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What drives inflation? Disentangling Demand and Supply Factors

CAMA Working Paper 74/2022
December 2022

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JEL Classification

E3, E5, E6, C3

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ISSN 2206-0332

What drives inflation? Disentangling demand and supply factors *

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*We thank Claudio Borio, Warwick McKibbin, Benoît Mojon, Athanasios Orphanides, Yves Schüler and seminar participants at the BIS and the Deutsche Bundesbank for helpful comments and suggestions. We also thank Jesus Laso Pazos and Bianca Piccirillo for excellent research assistance. The views expressed in this paper are those of the authors only and do not necessarily reflect those of the Deutsche Bundesbank, the Eurosystem or the Bank for International Settlements.

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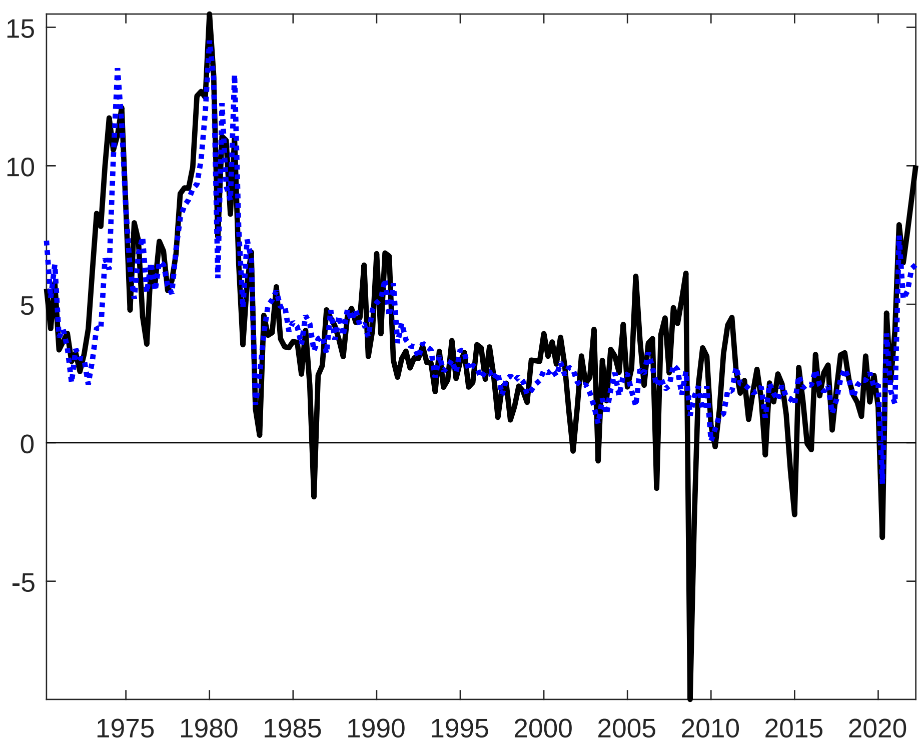
1 Introduction

Over the past year, inflation in the United States and many other countries has surged to its highest level since the 1970s (Figure 1). A key question is to which extent the surge is driven by demand or supply. The former would make the case for monetary and fiscal policy tightening, while the latter would be associated with tricky policy trade-offs. In the public debate, there is so far no consensus on the relative importance of supply and demand factors in the rise in inflation. While most contributions emphasise the role of adverse supply factors in the form of supply bottlenecks and higher energy prices (e.g. Budianto et al. 2021, some commentators point to excessive demand due to catch-up effects and massive monetary and fiscal stimulus in the wake of the Covid-19 pandemic (e.g. Summers (2021), Furman (2022)).[1]

Figure 1: **Inflation in the United States**



Notes: Consumer price index (CPI) inflation (black) and core CPI inflation (blue). Quarter-on-quarter, annualized, in %.

[1]See BIS (2022) for a detailed discussion of the various factors at work in the recent inflation surge.

The challenge of disentangling demand and supply factors behind observable inflation dynamics is, of course, not new. Over the decades, the relative weight assigned to underlying demand or supply factors has often played a key role in policy debates and decisions. For instance, the Great Inflation of the 1970s was attributed to misguided perceptions of primarily supply-side origins of inflation leading to an excessively loose monetary policy stance (Nelson, 2022). Another example is the debate about the missing disinflation after the Great Financial Crisis (GFC) which was ascribed to tightening supply conditions emanating from higher energy prices (Coibion and Gorodnichenko 2015) and negative financial shocks (Gilchrist et al. 2017). A third example is the period of persistent low inflation during the recovery from the GFC, which was linked to inadequate demand (Summers, 2014) as well as to disinflationary supply-side factors emanating from globalisation and technological advances (Borio et al. 2018).

This paper takes a novel approach to disentangle aggregate supply and demand. Based on a structural factor model comprising more than 140 quarterly time series measures of inflation and real activity in the United States going back to 1970, we identify aggregate demand and supply factors. That way, we obtain indicators of aggregate demand and supply conditions and can assess their role in the dynamics of inflation and real activity.

We estimate factors based on a principal component analysis and then rotate them to identify supply and demand using sign restrictions imposed on factor loadings. Specifically, we propose a set of theoretically motivated sign restrictions on the factor loadings of inflation and economic activity indicators to separate supply and demand. These restrictions are based on the standard supply and demand framework, where changes in supply move inflation and output in opposite directions, while changes in demand move both variables in the same direction. We thus identify supply as a factor that loads negatively on inflation and positively on economic activity, and demand as a factor that loads positively on both inflation and economic activity.

Our analysis has points of contact with several strands of literature. Or structural factor analysis is methodologically related to factor models using zero or sign restrictions on factor loadings to analyse the impact of monetary policy on the yield curve (Gürkaynak et al. 2005, Swanson (2021) and Andrade and Ferroni (2021)), international business cycles (Kose et al. 2003) and global financial conditions (Eickmeier et al. (2014)). We add to this literature by proposing a structural factor model that disentangles aggregate demand and supply based on sign restriction imposed on factor loadings.

The sign restriction we use to identify demand and supply factors are similar to those used in the literature on structural vector autoregressions to identify aggregate demand and supply shocks (Canova and de Nicoló 2003, Peersman 2005). Shapiro (2022*a*) has recently used similar restrictions to split the PCE basket into demand- and supply-driven groups based on the sign of unexpected changes in prices and quantities. In our analysis, we go beyond shocks and extract indicators of demand and supply conditions from the data.

By providing indicators of the stance of aggregate demand and supply, our analysis also contributes to the literature on business cycle indicators. This literature, which was pioneered by Stock and Watson (1998), Stock and Watson (2002*b*) and Stock and Watson (2010), uses factor models estimated on large macroeconomic datasets to derive indicators of the state of the business cycle. Prominent examples of such business cycle indicators are the Conference Board and the Eurocoin indicators. Our analysis disentangles business cycle conditions further into underlying demand and supply conditions. Moreover, based on our analytical framework, we can also perform historical decompositions, backing out the contribution of supply and demand factors to the evolution of inflation and economic activity measures over time. This allows us to assess, for instance, to which extent CPI inflation in a given point in time was driven by demand or supply conditions.

Our structural factors offer a narrative of the evolution of demand and supply conditions and of their role in inflation dynamics in the United States over the past five decades. In particular, for the recent period since 2021, our analysis indicates a combination of very strong demand conditions at levels not seen since the 1970s and tight supply. Historical decompositions suggest that recent inflation dynamics have been driven in particular by strong demand, and to a lesser extent also by tight supply. Also for other important historical episodes there are a number of findings worth highlighting. We find that a combination of occasionally tight supply and persistently expansionary demand conditions was driving the Great Inflation. The missing disinflation after the GFC was attributable to tight supply counteracting the disinflationary effects of weak demand according to our estimates. And for the period between the GFC and the pandemic, our analysis suggests that both supply and weak demand were responsible for persistently low inflation. These findings hold up in a number of robustness checks and are also robust in a pseudo real-time analysis estimating the factors recursively.

As an additional exercise, we use the estimated factors to assess the demand and supply effects of monetary policy shocks and of financial shocks (specifically shocks to the excess bond premium of Gilchrist and Zakrajšek (2012), thus exploring the relevance and strength of demand and supply channels in the monetary and financial transmission process. Most empirical papers analyse the effects of monetary policy and financial shocks on output and inflation which only provides information on whether supply or demand effects dominate. We assess whether and, if yes, how the shocks affect both supply and demand. This analysis relates to the literature on the supply effects of monetary policy and financial shocks through a cost channel (Barth and Ramey 2001, Christiano et al. 2005, Gilchrist et al. 2017) or through capital re-allocation across firms (Baqaee et al. 2021).

Finally, while the main part of the analysis is focused on the United States, we also assess the evolution over time of supply and demand conditions in the euro area. This part of the analysis is based on quarterly data for the four major euro-area economies (France, Germany, Italy, Spain) going back to 1999. The results suggest that, in the overlapping period of analysis, the dynamics of demand and supply in the euro area have been similar to those in the United States. Specifically, in the post-pandemic inflation surge, also both strong demand and weak supply factors appear to have been at work. However, tight supply conditions have been relatively more important compared to the United States, in particular in the first two quarters of 2022. This finding is consistent with the notion that supply factors play a relatively more important role in the euro-area inflation surge due to greater constraints in energy supply related to the Russia-Ukraine war.

The remainder of the paper is structured as follows. In section 2 we present the data. In section 3 we lay out the methodology to identify and estimate the structural demand and supply factors. Section 4 reports the main results of the analysis together with robustness checks and a real-time analysis. In section 5 we examine the dynamic effects of monetary policy and financial shocks on demand and supply. The analysis and the results for the euro area are reported in section 6. Section 7 concludes.

2 Data

The data used in the analysis comprise measures of inflation and of real economic activity in the United States over the period 1970Q1 until 2022Q2. The individual data series included in the database are listed in the appendix in Table A.1. There, we also provide information about the sources of the data, how they are transformed prior to the analysis and on the sign restrictions applied to the factor loading in the analysis.

In the group of inflation measures, the data set includes measures of aggregate and sectoral inflation, changes in labor costs, as well as indicators of inflation expectations. In the group of measures of real economic activity, the dataset covers measures of real output growth, in particular real GDP and its components, as well as industrial production growth at the aggregate and sectoral level, measures of aggregate and sectoral employment growth, unemployment rates and capacity utilisation rates. Overall, the dataset comprises a roughly equal number of inflation and economic activity data series. It is unbalanced as some series are not available over the entire sample period. In order to obtain a balanced dataset, we use the expectation maximisation (EM) algorithm to interpolate those data series where observations were missing (see Stock and Watson 2002*a* for details).

Since the factor model requires stationary data, the variables are transformed accordingly. Inflation rates are quarter-on-quarter log changes of price indices. Real GDP, industrial production and employment etc. also enter as quarter-on-quarter log changes of the underlying level series, while unemployment rates and capacity utilisation rates enter in levels. We remove outliers following the procedure proposed by Stock and Watson (2005).[2] Finally, we normalise each series to have a zero mean and a unit variance. We collect the data for the analyses below in the N-dimensional vector of variables $X_t = (x_{1,t}, \ldots, x_{N,t})'$ for $t = 1, \ldots, T$.

3 Methodology

The estimation of the demand and supply factors proceeds in several steps as summarised in Table 1. The first step is the estimation the factor model. The subsequent steps identify the structural factors through sign restrictions.

3.1 Factor model

We apply a factor model to X_t based on Stock and Watson (2002*b*) and Bai and Ng (2002). Each element of X_t is assumed to be the sum of a linear combination of r common factors $F_t = (f_{1,t}, \ldots, f_{r,t})'$ and an idiosyncratic or variable-specific

[2] Outliers are here defined as observations of the stationary data with absolute median deviations larger than 6 times the interquartile range. They are replaced by the median value of the preceding five observations.

Table 1: **Summary of the estimation approach**

Step 1: Estimation of the factors F_t as the first r principal components of X_t, the vector of macroeconomic variables (which have zero mean and unit variance). This yields the $r \times 1$-dimensional vector $\widehat{F}_t$. Those factors are only identified up to a rotation: For any orthonormal $r \times r$-dimensional matrix Q ($Q'Q = I_r$) we can write $\lambda_i' F_t = \lambda_i' Q\prime Q F_t = \underline{\widetilde{\lambda}}_i' \underline{F}_t$ with $\underline{\widetilde{\lambda}}_i' = \lambda_i' Q'$ and $\underline{F}_t = QF_t$. While this means that the raw principal component factors are not interpretable, it also means that factors can be identified by finding matrices Q that yield economically meaningful factor loadings.

Step 2: $\widehat{F}_t$ are rotated along the lines of Rubio-Ramírez et al. (2010). I.e. Q is obtained from a QR decomposition of a $r \times r$ random matrix, where each element has an independent standard normal distribution. This yields $\underline{\widehat{F}}_t = Q\widehat{F}_t$. See Rubio-Ramírez et al. (2010) for details.

Step 3: Regression of each variable on the rotated factor estimates, i.e. OLS estimation of $x_{it} = \overline{\lambda}_i \underline{\widehat{F}}_t + v_{it}$ for $i = 1, ..., N$. This yields, among others, estimates of $\overline{\lambda}_i$, $\widehat{\overline{\lambda}}_i$.

Step 4: Verify if the sign restrictions listed in Table 3 are satisfied for $\widehat{\overline{\lambda}}_i$ on average over all countries and the corresponding variables. If yes, keep $\underline{\widehat{F}}_t$ (and Q), otherwise reject the draw.

Step 5: Repeat steps 2-4 until 200 valid draws (i.e. 200 vectors of $\underline{\widehat{F}}_t$ for which the sign restrictions are satisfied) are obtained.

Step 6: While the 200 $\underline{\widehat{F}}_t$s are shown as black lines in Figure 1, the red line refers to the "Median Target" factors. Following Fry and Pagan (2007), we pick the one rotation matrix which yields demand and supply factors that are most closely related to the median factors. For details, see Fry and Pagan (2007).

component e_{it}:

$$x_{i,t} = \lambda_i' F_t + e_{i,t}, \quad i = 1, \ldots N \tag{3.1}$$

where λ_i is the $r \times 1$ vector of common factors loadings, and $\lambda_i' F_t$ is the common component of variable i. The factors are mutually orthogonal and uncorrelated with the idiosyncratic errors. The latter can be weakly mutually and serially correlated in the sense of Chamberlain and Rothschild (1983).

The commonality (i.e. the variance shares explained by the common factors) of a given set of variables is given by $var(\lambda_i' F_t)/var(x_{i,t})$. The common factors are estimated as the first r principal components of $X = (X_1, \ldots, X_T)'$, $\widehat{F} = (\widehat{F}_1, \ldots, \widehat{F}_T)' = \sqrt{T} v$, where v is the matrix of eigenvectors corresponding to the first r eigenvalues of XX', and the loadings are estimated as $\widehat{\Lambda} = (\widehat{\lambda}_1, \ldots, \widehat{\lambda}_N)' = X'\widehat{F}/T$.

Table 2 provides the variance shares and the cumulative variance shares explained by the first 10 principal components. The results suggest that three factors explain more than 50% of the variance of the dataset on average over all variables, which is a reasonable share for a heterogeneous macroeconomic dataset. Based on this informal criterion, we proceed in the subsequent analysis with three factors, identifying two as demand and supply respectively. The third factor is restricted not to satisfy the restrictions imposed on the other two factors. It is meant to capture everything else that is systematically driving the data besides the structural factors.

Table 2: **Cumulative variance shares**

Number of factors	Cumulative variance share
1	25
2	43
3	52
4	58
5	62
6	65
7	67
8	69
9	71
10	73

Notes: Cumulative variance shares explained by the first 10 principal components (in %).

As is well known, the common factors and factor loadings are not identified separately (see, e.g., Bai and Ng 2006) because

$$X_t = \Gamma F_t + v_t = \Gamma Q' Q F_t + v_t \tag{3.2}$$

where Γ is the matrix of factor loadings and Q denotes an orthonormal rotation matrix such that $Q'Q = I_r$. Conceptually motivated restrictions are needed to identify structurally interpretable factors.

3.2 Identification approach

The factors are identified by picking linear combinations of the elements of $\widehat{F}_t$ which yield signs on the factor loadings that are consistent with prior theoretical considerations (steps 4 to 8 in Table 1). Specifically, equation (3.2) can be written as follows:

$$X_t^L = \widetilde{\Gamma} Q F_t + v_t \tag{3.3}$$

where $\widetilde{\Gamma} = \Gamma Q'$. The sign restrictions are applied to the elements of the matrix $\widetilde{\Gamma}$. The corresponding identified factor is obtained as $\widetilde{F}_t = QF_t$.

To identify supply and demand, we propose a set of theoretically motivated sign restrictions on the factor loadings of inflation and economic activity indicators. The sign restrictions are based on a standard supply and demand framework, where changes in supply move inflation and output in opposite directions, while changes in demand move both variables in the same direction. Supply expansions would boost output and dampen inflation, while demand expansions would boost both inflation and output.

This translates – broadly – into the following sign restrictions on the factor loadings: inflation measures load negatively while real economic activity measures load positively on the supply factor; both inflation and real economic activity measures load positively on the demand factor. Table 3 summarises our broad identifying restrictions employed to disentangle demand and supply factors. Appendix Table A.1 provides more detailed information on which restrictions we impose on individual variables.

Specifically, we require the restrictions to hold for the arithmetic means of the loadings, for key variables which we define *ex ante* and for a large share of variables.[3] We leave some variables (unit labor cost variables, government consumption

[3] 92.5% is the largest share possible. When we try to restrict loadings of more variables, no

and investment and government consumption and investment deflators, variables capturing labor force participation) unrestricted. And we only restrict the loadings of the demand, not of the supply factor on capacity utilization and employment measures (including unemployment and hours worked) as the development of those variables to a change in aggregate supply is ambiguous *a priori*.

Table 3: **Identifying sign restrictions on factor loadings**

	Demand factor	Supply factor
Measures of price inflation	+	−
Measures of real economic activity	+	+

Notes: The table summarises the identifying restrictions in a broad sense. Appendix Table A.1 provides more detailed information on which restrictions we impose on individual variables.

We implement this identification scheme as explained in steps 2-4 in Table 1. The procedure yields 200 structural demand and supply factor estimates for which the sign restrictions are satisfied. We report in the following the full range of these 200 factors as well as the "Median Target" factors along the lines of Fry and Pagan (2007) (step 6 in Table 1).

The factors are orthogonal by construction. Orthogonality of the factors is an identifying assumption as it is for structural shocks. This assumption is, however, not exceedingly restrictive since nothing prevents the factors to affect each other with a lag. In order to facilitate the quantitative interpretation of the factors, we normalise them on real GDP growth, by multiplying the factors with the respective standard deviation and the factor loading. The units of the factors are in percentage points as the reflect the deviation of variables measured in percent from their normal level defined by the sample mean.

The structural factors thus identified are broadly defined. They incorporate any possible shifter of demand and supply, such as shocks to preferences, monetary policy, fiscal policy, energy price changes, labour supply changes etc.[4] However, this broad-based nature of the identified factors is exactly what we are aiming at, since

valid model (i.e. model where sign restrictions are satisfied) is found.

[4]That is, demand shocks can affect both demand and supply factors, and the same for supply shocks. An expansionary fiscal spending shock can, for example, affect domestic inflation and activity positively. By lowering import prices through the exchange rate channel it will affect inflation negatively and activity positively, *ceteris paribus* (possibly relevant in the case of the euro area). The first effect would be captured in our demand factor (loadings of domestic inflation and activity are positive), the second in our supply factor (loadings of import and domestic inflation are negative, those of activity positive).

the goal of our analysis is to identify factors that represent the structural drivers of demand and supply conditions in the broadest sense rather than the effects of some narrowly defined specific structural drivers, such as e.g. a mark-up shock.

The factors can be interpreted as measures of aggregate demand and supply conditions. A level of the demand factor above zero would indicate expansionary demand conditions, with a large number of inflation and real activity measures above their normal levels defined by their sample averages. A level of the supply factor above zero would indicate expansionary supply conditions, reflecting a large number of inflation measures below their normal level and a large number of real activity measures above normal levels. When both inflation and real activity rise, this would be reflected in the an increase in the level of the demand factor. If inflation falls and output rises, the supply factor would move up.

4 Empirical results

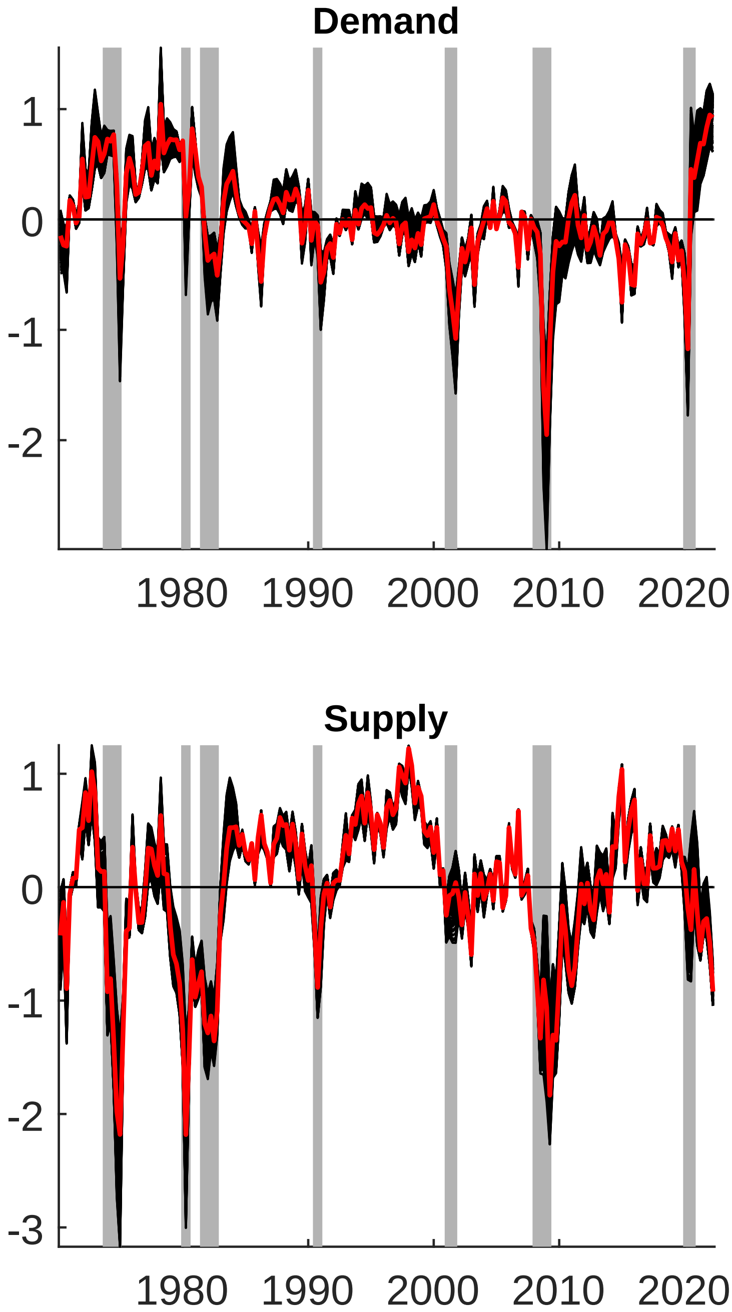
4.1 Aggregate demand and supply factors

Figure 2 shows the evolution of the estimated structural demand and supply factors over the sample period 1970Q1 – 2022Q2. We show the factors associated with all models satisfying the sign restrictions in black and the "Median Target" factors in red. As discussed before, a higher level of the factors reflect more expansionary demand and supply conditions, respectively. The shaded areas indicate recession dates as identified by the National Bureau of Economic Research (NBER).

Given the large cross section we do not need to account for estimation uncertainty (see also Bernanke et al. 2005). The range of factor estimates therefore only reflects the amount of identification (or model) uncertainty. The factor range is for most periods fairly tight. Hence, identification uncertainty does, in general, not seem to be a major issue.

The estimated factors offer a narrative of the evolution of demand and supply conditions over the past five decades. The results suggest that the Great Inflation of the 1970s was characterised by persistently strong demand and episodically tight supply conditions related to the oil price shocks. The charts also show how excess demand was eliminated in the wake of the Volcker disinflation in the early 1980s. Supply conditions eased only later, after the 1981–82 recession when oil prices receded sharply.

Figure 2: **Demand and supply conditions in the United States**



Notes: In percentage points. Normalised to have the same standard deviation as GDP growth and multiplied with its loadings. Red: Median Target estimates, black: estimates from all models. Grey bars: NBER recessions.

The period from the mid-1980s until the turn of the millennium was then characterised by a combination of mostly neutral demand conditions and generally strong supply. This was interrupted by the early 1990s recession, when demand contracted and at the same time supply tightened in the wake of the oil price shock triggered by the Iraq war. Subsequently, supply conditions loosened significantly, reflecting the so-called New Economy boom. Supply conditions strengthened considerably throughout the 1990s, peaking in 1998 and then receding sharply just before the bursting of the dot-com bubble in early 2000. The subsequent recession was associated with a marked tightening of demand conditions.

The first decade of the 2000s was characterised again by strengthening supply and on average balanced demand. The Great Recession in the wake of the GFC of 2007 – 2009 was associated with a strong contraction in both demand and supply. The post-crisis years were then characterised by subdued demand and supply conditions, with demand initially rebounding faster than supply. This would explain why the recession was not followed by a stronger and more persistent decline in inflation, i.e. the missing disinflation. From 2013 up to the outbreak of the Covid pandemic in 2020, supply conditions strengthened, while demand conditions were mostly subdued. This suggests that a combination of strong supply and weak demand seems to have been driving persistent low inflation over these years.

The Covid-19 recession in 2020 was associated with a steep fall in demand but also with tighter supply conditions. In 2021, demand conditions started to rebound sharply in the wake of catch-up demand effects as well as extraordinary monetary and fiscal policy easing. Supply conditions instead further tightened as supply bottleneck persisted and energy prices surged in the wake of the Russia-Ukraine war. In 2022Q2, the last observation of our sample period, estimated demand conditions reached the highest level on record, even higher than the levels seen in the 1970s, while supply conditions stayed restrictive.

In order to assess the role of demand and supply conditions in observable dynamics of inflation, we perform a historical decomposition based on the estimated factor models. We use the estimated factors and the respective estimated factor loadings to back out the contribution of the factors to the dynamics of individual inflation measures. Figure 3 shows the results for two key inflation gauges, quarter-on-quarter (not annualised) CPI inflation and core CPI inflation. Figure A.1 in the Appendix provides further historical decompositions for Personal Consumption Expenditure (PCE) deflator inflation, Gross Domestic Product (GDP) deflator inflation, Produce Price Index (PPI) inflation and unit labour cost inflation (based on unit labour costs in the non-farm business sector).

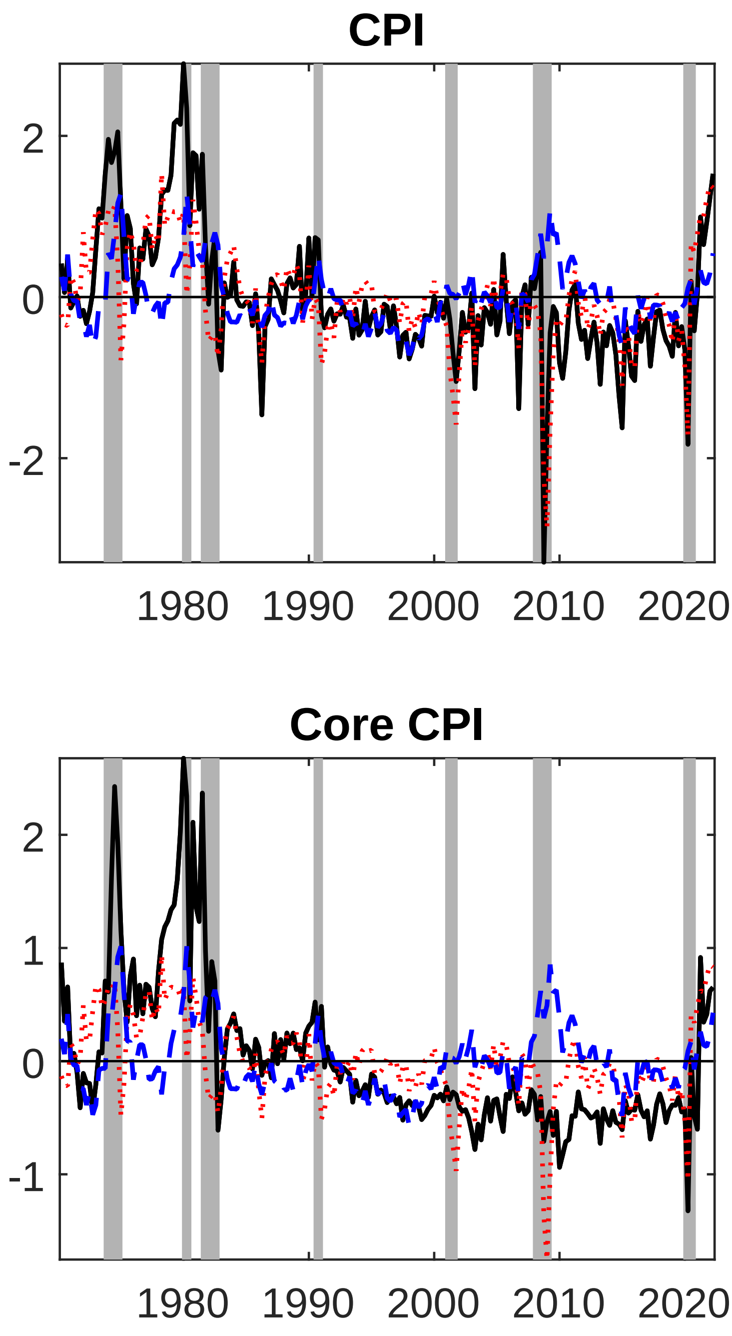
The charts reveal the varying relative importance of demand conditions (red dotted lines) and supply conditions (dashed blue lines) in inflation dynamics over the past 50 years, further substantiating the narrative provided above. While the contributions of demand and supply vary somewhat for different gauges of inflation, the overall picture is very similar. For instance, in the 1970s, high levels of inflation primarily reflected strong demand conditions. Supply conditions also played an important role, but more episodically at times of the oil price shocks. The disinflation of the early-1980s was initially driven by weaker demand and later also by stronger supply conditions.

The decompositions suggest that around the GFC the disinflationary effects of weak demand conditions were counterbalanced by the inflationary effects of tighter supply. This supports the notion that the missing disinflation was due to tighter supply conditions neutralising the disinflationary effects of weak demand. For the period of persistently low inflation between 2012 and 2020, our analysis suggests that this was driven by weak demand and strong supply to roughly equal extents.

For the recent period, the results suggest that the drop in inflation in 2020 reflected primarily the collapse in demand in the wake of the Covid-19 pandemic. The subsequent inflation surge since 2021 has then been driven both by demand and supply, reflecting the strong upsurge in demand and the tightening of supply conditions. Quantitatively, demand seems to be playing a somewhat larger role than supply. These findings are broadly consistent with those of Shapiro (2022*b*) who also finds that both demand and supply have driven the recent inflation surge, but that supply played a somewhat greater role than demand quantitatively.[5]

[5] Shapiro (2022*b*) splits the PCE basket into demand- and supply-driven groups, identifying the former as those where unexpected changes in prices and quantities move in the same direction and the latter where they move in opposite direction. The approach is developed in more detail in Shapiro (2022*a*).

Figure 3: **Historical decompositions**



Notes: Quarter-on-quarter, in %. Black: demeaned time series estimates. Red: contributions of the Median Target demand factor. Blue: contributions of the Median Target supply factor. Grey bars: NBER recessions.

4.2 Robustness analysis

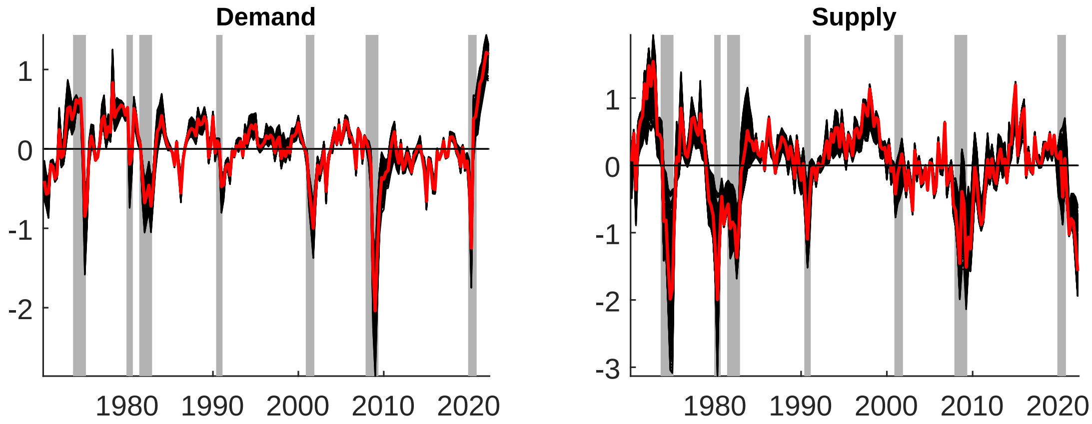
An important concern for our our analysis is structural change over time which could give rise to model instability. The analysis cuts across the volatile high inflation regime of the 1970s and the subsequent low-inflation Great Moderation regime. In order to assess whether structural breaks affect our analysis, we re-estimate the model accounting for possible structural breaks in two different ways. First, we re-estimate the model adjusting the time series included in the factor model for breaks in the mean. To that effect, we apply the Bai and Perron (1998) test for multiple breaks in the mean to each series in the dataset, determine the number of breaks based on the 5% significance level, adjust the series for the identified breaks in the mean and then re-estimate the model with the adjusted time series. Second, we re-estimate the model using only data from 1988. This takes into account not only different means of the variables over this sample period compared to the preceding one, but more generally also allows for changing dynamics in the factor model due to changes in the macroeconomic and monetary policy regime.

The results of these two robustness checks are in line with those of the baseline estimation. The evolution of the demand and supply factors over time is visually very similar to the baseline ones (Figure 4, panels (a) and (b)). This visual impression is confirmed by high correlations of the demand and supply factors estimated in the two robustness checks with the baseline factors (Table 4).

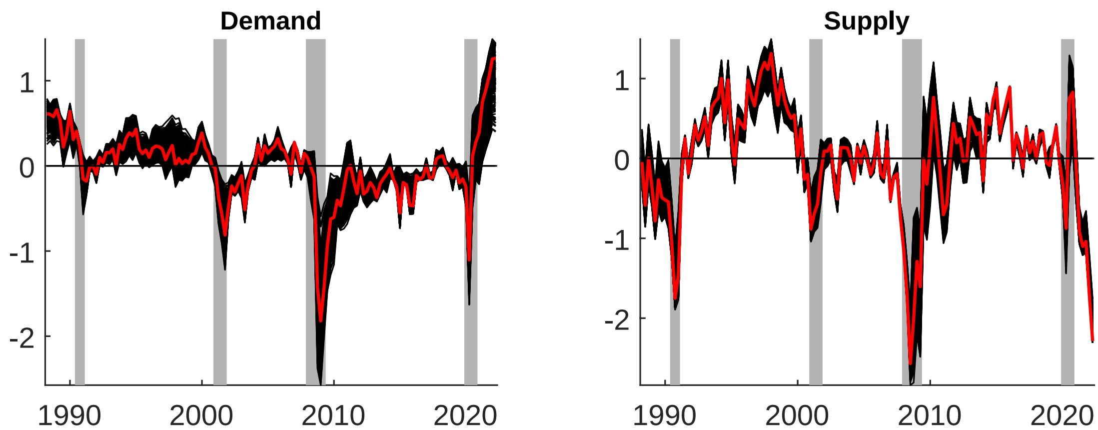
The narrative of demand and supply conditions over time therefore remains unaffected qualitatively, and also quantitatively the assessment of supply and demand conditions in specific points in time turns out to be very similar. In particular, the assessment that the recent surge in inflation has been driven by a combination of strong demand and restrained supply is confirmed. In fact, with respect to the role of demand conditions, the message comes out even more strongly. In both robustness checks, demand conditions register record highs at the end of the sample period in 2022Q2.

Figure 4: **Robustness checks**

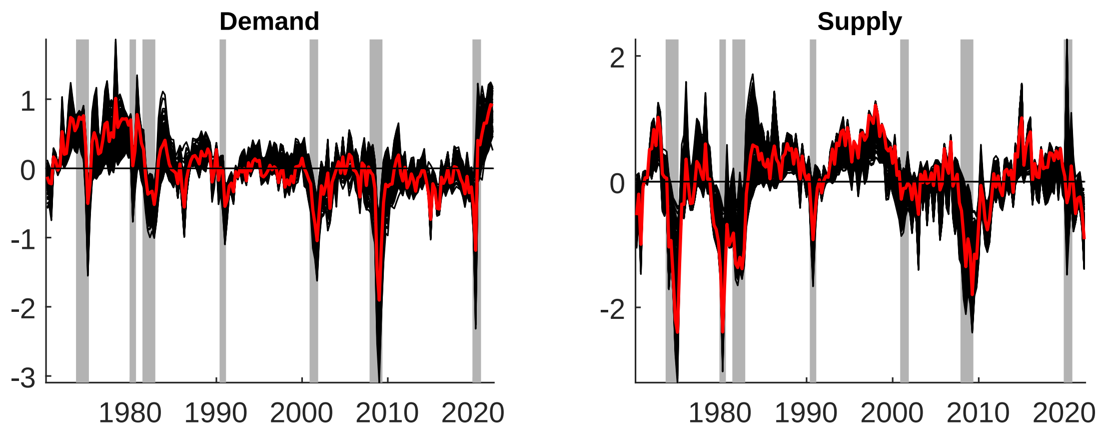
(a) Data adjusted for breaks in mean



(b) Post-1987 estimation



(c) Four factors



Notes: In percentage points. Normalised to have the same standard deviation as GDP growth and multiplied with its loadings. Red: Median Target estimates, black: estimates from all models. Grey bars: NBER recessions.