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Do SVARs identify unconventional monetary policy shocks?

We show that the technique employed in previous structural VAR estimates of the effects of unconventional monetary policy does not successfully identify unconventional monetary policy shocks in the euro area.

Therefore, the impulse responses reported by previous studies are not responses to monetary policy shocks and they do not support the conclusion that the ECB's balance sheet policies have been successful at stabilising the euro area economy. Replacing all information about the stance of monetary policy with random numbers produces statistically indistinguishable impulse responses and time series of purported monetary policy shocks.

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Do zero and sign restricted SVARs identify unconventional monetary policy shocks in the euro area?

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Abstract

We show that the identification schemes used by Burriel & Galesi (2018), Boeckx *et al.* (2017) and Gambacorta *et al.* (2014) fail to plausibly recover true unconventional monetary policy shocks in the euro area. In their identification schemes the information contained in the size of the central bank's balance sheet is key to distinguishing monetary policy shocks from other shocks that lower financial market stress. We show that replacing the size of the ECB's balance sheet with random numbers leads to statistically indistinguishable impulse response functions and time series of supposed unconventional monetary policy shocks. In contrast, using monetary policy shocks identified from futures rate data by Jarociński & Karadi (2018), we argue that unconventional monetary policy has not had a statistically significant effect on real economic activity.

JEL Classification: C32; E52

Keywords: Unconventional monetary policy; VAR models; Identification

1 Introduction

Recently, Boeckx *et al.* (2017), Burriel & Galesi (2018) and Gambacorta *et al.* (2014) have provided estimates of the effects of unconventional mone-

tary policy shocks in the euro area based on structural vector autoregression (SVAR) models identified using zero and sign restrictions. All three studies report similar statistically significant¹ hump-shaped responses for output and prices, which are interpreted as evidence that unconventional monetary policy has been effective at stabilising the euro area economy. The contribution of this paper is to show that these findings result from an identification strategy that does not succesfully uncover unconventional monetary policy shocks.

The identification scheme used by Boeckx *et al.* (2017), Burriel & Galesi (2018) and Gambacorta *et al.* (2014) (in a panel setting) is that an expansionary unconventional monetary policy shock increases the size of the central bank's balance sheet, lowers financial system stress and lowers the EONIA-MRO spread² whilst having no contemporaneous effect on output and prices. This combination of zero and sign restrictions is meant to distinguish monetary policy shocks from financial system shocks, which would not move the size of the balance sheet in the opposite direction to the financial stress indicators. As such, the information contained in the size of the balance sheet is vital for identifying unconventional monetary policy shocks.

The key result of this paper is that replacing the size of the balance sheet with a time series of independent random numbers produces very similar impulse responses for the euro area to those reported by Burriel & Galesi (2018), Boeckx *et al.* (2017) and Gambacorta *et al.* (2014). The same holds true if we switch the sign of the response of the balance sheet in the identification scheme such that an expansionary unconventional monetary policy shock reduces the size of the balance sheet. The implication of this is that the reported impulse response functions are independent of the information in the size of the balance sheet, which implies the identification scheme is not distinguishing monetary policy shocks from other shocks that lower financial system stress. Since the previously published results are not responses to unconventional monetary policy shocks, they do not support the conclusion that unconventional monetary policy has been effective in the euro area.

This lack of identification is not confined to the size of the balance sheet as the measure of the stance of monetary policy: we show that the same problem arises when the balance sheet is replaced by any of the various shadow short

¹At the 68% level.

²The VAR models used by Gambacorta *et al.* (2014) do not contain a spread, but the essence of the identification scheme is the same, since the spread is also a measure of financial system stress.

rates that have been proposed, the main alternative measure of the stance of monetary policy. Regardless of which measure of the stance of monetary policy is used with this combination of zero and sign restrictions, the shocks identified are highly correlated with each other. In other words, they identify the same shocks. In contrast, the SVAR shocks are almost entirely uncorrelated with other credible candidate monetary shocks identified from futures rate surprises by Jarociński & Karadi (2018) or Corsetti *et al.* (2018). This further reinforces our conclusion that the zero and sign restricted VAR models are not successfully identifying unconventional monetary policy shocks.

The remainder of this paper continues as follows. Section 2 presents our key result: replacing the size of the ECB's balance sheet with random numbers in models from the existing literature produces very similar impulse response functions for output and prices. Section 3 uses an SVAR model for the euro area to show that the same problem occurs when using a shadow short rate to capture the stance of monetary policy. Section 3 also shows that whichever variable is included for monetary policy, the underlying time series of shocks is very similar. Section 4 discusses the implications of these results and proposes an explanation for them. Section 5 presents alternative estimates of the effects of unconventional monetary policy using shocks identified from futures rate data by Jarociński & Karadi (2018). Finally, section 6 offers some concluding comments.

2 Identification in the existing literature

To illustrate the identification scheme used by Burriel & Galesi (2018), Boeckx *et al.* (2017) and Gambacorta *et al.* (2014), we use a textbook SVAR model. Whilst Burriel & Galesi (2018) estimate a Global VAR (GVAR) rather than a single country SVAR and Gambacorta *et al.* (2014) estimate a panel VAR, their identifying restrictions are imposed only using data on euro area aggregates. As such, identification in Burriel & Galesi (2018) and Gambacorta *et al.* (2014) is equivalent to that in a textbook SVAR. The SVAR has the following representation:

$$Y_t = \alpha + A(L)Y_{t-1} + B\epsilon_t, \tag{1}$$

where Y_t is a vector of endogenous variables, α is a vector of constants, A(L) is a matrix polynomial in the lag operator L, and B is the contemporaneous impact matrix of the mutually uncorrelated disturbances, ϵ_t . The underlying structural shocks, ϵ_t , are identified through restrictions on B.

For the shocks identified through restrictions on B to accurately capture true unconventional monetary policy shocks necessitates two things: that the variables chosen and the estimated coefficients of A(L) accurately describe the systematic response of monetary policy to the economy and that the restrictions on B successfully isolate unconventional monetary policy shocks from the other shocks that cause policy to deviate from the systematic component. Employing the best available data and a plausible set of restrictions on B, as Burriel & Galesi (2018), Boeckx *et al.* (2017) and Gambacorta *et al.* (2014) do, is a necessary but not sufficient condition for successfully identifying true unconventional monetary policy shocks. In the remainder of this section we show that Burriel & Galesi (2018) and Gambacorta *et al.* (2014) do not concinvingly identify true unconventional monetary policy shocks.

2.1 Burriel & Galesi (2018)

To recover unconventional monetary policy shocks Burriel & Galesi (2018) use the identification scheme and endogenous variables shown in table 1. The assumptions employed that are supposed to isolate an unconventional monetary policy shock are that an expansionary unconventional monetary policy shock increases the size of the central bank's balance sheet, lowers financial system stress and lowers the EONIA-MRO spread, whilst having no contemporaneous effect on output and prices. The logic behind this set of restrictions is that they are intended to distinguish monetary policy shocks from financial system shocks, which do not move financial stress indicators and the size of the balance sheet in the opposite direction. Hence, the movement of the ECB's balance sheet is of crucial importance to the identification scheme since other shocks, such as any news about the health of the financial system, would lower both financial system stress and the EONIA-MRO spread, whilst also having only a lagged effect on output and prices. Boeckx et al. (2017) and Gambacorta et al. (2014) use comparable identification schemes: Boeckx *et al.* (2017) do not include the exchange rate, which is of no importance to our arguments because the exchange rate is unrestricted in the identification scheme of Burriel & Galesi (2018), whilst in Gambacorta et al. (2014) there is also no exchange rate or a spread and equity volatility is used in place of the CISS index. The core identifying restriction remains the same across all the papers: unconventional monetary policy shocks lower financial stress indicators and increase the size of the balance sheet.

Figure 1 reproduces the GVAR responses of output and prices to an uncon-

	Balance sheet shock		Interest rate shock	
	On impact	One month after	On impact	One month after
Total assets	+	+	0	?
EONIA-MRO	-	-	?	?
CISS index	-	-	?	?
MRO rate	0	?	-	-
Output	0	?	0	+
Prices	0	?	0	+
Exchange rate	?	?	?	?

Table 1: Identification scheme used by Burriel & Galesi (2018)

ventional monetary policy shock reported in Burriel & Galesi (2018).³ These responses are qualitatively similar to the SVAR responses of Boeckx et al. (2017): both output and prices follow a hump-shaped increase with peaks occuring 8-12 months after an expansionary shock. Figure 1 also presents the impulse responses from two nonsense specifications: one where total assets is replaced by random numbers in the VAR specifications and one where the sign restriction on total assets is reversed so that the balance sheet shrinks during an expansionary unconventional monetary policy shock. For completeness, these identification schemes are reported in tables 3 and 4 in the appendix. The random responses in figure 1 are the mean IRFs from ten different random [0, 1] time series (all ten sets of IRFs are shown in the appendix). As figure 1 shows, the three sets of responses are very similar and the median response from each nonsense specification lie within the 68% bands of the original specification. In fact, if we were to make the bands tighter, the output response from random noise would lie entirely within 50% bands of the original specification and the price response within 40% bands. Statistically the nonsense identification scheme responses are indistinguishable from the Burriel & Galesi (2018) responses at conventional significance levels.

The obvious conclusion to draw from this observation is that the impulse responses of output and prices do not depend on what happens to the size of the ECB's balance sheet when the shock hits: it even doesn't matter if the GVAR model has no information on the size of the balance sheet at all. The shock identified in this model is driven by the restrictions on the other variables — and those other restrictions are insufficient to distinguish an unconventional monetary policy shock from various other shocks that would

³Using their original MATLAB code downloaded from the European Economic Review website.

Figure 1: Responses of output (left) and prices (right) to an unconventional monetary policy shock in the euro area under the original Burriel & Galesi (2018) specification and two nonsense specifications



Note: The dashed lines represent the middle 68% of models from the original Burriel & Galesi (2018) specification. Only the median responses of the other two specifications are shown. The random response is the mean of median responses from ten different series of random [0,1] numbers replacing total asset holdings of the ECB.

lower financial system stress.

2.2 Gambacorta et al. (2014)

Gambacorta *et al.* (2014) employ a very similar identification scheme with a panel of 8 economies over the sample period January 2008 to June 2011. The panel VAR model contains four variables: the natural logarithm of real GDP, the natural logarithm of the CPI, the natural logarithm of the level of central bank assets and the level of equity market volatility in each economy. The identification scheme used by Gambacorta *et al.* (2014) is similar to the schemes used by Boeckx *et al.* (2017) and Burriel & Galesi (2018): an unconventional monetary policy shock increases the size of the central bank balance sheet and lowers financial market volatility, but has no contemporaneous effect on output and prices. Since Gambacorta *et al.* (2014) use the mean group estimator, they actually estimate separate single country VAR models for each economy, before taking the mean across all eight models to produce their panel impulse response functions. As such, they also present results for a single country model of the euro area.

Figure 2 reproduces the impulse responses of output and prices in the euro

Figure 2: Responses of output (left) and prices (right) to an unconventional monetary policy shock in the euro area under the original Gambacorta *et al.* (2014) specification and two nonsense specifications



Note: The dashed lines represent the middle 68% of models from the original Gambacorta *et al.* (2014) specification. Only the median responses of the other two specifications are shown. The random response is the mean of median responses from ten different series of random [0,1] numbers replacing total asset holdings of the ECB.

area to an unconventional monetary policy shock.⁴ The results are comparable with the results obtained in Burriel & Galesi (2018) and Boeckx *et al.* (2017): both output and prices follow a hump-shaped increase.⁵ In figure 2 we also replace total assets with random [0, 1] numbers as we did in the previous section (figure 2 contains the mean of ten models employing random numbers: all ten IRFs are shown in the appendix). Once again, the impulse response functions display the same shapes as the original specification responses. For prices the magnitudes of the random number response are almost identical, whilst for output the random number response lies outside the 68% bands of the original specification. However, as figure 10 in the appendix shows, the output response of the random specification lies entirely within 96% bands, which in most of econometrics is a more conventional critical value than one standard deviation.

For the negative balance sheet response identification scheme, the response of output displays the same hump-shaped response as the original and the

⁴We use the authors original RATS code for replication. We also perform a similar analysis for the mean group estimator for the full panel of countries in Gambacorta *et al.* (2014), which can be found in the appendix. For the full panel, the random IRFs of both output and prices fall outside the 68% bands of the original specification.

⁵Here peaks occur at 3 months after an expansionary shock, which is earlier than the results from Burriel & Galesi (2018) and Boeckx *et al.* (2017).

magnitudes are very similar - the negative identification scheme response lies entirely within the 68% bands of the original specification. In contrast, the price level response of the negative response identification scheme lies a considerable distance below the bands of the original specification. As figure 10 in the appendix shows, the price level response of the negative response identification scheme even lies outside 96% bands.

All in all, only one response out of four from our nonsense identification schemes lies outside conventionally wide confidence bands around the original Gambacorta *et al.* (2014) responses. That's hardly convincing evidence that this identification scheme has succesfully distinguished unconventional monetary policy shocks from other shocks that lower financial market stress. The next section will use estimates from an SVAR model similar to Boeckx *et al.* (2017) to show that regardless of the measure of monetary policy employed, these identification schemes produce virtually the same time series of 'identified' shocks. That's why the original responses of Burriel & Galesi (2018) and Gambacorta *et al.* (2014) are so similar to the responses of the nonsense specifications: they're responses to very similar shocks.

3 An SVAR model for unconventional monetary policy

The results in section 2 suggest that the impulse responses of output and prices do not depend on the unconventional monetary policy instrument, and the restrictions are not able to distinguish unconventional monetary policy shocks from various other shocks which would lower financial stress. This section shows that this result also holds for a sample period during which unconventional monetary policy was the main instrument of monetary policy. To that end, the analyses in this section are performed with a 6 variable SVAR model over the period January 2009 to December 2016. The SVAR model here is therefore similar to that used by Boeckx *et al.* (2017) but estimated over a later sample period where there were few changes in the MRO. This section also shows that changing the measure of the monetary policy from total assets to any of the various shadow rates that have been proposed or random numbers produces very similar time series of 'identified' shocks.

Finally, abstracting from conventional monetary policy allows us to eas-

ily compare the estimated unconventional monetary policy shocks from the SVAR models with credible alternative measures of monetary surprises from Jarociński & Karadi (2018) and Corsetti *et al.* (2018), which are identifed using futures rate data. We do this in section 4, where we show the SVAR shocks have almost zero correlation with the futures rate shocks.

3.1 Data

All of our data for our SVAR models comes from the ECB's Statistical Data Warehouse, with the exception of the various shadow rates we use, which come from the authors. Following Gambacorta *et al.* (2014), Boeckx *et al.* (2017) and Burriel & Galesi (2018), we use monthly data.⁶

For our euro area SVAR models we use 6 endogenous variables over the sample period January 2009 to December 2016: output, prices, the CISS index of systemic financial stress of Holló *et al.* (2012), a measure of the stance of monetary policy, the EONIA-MRO spread and real equity prices as given by the Eurostoxx 50 index. This is the same as Boeckx *et al.* (2017) except we have replaced the MRO with equity prices.⁷ We include equity prices because many authors have reported finding consistent responses of these variables to unconventional monetary policy shocks (Beirne *et al.* (2011), Baumeister & Benati (2013) and Haitsma *et al.* (2016)) and as Jarociński & Karadi (2018) argue, equity can help distinguish monetary policy shocks from news shocks. As such, including equity gives our models significant additional information for identifying the policy shocks.

We use five measures of the stance of monetary policy: total assets and

⁶This is a common approach in the literature but is not without its drawbacks. The key drawback is that GDP is only measured at the quarterly frequency so a monthly output series either requires some statistical interpolation or using another series such as industrial production as a proxy. Both approaches effectively mean that our output measure is subject to measurement error. Therefore, when the ECB is setting monetary policy, policy makers might be looking at different output measures than the ones we include in our empirical specification. This, of course, makes identifying true policy shocks harder.

⁷We also estimate a 6 variable SVAR model with the MRO rate instead of equity prices as Boeckx *et al.* (2017), because the MRO rate still varied a bit during the crisis. The impulse responses of output and prices to an unconventional monetary policy shock with this specification are reported in the appendix. In line with the results in the main text, changing the measure of unconventional monetary policy to random numbers or any of the shadow rates has little effect on the impulse responses.



Figure 3: Comparison between different measures of the monetary policy stance

four shadow short rates. Shadow rates are calculated as a decomposition of the observed yield curve into a shadow yield curve plus an option which pays out cash following Black (1995). The shadow short-rate is the interest rate at the short-term end of the shadow yield curve (see Wu & Xia (2016), Krippner (2015) or Damjanović & Masten (2016) for more details). Figure 3 compares the measures of the stance of monetary policy we use. The different shadow short rates come from different specifications of the underlying term structure models: Krippner (2015) estimates a model with a fixed lower bound, while Kortela (2016), Lemke & Vladu (2017) and Wu & Xia (2017) estimate shadow rates with a time-varying lower bound. The differences between the shadow rates are minimal up to about the end of 2011. After that point they diverge to such an extent that the Wu and Xia shadow rate is about -6% at the end of our sample, whilst the Kortela and Lemke and Vladu rates are about -1%. The divergence is not just in magnitudes: they move in opposite directions at key moments. For example, at the start of the QE in early 2015, the Krippner shadow rate increases by about 200 basis points, the Wu and Xia rate is reasonably constant, whilst the Lemke and Vladu rate falls by about 100 basis points. One would expect such differences would lead to different identified shocks and different impulse response functions, but as we show below, they do not.

3.2 Identification

We use the same key restriction that unconventional monetary policy shocks push the size of the balance sheet and financial stress indicators in opposite directions. Table 2 presents the identification schemes when the monetary policy stance is measured by the size of the ECB's balance sheet, random numbers and any of the various shadow rates.⁸ When we use a shadow rate as the stance of monetary policy we simply flip the sign of the restriction on the policy instrument, since an expansionary change in interest rate space is negative.

 Table 2: Identification schemes used by SVAR models

	Policy measure			
	Total assets or Random $[0,1]$	Shadow rate		
Policy measure	+	-		
EONIA-MRO	-	-		
CISS index	-	-		
Equity prices	+	+		
Output	0	0		
Prices	0	0		

Since the MRO varies little in our sample period, we can keep the same degrees of freedom as Boeckx *et al.* (2017) but replace the MRO with another variable containing potentially useful information. As described above, we replace the MRO with equity prices, which various authors have reported consistently finding that expansionary unconventional monetary policy raises equity prices.

3.3 Empirical results

In our empirical specification the reduced form is estimated using Bayesian methods, following Uhlig (2005). His approach specifies a Normal-Wishart prior such that the posterior estimates are equivalent to OLS estimates of

⁸Paustian (2007) has argued that reducing the space of possible models by identifying other shocks in the system can aid in identification of the shocks of interest. Our result that replacing total assets with a shadow rate or random numbers hold for other plausible identification schemes where we identify other shocks in addition to the unconventional monetary policy shocks. Details available upon request.

the system. This is a very weak prior since it imposes no specific prior knowledge.⁹ Given a draw from the posterior distribution of the reduced form parameters, we use the algorithm of Arias *et al.* (2014) to collect 1000 draws from the posterior distribution of the structural parameters that satisfy our sign and zero restrictions.

Figure 4: SVAR impulse responses of output (left) and prices (right) to an unconventional monetary policy shock with different measures of monetary policy



Note: The dashed lines represent the middle 68% of models from the total assets specification. Only the median responses from the other specifications are shown.

Figure 4 show impulse responses from the models with each of the candidate measures of monetary policy. As with figure 1, despite the differences highlighted between the various measures of monetary policy, all of the impulse response functions display the same hump-shaped responses, and all of the responses lie entirely within the one standard deviation bands of the benchmark total assets model, except the price level response of the negative identification scheme model, which lies marginally outside the one standard deviation bands between 15 and 24 months. The reason that the responses are so similar is that the 'unconventional monetary policy shocks' identified by each specification are very highly correlated, as is shown in figure 5.¹⁰ The pairwise correlations between the shock series range from 0.61 to 0.71.

⁹See Uhlig (2005) p410 for details.

¹⁰Figure 5 shows the median shocks for each specification from all accepted models.

Figure 5: SVAR UMP shocks identified from various measures of monetary policy



4 Discussion

4.1 Zero and sign restrictions

So far we have shown that whatever information is contained in the various monetary policy measures is irrelevant for the identified shocks and the subsequent impulse response functions. To understand why it is useful to think about what the zero and sign restrictions algorithm is doing. Figure 6 illustrates two possibilities.¹¹ All possible models that reproduce the reduced form covariance matrix, Σ , are defined by the set A where $BB' = \Sigma$. The zero and sign algorithm samples this set and accepts only those that meet the zero and sign restrictions. If we do not impose the restrictions on the balance sheet the other restrictions define set B: the set of all models

 $^{^{11}\}mathrm{Assuming}$ that the other econometric assumptions such as constant parameters are satisfied.

that return shocks that lower financial market stress (and the spread, for those models including a spread) but only have a lagged effect on output and prices. Some of the models in set B identify unconventional monetary policy shocks and some do not.

The role of the restriction on total assets is to select out of set B those models that correctly identify unconventional monetary policy shocks. This is represented by set C in the first figure. However, if the errors in the balance sheet equation have little or nothing to do with monetary policy shocks and they are simply random errors due to econometric shortcomings, then the restriction on total assets will just return a randomly selected subset of set B. This is represented by the second figure where the darker spots are distributed throughout set B. If this is the case, then the time series of shocks identified by imposing the restriction on total assets will be very similar to the time series of shocks identified without the extra restriction. This is what we have shown in the previous section. Changing the measure of monetary policy from the balance sheet to random numbers or any of the shadow short rates should result in a different set C being selected, unless the extra restriction is on already random errors unrelated to monetary policy. Finding significant differences between the time series of shocks from each model would rule out the second case. That we find such a high correlation between the identified shocks for all models including the random number models and the widely differing shadow short rates is highly suggestive that we are dealing with the second case.

Figure 6: Zero and sign restrictions where the restriction on total assets is informative (left) and uninformative (right)



4.2 SVAR shocks vs directly identified monetary policy shocks

Since finding such similarity between the shock series does not completely rule out the possibility that the SVAR models have indeed succesfully pinned down monetary policy shocks, in this section we compare our SVAR shocks to two direct measures of monetary policy shocks. The direct measures are taken from surprises in forward rates within a window around monetary policy announcements. The first is the one year forward rate surprise as measured by Corsetti et al. (2018). The second is the monetary policy shock component of the surprise as identified by Jarociński & Karadi (2018). Figure 7 plots the identified SVAR shocks from the total assets model against these direct measures of monetary shocks. The correlation is almost zero: between the SVAR shocks and the Corsetti shocks it is 0.10, whilst the between the SVAR shocks and the Jarocinski and Karadi shocks it is -0.06. Not only is it highly implausible that the identification scheme of Gambacorta et al. (2014), Boeckx et al. (2017) and Burriel & Galesi (2018) recovers the true unconventional monetary policy shocks without the information contained in the size of the ECB's balance sheet, the resultant shocks bear no resemblance to other credibly identified monetary policy shocks in this period. As such, the logical conclusion is that the SVAR models are not identifying unconventional monetary policy shocks.

4.3 Econometric issues with the measures of unconventional monetary policy

So why do total assets and the shadow rates fail to identify unconventional monetary policy shocks? There are some obvious econometric issues with the balance sheet and the various shadow rates that have been used as a measure of the stance of monetary policy. Firstly, the balance sheet suffers from the foresight problem. That is, many of those unconventional monetary policy changes were announced some time in advance. For example, when the ECB announced QE in January 2015 it announced that €60bn of assets would be purchased each month until at least September 2016. Therefore, the balance sheet changes in the months following the January announcement were highly predictable in advance to agents in the real economy. It's not just QE that suffers from this: the ECB press release of 8 December 2011 announced both December 2011 and February 2012 LTRO allotments. As such, the





ECB balance sheet movements were therefore predictable in advance. This structure to the information available to agents creates an equilibrium with a non-fundamental moving average representation (Hansen & Sargent (1991)). Failing to take this into account in a VAR framework leads to biased estimates of the effects of policy. In fact, this is essentially the same problem as the fiscal foresight problem in empirical analyses of the effects of fiscal policy (Leeper *et al.* (2013)) and is driven by the information set of the econometric model differing significantly from the information set of economic agents in the economy under investigation. Secondly, the various shadow rates all suffer from the estimated regressors problem. The large differences between the shadow rates suggest that errors involved are large, which will also lead to incorrect inference. If one combines the obvious econometric shortcomings of these data series with sign restrictions, what Fry & Pagan (2011) call weak information, it is hardly surprising that they fail to correctly identify true monetary shocks.

4.4 Implications

Our conclusion that previous studies have not succesfully identified unconventional monetary policy shocks provides a simple explanation for a counterintuitive result reported by both Burriel & Galesi (2018) and Boeckx et al. (2017). They both report that financially stressed economies in the euro area tend to have the smallest output responses following unconventional monetary policy shocks (specifically, Cyprus, Greece, Portugal and Spain have the smallest output responses). Much of the ECB's unconventional monetary policy has been aimed at reducing financial system stress in these countries, which makes the finding that these countries have the smallest output responses counterintuitive. Our results provide a simple explanation for these results: Burriel & Galesi (2018) and Boeckx *et al.* (2017) are reporting the responses to some other unidentified shock rather than to unconventional monetary policy. As we discussed in the introduction, the positive sign restriction on total assets was supposed to distinguish unconventional monetary policy shocks from other shocks that would reduce financial system stress. Given the irrelevance of total assets to the identified responses and shocks, it seems at least as plausible that the responses are to other shocks that lower financial stress. For example, many of the euro area policy responses to the crisis that have lowered financial market stress in the euro system as a whole have done so because they have lowered the contagion risk from crisis countries to non-crisis countries. Hence, core euro area countries with healthy financial systems benefit from these developments, whilst the crisis countries do not. As a result of these shocks, one would expect smaller responses in periphery countries than in the core euro area countries, which is exactly what Burriel & Galesi (2018) and Boeckx et al. (2017) find.

A further reason to doubt the that the SVARs recover true unconventional monetary policy shocks is that the SVAR estimates imply that unconventional monetary policy in the crisis period is more effective than previous estimates of the effects of conventional monetary policy in normal times. A one standard deviation shadow rate shock is about 10 basis points (for the Wu and Xia shadow rate model) and the SVAR models tell us that a 10 basis points shadow rate shock raises output by about 0.05%. We can compare this to previous estimates of the effect of monetary policy shocks in the euro area. For example, Georgiadis (2015) reports that a 100 basis points contractionary shock in the period 1999Q1 to 2009Q4 lowered output in the core euro area countries by about 0.2-0.3%. Since the VAR models are linear, the zero and sign restricted SVAR estimates are claiming that unconventional monetary policy shocks at the effective lower bound are twice as effective at raising output than estimates of conventional monetary policy in normal times. Given the theoretical arguments about whether unconventional monetary policy works at all, it seems unlikely that it would have larger effects at the effective lower bound than conventional policy away from the lower bound.

5 Alternative approaches to estimating the effects of unconventional monetary policy

Identifying monetary policy shocks through restrictions on the covariance matrix of the residuals is not the only approach. The futures rate surprises shown in figure 7 can be used directly as monetary shocks (see Jarociński & Karadi (2018)), or they can be used as external instruments following Gertler & Karadi (2015). However, our analysis above, which argues that there are significant econometric problems with total assets or shadow rates, also implies that the external instruments approach is unlikely to be successful. That's because the errors in the equation for total assets or the shadow rate are, at best, only very weakly related to the underlying unconventional monetary shocks. Therefore, no matter how good the external instrument is, the econometrician will be faced with a weak instruments problem. That leaves using the futures rate surprises as a direct measure of unconventional monetary policy shocks, which is the approach we take in this section.

To make the results we present here as comparable as possible with those above, for the endogenous variables we employ exactly the same variables and lags as in the previous sections. We simply add the monetary shocks of Jarociński & Karadi (2018) as an exogenous variable. That is

$$Y_t = \alpha + A(L)Y_{t-1} + CX_t + u_t,$$
(2)

where X_t is the time series of monetary policy shocks, C a vector of coefficients and u_t a reduced form error term.

Figure 8 shows the impulse response functions to the monetary policy component of a futures rate surprise. In contrast to the responses of Burriel & Galesi (2018) and Boeckx *et al.* (2017), the output response is not statistically

significant at the 68% level, whilst the price level response is not significant at the 95% level and decays back to the baseline rather than following a hump-shaped response.¹² The magnitude of the effect on real economic activity is significantly smaller than that reported by Jarociński & Karadi (2018) for the period January 1998 to December 2016, which is plausible given the discussion above about the theoretical effectiveness of unconventional monetary policy.

Figure 8: VARX impulse responses of output (left) and prices (right) to an unconventional monetary policy shock identified from futures rates



6 Conclusion

In this paper, we have shown that the results reported in Burriel & Galesi (2018), Boeckx *et al.* (2017) and Gambacorta *et al.* (2014) depend on an identification scheme that does not successfully recover unconventional monetary policy shocks in the euro area. As such, their conclusion that unconventional monetary policy has been effective at stabilising the euro area economy is unwarranted. Using shocks credibly identified from futures rates, we do not find evidence that unconventional monetary policy has been successful at affecting real economic activity.

Nonetheless, our alternative estimates should come with a clear warning that applies to the majority of time series approaches to identifying the effects of unconventional monetary policy. The short sample period involved

 $^{^{12}}$ The price level response is just statistically significant at the 90% level at 1 and 2 months after the shock, so there is some weak evidence of an effect on prices.

necessitates using various unattractive econometric choices, such as using interpolated monthly data or assuming the transmission mechanism and central bank policy rule has remained unchanged throughout. All of these issues only make the task of identifying true policy shocks even harder. All we can really conclude is that the evidence from these VAR models does not support the claim that unconventional monetary policy has been successful in affecting real economic activity.

Appendices

A Nonsense identification schemes in the GVAR

Tables 3 and 4 show the nonsense identification schemes used in section 2.

Table 3: Nonsense identification scheme 1: iid noise as policy instrument

	Balance sheet shock		Interest rate shock	
	On impact	One month after	On impact	One month after
Random [0,1]	+	+	0	?
EONIA-MRO	-	-	?	?
CISS index	-	-	?	?
MRO rate	0	?	-	-
Output	0	?	0	+
Prices	0	?	0	+
Exchange rate	?	?	?	?

Table 4: Nonsense identification scheme 2: Negative response of total assets to expansionary shock

	Balance sheet shock		Interest rate shock	
	On impact	One month after	On impact	One month after
Total assets	-	-	0	?
EONIA-MRO	-	-	?	?
CISS index	-	-	?	?
MRO rate	0	?	-	-
Output	0	?	0	+
Prices	0	?	0	+
Exchange rate	?	?	?	?

B All random number Burriel & Galesi (2018) IRFs

Figure 1 compares the original Burriel & Galesi (2018) responses with the average of 10 impulse response functions generated with random numbers instead of total assets. This appendix shows all 10 of those IRFs. As figure 9 shows, all 10 IRFs for both output and prices fall entirely within the 68% bands of the original Burriel & Galesi (2018) specification.

Figure 9: Responses of output (left) and prices (right) to an unconventional monetary policy shock under the original Burriel & Galesi (2018) specification and ten specifications where random numbers replace total assets



The dashed lines represent the original Burriel & Galesi (2018) specification, whilst solid lines each represent the median responses from each of the random number specifications.

C Panel VAR IRFs with 96% bands

Figure 10 shows that the euro area responses of output and prices under the random number specification both lie entirely within 96% bands. For the negative balance sheet response identification scheme the output response lies entirely within the 96% bands but the price level response lies outside the 96% bands.

Figure 10: Responses of output (left) and prices (right) to an unconventional monetary policy shock in the euro area under the original Gambacorta *et al.* (2014) specification and two nonsense specifications and middle 96% confidence bands



Note: The dashed lines represent the middle 96% of models from the original Gambacorta *et al.* (2014) specification. Only the median responses of the other two specifications are shown. The random response is the mean of median responses from ten different series of random [0,1] numbers replacing total asset holdings of the ECB.

D Mean group estimator Panel VAR IRFs

Figure 2 presented impulse responses for the euro area. In contrast Gambacorta *et al.* (2014) present a panel VAR as their main specification. This appendix repeats our approach using random numbers or a negative restriction on total assets for the mean group panel estimator. As figure 11 shows, the output responses from both the random number and negative balance sheet response specifications lie mostly within the 96% bands of the original specification - only at 2-4 months does the random specification response lie outside these bands. For prices, both the random number and negative identification scheme responses lie outside the 96% bands of the original specification for the first 5 months. Nonetheless, this is hardly overwhelming evidence for the effectiveness of unconventional monetary policy because in those periods when the original Gambacorta *et al.* (2014) responses are significantly different from the nonsense specifications, they are not significantly different from zero.

Figure 11: Mean group estimator responses of output (left) and prices (right) to an unconventional monetary policy shock under the original panel VAR specification of Gambacorta *et al.* (2014) and two nonsense specifications



Note: The dashed lines represent the middle 96% of models from the original Burriel & Galesi (2018) specification. Only the median responses from the other two specifications are shown.

E All random number euro area IRFs from Gambacorta *et al.* (2014)

Figure 2 compares the original Gambacorta *et al.* (2014) responses with the average of 10 impulse response functions generated with random numbers instead of total assets. This appendix shows all 10 of those IRFs in figure 12.

Figure 12: Responses of output (left) and prices (right) to an unconventional monetary policy shock in the euro area under the original Gambacorta *et al.* (2014) specification and ten specifications where random numbers replace total assets



The dashed lines represent the original Gambacorta et al. (2014) specification, whilst solid lines each represent the median responses from each of the random number specifications.

F An SVAR model for unconventional monetary policy with the MRO rate

This appendix shows impulses responses for a model with the MRO instead of equity prices for the period January 2009 to December 2016. This model uses the same identification scheme as Boeckx *et al.* (2017) and differs from that used by Burriel & Galesi (2018) only by the lack of an unrestricted exchange rate variable. As figure 13, including the MRO does not alter our main argument that replacing any of the various measures of unconventional monetary policy with random numbers results in statistically indistinguishable impulse responses.

Figure 13: SVAR impulse responses of output (left) and prices (right) to an unconventional monetary policy shocks with different measures of monetary policy



Note: The dashed lines represent 68% bootstrapped confidence bands.

References

- Arias, Jonas E., Rubio-Ramírez, Juan F., & Waggoner, Daniel F. 2014 (Jan.). Inference Based on SVARs Identified with Sign and Zero Restrictions: Theory and Applications. Dynare Working Papers 30. CEPREMAP.
- Baumeister, Christiane, & Benati, Luca. 2013. Unconventional Monetary Policy and the Great Recession: Estimating the Macroeconomic Effects of a Spread Compression at the Zero Lower Bound. International Journal of Central Banking, 9(2), 165–212.
- Beirne, John, Dalitz, Lars, Ejsing, Jacob, Grothe, Magdalena, Manganelli, Simone, Monar, Fernando, Sahel, Benjamin, Sušec, Matjaž, Tapking, Jens, & Vong, Tana. 2011 (Jan.). The impact of the Eurosystem's covered bond purchase programme on the primary and secondary markets. Occasional Paper Series 122. European Central Bank.
- Black, Fischer. 1995. Interest rates as options. The Journal of Finance, 50(5), 1371–1376.
- Boeckx, Jef, Dossche, Maarten, & Peersman, Gert. 2017. Effectiveness and Transmission of the ECB's Balance Sheet Policies. *International Journal* of Central Banking, 13(1), 297–333.
- Burriel, Pablo, & Galesi, Alessandro. 2018. Uncovering the heterogeneous effects of ECB unconventional monetary policies across euro area countries. *European Economic Review*, **101**(C), 210–229.
- Corsetti, G., Duarte, J. B., & Mann, S. 2018 (Feb.). One Money, Many Markets - A Factor Model Approach to Monetary Policy in the Euro Area with High-Frequency Identification. Cambridge Working Papers in Economics 1816. Faculty of Economics, University of Cambridge.
- Damjanović, Milan, & Masten, Igor. 2016. Shadow short rate and monetary policy in the Euro area. *Empirica*, **43**(2), 279–298.
- Fry, Renée, & Pagan, Adrian. 2011. Sign Restrictions in Structural Vector Autoregressions: A Critical Review. Journal of Economic Literature, 49(4), 938–960.
- Gambacorta, Leonardo, Hofmann, Boris, & Peersman, Gert. 2014. The Effectiveness of Unconventional Monetary Policy at the Zero Lower Bound: A Cross-Country Analysis. *Journal of Money, Credit and Banking*, 46(4), 615–642.

- Georgiadis, Georgios. 2015. Examining asymmetries in the transmission of monetary policy in the euro area: Evidence from a mixed cross-section global VAR model. *European Economic Review*, **75**(C), 195–215.
- Gertler, Mark, & Karadi, Peter. 2015. Monetary Policy Surprises, Credit Costs, and Economic Activity. American Economic Journal: Macroeconomics, 7(1), 44–76.
- Haitsma, Reinder, Unalmis, Deren, & de Haan, Jakob. 2016. The impact of the ECB's conventional and unconventional monetary policies on stock markets. *Journal of Macroeconomics*, 48(C), 101–116.
- Hansen, Lars Peter, & Sargent, Thomas J. 1991. Two Difficulties in Interpreting Vector Autoregressions. *Pages 77–119 of:* Hansen, Lars Peter, & Sargent, Thomas J. (eds), *Rational Expectations Econometrics*. Boulder, CO.: Westview Press.
- Holló, Dániel, Kremer, Manfred, & Lo Duca, Marco. 2012 (Mar.). CISS a composite indicator of systemic stress in the financial system. Working Paper Series 1426. European Central Bank.
- Jarociński, Marek, & Karadi, Peter. 2018 (Feb.). Deconstructing monetary policy surprises: the role of information shocks. Working Paper Series 2133. European Central Bank.
- Kortela, Tomi. 2016 (June). A shadow rate model with time-varying lower bound of interest rates. Research Discussion Papers 19/2016. Bank of Finland.
- Krippner, Leo. 2015. Zero Lower Bound Term Structure Modeling: A Practitioner's Guide. Palgrave Macmillan.
- Leeper, Eric M., Walker, Todd B., & Yang, Shu-Chun Susan. 2013. Fiscal Foresight and Information Flows. *Econometrica*, 81(3), 1115–1145.
- Lemke, Wolfgang, & Vladu, Andreea Liliana. 2017 (Jan.). Below the zero lower bound: a shadow-rate term structure model for the euro area. Working Paper Series 1991. European Central Bank.
- Paustian, Matthias. 2007. Assessing sign restrictions. The BE Journal of Macroeconomics, 7(1).
- Uhlig, Harald. 2005. What are the effects of monetary policy on output? Results from an agnostic identification procedure. *Journal of Monetary Economics*, 52(2), 381–419.

- Wu, Jing Cynthia, & Xia, Fan Dora. 2016. Measuring the Macroeconomic Impact of Monetary Policy at the Zero Lower Bound. *Journal of Money*, *Credit and Banking*, 48(2-3), 253–291.
- Wu, Jing Cynthia, & Xia, Fan Dora. 2017. Time-varying lower bound of interest rates in Europe.