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DOES THE FED RESPOND TO OIL PRICE SHOCKS?*

Lutz Kilian and Logan T. Lewis

A common view in the literature is that systematic monetary policy responses to the inflation caused by oil price shocks have been an important source of aggregate fluctuations in the US economy. Earlier empirical evidence in support of such a link was based on inappropriate econometric models. We show that there is no credible evidence that monetary policy responses to oil price shocks caused large aggregate fluctuations in the 1970s and 1980s or more recently. Our analysis suggests that the traditional monetary policy reaction framework should be replaced by models that take account of the endogeneity of the real price of oil and that allow policy responses to depend on the underlying causes of oil price shocks.

Although it is common to attribute the recessions of the 1970s and early 1980s to oil price shocks, it has proved difficult to rationalise such large real effects based on standard macroeconomic models of the transmission of oil price shocks; see Kilian (2008) for a review. One channel that may help to amplify the effects of oil price shocks on real output is the endogenous policy response of the central bank to oil price shocks. Bernanke *et al.* (1997), henceforth referred to as BGW, stipulated that the Federal Reserve, when faced with potential or actual inflationary pressures triggered by a positive oil price shock, responds by raising the interest rate, thereby amplifying the decline in real output associated with positive oil price shocks.[1] In assessing the effect of this policy response, BGW postulated a counterfactual in which the Federal Reserve holds the interest rate constant. In other words, the Federal Reserve is not responding to any of the effects of the oil price shock on the economy. BGW concluded that the Fed's systematic and anticipated response to oil price shocks is the main cause of the recessions that tend to follow oil price shocks and that these recessions could have been avoided (at the cost of higher inflation) by holding the interest rate constant.[2]

BGW's results have not remained unchallenged. For example, Hamilton and Herrera (2004) showed that the estimates in BGW are sensitive to the choice of the vector autoregressive (VAR) lag order. Allowing for additional lags undermines the importance of the policy response. They also demonstrated that implementing a constant interest rate policy would have required policy changes so large to be unprecedented historically and hence not credible in light of the Lucas critique, a point acknowledged

* Corresponding author: Lutz Kilian, University of Michigan, Department of Economics, 611 Tappan Street, Ann Arbor, MI 48109-1220, USA. Email: lkilian@umich.edu.

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[1] BGW viewed the monetary policy response to oil price shocks merely as a convenient example in the context of the broader question of how important systematic monetary policy responses are relative to exogenous monetary policy shocks. This example, however, has subsequently received great attention in its own right and it is this aspect of the BGW study that we focus on in this article.

[2] In the words of BGW, 'an important part of the effect of oil price shocks on the economy results not from the change in oil prices, per se, but from the resulting tightening of monetary policy. This finding may help explain the apparently large effects found by Hamilton and many others' (p. 136). They conclude that their results 'provide substantial support for the view that the monetary policy response is the dominant source of the real effects of an oil price shock' (p. 124).

by Bernanke *et al.* (2004). This evidence has done little to diminish the appeal of BGW's results, however.

BGW's empirical results also have motivated a theoretical literature that examines the potential macroeconomic impact of monetary policy responses to oil price shocks using dynamic stochastic general equilibrium (DSGE) models. The conclusions reached in this literature very much depend on the specification of the DSGE model. Whereas Leduc and Sill (2004), for example, concluded that in their DSGE model monetary policy contributes about 40% to the drop in real output following a rise in the price of oil, Carlstrom and Fuerst (2006) found that under alternative assumptions the entire decline in real output following an oil price shock is due to oil and none attributable to monetary policy responses.[3] Thus, the key question remains of how plausible the original empirical estimates in BGW are. In this article, we re-examine the evidence presented in BGW within the context of the class of VAR models they employed. We build on recent insights as to the specification of these models, introduce additional data and exploit additional econometric tools that aid in the interpretation of the model estimates.

The article is organised as follows. In Section 1, we discuss the rationale of the narrative account presented in BGW. In Section 2, we motivate and summarise the innovations in our VAR model specification relative to BGW's original analysis. In Section 3, we analyse the responses to oil price shocks over the periods of 1967.5–1987.7 and 1987.8–2008.6. Our analysis of the VAR framework used in BGW implies that the Federal Reserve during the 1970s and early 1980s responded not to actual inflation triggered by oil price shocks but rather responded directly to the oil price shocks, consistent with a pre-emptive move to counteract potential inflationary pressures. In contrast, there is no evidence at all of a systematic policy response to oil price shocks since the late 1980s.

One interpretation of this evidence is that monetary policy responses to oil price shocks for the pre-1987 period are not well identified. There is no compelling evidence of the Federal Reserve tightening in response to the 1973/4 oil price shock; in fact, the Federal Reserve lowered the interest rate when oil prices increased sharply in late 1973. As BGW acknowledge, their empirical estimates rest mainly on evidence from 1979. This finding raises the question of whether Paul Volcker raised interest rates in 1979 in response to the oil price shock of that year or whether he would have raised interest rates in response to rising inflation even in the absence of the oil price shock, as suggested, for example, in Barsky and Kilian (2002). One way of discriminating between these hypotheses is to focus on the post-Volcker period. Clearly, Greenspan and Bernanke have been rightly credited for putting the inflation objective first in the tradition of Volcker's policies, and there have been enough oil price shocks between 1987 and 2008 to help us identify the Federal Reserve's systematic policy response to oil price shocks. Yet the type of model proposed by BGW shows no evidence at all of systematic monetary policy responses to oil price shocks after 1987, during the Greenspan–Bernanke era. This evidence is consistent with the view that the response estimates based on the 1979 data are spurious. An alternative explanation of the lack of evidence of a monetary policy response to oil price shocks after 1987 is that oil price

[3] For related work, see Harris *et al.* (2009), Blanchard and Galí (2010) and Rotemberg (2010), among others.

shocks have become less inflationary over time, allowing the policy maker to respond less aggressively to oil price shocks without causing a major recession. In Section 4, we show that this recent debate is largely irrelevant because even prior to 1987 monetary policy responses to oil price shocks did not have large cumulative effects on aggregate fluctuations, as measured by historical decompositions. That conclusion is independent of the choice of counterfactual.

This finding makes sense in light of evidence that the Federal Reserve's policy response has been much more sophisticated than BGW's model gives it credit for. In Section 5, we present evidence that the Federal Reserve on average has been responding differently to oil price shocks driven by global demand pressures than to those driven by oil supply disruptions, for example. Our analysis suggests that DSGE models of monetary policy responses in particular must account for a variety of structural shocks in the crude oil market, each of which may necessitate a different policy response. For example, the policy response to dealing with oil price shocks reflecting shifts in the global demand for oil driven by unexpected growth in emerging Asia should look different from the response to dealing with oil price shocks triggered by oil supply disruptions in the Middle East. These results suggest that the traditional framework of monetary policy reactions to oil price shocks explored by BGW and incorporated into subsequent DSGE models should be replaced by models that take account of the endogeneity of the real price of oil and allow policy responses to depend on the underlying causes of oil price shocks. A recent example of such a model is Nakov and Pescatori (2010) who use a stylised DSGE model to establish formally that it is suboptimal from a welfare point of view for a central bank to respond to oil price shocks rather than to the underlying causes of these price shocks. We conclude in Section 6 with a discussion of the relevance of our results for today's policy makers.

1. The Rationale for a Monetary Tightening in Response to Oil Price Shocks

Although few researchers have questioned the narrative in BGW, the rationale for the policy response that BGW stipulated is not self-evident. There are three problems. First, it is widely accepted that the Federal Reserve in the 1970s was as much concerned with maintaining output and employment as it was concerned with containing inflation. In fact, it has been argued that the Federal Reserve was overly concerned with the output objective during this period (Barsky and Kilian, 2002). To the extent that oil price shocks are recessionary, in the absence of a policy response one would have expected the Federal Reserve to ease rather than tighten monetary policy in response. Even if one were to grant that oil price shocks also have inflationary effects, it would not be obvious that the appropriate policy response on balance would be to raise the interest rate. In fact, BGW's notion of a policy maker responding aggressively to inflationary pressures seems more consistent with the Volcker era than with US monetary policy in the 1970s.

Second, while a robust theoretical finding is that oil price shocks are at least mildly recessionary in the absence of a monetary policy response, it is not clear that oil price shocks are necessarily inflationary. For simplicity suppose that a one-time oil price shock occurs, while everything else is held constant. There are two main channels of transmission. One is the increased cost of producing domestic output (which is akin to an adverse aggregate supply shock); the other is the reduced purchasing power of domestic households (which is akin to an adverse aggregate demand shock). The latter channel of transmission may be amplified by increased precautionary savings and by the increased operating cost of energy-using durables (Edelstein and Kilian, 2009). Recent empirical evidence suggests that the supply channel of transmission is weak and that the demand channel of transmission dominates in practice; see Kilian (2008) for a review. On that basis, one would expect an exogenous oil price shock, if it occurs in isolation, to be recessionary and deflationary, suggesting that there is no reason for monetary policy makers to raise the interest rate at all. In fact, one could make the case that policy makers should lower the interest rate to cushion the recessionary impact. Moreover, if both the aggregate demand and the aggregate supply curves shift to the left, as seems plausible, the net effect on the domestic price level is likely to be small, so there is little need for central bankers to intervene under the price stability mandate. Thus, unless a good case can be made for the risk of a wage–price spiral, oil price shocks would not be expected to cause sustained inflation. This analysis shows that BGW implicitly take the rather extreme view that oil price shocks necessarily represent adverse aggregate supply shocks that are both recessionary – if only mildly so because otherwise there would be no need for an amplifier – and inflationary.

The third problem is BGW's premise that all oil price shocks are the same. The recent literature has established that oil price shocks do not take place in isolation, casting doubt on the premise that monetary policy makers respond directly and mechanically to innovations in the price of oil. For example, Kilian (2008) stresses that policy makers should respond not to innovations in the price of oil (which are merely a symptom rather than a cause) but directly to the underlying demand and supply shocks that drive the real price of oil along with other macroeconomic variables. More specifically, Nakov and Pescatori (2010) demonstrate that a welfare-maximising central banker should not respond to innovations in the price of oil in models of endogenous oil price shocks.

2. Innovations in the Model Specification Relative to BGW's Analysis

This does not imply, of course, that policy makers may not have chosen to respond to oil price shocks as stipulated in BGW, but, in light of the caveats discussed in Section 1, the empirical success of BGW's model is by no means a foregone conclusion. Next, we re-examine their conclusions bringing to bear additional data as well as additional econometric tools. We do so within the context of the class of models BGW postulated. In addition to examining a much longer sample period and conducting subsample analysis, we modify the VAR model used by BGW as follows:

First, the impulse response analysis in BGW is mainly based on the nominal net oil price increase measure of Hamilton (1996, 2003). Kilian and Vigfusson (2009) have shown that censored VAR models of the type estimated by BGW produce inconsistent estimates and have a tendency to exaggerate the responses to oil price shocks.[4]

[4] This tendency applies to the BGW model as well. For example, replacing the percentage change in the real price of oil in our baseline model below by the three-year net real oil price increase roughly doubles the magnitude of the response of real output and implies much larger, if still modest, cumulative effects of oil price innovations on the evolution of US real output because fluctuations in the real price of oil are dominated by fluctuations in the nominal price.

Moreover, the hypothesis of symmetric response functions in oil price increases and decreases cannot be rejected even for large oil price innovations, suggesting that standard linear VAR models are adequate for modelling the responses to oil price shocks. For that reason we follow an alternative strand of the literature and replace the net nominal oil price increase measure by the per cent change in the real price of oil (Rotemberg and Woodford, 1996; Herrera and Pesavento, 2009; Kilian, 2009). This approach is consistent with the specification of standard economic models of the transmission of oil price shocks.[5]

Second, BGW relied on an interpolated measure of real gross domestic product (GDP). The dangers of interpolating economic data are well known (Angelini *et al.*, 2006). Since BGW's original analysis, much progress has been made in constructing coincident indicators of monthly real activity. In our analysis, we use a version of the Chicago Fed's National Activity Index (CFNAI), which is based on the leading principal component of a wide range of monthly indicators of US real activity.[6] The effectiveness of the use of principal components and related data dimension reduction methods in the context of VAR models of monetary policy has been demonstrated by Bernanke *et al.* (2005) and Bańbura *et al.* (2008), among others. The CFNAI index produces temporary declines in real activity in response to an unanticipated monetary tightening that persist for less than two years, whereas the interpolated real GDP series of BGW implies much more persistent and hence less plausible effects on real output. In addition, our approach is consistent with the view that central bankers consider a wide range of indicators of real activity in making policy decisions rather than real GDP only (Evans, 1999). Figure 1 shows that the CFNAI business cycle fluctuations differ from those in the quarterly real GDP series in amplitude and timing, although there are many commonalities as well. The NBER recessions are shown as shaded areas. Figure 1 illustrates why the CFNAI is a credible measure of the business cycle.[7]

Third, rather than expressing all variables in the VAR model in levels we log difference the consumer price index (CPI), consistent with the common view that the price level is I(1). This transformation facilitates the construction of historical decompositions for the inflation rate. The CFNAI real output variable is already stationary by construction and does not require differencing or filtering. In addition, we also difference the real price of oil and the real price of imported commodities in the baseline specification. This transformation has little effect on the qualitative pattern of the impulse responses. An alternative specification with the real price of oil in levels

[5] There are good economic reasons for specifying the VAR model in the real price of oil but we note that very similar empirical results would be obtained if in the VAR model we replaced the percentage change in the real price of oil by the percentage change in the nominal price of oil.

[6] The CFNAI is methodologically identical to the index of real economic activity developed in Stock and Watson (1999). It is based on five categories of data: output and income (21 series); employment, unemployment and hours (24 series); personal consumption, housing starts and sales (13 series); manufacturing and trade sales (11 series); and inventories and orders (16 series). All nominal series are adjusted for inflation. We employ the three-month average version of the index, as is standard. Very similar if somewhat noisier results are obtained with the unsmoothed series.

[7] Another possible choice for the monthly measure of US real output would have been US industrial production. An obvious advantage of the monthly CFNAI is that it captures a wide range of information the Federal Reserve uses in assessing the business cycle, only one item of which is industrial production. This distinction has become more important over time, as the share of industrial production in US real output has been declining, while the share of the service sector has increased.

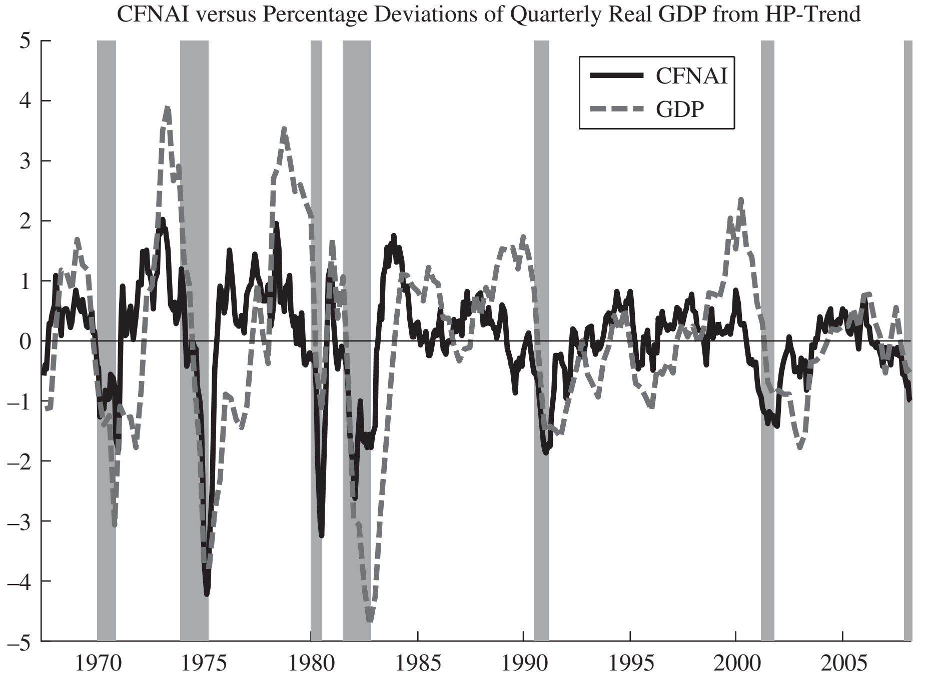

Fig. 1. *Alternative Measures of the US Business Cycle*
Notes. Three-month moving average of the Chicago Fed National Activity Index and Hodrick–Prescott-filtered log real US gross domestic product in percentage deviation from trend. NBER recessions are shown as shaded areas.

and the linearly detrended real price of commodities produced similar results; so did a specification allowing for a trending cointegration relationship between the real price of oil and the real price of commodities, reflecting the secular decline in real non-oil commodity prices.[8] We also experimented with dropping the real commodity price index from the baseline model. Again, the qualitative results were robust to this sensitivity analysis.

Finally, we reduced the model to its essentials by dropping the term structure variables ordered below the interest rate in BGW's original models. Those additional variables are not required for our analysis and may be dropped without loss of generality. A similar approach was followed by Leduc and Sill (2004) and Herrera and Pesavento (2009), for example.

Rather than show how each of these changes in the analysis alters the results of BGW one at a time, our strategy is to show that the modified model proposed in this article produces more credible estimates of the responses to monetary policy shocks as well as more credible counterfactuals than the BGW model. A direct comparison of our results with BGW's is not possible, given BGW's use of a censored oil price variable in constructing VAR impulse responses. Not only are these impulse response estimates

[8] Standard tests do not reject the null of no cointegration between the real price of oil and the real price of commodities at conventional significance levels, even allowing for separate trends.

inconsistent, as demonstrated by Kilian and Vigfusson (2009), making that comparison rather academic, but the nature of an innovation in the net oil price increase is inherently different from that of an innovation in the per cent change in the price of oil, making it impossible to compare the magnitudes of the implied response functions. Nor does the log-level specification of BGW allow estimation of the cumulative effect of each shock on US inflation and real activity, which is central to our analysis.

3. The Benchmark VAR Model

Our data are monthly and span 1967.5–2008.6. We deliberately exclude the episode of the recent financial crisis from consideration, as standard monetary policy reaction functions would not be expected to apply to that period. Our baseline model focuses on the sample period of 1967.5–1987.7. Although one might be concerned about the inclusion of data prior to 1973, given the institutional changes in global oil markets after 1972, the results are not overly sensitive to the starting date. The starting date of 1967.5 is dictated by the availability of the CFNAI data. It is almost identical to the starting date of 1965.1 in BGW. The ending date of 1987.7 is more natural in our view than the ending date of 1995.12 in BGW, given the transition from Volcker to Greenspan in 1987. This shorter sample period also takes account of Hamilton and Herrera's (2004, p. 267) observation that the 1990/91 oil price shock episode may not fit the narrative in BGW. We verified that our substantive results are not sensitive to shortening the sample in this manner. Using additional data not available to BGW at the time, we provide a separate analysis of the post-1987.7 period in Section 3.4.

The baseline VAR model includes five variables: the percentage change in the real price of imported commodities, the percentage change in the real price of imported crude oil, the CFNAI measure of US real activity, the US CPI inflation rate and the federal funds rate (FFR; in this order). The commodity price index is the spot index provided by the Commodity Research Board (CRB) and excludes the price of crude oil. We follow Mork (1989) in using the US composite refiner's acquisition cost of crude oil. The refiner's acquisition cost is provided by the Energy Information Administration as far back as 1974.1. This price series is extrapolated backwards at the rate of growth of the US producer price for oil and deflated by the US CPI.[9]

The VAR model includes 12 lags and an intercept.[10] The model allows identification of the monetary policy shock as well as the oil price shock based on a recursive ordering. The identification of the oil price shock exploits the conventional assumption that oil prices are predetermined with respect to domestic macroeconomic

[9] The producer price index is the PW561 series of Hamilton (2003). Mork (1989, p. 741) observes that 'during the price controls of the 1970s, this index is misleading because it reflects only the controlled prices of domestically produced oil. However, as the price control system closely resembled a combined tax/subsidy scheme for domestic and imported crude oil, the marginal cost of crude to US refiners can be approximated by the composite (for domestic and imported) refiner acquisition cost (RAC) for crude oil'.

[10] Hamilton and Herrera (2004) discuss the importance of choosing a lag order that is large enough to capture the effects of oil price shocks. They suggest that choosing a lag order below 12 is likely to undermine the reliability of the impulse response estimates, whereas there is no indication that more than 12 lags are needed in typical monthly VAR models of the transmission of oil price shocks. Our main results are robust to using 18 lags instead.

aggregates (Kilian and Vega, forthcoming). The real price of commodities is included following BGW because it is widely viewed as an indicator of inflationary pressures to which the Federal Reserve responds (see also Barsky and Kilian, 2002, 2004). We order the real price of imported non-oil commodities first in an effort to control for global demand pressures in isolating exogenous oil price shocks. The results are not sensitive to that assumption, however. The monetary policy shock is identified as in BGW as the residual of the FFR after accounting for the contemporaneous feedback from all variables ordered above the FFR. This approach is standard in the literature (Christiano *et al.*, 1999). The remaining structural shocks in the VAR model are not identified.

3.1. *Responses to an Exogenous Monetary Policy Shock*

A useful starting point for the analysis is a review of the responses to an exogenous monetary policy shock in the modified VAR model. We consider an exogenous increase of 10 basis points in the FFR. Figure 2 shows response patterns fully consistent with similar VAR models in the literature (Christiano *et al.*, 1999). A monetary tightening induces a temporary increase in the FFR and a temporary decline in real output. Real commodity prices and the real price of oil fall. There is evidence of the usual price puzzle. Over time, CPI inflation declines significantly but the effect on the price level is not significant.

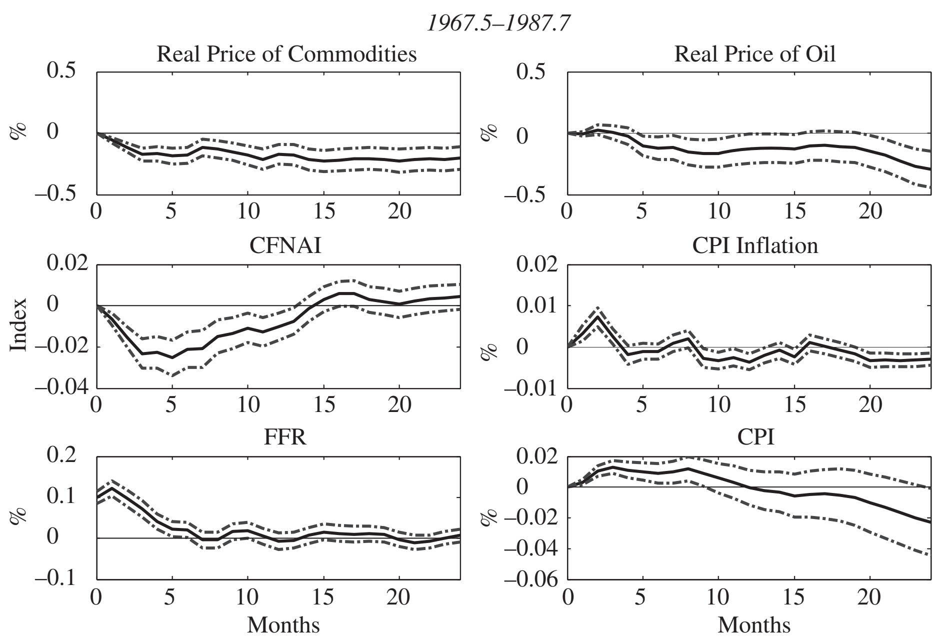

Fig. 2. *Responses to a 10 Basis Points Exogenous Increase in the Federal Funds Rate* (with one-standard error bands)

Notes. The error bands were constructed using the recursive-design wild bootstrap method of Gonçalves and Kilian (2004).

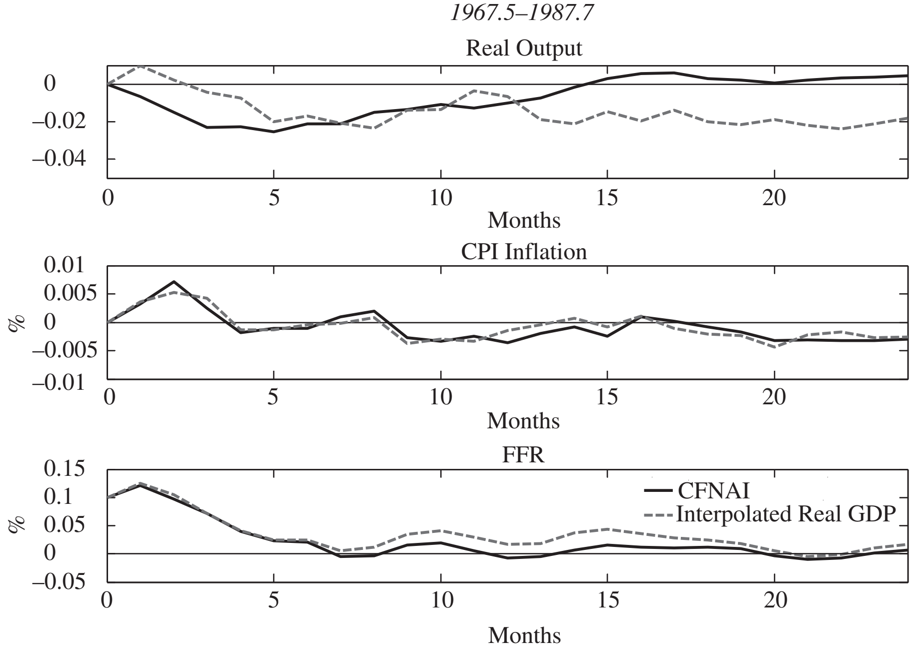

Fig. 3. *Responses to a* 10 *Basis Points Exogenous Increase in the Federal Funds Rate*

Figure 3 illustrates that the implications of our modified VAR model using the CFNAI measure of real output are more economically plausible than those from the same model using interpolated real GDP as in BGW. In particular, the latter model implies an implausibly persistent decline in real output in response to a monetary policy tightening. The real output measure based on interpolated and Hodrick–Prescott-filtered real GDP as in BGW's analysis returns to its steady state only after four years, compared with one-and-a-half years if real output is measured based on the CFNAI. The inflation and interest rate dynamics are very similar. We conclude that our modified model provides a credible baseline for further analysis.

3.2. *Systematic Policy Responses to an Oil Price Shock during 1967–87*

The main question of interest is how the Federal Reserve responds endogenously to an oil price shock. We consider a 10% increase to the real price of oil not related to other innovations in global commodity prices. Our initial analysis focuses on 1967.5–1987.7. The results in the left column of Figure 4 are seemingly very much in line with the narrative in BGW. The oil price shock is associated with a persistent increase in the real price of oil. Within two months, CPI inflation sharply spikes. Following the spike in inflation, the FFR rises temporarily, followed by a temporary drop in real output and a gradual reduction in inflation. The decline in the CFNAI reaches −0.5 after one year. Most past recessions have been associated with a value of −0.7 or lower. Compared with the original BGW results, the interest rate response is somewhat smaller. It only involves a cumulative increase within the first year of 60 basis points rather than 80 basis points.

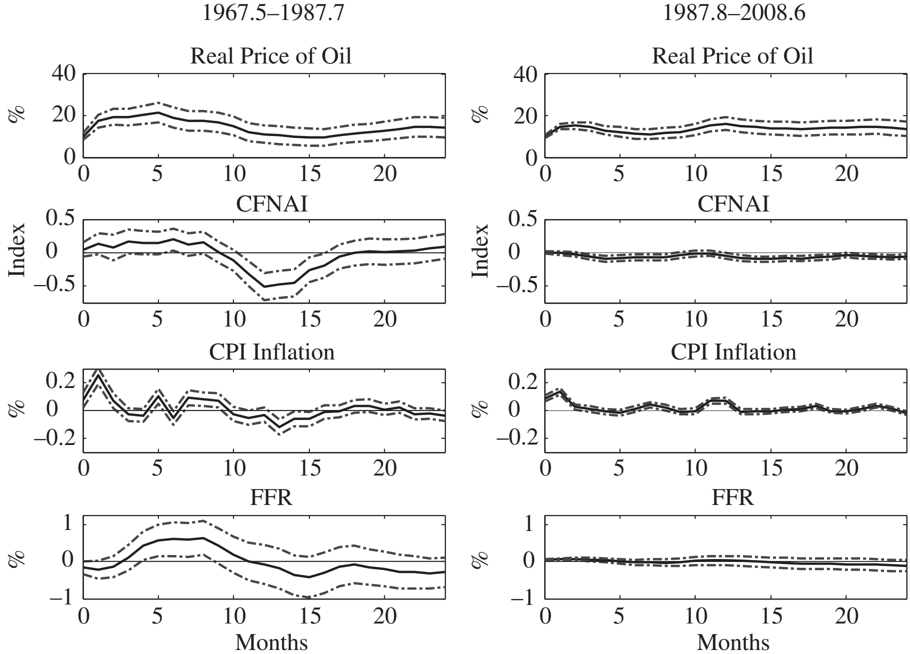

Fig. 4. *Responses to a 10% Real Oil Price Shock* (with one-standard error bands)
Notes. Estimates based on a recursively identified VAR(12) model for the percentage change in real Commodity Research Board commodity prices, the percentage change in the real price of oil, Chicago Fed National Activity Index (CFNAI), consumer price index inflation and the federal funds rate. A CFNAI value below −0.7 is commonly associated with the onset of a recession.

The magnitude of our estimate is consistent with Hamilton and Herrera's (2004, p. 282) preferred response estimate.

3.2.1. *What was the Federal Reserve responding to?*

It is useful to examine in more detail what variables the Federal Reserve is responding to in the VAR model of Section 3.1 by means of a decomposition of the policy response to the dynamics triggered by an oil price shock. The intuition underlying this procedure is straightforward. In any given period following an exogenous oil price shock, the deviation of the response of the FFR from the baseline of zero can be written as the sum of the response to its own lagged values and of the responses to lagged values of other variables in the system. This allows us to analyse which variables are driving the policy response.

Consider the structural VAR(p) representation

$$\boldsymbol{A}_0\boldsymbol{y}_t = \boldsymbol{A}_1\boldsymbol{y}_{t-1} + \cdots + \boldsymbol{A}_p\boldsymbol{y}_{t-p} + \boldsymbol{\varepsilon}_t,$$

where $\boldsymbol{y}_t$ is the K-dimensional vector of variables, $\boldsymbol{\varepsilon}_t$ denotes the vector of structural innovations, the $K \times K$ matrix $\boldsymbol{A}_0$ is lower triangular and the intercept has been suppressed for notational convenience. Express this VAR system as:

$$y_t = Cy_t + A_1 y_{t-1} + \cdots + A_p y_{t-p} + \varepsilon_t$$

where C is a $K \times K$ dimensional lower triangular matrix with zeroes on the diagonal. Define

$$B \equiv \begin{bmatrix} C & A_1 & \ldots & A_p \end{bmatrix}.$$

The contribution of variable i to the response of the FFR at horizon h to an oil price shock at date 0 is given by:

$$d_{\text{FFR,i,h}} = \sum_{m=0}^{\min(p,h)} B_{5,mK+i}\theta_{i,2,h-m} \quad h = 0, 1, 2, \ldots ; i = 1, \ldots, K,$$

where $\theta_{i,2,h-m}$ refers to the $\{i, 2\}$ element of the $K \times K$ impulse response coefficient matrix at horizon $h - m$, denoted by Θ_{h-m}, as defined by Lütkepohl (2005).

The left column of Figure 5 shows the decomposition of the response of the FFR along these lines. To improve the readability of the graph, results are shown in two separate plots. On impact, the response of the FFR is explained entirely by the Federal Reserve's direct reaction to the oil price shock; there is essentially no contemporaneous response to inflation, real output or commodity prices. For the first three months, the Federal Reserve responds to the oil price shock by lowering interest rates, which is inconsistent with the narrative of BGW. For the next three months, the Federal Reserve responds directly to oil price shocks by raising the interest rate. There is little evidence of the Federal Reserve's policy response working through inflation. That response is negligible for the first three months and small thereafter. Moreover, the sign of the response to inflation varies across the horizon. Likewise, there is very little reaction to

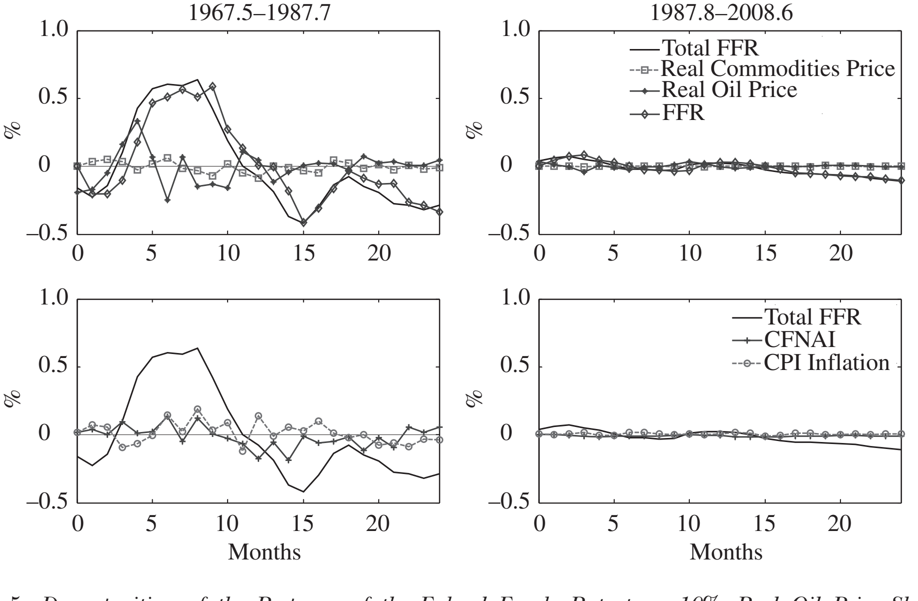

Fig. 5. *Decomposition of the Response of the Federal Funds Rate to a 10% Real Oil Price Shock*
Notes. The decomposition underlying this Figure is described in Section 3.2.1.

the real output dynamics triggered by oil price shocks. Thus, to a first approximation, almost all of the responses of the FFR after the impact period are accounted for by the own lags of the FFR.

This analysis is useful in that it shows that the Federal Reserve during the 1970s and early 1980s responded not to actual inflation triggered by oil price shocks but rather responded directly to the oil price shocks, consistent with a preemptive move against potential inflationary pressures. For example, the Federal Reserve might have been responding to oil price shocks because they were seen as potential causes of wage-price spirals. This interpretation seems conceivable in an unstable monetary environment. To the extent that this policy response is successful in preempting the risk of inflation, one would never actually observe wage-price spirals or a large response of inflation to the real price of oil in the data.

3.2.2. *Counterfactual analysis*

The decomposition used in Section 3.2.1 also is helpful in the construction of explicit counterfactuals. The key contribution of BGW is the inclusion of the price of oil in the monetary policy reaction function. How much of a difference does it make that the Federal Reserve is allowed to respond directly to oil price shocks? The relevant counterfactual in answering this question is not one in which the Federal Reserve holds the interest constant in response to an oil price shock, as postulated by BGW, but a counterfactual in which the Federal Reserve reacts to fluctuations in other macroeconomic state variables (such as inflation and real output) as it normally would with only the direct response to the real price of oil being shut down. Next, we contrast the construction and implications of these two counterfactuals.

Under the counterfactual of only shutting down the direct response to the real price of oil, we construct a sequence of hypothetical shocks to the FFR that offsets the contemporaneous and lagged effects of including the real price of oil in the policy reaction function. This sequence of shocks is:

$$\varepsilon_{\mathrm{FFR,h}} = -B_{5,2}x_{2,h} - \sum_{m=1}^{\min(p,h)} B_{5,mK+2}z_{2,h-m}, \quad h = 0, 1, 2, \ldots$$

where $x_{i,0},\ i = 1, \ldots, K$, denotes the contemporaneous response of variable i to the oil price shock in the absence of a counterfactual policy intervention. The change in variable i in response to the oil price shock after the counterfactual policy response is denoted by:

$$z_{i,0} = x_{i,0} + \frac{\theta_{i,5,0}\varepsilon_{\mathrm{FFR},0}}{\sigma_5},$$

where σ_5 denotes the standard deviation of the exogenous monetary policy shock. The corresponding values for $h > 0$ can be generated recursively, starting with $i = 1$, from:

$$x_{i,h} = \sum_{m=1}^{\min(p,h)} \sum_{j=1}^{K} B_{i,mK+j}z_{i,h-m} + \sum_{j<i} B_{i,j}x_{j,h}$$

and

$$z_{i,h} = x_{i,h} + \frac{\theta_{i,5,0}\varepsilon_{\text{FFR},h}}{\sigma_5},$$

where $j = 1, \ldots, K$.

In contrast, for the original BGW counterfactual, which BGW refer to as the Sims–Zha counterfactual based on a proposal in Sims and Zha (2006), one simply constructs a hypothetical path of the shock $\varepsilon_{\text{FFR},t}$ that offsets all endogenous dynamics in the FFR such that the FFR remains unchanged over time. In our notation, this can be expressed as:

$$\varepsilon_{\text{FFR,h}} = -\sum_{j=1}^{K} B_{5,j}x_{j,5} - \sum_{m=1}^{\min(p,h)} \sum_{j=1}^{K} B_{5,mK+j}z_{j,h-m}, \quad h = 0, 1, 2, \ldots,$$

building on the same recursion as in the construction of the alternative counterfactual described before. For an alternative description of the BGW counterfactual, see Hamilton and Herrera (2004).

Figure 6 compares these counterfactuals with the unconstrained responses in the VAR model. Shutting down the direct response to oil price shocks has virtually no effect on inflation and little effect on real output. The Federal Reserve still would have raised interest rates by a roughly similar number of basis points in response to an exogenous positive oil price shock, but the bulk of that response would have occurred three

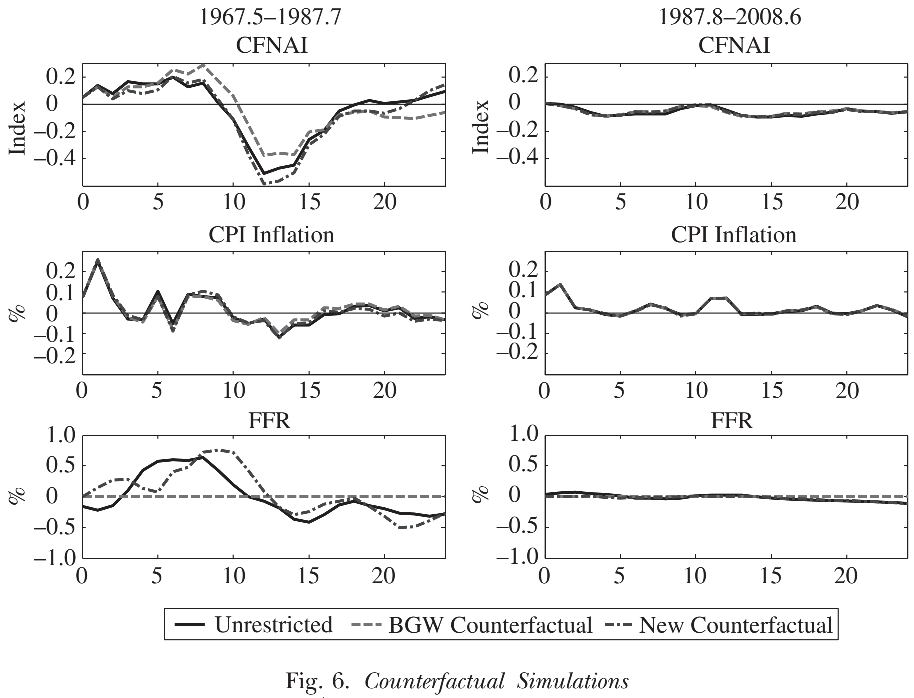

Fig. 6. *Counterfactual Simulations*

Notes. BGW (Bernanke *et al.*, 1997) counterfactual refers to the counterfactual of holding the interest rate constant; new counterfactual refers to the counterfactual of shutting down the direct monetary policy response to oil price shocks in the policy reaction function.

months later. This evidence casts serious doubt on the narrative in BGW. For completeness, we also include the original counterfactual computed as in BGW in Figure 6. In that case, the FFR remains constant by construction. This policy would have had essentially no effect on inflation and real output would have been only slightly higher, if at all.

An interesting question is what policy surprises each counterfactual would have involved compared with actual policy choices. Figure 7 shows that under the new counterfactual interest rates would have unexpectedly risen by about 17 basis points on impact, would have fallen by about 33 basis points in month 4 after the oil price shock and would have risen again by about 25 basis points in month 6, relative to actual policy choices. This sequence of policy surprises is somewhat different from that under the BGW counterfactual. One way of assessing how reasonable the implied departures from actual policy outcomes would have been is to focus on the magnitude of actual policy changes in the past; given that we are interested in unanticipated policy changes, however, a better approach is to compare these implied changes to historical policy shocks in the fitted VAR model. The largest policy surprises in the structural VAR model are 446 and −662 basis points and occurred in 1980. About 30% of all policy shocks in the sample period exceed 30 basis points and a further 32% are below −30 basis points. By that standard, the policy changes of up to −33 basis points and up to +25 basis points required to implement the counterfactuals in the left panel of Figure 7 do not seem unreasonable.

A closely related concern is that constructing any counterfactual is subject to the Lucas critique (Bernanke *et al.*, 2004; Hamilton and Herrera, 2004; Sims and Zha,

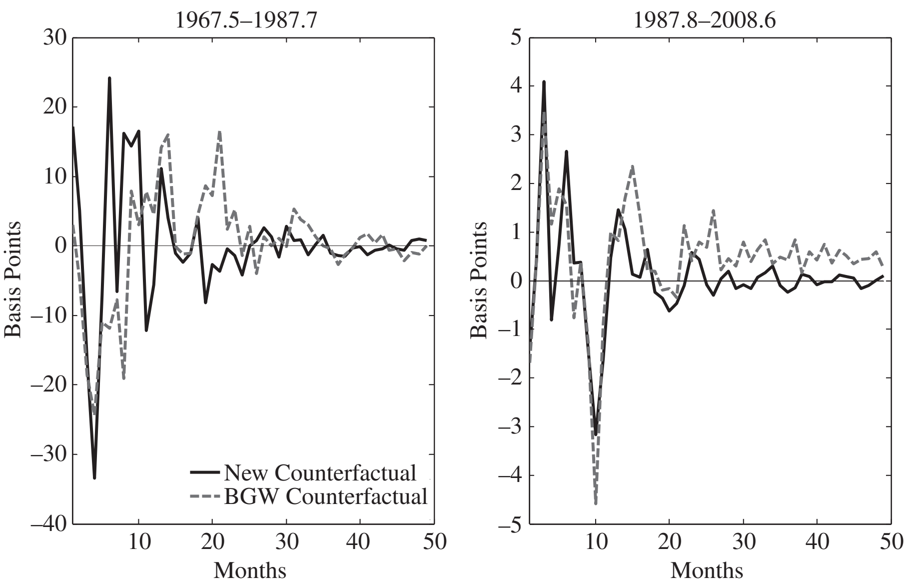

Fig. 7. *Policy Shocks Required for the Implementation of the Counterfactual*
Notes. BGW (Bernanke *et al.*, 1997) counterfactual refers to the counterfactual of holding the interest rate constant; new counterfactual refers to the counterfactual of shutting down the direct monetary policy response to oil price shocks in the policy reaction function.

2006). Rather than provide a comprehensive analysis of this issue, we follow Hamilton and Herrera (2004) in analysing BGW's approach on its own terms. We follow the common assumption in this literature of assuming that the policy changes contemplated are small enough not to affect the structure of the economy materially. This assumption is more credible in our context than in the original analysis in BGW because the counterfactuals in the left panel of Figure 7 do not involve a surprise change in interest rates relative to actual policy outcomes in the same direction 'for 36 months in succession' (Hamilton and Herrera, 2004, p. 269). The obvious concern raised by Hamilton and Herrera is that the sequence of policy shocks required to implement the counterfactual may be predictable. This is not a problem in the left panel of Figure 7. It can be shown that not only is the sequence of policy shocks in Figure 7 required under the new counterfactual less predictable than the sequence under the BGW counterfactual but that evaluating the first six autocorrelations of our policy shocks under the null of i.i.d. shocks provides no evidence of statistically significant predictability. Moreover, the time path of the FFR shocks in the left panel of Figure 7 does not look noticeably different from plots of actual policy surprises for a period of similar length in the estimated model. Hence, it is not evidently unreasonable to presume that the model structure is stable with respect to these policy interventions.

3.3. *Does the Narrative Account in BGW Match Actual Policy Decisions?*

Although our estimates for 1967–87 – unlike the original estimates in BGW – pass simple plausibility checks, as shown in the preceding Section, there are other reasons to be sceptical of BGW's interpretation of the evidence. It is instructive to focus on the relationship of the narrative account in BGW with the actual evolution of the FFR during the two oil price episodes of the 1970s. Although the Federal Reserve was not following an interest rate rule at the time, we follow the literature in postulating that the FFR effectively was controlled by the Federal Reserve.[11] The left panel of Figure 8 covers the first oil price shock episode of late 1973 and early 1974. A striking feature of these data is that the Federal Reserve had been raising interest rates steadily from early 1972 until mid-1973. This finding is consistent with evidence from Federal Reserve policy statements. The Federal Reserve by its own account was responding to rising commodity prices when it continuously raised interest rates long before the oil price shock of late 1973. The observed rapid increases in global industrial commodity prices in 1972/3 were an indication of an overheating global economy, consistent with the analysis by Barsky and Kilian (2002). In contrast, when the oil price shocks did occur in late 1973, the Federal Reserve lowered interest rates for the first time in more than a year, consistent with the interpretation of oil price shocks as adverse aggregate demand shocks. The decline in interest rates continued into 1974, even after oil prices doubled again in January. Only in March of 1974, interest rates began to rise again, reaching a peak in July, before gradually receding to about 6 percentage points by early 1975.

This response is clearly different from the narrative account in BGW of a generic oil price shock episode and BGW readily conceded that the 1974–75 decline in real output

[11] For related accounts of US monetary policy in the 1970s, see Barsky and Kilian (2002) and Kozicki and Tinsley (2009).

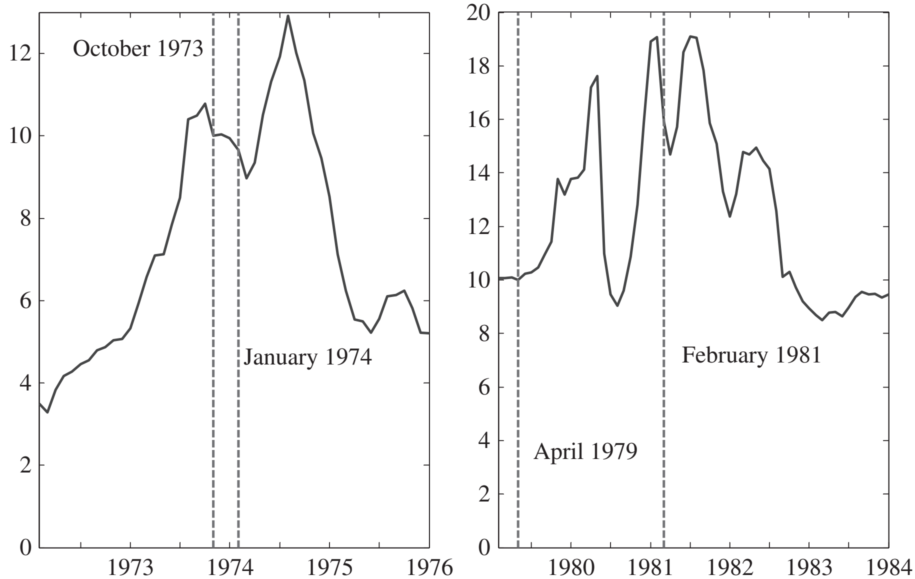

Fig. 8. *The Evolution of the Federal Funds Rate during the Oil Price Shocks of the* 1970s *and early* 1980s

Notes. In October of 1973 and January of 1974 the price of oil doubled. April 1979 marks the beginning of the 1979 oil price surge; in February of 1981 the price of imported crude oil peaks.

is generally not well explained by the oil price shock. 'The ... major culprit was (non-oil) commodity prices. Commodity prices ... rose very sharply before this recession and stimulated a sharp monetary policy response of their own' (p. 121).

Thus, BGW's evidence in favour of a monetary policy response to oil price shocks rests squarely on the 1979 episode covered in the right panel of Figure 8. Given that both the FFR and the real price of oil began to increase in May of 1979, it is not surprising that data from this episode tend to dominate estimates of the contemporaneous correlation of oil price shocks and interest rate changes.[12] This fact is troublesome because we do not know whether Paul Volcker raised interest rates in response to the oil price shock of 1979 or in response to rising inflation driven by domestic policies. Given that both interest rates and oil prices moved at about the same time, it is difficult to separate correlation from causation. In short, there is reason to suspect an identification problem. This explanation also would help account for the fact that the interest rate response to oil price shocks does not work through the higher inflation or lower output triggered by unexpected oil price increases, but rather occurs in direct response to the real oil price increase, as we documented earlier (see left panel of Figure 5). This is precisely the type of pattern we would expect if the VAR model incorrectly interpreted an exogenous increase in interest rates under Chairman Volcker as an endogenous response to the oil price shocks of 1979.

[12] BGW (p. 133) are aware of this point. They acknowledge the instability of their VAR results across subsamples, but attribute the stronger response of the Federal Reserve to oil price shocks during 1976–85 to the Federal Reserve's substantially increased concern with inflation during the Volcker era.

3.4. *Systematic Policy Responses to an Oil Price Shock during* 1987–2008

The discussion in Section 3.3 suggests that the monetary policy response to oil price shocks is not well identified. Much depends on whether we interpret the rise in interest rates in 1979 under Paul Volcker as a response to the oil price shocks of that year or as a shift in the policy regime away from the employment objective that would have taken place even in the absence of the oil price shocks of 1979. One way of discriminating between these hypotheses is to focus on the pre-Volcker period 1967.5–1979.7. Estimates for this period (which are not shown to conserve space) indicate that in response to an oil price shock the FFR initially declines below its mean, then rises substantially above its mean (with a peak after seven months), and finally drops substantially below its mean (with a trough after 17 months), before returning to its mean. This pattern roughly matches the evolution of the FFR after late 1973 in the left panel of Figure 8. The estimated responses of the FFR are statistically significant based on one-standard error bands. Clearly, this response pattern differs from the narrative in BGW who did not envision that the Federal Reserve would lower the interest rate in response to an oil price shock in the short run or, for that matter, in the second year following the oil price shock. These estimates are not dispositive, however, because there is reason to doubt that the Federal Reserve prior to Paul Volcker was committed to the price stability objective.

We also estimated the same model for the Volcker period of 1979.8–1987.7 for comparison (with pre-sample observations from the pre-Volcker period). Interestingly, the estimated responses provide no support for the notion that Volcker raised interest rates in response to oil price shocks and thereby caused a recession, although we hasten to add that this sample is likely to be too small to allow meaningful inference. A better way of assessing whether there is an identification problem in 1979 is to focus on the post-Volcker period. Clearly, Greenspan and Bernanke have been rightly credited for putting the inflation objective first in the tradition of Volcker's policies, and there have been enough oil price shocks between 1987 and 2008 to help us identify the Federal Reserve's systematic policy response to oil price shocks.

The right column of Figure 4 shows that there is no evidence at all of systematic monetary policy responses to oil price shocks after 1987, during the Greenspan–Bernanke era. Although the response of the real price of oil to an oil price shock is quite similar to that in the first subsample, there is almost no increase in the FFR or in real output and the path of inflation shows no evidence of significant price pass-through even in the absence of a policy reaction. Only on impact and 12 months later are there small spikes in inflation. The right column in Figure 5 decomposes the rather small response of the FFR further. The positive impact response reflects a direct response to the oil price shock; subsequent FFR movements are merely responses to own lags. Finally, the right column in Figure 6 illustrates that the counterfactual departures from the actual policy outcomes would have made essentially no difference for the inflation and real output responses. In light of that finding, the implication of Figure 7 (right column) that the original BGW counterfactual (unlike the alternative counterfactual proposed in this article) would have involved positive policy surprises for at least three years in a row is a moot point. On the basis of these results, there is clearly no reason to include the real price of oil in the policy reaction function of the VAR model after 1987.

4. Historical Decompositions

An alternative explanation of the lack of evidence of a monetary policy response after 1987 is that oil price shocks have become less inflationary over time, allowing the policy maker to respond less aggressively to oil price shocks without causing a major recession.[13] The implicit premise in this literature is that monetary policy responses to oil price shocks had large cumulative effects on real activity prior to 1987, making it important to explain the absence of large cumulative effects after 1987. Large responses to a one-time oil price shock, however, need not translate into large cumulative effects of oil price shocks on macroeconomic aggregates in actual data because the actual data involve a vector sequence of oil price innovations of different magnitudes and signs. Thus, in assessing the historical evidence, we need to move beyond impulse response analysis and construct historical decompositions of the data. Figure 9 shows that, notwithstanding the impulse response results in Figure 4, the cumulative contribution of oil price shocks through time on US real output is negligible. Figure 9 plots the actual (demeaned) real output and inflation data and the fluctuations in the same variable explained by the direct effect of oil price shocks and the endogenous policy response combined. It is evident that oil price shocks overall had little impact on observed US real activity and inflation even in the first subsample. Likewise, we see that oil price shocks had little effect on the FFR not only in 1973/4, but more importantly under Volcker in 1979/80.

Because the indirect effect on US real activity associated with the monetary policy response and the direct effect of oil price shocks on US real activity are of the same sign, an immediate implication of Figure 9 is that central bankers' monetary policy responses to oil price shocks cannot have been a major contributor to the US recessions of the 1970s and the early 1980s.[14] This result is quite powerful in that it does not depend on any counterfactual and is in striking contrast to BGW's original analysis.

Despite BGW's failure to explain the 1974/5 recession based on the Federal Reserve's reaction to the oil price shock and despite their limited success in explaining subsequent recessions based on policy reactions to oil price shocks, BGW concluded that the data overall were supportive of a dominant role for monetary policy reactions. The historical decomposition of real output in Figure 9 does not support that view. There is no indication that US real activity would have been much different under alternative policy scenarios, even in the late 1970s and early 1980s, despite the fact that our results pass standard tests of whether the counterfactual is reasonable, as discussed in Section 3.2.2. This conclusion is much more in line with the theoretical results in Carlstrom and Fuerst (2006) regarding the impotence of systematic monetary policy

[13] For related discussion, see Herrera and Pesavento (2009), Edelstein and Kilian (2009), Kilian (2009, 2010) and Blanchard and Galí (2010), among others.

[14] A very similar result applies to the second subsample (but is not shown to conserve space). The model provides no evidence that a monetary policy response to oil price shocks played a dominant role in the recessions of 1990, 2001, or late 2007, for example.

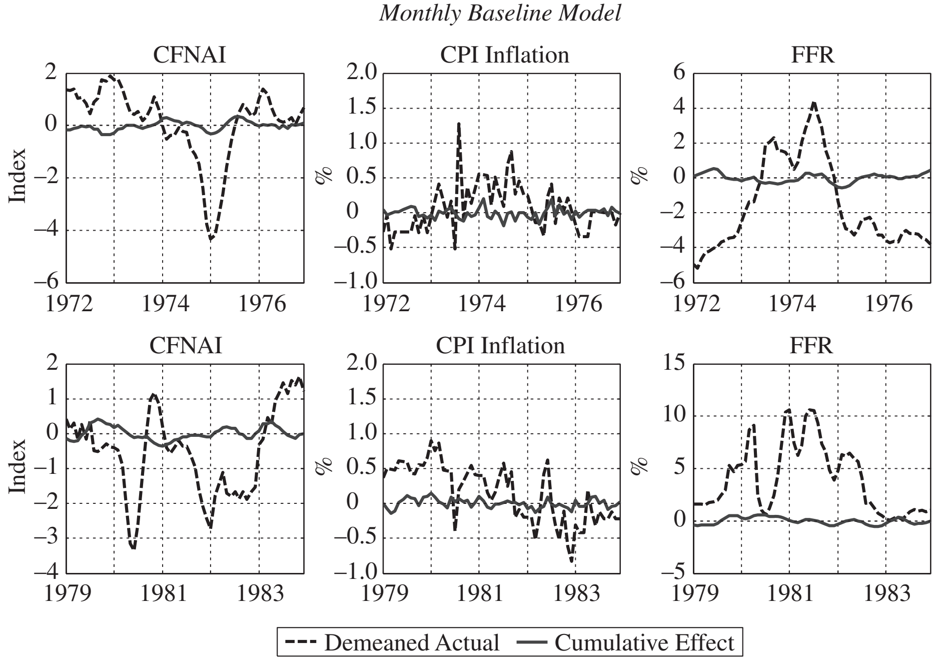

Fig. 9. *Cumulative Effect of Real Oil Price Shocks on US Real Output, Inflation and Interest Rates during Selected Episodes*
Note. Historical decompositions constructed from the model underlying Figure 4.

than with BGW's original results, although unlike Carlstrom and Fuerst we do not find any evidence of large direct effects of oil price shocks on the US economy either.

It is interesting to compare our findings with the analysis in Herrera and Pesavento (2009). As part of a comprehensive study of potential causes of the Great Moderation, Herrera and Pesavento (2009) examined the extent to which systematic monetary policy responses had dampened fluctuations in real activity during the 1970s. Unlike our model, theirs was based on quarterly data. Here, we consider a simplified version of their model. Figure 10 presents historical decompositions for quarterly US real GDP growth and GDP deflator inflation. The recursively identified model includes the percentage change in the real price of oil, the percentage growth rate of real GDP, GDP deflator inflation and the FFR (in that order).[15] The results shown are based on the same sample period of 1967.II–1987.II. Essentially identical results would be obtained using Herrera and Pesavento's original sample period. Figure 10 contrasts the actual demeaned data with the cumulative effect of oil price shocks on real GDP growth and deflator inflation. Notwithstanding important differences in the

[15] We follow Herrera and Pesavento in fitting a VAR(4) model. Unlike Herrera and Pesavento we order the percentage change in the real price of oil first in line with the results in Kilian and Vega (forthcoming) and we drop the growth rate of potential output. These changes do not materially alter the results of the historical decomposition nor does the exclusion of industry-level variables that do not relate to our analysis. Our results for real GDP growth are substantively identical with those in Herrera and Pesavento (2009, figure 7) for the larger quarterly model.

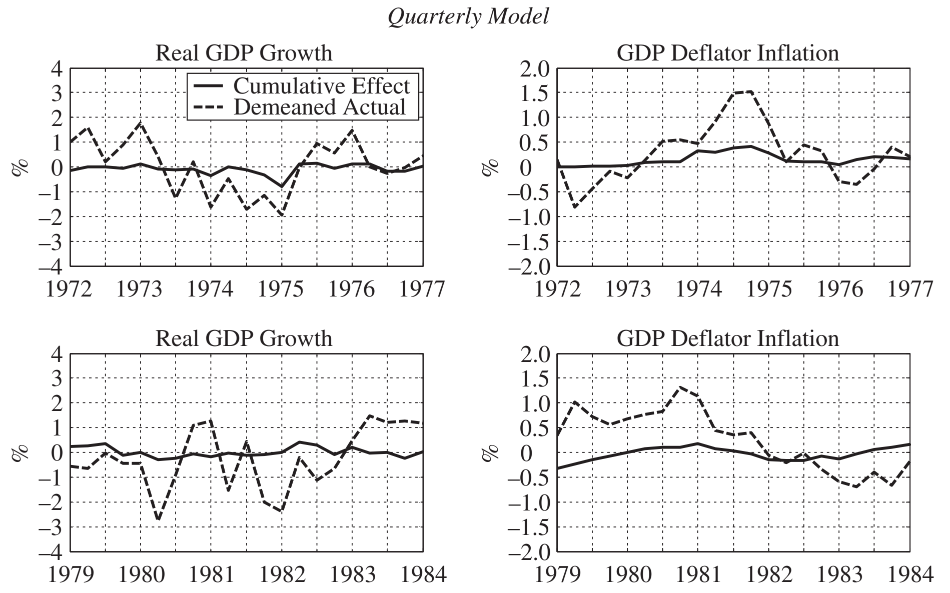

Fig. 10. *Cumulative Effect of Real Oil Price Shocks on US Real Output and Inflation during Selected Episodes*

Notes. Estimates based on macroeconomic block and oil block of the quarterly vector autoregression model of Herrera and Pesavento (2009). Unlike Herrera and Pesavento, we order the per cent change in the real price of oil first in line with the results in Kilian and Vega (forthcoming), and we drop the growth rate of potential output. These changes do not materially alter the results. The results shown are based on the same sample period as our earlier estimates. Essentially identical results for the upper row would be obtained using Herrera and Pesavento's original sample period.

sample period, model specification and data, the empirical results are fully consistent with our earlier analysis. In particular, the historical decompositions of real GDP growth based on the quarterly model in Figure 10 substantively agree with our historical decompositions of the CFNAI measure of real output in Figure 9. Regardless of the model adopted, there is no evidence that oil price shocks were a major contributor to the recessions of 1974/5, 1980 or 1981–3 directly or indirectly through the monetary policy reaction.

5. Towards a New Class of Monetary Policy Reaction Functions

One reason why the conventional monetary policy reaction model fails to explain large fluctuations in US real activity may be that not all oil price shocks are the same. Oil price shocks are best viewed as symptoms of deeper structural shocks in oil markets. One would expect the Federal Reserve to respond differently to oil price shocks associated with, say, unexpected booms in global demand, than oil supply disruptions. An unexpected demand boom driven by the global business cycle, for example, will stimulate the US economy in the short run, whereas an unanticipated oil supply disruption will not, calling for different policy responses depending on the composition of the oil demand and oil supply shocks underlying the oil price shock. For that reason,

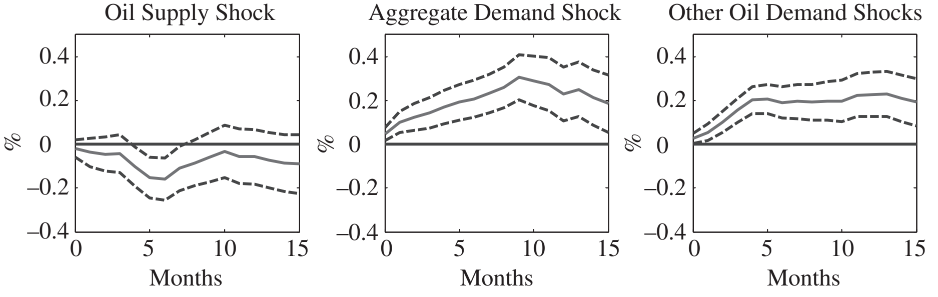

Fig. 11. *Response of the Effective Federal Funds Rate to Oil Demand and Oil Supply Shocks* (with one-standard error bands)

Notes. Estimates from a recursively identified oil market vector autoregression model based on Kilian (2009) augmented by the change in the federal funds rate as the fourth variable. The sample period is 1973.2–2008.6. All shocks have been normalised to imply an increase in the real price of oil. Aggregate demand shocks refer to shocks that increase the flow demand for all industrial commodities (including crude oil); other oil demand shocks include shocks to the inventory demand for crude oil driven by forward looking behaviour; oil supply shocks represent unexpected disruptions of the global production of crude oil.

one would not expect the relationship between interest rates and the real price of oil to be stable over time.[16]

Figure 11 investigates this point by adding the FFR as the fourth variable to the recursively identified VAR model utilised in Kilian (2009).[17] We trace out the effects on the FFR of unanticipated oil production disruptions ('oil supply shocks'), unexpected positive innovations to the flow demand for oil driven by global business cycle ('aggregate demand shocks') and 'other oil demand shocks' such as shocks to the inventory demand of oil driven by forward-looking behaviour. Figure 11 shows that the Federal Reserve tends to respond to positive oil demand shocks by raising the interest rate, whereas it tends to lower the interest rate in response to oil supply disruptions. The positive response to aggregate demand shocks in particular is consistent with the Federal Reserve's decision to raise interest rates long before the oil price shock of late 1973. The negative response to unanticipated oil supply disruptions is consistent with the view that the Federal Reserve views the resulting oil price increases as adverse aggregate demand shocks. Interpreting the positive response to demand shocks in this context is more difficult, as higher oil prices tend to be but one of many consequences of such demand shocks.

Although the responses shown in Figure 11 correctly represent historical averages, they need not be representative of actual policy responses at any given point in time. Even granting that the Federal Reserve does distinguish between oil demand and oil supply shocks in setting interest rates, it would be surprising if the Federal Reserve had pursued a consistent policy over time. It is equally important to recognise that embedding such a modified policy reaction function in the BGW model and estimating

[16] Note that this source of instability is different from the other potential explanations in that it does not involve changes in the unconditional distribution of the economy.

[17] The assumption that the price of oil and hence that oil demand and supply shocks are predetermined with respect to the US interest rate is consistent with evidence in Kilian and Vega (forthcoming).

this VAR model on historical data is not a sensible idea. On one hand, the well-documented shifts in US monetary policy regimes between 1973 and 2008 imply that any VAR model that embeds oil demand and supply shocks in the policy reaction function would have to allow for time-varying coefficients or would have to be based on split samples. On the other hand, the methodology underlying Figure 11 requires long samples with sufficient variation in all oil demand and oil supply shocks to ensure identification. Thus, the idea of embedding oil demand and oil supply shocks within a time-varying parameter VAR monetary policy reaction function, while perhaps natural, does not seem practical.

This caveat does not apply, however, to theoretical studies of the optimal monetary policy response to oil demand and oil supply shocks. Such studies require a different class of structural models than are customarily used by policy makers and macroeconomists. Recent advances in the DSGE modelling of endogenous oil price shocks are a step in that direction.[18] While none of these papers provides a comprehensive analysis of all relevant aspects of the relationship between oil prices and the macro economy, a new class of models is beginning to emerge that allows policy makers to respond differently to different types of oil price shocks.[19] Such DSGE models also allow economists to distinguish between alternative causes of fluctuations in the global demand for industrial commodities, and to simulate the impact of alternative policy choices. Given that traditional DSGE models of the role of systematic monetary policy responses to oil price shocks ignore the distinction between different oil demand and oil supply shocks, they are not directly relevant to question of how the Federal Reserve should respond to shocks in global oil markets. Thus, the fundamental question raised in BGW of how large the effects are of systematic monetary policy responses to these shocks remains as relevant as ever.

6. Conclusion

Since BGW (1997), a common view in the literature has been that systematic monetary policy responses to the actual or potential inflationary pressures triggered by oil price shocks are an important source of aggregate fluctuations in the US economy. Notwithstanding the popularity of this view, doubts remain about the empirical strategy used in support of that proposition. Using improved model specifications, additional data and additional econometric tools that aid in the interpretation of the model estimates, we documented that there is no empirical support for an important role of monetary policy responses in amplifying the effects of oil price shocks. This finding is not completely surprising. We observed that the narrative underlying BGW's analysis of the 1970s is not self-evident in light of economic theory and at odds with recent empirical and theoretical work accounting for

[18] For example, Bodenstein *et al.* (2011) model oil market-specific demand shocks as foreign preference shocks, and Balke *et al.* (2009) model the dependence of oil demand on global macroeconomic conditions. In related work, Nakov and Pescatori (2010) explicitly model the endogeneity of oil production decisions.

[19] Useful extensions in this context also include a model of the external transmission of oil demand and oil supply shocks (see Kilian *et al.*, 2009) and of the nexus between crude oil prices and retail energy prices (see Edelstein and Kilian, 2009).

the endogeneity of the price of oil. Moreover, actual policy actions during the two oil price shock episodes of the 1970s do not fit well with the narrative account in BGW.

It is useful to put our results in perspective relative to earlier studies of the BGW model. Hamilton and Herrera (2004) showed that the counterfactual constructed in BGW is not credible because it evidently violates the Lucas critique. Based on our analysis of the same sample period, using the same criteria employed in Hamilton and Herrera, the economically more relevant counterfactual proposed in this article of shutting down the response to oil price shocks appears credible. Nevertheless, there is no evidence that the monetary policy response had large effects on US real activity or CPI inflation. The latter conclusion is independent of the choice of counterfactual. Hence, our results differ from BGW's but for different reasons than Hamilton and Herrera's.

Hamilton and Herrera (2004) also made the case that the direct effects of oil price shocks on the US economy were substantial, making it less important to consider mechanisms of amplifying the effects of oil price shocks such as endogenous monetary policy responses. In contrast, we found that the combined direct and indirect effects of oil price shocks on the US economy have been negligible. This result is driven mainly by the specification of the oil price shock measure. The censored VAR model used in BGW's and in Hamilton and Herrera's (2004) analysis has been shown to yield inconsistent impulse response estimates (Kilian and Vigfusson, 2009). Indeed, such inconsistent models tend to show much larger effects of oil price shocks on real output than the estimates we found. Given the lack of evidence for asymmetries in the responses of real output to oil price innovations recently documented in Kilian and Vigfusson, our analysis relies on conventional linear VAR specifications rather than alternative nonlinear regression models. Such models are consistent with standard macroeconomic models of the transmission of oil price shocks and can be consistently estimated using standard methods.

A potential concern with all monetary policy VAR models is the possibility of breaks in the policy reaction function associated with the transition from one chairman of the Federal Reserve to the next. Our subsample analysis addressed this issue within the constraints imposed by the data. In addition to re-examining the analysis of BGW on data for the 1967.5–1987.7 period (as well as the Volcker and pre-Volcker era within that period), we examined in detail policy responses to oil price shocks during the Greenspan–Bernanke era of 1987.8–2008.6. Ours is not the first study to find important differences in policy responses after 1987. For example, as part of a comprehensive study of potential causes of the Great Moderation, Herrera and Pesavento (2009) concluded that systematic monetary policy responses had dampened fluctuations in real activity during the 1970s but had virtually no effect after the mid-1980s. Their conclusion appears to have been based on impulse response analysis and forecast error variance decompositions. Indeed, notwithstanding important differences in the sample period, model specification and data, our empirical analysis supported their conclusions, as far as impulse response analysis is concerned. The difference is in the emphasis. Whereas Herrera and Pesavento (2009) stressed differences in average volatility and in the magnitude of impulse responses across the two samples, we are more specifically concerned with the ability of systematic monetary policy responses to explain specific recessions in the 1970s and early 1980s. We showed based on historical decompositions that, even before the mid-1980s, systematic monetary policy responses to oil price shocks were not an important source of recessions. Historical decompositions of real GDP growth based on Herrera and Pesavento's quarterly model substantively agree with our historical decompositions of the CFNAI measure of monthly real output. Regardless of the model adopted, there is no evidence that oil price shocks were a major contributor to the recessions of 1974/5, 1980 or 1981–3 indirectly or directly through the monetary policy reaction.

An important question in the recent literature has been what explains the apparent absence of a monetary policy response after the mid-1980s. We stressed that the evidence in favour of policy responses to oil price shocks in the 1970s and early 1980s is heavily influenced by the episode of 1979, and that it is unclear whether Volcker raised interest rates in 1979 in response to the oil price shock or whether he would have raised interest rates in response to rising inflation even in the absence of that shock. This point is important because, to the extent that there indeed is no causal link from the oil price shock of 1979 to rising interest rates, the disappearance of this dynamic correlation in subsequent data is no longer surprising.

Much of the discussion in this article has been about whether there were large real effects from monetary policy responses to oil price shocks in the 1970s and early 1980s. It may seem that this question should be primarily of interest to economic historians. This interpretation would be a mistake. Not only is this question central in designing theoretical models of the transmission of oil price shocks but recent work by Harris *et al.* (2009), for example, has suggested that the Federal Reserve after 2005 may have been too passive in dealing with the determinants of high asset and oil prices. Moreover, the question of how to respond to higher oil prices is likely to take on a new urgency, as the world economy recovers from the current crisis. Moreover, the policy environment of 2009 in many ways resembles that at the beginning of the 1970s (Kilian, 2010). Understanding the monetary policy regimes in that era, to what extent they were successful and to what extent they can be improved upon is crucial for monetary policy makers as the global recovery unfolds.

Our analysis suggests that the traditional monetary policy reaction framework explored by BGW and incorporated in subsequent DSGE models has outlived its usefulness. There is growing, but not yet universal, awareness that it would be a mistake for policy makers to respond to oil price shocks rather than its underlying determinants. Rather than respond to relative price shocks that often are merely symptoms of broader global macroeconomic developments, central banks must identify and respond to the deeper causes of oil price shocks. This requires a different class of structural models than are customarily used by policy makers. It calls for DSGE models that take account of the endogeneity of the real price of oil and that allow policy responses to depend on the underlying causes of oil price shocks. Recent advances in the DSGE modelling of oil price shocks have made important strides in that direction, although more remains to be done to make these models operational for policy use.

University of Michigan and CEPR
University of Michigan

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