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# DECOMPOSING THE FISCAL MULTIPLIER

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**ABSTRACT**

The fiscal "multiplier" seeks to measure how many additional dollars of output are gained or lost for each dollar of fiscal expansion or contraction. In practice, the multiplier at any point in time depends on the monetary policy response and existing conditions in the economy. Using the IMF fiscal consolidations dataset for identification and a new decomposition-based approach, we show how to quantify the importance of these monetary-fiscal interactions. In the data, the fiscal multiplier varies considerably with monetary policy: it can be as small as zero, or as large as 2, depending on the monetary offset. More generally, we show how to decompose the typical macro impulse response function by extending local projections to carry out the well-known Kitagawa-Blinder-Oaxaca decomposition. This provides a convenient way to evaluate the effects of policy, state-dependence, time-variation, and the balance conditions for identification.

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# 1. Introduction

What is the fiscal multiplier? In principle the definition is clear: The multiplier tells us how many extra dollars of additional economic output are gained or lost by changing government expenditure or taxation (or a mix of the two) by one dollar. Given the turbulent economic events and dramatic policy actions of the last decade or so—and those now underway—there continues to be much interest in empirical estimates of this object. However, there is no such thing as *the* fiscal multiplier. One of the most obvious reasons is that monetary policy may not offset the effects of fiscal policy in the same way across states of the world, countries, or time.

This insight, of course, exists in many macroeconomic theories and has been noted in policy debate. For example, the fiscal multiplier in the data is not, in general, the same object as the Keynesian multiplier found in many undergraduate textbooks. That concept, which follows from the Keynesian Cross, usually assumes *unchanged interest rates*. Recent theoretical work on the Zero Lower Bound (ZLB) on interest rates notes that when monetary policy is unable or unwilling to offset the effects of a fiscal stimulus, fiscal multipliers can be considerably larger.[1] And, more generally, several papers using New Keynesian models note that the fiscal multiplier is sensitive to the degree of monetary accommodation, a theoretical result that is part of our main motivation.[2] To date, however, there is relatively little evidence quantifying the importance of the "monetary offset" empirically. As a result, much policy advice has been given using multiplier estimates that are likely to depend on the particular average response of monetary policy in the past.

In this paper we introduce a new empirical approach for examining this interaction of monetary and fiscal policy. Our goal is to answer a question that has remained unresolved in the literature up to now: Does the fiscal multiplier in the data depend on the behavior of monetary policy? And, if so, by how much? In answering these questions we provide a new framework for decomposing impulse responses. This allows us to unpack the heterogeneity behind the average effects often estimated in the literature. We see the approach having broad application to a wide range of applied macroeconomic and policy problems.

We first show that the local projection (LP) approach in Jordà (2005) can be easily extended to carry out the well-known Kitagawa-Blinder-Oaxaca decomposition (Kitagawa, 1955; Blinder, 1973; Oaxaca, 1973). This decomposition is standard in applied microeconomics (Fortin, Lemieux, and Firpo, 2011), but has not found equivalent acceptance in applied macroeconomics. We argue that it should. The Kitagawa-Blinder-Oaxaca decomposition of an impulse response function allows us to evaluate three separate effects following an exogenous change in fiscal policy: First, the *direct* effect of a fiscal intervention on outcomes, such as GDP. This effect embeds the typical response of monetary policy (and of other controls) in the sample and can be seen as the effect of an intervention on average. Second and most important for our purpose, the *indirect* effect. Policy interventions can

[1] See, among others, Christiano, Eichenbaum, and Rebelo (2011) and Eggertsson (2011).

[2] For example, see Woodford (2011) for an analysis of this point in the standard closed economy New Keynesian model and Leeper, Traum, and Walker (2017) in the context of a larger medium-scale DSGE model.

themselves modify how other variables influence the outcomes. This motivates a very natural way to think about monetary-fiscal interactions: fiscal treatment may be less effective if there is a monetary offset. Third, the *composition* effect. This allows us to quantify, in an easily expressible manner, any bias due to imperfect identification. If fiscal interventions are truly exogenous, the average value of the controls should be the same whether or not there is an exogenous fiscal intervention. In small samples, this will not be exactly true even in the ideal case, let alone when identification fails, and it is vital to control for this disparity.

This paper therefore makes three main contributions. First, using our approach, we show that fiscal multipliers are around or below 1 on average, but there is a sizable degree of heterogeneity. Second, on the latter point, following a fiscal contraction—when the degree of monetary accommodation is limited—fiscal multipliers can become large. In our policy experiments, fiscal multipliers can be as low as zero, or as high as 2 depending on the monetary policy configuration. The latter is similar to the original multiplier estimate of 2.5 posited by Keynes (1936) under the U.S. gold standard of the early 1930s. This result also has wider theoretical implications as an interaction effect is only present in models with nominal rigidities and where fiscal policy, at least partly, affects GDP through aggregate demand. Third, we show how to introduce decomposition methods in macroeconomics more generally. Our decomposition approach turns out to be straightforward to implement and allows for a great deal of unspecified heterogeneity. We also show that a number of other "state" variables, such as the change in the fiscal deficit and the size of the fiscal consolidation, do not materially affect the size of the fiscal multiplier. But, like other papers in the literature, we confirm that fiscal multipliers are larger in slumps (cyclically-low output states). Our approach will hopefully help researchers interested in estimating the non-linear, state-dependent, or time-varying effects of policy interventions using straightforward linear estimators.

State-dependent impulse response applications are numerous and seen frequently in the research literature already (as we will discuss in more detail momentarily). So what is gained from the Kitagawa-Blinder-Oaxaca decomposition? We show that the Kitagawa-Blinder-Oaxaca decomposition provides a very natural unifying framework for analyzing state and policy dependent impulse responses.

In particular, we highlight two features that have often been neglected in the literature so far. First, treatment effects may be heterogeneous along a number of dimensions, many of which may be correlated and endogenous. As Fortin, Lemieux, and Firpo (2011) note, the Kitagawa-Blinder-Oaxaca decomposition follows a partial equilibrium type of approach and, without further assumptions, it is not necessarily correct to infer how much more or less effective a policy would be if, say, GDP growth were negative versus positive. The chosen dimension of heterogeneity is likely to be correlated with many other macroeconomic outcomes. This insight illustrates the issue facing almost all papers examining state-dependence in the effects of policy. Understanding the state dependent nature of policy interventions in a causal sense therefore requires further identifying assumptions, as we will explain below. Second, given the potentially multi-dimensional nature of this heterogeneity, the actual response of the economy to a policy intervention will depend on prevailing factors at the time. In our framework, the impulse response function will be a naturally time-varying object.[3]

To take the next step and address the causality issue in the context of monetary-fiscal interactions, we will use cross-country panel data and exploit the fact that different countries may have different monetary regimes with respect to accommodation.[4] This heterogeneity makes interest rates differentially sensitive to fiscal policy on average and generates *cross-sectional* variation that is useful for identification. This differential sensitivity allows us to construct a proxy for the monetary regime that we can vary to undertake policy experiments.[5] Using this feature of the data, we show that fiscal interventions have very different effects on GDP depending on whether the intervention occurs in a more or less accommodative monetary regime.[6] Exploiting the Kitagawa-Blinder-Oaxaca decomposition, we can then quantify how the fiscal multiplier varies with the degree of monetary accommodation.

Naturally, this paper is related to a sizable literature on the empirical fiscal multiplier. For example, Blanchard and Perotti (2002) and Mountford and Uhlig (2009) identify the effect of fiscal policy by imposing restrictions in a vector autoregression (VAR) framework. Numerous applications have followed these VAR-based approaches. Romer and Romer (2010) pioneered a "narrative" approach which uses historical information to isolate episodes of exogenous fiscal policy changes unrelated to current economic conditions. These methods are essentially looking for historical natural experiments. A number of papers have applied or refined this method including Barro and Redlick (2011), Cloyne (2013), Mertens and Ravn (2013), Guajardo, Leigh, and Pescatori (2014), Hayo and Uhl (2014), Cloyne and Surico (2017), Gunter, Riera-Crichton, Végh, and Vuletin (2018), Nguyen, Onnis, and Rossi (2021), Hussain and Lin (2018), Cloyne, Dimsdale, and Postel-Vinay (2018).

Following the narrative tradition, we will use an influential and established study from the IMF which identifies periods of exogenous fiscal treatment. This study by Guajardo, Leigh, and Pescatori (2014) employs the Romer and Romer (2010) definition of an exogenous fiscal consolidation to identify exogenous episodes across 17 OECD countries from 1978 to 2009. There are a few key reasons for using the Guajardo, Leigh, and Pescatori (2014) dataset. First, our contribution is not a new identification of fiscal shocks. Rather, we take the existing Guajardo, Leigh, and Pescatori (2014) consolidation episodes off the shelf, and then show how the fiscal multiplier varies with monetary policy. Second, as noted above, the cross-country coverage of the IMF study allows us to exploit the panel nature of the dataset for identification of the monetary offset. Third, studying non-linear effects and state-dependence naturally asks more of the data and larger sample sizes are preferable.

[3]This echoes Ramey (2019) who notes "to understand whether a particular estimate of fiscal effects is suitable for use in predicting the effects of a proposed policy, one must understand how the current circumstances differ from those present in the sample used to generate that estimate."

[4]Because monetary-fiscal interactions are about the *subsequent* response of monetary policy rates, this environment is different to typical exercises studying state dependence, which tend to focus on how the effect of policy varies with some initial condition, e.g. the lagged output gap. This is why we often use the term *policy* dependence to differentiate our dimension of heterogeneity from more traditional state dependence.

[5]We discuss the more detailed assumptions below.

[6]In exploiting the differential sensitivity of countries to shocks, our method has a connection to the approach in Nakamura and Steinsson (2014) and Guren, McKay, Nakamura, and Steinsson (2020).

In considering how the effect of a fiscal intervention varies with monetary policy, we also relate to a growing literature on the state-dependent effects of policy. For example, a number of papers have examined whether the impact of fiscal policy could vary depending on circumstances (Auerbach and Gorodnichenko, 2012; DeLong and Summers, 2012; Bachmann and Sims, 2012; Riera-Crichton, Vegh, and Vuletin, 2015; Jordà and Taylor, 2016; Banerjee and Zampolli, 2019; Ferrière and Navarro, 2020; Barnichon, Debortoli, and Matthes, 2020; Ghassibe and Zanetti, 2021; Jo and Zubairy, 2021). This literature has often focused on a particular dimension of state dependence such as booms versus slumps, or expansions versus recessions. Another related literature has considered whether the fiscal multiplier is larger when there is no response of monetary policy at the Zero Lower Bound (e.g., Ramey and Zubairy, 2018; Crafts and Mills, 2013; Kato, Miyamoto, Nguyen, and Sergeyev, 2018; Miyamoto, Nguyen, and Sergeyev, 2018). Canova and Pappa (2011) use sign-restrictions in a vector auto-regression framework and find that imposing a no-monetary response generates a larger multiplier.

Our findings also relate to multiplier estimates using regional variation where, among other things, the aggregate effects of monetary policy are held constant (for examples see Acconcia, Corsetti, and Simonelli, 2014; Nakamura and Steinsson, 2014; Corbi, Papaioannou, and Surico, 2019). Reviewing this literature, Chodorow-Reich (2019) concludes that these "cross-sectional" multipliers are consistent with an aggregate "no-monetary-policy-response" multiplier of 1.7 or above.[7] Finally, some papers find that the exchange rate regime affects the size of the multiplier (e.g., Corsetti, Meier, Müller, and Devereux, 2012; Born, Juessen, and Müller, 2013; Ilzetzki, Mendoza, and Végh, 2013; Born, D'Ascanio, Müller, and Pfeifer, 2021), which is obviously related to whether policymakers are willing and able to use monetary tools.

These existing papers highlight the importance of the monetary offset, but often refer to a particular environment (e.g., the zero lower bound) and it is hard to know the right benchmark against which to measure the "usual" monetary response. Relative to all these papers, our focus is therefore different. We aim to directly quantify the importance of this monetary-fiscal interaction on the aggregate fiscal multiplier more generally, and not just in certain episodes, and thus map out a range for how the fiscal multiplier varies with the monetary offset.

The structure of the paper is as follows. Section 2 provides some theoretical motivation for the monetary offset and shows the precise object we will try to identify in the data. Section 3 formally discusses the decomposition methods we use and how these can be introduced into macroeconomic analysis using local projections. Section 4 applies this new method to study the interaction of monetary policy and the fiscal multiplier, including showing that the approach recovers the theoretical multiplier when applied to simulated model data. Section 5 conducts a number of robustness checks. We then conclude and discuss some policy implications.

[7] Guajardo, Leigh, and Pescatori (2011) also discuss how the degree of monetary accommodation might explain differences between their estimated spending and tax multipliers but do not formally attempt to estimate this interaction more generally.

## 2. Theoretical Motivation

To motivate our empirical approach, this section illustrates how the fiscal multiplier varies with the monetary policy offset in a standard New Keynesian model. A number of papers in the literature have, of course, noted that the fiscal multiplier depends on the model's monetary policy rule (see, for example, Woodford (2011) or Leeper, Traum, and Walker (2017)), and a more realistic quantitative model would also include a range of other features and mechanisms. Our goal here, however, is simply to illustrate the key monetary-fiscal interaction we have in mind, and to fix ideas about what we will seek to quantify in the data.[8]

For monetary policy to affect the fiscal multiplier, the model needs some form of nominal rigidity. This motivates our focus on the New Keynesian class of models. To generate a wider range of multipliers the model needs to have some other rigidities beyond the simple textbook New Keynesian model. A range of mechanisms could be included but, for simplicity, we follow Galí, López-Salido, and Vallés (2007) and include two types of households, one group who fully optimize and another group who act in a rule-of-thumb manner.[9] In the presence of nominal rigidities, this allows the model to produce a range of different results for the multiplier, some of which are larger than 1 (see Leeper, Traum, and Walker, 2017). Fiscal policy is modeled as a persistent change in government spending. We will assume this policy experiment is financed by lump-sum taxes on saver households.[10] The model is therefore very standard. Here we sketch the most important features for our purpose. More details are provided in the Appendix.

On the household side, the economy is populated by a continuum of households. A share $1 - \mu$ of the households can save (or borrow) freely. They fully optimize their intertemporal choices: they choose consumption, saving, hours worked, and bond holdings to maximize expected lifetime utility subject to their budget constraint. We refer to these households as saver households, and their choices with a superscript $S$. The saver household's consumption plan follows the familiar Euler equation which relates consumption growth to the real interest rate. In linearized form this is

$$E_t \, \Delta \hat{c}^S_{t+1} = \frac{1}{\sigma} \left( \hat{R}_t - E_t \, \hat{\pi}_{t+1} \right) ,$$

where $\hat{c}^S_t$ is consumption of the saver household in log deviation from steady state. $\hat{\pi}_t$ is the log change in the price of the consumption good and $\hat{R}_t$ is the monetary policy interest rate, both in deviations from the deterministic steady state. With sticky prices monetary policy can exert control over the real interest rate $(\hat{R}_t - E_t \, \hat{\pi}_{t+1})$.

[8] See Leeper, Traum, and Walker (2017) for a recent and extensive investigation of the effects of changes in government spending changes in a range of macroeconomic models with different frictions and assumptions.

[9] Again, this is purely expositional and, as discussed in Leeper, Traum, and Walker (2017), a number of modeling devices can be used to generate positive consumption effects that produce larger multipliers following a fiscal stimulus.

[10] Alternatively we could have assumed that government spending changes are financed with debt owned by the saver households but, because saver households finance the government, a form of Ricardian equivalence applies here and there is no need to model debt explicitly.

We assume that the remaining share $\mu$ of households are rule-of-thumb decision-makers in the sense that they have no access to bonds and consume all their labor income. We refer to these households as non-saver households, and denote their choices with a superscript $N$.[11] For them, consumption is therefore pinned down by their budget constraint

$$C_t^N = w_t N_t^N .$$

where $C_t^N$ is the level of non-saver consumption, $w_t$ is the real wage and $N_t^N$ are hours worked by non-savers. Total consumption in this economy is equal to

$$C_t = \mu C_t^N + (1-\mu) C_t^S .$$

On the production side of the model, to rationalize price stickiness, there are two types of firms. Intermediate goods $y_t(j)$ are produced by a constant returns to scale technology $y_t(j) = An_t(j)$ under monopolistic competition. We normalize total factor productivity, $A$, to 1. Intermediate goods are turned into final goods $Y_t$ by competitive final goods firms using a CES production function $Y_t = (\int_0^1 y_t(j)^{\frac{\epsilon-1}{\epsilon}} dj)^{\frac{\epsilon}{(\epsilon-1)}}$. Final goods are either purchased by households or government, i.e. $Y_t = C_t + G_t$ where $G_t$ is government consumption expenditure. All varieties of intermediate good are substitutable with one another with an elasticity of demand $\epsilon$ and the demand curve for variety $y_t(j)$ is given by $y_t(j) = \left(\frac{p_t(j)}{P_t}\right)^{-\epsilon} Y_t$, which the intermediate goods firm takes as given.

Intermediate goods firms set prices and choose labor demand to minimize costs. Their decision problem is standard in the New Keynesian literature, so we only report it in the appendix. With probability $\theta$ a firm is unable to change its price and keeps the same price as at $t-1$. With probability $1-\theta$ the firm is able to fully reset its price. The equilibrium conditions from the firm side lead to a standard dynamic pricing relationship. In linearized form this is the familiar New Keynesian Phillips Curve where inflation depends on expected future inflation and real marginal cost,

$$\hat{\pi}_t \; = \; \beta \, E_t \hat{\pi}_{t+1} \; + \; \tilde{\kappa} \, \widehat{mc}_t \, , \tag{1}$$

where $\tilde{\kappa} = \frac{1}{\theta}(1-\theta)(1-\beta\theta)$, $\theta$ is the probability of having a fixed price, and $\beta$ is the household's discount factor. $\widehat{mc}_t$ is real marginal cost in log deviation from steady state. As usual in the New Keynesian model, the dynamics of real marginal cost are closely related to the output gap.

Fiscal policy is described by an exogenous, persistent stream of government purchases, $G_t$. We assume that the government finances government spending using lump sum taxes on saver households and the government budget constraint is simply $G_t = T_t$, but similar results would be obtained if we formally allowed for government debt owned by the savers. We will write $\hat{g}_t = \frac{G_t - G}{Y}$, the deviation of $G_t$ from its steady state $G$ relative to steady state output $Y$. Impulse response

[11] These households still make an intratemporal consumption and labor choice. The intratemporal labor supply equation is the same as for the saver household and, given the competitive nature of the labor market, both types of household face the same real wage.

functions can then be expressed as fiscal multipliers under a standard definition $\frac{\Delta Y_t}{\Delta G_t}$. We will assume that government spending deviations follow an AR(1) process,

$$\hat{g}_t = \rho_g \hat{g}_{t-1} + e_t .$$

Monetary policy follows a Taylor Rule. In terms of monetary-fiscal interactions, our point of departure is that the effects of a change in fiscal policy will be modulated by the monetary regime in which it is implemented. We therefore assume that the policy rule relates interest rate changes to inflation, with some persistence,

$$\hat{R}_t = \rho \hat{R}_{t-1} + (1-\rho) \phi^i \hat{\pi}_t , \tag{2}$$

and where $\phi^i$ can take a number of distinct values, indicating a different monetary policy regime $i$.

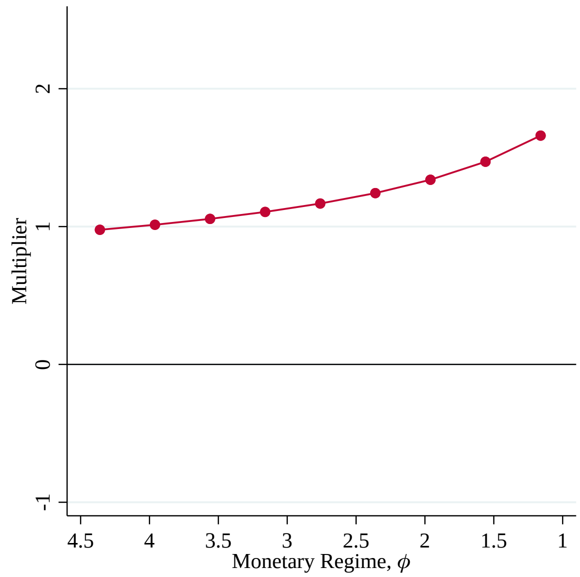
To illustrate how the fiscal multiplier in this model depends on the degree of the "monetary offset", we solve the model using standard linearization-based methods for a range of possible values of $\phi$. In particular, we consider $\phi \in [1, 4.5]$.[12] Each time we solve the model we are assuming that agents in the model take $\phi$ as given. Later, we will exploit potential cross-country variation in $\phi$ for identification and we will interpret differences in $\phi$ as cross-country variation in average monetary policy behavior over the sample.

Figure 1 shows how the model-implied fiscal multiplier varies with the strength of the monetary offset, governed by $\phi$. A more aggressive monetary policy rule with higher values of $\phi$ is associated with smaller fiscal multipliers. In contrast, a less activist monetary authority is associated with larger fiscal multipliers. Of course, this figure confirms what is already known in the theoretical literature: that the monetary policy rule has important implications for the size of the fiscal multiplier. Furthermore, note that the slope of the line in Figure 1 is only positive when nominal rigidities are present. Otherwise, monetary policy would have no effect on the fiscal multiplier.

Although our model is standard, Figure 1 is useful for two reasons. First, our goal in this paper is to produce the empirical counterpart of Figure 1. Our idea is that the monetary regime modulates the effects of fiscal policy in the data and this insight provides an interesting way to try and quantify the strength of the monetary offset empirically. Second, we will use this model to validate the empirical approach developed below. In particular, we will show that our empirical approach correctly recovers Figure 1 when applied to simulated data from the model. Estimating the empirical counterpart to Figure 1 requires addressing two questions. First, what is the right empirical framework for studying this type of interaction? Second, how can we identify the role of variations in $\phi$ in the data? The next two sections address each of these questions in turn.

[12] The rest of the model's parameters are calibrated as follows. We set $\psi = 1.7$, implying a Frisch elasticity of around 0.6. The probability of having a fixed price is set to $\theta = 0.85$. The household's discount factor $\beta = 0.99$. The persistence of government spending is set to $\rho_g = 2/3$ and interest rate smoothing is set to $\rho = 0.75$. We set the share of hand-to-mouth households to $\mu = 30\%$. Following Leeper, Plante, and Traum (2010), we set the government consumption share to 8%.

**Figure 1:** *Variation in the fiscal multiplier by monetary offset*




*Notes:* This chart shows how the cumulative fiscal multiplier at 2 years ($\sum \hat{y}_t / \sum \hat{g}_t$) varies with the monetary policy response in the theoretical model. The horizontal axis shows the inflation coefficient in the Taylor Rule, $\phi$. This is expressed so that moving from left to right on the horizontal axis implies a "less active" monetary policy which results in a larger multiplier.

# 3. Empirical Framework

Our motivating idea is that the monetary regime in which a fiscal policy intervention occurs will influence economic outcomes. That is, the monetary regime modulates the response of the economy to a change in fiscal policy. How can we identify this effect in the data?

The nature of this problem is actually relatively common in many areas of economics. In many applied-micro applications, we are often interested in how the characteristics of the treated sub-population may influence the effects of a policy intervention. For example, a background in mathematics may translate into a higher salary for workers assigned to take additional training in computer science, but may not be otherwise helpful if there is no complementarity between both knowing mathematics and computer science. In a number of applications, the researcher may be interested in decomposing the average treatment effect and exploring the importance of different characteristics. The well-known Kitagawa-Blinder-Oaxaca decomposition (Kitagawa, 1955; Blinder, 1973; Oaxaca, 1973) is used often in applied microeconomics for this purpose.

In this section we show that the local projection (LP) approach (Jordà, 2005) for estimating impulse response functions in macroeconomics can be easily extended to carry out the Kitagawa-Blinder-Oaxaca decomposition in a time-series context. This leads to a very natural empirical framework for studying monetary-fiscal interactions and allows us to decompose the typical macro impulse response function to quantify how the fiscal multiplier may vary with monetary policy. The Kitagawa-Blinder-Oaxaca decomposition will also provide a general framework for thinking about decomposing heterogeneity around the average effect of a policy intervention in a multi-variate and time-varying manner. We begin this section with some preliminary statistical discussion and then show how to apply the Kitagawa-Blinder-Oaxaca decomposition in a time series context.

## 3.1. Preliminary statistical discussion and intuition

This section introduces the main ideas with simplified examples. Formal statements of usual assumptions can be found in, e.g., Wooldridge (2001) and Fortin, Lemieux, and Firpo (2011). Later on we provide assumptions for typical macroeconomics applications as we expand on our examples. Here we focus on the intuition. Note that when describing the behavior of random variables, we omit observation indexes, which are used once the discussion moves on to a finite sample.

Suppose we are interested in the response of an outcome variable, $y$, to a *randomly assigned* intervention, $f$. In general, we will assume only that $f \in \{0, 1\}$ is randomly assigned, at least conditional on controls $\boldsymbol{x}$, and the observed data are generated by the following mixture of unobservable latent variables, $y_1$ and $y_0$,

$$y = (1-f)\, y_0 + f\, y_1 = y_0 + f\,(y_1 - y_0)\,. \tag{3}$$

That is, the observed random variable $y$ is either the random variable $y_0$, which is observed when $f = 0$, or it is $y_1$ when $f = 1$. Note that the observed data belong to one state or the other. One cannot simultaneously observe both states. As is standard, we refer to $y_0$ and $y_1$ as *potential outcomes* in the terminology of the Rubin causal model (Rubin, 1974).

These potential outcomes are random variables $y_j$ with $j \in \{0, 1\}$. Suppose they have unconditional mean $E(y_j) = \mu_j$. A natural statistic of interest is $E(y_1 - y_0) = \mu_1 - \mu_0$, that is, the average difference in the unconditional mean between the treated and the control subpopulations. Although the potential outcomes $y_1$ and $y_0$ cannot be simultaneously observed, their moments (under random assignment), can be easily calculated.

We note that the potential outcomes approach and its notation can be somewhat new to applied macroeconomists. A few examples can help clarify basic notions. In a randomized controlled trial, a common (strong) ignorability assumption is that $y_j \perp f$ for $j = 0, 1$. This assumption does not imply that $y$ and $f$ are unrelated. Rather, the assumption means that the choice of intervention $f$ is unrelated to the potential outcomes that may happen for a given choice of $f \in \{0, 1\}$. Hence a quantity such as $E(y_1 \,|\, f = 0)$ is well defined. It refers to the expected value that the random variable $y_1$ — referring to units in the treated subpopulation — would *counterfactually* take were it not exposed to treatment and instead had been placed in the control group with $f = 0$. We will use such counterfactual expectations below.

We might reflect on the strong ignorability condition. It bears noting that even when this fails in practice, a milder condition of selection on observables, that is, $y_j \perp f \,|\, \boldsymbol{x}$ for $j = 0, 1$ would allow most of the results here to carry through and is akin to identification based on exclusion restrictions (depending on what is included in $\boldsymbol{x}$), using the VAR vernacular. We expand on this point below.

## 3.2. The Kitagawa-Blinder-Oaxaca decomposition

Without loss of generality, we can write $y_j = \mu_j + v_j$ where $E(v_j) = 0$, since $E(y_j) = \mu_j$ by definition, with $j \in \{0, 1\}$. Any heterogeneity in the treated and control subpopulations is therefore relegated to the terms $v_j$. Whenever covariates (explanatory variables or, simply, controls) $\boldsymbol{x}$ are available, they are useful to characterize heterogeneity across units (and later for us, across time) and we may assume additivity so that $v_j = g(\boldsymbol{x}) + \epsilon_j$. As a starting point it is natural to further assume that these covariates enter linearly, so that $v_j = (\boldsymbol{x} - E(\boldsymbol{x}))\gamma_j + \epsilon_j$. We include the covariates in deviations from their unconditional mean to ensure that $E[(\boldsymbol{x} - E(\boldsymbol{x}))\gamma_j] = 0$, in which case unobserved heterogeneity is such that $E(\epsilon_j) = 0$. If observed heterogeneity is well captured by the vector of explanatory variables and the linearity assumption is correct, then it is also the case that $E(\epsilon_j \mid \boldsymbol{x}_j) = 0$. That is, the projection of $y_j$ onto $\boldsymbol{x}_j$ is properly specified.

Researchers are often interested in understanding the overall effect of the intervention on outcomes. The Kitagawa-Blinder-Oaxaca decomposition (Kitagawa, 1955; Blinder, 1973; Oaxaca, 1973) is used often in applied microeconomics for this purpose. It is worth going through its derivation here before later using similar arguments on local projections. These derivations borrow heavily from Wooldridge (2001) and Fortin, Lemieux, and Firpo (2011).

The overall average treatment effect of the intervention can be obtained by first calculating

$$\begin{aligned} E(y_1 \mid f = 1) - E(y_0 \mid f = 0) &= E(y_1 \mid \boldsymbol{x}, f = 1) - E(y_0 \mid \boldsymbol{x}, f = 0) \\ &= \{ \mu_1 + E[\boldsymbol{x} - E(\boldsymbol{x}) \mid f = 1]\gamma_1 + \underbrace{E(\epsilon_1 \mid f = 1)}_{=0} \} \\ &\quad - \{ \mu_0 + E[\boldsymbol{x} - E(\boldsymbol{x}) \mid f = 0]\gamma_0 + \underbrace{E(\epsilon_0 \mid f = 0)}_{=0} \} . \end{aligned} \tag{4}$$

Straightforwardly, by adding and subtracting $E[\boldsymbol{x} - E(\boldsymbol{x}) \mid f = 1]\gamma_0$, Equation 4 can be rearranged as

$$\begin{aligned} E(y_1 \mid f = 1) - E(y_0 \mid f = 0) &= (\mu_1 - \mu_0) \\ &\quad + E[\boldsymbol{x} - E(\boldsymbol{x}) \mid f = 1](\gamma_1 - \gamma_0) \\ &\quad + \{ E[\boldsymbol{x} - E(\boldsymbol{x}) \mid f = 1] - E[\boldsymbol{x} - E(\boldsymbol{x}) \mid f = 0] \}\gamma_0 . \end{aligned} \tag{5}$$

Equation 5 contains three interesting terms. The first $\mu_1 - \mu_0$ is the difference in the unconditional means of the treated and control subpopulations. We refer to it as the *direct* effect of an intervention.

The second term $E[\boldsymbol{x} - E(\boldsymbol{x}) \mid f = 1](\gamma_1 - \gamma_0)$ reflects changes in how the covariates affect the outcome due to the intervention. We will refer to this term as the *indirect* effect of intervention. To build on the earlier example, this term would capture the idea that a background in mathematics may translate into a higher salary for workers assigned to take additional training in computer science, but may not be otherwise helpful if there is no complementarity between both knowing mathematics and computer science. Notice that $E[\boldsymbol{x} - E(\boldsymbol{x}) \mid f = 1]\gamma_0$ explores the salary of workers with a given background in mathematics, had they been counterfactually assigned *not* to take the additional training in computer science.

A natural hypothesis we will be interested in testing is $H_0 : \gamma_1 - \gamma_0 = \mathbf{0}$. Failure to reject the null suggests that the effect of the covariates on the outcome is not affected by the intervention. Crucially, it turns out that, up to now, traditional estimates of impulse responses have implicitly assumed this to be the case. Later on, we will see that such a hypothesis plays a critical role in evaluating impulse response state-dependence. Note that, in a properly designed randomized control trial, covariate balance implies the expectation term is zero, so the indirect effect should be zero. However, this does not mean that $\gamma_1 - \gamma_0 = \mathbf{0}$. The covariates $\boldsymbol{x}$ will still influence the way in which treatment affects the outcomes for particular values of $\boldsymbol{x}$.

The final term $\{E[\boldsymbol{x} - E(\boldsymbol{x}) \,|\, f = 1] - E[\boldsymbol{x} - E(\boldsymbol{x}) \,|\, f = 0]\}\gamma_0$ reflects how, all else equal, the effect of the intervention may be driven simply by differences in the average value of the explanatory variables between the treated and control subpopulations. We will call this term the *composition* effect. A test of the null $H_0 : E[\boldsymbol{x} - E(\boldsymbol{x}) \,|\, f = 1] - E[\boldsymbol{x} - E(\boldsymbol{x}) \,|\, f = 0] = \mathbf{0} \rightarrow H_0 : E[\boldsymbol{x} \,|\, f = 1] - E[\boldsymbol{x} \,|\, f = 0] = \mathbf{0}$ is useful to determine the balance of the distribution of covariates between treated and control subpopulations. Again, in a proper randomized control trial, covariate balance implies the expectation terms are zero, there should be no differences and the null would not be rejected. A rejection of the null instead indicates that selection into treatment could depend on the covariates with the possibility of selection bias in the estimation. In small samples, measurement of the composition effect can be helpfully used to sterilize the biased average treatment effect estimate that would result otherwise.

In practice, a natural way to obtain each term in the decomposition of Equation 5 in a finite sample with $i = 1, \ldots, N$; $t = 1, \ldots, T$, would be to estimate the following regression, using Equation 3 as the springboard,

$$y_{it} \;=\; \mu_0 \;+\; (\boldsymbol{x}_{it} - \bar{\boldsymbol{x}})\gamma_0 \;+ f_{it}\,\{\beta + (\boldsymbol{x}_{it} - \bar{\boldsymbol{x}})\boldsymbol{\theta}\} \;+\; \omega_{it}\,, \tag{6}$$

where $\hat{\beta} = \hat{\mu}_1 - \hat{\mu}_0$ is an estimate of the *direct* effect; $\hat{\boldsymbol{\theta}} = \hat{\gamma}_1 - \hat{\gamma}_0$ and hence $(\bar{\boldsymbol{x}}_1 - \bar{\boldsymbol{x}})\hat{\boldsymbol{\theta}}$ is an estimate of the *indirect* effect. An important lesson is that $\boldsymbol{x}_{it}$ should be expressed relative to the mean $\bar{\boldsymbol{x}}$ to ensure the direct effect captures the average impact and the indirect effect captures heterogeneity around the average. For expositional purposes, we do not discuss here natural extensions with fixed effects but will consider these later. The notation $\bar{\boldsymbol{x}}_1$ refers to the sample mean of the covariates for the treated units. A test of the null $H_0 : \boldsymbol{\theta} = \mathbf{0}$ is a test of the null that the indirect effect is zero *on average* (although the specific realizations may have non-zero effects, as we shall see). In that case the covariates affect the outcomes in the same way, *on average* whether or not a unit is treated. Finally, the term $(\bar{\boldsymbol{x}}_1 - \bar{\boldsymbol{x}}_0)\gamma_0$ is an estimate of the composition effect and a natural balance test is a test of the null $H_0 : E(\boldsymbol{x} \,|\, f = 1) - E(\boldsymbol{x} \,|\, f = 0) = 0$. Note that the error term is $\omega_{it} = \epsilon_{0,it} + f_{it}\,(\epsilon_{1,it} - \epsilon_{0,it})$. Under the maintained assumptions, it has mean zero conditional on covariates.

## 3.3. Decomposing local projection responses

The methods discussed in Section 3.1 and Section 3.2, while common in applied microeconomics research, have not permeated macroeconomics as much. In this section we show that local projections offer a natural bridge between literatures and hence offer a more detailed understanding of impulse responses, the workhorse of applied macroeconomics research.

In order to move from the preliminary statistical discussion to a time series setting in which to investigate impulse responses, we define the outcome random variable observed at a horizon $h$ periods after the intervention as $y(h)$, where a typical single observation from a finite sample of $T$ observations is denoted $y_{t+h}$. We omit the cross-section index $i$ for the moment to keep things simple and focus on the pure time series case.

As before, we begin with a binary policy intervention (i.e., the treatment) denoted $f \in \{0, 1\}$ where a typical single observation from a finite sample is denoted $f_t$. A vector of observable predetermined variables is denoted $\boldsymbol{x}$, where a typical single observation from a finite sample is denoted $\boldsymbol{x}_t$. Note that $\boldsymbol{x}$ includes contemporaneous values and lags of a vector of variables including the intervention, as well as lags of the (possibly transformed) outcome variable, among others. Moreover, define $\boldsymbol{y} = (y(0), y(1), \ldots, y(H))$ or when denoting an observation from a finite sample, $\boldsymbol{y}_t = (y_t, y_{t+1}, \ldots y_{t+H})$.

A natural starting point regarding the assignment of the policy intervention is to follow Angrist, Jordà, and Kuersteiner (2018), whose selection-on-observables assumption we restate here for convenience:

**Assumption 1. Conditional ignorability or selection on observables.** *Let $\boldsymbol{y}_f$ denote the potential outcome that the vector $\boldsymbol{y}$ can take on impact and up to H periods after intervention $f \in \{0, 1\}$. Then we say $f$ is randomly assigned conditional on $\boldsymbol{x}$ relative to $\boldsymbol{y}$ if*

$$\boldsymbol{y}_f \perp f \,|\, \boldsymbol{x} \qquad \textit{for } f = f(\boldsymbol{x}, \eta; \boldsymbol{\phi}) \in \{0, 1\}\,; \;\; \boldsymbol{\phi} \in \Phi\,.$$

The conditional ignorability assumption makes explicit that the policy intervention $f$ is itself a function the observables $\boldsymbol{x}$, unobservables $\eta$, and a parameter vector $\boldsymbol{\phi}$. It means that $\boldsymbol{y}_f \perp \eta$, that is, the unobservables are random noise. Moreover, we assume that $\boldsymbol{\phi}$ is constant for the given sample considered. In other words, we rule out variation in the rule assigning intervention.

Although such a general statement of conditional ignorability provides a great deal of flexibility (see Angrist, Jordà, and Kuersteiner, 2018), a simpler assumption can be made when considering a linear framework, as we do in the analysis that follows. In particular, for our purposes, the following assumption will suffice:

**Assumption 2. Conditional mean independence.** *Let $E(\boldsymbol{y}_f) = \boldsymbol{\mu}_f$ for $f \in \{0, 1\}$ so that, without loss of generality, $\boldsymbol{y}_f = \boldsymbol{\mu}_f + \boldsymbol{v}_f$. As before, we now assume linearity so that $\boldsymbol{v}_f = (\boldsymbol{x} - E(\boldsymbol{x}))\Gamma_f + \boldsymbol{\epsilon}_f$. Because of the dimensions of $\boldsymbol{y}_f$, we use the notation $\Gamma_f$ instead of $\gamma_f$ since $\Gamma_f$ is now a matrix of coefficients with row* *dimension $H+1$, each row containing the corresponding $\gamma_f^h$ vector for $h = 0, \ldots, H$. Then,*

$$E(\boldsymbol{y}_f \mid \boldsymbol{x}) = \boldsymbol{\mu}_f; \quad E(\boldsymbol{v}_f) = \mathbf{0}; \quad E(\boldsymbol{\epsilon}_f \mid \boldsymbol{x}) = \mathbf{0}; \quad \textit{for } f \in \{0, 1\}\,. \tag{7}$$

Based on Assumption 2, local projections can be easily extended to have the same format as expression Equation 6. Specifically,

$$\begin{aligned} y_{t+h} &= \underbrace{\mu_0^h + (\boldsymbol{x}_t - \overline{\boldsymbol{x}})\gamma_0^h + f_t\,\beta^h}_{\text{usual local projection}} + \underbrace{f_t\,(\boldsymbol{x}_t - \overline{\boldsymbol{x}})\,\boldsymbol{\theta}^h}_{\substack{\text{Kitagawa-Blinder-Oaxaca}\\ \text{extension}}} + \omega_{t+h}\,; \\ &\text{for } \ h = 0, 1, \ldots, H\,;\ t = h, \ldots, T\,. \end{aligned} \tag{8}$$

Once again, we maintain the time series notation and refrain from adding additional parameters, such as fixed effects as is common in panel data applications, for simplicity. Thus, relative to the usual specification of a local projection, the only difference is the additional Kitagawa-Blinder-Oaxaca term, $f_t\,(\boldsymbol{x}_t - \overline{\boldsymbol{x}})\,\boldsymbol{\theta}^h$. As a result of this simple extension, estimates of the components of an impulse response at any horizon $h$ can be calculated in parallel fashion to Section 3.2, with

$$\begin{aligned} \text{Direct effect:} &\quad \hat{\mu}_1^h - \hat{\mu}_0^h = \hat{\beta}^h\,, \\ \text{Indirect effect:} &\quad (\overline{\boldsymbol{x}}_1 - \overline{\boldsymbol{x}})(\hat{\gamma}_1^h - \hat{\gamma}_0^h) = (\overline{\boldsymbol{x}}_1 - \overline{\boldsymbol{x}})\hat{\boldsymbol{\theta}}^h\,, \\ \text{Composition effect:} &\quad (\overline{\boldsymbol{x}}_1 - \overline{\boldsymbol{x}}_0)\hat{\gamma}_0^h\,, \end{aligned} \tag{9}$$

where $\overline{\boldsymbol{x}}_f$ refers to the sample mean of the controls in each of the subpopulations $f \in \{0, 1\}$.

In a time series context, one requires an assumption about the stationarity of the covariate vector $\boldsymbol{x}$. Without it, calculating means for the treated and control subpopulations would not be a well-defined exercise. In a typical local projection, it is not necessary to make such an assumption because the parameter of interest is $\hat{\beta}^h$ and all that is required for inference is for the projection to have a sufficiently rich lag structure to ensure that the residuals are stationary. Consequently, we make an additional assumption here, as follows:

**Assumption 3. Ergodicity.** *The vector of covariates $\boldsymbol{x}_{it}$ — which can potentially include lagged values of the (possibly transformed) outcome variable and the treatment, as well as current and lagged values of other variables — is assumed to be a covariance-stationary vector process ergodic for the mean (Hamilton, 1994).*

Ergodicity ensures that the sample mean converges to the population mean. Assuming covariance-stationarity is a relatively standard way to ensure that this is the case. More general assumptions could be made to accommodate less standard stochastic processes. However, covariance-stationarity and ergodicity are sufficiently general to include commonly observed processes in practice.

## 3.4. Beyond binary policy interventions

Policy interventions sometimes vary from one intervention to the next. Think of fiscal policy and the different amounts by which taxes and spending can be raised or lowered. Call it the problem of choosing the policy dose. When the set of alternative doses is finite and small, it is easy to extend the analysis from the Section 3.1 by defining $f \in \{f^0, f^1, \ldots, f^J\}$ where $f^0$ refers to the benchmark case (e.g., $f^0 = 0$) against which alternative treatments $\{f^1, \ldots, f^J\}$ are compared. An example of such an approach in a time series setting can be found in Angrist, Jordà, and Kuersteiner (2018).

Investigating dose responses in this manner is advantageous. No assumption is made on possible non-linear and non-monotonic effects of the treatment on the outcome. We know that, for example, drugs administered in certain doses can be quite beneficial, but doubling the dose does not mean that the benefit doubles—in fact, most drugs become lethal at higher and higher doses!

When doses vary continuously, say $-\infty < \delta < \infty$, extending the standard ignorability assumptions of the potential outcomes approach becomes impractical. There would be infinite potential outcomes (one for each value of the dose received) and, hence, we would be unable to recover parameters from finite samples. However, with little loss of generality, we can assume that variation in doses affect outcomes through a policy scaling factor $\delta = \delta(\boldsymbol{x})$. The dependence of $\delta$ on $\boldsymbol{x}$ captures policy considerations and also allows for non-monotonic effects in the choice of dose. Though we will assume below that the dose assignment does not depend on $\boldsymbol{x}$, we find it helpful to formally state the assumption described next.

Under this more general form of $\delta$, Equation 3 now requires a further assumption regarding the choice of dose given policy intervention in order for us to be able to identify the policy effect. A natural assumption is conditional mean independence of dose given assignment, stated as follows:

**Assumption 4. Conditional mean independence of dose given assignment**. *As in Assumption 2, let $\boldsymbol{y}_f = \boldsymbol{\mu}_f + \boldsymbol{v}_f$ with $\boldsymbol{v}_f = (\boldsymbol{x} - E(\boldsymbol{x}))\Gamma_f + \boldsymbol{\epsilon}_f$ where each row of $\Gamma_f$ corresponds to the vector $\gamma_f^h$ at each impulse response horizon, $h = 0, \ldots, H + 0$. Define the scaling factor $\delta(\boldsymbol{x})$. Then we assume that*

$$E[\delta(\boldsymbol{x})y_1 \mid \boldsymbol{x}) = \delta(\boldsymbol{x})\mu_1 \ .$$

*That is, $E[\delta(\boldsymbol{x})\boldsymbol{\epsilon}_1] = 0$, since $E[\delta(\boldsymbol{x})(\boldsymbol{x} - E(\boldsymbol{x}))\Gamma_f \mid \boldsymbol{x}] = 0$.*

(Notice that no further assumption is necessary regarding $\boldsymbol{y}_0$.)

Assumption 4 is a useful reminder of the conditions required to explore impulse responses in general settings. Because this paper introduces several novel elements, we henceforth restrict the analysis to the case where $\delta(\boldsymbol{x}) = \delta$ and leave for a different paper a more thorough investigation of non-monotonicities in dose assignment. This is a standard assumption in applied macroeconomics and it simply says that doubling the dose will double the response. We think that given the typical policy interventions observed, and given that outcomes are usually analyzed in logarithms — so that policy interventions have proportional effects — this is a very reasonable starting point.

Based on this simplifying assumption, Equation 6 can now be extended as follows,

$$y_{t+h} = \mu_0^h + (\boldsymbol{x}_t - \bar{\boldsymbol{x}})\gamma_0^h + \delta_t\,\beta^h + \delta_t(\boldsymbol{x}_t - \bar{\boldsymbol{x}})\boldsymbol{\theta}^h + \omega_{t+h} \;; \quad \text{for } h = 0, 1, \ldots, H;\ t = h, \ldots, T\,, \tag{10}$$

using the convention $\delta_t = 0$ iff $f_t = 0$. The parameters $\beta^h$ and $\boldsymbol{\theta}^h$have the same interpretation as in expression (8) in that scaling by the dosage allows one to interpret the coefficients on a per-unit-dose basis. In the fiscal policy application, this would correspond, say, to a 1% of GDP tightening in the fiscal balance. Dividing by, say, −2 would then equivalently generate responses to a 0.5 % of GDP *stimulus* instead. Importantly, the direct, indirect, and composition effects can be estimated using estimates from the extended local projections in Equation 10 in the same way as in the case of a binary treatment as explained in expression Equation 9.

## 3.5. Kitagawa-Blinder-Oaxaca impulse response functions

An interesting feature of the Kitagawa-Blinder-Oaxaca decomposition is that it allows us to evaluate the indirect effect of the policy intervention at a particular value of the controls. Auerbach and Gorodnichenko (2012) find asymmetric effects of government spending changes based on whether the economy is in a boom or a bust. Jordà and Taylor (2016) find similar asymmetries using the Guajardo, Leigh, and Pescatori (2014) dataset. In the monetary policy literature, for example, Angrist, Jordà, and Kuersteiner (2018) show that monetary policy loosening is less effective at stimulating the economy than tightening is at dampening it. Tenreyro and Thwaites (2016) find asymmetric effects based on whether the economy is in a boom or a bust. Jordà, Schularick, and Taylor (2020), using a different approach, find that low inflation environments and large output gaps seem to dull stimulative policy.

We now show how these, and many other scenarios, can be easily entertained jointly in our setup by using the Kitagawa-Blinder-Oaxaca decomposition and the *same* set of parameter estimates. In particular, notice that for a specific value of $\boldsymbol{x}$, say, $\boldsymbol{x}^*$, we have,[13]

$$\begin{aligned} E(\boldsymbol{y}_1 \,|\, \boldsymbol{x}^*, \delta) - E(\boldsymbol{y}_0 \,|\, \boldsymbol{x}^*, \delta = 0) &= \delta\mu_1 + \delta[\boldsymbol{x}^* - E(\boldsymbol{x})]\gamma_1 - \{\mu_0 + [\boldsymbol{x}^* - E(\boldsymbol{x})]\gamma_0\} \\ &= \beta + \delta[\boldsymbol{x}^* - E(\boldsymbol{x})]\boldsymbol{\theta}\,. \end{aligned} \tag{11}$$

Hence, based on the same estimates as those of the extended local projection in Equation 10, given a specific value of $\boldsymbol{x}^*$, the implied estimate of the impulse response at that value is

$$\delta\hat{\beta} + \delta(\boldsymbol{x}^* - \bar{\boldsymbol{x}})\hat{\boldsymbol{\theta}}\,, \tag{12}$$

and this holds for a given $\delta$, since the composition effect is zero. This happens because $(\boldsymbol{x}^* - \bar{\boldsymbol{x}})$ is the same for the treated and control subpopulations. Here we rely on the residuals having zero mean conditional on $\boldsymbol{x}$. It is also important to note that because identification usually centers on

[13]Since $E(\delta\epsilon_1 \,|\, \boldsymbol{x}^*) = 0$.

treatment assignment rather than identification for the controls, conditioning on certain values of $\boldsymbol{x}$ can only be interpreted from a partial equilibrium perspective. Nevertheless, because in time series applications lagged values of $\boldsymbol{x}$ are pre-determined with respect to the policy intervention, they are a legitimate description of a state of the world in which we envisage conducting the counterfactual experiment.

Before concluding this section, a few practical implications are worth highlighting. First, several hypotheses of interest underlie Equation 9. Absence of direct effects can be assessed by evaluating $H_0 : \beta^h = 0$; absence of indirect effects with $H_0 : \boldsymbol{\theta}^h = 0$; and absence of composition effects with $H_0 : \gamma_0^h = 0$. All these null hypotheses only require standard Wald tests directly obtainable from standard regression output given our maintained assumptions. Thus formal tests of economically meaningful hypotheses are easily reported as we show below.

Second, as noted earlier, although it is a convenient tool to investigate state-dependence, given the assumptions we have made, the Kitagawa-Blinder-Oaxaca decomposition lacks enough information to evaluate how the impulse response indirect effect would vary if, say, the control $x_{jt}$ increased by one unit. The reason is that we have made no assumptions about the assignment of the controls. We cannot infer causal effects about them without further assumptions. The measured indirect effect for the $j^{th}$ control could be polluted by any correlation with other controls, for example. Of course, this issue potentially confronts all papers in the literature on state-dependence in macroeconomics. The Kitagawa-Blinder-Oaxaca decomposition allows for a more systematic analysis of state dependence and clarifies how these identification issues arise. In the next section we will introduce an approach to explicitly address this issue in the context of monetary-fiscal interactions.

Third, in principle the $\boldsymbol{x}$ variables should be seen as controls and variables that might modulate the way in which treatment affects outcomes. To evaluate the impact of a policy intervention at any given point in time, we need to consider the whole vector $\boldsymbol{x}$ at the time of intervention. The impulse response function that follows from this decomposition is therefore a naturally time varying object. Our approach can therefore provide real-time estimates of the likely effect of a policy intervention given today's values for the "state" vector $\boldsymbol{x}$.

## 4. How does the fiscal multiplier depend on monetary policy?

Our goal is to study the dynamic causal effect of changes in fiscal policy on economic activity, allowing this effect to interact with the monetary policy regime. In this section we apply the Kitagawa-Blinder-Oaxaca decomposition to this question. As discussed above, in order to make causal statements we require identification of *both* the fiscal treatment variable and the variable measuring the monetary regime.[14] The first two sections below explains how we tackle these identification issues. We then present our main results.

[14] And, more generally, the researcher requires identified variation in any state variable of interest.

## 4.1. Data and approach

Identifying the causal effect of a change in fiscal policy requires some exogenous variation in policy, even if we are interested in the average effect. As a result, there is a large literature on the identification of exogenous changes in fiscal policy and we rely on an off-the-shelf and well-established dataset of exogenous fiscal interventions. Guajardo, Leigh, and Pescatori (2014) construct a cross-country panel dataset of plausibly exogenous movements in government spending and taxes that were introduced for the purpose of fiscal consolidation. The identification approach follows Romer and Romer (2010) and focuses on consolidations that were designed to tackle an inherited historical budget deficit, but were not responding to current business cycle fluctuations.

Although Guajardo, Leigh, and Pescatori (2014) use a mix of distributed lag models and vector autoregressions for estimation, in the next section we will follow Jordà and Taylor (2016) and employ local projections to show how the Kitagawa-Blinder-Oaxaca decomposition can be tractably applied to the estimation of impulse response functions in that framework. Following Equation 10 in Section 3, we estimate the following sequence of local projections,

$$y_{i,t+h} - y_{i,t-1} = \mu_i^h + (\boldsymbol{x}_{i,t} - \bar{\boldsymbol{x}}_i)\,\boldsymbol{\gamma}_0^h + f_{i,t}\,\beta^h + f_{i,t}\,(\boldsymbol{x}_{i,t} - \bar{\boldsymbol{x}}_i)\,\boldsymbol{\theta}_x^h + \omega_{i,t+h} \qquad h = 0, 1, \ldots, H, \tag{13}$$

where $y$ is a particular variable of interest, for example log GDP, the deficit to GDP ratio or the real interest rate; $t$ refers to the time period and $i$ refers to the country; $\mu_i^h$ is a country fixed effect; $f_{i,t}$ is the policy intervention or treatment, in this case the country-specific fiscal consolidation shock. $\boldsymbol{x}_{i,t}$ is the vector of additional covariates, with mean $\bar{\boldsymbol{x}}_i$.

In typical empirical fiscal multiplier papers, $\beta^h$ is the key object of interest: the percent effect on, e.g., GDP, following a 1% of GDP fiscal consolidation.[15] The Kitagawa-Blinder-Oaxaca interaction terms are typically ignored in Equation 13 or a particular specification is employed using a single state variable. In our framework, $\boldsymbol{x}_{i,t}$ are both control variables *and* characteristics of the treated subpopulation that may influence the way in which treatment affects the outcome. In principle, a broad range of $\boldsymbol{x}_{i,t}$ variables could modulate the effects of fiscal treatment and many $\boldsymbol{x}_{i,t}$ variables in macroeconomics will be highly correlated, making causal statements difficult.

In our baseline specification $\boldsymbol{x}_{i,t}$ includes the typical controls used in other studies. Specifically, we include two lags of real GDP growth, the deficit to GDP ratio, the change in the real interest rate and, following Jordà and Taylor (2016), the output gap to control for the state of the cycle.[16] In terms of the dependent variables, the response of the deficit to GDP ratio are not available in the Guajardo, Leigh, and Pescatori (2014) dataset, but is useful for computing certain definitions of the fiscal multiplier. We therefore merge the Guajardo, Leigh, and Pescatori (2014) fiscal consolidation shocks with the Jordà,

[15] This could be interpreted as one measure of a fiscal multiplier. But later we compute cumulative multipliers from the IRFs to explicitly take account of the full dynamic path of GDP and the fiscal variables.

[16] Including time fixed effects extends standard error bands without affecting the point estimates. Thus, to improve the precision of the estimates in the Kitagawa-Blinder-Oaxaca decomposition discussed below, we capture a time-varying global factor by including world real GDP growth.

Schularick, and Taylor (2017) Macrohistory Database (http://www.macrohistory.net/database/), which contains a wider array of variables that we can employ as outcomes in our local projection analysis.

As an empirical starting point, Figure 2 showing the impulse response functions estimated from Equation 13 under the assumption that $\theta_x^h = 0$. This is close to specifications typically seen in the existing literature and provides a baseline average effect. The figure shows that a 1% of GDP improvement in the government fiscal balance leads to a peak fall in GDP of around 1% over 4 years. Despite some differences in sample and specification, Panel (a) of Figure 2 is very similar to the original results in Guajardo, Leigh, and Pescatori (2014). The comparable IRF is shown in Figure 2 of the working paper (Guajardo, Leigh, and Pescatori, 2011), and is very similar to Figure 2, with a peak effect on GDP occurring 2–3 years after the shock, and between 0.5 and 1% in magnitude.[17]

Panel (b) of Figure 2 show how monetary conditions change on average. Real short term interest rates fall following a fiscal consolidation. To the extent that monetary policy can support the economy when GDP falls, the decline in the real short rate implies that the average fiscal consolidation is associated with monetary accommodation, which is perhaps not unexpected. The exact effect on GDP, however, will depend in the precise degree of accommodation by the monetary authority, in other words the strength of the "monetary offset" at the time. What we see in Figure 2 is only the effect on average. If the fall in the real rate were smaller, for example, we might expect to see a more severe contraction in GDP. Decomposing this average, and characterizing the heterogeneity around it, is, of course, the crux of this paper.

To decompose the average effect into the part related to the monetary offset, we start from the general Kitagawa-Blinder-Oaxaca equation above, Equation 13. For clarity, let $\boldsymbol{x}_{i,t}$ denote the vector of conventional covariates (discussed above) and we will now include a further covariate that captures the monetary regime in a particularly country. Denote this variable $\Theta_{i,t}$. Then we have

$$y_{i,t+h} - y_{i,t-1} = \mu_i^h + (\boldsymbol{x}_{i,t} - \bar{\boldsymbol{x}}_i)\,\gamma_0^h + f_{i,t}\,\beta^h + f_{i,t}\,(\boldsymbol{x}_{i,t} - \bar{\boldsymbol{x}}_i)\,\boldsymbol{\theta}_x^h + \underbrace{f_{i,t}\,\Theta_{i,t}\,\theta_f^h}_{\substack{\text{monetary-fiscal}\\ \text{interaction}}} + \omega_{i,t+h}\,. \tag{14}$$

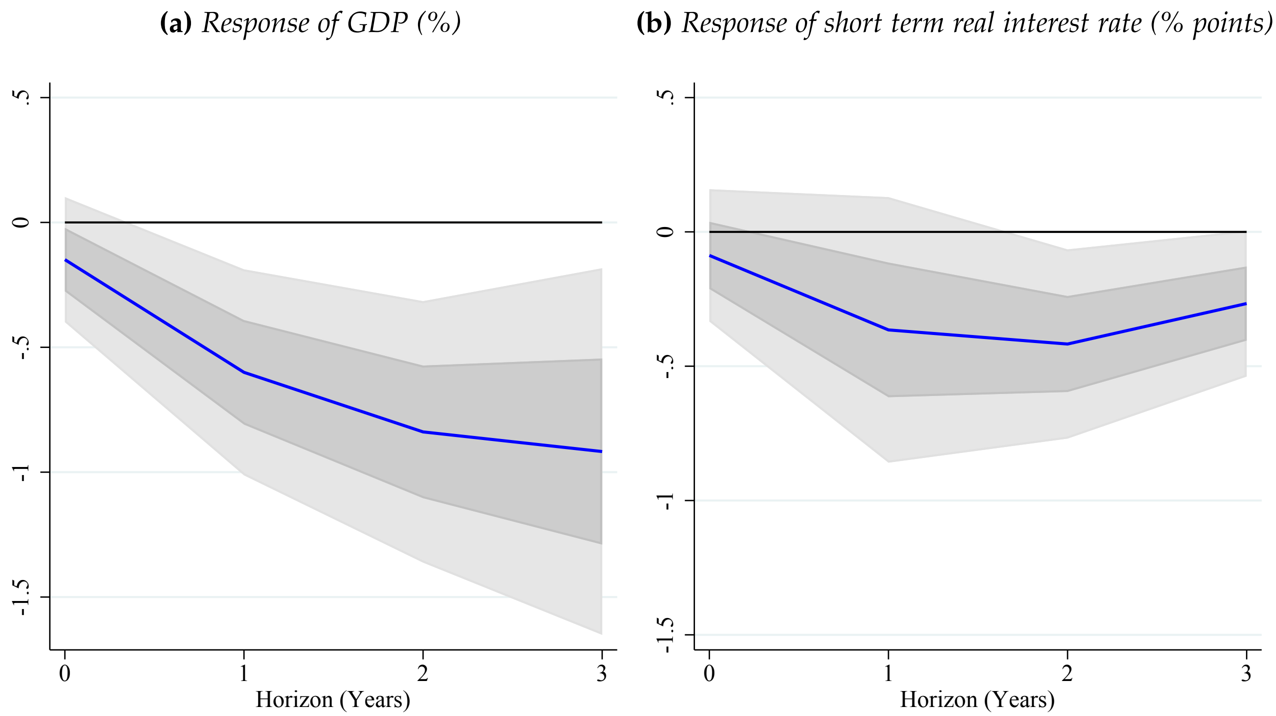
The term $f_{i,t}\,\Theta_{i,t}\,\theta_f^h$ explores how the effects of the fiscal intervention are modulated by the monetary

[17] Guajardo, Leigh, and Pescatori (2011, 2014) estimate the following type of empirical specification,

$$\Delta y_{i,t} = a_i + \lambda_t + \sum_{j=1}^{2} b_i\,\Delta y_{i,t-j} + \sum_{j=0}^{2} c_j\,F_{i,t-j} + e_{i,t}\,.$$

In the published paper $F$ is the change in the Cyclically Adjusted Primary Balance, instrumented with the newly constructed fiscal shocks, $f_{i,t}$. In the working paper version, the underlying impulse response functions for GDP following a 1% movement in the newly constructed fiscal shock are reported. As discussed in Ramey (2016), the 2SLS estimate of the multiplier is equivalent to computing the raw effect on the level of GDP and dividing this by the response of the endogenous fiscal variable (e.g., the cyclically-adjusted primary balance, CAPB, or the fiscal deficit). When we construct fiscal multipliers below we will follow a similar approach by effectively instrumenting the deficit to GDP ratio with the Guajardo, Leigh, and Pescatori (2014) constructed fiscal shocks.

**Figure 2:** *Effects of a 1 percentage point of GDP fiscal consolidation*




*Notes:* Vertical axes reported in percent change with respect to the origin. One and two standard deviation confidence bands for each coefficient estimate shown as grey areas. Local projections as specified in equation (13) excluding indirect effects and using two lags of each control described therein. Sample 1978:1–2009:4. See text.

regime in a particular country. From the Kitagawa-Blinder-Oaxaca decomposition, the indirect effect from a 1% of GDP fiscal consolidation is given by $\Theta_{i,t}\,\theta_f^h$.

As discussed in Section 3, this empirical specification follows from a *decomposition* approach. As such, without further assumptions, we cannot interpret the coefficients on the $\boldsymbol{x}$ variables as causal. This, of course, has implications for all existing papers studying state dependence. In our context the idea is that the strength of the monetary offset varies with the monetary regime: fiscal stimulus may be less effective if the monetary policymaker is a hawk. But to implement this we need a proxy for the monetary regime, i.e., $\Theta_{i,t}$, that can be used for identification of the monetary offset.[18]

To address this identification question, we take inspiration from Nakamura and Steinsson (2014) and Guren, McKay, Nakamura, and Steinsson (2020), who use the differential sensitivity of regions to more aggregate fluctuations as an identification strategy. In our approach, we use the differential sensitivity of interest rates to identified fiscal treatment across countries. Here we exploit the panel nature of our dataset. Our identifying variation relies on the idea that there is some cross-country variation in the monetary policy framework. This could be related to different preferences of policymakers, different historical attitudes towards the degree of stabilization, different compositions

[18]As noted earlier, monetary-fiscal interactions are about the monetary regime influencing the *subsequent* response of monetary policy rates. This environment is different to typical exercises studying state dependence, which tend to focus on how the effect of policy varies with some initial condition, e.g., the lagged output gap.

of the policy committees etc. In the model in Section 2, this idea is captured by variation in the coefficient in the Taylor Rule. For our empirical approach, we will exploit the panel nature of the fiscal dataset and focus on average cross-country differences in monetary policy behavior. As such, $\Theta_{i,t} = \Theta_i$.

The challenge, of course, is that the nature of the monetary regime is not directly observed. We therefore need to construct a proxy. The next section discusses a straightforward to implement proxy based on directly estimating the differential sensitivity of interest rates to fiscal treatment across countries. The identification assumption is that heterogeneity in the monetary regime explains the majority of the cross-country correlation of (exogenous) fiscal treatment and monetary policy rates in the data. In the following section we relax this assumption using a form of Taylor Rule estimation to extract a sensitivity-based proxy for $\Theta_i$.

## 4.2. A simple policy sensitivity-based proxy for the monetary regime

In this section, we propose a simple proxy for $\Theta_i$ based on the cross-country sensitivity of monetary policy rates to exogenous fiscal treatment. There are two steps. First, we estimate $\Theta_i$ by regressing the change in the *nominal* policy interest rate from $t-1$ to $t+h$ on the fiscal consolidation variable $f_{i,t}$, allowing the coefficient to vary by country. More specifically, we estimate the following sequence of local projections,

$$R_{i,t+h} - R_{i,t-1} = \mu_i^h + (\boldsymbol{x}_{i,t} - \bar{\boldsymbol{x}}_i)\,\gamma_0^h + \sum_{j=1}^{N} f_{i,t} \cdot \mathrm{I}\left[i = j\right] \cdot \tilde{\Theta}_i^h + \omega_{i,t+h}\,, \tag{15}$$

where $R_{i,t}$ is the short-run interest rate under the control of the monetary authority in country $i$ in time $t$. Our key variable of interest is $\tilde{\Theta}_i^h$ which is allowed to vary by country. $\tilde{\Theta}_i^h$ captures the differential sensitivity of policy rates in country $i$ to fiscal treatment.[19] We therefore use this as the basis of our proxy of the monetary regime in a second stage regression that explores heterogeneity in the fiscal multiplier.

In the second stage we estimate our main empirical specification, Equation 14 using the estimated coefficients $\tilde{\Theta}_i^h$ from the first step above as our proxy of the monetary regime. Note that in Equation 14 all covariates should be expressed relative to the mean. $\Theta_i$ in Equation 14 therefore refers to the de-meaned $\tilde{\Theta}_i^h$ from the first stage above.[20] Since we are interested in the dynamic

[19]In terms of other controls, $\boldsymbol{x}_{i,t}$ includes the lagged change in the policy rate to capture persistence in the policy rate and the regression also includes country fixed effects. For the baseline results we keep this specification parsimonious, which helps improve the precision of the estimates. We have also reproduced the main results considering more elaborate specifications with further controls. The results for how the multiplier varies with monetary policy are very similar, so we maintain the parsimonious specification for the baseline results. Part of the reason for this robustness is that we are constructing a proxy for the sensitivity of interest rates to shocks rather than trying to precisely identify the coefficients of the Taylor Rule.

[20]This ensures that our experiments below are relative to the "typical" average response of policy rates in the sample. The average of the coefficients from the first stage regression also accords with conventional wisdom about how monetary policy tends to loosen following a fiscal consolidation on average. For example,

causal effect via impulse response functions, all these steps are run for each $h$. The right hand side of Equation 14 therefore contains $f_{i,t}\,\Theta_i^h\,\theta_f^h$ . This is like interacting fiscal treatment at time $t$ with the predicted subsequent response of the real interest rate: $f_{i,t}\,\Theta_i^h$ is the fitted value for the *future interest rate response* from the first stage regression. As a result, this approach is like instrumental variables estimation where $f_{i,t}\,\Theta_i^h$ is the fitted value taken from the first stage. Our approach is therefore somewhat related to the sensitivity instrument approach of Guren, McKay, Nakamura, and Steinsson (2020).[21]

The identification assumption underlying this approach is that there is variation in the average response of monetary policy to shocks across countries but that this variation is not, on average, correlated with other factors that make the economy more sensitive to fiscal policy. Note that average differences across country are not a threat to identification, as these factors are captured by the country fixed effects. It is also not a problem if policy rates are more sensitive to *other* macroeconomic shocks, this is because our fiscal shocks are identified as orthogonal to other macroeconomic disturbances.[22] The strategy *is* therefore identifying how the fiscal multiplier varies with the cross-country sensitivity of policy rates to fiscal treatment.

The remaining issue is more specific. The concern is that this cross-country sensitivity of monetary policy to exogenous fiscal treatment might occur for reasons other than the monetary regime. This could occur if there is heterogeneity in the multiplier on average across countries for non-monetary reasons, and if monetary policy responds to fiscal treatment *indirectly*. In the next section we will show an extension to our approach that is robust to this concern, but it is worth making a few remarks here about the usefulness of the simpler approach in this section.

First, non-monetary multiplier heterogeneity would tend to attenuate the strength of the monetary offset, so at a very minimum, this approach puts a lower bound on the strength of the monetary offset. This is because larger contractionary forces would typically be associated with bigger—not smaller—movements in interest rates. In other words, a seemingly weak monetary policy response would be the result of a *smaller* underlying fiscal multiplier. Instead, we find that a less activist monetary regime is associated with much *larger* fiscal multipliers.

Second, we are already allowing for a sizable degree of unspecified state-dependence by admitting indirect effects via each of the controls already included in Section 4.1. Finally, the flexibility of this approach allows us to include additional cross-country controls that might be other candidates for multiplier heterogeneity. We consider a number of cases later in the robustness section and show our main results are not materially affected.[23]

in years 0, 1, 2 and 3 the average value of the country level coefficients is $-0.3, -0.6, -0.7$ and $-0.5$ respectively.

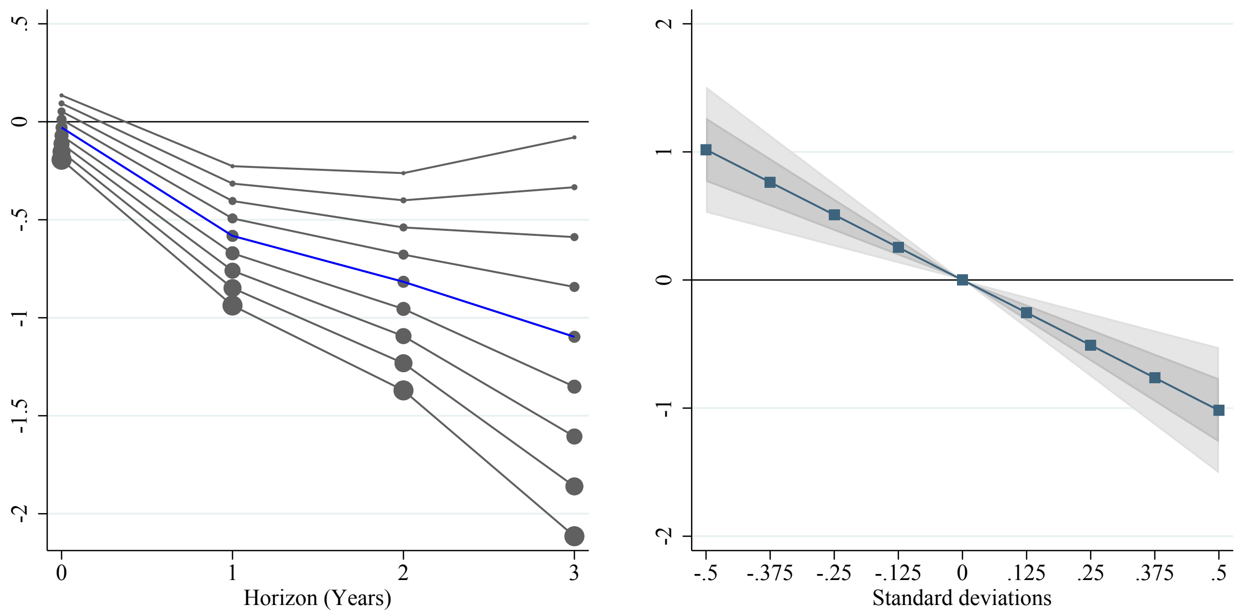
[21] We are therefore using cross-country heterogeneity in the country interest rate response to identified country-level shocks. This differs from Nakamura and Steinsson (2014) and Guren, McKay, Nakamura, and Steinsson (2020) who exploit differential local sensitivity to *common* aggregate or regional fluctuations.

[22] The appendix provides an illustration of how our approach a works in a simple two equation static system.

[23] Identification then comes from the residual variation in $\Theta_i$. A related logic applies to the approach in Guren et al. (2020) where other region-level controls are used to isolate the residual variation in the sensitivity instrument.

**Figure 3:** *Policy experiments varying the response of monetary policy*

**(a)** *GDP Response (%)* **(b)** *Indirect Effect for GDP $h = 3$*




*Notes:* Panel (a) shows how the response of GDP varies with the degree of monetary policy accommodation. The blue lines report the direct effect, which should be compared to the average effect in Figure 2. The gray lines consider experiments which vary the degree of monetary accommodation. A larger marker indicates a tighter monetary policy scenario. Panel (b) plots the indirect effect on GDP for the peak effect at $h = 3$. The figure illustrates the effect of the monetary-fiscal interaction relative to the average multiplier in the full sample. This also allows us to formally test whether the indirect effect is statistically significant. The light and dark gray areas refers to a confidence interval of two and one standard deviations.

We are now ready to examine how the fiscal multiplier varies with monetary policy. Below we show the results from estimating the Kitagawa-Blinder-Oaxaca specification Equation 14. To calculate the fiscal multiplier, two outcome variables are of interest: the cumulative percentage change in GDP, i.e. $y_{i,t+h} = {}^{(GDP_{i,t+h} - GDP_{i,t-1})}/_{GDP_{i,t-1}}$ and the cumulative change in the deficit ($D$) relative to initial GDP, $y_{i,t+h} = {}^{(D_{i,t+h} - D_{i,t-1})}/_{GDP_{i,t-1}}$.[24] The $\beta^h$ coefficients estimate the conventional impulse response function for the percentage change in the level of GDP or the deficit relative to GDP.

Figure 3 reports the main results from this exercise. Panel (a) shows the percentage response of GDP following a 1% of GDP fiscal consolidation (as measured by Guajardo, Leigh, and Pescatori, 2014). The central blue line in the fan reports the direct effect which, roughly, should be compared to the results from the linear model is Figure 2. As in Figure 2, GDP falls by around 1% over the course of 2–3 years. To examine how the effect varies with monetary policy, the gray lines then conduct experiments where we vary the indirect effect estimated using the Kitagawa-Blinder-Oaxaca decomposition from Equation 14. In particular, Figure 3 shows a range of scenarios where we vary $\Theta_i^h$, the sensitivity of interest rates to fiscal policy. In keeping with the Kitagawa-Blinder-Oaxaca formulation $\Theta_i^h$ — like all state variables — is expressed relative to its mean. The results therefore consider how the multiplier varies as we change the degree of monetary offset relative to the average

[24]This ensures the ratio of these two IRFs can be interpreted as a multiplier, as discussed below.

degree of accommodation in the sample (captured in the direct effect). In Figure 3 the size of the circular marker indicates a less activist (more contractionary) monetary policy. We vary $\Theta_i^h$ by one standard deviation, which produces real interest rate variation of the order of 100bps on average over the period (see Appendix Figure A.4). In the face of a fiscal consolidation (a negative shock to GDP), a more muted real rate response is consistent with less monetary accommodation and a larger fiscal multiplier. This is indeed what is shown in Figure 3. As monetary policy becomes less accommodative, the multiplier becomes larger. Appendix Figure A.4 reports the associated figure for the response of the real interest rate. As expected tighter monetary policy is associated with less accommodation in terms of the real interest rate.

Panel (b) of Figure 3 shows the indirect effect on GDP for the peak effect at $h = 3$ and the standard errors.[25] This figure therefore shows the effect of the monetary-fiscal interaction relative to the average multiplier in the full sample (the central blue line in Panel (a)). This also allows us to formally test whether the indirect effect is statistically significant. The light and dark gray areas refer to a confidence interval of two and one standard deviations. As shown in the figure, for less accommodative monetary policy regimes, the negative effect on GDP is nearly 1% larger than in the baseline and this effect is statistically significant. In Table A.1 we report the precise coefficient estimates for $\beta^h$ (the direct effect), $\theta_f^h$ (the strength of the indirect effect) and the standard errors at all horizons.[26]

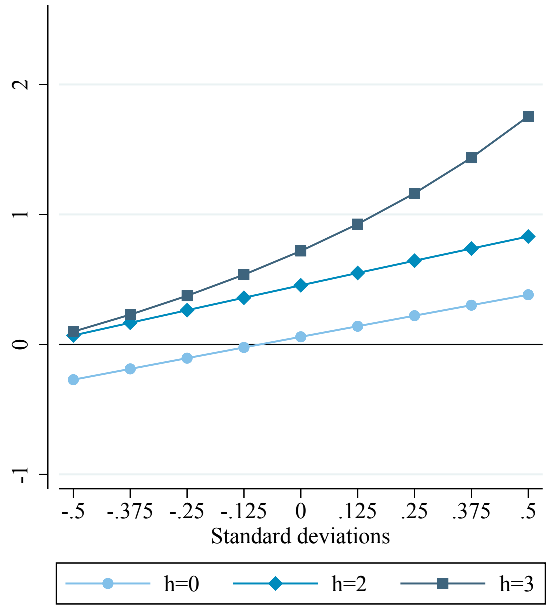
Although these responses for GDP can be roughly interpreted as a measure of the fiscal multiplier, the $f_{i,t}$ shocks may be noisy measures of the true policy change (see, e.g., Mertens and Ravn, 2013). As a statistic, the fiscal multiplier is typically defined as the $ movement in GDP for a one $ change in fiscal policy. Following Ramey (2016), this object can be computed empirically by estimating the effect on GDP and dividing by the associated change in the deficit relative to GDP. It is therefore instructive to also consider what happens to the deficit to GDP ratio to get a sense of the magnitude of the fiscal intervention in the data. The response of the deficit may also vary with the behavior of monetary policy, for example higher interest rates and lower demand could make it harder to reduce the deficit. The response of the deficit relative to GDP is shown in Figure A.2. A 1% fiscal consolidation (as measured by Guajardo, Leigh, and Pescatori (2014)) takes some time to have its full effect. The deficit to GDP ratio moves by around 0.5% in the current year, and is around 1% lower from the following year onwards. This path also depends on monetary policy, although in these experiments, there is not much state-dependence in the deficit to GDP ratio until the later years.

Dividing the results in Figure 3 Panel (a) by the associated change in the deficit is also equivalent to the 2SLS estimate of the multiplier using the Guajardo, Leigh, and Pescatori (2014) shocks as instruments for the deficit to GDP ratio. In our case this is a useful way of representing the multiplier because different experiments produce different paths of the deficit. This approach

[25] Standard errors computed using Monte Carlo, applied to both estimation of the proxy and second stage Kitagawa-Blinder-Oaxaca decomposition. Standard errors capture that $\Theta_i$ is a generated regressor.

[26] For presentational reasons, panel (a) of Figure 3 does not display the standard errors but Figure A.3 also visually shows that the direct effect (the blue line) is statistically significant.

**Figure 4:** *Cumulative fiscal multiplier by monetary response*



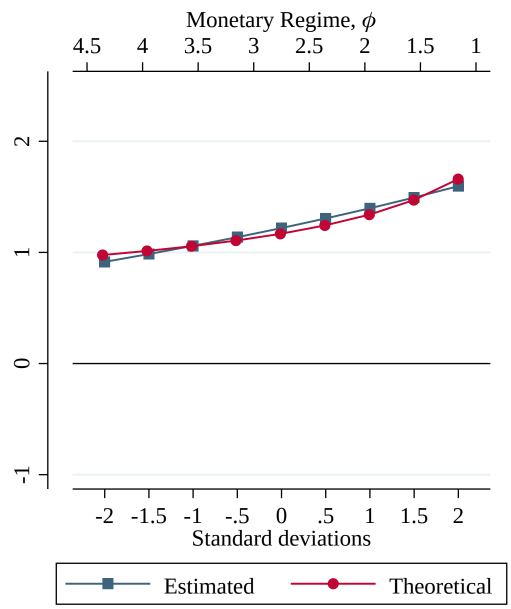

*Notes:* This chart shows the cumulative fiscal multiplier from each scenario in Figure 3. This is computed as the cumulative sum of the GDP response relative to the cumulative deficit to GDP response (based on Figure A.2). Each line refers to a different horizon, $h$. As in Figure 3, $h$ goes from the current year $h = 0$ to the third year after the shock $h = 3$. $h = 1$ is omitted to avoid overcrowding the figure. Moving from left to right on the horizontal axis implies a "less active" monetary policy which results in a larger multiplier.

therefore harmonizes the policy interventions across the scenarios. In computing the multiplier, we would also like to consider the differential effect on the deficit and GDP at all horizons. Since GDP is a flow, one can think of the cumulative lost GDP in dollars relative to the cumulative improvement in the deficit, also in dollars. This measure, known as the cumulative, integral, or present-value multiplier, is increasingly seen in the literature, as recommended by Uhlig (2010) and Ramey (2016) .

Figure 4 converts the state-dependent IRFs from Figure 3 and Figure A.2 into cumulative multipliers at different horizons. The cumulative multiplier is reported on the y-axis. As before, the x-axis varies $\Theta_i^h$ from –0.5 to +0.5 standard deviations. The three lines report the multiplier at different horizons. Note that the 0 point on the x-axis corresponds to the average treatment effect usually estimated in linear models. Interestingly, this is around or below 1 at *all* horizons. As monetary policy becomes more inert (rates are cut less aggressively in the face of falling demand), the multiplier rises. In these experiments the multiplier varies from around zero to nearly 2. Thus, in any fiscal intervention, the fiscal multiplier crucially depends on the monetary response. Interestingly, magnitudes around 2 are close to Keynes' original prediction of 2.5 (Keynes, 1936).

Finally, it is worth making a few remarks about the flexibility of this approach. Note that, in principle, by allowing fiscal policy interventions to have different marginal effects depending on the whole set of controls $x$, we can handle state-dependence in a very flexible and multivariate manner. The existing literature has often studied the effects of one dimension in isolation (or one at a time).

**Figure 5:** *Theoretical state dependence versus Kitagawa-Blinder-Oaxaca estimates*




*Notes:* This chart shows how the cumulative fiscal multiplier at 2 years varies with the monetary policy response both in the theoretical model and when the effect is estimated on simulated data. The red circles show the true theoretical variation by inflation coefficient $\phi$ (top horizontal axis). The blue squares show the empirical estimates obtained by using our Kitagawa-Blinder-Oaxaca decomposition estimates on data simulated from the model. The estimated monetary sensitivity parameter $\Theta_i$ is varied by 2 standard deviations (bottom horizontal axis). We simulate the model for 2000 periods, discarding the first 10%. For presentation, the theoretical results shown in the red line have been collapsed into nine bins to facilitate comparison with the nine points in the blue line. Moving from left to right on the horizontal axis implies a "less active" monetary policy which results in a larger multiplier.

## 4.3. The theoretical model revisited

To illustrate further how our approach works, we now conduct the same empirical experiment above, but using simulated data from the theoretical model in section 2. Specifically, we simulate data from the model for a hypothetical set of "countries" where each country differs in how monetary policy responds to inflation.[27] This environment theoretically captures the identification assumptions made in the previous section.[28]

The results are shown in Figure 5. The red line with circles shows how the cumulative fiscal multiplier varies with $\phi$ in the model, this line is the "true" theoretical result and repeats the red line in Figure 1 for reference, with $\phi$ on the top horizontal axis. The blue line with squares shows the Kitagawa-Blinder-Oaxaca decomposition-implied fiscal multiplier. We apply exactly the same empirical approach from the previous section to simulated data from the model. As in the previous section, the response of interest rates to the fiscal shock is estimated by "country" and this coefficient

[27] We use the term "country" loosely here. In this simple example these are simply cross sectional units with different degrees of monetary accommodation.

[28] Our goal is to illustrate how the Kitagawa-Blinder-Oaxaca approach identifies the importance of monetary-fiscal interactions for the size of the fiscal multiplier. This section does not develop a theoretical framework to quantitatively rationalize the magnitudes found in the previous section.

is used as a state variable in the Kitagawa-Blinder-Oaxaca decomposition. The bottom horizontal axis refers to standard deviations of this object.[29] The figure shows that the Kitagawa-Blinder-Oaxaca decomposition captures the monetary interaction in the simulated data very well.[30]

Two important results flow from this exercise. First, it shows that the identification approach outlined in the previous section, using differential sensitivity of interest rates to fiscal shocks across countries to identify how the fiscal multiplier varies with the systematic part of monetary policy, works well. Second, the Kitagawa-Blinder-Oaxaca decomposition is a very effective way of isolating state-dependence in the fiscal multiplier. Finally note that, although the model is deliberately simple, more elaborate features and/or changes to the calibration would simply change the quantitative magnitudes in Figure 5, not the two main results mentioned here.

## 4.4. Allowing for multiplier heterogeneity

The previous section considered a straightforward and easy to implement approach to constructing a proxy for the monetary regime. This was based on the sensitivity of policy rates to fiscal treatment. In this section, we consider a more general approach that relaxes the identification assumptions made in the simpler approach. Rather than constructing a proxy by regressing policy rates on the fiscal shock directly, this section makes use of a more conventional Taylor Rule-type approach.

To motivate this further approach, and fix ideas, consider again the policy rule from the model in section 2, with

$$\hat{R}_t \;=\; \rho_i \, \hat{R}_{t-1} \;+\; (1-\rho_i)\, \phi^i \, \hat{\pi}_t \,, \tag{16}$$

The variation we are interested in capturing is the idea that the policy rule may vary across country $i$ through variation in $\phi^i$.

Note that, as discussed in the previous section, our sensitivity approach can be seen as a form of instrumental variables. We are not necessarily trying to identify all the specific individual parameters of the Taylor Rule. Instead, all we need is to obtain a proxy for the sensitivity of interest rates to the economy where the ranking across countries is correctly captured.

We can therefore estimate a more reduced form expression,

$$\hat{R}_t \;=\; \alpha^i_l \, \hat{R}_{t-1} \;+\; \alpha^i_\pi \, \hat{\pi}_t \,, \tag{17}$$

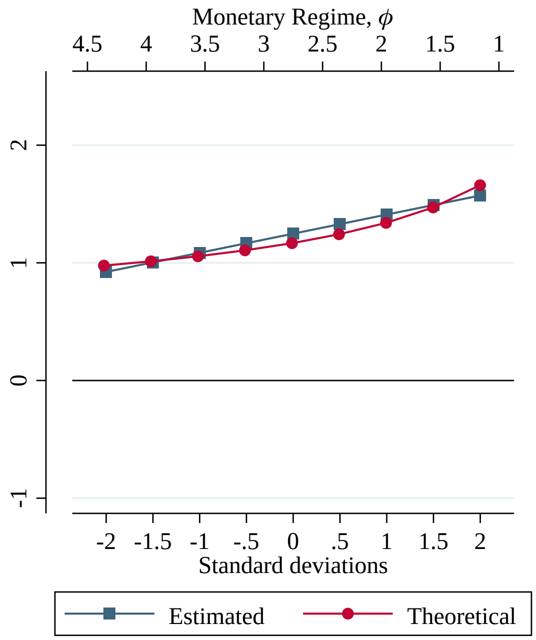
where there is a monotonic mapping between the cross-country variation in $\phi$ and $\alpha_\pi$. We therefore estimate a variant of Equation 15 but where the $f_{i,t}$ variable is replaced with inflation. In keeping with the Taylor Rule estimation literature, we then instrument inflation with its lag. The coefficient

[29]The figure uses 2 standard deviations which captures well the range of different $\phi$ values in the simulated data. Note that, the Kitagawa-Blinder-Oaxaca indirect effect estimates a non-linear function of the model's parameters so there is a monotonic but not one-to-one mapping between $\phi$ and the indirect effect estimated in the data. There is also not an easy way to analytically map the estimated coefficients to the model parameters, which is why the x-axis still relies on standard deviations and we present two axes.

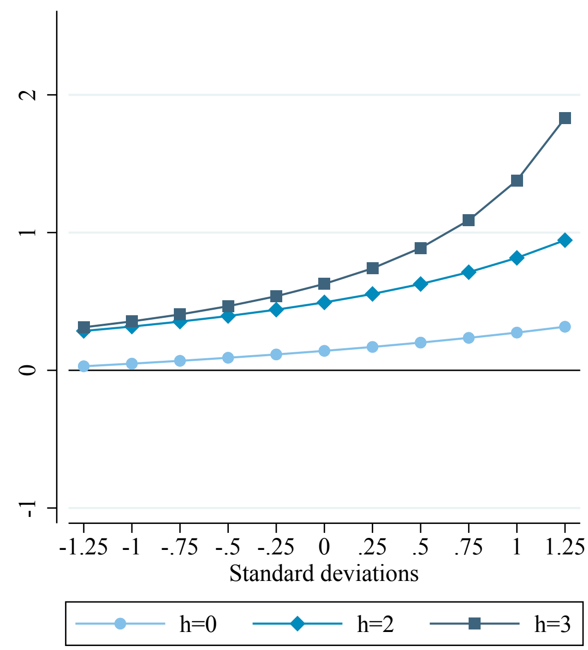
[30]The only discrepancy is that the model's solution is slightly non-linear in $\phi$.

**Figure 6:** *The cumulative fiscal multiplier by monetary response: more general approach*

**(a)** *True theoretical versus estimates*




**(b)** *Empirical fiscal multiplier by monetary response*




*Notes:* Panel (a) shows how the cumulative fiscal multiplier at 2 years varies with the monetary policy response both in theory and when the effect is estimated on simulated data. The red circles show the true theoretical variation by inflation coefficient (top x-axis). The blue squares show the empirical estimates obtained by using our Kitagawa-Blinder-Oaxaca decomposition estimates on data simulated from the model. The estimated monetary sensitivity parameter $\Theta_i$ is varied by 2 standard deviations (bottom x-axis). For presentation, the theoretical results shown in the red line have been collapsed into nine bins to facilitate comparison with the nine points in the blue line. This figure is produced using an extended version of the model where the other structural parameters of the model also vary by "country". The monetary regime is then estimates from a Taylor Rule regression. See main text for details. Panel (b) shows the cumulative fiscal multiplier varying the degree of monetary offset. This is computed as the cumulative sum of the GDP response relative to the cumulative deficit to GDP response. Each line refers to a different horizon, $h$. As in Figure 3, $h$ goes from the current year $h = 0$ to the third year after the shock $h = 3$. $h = 1$ is omitted to avoid overcrowding the figure. Relative to the baseline figure in the main text, this is produced using the alternative monetary regime proxy as discussed in Section 5. Note that the standard deviation of the two proxies (the new proxy and the baseline method) are different. The experiment here is therefore calibrated so the real interest rate varies on impact by a similar amount to the baseline figure.

$\Theta_i$ is then a proxy for the cross-country sensitivity of interest rates to inflation.

To illustrate how this works, the first panel of Figure 6 implements this approach with simulated data from the theoretical model. In the model we allow for heterogeneity in $\phi^i$, but also also allow for cross-country heterogeneity in the other structural parameters of the model. In particular, the model now features "cross-country" heterogeneity in the share of non-savers, the degree of price stickiness, the persistence of the fiscal shock and the Frisch elasticity. Panel (a) in Figure 6 is the counterpart of Figure 1 and shows that even in this more general environment our Kitagawa-Blinder-Oaxaca approach still correctly recovers how the fiscal multiplier varies with the monetary offset.

The intuition for why this more general approach works is similar to the discussion in the previous section. $\Theta_i f_{i,t}$ is a type of sensitivity instrument. In our simpler approach $\Theta_i f_{i,t}$ was the predicted interest rate response directly from the first stage regression. In this more general approach, $\Theta_i f_{i,t}$ is a *counterfactual prediction* for the interest rate response assuming that differences in the interest rate response are only generated by variation in the monetary regime, $\Theta_i$.

The second panel of Figure 6 then conducts the same experiment in the data. The results are broadly similar to the baseline findings, with some evidence of a downward bias in our simpler approach. The drawback of this more flexible method is that it requires making assumptions about the arguments of the Taylor Rule, so it is not as transparent or easy to implement.[31] As a result, we see both approaches to implementing our sensitivity proxy idea as useful approaches to examining the strength of the monetary offset in the data.

To conclude this section, it is worth noting the flexibility and general applicability of our approach. In principle, these methods could be used to study the role of other sources of heterogeneity in the fiscal multiplier. The challenge, of course, would be to find good proxies for those characteristics that could be used for identification. This seems an interesting avenue for future work.

# 5. Robustness and extensions

In this section we subject our approach to several robustness checks and extensions.

## 5.1. Tax- versus spending-led consolidations

It is possible that countries differ in the composition of the fiscal consolidation. For example, some countries may rely more on tax increases than spending cuts. The fiscal multiplier literature has often noted differences in spending versus tax multipliers. Furthermore, Guajardo, Leigh, and Pescatori (2014) find that tax-based consolidations are more contractionary.

This could affect our results in the following way. Suppose, for example, that tax multipliers are larger than those for spending (for reasons unrelated to monetary policy, as is the case in some macro models). Different policies might then induce different relative movements in GDP and interest rates. If countries differ in their *average* reliance on tax increases versus spending cuts, this could conceivably be captured in the $\Theta_i$ in our simple sensitivity proxy approach. It should not, however, bias the Taylor-Rule approach provided that the degree of monetary activism is uncorrelated with the fiscal authorities preferences for adjusting taxes versus spending.

The flexibility of the Kitagawa-Blinder-Oaxaca specification allows us to investigate and control for this effect. Specifically, we construct a country-specific measure of the average propensity to use tax increases versus spending cuts.[32] We then interact this cross-country characteristic with the fiscal treatment $f_{i,t}$, essentially adding it as an additional Kitagawa-Blinder-Oaxaca state variable. The *residual* variation in $\Theta_i$ is then being used to examine the monetary offset.[33]

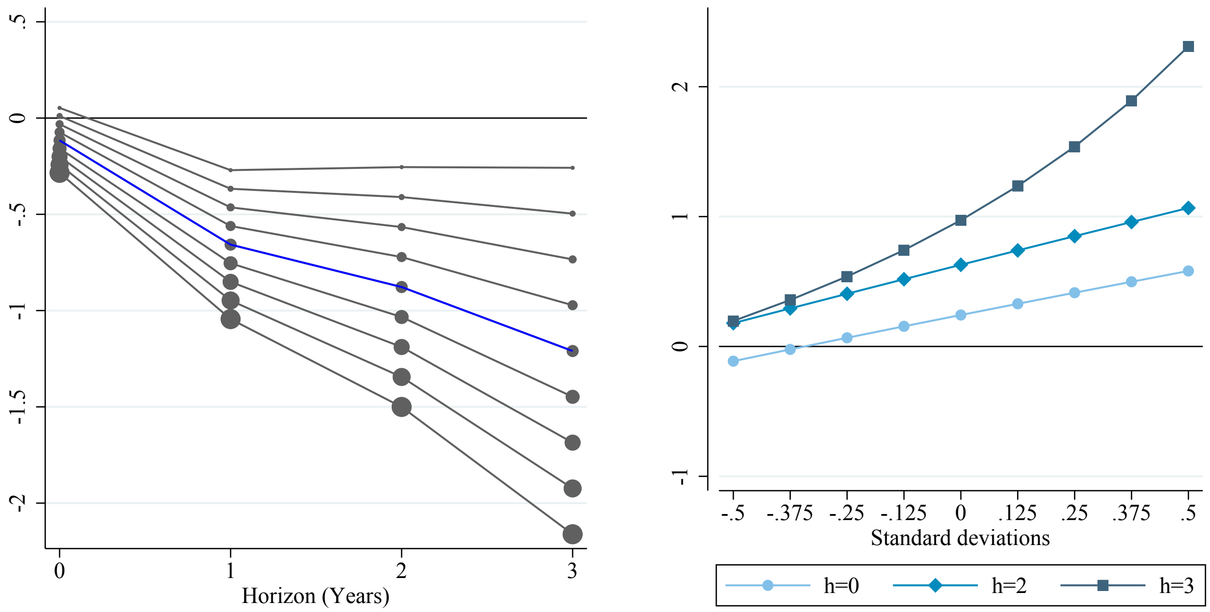
[31] As an extension we considered a factor approach where inflation above is replaced by the first principal component of inflation and the output gap. This is one way to incorporate more arguments in the rule but estimate a single parameter to act as the proxy for the monetary regime. The results are very similar.

[32] In particular, we calculate the share of consolidation episodes that are tax-led by country.

[33] Guren, McKay, Nakamura, and Steinsson (2020) follow a similar logic to focus on residual variation in their sensitivity instrument, albeit in a different setting where the variation of concern is a time-region effect.

**Figure 7:** *Policy experiments: time fixed effects*

**(a)** *Response of GDP (%)* **(b)** *Cumulative fiscal multiplier by monetary response*




*Notes:* Panel (a) shows how the response of GDP varies with the degree of monetary policy accommodation. The blue lines report the direct effect. The gray lines consider experiments which vary the degree of monetary accommodation. A larger marker indicates a tighter monetary policy scenario. Panel (b) reports the associated cumulative fiscal multiplier. Relative to baseline Figure 3 and Figure 4, the specification in these figures include time fixed effects rather than world GDP growth.

The results of this exercise are shown in Figure A.5. The estimated monetary offset is very similar to the baseline case.

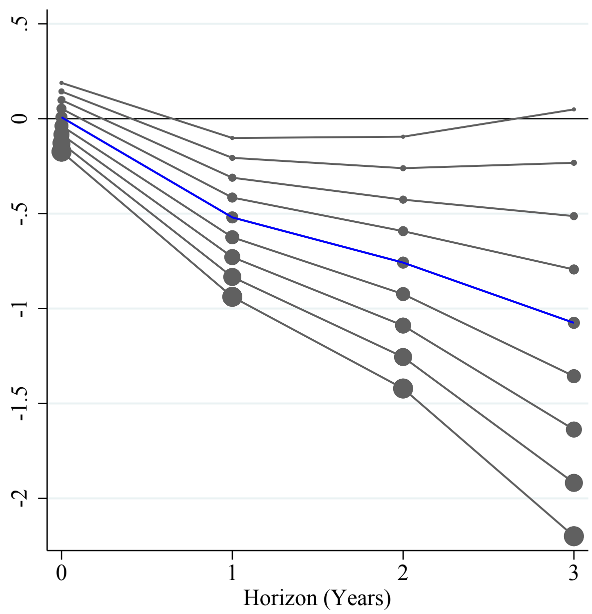
## 5.2. Global factors

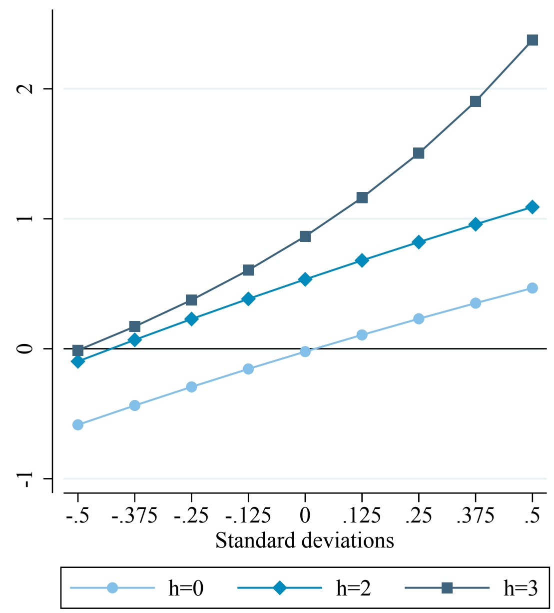
In the baseline specification we included world GDP growth to capture time varying global factors that might account for the timing of particular fiscal consolidations. In the original Guajardo, Leigh, and Pescatori (2014) paper, the authors use time fixed effects as a more general way of capturing global factors. Earlier we noted that this seems to come at the cost of precision in our specification, but in this section we re-estimate our main results for the monetary-fiscal multiplier using time fixed effects rather than world GDP growth.

The results are shown in Figure 7. These figures are very similar to the baseline specification in Figure 3 and Figure 4. Our use of world GDP growth does not, therefore, affect our main results.

The strategy used above could also be applied to rule out other cross-country concerns, although these types of issues are also dealt with in a more general sense in the previous subsection using a different approach.

**Figure 8:** *Policy experiments: controlling for trade openness*




*Notes:* Panel (a) shows how the response of GDP varies with the degree of monetary policy accommodation. The blue lines report the direct effect. The gray lines consider experiments which vary the degree of monetary accommodation. A larger marker indicates a tighter monetary policy scenario. Panel (b) reports the associated cumulative fiscal multiplier. Relative to baseline Figure 3 and Figure 4, the specification in these figures controls for the influence of openness on the fiscal multiplier.

## 5.3. Openness

A number of papers in the open economy macroeconomics literature have noted that the fiscal multiplier may vary with the degree of openness (e.g. Ilzetzki, Mendoza, and Végh (2013) find that more open economies tend to have smaller fiscal multipliers). To what extent are our main results driven by variations in openness across countries? Note that, if our sensitivity proxy is correctly ranking countries based on the degree of monetary activism, variations in openness should not be biasing our findings. But one may be concerned that variation in openness is correlated with our monetary proxy, therefore confounding the conclusions.

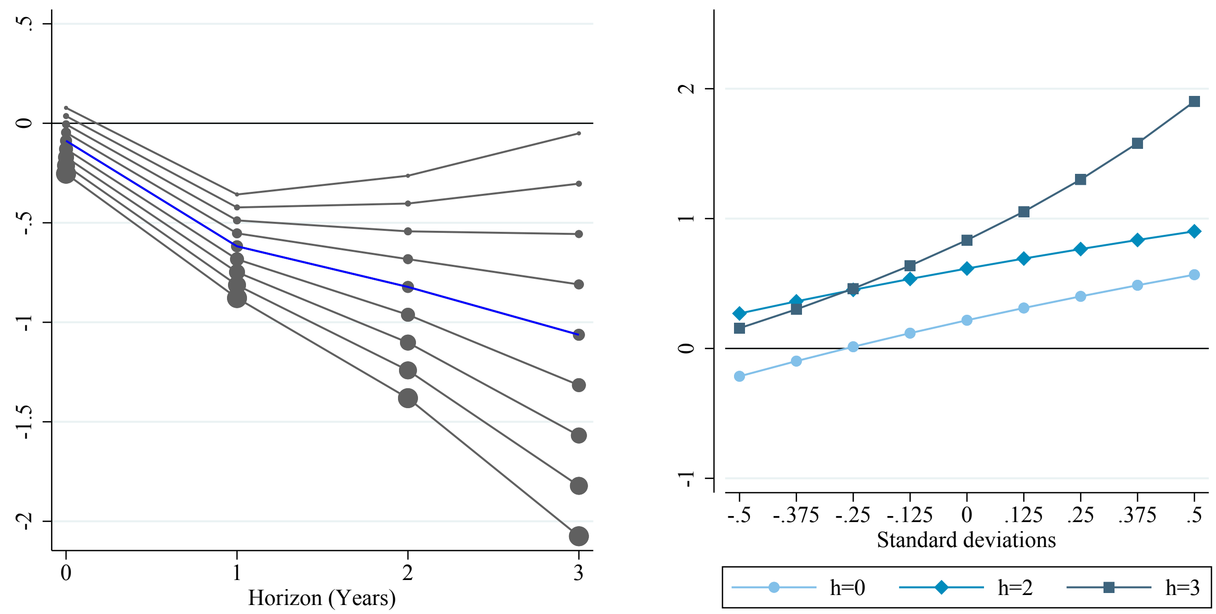
The flexibility of our approach is that we can easily check this by including trade openness as an additional state variable. We measure openness as exports plus imports relative to GDP and include this in the vector of state variables $x$. The results are shown in Figure 8. The GDP and multiplier plots are very similar to the baseline case, and the multiplier varies from around 0 to 2.

## 5.4. Lag structure

If the fiscal shocks reflect purely random variation, the choice of additional controls should not affect the main set of estimates. In small samples however, serial correlation could potentially be an issue. As a further robustness check we show that the main results are not overturned by using

**Figure 9:** *Policy experiments: longer lag structure*

**(a)** *Response of GDP (%)* **(b)** *Cumulative fiscal multiplier by monetary response*




*Notes:* Panel (a) shows how the response of GDP varies with the degree of monetary policy accommodation. The blue lines report the direct effect. The gray lines consider experiments which vary the degree of monetary accommodation. A larger marker indicates a tighter monetary policy scenario. Panel (b) reports the associated cumulative fiscal multiplier. Relative to baseline Figure 3 and Figure 4, the specification in these figures include 3 lags of all controls in $x$.

a slightly longer lag structure for the controls. In the baseline results we chose two years of lags. Note that, relative to standard empirical papers using quarterly data, this is already controls for a reasonable degree of persistence. We also face a trade-off in that longer lag structures lead to loss of data and more parameters to be estimated.

That said, we re-run our main results using three years of lags (equivalent, of course, to 12 quarters of lags in typical macro papers). Figure 9 shows that the results are very similar to the baseline findings in Figure 3 and Figure 4.

## 5.5. Monetary-fiscal interactions using shocks

To further corroborate the magnitudes found above, in this section we consider a different approach to studying monetary-fiscal interactions. Instead of relying on variation in the response of interest rates to fiscal policy across countries, here we use an approach based on monetary policy shocks.

To motivate the approach consider the following simple motivating setup:[34]

$$y_{i,t} = \delta_f f_{i,t} + \delta_r r_{i,t} + u^y_{i,t}, \tag{18}$$

$$r_{i,t} = \Theta_y y_{i,t} + \Theta_f f_{i,t} y_{i,t} + u^r_{i,t}. \tag{19}$$

[34] A related setup is considered in the Appendix, which illustrates the baseline approach used earlier.

Here $y_{i,t}$ denotes real GDP growth and $r_{i,t}$ denotes the real rate. For simplicity, assume the fiscal intervention is binary with $f_{i,t} \in [0, 1]$ and that the monetary authority sets the real interest rate directly. In this case, the sensitivity of interest rates to fiscal policy does not vary across country, but it does vary with the type of shock. During episodes of fiscal treatment, the monetary authority may respond to output fluctuations differently than in other periods. In the formulation above, this is captured by the $\Theta_f$ term, which is only relevant in periods of fiscal treatment. Note that, when there is no fiscal treatment, $f_{i,t} = 0$.

We can combine these expressions to create a reduced form equation. Given the binary nature of this example, we can then inspect the reduced form in the case of treatment, $f_{i,t} = 1$ and no treatment, $f_{i,t} = 0$. The resulting equation for estimation can be written as:

$$y_{i,t} = \beta_f f_{i,t} + \beta_r u^r_{i,t} + \beta_{rf} u^r_{i,t} f_{i,t} + u^y_{i,t}, \tag{20}$$

where

$$\beta_r = \frac{\delta_r}{1 - \delta_r \Theta_y}, \qquad \beta_f = \frac{\delta_f}{1 - \delta_r (\Theta_y + \Theta_f)}, \qquad \beta_{rf} = \frac{\delta_r}{1 - \delta_r (\Theta_y + \Theta_f)} - \beta_r .$$

The third term on the right hand side of Equation 20 captures the indirect effect from the interaction of monetary and fiscal policy. The amount of accommodative monetary policy is captured by the size of the monetary shocks $u^r_{i,t}$ (since these capture the policy stance relative to what would have been expected given the rule). The indirect effect captures the fact that, less accommodative monetary policy may translate into a larger recession during periods of fiscal treatment.

In estimating an equation of the form of equation 20 the technical challenge is that we do not observe $u^r_{i,t}$ directly and commonly constructed proxies for $u^r_{i,t}$ are usually only available for countries like the United States. To our knowledge, there is no consistent cross-country dataset of monetary policy shocks. In this section, as a robustness check, we therefore rely on a simple approach to validate the results in the previous section.

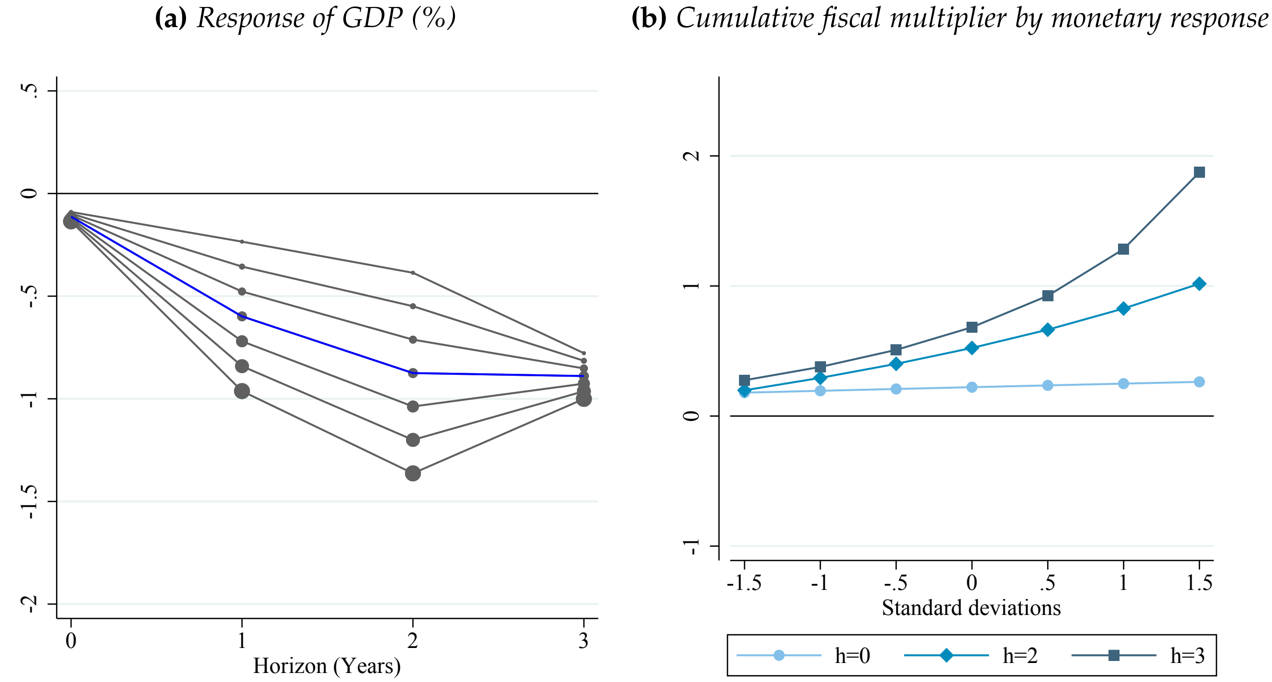
First, using a panel ordered probit, we predict the probability of observing an interest rate change based on two lags of GDP growth, inflation, the lagged change in the policy rate, and world GDP growth. We are implicitly assuming a common policy rule across countries. Monetary policy shocks are then constructed as follows,

$$u^r_{i,t} = \Delta R_t - (p_{-1} \times -1 + p_0 \times 0 + p_{+1} \times 1),$$

where $R_t$ is the nominal policy rate and the $p$ terms are the predicted probabilities of a rate cut, no change or an increase. This approach therefore attempts to remove the predictable component of monetary policy. As in the previous section, the Kitagawa-Blinder-Oaxaca decomposition is estimated from the following regression,

$$y_{i,t+h} = \mu^h_0 + (\boldsymbol{x}_{i,t} - \bar{\boldsymbol{x}}_i)\, \gamma^h_{0,x} + u^r_{i,t+h}\, \gamma^h_{0,r} + f_{i,t}\, \beta^h + f_{i,t}\, (\boldsymbol{x}_{i,t} - \bar{\boldsymbol{x}}_i)\, \boldsymbol{\theta}^h_x + f_{i,t}\, u^r_{i,t+h}\, \theta^h_r + \omega_{i,t+h} . \tag{21}$$

**Figure 10:** *Policy experiments: an alternative approach*




*Notes:* Panel (a) shows how the response of GDP varies with the degree of monetary policy accommodation. The blue lines report the direct effect. The gray lines consider experiments which vary the degree of monetary accommodation. A larger marker indicates a tighter monetary policy scenario. Panel (b) reports the associated cumulative fiscal multiplier. Relative to baseline Figure 3 and Figure 4, this figure is produced using an alternative approach to monetary-fiscal interactions, as discussed in the text.

The main difference from the previous section is that the future stance of monetary policy during the consolidation episode is captured by the deviation of the policy from what was expected, i.e., the shock term $u^r_{i,t+h}$.

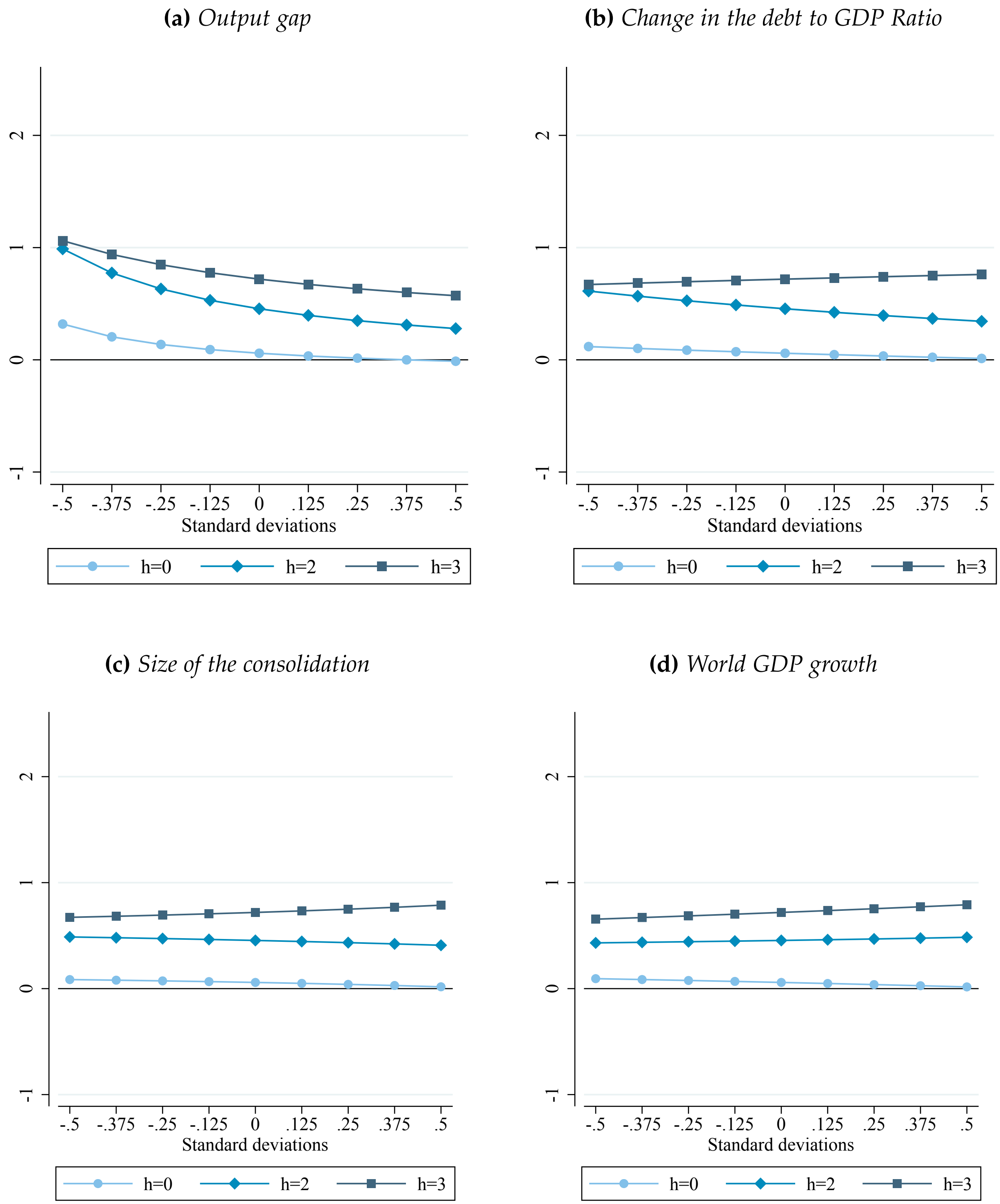
Figure 10 shows the results. Once again, the first panel shows the effect on GDP on average (blue line), and for tighter and looser monetary policy during the consolidation episode (gray lines). We consider experiments from −1.5 standard deviation shocks to +1.5 standard deviation shocks. We use a wider range for this experiment as a one-standard deviation shock produces smaller variations in interest rates. Episodes with tighter monetary policy are associated with a much larger fall in GDP. In Figure A.6, the deficit to GDP ratio also improves by less in these more contractionary episodes. In Figure 10 Panel (b), we therefore report the cumulative fiscal multiplier. The multiplier rises to nearly 2 when monetary conditions are tight.

## 5.6. Other forms of state-dependence

Our regressions contain a number of other state variables and the Kitagawa-Blinder-Oaxaca decomposition allows us to consider how the fiscal multiplier varies along each of these dimensions while controlling for the other states.[35] Figure 11 shows how the multiplier varies according to each of the

[35] This is a type of selection-on-observables strategy and, of course, there still remains a question about whether these variables can be moved around assuming "all else equal". Still, these dimensions of hetero-

**Figure 11:** *Other forms of state dependence in the fiscal multiplier*




*Notes:* This chart shows how the cumulative fiscal multiplier varies with the other state variables in our regressions. As before, the multiplier is computed as the cumulative sum of the GDP response relative to the cumulative deficit to GDP response. Each line refers to a different horizon, $h$. As in Figure 3, $h$ goes from the current year $h = 0$ to the third year after the shock $h = 3$. $h = 1$ is omitted to avoid overcrowding the figure. Panel (a) shows variation in the multiplier depending on the size of the (lagged) output gap, Panel (b) is for difference changes in the (lagged) deficit to GDP ratio, Panel (c) varies the size of the fiscal consolidation and Panel (d) varies World GDP growth.

other macro controls in our regressions, holding the other variables constant. The other variables are the output gap, the change in the fiscal deficit to GDP ratio, World GDP growth and the size of the fiscal consolidation.[36]

Figure 11 shows that along each of these dimensions, once we control for the other variables simultaneously, there is only sizable state dependence by the size of the output gap. This confirms results in the existing literature, such as Auerbach and Gorodnichenko (2012) and Jordà and Taylor (2016), that fiscal multipliers tend to be larger in periods of above-average slack. To the extent that a large change in the deficit to GDP ratio is associated with fiscal stress, our results do not suggest a smaller multipliers in these states. Further, the multiplier does not seem to be smaller for larger consolidations, which was one regularity considered in the expansionary fiscal consolidations literature.

## 6. Conclusion and policy implications

This paper has shown that using the Kitagawa-Blinder-Oaxaca decomposition from applied microeconomics in a local projections framework, the impulse response can be decomposed into (1) the *direct* effect of the intervention on the outcome; (2) the *indirect* effect due to changes in how other covariates affect the outcome when there is an intervention; and (3) a *composition* effect due to differences in covariates between treated and control subpopulations. This provides a unified framework for decomposing average treatment effects and evaluating policy-dependence, state-dependence and the balance conditions for identification in a multi-dimensional setting.

A natural application of this logic is in the area of monetary-fiscal interactions. The fiscal multiplier is a key statistic for understanding how fiscal policy changes might stimulate or contract the macroeconomy. The size of the multiplier has been a subject of intensive debate since the Global Financial Crisis in 2008. But, despite the importance of this object, there is still much disagreement about existing empirical estimates. A large literature has focused on tackling the inherent identification issues that researchers face in this area. Our paper tackles a more conceptual problem: there is no such thing as *the* fiscal multiplier in the data. One of the most obvious reasons is that monetary policy may not offset the effects of fiscal policy in the same way across time or across countries. We show that the Kitagawa-Blinder-Oaxaca decomposition provides a natural way to try to disentangle these effects and decompose the drivers of variation in the multiplier.

Our main result is that fiscal multipliers can be large when monetary policy is less activist. This accords with conventional wisdom and the mechanism can be found in many models. To date,

geneity are important and common in the literature and it is interesting to revisit these in our framework. In the literature, state dependence is often investigated by considering one dimension at a time and with a variety of empirical specifications, although typical macro variables that are often used to define the state are likely to be highly correlated. For example, boom periods are likely to be correlated with periods of high inflation, high house prices, and potentially high private credit growth.

[36]Our main regression also includes GDP growth. The results are very similar to those using the output gap and are thus omitted for brevity.

despite the key policy relevance of the issue, empirical evidence on the magnitude of this important interaction remains somewhat limited. In our experiments, fiscal multipliers can be as low zero or as high as 2 and above, depending on the actions of the monetary authority. This has important implications for measuring "the multiplier" and for evaluating and predicting the likely effects of particular macro-policy interventions.

The Kitagawa-Blinder-Oaxaca decomposition we propose also has wider implications for measuring the effects of all kinds of policy treatments in macroeconomics, and can allow for many other possible dimensions of heterogeneity in a very flexible way. Using our decomposition approach, the tasks of estimation and inference can be easily undertaken by using standard linear regression methods while still being sufficiently general to allow for a great deal of unspecified state dependence and time-variation. We therefore hope these techniques will be of use to all researchers interested in the study of state-dependent, non-linear, and time-varying effects of policy interventions more generally.

## References


Acconcia, Antonio, Giancarlo Corsetti, and Saverio Simonelli. 2014. Mafia and Public Spending: Evidence on the Fiscal Multiplier from a Quasi-experiment. *American Economic Review* 104(7): 2185–2209.

Angrist, Joshua D., Òscar Jordà, and Guido M. Kuersteiner. 2018. Semiparametric Estimates of Monetary Policy Effects: String Theory Revisited. *Journal of Business & Economic Statistics* 36(3): 371–387.

Auerbach, Alan J., and Yuriy Gorodnichenko. 2012. Measuring the Output Responses to Fiscal Policy. *American Economic Journal: Economic Policy* 4(2): 1–27.

Bachmann, Rüdiger, and Eric R. Sims. 2012. Confidence and the transmission of government spending shocks. *Journal of Monetary Economics* 59(3): 235 – 249.

Banerjee, Ryan, and Fabrizio Zampolli. 2019. What drives the short-run costs of fiscal consolidation? Evidence from OECD countries. *Economic Modelling* 82: 420–436.

Barnichon, Régis, Davide Debortoli, and Christian Matthes. 2020. Understanding the size of the government spending multiplier: It's in the sign. Economics Working Papers 1688, Department of Economics and Business, Universitat Pompeu Fabra.

Barro, Robert J., and Charles J. Redlick. 2011. Macroeconomic Effects From Government Purchases and Taxes. *Quarterly Journal of Economics* 126(1): 51–102.

Blanchard, Olivier, and Roberto Perotti. 2002. An Empirical Characterization of the Dynamic Effects of Changes in Government Spending and Taxes on Output. *Quarterly Journal of Economics* 117(4): 1329–1368.

Blinder, Alan S. 1973. Wage Discrimination: Reduced Form and Structural Estimates. *Journal of Human Resources* 8(4): 436–455.

Born, Benjamin, Francesco D'Ascanio, Gernot J. Müller, and Johannes Pfeifer. 2021. Mr. Keynes meets the Classics: Government Spending and the Real Exchange Rate. ifo Working Paper 352.

Born, Benjamin, Falko Juessen, and Gernot J. Müller. 2013. Exchange rate regimes and fiscal multipliers. *Journal of Economic Dynamics and Control* 37(2): 446–465.

Canova, Fabio, and Evi Pappa. 2011. Fiscal Policy, Pricing Frictions and Monetary Accommodation. *Economic Policy* 26(1): 555–598.

Chodorow-Reich, Gabriel. 2019. Geographic Cross-Sectional Fiscal Spending Multipliers: What Have We Learned? *American Economic Journal: Economic Policy* 11(2): 1–34.

Christiano, Lawrence, Martin Eichenbaum, and Sergio Rebelo. 2011. When is the government spending multiplier large? *Journal of Political Economy* 119(1): 78–121.

Cloyne, James. 2013. Discretionary Tax Changes and the Macroeconomy: New Narrative Evidence from the United Kingdom. *American Economic Review* 103(4): 1507–1528.

Cloyne, James, Nicholas Dimsdale, and Natacha Postel-Vinay. 2018. Taxes and Growth: New Narrative Evidence from Interwar Britain. NBER Working Paper 24659.

Cloyne, James S., and Paolo Surico. 2017. Household Debt and the Dynamic Effects of Income Tax Changes. *Review of Economic Studies* 84(1): 45–81.

Corbi, Raphael, Elias Papaioannou, and Paolo Surico. 2019. Regional Transfer Multipliers. *Review of Economic Studies* 86(5): 1901–1934.

Corsetti, Giancarlo, André Meier, Gernot J. Müller, and Michael B. Devereux. 2012. What determines government spending multipliers? *Economic Policy* 27(72): 521–565.

Crafts, Nicholas, and Terence C. Mills. 2013. Rearmament to the Rescue? New Estimates of the Impact of "Keynesian" Policies in 1930s' Britain. *Journal of Economic History* 73(4): 1077–1104.

DeLong, J. Bradford, and Lawrence H. Summers. 2012. Fiscal Policy in a Depressed Economy. *Brookings Papers on Economic Activity* 2012(1): 233–297.

Eggertsson, Gauti B. 2011. What Fiscal Policy is Effective at Zero Interest Rates? In *NBER Macroeconomics Annual 2010*, edited by Acemoglu, Daron, and Michael Woodford, volume 25, 59–112. Chicago: University of Chicago Press.

Ferrière, Axelle, and Gaston Navarro. 2020. The Heterogeneous Effects of Government Spending : It's All About Taxes. International Finance Discussion Papers 1237, Board of Governors of the Federal Reserve System.

Fortin, Nicole, Thomas Lemieux, and Sergio Firpo. 2011. Decomposition Methods in Economics. In *Handbook of Labor Economics*, edited by Ashenfelter, O., and D. Card, volume 4, chapter 1, 1–102. Amsterdam: Elsevier.

Galí, Jordi. 2015. *Monetary Policy, Inflation, and the Business Cycle: An Introduction to the New Keynesian Framework and Its Applications*. Princeton, N.J.: Princeton University Press, 2nd edition.

Galí, Jordi, J. David López-Salido, and Javier Vallés. 2007. Understanding the Effects of Government Spending on Consumption. *Journal of the European Economic Association* 5(1): 227–270.

Ghassibe, Mishel, and Francesco Zanetti. 2021. State Dependence of Fiscal Multipliers: The Source of Fluctuations Matters. Economics Series Working Papers 930, University of Oxford, Department of Economics.

Guajardo, Jaime, Daniel Leigh, and Andrea Pescatori. 2011. Expansionary Austerity: New International Evidence. IMF Working Paper WP/11/158.

Guajardo, Jaime, Daniel Leigh, and Andrea Pescatori. 2014. Expansionary Austerity? International Evidence. *Journal of the European Economic Association* 12(4): 949–968.

Gunter, Samara, Daniel Riera-Crichton, Carlos Végh, and Guillermo Vuletin. 2018. Non-Linear Effects of Tax Changes on Output: The Role of the Initial Level of Taxation. World Bank Policy Research Working Paper 8668.

Guren, Adam M., Alisdair McKay, Emi Nakamura, and Jón Steinsson. 2020. Housing Wealth Effects: The Long View. *Review of Economic Studies* 88(2): 669–707.

Hamilton, James D. 1994. *Time Series Analysis*. Princeton, N.J.: Princeton University Press.

Hayo, Bernd, and Matthias Uhl. 2014. The Macroeconomic Effects of Legislated Tax Changes in Germany. *Oxford Economic Papers* 66(2): 397–418.

Hussain, Syed M., and Liu Lin. 2018. Comparing the Effects of Discretionary Tax Changes between the US and the UK. *The B.E. Journal of Macroeconomics* 18(1): 1–17.

Ilzetzki, Ethan, Enrique G. Mendoza, and Carlos A. Végh. 2013. How big (small?) are fiscal multipliers? *Journal of Monetary Economics* 60(2): 239–254.

Jo, Yoon J., and Sarah Zubairy. 2021. State dependent government spending multipliers: Downward nominal wage rigidity and sources of business cycle fluctuations. Working Papers 20210127-001, Texas A&M University, Department of Economics.

Jordà, Òscar. 2005. Estimation and Inference of Impulse Responses by Local Projections. *American Economic Review* 95(1): 161–182.

Jordà, Òscar, Moritz Schularick, and Alan M. Taylor. 2017. Macrofinancial History and the New Business Cycle Facts. *NBER Macroeconomics Annual* 31(1): 213–263.

Jordà, Òscar, Moritz Schularick, and Alan M. Taylor. 2020. The effects of quasi-random monetary experiments. *Journal of Monetary Economics* 112: 22–40.

Jordà, Òscar, and Alan M. Taylor. 2016. The Time for Austerity: Estimating the Average Treatment Effect of Fiscal Policy. *Economic Journal* 126(590): 219–255.

Kato, Akihisa, Wataru Miyamoto, Thuy Lan Nguyen, and Dmitriy Sergeyev. 2018. The Effects of Tax Changes at the Zero Lower Bound: Evidence from Japan. *AEA Papers and Proceedings* 108: 513–18.

Keynes, John Maynard. 1936. The Marginal Propensity to Consume and the Multiplier. In *The General Theory of Employment, Interest, and Money*, chapter 10. London: Macmillan.

Kitagawa, Evelyn M. 1955. Components of a difference between two rates. *Journal of the American Statistical Association* 50(272): 1168–1194.

Leeper, Eric M., Michael Plante, and Nora Traum. 2010. Dynamics of fiscal financing in the United States. *Journal of Econometrics* 156(2): 304–321.

Leeper, Eric M., Nora Traum, and Todd B. Walker. 2017. Clearing Up the Fiscal Multiplier Morass. *American Economic Review* 107(8): 2409–54.

Mertens, Karel, and Morten O. Ravn. 2013. The Dynamic Effects of Personal and Corporate Income Tax Changes in the United States. *American Economic Review* 103(4): 1212–1247.

Miyamoto, Wataru, Thuy Lan Nguyen, and Dmitriy Sergeyev. 2018. Government Spending Multipliers under the Zero Lower Bound: Evidence from Japan. *American Economic Journal: Macroeconomics* 10(3): 247–77.

Mountford, Andrew, and Harald Uhlig. 2009. What are the Effects of Fiscal Policy Shocks. *Journal of Applied Econometrics* 24(6): 960–992.

Nakamura, Emi, and Jón Steinsson. 2014. Fiscal Stimulus in a Monetary Union: Evidence from US Regions. *American Economic Review* 104(3): 753–92.

Nguyen, Anh D. M., Luisanna Onnis, and Raffaele Rossi. 2021. The Macroeconomic Effects of Income and Consumption Tax Changes. *American Economic Journal: Economic Policy* 13(2): 439–66.

Oaxaca, Ronald. 1973. Male-Female Wage Differentials in Urban Labor Markets. *International Economic Review* 14(3): 693–709.

Ramey, Valerie A. 2016. Macroeconomic Shocks and Their Propagation. In *Handbook of Macroeconomics*, edited by Taylor, John B., and Harald Uhlig, volume 2, chapter 2, 71–162. Amsterdam: Elsevier.

Ramey, Valerie A. 2019. Ten Years after the Financial Crisis: What Have We Learned from the Renaissance in Fiscal Research? *Journal of Economic Perspectives* 33(2): 89–114.

Ramey, Valerie A., and Sarah Zubairy. 2018. Government Spending Multipliers in Good Times and in Bad: Evidence from US Historical Data. *Journal of Political Economy* 126(2): 850–901.

Riera-Crichton, Daniel, Carlos A. Vegh, and Guillermo Vuletin. 2015. Procyclical and countercyclical fiscal multipliers: Evidence from OECD countries. *Journal of International Money and Finance* 52: 15–31.

Romer, Christina D., and David H. Romer. 2010. The Macroeconomic Effects of Tax Changes: Estimates Based on a New Measure of Fiscal Shocks. *American Economic Review* 100(3): 763–801.

Rubin, Donald B. 1974. Estimating Causal Effects of Treatments in Randomized and Nonrandomized Studies. *Journal of Educational Psychology* 66(5): 688–701.

Tenreyro, Silvana, and Gregory Thwaites. 2016. Pushing on a String: US Monetary Policy Is Less Powerful in Recessions. *American Economic Journal: Macroeconomics* 8(4): 43–74.

Uhlig, Harald. 2010. Some Fiscal Calculus. *American Economic Review* 100(2): 30–34.

Woodford, Michael. 2011. Simple Analytics of the Government Expenditure Multiplier. *American Economic Journal: Macroeconomics* 3(1): 1–35.

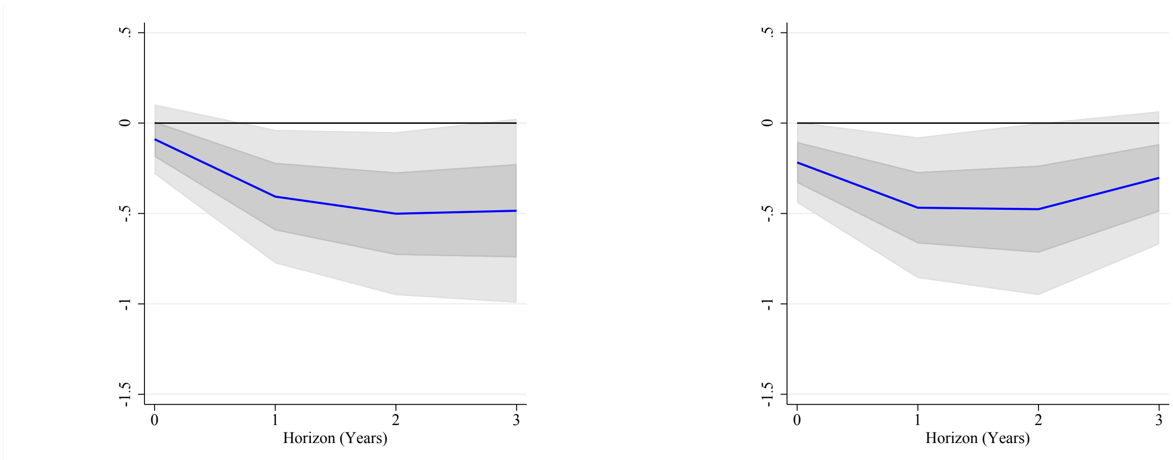
Wooldridge, Jeffrey M. 2001. *Econometric Analysis of Cross Section and Panel Data*. Cambridge, Mass.: MIT Press.

# ONLINE APPENDIX

## A: Original Guajardo, Leigh, and Pescatori (2014) specification

**Figure A.1:** *Effects of a 1% of GDP fiscal consolidation: original IMF specification*

**(a)** *% response of GDP* **(b)** *Response of the short term real interest rate*




*Notes:* Vertical axes reported in percent change with respect to the origin. One and two standard deviation confidence bands for each coefficient estimate shown as grey areas. Local projections as specified in equation (13) without indirect effects and using two lags of each control described therein. Sample 1978:1–2009:4. This specification uses the original control set from Guajardo, Leigh, and Pescatori (2014). See text for details.

# B. Sensitivity Proxy: A Simple Example

To formalize the interaction we have in mind consider the following, stylized, setup. In the main text we show that this approach works well using simulations from a standard New Keynesian DSGE model. Let some outcome $y_{i,t}$, e.g., GDP growth in country $i$ at time $t$, depend on fiscal treatment $f_{i,t}$ and the choice of the real interest rate $r_{i,t}$. All variables as expressed relative to their means. Furthermore, suppose the interest rate is set by a monetary authority following a rule. For simplicity, assume that the monetary authority sets the real interest rate directly. Real interest rates are set to offset the negative effects of shocks to GDP, including changes in fiscal policy. Specifically,

$$y_{i,t} = \delta_f f_{i,t} + \delta_r r_{i,t} + u^y_{i,t}, \tag{22}$$

$$r_{i,t} = \overline{\Theta}^f f_{i,t} + \Theta^f_i f_{i,t} + \Theta^y u^y_{i,t} + u^r_{i,t}, \tag{23}$$

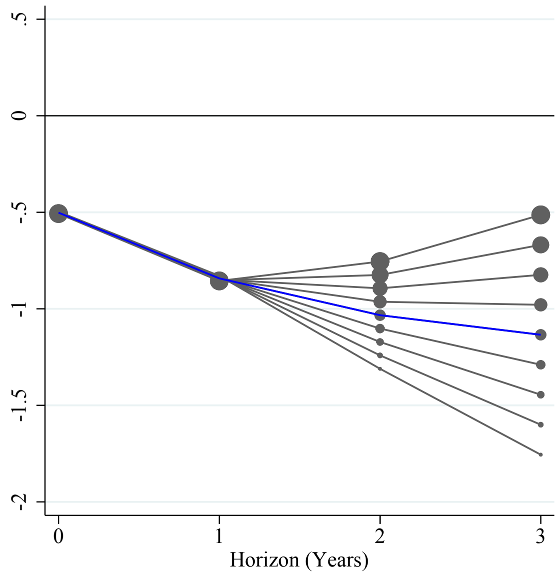
where $\delta_f$ measures the fiscal multiplier holding interest rates constant. In the data this cannot typically be estimated because interest rates are likely to endogenously respond to fiscal treatment, as is the case in Equation 23. This equation says that monetary policy responds to fiscal interventions but, in the way this rule is written, the degree of monetary accommodation could vary across countries. $\overline{\Theta}^f$ reflects the average response across all countries and $\Theta^f_i$ is the idiosyncratic component. Monetary policy also potentially responds to other economic shocks, captured by the term $u^y_{i,t}$. Combining Equation 22 and Equation 23 yields

$$y_{i,t} = (\delta_f + \delta_r \overline{\Theta}^f) f_{i,t} + \delta_r \Theta^f_i f_{i,t} + \delta_r u^r_{i,t} + (1 + \delta_r \Theta^y) u^y_{i,t}. \tag{24}$$

On the assumption that treatment $f_{i,t}$ is randomly assigned (as should be the case if the fiscal shocks are exogenous), the first term illustrates that the reduced-form estimate of the fiscal multiplier depends on the average monetary response in the data, $\delta_r \overline{\Theta}^f$. In other words, $\delta_f$, $\delta_r$ and $\overline{\Theta}_f$ are not separately identified using the fiscal shock alone. The second term captures heterogeneity in the interest rate response. Note that Equation 24 has the form of the Kitagawa-Blinder-Oaxaca decomposition in Equation 8. In this simple case without any other controls, $f$ (the policy treatment) in Section 3.2 corresponds to $f_{i,t}$ here and $(x_{i,t} - \overline{x}) = \Theta^f_i$. The indirect effect is then $\delta_r \Theta^f_i$. Since the total response (ignoring the composition effect) is simply the direct effect plus the indirect effect, we can consider experiments around the average effect by arbitrarily varying the indirect effect.

## C. Variation in the deficit to GDP ratio by monetary policy response

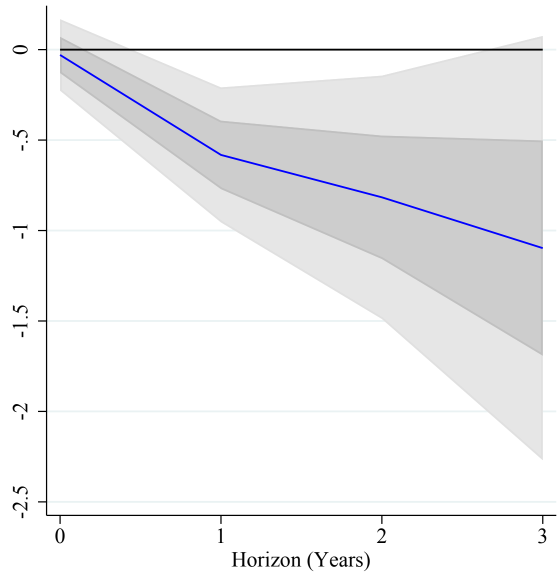
**Figure A.2:** *Deficit/GDP ratio* $((D_{t+h} - D_{t-1})/Y_{t-1})$




*Notes:* This Figure shows how the response of the deficit to GDP ratio varies with the degree of monetary policy accommodation. The blue lines report the direct effect. The gray lines consider experiments which vary the degree of monetary accommodation. A larger marker indicates a tighter monetary policy scenario.

## D. Significance of the direct effect

**Figure A.3:** *Direct effect: response of GDP (%) to a 1% of GDP fiscal consolidation*




*Notes:* This Figure shows how the response GDP (%) following a 1% of GDP fiscal consolidation. The blue lines report the direct effect estimated from the Kitagawa-Blinder-Oaxaca decomposition together with the one and two standard deviation error bands.

# E. Coefficient estimates

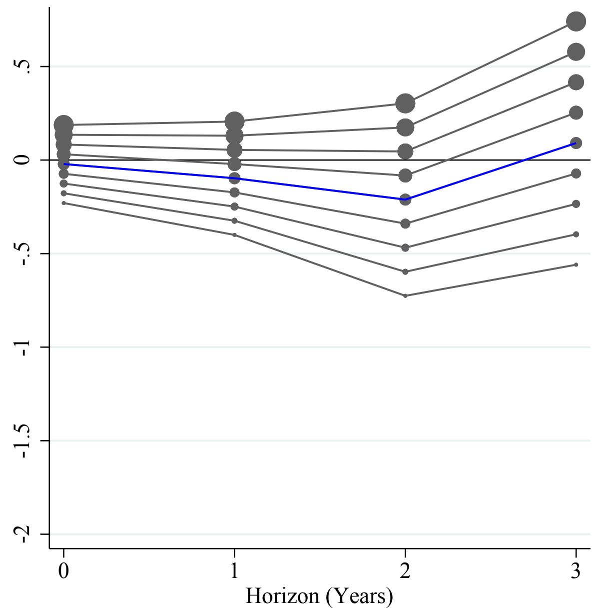
**Table A.1:** *Coefficient estimates for the direct and indirect effects*

| Horizon (Years) | $\beta^h$ | $\theta_f^h$ |
|---|---|---|
| 0 | -0.03 | -0.50 |
| | (0.10) | (0.43) |
| 1 | -0.58 | -0.60 |
| | (0.19) | (0.29) |
| 2 | -0.82 | -0.71 |
| | (0.34) | (0.15) |
| 3 | -1.10 | -1.25 |
| | (0.60) | (0.16) |

*Notes:* This table reports coefficient estimates based on equation 14. $\beta^h$ is the impulse response function for the direct effect and therefore corresponds to the Figure A.3. $\theta_f^h$ governs the strength of the indirect effect. A negative value implies that, following a fiscal consolidation, real GDP is more negative when monetary policy is less accommodative. Standard errors are reported in parenthesis.

## F. Response of the real rate

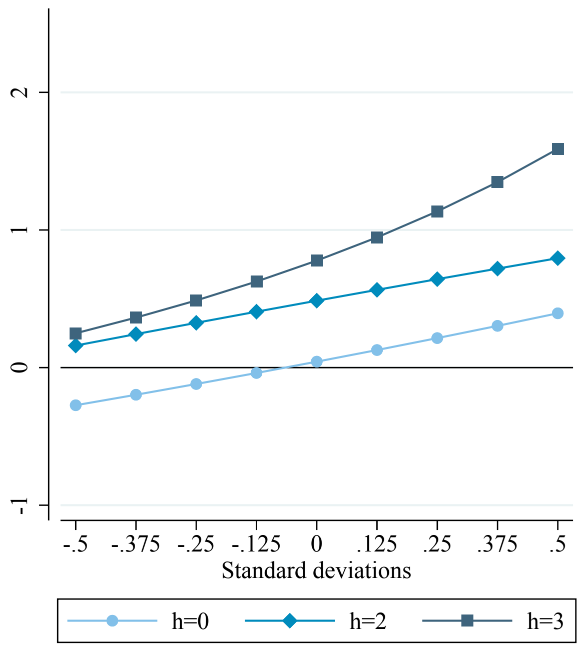
**Figure A.4:** *Response of the real interest rate by monetary regime*




*Notes:* This Figure shows the response of the real interest rate to a 1% of GDP fiscal consolidation. The blue lines report the direct effect. The gray lines consider experiments which vary the degree of monetary accommodation. A larger marker indicates a tighter monetary policy scenario.

# G. Controlling for fiscal composition

**Figure A.5:** *Cumulative fiscal multiplier by monetary response*

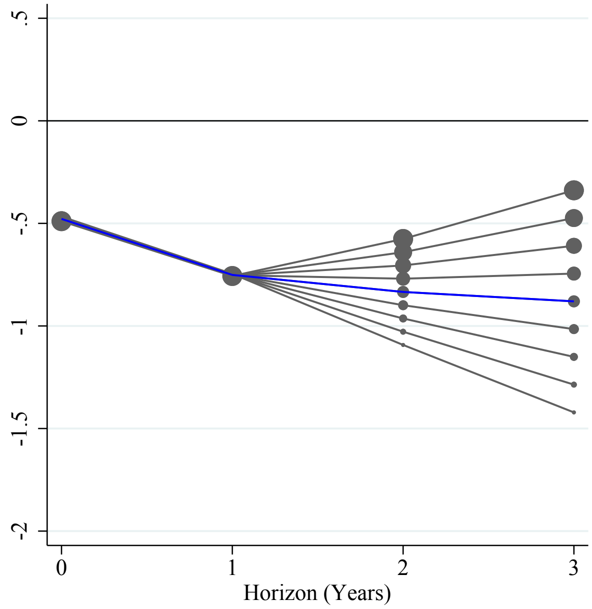



*Notes:* This chart shows the cumulative fiscal multiplier varying the degree of monetary offset. This is computed as the cumulative sum of the GDP response relative to the cumulative deficit to GDP response. Each line refers to a different horizon, $h$. As in Figure 3, $h$ goes from the current year $h = 0$ to the third year after the shock $h = 3$. $h = 1$ is omitted to avoid overcrowding the figure. Relative to the baseline figure in the main text, this is produced controlling for the cross-country propensity to use taxes versus spending instruments, as discussed in Section 5.

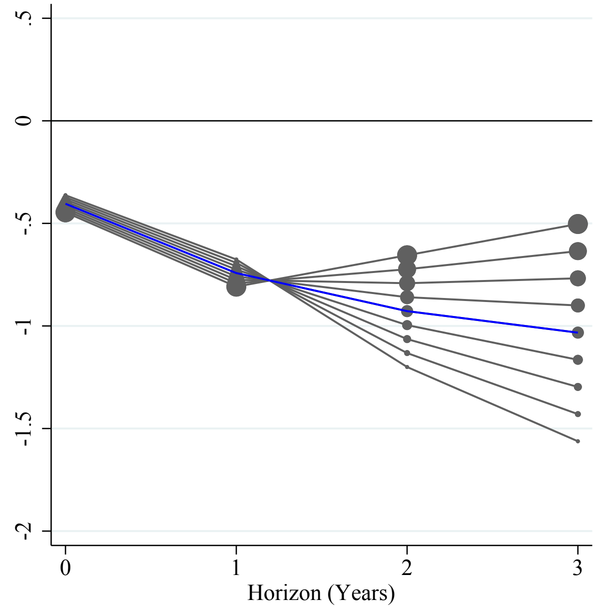
# H. Robustness exercises: deficit/GDP ratio

**Figure A.6:** *Robustness exercises: deficit/GDP ratio* $((D_{t+h} - D_{t-1})/Y_{t-1})$

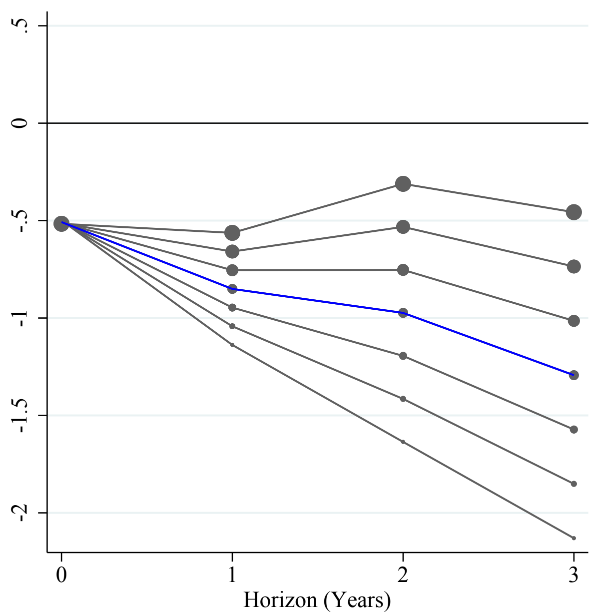
**(a)** *Time fixed effects*




**(b)** *Longer lag structure*




**(c)** *Alternative interactions approach*




*Notes:* This Figure shows how the deficit to GDP ratio varies with the degree of monetary policy accommodation in each of the robustness exercises covered in Section 5. The blue lines report the direct effect. The gray lines consider experiments which vary the degree of monetary accommodation. A larger marker indicates a tighter monetary policy scenario.

# I: Further details on the model

The model is a simple variant of the textbook 3-equation New Keynesian model (e.g., as in Gal´ı, 2015) with optimizing and hand-to-mouth households as in Galí, López-Salido, and Vallés (2007). The details below are therefore very standard.

## Households

**Savers** The economy is populated by $1-\mu$ saver/optimizing households:

$$\max_{C_t, N_t, B_t} E_0 \sum_{t=0}^{\infty} \beta^t \left( \log C_t - \frac{N_t^{1+\psi}}{1+\psi} \right) , \tag{25}$$

subject to

$$P_t C_t + Q_t B_t = B_{t-1} + W_t N_t + D_t - T_t \,. \tag{26}$$

Which leads to the following set of first order conditions:

$$(C_t) : \lambda_t = C_t^{-\sigma} , \tag{27}$$

$$(N_t) : \lambda_t \frac{W_t}{P_t} = N_t^{\psi} , \tag{28}$$

$$(B_t) : Q_t = 1/R_t = 1/(1+i_t) = \beta E_t \frac{\lambda_{t+1}}{\lambda_t} \frac{P_t}{P_{t+1}} , \tag{29}$$

where saver households own firms and receive any profits $D_t$ lump sum. These households also finance government activities via a lump sum tax $T_t$.

In linearized form these equilibrium conditions can be written as:

$$\hat{w}_t = \hat{c}_t^S + \psi \hat{n}_t^S ,$$

$$E_t \Delta \hat{c}_{t+1}^S = \frac{1}{\sigma} \left( \hat{R}_t - E_t \hat{\pi}_{t+1} \right) .$$

**Non-savers** Non-saver rule of thumb households simply consume their entire labor income.

$$C_t^N = w_t N_t^N \,.$$

They also, in principle, have an intratemporal labor supply condition which comes from solving the same optimization problem as above for $C$ and $N$ but where $B = D = T = 0$.

$$\frac{W_t}{P_t} = C_t^N N_t^{N^{\psi}} \,. \tag{30}$$

Total consumption is given by:

$$C_t = \mu C_t^N + (1-\mu) C_t^S .$$

In linearized form these are:

$$\hat{w}_t = \hat{c}_t^N + \psi \hat{n}_t^N ,$$

$$\hat{c}_t^N = \hat{w}_t + \hat{n}_t^N ,$$

$$\hat{c}_t = \mu \frac{C^N}{C} \hat{c}_t^N + (1-\mu) \frac{C^S}{C} \hat{c}_t^S .$$

## Firms

**Final goods firms** Different varieties of goods $y(j)_t$ are aggregated by the final goods firm:

$$Y_t = \left[ \int_0^1 y_t(j)^{\frac{\epsilon-1}{\epsilon}} dj \right]^{\frac{\epsilon}{(\epsilon-1)}} , \tag{31}$$

where $\epsilon$ is price elasticity of demand for good $j$. Final goods firms choose intermediate inputs to maximize profit:

$$\max_{y_t(j)} \left( P_t \left[ \int_0^1 y_t(j)^{\frac{\epsilon-1}{\epsilon}} dj \right]^{\frac{\epsilon}{(\epsilon-1)}} - \int_0^1 p_t(j) y_t(j) dj \right) . \tag{32}$$

Which yields the following demand curve and aggregate price index

$$y_t(j) = \left( \frac{p_t(j)}{P_t} \right)^{-\epsilon} Y_t , \tag{33}$$

$$P_t = \left( \int_0^1 p_t(j)^{1-\epsilon} dj \right)^{\frac{1}{1-\epsilon}} . \tag{34}$$

**Intermediate goods firms** Intermediate goods firms solve a static labor demand problem and an intertemporal pricing problem subject to Calvo pricing frictions. Each period firms can re-optimize labor demand.

The firm minimizes labor costs by choosing $n(j)_t$ to minimize the following Lagrangian:

$$\min_{n_t(j)} \frac{W_t}{P_t} n_t(j) + mc_t (y_t(j) - A n_t(j)) , \tag{35}$$

where $mc_t$ is real marginal cost. The first order condition is:

$$mc_t = (W_t / P_t) / A . \tag{36}$$

When the firm is able to re optimize, they choose $p_t(j)$ to maximize expected profits:

$$E_t \sum_{s=0}^{\infty} \theta^s \left( \beta^s \frac{\lambda_{t+s}}{\lambda_t} \right) \left[ \frac{p_t(j)}{P_{t+s}} y_{t+s}(j) - mc_{t+s} y_{t+s}(j) \right] , \tag{37}$$

subject to

$$y_t(j) = \left( \frac{p_t(j)}{P_t} \right)^{-\epsilon} Y_t \,, \tag{38}$$

which yields:

$$\sum_{s=0}^{\infty} \theta^s E_t \left( \beta^s \frac{\lambda_{t+s}}{\lambda_t} \right) \left( \frac{p_t^*}{P_{t+s}} y_{t+s}(j) - \frac{\epsilon}{\epsilon - 1} mc_{t+s} y_{t+s}(j) \right) = 0 \,. \tag{39}$$

Linearization of equation 39 and the price index 32 yields the New Keynesian Phillips Curve given in the text.

## Policy

As mentioned in the main text, government consumption is simply a persistent exogenous stream of purchases funded with lump sum taxes on savers. The budget constraint is therefore:

$$G_t = T_t \,.$$

In linearized form, government spending evolves as follows:

$$\hat{g}_t = \rho_g \hat{g}_{t-1} + e_t \,,$$

where $e_t$ is a mean zero i.i.d. shock.

Monetary policy follows a simple Taylor Rule. The nominal interest rate $\hat{R}_t$, written in deviations from steady state, is set relative to inflation. Importantly, we will think of this rule as varying across country, $c$, but where each country operates as a closed economy. The policy rule is therefore:

$$\hat{R}_t = \rho_i \hat{R}_{t-1} + (1 - \rho_i) \phi^i \hat{\pi}_t \,. \tag{40}$$