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What Do Monetary Contractions Do? Evidence From Large, Unanticipated Tightenings

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What Do Monetary Contractions Do? Evidence From Large, Unanticipated Tightenings*

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Abstract

As the "Volcker shock" is believed to have generated useful information on the effects of monetary policy, this paper develops a transparent procedure to identify other unanticipated monetary contractions. The approach is applied to a panel data set spanning 162 countries (over the period 1970-2017), in which it identifies 147 large monetary contractions. The procedure selects episodes where a protracted period of loose monetary policy was suddenly followed by sizeable, unexpected interest rate increases. Focusing on contractions of significant size increases the signal-to-noise ratio, while they are unlikely to be accompanied by confounding "information effects" (markets interpreting a rate hike as the Central Bank being optimistic about the real side of the economy). A subsequent panel VAR analysis suggests that a 100-basis point rate hike reduces real GDP by 0.5 percent. This reduction in output seems to be persistent, pointing to a certain degree of hysteresis. The price level falls by 1.5 percent, indicating that the medium-/long-run impact of contractionary monetary shocks is not characterized by a neo-Fisherian response. Advanced economies appear to display more price stickiness than emerging/developing countries, as the former combine a more muted price response with a larger effect on output.

JEL-classification: E31, E32, E52.

Key words: monetary policy, inflation, output.

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1 Introduction

If one is seeking to uncover the causal effect of changes in monetary policy, one would like to have access to shifts in monetary policy that are free of endogenous and anticipated movements (cf. Romer and Romer (2004: 1055); Cochrane (2018: 94-95)). This paper aims to find such shifts by searching for significant rate hikes following a protracted period of loose monetary policy (giving the Central Bank a dovish reputation, adding plausibility to the assumption that the hike was unanticipated), where the Central Bank's objective seems to have been fighting inflation (yielding exogeneity with respect to output). Herewith, this paper tries to identify non-US equivalents to the "Volcker shock", which is believed to have improved our understanding of monetary policy (see e.g. Romer and Romer (1989); Summers (1991)).

Causal analysis of the effects of monetary policy is typically complicated by the fact that monetary policy often *responds to* economic developments. For example, the observation that high interest rates tend to coexist with high growth rates could easily lead to the mistaken conclusion that high interest rates cause high rates of growth. Further complications arise because many changes in the policy stance are anticipated: if a Central Bank has a strong record of responding to inflation, an anticipated acceleration of inflation will immediately lead to expectations of future rate increases. Subsequent materializations of such rate hikes might prove uneventful (as they were already "priced in" by financial markets and forward-looking price-setters) – possibly leading to the erroneous conclusion that policy changes don't establish much. Similarly, seeing inflation rise following a rate hike does not necessarily imply a causal link: the Central Bank might have contracted because it saw future inflation coming, which would have been even higher had the Central Bank refrained from increasing its policy rate (Sims, 1992).

To overcome these problems, researchers have tried to identify "monetary policy shocks" (unanticipated changes in monetary policy, not driven by economic conditions). Some have done this by relying on recursive identification (e.g. Christiano, Eichenbaum, and Evans (1999)), others have used sign restrictions (cf. Uhlig, 2005), while yet others have based inference on countries without monetary autonomy (for whom monetary policy is set by a foreign Central Bank; cf. Willems (2011) and Jorda, Schularick, and Taylor (2017)). Results between the various methods differ,[1] as a result of which there is

[1] For example: studies relying on recursive identification tend to find the "price puzzle" (the price level going up after a monetary tightening), while studies like Uhlig (2005) and Nakamura and Steinsson (2018a) fail to rule out the possibility that real GDP *rises* following a contractionary monetary policy shock (generating an "output puzzle"; also see Ramey (2016) and Arias, Caldara, and Rubio-Ramirez (2019) for contributions to this debate).

not even a broad consensus on *the sign* of the effects of monetary policy (cf. Cochrane (2018)). Prominent models like Christiano, Eichenbaum, and Evans (2005) also feature a working capital channel to match the price puzzle.

This paper takes a different "algorithmic" approach to identifying shifts in monetary policy, which – I will argue – has some advantages over existing approaches.

I start by constructing a dataset covering data on short-term interest rates, prices, and output in 162 countries. Next, I say that a monetary contraction takes place in a country in year T if two conditions are met:

1. [*To identify episodes of sharp nominal rate hikes*:] During year T, the country's deposit rate[2] increases by 200 basis points or more, provided that the increase is at least 20 percent in relative terms. Here, the restriction on the absolute value prevents the selection of gentle rate hikes starting from a low base (like the gradual lift-off of US interest rates post-2015); the relative requirement raises the bar for countries with high nominal interest rates (where an increase of 200 basis points might not be much of a contraction[3]).

2. [*To obtain unexpected hikes, following high inflation*:] The average real interest rate (as proxied by the difference between the deposit rate and the realized rate of inflation) calculated over years $(T-2)$, $(T-1)$, and T was negative – pointing to a loose stance of monetary policy in the recent past.[4]

I will henceforth refer to the identified episodes as "monetary contractions" or "monetary tightenings".

While it might have seemed tempting to phrase condition 2 (which is partly aimed at selecting inflationary periods) directly in terms of inflation, that produces difficulties as countries differ in their inflation tolerance (which is unobserved). By requiring the *real* interest rate to be negative for a protracted period, condition 2 ensures a focus on periods

[2]The use of deposit rates is helpful in a world where different Central Banks use different policy instruments. By using deposit rates, instead of instruments that are directly under the Central Bank's control, this paper does condition on the existence of a meaningful transmission channel from the Central Bank's policy instrument to other short-term rates. Results are robust to using money market rates, but in that case the number of available observations is cut in half.

[3]This requirement only becomes binding at nominal interest rates higher than 10 percent. For example: if the nominal interest rate equals 20 percent, the bar is raised to rate hikes of 400 basis points or more.

[4]Results are robust to averaging over years $(T-2)$ and $(T-1)$ only. Since inflation is believed to respond with a lag to changes in monetary policy, the baseline includes the year of the contraction (T) in the average – as the lag suggests that year-T inflation was partly pre-determined by policy prior to the rate hike. This is especially true for contractions later in the year, with the Romer dates suggesting that most US contractions happened towards year-end (the only exception being the April 1974 contraction). Given the dominant, leading role of US monetary policy, such a pattern might spill over to other countries.

where inflation was high relative to nominal interest rates in the country. This is a way to take country-specific factors into account, whilst simultaneously yielding a sense of the monetary policy stance (tight or loose). In addition, incorporation of the nominal rate in criterion 2 enables the algorithm to select cases where the Central Bank initially did *not* respond to inflation accelerations (causing the real rate to go negative).[5] This is to strengthen the case that the subsequent rate hike came with a surprise element. After all, the prolonged period of negative real rates is likely to have given the Central Bank a dovish, inflation-tolerant reputation – potentially operating under a fiscal regime (being "passive" in the sense of Leeper (1991)) and unlikely to raise rates by several hundred basis points in a year.

Calculating average inflation over years $(T-2)$ through T, and comparing it with inflation in other years, indeed suggests that the algorithm is able to select interest rate hikes that followed periods of high inflation (see Table 1 in Section 2). As a result, it seems reasonable to assume that the identified rate hikes were (a) motivated by inflation (as opposed to output[6]) while (b) taking agents by surprise (limiting the presence of anticipated policy shifts which might obscure inference).

Such unexpected policy changes can for example be caused by a new incoming Central Bank Governor (Paul Volcker taking over from William Miller as Chairman of the Federal Reserve in 1979), by a sitting Governor suddenly changing his or her mind about the right course of action, or through pressure exerted by international lenders or rating agencies.

The recent case of Turkey forms a good example: coming from a protracted period of accelerating inflation and negative real rates, during which President Erdogan expressed the view that rate hikes would only fuel inflation, the Central Bank of Turkey finally gave in to (predominantly international) pressures in May 2018 – increasing their policy rate by 850 basis points. Bloomberg survey data from that time however suggest that market participants were expecting the Central Bank to *keep the policy rate unchanged* at 8 percent – as it had done in the years before – thus suggesting that the entire rate change was a surprise.

The route taken by this paper is most closely related to the "narrative" approach to monetary policy shock identification (Romer and Romer, 1989). While the large cross-

[5]Recent experiences in developed countries have shown that negative real interest rates can also be accompanied by low inflation ("secular stagnation"). Such episodes are however unlikely to be followed by significant rate hikes, so the ensuing period is unlikely to pass condition 1 and hence would not be selected as a monetary contraction.

[6]It is hard to imagine a sudden boom that is so large that it triggers the Central Bank to raise interest rates by several hundred basis points in a year. Monetary contractions of such a size are almost exclusively implemented to fight inflation.

country scale of the exercise precludes a truly narrative approach, conditions 1 and 2 specified above can be seen as transparent, algorithmic short-cuts to "narratively-identifying" episodes during which monetary policy appears to have been looking to bring inflation down – without agents expecting it, and without the policy shift being driven by output developments. Exactly because the identified interest rate increases are unlikely to be motivated by (future) output considerations, they are particularly suitable to assess the causal impact of monetary contractions on output (see Proposition 1 in Cochrane (2004), while this is also the strategy underlying Romer and Romer (1989) and the subsequent "narrative" literature[7]).

At the same time, inference on the price level is complicated by the fact that the policy changes were taken in response to inflation. The usual worry is that the Central Bank contracts in response to signs about *future* inflation. This poses a challenge and might contribute to the emergence of the price puzzle, as future inflation typically isn't part of the econometrician's information set (Sims, 1992). But since conditions 1 and 2 select monetary contractions *following* high inflation (which has materialized and hence *is* part of the econometrician's information set), Sims' concern about the Central Bank responding to not-yet-existing future inflation is less relevant. This holds particularly true in less developed countries, where monetary policy tends to be more backward looking (in the absence of forward-looking Central Bank models and/or data on inflation expectations). As an additional safeguard, I proceed by treating the contraction dummy as an endogenous variable in the VAR and impose identifying restrictions, which re-opens the door to causal inference on the price level (whilst bearing in mind that the price response might still suffer from an upward bias, especially in more advanced economies).

As with all approaches, the one entertained by this paper comes with both strengths and weaknesses. The most obvious weakness relates to the fact that the necessary cross-country data are only available at an annual frequency, preventing this paper from analyzing the short-term effects of monetary contractions.[8]

The present paper's focus on larger rate hikes comes with particular advantages. First of all, it increases the signal-to-noise ratio – overcoming the "small power problem" which for example hampers high frequency studies based on US data (Nakamura and Steinsson, 2018). Secondly, and relatedly, the more systematic conduct of monetary policy in advanced economies makes true monetary policy shocks rare and hard to identify (Ramey,

[7]As set out in Romer and Romer (1989: 134), the validity of this approach rests on the assumption that the level of inflation does not exert a *direct* negative impact on ensuing output dynamics (e.g. by distoring the supply-side of the economy) – more on which in Section 3 of the present paper.

[8]The cross-country exercise by Jorda, Schularick, and Taylor (2017) faces the same restriction.

2016); instead, unbiased causal estimates are more easily obtained in environments where monetary policy is conducted in a more erratic fashion. In this context, going cross-country whilst focusing on larger shifts – thereby including instances where monetary policy was executed in a less systematic manner – makes practical sense. Third, episodes featuring sharp interest rate increases are unlikely to be accompanied by confounding "information effects". As for example set out in Romer and Romer (2000), monetary policy comes with signaling effects through which a tightening can be interpreted as the Central Bank being relatively bullish on growth prospects. Potentially as a result of this channel, Nakamura and Steinsson (2018a) find that professional forecasters tend to *increase* their growth projections following a more hawkish Fed signal, with various other studies showing output puzzles as well (see e.g. Uhlig (2005) and Ramey (2016)). While the signaling channel might play a role for monetary shocks that are of a relatively small magnitude (as found in US data), it is hard to believe that the sharp rate hikes central to this paper will ever be interpreted as the Central Bank being optimistic about the state of an economy; the Central Bank being worried about inflation seems a more natural interpretation.

Applying the algorithm identifies 147 "monetary contractions". Of these, 71 were implemented in the year of, or in the year following, the arrival of a new Central Bank Governor (very much like the Volcker shock). The identified contractions increase the bank deposit rate by just over 650 basis points on average. Results indicate that monetary contractions reduce both output and prices: following a rate hike of 100 basis points, real GDP declines by about 0.5 percent, while the price level falls by 1.5 percent. The significantly negative response of the price level (not showing any signs of the price puzzle) is a strong finding given that this paper's identification strategy implies that the price response might suffer from an upward bias. Emerging/developing countries seem closer to a situation of monetary neutrality, combining a greater impact on prices with smaller output effects (although still non-negligible: –0.3 percent per 100 basis points). Results point to larger output effects of monetary contractions in advanced economies (–1.1 percent per 100 basis points). In all cases, the contractionary output effects of monetary tightenings seem to be rather persistent – pointing to some degree of hysteresis in the economy.

2 Data and Estimation

Data on real GDP, the Consumer Price Index (CPI), and commercial bank deposit rates are taken from IMF databases (WEO and IFS, respectively). In principle, they cover all 189 IMF member states but due to data limitations (mostly on the deposit rate), this paper's exercise is based upon a panel of 162 countries. The data span the period from 1970 to 2017. As documented in Table 1, the algorithm identifies 147 monetary contractions over this sample period. Table 1 furthermore suggests that the algorithm is able to identify monetary contractions that occurred following inflationary pressures. In particular, it shows that average inflation in years prior to the contraction stood above the average prevailing over other years. This holds for the entire sample, as well as for the subsamples of advanced and emerging/developing countries. The size of the average monetary contraction in advanced economies is similar to the Volcker shock: during 1979, the Federal Funds Rate increased by 375 basis points – very close to the average size of the year T nominal rate increase in advanced economies (+351 basis points). For emerging/developing economies, the average contraction is roughly double in size (+714 basis points) – which makes sense given the higher inflation (and nominal interest) rates found in those countries.

Table 1: summary statistics, 1970-2017

	All countries	ADV	EME/DEV
Average inflation rate excluding years $(T-2), (T-1), T$	32.8%	5.8%	38.7%
Average inflation rate over years $(T-2), (T-1), T$	93.3%	11.9%	106.8%
Number of identified monetary contractions	147	21	126
Average increase in deposit rate in year T	662 bps	351 bps	714 bps
Countries	162	28	134

Note: year T is the year of the identified monetary contraction. "ADV" refers to advanced economies, "EME/DEV" to emerging and developing ones.

Closer inspection of actual identified dates suggests that the algorithm errs on the side of caution by picking only the most extreme contractions: for the US, it only selects 1979 (the year Paul Volcker was appointed as Fed Chair), while Romer and Romer (1989, 1994) also identify contractions in 1974, 1978, and 1988.[9] This suggests that the algorithm trades off a relatively higher rate of type I errors (failing to select a true contraction), with fewer type II errors (erroneously selecting a "false" contraction). Such a cautious approach, and accompanying focus on more extreme, undisputed episodes with a higher signal-to-noise ratio, seems appropriate: given that this paper is able to incorporate cross-country data, the algorithm still leaves us with a reasonable number of 147 contractions.

[9]See https://eml.berkeley.edu/~dromer/papers/RomerandRomerDates.pdf.

Figure 1 shows that the identified contractions are spread across the sample period. One can discern global tightening waves following the Volcker shock and during the late 1990s (when many economies were booming). The spike in 1989 is driven by the appointment of Chris Stals as Governor of the South African Reserve Bank. As set out in Gidlow (2011), Stals was an inflation hawk who started tightening monetary policy upon taking office (which is picked up by the algorithm as it signals a monetary contraction in South Africa in 1989). Following this lead, several neighboring countries followed, which the algorithm reflects as well (identifying contemporaneous contractions in Lesotho, Swaziland, Uganda, and Zambia). The uptake visible the late 2000s is mostly driven by emerging/developing economies, many of whom experienced limited negative fall-out from the financial crisis – often battling high inflation instead.[10] The algorithm also identifies monetary contractions in Tanzania (2011) and Uganda (2012), which is consistent with the dates resulting from the truly narrative analysis for these countries by Berg et al. (2013).[11]

$[Insert\ Figure\ 1]$

I analyze the data by estimating a panel VAR with country fixed effects using the least squares dummy variable estimator; 95% confidence bands result from Monte Carlo simulation (see Cagala and Glogowsky (2014) for details). I set the lag length equal to 4, as suggested by both the AIC and BIC. Output (real GDP, Y) and prices (CPI, P) enter the VAR in natural logs. The baseline specification thus reads:

$$Z_{i,t} = \sum_{q=1}^{4} B_{i,q} Z_{i,t-q} + u_{i,t},$$

where $Z_{i,t} \equiv (ln(Y_{i,t}), ln(P_{i,t}), D_{i,t})'$ and $D_{i,t}$ is a dummy variable that takes the value 1 in identified contraction years.

As explained in the Introduction, causal inference on the price level is complicated by the fact that the identified contractions are mostly implemented to fight inflation. In particular, the estimated response of the price level might suffer from an upward bias as

[10] The algorithm for example identifies contractions in Argentia (2007), Ghana (2008), and Costa Rica (2009). This lines up well with available independent evidence, see Burke (2007) for Argentina, Kovanen (2011) for Ghana, and Cordero (2009) for Costa Rica.

[11] I am not aware of narrative analyses that establish "Romer dates" for yet other countries. For Canada, however, it has been suggested to me that monetary policy contracted in 1974 (the year in which the Bank of Canada underwent major reform). Indeed, this paper's algorithm does signal a monetary contraction in 1974 for Canada.

the contraction could take place in anticipation of future inflation (Sims, 1992) – especially in advanced economies where monetary policy is set in a more forward-looking way. To reduce the impact of this bias, I treat the contraction dummies as endogenous variables in the VAR.[12] I then make a classic recursiveness assumption (entertained by Christiano, Eichenbaum, and Evans (1999), among many others). This lets the Central Bank respond to output and inflation developments taking place during the year, while allowing policy changes to start affecting those variables only in the year following the contraction. As some contractions will only be implemented – or completed – towards the end of the year (recall footnote 4), this assumption seems most natural.

3 Results

Figure 2 summarizes the main results of this paper. It shows impulse-response functions ("IRFs") for output and the price level after a unit shock to the contraction dummy (which, remember, corresponds to a rate hike of 662 basis points on average). As the top-left panel shows, real GDP falls for about 3 years following the contraction to a level that is 3 percent lower. In line with Romer and Romer (1989, 2004), Jorda, Schularick, and Taylor (2017), and Antolin-Diaz and Rubio-Ramirez (2018), among others, results point to persistent output effects of monetary contractions – yielding responses that are for example in line with models featuring labor market hysteresis (such as Gali (2018)).

The price level decreases as well: while the impact response is zero by construction and while the one-year horizon shows signs of price-stickiness, the CPI ends up falling by about 10 percent. Most of the price adjustment takes place at horizons in between 1 and 3 years after the shock. This negative price response suggests that the algorithm does not confuse monetary contractions with oil price rises[13] (as those would increase inflation). Similarly, Figure 2 does not suggest that output dynamics are impacted directly by the high level of inflation prior to the contraction (which would weaken this paper's empirical strategy; recall footnote 7): the associated negative supply-side effects (for example stemming from inflation-induced misallocation of capital), would lead to *higher* inflation – not lower, as

[12]See Gertler and Gilchrist (1994), Leeper (1997), and Monnet (2014) for similar approaches. In contrast, Eichenbaum and Evans (1995) and Christiano, Eichenbaum, and Evans (1999) are less worried about this potential problem and analyze price responses while treating the Romer dummies as exogenous to all variables in their VAR. Leeper's (1997) results however suggest that there is positive bias when the dummies are treated as exogenous (it produces a major price puzzle). He also finds that modeling the Romer dummies as endogenous in the VAR, like this paper does, seems to reduce the bias.

[13]Hoover and Perez (1994) argue that the Romer-dates are subject to this confusion. I return to this concern in Section 4 below.

observed in Figure 2.

The size of the price response is similar to the magnitudes obtained in studies on the US economy: for example, linear extrapolation of the results in Uhlig (2005) suggests that a 662-basis point hike in the Federal Funds Rate would decrease the price level by about 13 percent.[14]

Results in Figure 2 are based upon the global sample and hide some heterogeneity. Figure 3 displays results stemming from the exact same exercise, but with the sample limited to emerging and developing economies. As monetary policy tends to be more backward looking in this group, results are less likely to be distorted by Sims' (1992) concern (where the price response suffers from an upward bias as many monetary contractions are driven by the Central Bank responding to signals about *future* inflation). Findings suggest a slightly stronger response of the price level (–12 percent) with an effect on output that is somewhat smaller (–2 percent). Both elements are consistent with each other, as they point to a greater degree of price flexibility (and a situation closer to monetary neutrality) for emerging/developing countries.

Finally, Figure 4 shows results for the sample of advanced economies only. In this case, the price level fails to display a significant response – showing greater evidence of price stickiness instead. It is however possible that this price response is suffering from Sims' (1992) upward bias, as monetary policy in advanced economies tends to be forward-looking. The case for unbiasedness is stronger for the response of real GDP (since the identified contractions were not motivated by considerations relating to (future) output; and recall Proposition 1 in Cochrane (2004)). Here, the output response is actually consistent with the hypothesis of more price stickiness in advanced economies, as real GDP shows a stronger decline (–4 percent, despite the fact that the average increase in the year T deposit rate is less than half of that in emerging/developing countries: 351 basis points versus 714).

A higher degree of price stickiness following monetary shocks might be caused by Ramey's (2016) observation that monetary policy tends to be more systematic (and hence predictable) in advanced economies. This can induce price setters to pay relatively little attention to changes in monetary policy, leading to a smaller response of the price level following monetary shocks (cf. rational inattention-based theories, like Mackowiak and Wiederholt (2009)). Alternatively, it could also reflect a situation of larger costs associated

[14] Although it is certainly possible that the effects of monetary policy are non-linear in shock size (which would render linear extrapolation invalid), I am not aware of theoretical models which have this prediction and which can provide guidance on the direction of the non-linearity. The assumption of linearity is widespread in VAR-based exercises, as they tend to rely upon linear specifications.

with price adjustment – be it due to higher menu costs, or due to stronger implicit contracts between firms and customers (Blinder et al., 1998).

$$[Insert\ Figures\ 2, 3, 4]$$

Table 2 summarizes the point estimates of responses of output and inflation in the medium run (4-5 years after the shock) and converts them to a 100 basis point move (subject to the non-linearity caveat expressed in footnote 14). Comparing the standardized impact of monetary shocks on output and prices, illustrates the notion that emerging/developing economies seem closer to a situation of monetary neutrality (combining a stronger price response with a smaller impact on output). I see the observation that the IRFs consistently associate a stronger price response with a weaker response of output (and vice versa, also in the robustness checks below) as comforting, given that it is in line with monetary theory.

While the above results reflect responses which are essentially cross-country averages, it should be noted that one can also use the identified monetary contractions to generate country-/region-specific estimates concerning the effects of monetary policy – either by using the approach adopted by Romer and Romer (1989) or by employing more recent techniques, such as the Synthetic Control Method.

Table 2: summary of medium-run impact of output and inflation to a monetary contraction (actual and standardized sizes)

	All countries	ADV	EME/DEV
Contraction	662 bps	351 bps	714 bps
Real GDP	-3.0%	-4.0%	-2.3%
CPI	-10.0%	-2.5%	-12.0%
Standardized contraction	100 bps	100 bps	100 bps
Real GDP	-0.5%	-1.1%	-0.3%
CPI	-1.5%	-0.7%	-1.7%

Note: standardizing calculations assume linearity (-0.5% = -3.0%/662*100). "ADV" refers to advanced economies, "EME/DEV" to emerging and developing ones.

4 Do the Contraction Dummies Represent Exogenous Events?

An important criticism to Romer and Romer (1989) was voiced by Leeper (1997). He showed that the Romer-Romer dummy variable series is highly predictable from other variables – with the average logit-predicted probability of the dummy equaling 1 at the Romer-identified dates equaling 0.43. This suggests that the Romer dates do not capture true changes in policy-makers' tastes (orthogonal to economic fundamentals), but rather represent endogenous responses to economic developments.

Applying Leeper's (1997) analysis to this paper's contraction dummy series yields a much lower average logit-predicted probability of 0.04[15]– supporting the hypothesis that the identified dates represent exogenous events. As set out in Romer and Romer (1997), this number is likely to form an upper-bound of true predictability since it is not based upon an out-of-sample forecasting exercise. Once they take Leeper's specification out of sample via a "leave-one-out" procedure,[16] they find that the average logit-predicted probability drops from 0.43 to 0.02. When applying Romer and Romer's (1997) out-of-sample testing procedure to the dummy series underlying this paper, the average logit-predicted probability of the dummy equaling 1 at the identified dates equals 0.03.

While a test of this sort does not provide conclusive evidence in favor of exogeneity, the fact that this paper's contraction dummy series survives Leeper's (1997) exercise is encouraging. It moreover rhymes well with the observation that about half of all identified dates correspond to the appointment of a new Central Bank Governor, which are often exogenous events. In several cases, a change of Governor in a "leader" country also brought about contractions in neighboring/following countries (recall the aforementioned examples of Paul Volcker arriving at the US Fed and Chris Stals at the South African Reserve Bank). Since such externally-induced changes are not necessarily driven by economic developments in the neighboring/following countries themselves, this adds to the exogeneity of the policy change (see Willems (2011) and Jorda, Schularick, and Taylor (2017), who exploit this observation to its full extend).

[15]This exercise is based upon a panel logit-specification with country- and year-fixed effects (the latter controlling for global factors such as commodity prices and the state of US monetary policy). In addition, and in line with results reported in Section 3, the specification includes four lags of output and prices.

[16]This involves estimating the logit iteratively, every time dropping a different contraction date and computing the predicted probability of the dummy equaling 1 for the omitted date.

5 Robustness

Lastly, it is also important to assess robustness of results to different time periods and to the inclusion of additional variables. First of all, as the 1970s were a volatile decade, and as the conduct of monetary policy has improved since, it is instructive to analyze results for the post-1980 sample period. The relevant summary statistics can be found in Table 3. Again, this table provides evidence that the algorithm is able to select contractions in response to above-average rates of inflation, while the sizes of the monetary shocks are very much in line with those underlying the full sample (recall Table 1).

Table 3: summary statistics, 1980-2017

	All countries	ADV	EME/DEV
Average inflation rate excluding years $(T-2),(T-1),T$	36.4%	5.0%	43.6%
Average inflation rate over years $(T-2),(T-1),T$	101.2%	12.9%	107.5%
Number of identified monetary contractions	134	9	125
Average increase in deposit rate in year T	691 bps	349 bps	716 bps
Countries	162	28	134

Note: year T is the year of the identified monetary contraction. "ADV" refers to advanced economies, "EME/DEV" to emerging and developing ones.

Findings are shown in Figures 5, 6, and 7. As one can see, results are similar to those obtained using the full sample. If anything, results in Figure 5 suggest a slightly greater degree of price flexibility (with prices falling by nearly 15 percent, instead of 10 percent) along with a corresponding smaller effect on output (–2 percent, rather than –3 percent). The highest degree of price flexibility seems to remain with the emerging/developing countries, although the output response of the advanced economy sample is no longer significant at the 5 percent level (which could reflect a situation of fully flexible prices). Here, it should however be noted that the algorithm identifies only 9 contractions in advanced economies post-1980 (consistent with Ramey's (2016) observation that the more systematic conduct of monetary policy over time renders true shocks rare) which explains at least part of the widening in confidence bands. The point estimate is very similar to the one obtained on the full sample though, which hints at stability.

$[Insert\ Figures\ 5, 6, 7]$

In addition, one can also analyze the robustness of results to the inclusion of various other variables. First of all, Figure 8 adds the natural log of broad money to the VAR (data are again taken from the IMF WEO series). Looking at its negative response shows that there is no "liquidity puzzle", strengthening the case that this paper's algorithmic approach identifies monetary *contractions*. In addition, it suggests that the approach is capturing issues related to monetary policy, as opposed to episodes of financial liberalization. Responses of output and the price level are similar to the baseline results.

Second, following Sims (1992), the inclusion of oil prices in monetary VARs has become widespread. Although this was mostly done to eliminate the price puzzle[17] (which this paper does not encounter to begin with), Figure 9 illustrates that findings are robust to the addition of logged oil prices to the VAR-specification. The response of the oil price itself moreover suggests that the identified monetary contractions are not mis-identified contractionary oil price shocks (the Hoover and Perez (1994)-criticism to Romer and Romer (1989)).

The latter concern is investigated more carefully in Figure 10. These IRFs are based upon a contraction dummy series which makes the conservative assumption that monetary tightenings can *never* take place in years associated with contractionary oil price shocks (defined as those years during which the oil price rose by more than 30 percent[18]). As Figure 10 shows, the resulting IRFs look very similar to the original ones – confirming the hypothesis that the main findings are not due to the algorithm erroneously selecting contractionary oil price shocks (rather than monetary contractions).

Along similar lines, one can also analyze the role played by potential spillover effects from US monetary policy. To investigate this possible channel, Figure 11 repeats the analysis under the conservative assumption that monetary contractions in countries other than the US can *never* take place in years of tightening US monetary policy. For the purpose of this robustness check, I identify the latter as years in which the US deposit rate increased by (a rather lax) 100 basis points or more.[19] In this case, I do not condition

[17] Hanson (2004) however questions the variable's ability to do so.

[18] This criterion suggests oil price shocks in the following years: 1974, 1979, 1999, 2000, 2004, 2005, 2008, and 2011. So the contraction dummy series underlying Figure 10 cautiously assumes that monetary tightenings cannot take place during any of those years (even if they satisfy conditions 1 and 2 stated in the Introduction). This still leaves us with 121 years featuring monetary tightenings (as opposed to 147 in the baseline specification underlying Section 3), showing that they did not very often coincide with years of oil price shocks to begin with.

[19] Results are robust to using a more stringent threshold (such as 200 basis points), but setting a lower bar for US rate hikes (like 100 basis points) makes for a tougher robustness check. Using the threshold of 100 basis points, the algorithm leaves 99 contractions in our sample. With a threshold of 200 basis points, it identifies 131 contractions (thereby bringing the series closer to the baseline underlying Section 3, which identifies 147 contraction years).

on the tightening taking place in response to inflation, as *any* increase in US interest rates can be seen as a *shock* from the perspective of the receiving country (because Fed decisions are not taken in response to economic conditions in other countries; Willems, 2011). As Figure 11 shows, results are very close to the baseline – suggesting that there are no major distortions coming from such spillovers.

Finally, one may also wonder whether the exchange rate regime plays a role. In particular, the inflation-induced contractions identified in this paper might induce different dynamics in countries with fixed exchange rate regimes (where a country will suffer from a loss of competitiveness as inflation accelerates, slowing the export sector). The contraction dummy series underlying Figure 12 therefore eliminates all 28 contractions which occurred under a pegged exchange rate regime (as classified by Ilzetzki, Reinhart, and Rogoff (2017)). As the figure shows, results are relatively unaffected by this – suggesting that the main findings are not driven by confounding forces related to external competitiveness.[20]

$$[Insert\ Figures\ 8, 9, 10, 11, 12]$$

6 Conclusion

As noted by Nakamura and Steinsson (2018b: 59), identifying the causal effect of changes in monetary policy is complicated by the fact that Central Banks typically do not randomize when setting rates – in fact employing “hundreds of PhD economists to pore over every bit of data about the economy so as to make monetary policy as endogenous as it possibly can be”. Faced with this challenge, this paper focuses at more erratic episodes – times at which monetary policy was conducted in a less systematic way.

Using a transparent data-based procedure, this paper has identified 147 episodes of large monetary contractions following inflationary pressures. These contractions, implemented by a freshly appointed Central Bank Governor in about half of all cases, seem to have been unanticipated and not motivated by output considerations (as a result of which they are particularly well-suited for analyzing the causal impact of monetary tightenings on real GDP). The focus on large contractions overcomes two problems identified by Nakamura and Steinsson (2018a), namely that of small statistical power and the information effect (as it is unlikely that large interest rate increases will be interpreted as

[20]In addition, results are also robust to dropping rate hikes that might have been motivated by exchange rate pressures: eliminating contractions that occurred around currency crises, as identified by Laeven and Valencia (2013), leaves results intact as well.

conveying positive Central Bank expectations about future output growth).

Results suggest that output falls by about 0.5 percent after a monetary contraction of 100 basis points, and in a rather persistent way – pointing to a certain degree of hysteresis. The price level falls by 1.5 percent, with most of the adjustment taking place at horizons in between 1 and 3 years. Emerging/developing countries seem to exhibit more price flexibility (bringing them closer to a situation of monetary neutrality), while advanced economies show greater signs of price stickiness. This is not only suggested by the price response (which may be biased), but also by the response of output (for which the case of unbiasedness is stronger): in advanced economies, increasing interest rates by 100 basis points is estimated to decrease real GDP by 1.1 percent (as opposed to only 0.3 percent in emerging/developing countries). Such a stronger output response is consistent with a greater degree of price stickiness following monetary shocks in advanced economies.

While one may debate the usefulness of the exact quantitative dimension of this cross-country exercise (as the effects of monetary policy could be highly country-specific[21]), I believe that this paper at the very least contains useful information on *the sign* of monetary policy (which most believe to be of a more universal nature). Other studies analyzing the effects of monetary policy shocks have generated puzzling responses, both for output and prices. In addition, Cochrane (2018) has recently pointed out that many models display a "neo-Fisherian" feature whereby interest rate increases lead to higher inflation in both the short and long run. This paper, in contrast, supports the conventional view where contractionary monetary shocks decrease the price level.[22] Given that this paper's price response might suffer from an upward bias, this is a strong finding. At the same time, results firmly confirm the conventional view that monetary contractions also contract output, suggesting that the output puzzle is due to shock misidentification (e.g. the information effect).

[21] As noted in Section 3, the monetary contractions identified in this paper can also be used in isolation to obtain country-specific estimates. This is not the route taken in this paper, but the contraction dates are available for use at https://sites.google.com/site/twillems85/working-papers/.

[22] Given the underlying annual data, results in this paper cannot rule out a "price puzzle" at horizons shorter than a year.

7 References

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8 Figures

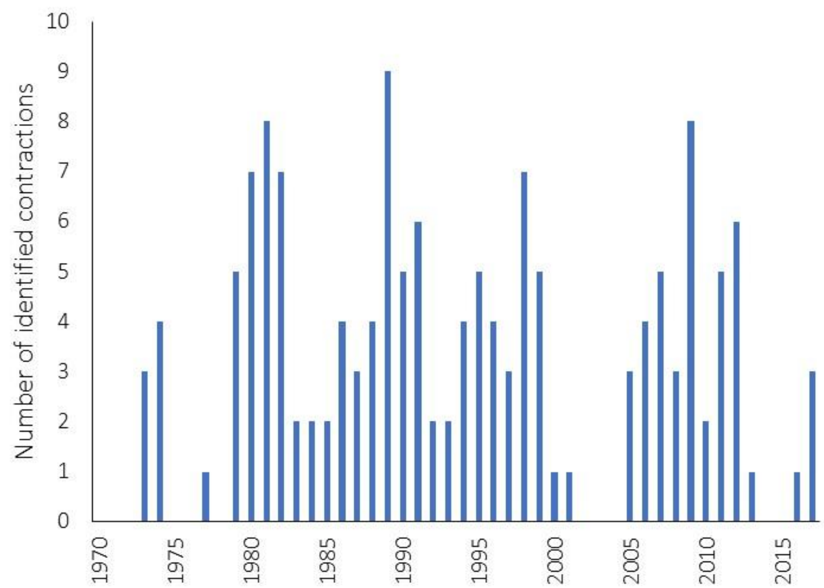

Figure 1: Distribution of identified monetary contractions over time.

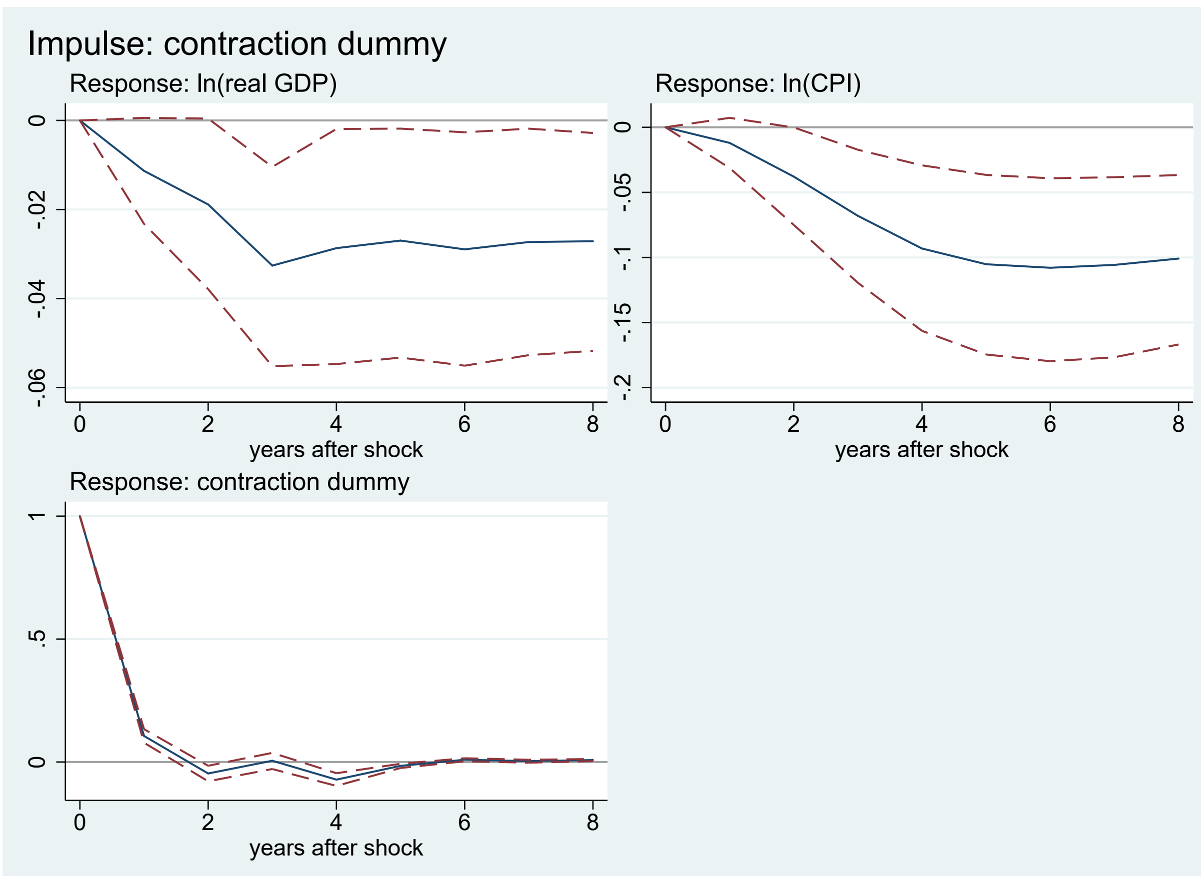

Figure 2: Impulse-responses following a unit shock to the contraction dummy (with 95% confidence interval), full sample, 1970-2017.

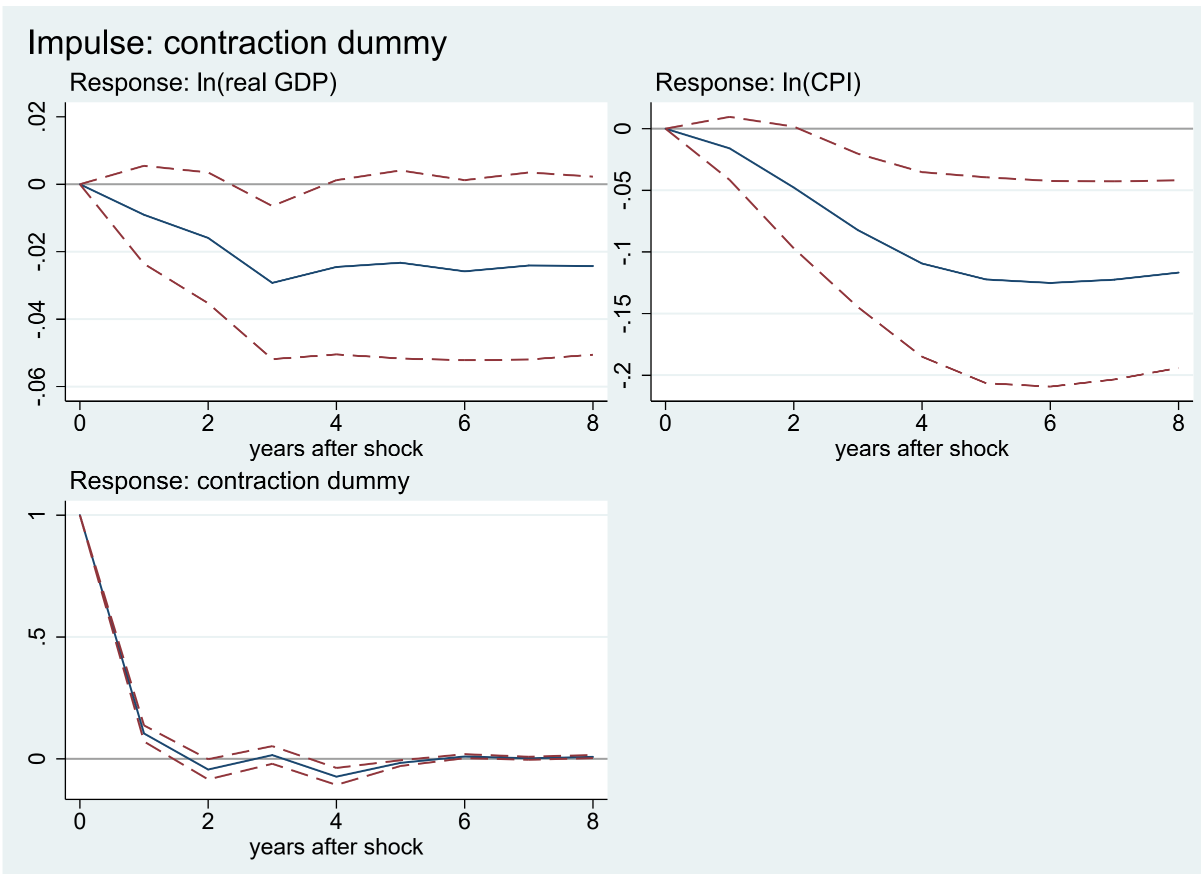

Figure 3: Impulse-responses following a unit shock to the contraction dummy (with 95% confidence interval), emerging and developing economies, 1970-2017.

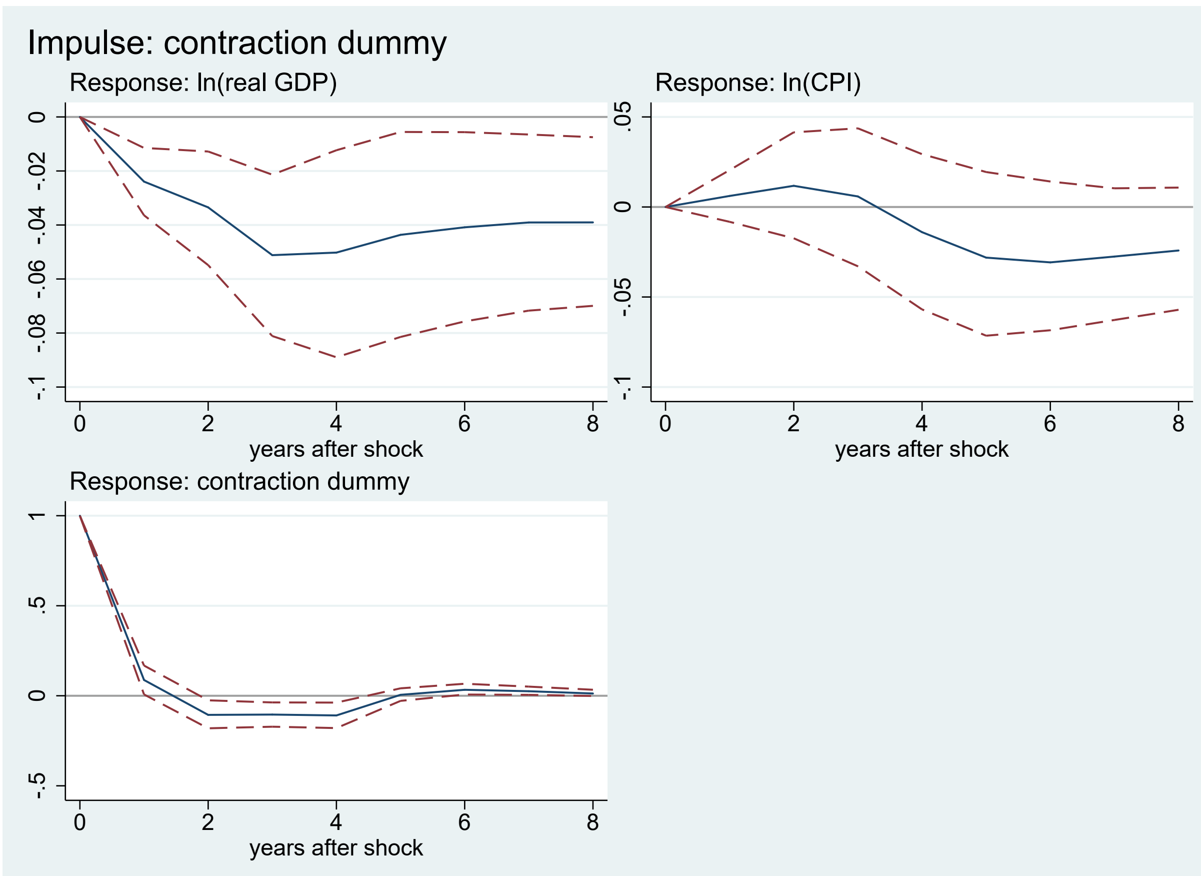

Figure 4: Impulse-responses following a unit shock to the contraction dummy (with 95% confidence interval), advanced economies, 1970-2017.

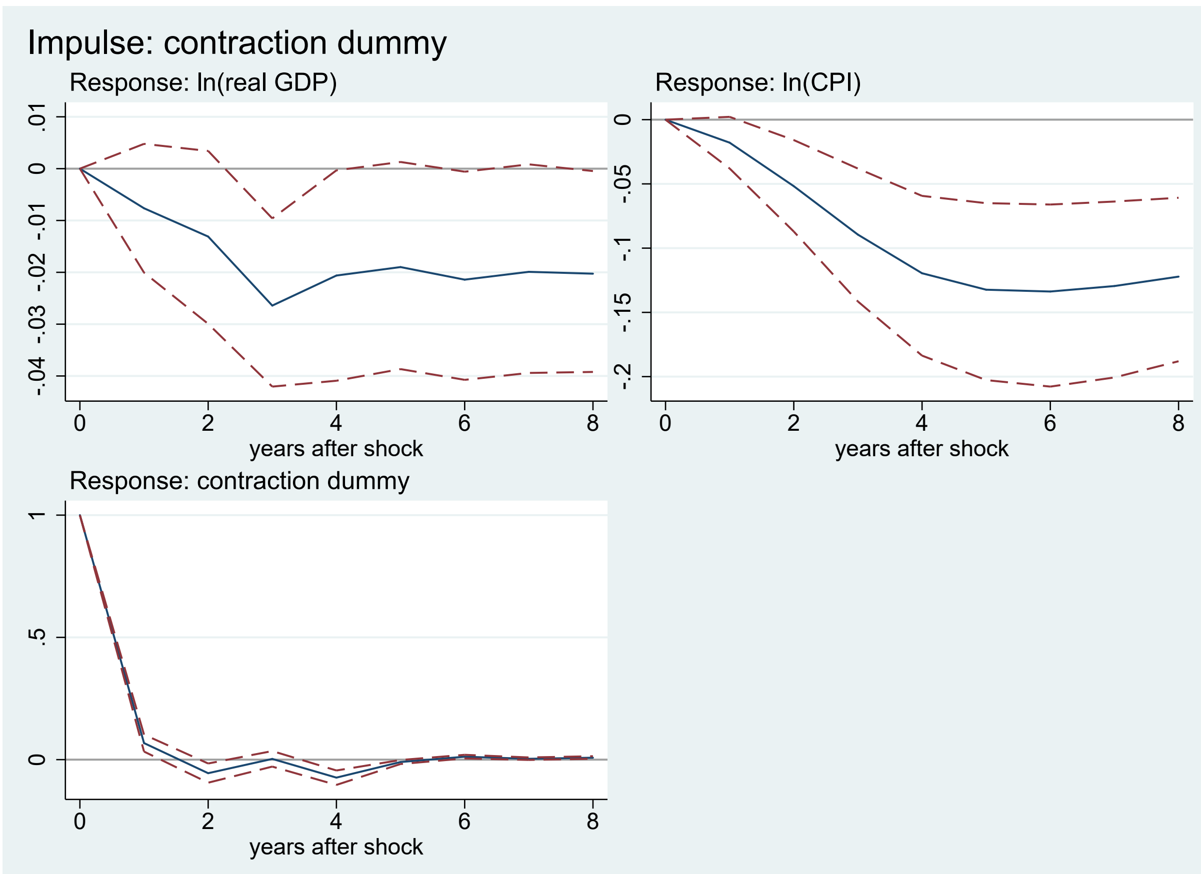

Figure 5: Impulse-responses following a unit shock to the contraction dummy (with 95% confidence interval), full sample, 1980-2017.

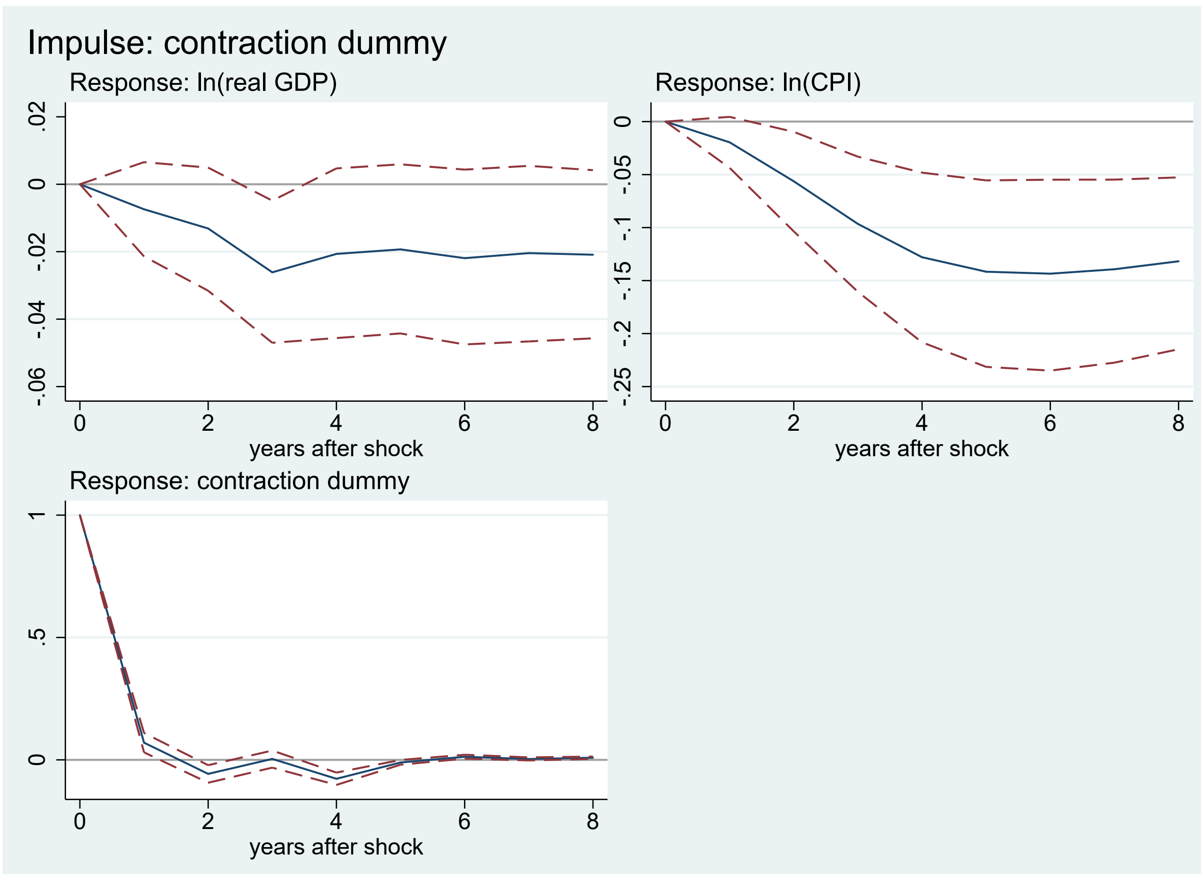

Figure 6: Impulse-responses following a unit shock to the contraction dummy (with 95% confidence interval), emerging and developing economies, 1980-2017.

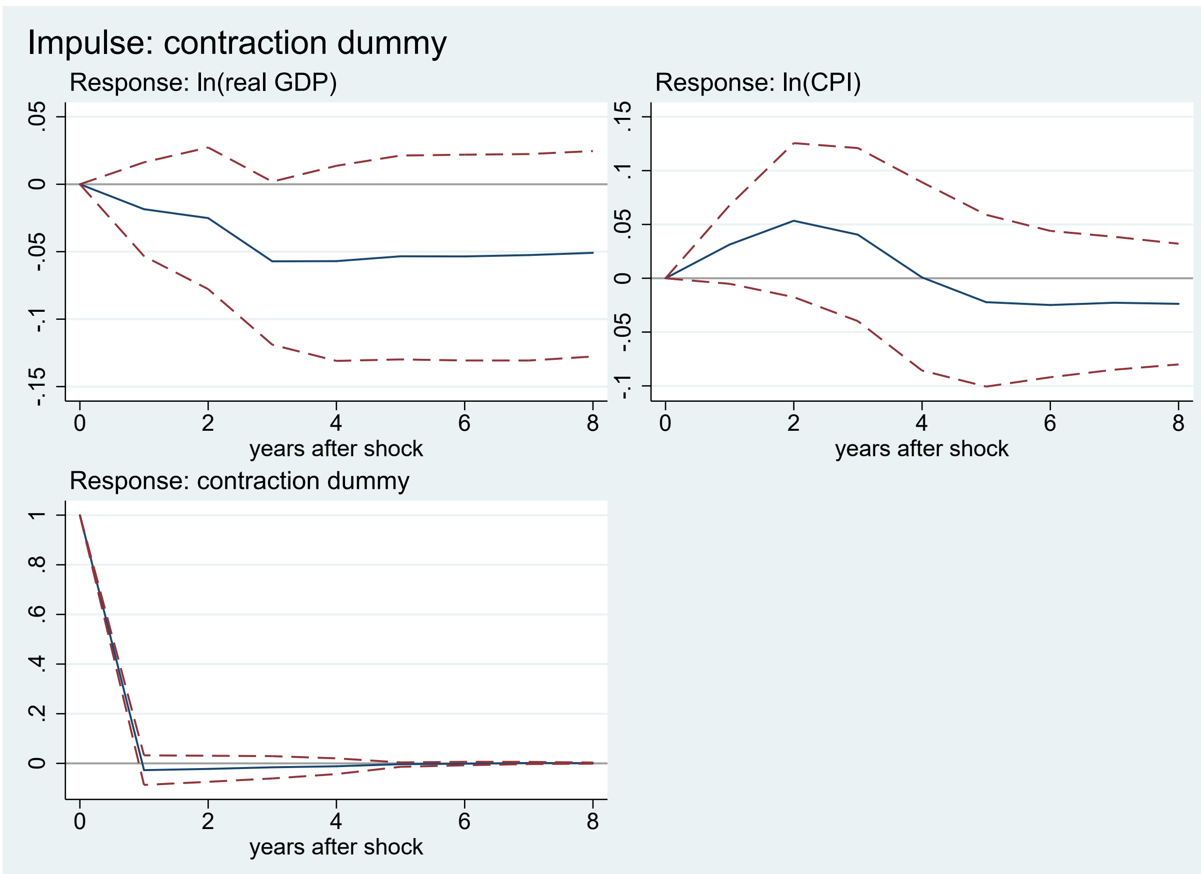

Figure 7: Impulse-responses following a unit shock to the contraction dummy (with 95% confidence interval), advanced economies, 1980-2017.

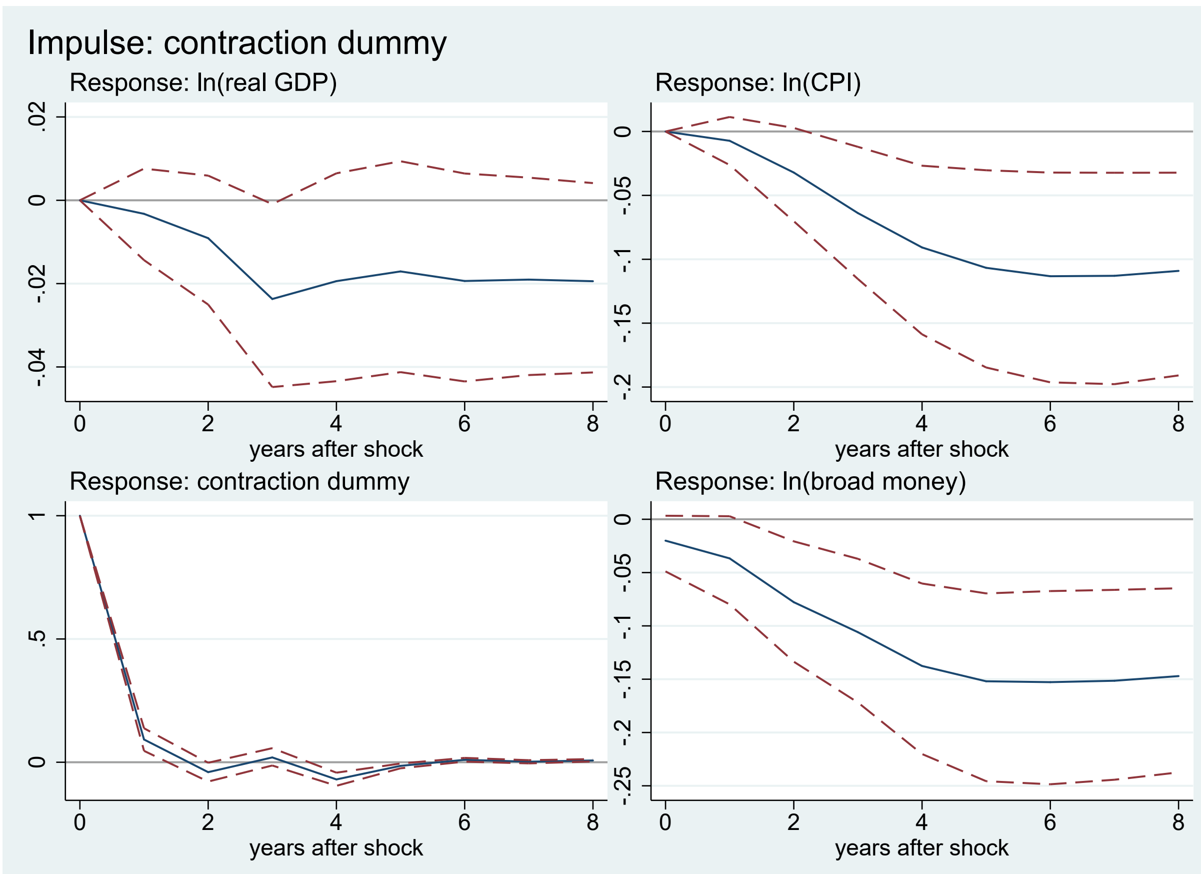

Figure 8: Impulse-responses following a unit shock to the contraction dummy (with 95% confidence interval), full sample, 1970-2017, including broad money.

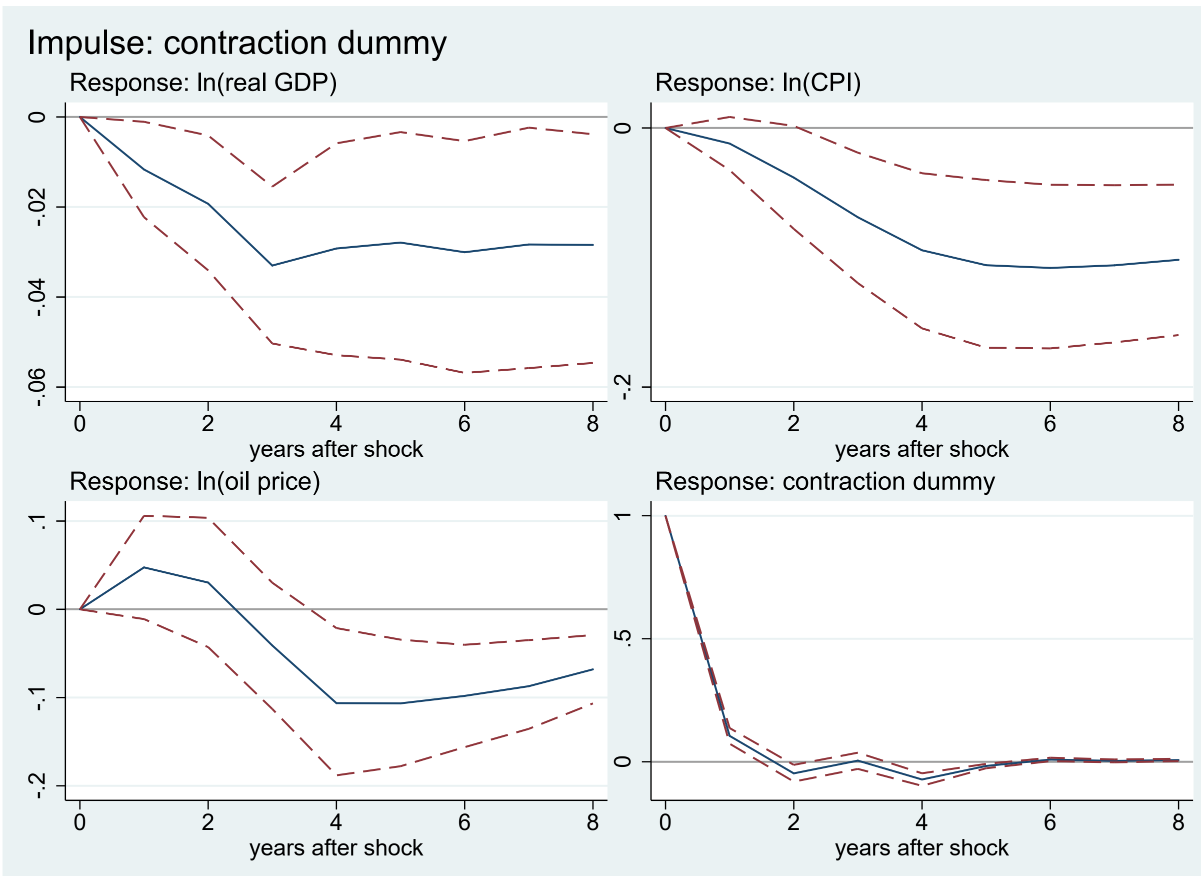

Figure 9: Impulse-responses following a unit shock to the contraction dummy (with 95% confidence interval), full sample, 1970-2017, including oil prices.

Figure 10: Impulse-responses following a unit shock to the contraction dummy assuming monetary contractions cannot take place during years of oil price shocks (with 95% confidence interval), full sample, 1970-2017.

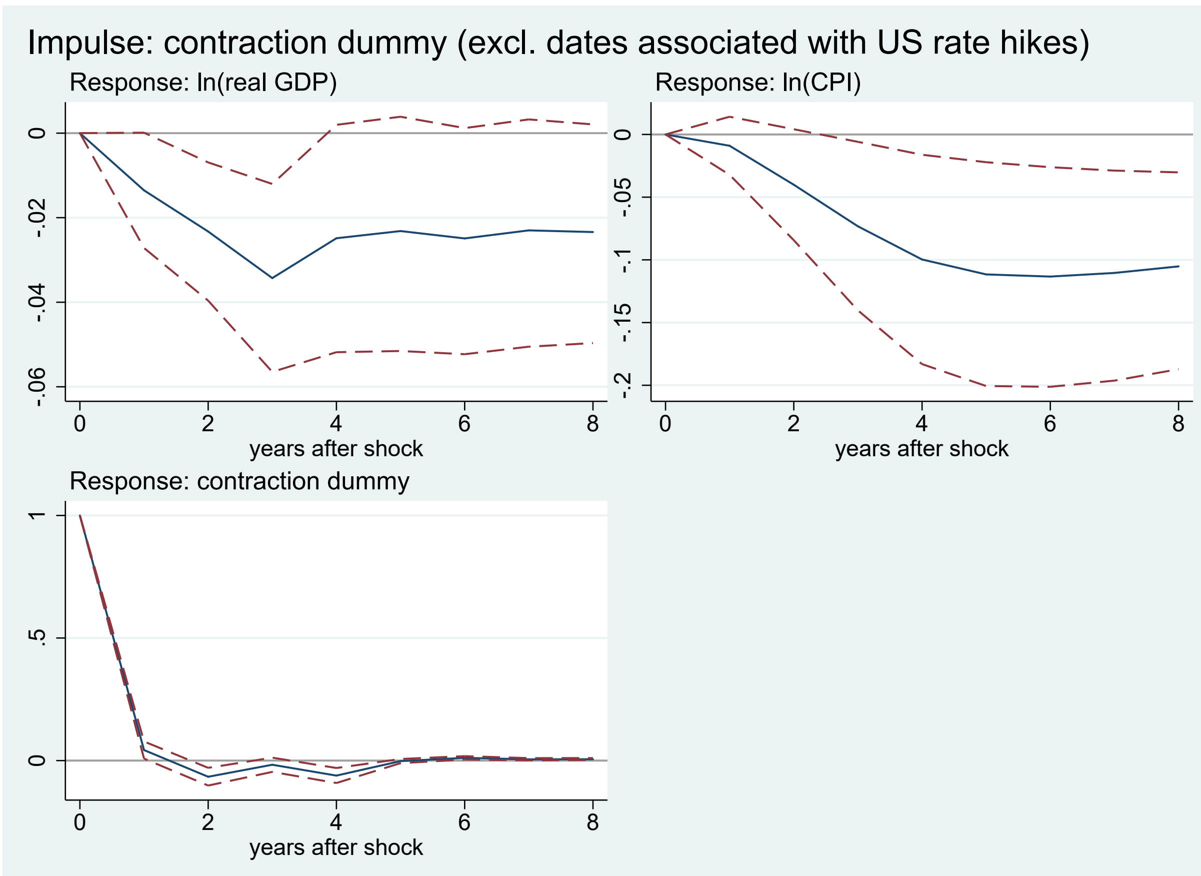

Figure 11: Impulse-responses following a unit shock to the contraction dummy assuming monetary contractions cannot take place during years of tightening US monetary policy (with 95% confidence interval), full sample, 1970-2017.

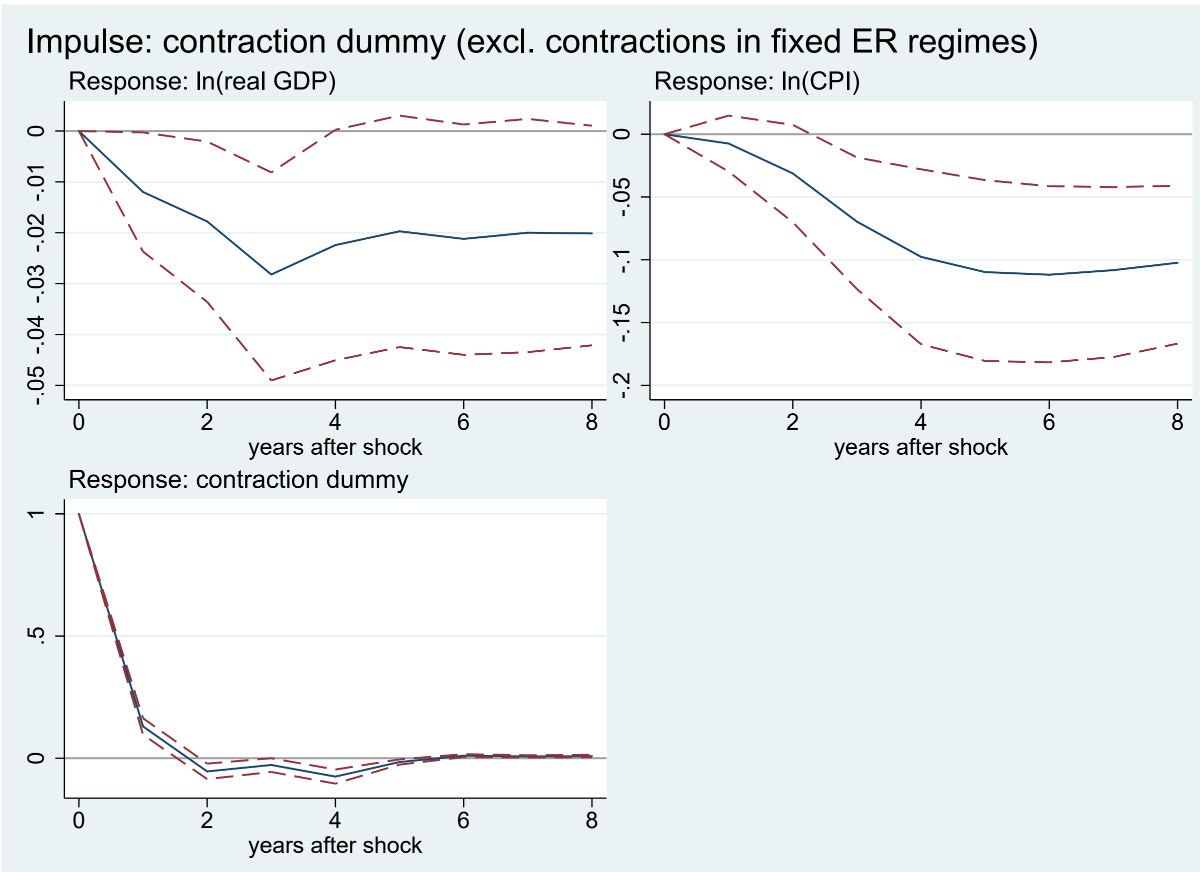

Figure 12: Impulse-responses following a unit shock to the contraction dummy assuming monetary contractions cannot take place under fixed exchange rate regimes (with 95% confidence interval), full sample, 1970-2017.