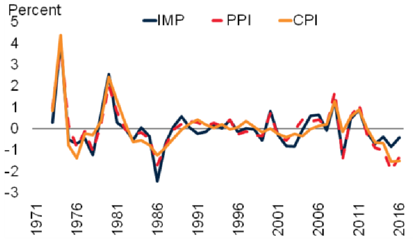
Is the degree of inflation synchronization reported in this chapter "high"? A comparison with output growth synchronization suggests that the answer is a qualified yes. Since 1970, global inflation synchronization has been more than twice as large as global output synchronization. The difference may reflect a multitude of shocks to internationally traded prices, which affected domestic inflation more directly than output, or technology spillovers that affected prices more than output because central banks responded proactively to the shocks. Over time, inflation and output synchronization have risen.

prices that are heavily exposed to, if not determined in, global markets (Figure 2.3). During global recessions and episodes of large oil price swings, the global PPI and import price factors exhibited sharper movements than the global headline CPI factor. With a larger share of nontradable goods and services prices in the *GDP deflator*, the global factor for this measure has been considerably less volatile than those for headline CPI, PPI, and import price inflation.

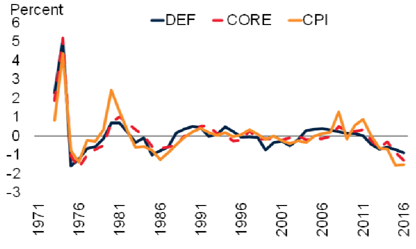
FIGURE 2.3 Global inflation factors: Various inflation measures

Global factors for PPI and import price inflation have tended to move together over the past four to five decades, and they have been considerably more volatile than the global factor for headline CPI inflation. With a larger share of nontradable goods and services prices in the GDP deflator, the contribution of the global factor to variations in GDP deflator growth has been smaller and considerably less volatile than those for PPI and import price inflation. The contribution of the global factor to core CPI inflation variation—which contains the largest share of nontradable goods and services among the inflation measures used here—has been the smallest among various inflation measures.

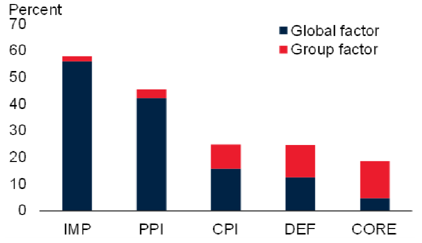
A. Global factors: Headline CPI, PPI, and import price



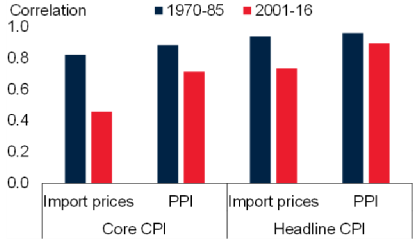
B. Global factors: Headline CPI, core CPI, and GDP deflator



C. Contribution of global and group-specific factors to inflation variation: Various measures



D. Correlations of headline and core CPI inflation factors with other global factors



Source: World Bank.

Note: The global and group inflation factors are estimated with a baseline dynamic factor model (two-factor model) using detrended inflation rates in 38 countries (25 advanced economies and 13 EMDEs) for 1970-2016. CORE = core CPI; CPI = headline consumer price index; DEF = GDP deflator; GDP = gross domestic product; IMP = import prices; PPI = producer price index.

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- Since the mid-1980s, the global factor for *core CPI* inflation—which contains the largest share of nontradable goods and services among the inflation measures examined here—has been less volatile than those for the other inflation measures. This may reflect the exclusion of energy prices (which tend to comove globally), as well as strengthened monetary policy frameworks and better-anchored inflation expectations, as a growing number of central banks succeeded in lowering inflation from high levels and began to employ inflation-targeting frameworks (as discussed in Chapters 1 and 4). The decoupling of core inflation from other inflation measures was also reflected in declining correlations between the global factors for core CPI and other measures of inflation. Thus, the correlation of the global factor for core CPI inflation with that for import price inflation halved between 1970-85 (0.8) and 2001-16 (0.4), while the correlation of PPI or headline CPI inflation with import price inflation remained high, at around 0.7-0.9.

Contribution of global factors to inflation variation. The estimated global factor's contribution to inflation variation was higher in inflation measures with greater tradable goods and services content (Figure 2.3; Table 2.3). For example, the global factor's contribution to inflation variation was largest for import prices (54 percent in the median country) and smallest for core CPI inflation (5 percent). Between these two extremes, the global factor's contribution to variation in PPI inflation was 42 percent and that to GDP deflator growth was on the order of 13 percent, which was comparable to that for headline CPI inflation.

Contribution of the group-specific factor to inflation variation. In contrast to the results for the global factor, the group-specific inflation factor contributed more to variation in inflation measures with less tradables content: it was largest for the core CPI, followed by the GDP deflator, headline CPI, PPI, and import prices. The median contribution of the group-specific factor to the variation in core CPI inflation was 14 percent—considerably more than that of the global factor (5 percent). For GDP deflator growth, the median contributions of the global and group-specific factors were similar, at 13 and 12 percent, respectively. For import prices and PPI, the contributions of the group-specific factors were negligible (less than 5 percent).

Evolution of inflation synchronization: Different measures

Trends in inflation synchronization over time were similar across the five inflation measures (Figure 2.4; Table A.2.1.3). During 1970-85, the role of the global inflation factor was sizable for all five inflation measures except core CPI inflation; global inflation synchronization weakened during 1986-2000, but returned in the 2000s to levels similar to those of 1970-85. During 1970-85, the median contribution of the global inflation factor was 68 percent for inflation variation in import prices, followed by PPI (52 percent) and core CPI (8 percent).

During 1970-85, the contribution of the global factor to inflation variation was much greater than that of the group-specific factor for all inflation measures except core CPI inflation. During 1986-2000, however, the global factor's contribution fell below 10 percent for all five measures, and the contribution of

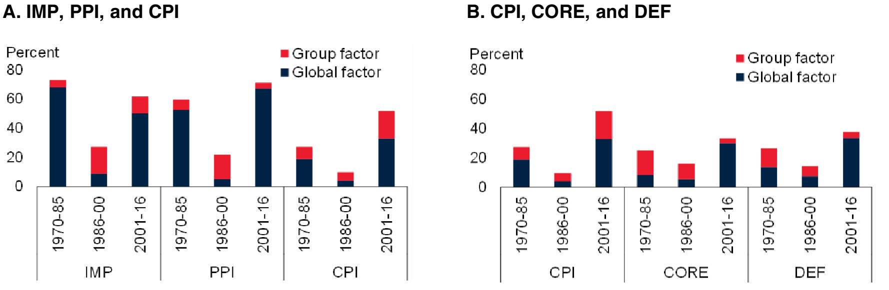
TABLE 2.3 Variance decompositions: Various inflation measures (percent)

	Import prices	PPI	Headline CPI	GDP deflator	Core CPI
Factor			**All countries**		
Global	54.4 (51.8, 45.6-66.1)	42.1 (41.1, 15.3-61.7)	15.7 (22.9, 6.2-36.5)	12.6 (18.7, 3.2-30.5)	4.7 (12.5, 1.7-15.4)
Group	2.1 (8.5, 1.1-15.1)	3.2 (6.6, 0.9-8.8)	9.1 (12.8, 3.4-21.4)	12.1 (16.0, 4.6-25.5)	14.1 (18.8, 2.9-26.6)
Global + Group	63.2 (60.4, 51.5-70.4)	49.9 (45.2, 19.7-67.3)	34.1 (35.7, 25.4-44.6)	35.3 (33.8, 19.1-45.0)	26.3 (27.2, 10.9-40.4)
Factor			**Advanced economies**		
Global	54.4 (52.7, 45.6-66.1)	56.1 (48.4, 33.9-63.7)	21.4 (23.7, 11.0-36.6)	13.4 (19.1, 6.5-31.5)	7.9 (15.5, 3.1-21.4)
Group	2.5 (7.5, 1.4-15.1)	4.5 (7.7, 1.1-9.6)	11.5 (14.0, 4.1- 24.1)	12.6 (15.9, 3.5- 25.0)	17.7 (21.9, 8.7-34.8)
Global + Group	63.2 (60.2, 49.5-72.5)	60.6 (51.6, 31.2-68.1)	35.9 (37.7, 31.1-44.8)	37.3 (33.6, 18.1- 45.8)	34.3 (33.5, 18.9-46.4)
Factor			**EMDEs**		
Global	56.9 (48.2, 40.2-64.9)	16.2 (28.3, 11.1-40.4)	11.6 (21.4, 3.4-36.3)	9.3 (18.0, 2.2-26.1)	1.7 (8.0, 1.3-9.1)
Group	1.0 (12.8, 0.7-13.1)	1.4 (4.7, 0.8-4.0)	7.7 (10.4, 0.9- 11.8)	9.5 (16.2, 6.2- 25.5)	2.9 (11.5, 1.5-13.5)
Global + Group	61.4 (61.1, 57.0-65.5)	22.6 (33.0, 13.5-41.0)	25.6 (31.9, 16.7-43.9)	33.7 (34.2, 22.2-37.4)	11.8 (15.0, 3.0-16.5)

Note: The contributions of global and group inflation factors to inflation variance are estimated with a two-factor dynamic factor model for each of the five different inflation measures: Import prices, PPI, headline CPI, GDP deflator, and core CPI (Annex 2.1). The sample includes 38 countries (25 advanced economies and 13 EMDEs), except for import prices, which are only available for 21 countries (17 advanced economies and 4 EMDEs). In each pair of rows, the first number in the first row indicates medians across countries. The first number in the second row (in parentheses) is the unweighted mean variance share across countries. The second and third numbers in the second row (in parentheses) indicate the interquartile range (25th and 75th percentiles). The results for headline inflation may differ from Tables 2.1 and 2.2 because of a smaller sample size, to match the sample with available data for other measures of inflation. CPI = consumer price index; EMDEs = emerging market and developing economies; GDP = gross domestic product; PPI = producer price index.

FIGURE 2.4 Contribution of global and group factors to inflation over time: Various inflation measures

Across all measures of inflation, global inflation synchronization decreased in the mid-1980s and 1990s before rising again in the 2000s.



Source: Haver Analytics; OECD; World Bank.

Note: The global and group inflation factors are estimated with a dynamic factor model using annual inflation in 38 countries (25 advanced economies and 13 EMDEs) for 1970-2016 (Annex 2.1). CORE = core consumer price index; CPI = headline consumer price index; DEF = GDP deflator; IMP = import prices; PPI = producer price index.

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the group-specific factor rose to match or even exceed that of the global factor for virtually all inflation measures. Since 2001, the contribution of the global inflation factor has risen to around two-thirds for PPI inflation variation and around one-third for core CPI inflation and GDP deflator growth variation.

Inflation synchronization: Tradable versus nontradable goods and services

Similar results are obtained from an exercise that extracts separate global and group-specific factors for mainly tradables (headline CPI, PPI, and import prices) and mainly nontradables (headline CPI, GDP deflator, and core CPI) inflation measures.[6] The global factor accounted for a much larger share of tradables inflation (40 percent) than nontradables inflation variation (13 percent) (Figure 2.5; Table 2.4). The median contribution of the group-specific factor to inflation variation was similarly low for the nontradables sector as for the tradables sector (6 percent). The differences between the contributions of global and group-specific factors to tradables and nontradables inflation were larger for advanced economies than for EMDEs.

Sources of inflation synchronization

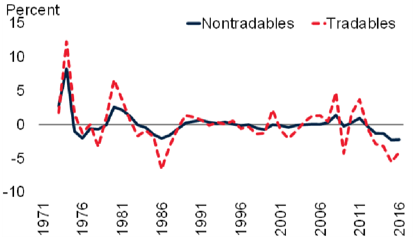
A wide range of factors could be responsible for the global synchronization of inflation. This section starts with a brief conceptual discussion of three broad

[6] The results are robust to the exclusion of headline CPI from the estimation of the global factor for the nontradables sector.

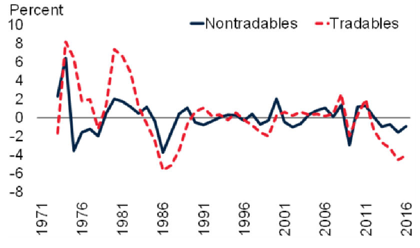
FIGURE 2.5 Global and group inflation factors: Tradables and nontradables

Global inflation factors for tradable and nontradable goods moved broadly together until the late 1990s when the nontradables factor stabilized while the tradables factor did not. The share of inflation variance explained by the global inflation factor is greater for tradable goods than nontradable goods and larger for advanced economies than for EMDEs. Group -specific inflation synchronization is stronger for nontradable goods and services than for tradables.

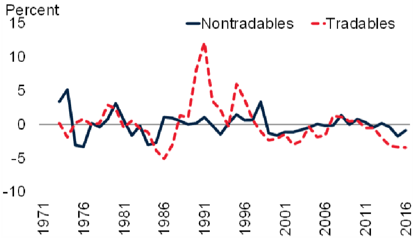
A. Global inflation factors: Tradables and nontradables inflation



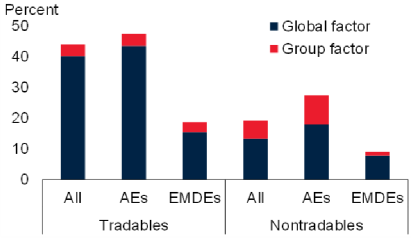
B. AE-specific inflation factors: Tradables and nontradables inflation



C. EMDE-specific inflation factors: Tradables and nontradables inflation



D. Contributions of global and group factors to tradables and nontradables inflation variation



Source: World Bank.

Note: The global and group inflation factors for tradable and nontradable goods are estimated with a two-factor dynamic factor model for 1970-2016 (Annex 2.1). The common factor from three measures for domestic inflation (import prices, PPI, and headline CPI) is used as a proxy variable for the common component for tradable goods. Similarly, common factors for headline CPI, core CPI, and the GDP deflator are extracted as a proxy for global inflation factor for nontradable goods. The data are detrended annual inflation for 25 AEs and 13 EMDEs for 1970-2016. AEs = advanced economies; CPI = consumer price index; EMDEs = emerging market and developing economies; GDP = gross domestic product; PPI = producer price index.

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factors that could explain inflation synchronization: shocks, policy responses, and structural changes. This discussion is followed by an analysis of country-specific structural and policy-related features that correlate with inflation synchronization.

Conceptual considerations

Shocks. Inflation synchronization across countries could be driven by common shocks that spread evenly (or at least simultaneously) across countries, and/or by

TABLE 2.4 Variance decompositions: Tradables and nontradables (percent)

	Nontradable sector	Tradable sector
Factor	**All countries**	
Global	13.2 (19.3, 4.3 - 31.6)	40.1 (36.7, 14.5 - 53.6)
Group	5.9 (10.9, 0.7 - 15.4)	3.8 (7.2, 1.7 - 9.8)
Global + Group	30.2 (30.2, 13.3 - 41.8)	45.7 (43.9, 24.1 - 62.8)
Factor	**Advanced economies**	
Global	17.9 (21.5, 9.3 - 32.1)	43.4 (41.7, 29.7 - 55.2)
Group	9.4 (11.3, 2.8 - 16.6)	3.9 (7.4, 1.3 - 10.1)
Global + Group	33.7 (32.8, 20.0 - 43.3)	52.4 (49.0, 34.4 - 63.7)
Factor	**EMDEs**	
Global	7.8 (15.2, 2.5 - 21.0)	15.3 (25.6, 8.6 - 40.4)
Group	1.2 (10.0, 0.2 - 8.5)	3.4 (6.7, 1.9 - 7.1)
Global + Group	13.3 (25.2, 8.7 - 39.8)	24.1 (32.3, 12.7 - 52.4)

Note: The global and group inflation factors for tradable and nontradable goods and services are estimated with the baseline two-factor dynamic factor model for 1970-2016 (Annex 2.1). The common factor from three measures of domestic inflation (import prices, PPI, and headline CPI) is used as a proxy variable for the common component for tradable goods. Similarly, common factors for headline CPI, core CPI, and the GDP deflator are extracted as a proxy for the global inflation factor for nontradable goods. The sample includes annual inflation in 38 countries (25 advanced economies and 13 EMDEs) for 1970-2016. The long-term trend (15-year moving average) is eliminated from annual inflation rates. For each pair of rows, the number in the first row indicates medians across countries. The first number in the second row (in parentheses) is the unweighted mean across countries. The second and third numbers in the second row (in parentheses) indicate the interquantile range (25th and 75th percentiles). CPI = consumer price index; EMDEs = emerging market and developing economies; GDP = gross domestic product; PPI = producer price index.

country-specific shocks that spill over from one country or a subset of countries to others. Commodity price shocks, internationally correlated productivity shocks, other cost-push shocks, and real demand shocks that trigger global recessions or expansions could all affect national inflation rates widely and often in the same direction, which would represent inflation synchronization. For example, the 2009 global recession was followed by a prolonged period of globally depressed inflation. Other shocks could affect countries asymmetrically. For example, oil price shocks would affect oil importers and oil exporters differently (Baffes et al. 2015).

Similarly, a recession in a relatively large economy could have greater spillover effects on activity and inflation in its close trading partners than elsewhere (Huidrom, Kose, and Ohnsorge 2017). Exchange rate changes, especially ones that go beyond movements warranted by real-economy developments, such as domestic currency crises or confidence shocks, will also tend to pass through into national inflation rates asymmetrically (Shambaugh 2008). On average, traded goods account for over 60 percent of consumer baskets in EMDEs and 47 percent of consumer baskets in advanced economies. Hence, exchange rate movements would tend to affect consumer prices directly and significantly. The extent of such exchange rate pass-through is discussed in detail in Chapter 5.

Similar policy responses. Earlier studies have often highlighted the contribution of correlated or coordinated monetary policies as a main source of inflation comovement, especially among advanced economies (Clarida, Gali, and Gertler 2002; Rogoff 2003). Even if there is no deliberate coordination of policies, similar monetary policy frameworks can trigger similar policy responses to global shocks. This policy synchronicity would then translate into inflation synchronicity.

For example, a growing number of countries have introduced inflation targeting monetary policy frameworks. In many of these countries, inflation targets have been lowered over the past three decades, and in advanced economies the targets are now virtually universally at or around 2 percent (Chapter 1). In EMDEs, inflation targeting has been associated with lower inflation, and the switch to inflation targeting has been associated with larger declines in inflation (Fang, Miller, and Lee 2012; Gonçalves and Salles 2008). Henriksen, Kydland, and Šustek (2013) develop an international business cycle model with technological spillovers in which central banks' Taylor rules trigger monetary policy responses to productivity shocks that are similar across countries. As a result, their model generates movements in inflation that are synchronized across countries.

Structural changes. Over the past four to five decades, the degree of global integration in trade and financial markets has grown rapidly (Chapter 1). These structural changes have often strengthened cross-country spillovers of real and nominal shocks, which have in turn led to more synchronized movements in inflation.

- *Stronger trade linkages* increase an economy's exposure to external shocks. With growing trade linkages, import prices have accounted for rising shares of global production costs and domestic prices of final goods and services. As a result, domestic inflation has become more sensitive to global shocks

[7] This study is broadly in line with the literature that investigates the role of international input-output linkages in driving the synchronization of global business cycles (Kose and Yi 2006; di Giovanni and Levchenko 2010; Johnson 2014). Martínez-García (2015) develops a new open-economy macro model for the United States and 38 of its trading partners. The model can account for inflation synchronization even in the absence of common shocks, simply through the presence of strong spillovers associated with trade linkages.

that raise or lower import prices (Bianchi and Civelli 2015).[7] The results in the previous section indicate that inflation synchronization has been greater for measures with larger tradables content and, since 2001, has increased across inflation measures. These findings likely reflect that prices are more likely to be internationally determined in sectors with strong trade linkages to global markets where they are subject to common demand and supply shocks (Karagedikli, Mumtaz, and Tanaka 2010; Parker 2018). Over time, the impact of global shocks in traded goods prices tend to be passed through to other prices, with the degree and speed of the pass-through depending on country characteristics, including trade and financial openness and the credibility of the central bank's inflation objective (Chapter 5).

- *Rapidly expanding global supply chains* allow global supply and demand shocks as well as commodity price swings to ripple through global input-output linkages and global labor markets and cause comovement in national inflation rates (Rogoff 2003; Auer, Borio, and Filardo 2017).

- Greater international competition has made *domestic inflation less sensitive to domestic output gaps*, flattening Phillips curves (Eickmeier and Pijnenburg 2013; Carney 2017; Kabukçuoğlu and Martínez-García 2018).

- *Financial linkages.* Increased international integration of financial markets has been accompanied by greater synchronization of financial conditions—including financial stress—across countries (Neely and Rapach 2011; Carney 2017). As financial stress spreads (or recedes) across global financial markets, it tightens (or loosens) credit and financial conditions in a wide range of countries. As a result, movements in domestic demand and disinflationary or inflationary pressures are also synchronized across countries.

- *Technological changes*, in addition to deepening supply chains, can also help globalize markets for nontradable service sectors. This may extend and deepen the impact of global forces on domestic inflation (Henriksen, Kydland, and Šustek 2013; Carney 2017).

Country-specific features

The results in the previous sections indicate that, since 2001, the global factor has accounted for 27 percent of domestic inflation variation in advanced economies and 18 percent in EMDEs. Similarly, the group factor has grown in importance such that, since 2001, it has accounted for 21 percent in the median advanced economy and 8 percent in the median EMDE. However, there has been wide heterogeneity in these shares across countries, especially among EMDEs, pointing to the importance of country characteristics (Monacelli and Sala 2009; Neely and Rapach 2011). This section briefly examines the country-specific correlates of the contribution of the global and group-specific factors to EMDE inflation variation.

Correlates of the contribution of the global factor. The global factor has generally contributed more to inflation variation in advanced economies than in EMDEs and, among EMDE regions, has contributed most in East Asia and Pacific, Latin America and the Caribbean, and South Asia. The global inflation factor also explains a larger share of inflation variation in commodity-importing and more trade-open EMDEs (Figure 2.6). Lower trade openness and the heavy reliance on commodity exports in three-quarters of LICs may, in part, explain the weak inflation synchronization in LICs.

A panel regression of the contribution of global or group factors to inflation variation on indicators of integration into the global economy and policy frameworks helps identify those features that are most significantly correlated with greater inflation synchronization. The data set includes annual data for 25 advanced economies and 58 EMDEs (of which 16 are LICs) for 1970-2017. The results suggest that the global factor was significantly more important for inflation in countries with higher trade openness, greater commodity-import intensity, and lower trade concentration (Table A.2.1.4, Annex 2.1). This is consistent with studies that have attributed inflation synchronization to trade or supply chain integration in advanced economies (Box 2.1).[8]

Evolution of the contribution of the global factor over time. The cross-country heterogeneity in the contribution of the global factor to inflation variation seems to have been a phenomenon of the 1970s-1990s that largely disappeared in the 2000s. During 1970-85, as in the full sample period, higher trade openness, commodity importer status, and a more flexible exchange rate regime were each associated with greater contributions of the global factor to inflation. Since 2001, these differences have become less pronounced: the range of contributions of the global factor narrowed from 0-87 percent in 1970-85 to 0-58 percent in 2001-17, without any evidence of systematic differences by country characteristics (Figure 2.6; Table A.2.1.4, Annex 2.1).[9]

Correlates of the contribution of the EMDE factor. Overall, the contributions of the EMDE-specific factor to inflation variation were more homogeneous

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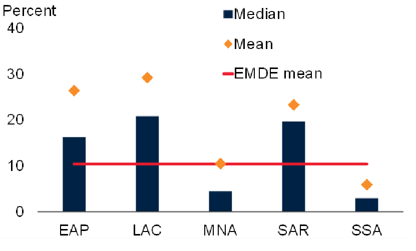
[8] See Monacelli and Sala (2009); Karagedikli, Mumtaz, and Tanaka (2010); Martínez-García (2015); and Auer, Borio, and Filardo (2017). For instance, in a Phillips curve framework, Auer, Borio, and Filardo (2017) present evidence that cross-border trade in intermediate goods and services is the main channel through which global economic slack influences domestic CPI inflation.

[9] In the regression analysis, this loss of systematic differences is apparent in the lack of statistically significant coefficients in the subsample for 2001-17 in Table A.2.1.4, Annex 2.1.

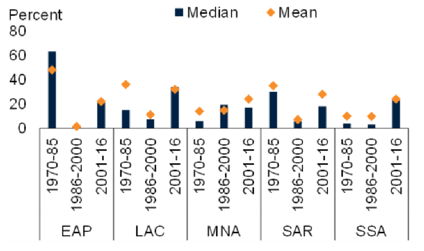
FIGURE 2.6 Contribution of the global factor to inflation: EMDEs

Among EMDEs, the share of the global factor in domestic inflation variance has been particularly high in East Asia and Pacific, Latin America and the Caribbean, and South Asia. In trade-open EMDEs and commodity-importing EMDEs, the global factor also explains a larger share of domestic inflation variance than elsewhere. Since 2001, the differences across EMDE country groups have narrowed, and the contribution of the global factor has become more broad-based.

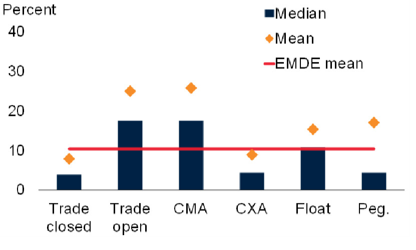
A. EMDE regions, 1970-2017



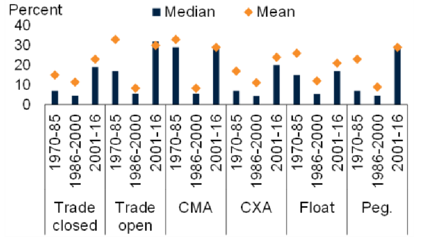
B. EMDE regions, over time



C. By EMDE country groups, 1970-2017



D. By EMDE country groups, over time



Source: World Bank

Note: Contribution of global and group inflation factors to inflation variance. The global and group inflation factors are estimated with the baseline two-factor dynamic factor model for 1970-2017 (Annex 2.1). The sample includes 25 advanced economies and 74 EMDEs, including 16 low-income countries. CMA = commodity importing EMDEs; CXA = commodity exporting EMDEs; EAP = East Asia and Pacific; EMDEs = emerging market and developing economies; Float = EMDEs with floating exchange rate regimes; LAC = Latin America and the Caribbean; MNA = Middle East and North Africa; Peg. = EMDEs with pegged exchange rate regimes; SAR = South Asia; SSA = Sub-Saharan Africa; Trade closed = EMDEs with lower trade openness, measured by the trade-to-GDP ratio (below the median across countries); Trade open = EMDEs with higher trade openness measured by the trade-to-GDP ratio (above the median across countries).

Click here to download data and charts.

than those for the global factor and have, if anything, also become more homogeneous over time. That said, there are some systematic differences by country characteristics. In particular, the group factor contributed more to inflation variation in commodity exporters as well as in countries with pegged exchange rates (Figure 2.6; Table A.2.1.5, Annex 2.1). However, these correlates have shifted over time such that, since 2001, the exchange rate regime has no longer been systematically correlated with the contribution of the group factor. Instead, since 2001, as a growing number of EMDEs shifted toward inflation targeting monetary policy regimes, a systematic negative correlation has emerged between the contribution of the group factor to inflation variation and inflation targeting.

Conclusion

This chapter examines three questions about the extent of global inflation synchronization.

How has inflation synchronization evolved over time? Inflation has become increasingly synchronized globally: 18 percent (in the median EMDE) to 27 percent (in the median advanced economy) of inflation variation since 2001 has been accounted for by the global factor. Over the past four decades, an EMDE-specific factor has emerged that has explained about 8 percent of EMDE inflation variation since 2001, one-quarter higher than in the 1970s although still below the contribution of an advanced economy factor (21 percent). Inflation synchronization varies widely across countries but has become more broad-based over time. During 1986-2000, the global factor contributed more than 10 percent to inflation variation in around one-third of the countries in the sample; by 2001-17, this share had risen to two-thirds.

Which goods and price indexes have been associated with greater inflation synchronization? Inflation synchronization has become more pronounced across inflation measures over time. Although the global factor continues to contribute much more to inflation measures with a higher tradables content (import prices and the PPI) than to measures with a lower tradables content (core and headline CPI and the GDP deflator), this contribution has risen for all inflation measures: to two-thirds for PPI inflation and around one-third for core CPI inflation and GDP deflator growth.

Which country characteristics have been associated with greater inflation synchronization? Countries differ widely in the degree to which global factors and, to a lesser extent, group factors account for domestic inflation variation. The global factor has accounted for a larger share of domestic inflation variation in countries that have been more open to global trade, relied on commodity imports, had more concentrated trade, were more economically developed, or were EMDEs in the East Asia and Pacific, Latin America and the Caribbean, and South Asia regions. That said, over the past four to five decades, this heterogeneity has narrowed such that, since 2001, no country characteristic appears to account systematically for the greater contributions of global factors. Since 2001, the EMDE group factor has explained a greater share of inflation variability in EMDEs that did not have inflation targeting monetary policy frameworks.

The increased synchronicity of global inflation could pose challenges for policy makers. Inflation synchronization in and of itself need not warrant policy intervention (IMF 2018). However, it increases the risk of policy errors when the appropriate response to excessively low or high inflation differs depending on the origin (domestic or foreign) of the underlying inflation shock (Hartmann and McAdam 2018). In the context of exchange rate pass-through, this issue is explored in detail in Chapter 5.

Inflation synchronization raises concerns that central banks' control over domestic inflation may have weakened (Carney 2017). Heads of major advanced economy central banks have acknowledged the need to consider the global environment in setting monetary policy (Bernanke 2007; Draghi 2015; Carney 2015). Weaker monetary policy transmission would increase the burden on fiscal policy to respond to excessive or deficient domestic demand. It would also increase the need for product and labor market flexibility to be able to adjust before relative price changes driven by foreign shocks turn into general inflation. Global inflation synchronization could also strengthen the case for coordinated policy action (IMF 2018). A coordinated response to uncomfortably low or high global inflation could amplify the impact of policies advanced by an individual country.

Future research could take two directions. First, it could delve further into the sources of the inflation synchronization that has been documented here. Synchronization could be generated by common shocks that affect all countries, or by country-specific shocks that spill over between countries. This chapter—as well as the next one—is agnostic about these two sources. Second, this chapter estimates synchronization in short-term inflation movements, not in long-term inflation trends. Yet, as documented in Chapter 1, inflation has trended downward steeply around the world over the past four decades. Future research could aim to quantify the extent of synchronization in these long-term inflation trends.

ANNEX 2.1 Methodology and database

Dynamic factor model

Following Kose, Otrok, and Prasad (2012), this chapter decomposes fluctuations in inflation into one or more latent factors in the context of a dynamic factor model. Dynamic factor models are designed to extract a small number of unobservable common elements from the covariance or comovement between (observable) macroeconomic time series across countries. Thus, the model allows for a parsimonious representation of the data in terms of the unobservable common elements—typically referred to as factors. From a theoretical standpoint, dynamic factor models are appealing because they can be framed as reduced-form solutions to a standard dynamic stochastic general equilibrium (DSGE) model.

This chapter estimates two types of common driving forces in fluctuations in global inflation.

- **Global inflation factor**. This is the broad common elements in inflation fluctuations across countries.

- **Group-specific inflation factors**. These are common elements in the cyclical inflation fluctuations in the countries in a particular group. Here, it is assumed that national inflation rates are explained by a "country group" factor and advanced economy and EMDE factors.

- **Residual ("idiosyncratic") factors.** These capture elements in the fluctuations of an individual variable in a country that cannot be attributed to the other factors.

Thus, the inflation equation for each country takes the following form:

$$\pi_{i,t} = \beta^i{}_{Global}\, f_t^{Global} + \beta^i{}_{Group}\, f_t^{Group} + \varepsilon_{i,t}$$

where π_i denotes inflation in country i; the global and group factors are represented by f_t^{Global} and f_t^{Group}, respectively; and the coefficients before them (β), typically referred to as factor loadings, capture the sensitivities of the macroeconomic series to these factors. The error terms ($\varepsilon_{i,t}$) are assumed to be uncorrelated across countries at all leads and lags. The error terms and factors follow an autoregressive process. The model is estimated using Bayesian techniques as described in Kose, Otrok, and Whiteman (2003).

The importance of each factor in explaining inflation is measured by the fraction of total variance of inflation due to the respective factor. This is computed by applying the variance operator to each equation in the system. Specifically, for inflation in country *i*:

$$Var\,(\pi_i) = (\beta^i{}_{Global})^2\, Var\,(f^{Global}) + (\beta^i{}_{Group})^2\, Var\,(f^{Group}) + Var\,(\varepsilon_i^{\pi})$$

Since there are no cross-product terms between the factors, the variance in inflation attributable to the global factor is:

$$\frac{(\beta^i{}_{Global})^2\, Var\,(f^{Global})}{Var\,(\pi_i)}$$

The variance shares due to the group factors and idiosyncratic terms are calculated using a similar approach.

Regression analysis between the variance contributions of the inflation factors and country characteristics

To explore the relations between the impact of global and group-specific inflation factors on domestic inflation, the contributions of the global and group factors in individual countries are regressed on a variety of indicators for country characteristics. They include variables on the structure of an economy as well as policy frameworks. The variables include dummy variables for above-average commodity import intensity, income groups, and regions; dummy variables for exchange rate and monetary policy regimes; measures of trade and financial openness (trade-to-GDP ratio, capital account openness index by Chinn and Ito [2017], and index of trade concentration) and degree of participation in global value chains (share of foreign value added in exports); and measures of central bank independence and transparency and the turnover ratio of central bank heads. A more detailed description of the country characteristics is provided in the Appendix.

The regression analysis starts with a set of bivariate regressions that include a variable of interest and the constant as explanatory variables for the global or group factor's variance share of inflation. Based on the results from bivariate regressions, a multivariate regression is estimated using Bayesian model averaging (baseline) or multivariate least squares (for robustness). Considering that regional dummy variables are highly correlated with other structural and policy variables, each set of multivariate regressions is executed with and without the regional dummy variables. The estimations are conducted for the full sample (1970-2017) as well as three subsamples (1970-85, 1986-2000, and 2001-17). The list of countries is provided in Table A.2.1.2, Annex 2.1.

TABLE A.2.1.1 Factor models for inflation synchronization in the literature

Related work	Inflation measures	Data coverage	Empirical framework (economic factors)	Results
Ciccarelli and Mojon (2010)	Headline CPI	22 OECD countries (1960-2008, quarterly)	Static factor model (one global factor)	A simple average of 22 OECD countries' inflation, which the authors call global inflation, accounts for almost 70 percent of the variance of inflation in these countries between 1960Q1 and 2008Q2. First, at business cycle frequencies, the variance explained by global inflation is about 37 percent on average and much larger in many countries. Second, domestic inflation reverts to the global component. Third, in countries that have experienced stronger commitment to price stability (such as Germany) global inflation has a lesser impact on domestic inflation than in those with weaker inflation discipline (such as Italy).
Hakkio (2009)	Headline and core CPI	30 OECD and 6 non-OECD countries (1960-2008, quarterly)	Principal component analysis (global and regional factors)	The first common factor is an important determinant of national inflation rates in industrial countries and non-industrial and regional inflation rates (with R squareds of regressions of national inflation on the first common factor averaging 0.71). The commonality of industrial inflation rates appears to reflect the commonality of macro variables that are determinants of inflation.
Auer, Levchenko, and Sauré (2017)	Sectoral PPI	30 countries (1995-2011, monthly)	Dynamic factor model (global, sectoral, and country factors)	For the median country, the global component accounts for 51percent of the variance of the PPI. Input-output linkages account for half of this global component of PPI inflation. On average, a shock that raises inflation by 1 percent in the other countries in the world other than the country under observation raises domestic PPI by 0.19 percent. PPI synchronization across countries is driven primarily by common sectoral shocks and input-output linkages amplify comovement primarily by propagating sectoral shocks.
Parker (2018)	Sub-components of headline CPI	223 countries (unbalanced panel) (1980-2010, quarterly)	Dynamic hierarchical model (global, index-specific, and group factors)	Global inflation accounts for a large share of the variance of national inflation rates in OECD countries. For middle-income countries the share of national inflation variance explained by global factors is on the order of 15 to 20 percent, falling to around 10 percent for low-income countries. Higher income, greater financial sector development, and more transparent central banks are associated with a larger influence of global inflation. Relatively rich countries with deep domestic capital markets and good monetary policy are likely to be better able to mitigate idiosyncratic, domestic shocks. Global inflation factors also have greater influence on the national inflation rates of countries with fixed exchange rates. There is a more marked influence of global energy and food prices on the respective national inflation rates. Housing prices appear for the most part idiosyncratic and unrelated to global factors.

TABLE A.2.1.1 Factor models for inflation synchronization in the literature (*continued*)

Related work	Inflation measures	Data coverage	Empirical framework (economic factors)	Results
Mumtaz and Surico (2012)	Headline CPI other inflation indicators	10 advanced economies (1961-2004, quarterly)	Dynamic factor model (global and country factors)	The historical decline in the level and persistence of inflation is shared by most countries. An international factor tracks the level and persistence of national inflation rates reasonably well. The rise and fall of national contributions to inflation fluctuations are not synchronized across economies and their timing confirms conventional wisdom on the conduct of national policies: income policies and accommodative monetary policies are associated with periods of volatile inflation in the United Kingdom, the United States, Italy, and Japan. The fall in inflation predictability is a common feature of the industrialized world since the late 1980s. Differences in the pace of productivity growth appear important to explain differences in the national factors. International comovements in money growth are significantly related to international comovements in inflation.
Neely and Rapach (2011)	Headline CPI	64 countries (1950-2009, annual)	Dynamic factor model(global and regional factors)	The global factor explains 35 percent of annual inflation variability on average across the 64 countries; the regional factor explains 16 percent of inflation variability on average; and the country-specific component explains 49 percent. Although the world factor explains about a third of inflation variability on average across countries, its importance within that group varies substantially (83 percent of inflation variability in Canada; less than 10 percent in some other countries). The global inflation factor more strongly influences advanced economies with strong institutions, developed financial markets, low average inflation, and independent central banks. The relative importance of the factors is fairly stable over subsamples 1951-79 and 1980-2009, although the regional (global) factor clearly increases in importance for several North American and European (Latin American and Asian) countries during the second subsample.
Forster and Tillmann (2014)	Headline, food and energy CPI	101 economies (1996:1-2011:4)	Hierarchical factor model	About two-thirds of overall inflation volatility is due to country-specific determinants. For CPI inflation net of food and energy, the global factor and CPI basket–specific factor account for less than 20 percent of inflation variation. Only energy price inflation is dominated by common factors.
Karagedikli, Mumtaz and Tanaka (2010)	CPI of 28 product categories	14 advanced economies (1998:1 -2008:2)	Dynamic factor model	Category-specific (for 28 product categories) factors account for a large part of the comovement in the prices of goods in advanced economies which are intensive in internationally traded primary commodities; but this is less evident for other traded goods. The world factor and the category-specific factors become more significant in explaining the movement in the relative prices in the second half of the sample (2003-08).

TABLE A.2.1.1 Factor models for inflation synchronization in the literature (*continued*)

Related work	Inflation measures	Data coverage	Empirical framework (economic factors)	Results
Ferroni and Mojon (2018)	Headline CPI	22 OECD countries (1991:1-2013:3)	Forecasting model suite	The share of volatility explained by global inflation remains dominant. In a (pseudo) out-of-sample exercise, global inflation remains the only variable that can help to improve the one-year-ahead inflation forecast relative to univariate models. Commodity prices do not seem to be better predictors of domestic inflation dynamics than measures of global inflation.
Henriksen, Kydland and Šustek (2013)	Headline CPI	6 advanced economies (1974:1-2006:4)	Bilateral correlations	Fluctuations in nominal variables—aggregate price levels and nominal interest rates—are documented to be substantially more synchronized across countries at business cycle frequencies than bilateral correlations fluctuations in real output. Specifically, for 1960:1-2006:4 the average bilateral correlation of price levels is 0.52, that of short-term nominal interest rates 0.57, while that of real GDP is only 0.25.
Wang and Wen (2006)	Headline CPI	18 advanced economies	Correlations	The average cross-country correlation of inflation is significantly and systematically stronger than that of output, and the cross-country correlation of money growth is essentially zero. Yet, movements in the money stock are not significantly and systematically correlated across countries. Neither the new Keynesian sticky-price model nor the sticky-information model can fully explain the data.

Note: CPI = consumer price index; OECD = Organisation for Economic Co-operation and Development; PPI = producer price index.

TABLE A.2.1.2 List of countries

A. Full-sample country group (headline CPI inflation)	
Advanced economies (25)	Australia; Austria; Belgium; Canada; Cyprus; Denmark; Finland; France; Germany; Greece; Iceland; Ireland; Italy; Japan; Korea, Rep.; Luxembourg; New Zealand; Norway; Portugal; Singapore; Spain; Sweden; Switzerland; United Kingdom; and United States
EMDEs (58)	Algeria; Antigua and Barbuda; The Bahamas; Bahrain; Bangladesh; Barbados; Belize; Bhutan; Botswana; Cabo Verde; Cameroon; China; Colombia; Congo, Rep.; Côte d'Ivoire; Dominica; Dominican Republic; Ecuador; Egypt, Arab Rep.; El Salvador; Equatorial Guinea; Fiji; Gabon; Grenada; Guatemala; Honduras; Hungary; India; Indonesia; Iran, Islamic Rep.; Jordan; Kenya; Kuwait; Lesotho; Libya; Malaysia; Maldives; Mauritius; Morocco; Oman; Pakistan; Panama; Papua New Guinea; Paraguay; Philippines; Samoa; Saudi Arabia; Seychelles; South Africa; Sri Lanka; St. Kitts and Nevis; St. Lucia; St. Vincent and the Grenadines; Eswatini; Thailand; Trinidad and Tobago; Tunisia ;and Vanuatu
LICs (16)	Benin; Burkina Faso; Burundi; Central African Republic; Comoros; Ethiopia; The Gambia; Guinea; Madagascar; Mali; Nepal; Niger; Rwanda; Senegal; Tanzania; and Togo
B. Subsample country group (five inflation measures)	
Advanced economies (25)	Australia; Austria; Belgium; Canada; Cyprus; Denmark; Finland; France; Germany; Greece; Ireland; Italy; Japan; Korea, Rep.; Luxembourg; Netherlands; New Zealand; Norway; Portugal; Singapore; Spain; Sweden; Switzerland; United Kingdom; and United States
EMDEs (13)	Egypt, Arab Rep.; El Salvador; Hungary; India; Indonesia; Iran, Islamic Rep.; Kuwait; Pakistan; Panama; Philippines; South Africa; Thailand; and Tunisia

Note: Numbers in the parentheses indicate the number of countries in each group. EMDEs exclude LICs. CPI = consumer price index; EMDEs = emerging market and developing economies; LICs = low-income countries.

TABLE A.2.1.3 Variance decompositions over time: Various inflation measures—Panel A. Import Prices (Percent)

	1970-85	1986-2000	2001-16
Factor		**All countries**	
Global	67.7 (62.6, 54.9 - 74.9)	8.7 (15.5, 3.1 - 24.5)	50.1 (49.2, 42.6 - 63.3)
Group	5.1 (10.7, 0.7 - 13.9)	18.5 (25.7, 2.8 - 44.5)	11.4 (13.7, 6.1 - 19.2)
Global + Group	77.5 (73.2, 64.3 - 85.5)	37.6 (41.2, 18.5 - 58.8)	67.7 (62.9, 48.6 - 77.6)
Factor		**Advanced economies**	
Global	66.3 (62.3, 54.9 - 74.9)	8.7 (14.9, 3.4 - 24.5)	59.2 (50.9, 44.3 - 63.3)
Group	5.1 (8.7, 0.7 - 10.5)	18.5 (28.6, 3.9 - 52.3)	11.4 (13.6, 6.1 - 18.4)
Global + Group	71.7 (71.1, 61.8 - 85.5)	39.1 (43.5, 18.5 - 69.2)	68.0 (64.4, 52.0 - 77.6)
Factor		**EMDEs**	
Global	70.1 (63.5, 56.8 - 76.8)	9.9 (18.2, 2.9 - 25.1)	42.2 (42.4, 36.9 - 47.8)
Group	8.2 (18.9, 1.8 - 25.2)	11.8 (13.2, 2.5 - 22.5)	12.9 (13.9, 5.0 - 21.8)
Global + Group	82.5 (82.4, 79.9 - 85.0)	33.9 (31.4, 23.8 - 41.4)	49.4 (56.4, 47.0 - 58.7)

Note: The contribution of global and group inflation factors to inflation variance is estimated over the three subsample periods with a two-factor dynamic factor model for each of the five different inflation measures: import prices, PPI, headline, GDP deflator, and core CPI. The data set includes 38 countries (25 advanced economies and 13 EMDEs) except import prices for 21 countries (17 advanced economies and 4 EMDEs). The first argument in the first row indicates the unweighted median across countries. The first argument in the second row (in parentheses) is the mean variance share across countries. The second and third arguments in the second row (in parentheses) indicates the interquartile range (25th and 75th percentiles) of variance shares. CPI = consumer price index; EMDEs = emerging market and developing economies; GDP = gross domestic product; PPI = producer price index.

TABLE A.2.1.3 Variance decompositions over time: Various inflation measures—Panel B. PPI (Percent)

	1970-2016	1970-85	1986-2000	2001-16
Factor	**All countries**			
Global	42.1 (41.1, 15.3 - 61.7)	52.3 (45.2, 22.1 - 67.5)	5.2 (9.2, 2.3 - 11.2)	67.2 (61.4, 55.1 - 76.4)
Group	6.6 (3.2, 0.9 - 8.8)	7.3 (12.6 , 2.2 - 18.3)	16.7 (22.5, 7.1 - 29.9)	3.9 (6.1, 1.3 - 8.1)
Global + Group	49.9 (45.2, 19.7 - 67.3)	65.0 (54.8, 32.9 - 81.0)	24.9 (30.0, 16.1 - 42.7)	71.3 (63.9, 54.9 - 82.1)
Factor	**Advanced economies**			
Global	56.1 (48.4, 33.9 - 63.7)	62.1 (50.0, 27.5 - 70.7)	4.0 (9.0, 2.3 - 8.3)	71.7 (68.3, 65.8 - 77.0)
Group	4.5 (7.7, 1.1 - 9.6)	7.1 (13.2, 3.2 - 23.1)	20.7 (28.6, 11.9 - 45.8)	5.9 (6.8, 1.1 - 8.4)
Global + Group	60.6 (51.6, 31.2 - 68.1)	71.7 (58.1, 38.9 - 85.1)	35.8 (34.5, 19.1 - 52.1)	77.3 (69.1, 66.8 - 87.8)
Factor	**EMDEs**			
Global	16.2 (28.3, 11.1 - 40.4)	33.7 (36.9, 12.9 - 57.8)	6.9 (9.8, 3.1 - 11.6)	49.4 (49.0, 27.6 - 63.4)
Group	1.4 (4.7, 0.8 - 4.0)	11.4 (11.6, 2.2 - 16.6)	13.2 (11.7, 5.2 - 15.9)	3.5 (4.8, 2.4 - 7.4)
Global + Group	22.6 (33.0, 13.5 - 41.0)	50.3 (48.4, 31.5 - 70.0)	20.0 (21.4, 14.9 - 26.6)	57.6 (53.9, 41.2 - 66.6)

Note: The contribution of global and group inflation factors is estimated over the three subsample periods with the dynamic factor model (two-factor model) for each of the five different inflation measures: import prices, PPI, headline, GDP deflator, and core CPI. The data set includes 38 countries (25 advanced economies and 13 EMDEs) except import prices for 21 countries (17 advanced economies and 4 EMDEs). The first argument in the first row indicates the unweighted median across countries. The first argument in the second row (in parentheses) is the mean variance share across countries. The second and third arguments in the second row (in parentheses) indicate the interquartile range (25th and 75th percentiles) of variance shares. CPI = consumer price index; EMDEs = emerging market and developing economies; GDP = gross domestic product; PPI = producer price index.

TABLE A.2.1.3 Variance decompositions over time: Various inflation measures—Panel C. Headline CPI (Percent)

	1970-2016	1970-85	1986-2000	2001-16
Factor	**All countries**			
Global	15.7 (22.9, 6.2 - 36.5)	18.7 (28.2, 10.3 - 42.4)	4.0 (5.8, 1.9 - 7.5)	32.8 (30.8, 19.5 - 44.7)
Group	9.1 (12.8, 3.4 - 21.4)	8.6 (14.5, 3.8- 22.9)	5.7 (9.5, 4.8 - 10.3)	19.1 (20.2, 10.3 - 24.7)
Global + Group	34.1 (35.7, 25.4 - 44.6)	42.9 (42.7, 25.0 - 56.7)	12.1 (15.3, 8.1 - 19.0)	55.2 (51.2, 47.7 - 60.8)
Factor	**Advanced economies**			
Global	21.4 (23.7, 11.0 - 36.6)	20.0 (27.3, 8.7 - 42.6)	4.3 (6.2, 1.9 - 7.6)	37.0 (35.0, 28.8 - 44.9)
Group	11.5 (14.0, 4.1 - 24.1)	19.8 (18.9, 4.3 - 29.7)	5.5 (6.4, 4.7 - 7.0)	17.3 (16.6, 9.1 - 19.9)
Global + Group	35.9 (37.7, 31.1 - 44.8)	45.1 (46.1, 28.3 - 59.1)	12.0 (12.6, 7.8 - 14.6)	54.4 (52.8, 48.5 - 58.3)
Factor	**EMDEs**			
Global	11.6 (21.4, 3.4 - 36.3)	17.4 (30.0, 13.8 - 41.9)	3.2 (5.1, 1.0 - 5.2)	18.1 (21.0, 3.4 - 24.7)
Group	7.7 (10.4, 0.9 - 11.8)	6.8 (6.2, 3.2 - 8.6)	10.2 (15.5, 5.7 - 19.2)	25.6 (30.4, 12.4 - 42.6)
Global + Group	25.6 (31.9, 16.7 -43.9)	26.2 (36.2, 23.0 - 45.1)	12.6 (20.6, 10.1 - 27.8)	59.2 (48.3, 28.8 - 64.7)

Note: The contribution of global and group inflation factors is estimated over the three subsample periods with the dynamic factor model (two-factor model) for each of the five different inflation measures: import prices, PPI, headline, GDP deflator, and core CPI. The data set includes 38 countries (25 advanced economies and 13 EMDEs) except import prices for 21 countries (17 advanced economies and 4 EMDEs). The first argument in the first row indicates the unweighted median across countries. The first argument in the second row (in parentheses) is the mean variance share across countries. The second and third arguments in the second row (in parentheses) indicate the interquartile range (25th and 75th percentiles) of variance shares. The results differ from Tables 2.1 and 2.2 because of the smaller sample size to match the sample with available data for other measures of inflation. CPI = consumer price index; EMDEs = emerging market and developing economies; GDP = gross domestic product; PPI = producer price index.

TABLE A.2.1.3 Variance decompositions over time: Various inflation measures —Panel D. GDP deflator (Percent)

	1970-2016	1970-85	1986-2000	2001-16
Factor		All countries		
Global	12.6 (18.7, 3.2 - 30.5)	13.7 (25.9, 5.5 - 43.0)	7.4 (16.7, 3.1 - 28.8)	33.4 (32.4, 16.2 - 50.0)
Group	12.1 (16.0, 4.6 - 25.5)	12.7 (18.6, 5.8 - 28.3)	7.1 (11.7, 3.4 - 18.8)	4.1 (11.3, 0.8 - 10.9)
Global + Group	35.3 (33.8, 19.1 - 45.0)	45.3 (43.3, 19.9 - 63.2)	25.0 (27.6, 11.8 - 37.8)	44.8 (42.6, 30.7 - 58.0)
Factor		Advanced economies		
Global	13.4 (19.1, 6.5 - 31.5)	14.8 (27.1, 9.4 - 42.1)	12.8 (18.1, 3.4 - 28.9)	35.7 (34.4, 19.5 - 48.0)
Group	12.6 (15.9, 3.5 - 25.0)	9.3 (13.8, 5.0 - 23.0)	7.2 (11.5, 3.4 - 15.9)	2.3 (3.2, 0.6 - 5.2)
Global + Group	33.6 (37.3, 18.1 - 45.8)	37.8 (39.3, 19.9 - 59.3)	29.7 (28.4, 15.9 - 42.8)	39.2 (36.1, 22.1 - 47.6)
Factor		EMDEs		
Global	9.3 (18.0, 2.2 - 26.1)	9.8 (23.7, 1.9 - 44.5)	3.5 (14.2, 3.1 - 15.5)	19.7 (28.7, 10.3 - 50.0)
Group	9.5 (16.2, 6.2 - 25.5)	19.6 (27.5, 9.1 - 44.5)	7.1 (12.0, 3.4 - 18.8)	25.5 (26.3, 10.4 - 44.4)
Global + Group	33.7 (34.2, 22.2 - 37.4)	54.9 (51.2, 32.5 - 70.1)	22.8 (26.2, 10.5 - 35.9)	56.7 (55.0, 53.0 - 65.5)

Note: The contribution of global and group inflation factors is estimated over the three subsample periods with the dynamic factor model (two-factor model) for each of the five different inflation measures: import prices, PPI, headline, GDP deflator, and core CPI. The data set includes 38 countries (25 advanced economies and 13 EMDEs) except import prices for 21 countries (17 advanced economies and 4 EMDEs). The first argument in the first row indicates the unweighted median across countries. The first argument in the second row (in parentheses) is the mean variance share across countries. The second and third arguments in the second row (in parentheses) indicate the interquartile range (25th and 75th percentiles) of variance shares. CPI = consumer price index; EMDEs = emerging market and developing economies; GDP = gross domestic product; PPI = producer price index.

TABLE A.2.1.3 Variance decompositions over time: Various inflation measures —Panel E. Core CPI (Percent)

	1970-2016	1970-85	1986-2000	2001-16
Factor		**All countries**		
Global	4.7 (12.5, 1.7 - 15.4)	8.4 (14.2, 6.9 - 14.5)	5.4 (17.5,1.3 - 29.1)	29.8 (27.8, 9.7 - 42.1)
Group	14.1 (18.8, 2.9 - 26.6)	16.5 (18.9, 5.2 - 31.8)	10.6 (15.3, 3.1 - 25.6)	3.5 (5.8, 2.1 - 7.7)
Global + Group	26.5 (27.9, 10.9 - 40.4)	28.6 (29.6, 11.6 - 44.3)	31.3 (29.2, 11.9 - 44.9)	33.0 (30.0, 13.8 - 46.9)
Factor		**Advanced economies**		
Global	7.9 (14.5, 3.1 - 21.4)	8.5 (16.0, 7.7 - 22.6)	5.3 (16.1, 2.3 - 26.3)	31.9 (29.5, 25.0 - 44.1)
Group	17.7 (21.9, 8.7 - 34.8)	16.9 (21.0, 5.2 - 35.7)	17.9 (17.1, 2.3 - 29.2)	3.1 (5.8, 2.0 - 5.4)
Global + Group	34.6 (34.9, 18.9 - 46.4)	40.1 (35.5, 13.2 - 53.7)	31.8 (30.9, 20.6 - 46.6)	35.1 (33.0, 20.6 - 47.7)
Factor		**EMDEs**		
Global	1.7 (8.0, 1.3 - 9.1)	10.1 (8.9, 2.5 - 12.9)	26.3 (26.2, 0.7 - 29.1)	22.2 (23.3, 0.6 - 29.0)
Group	2.9 (11.5, 1.5 - 13.5)	9.4 (11.5, 5.3 - 19.2)	7.0 (6.9, 4.6 - 10.9)	6.4 (7.6, 4.2 - 13.2)
Global + Group	11.8 (15.0, 3.0 - 16.5)	17.2 (18.7, 5.6 - 27.5)	22.4 (24.9, 5.9 - 33.6)	11.8 (22.9, 1.1 - 31.1)

Note: The contribution of global and group inflation factors is estimated over the three subsample periods with the dynamic factor model (two-factor model) for each of the five different inflation measures: import prices, PPI, headline, GDP deflator, and core CPI. The data set includes 38 countries (25 advanced economies and 13 EMDEs) except import prices for 21 countries (17 advanced economies and 4 EMDEs). The first argument in the first row indicates the unweighted median across countries. The first argument in the second row (in parentheses) is the mean variance share across countries. The second and third arguments in the second row (in parentheses) indicate the interquartile range (25th and 75th percentiles) of variance shares. CPI = consumer price index; EMDEs = emerging market and developing economies; GDP = gross domestic product; PPI = producer price index.

TABLE A.2.1.4 Correlates of the variance share of the global inflation factor

	All	1970-85	1986-2000	2001-17
EMDE	0.03	0.033	0.01	-0.02
	(0.07)	(0.09)	(0.04)	(0.06)
GDP per capita	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Commodity exporter	-0.11**	-0.059	0.04	-0.02
	(0.04)	(0.06)	(0.04)	(0.04)
Inflation target	-0.06	-0.09	0.07	-0.03
	(0.05)	(0.07)	(0.04)	(0.05)
Exchange rate peg (R)	0.004	0.003	0.002	0.001
	(0.02)	(0.03)	(0.02)	(0.02)
Exchange rate peg (S)	-0.05	-0.11**	-0.02	0.03
	(0.04)	(0.05)	(0.03)	(0.03)
Trade openness	0.001**	0.001	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Trade concentration	-0.33**	-0.58***	-0.004	-0.047
	(0.12)	(0.17)	(0.1)	(0.10)
Financial openness	0.06	0.13	0.02	0.088
	(0.07)	(0.09)	(0.06)	(0.06)
Global value chain	-0.003	-0.004	-0.001	-0.001
	(0.00)	(0.00)	(0.00)	(0.00)
Debt-to-GDP ratio	-0.001	-0.001	0.002**	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Central bank independence and transparency	-0.004	-0.027*	-0.01	-0.003
	(0.01)	(0.01)	(0.01)	(0.01)

Note: Results of an ordinary least squares regression of the variance share of the global factor in inflation variation on a number of country characteristics as explanatory variables. The global factor is estimated with the dynamic factor model described in this Annex for the period of a full sample (1970-2017) and three subsamples (1970-85, 1986-2000, and 2001-17). The global factor is estimated in a sample of 99 countries (25 advanced economies and 74 EMDEs, including 16 low-income countries). Of these, 25 advanced economies and 58 EMDEs are included in this regression. The numbers in parentheses refer to standard errors (*** p < 0.01, ** p < 0.05, *p < 0.1). Inflation targeting regimes are defined as in IMF (2016). A value of 1 indicates the existence of an inflation targeting regime, a value of 0 its absence. Exchange rate regime (R) is based on Ilzetzki, Reinhart, and Rogoff (2017), and exchange rate regime (S) is based on Shambaugh (2004). A higher value indicates greater exchange rate flexibility. The measures of trade and capital account openness are, respectively, trade (exports plus imports)-to-GDP ratios (in percent) and the index compiled by Chinn and Ito (2006). Trade concentration is based on product concentration and diversification indexes of exports and imports by UNCTAD. Central bank independence and transparency is based on Dincer and Eichengreen (2014). A higher value indicates greater central bank independence and transparency. The EMDE dummy equals 1 for any EMDE and 0 for any other country. Dependent variables are based on median values over the country-specific sample periods except that the variables on exchange rate regime and inflation targeting are based on the mode. For details on the data definitions, refer to the Appendix.
EMDEs = emerging market and developing economies; GDP = gross domestic product.

TABLE A.2.1.5 Correlates of the variance share of the group inflation factor

	All	1970-85	1986-2000	2001-17
EMDE	-0.13*	0.00	-0.17	-0.20**
	(0.07)	(0.02)	(0.11)	(0.10)
LIC	0.00	-0.02	0.04	-0.25**
	(0.06)	(0.04)	(0.1)	(0.13)
GDP per capita	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Commodity exporter	0.09**	-0.02	0.08	0.04
	(0.04)	(0.03)	(0.06)	(0.03)
Inflation target	-0.07	0.005	-0.12	-0.07*
	(0.05)	(0.05)	(0.08)	(0.04)
Exchange rate regime (S)	0.13***	0.06**	0.20***	0.02
	(0.04)	(0.03)	(0.05)	(0.03)
Trade openness	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Trade concentration	0.10	0.11	0.20	-0.17*
	(0.11)	(0.10)	(0.16)	(0.09)
Financial openness	-0.10	0.04	-0.19**	0.03
	(0.06)	(0.05)	(0.09)	(0.05)
Global value chain	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Debt-to-GDP ratio	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Central bank independence and transparency	0.01	0.02**	0.03**	-0.01
	(0.01)	(0.01)	(0.01)	(0.01)

Note: Results of an ordinary least squares regression of the variance share of the EMDE factor in inflation variation on a number of country characteristics as explanatory variables. The global factor is estimated with the dynamic factor model described in this Annex for the period of a full sample (1970-2017) and three subsamples (1970-85, 1986-2000, and 2001-17). The global factor is estimated in a sample of 99 countries (25 advanced economies and 74 EMDEs, including 16 LICs). Of these, 25 advanced economies and 58 EMDEs are included in this regression. The numbers in parentheses refer to standard errors (*** $p < 0.01$, ** $p < 0.05$, *$p < 0.1$). Inflation targeting regimes are defined as in IMF (2016). A value of 1 indicates the existence of an inflation targeting regime, a value of 0 its absence. Exchange rate regime (S) is based on Shambaugh (2004). A higher value indicates greater exchange rate flexibility. The measures of trade and capital account openness are, respectively, trade (exports plus imports)-to-GDP ratios (in percent) and the index compiled by Chinn and Ito (2006). Trade concentration is based on product concentration and diversification indexes of exports and imports by UNCTAD. Central bank independence and transparency is based on Dincer and Eichengreen (2014). A higher value indicates greater central bank independence and transparency. The LIC dummy equals 1 for any LIC and 0 for any other country. The EMDE dummy equals 1 for any EMDE and 0 for any other country. Dependent variables are based on median values over the country-specific sample periods except that the variables on exchange rate regime and inflation targeting are based on the mode. For details on the data definitions, refer to the Appendix. EMDEs = emerging market and developing economies; GDP = gross domestic product; LIC = low-income country.

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