Wesleyan Economics Working Papers

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N^o: 2006-006

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January 27, 2006

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Current version: January 27, 2006

Abstract

We estimate the impact of U.S. monetary policy on the cross-sectional distribution of state economic activity for a 35-year panel. Our results indicate that the effects of policy have a significant history dependence, in that relatively slow growth regions contract more following contractionary monetary shocks. Moreover, policy is asymmetric, in that expansionary shocks have less of a beneficial impact upon relatively slow growth areas. As a result, we conclude that monetary policy on average widens the dispersion of growth rates among U.S. states, and those locations initially at the low end of the cross-sectional distribution benefit least from any given change in monetary policy.

JEL Categories: E32, E59, R10.

Keywords: Monetary policy, asymmetric effects, state dependence, regional business cycles.

Thanks to seminar participants at the Federal Reserve Bank of New York, the 2004 NBER Summer Institute Workshop in Capital Markets, and Wesleyan University for helpful comments.

1 Introduction

Milton Friedman's oft-quoted observation that monetary policy has "long and variable lags" implies a more complicated propagation mechanism than is typically incorporated in aggregate linear macroeconomic models. Most common approaches to quantifying the macroeconomic effects of changes in monetary policy ignore the possibility that these effects might be asymmetric, in that the economic impact of contractionary policy might not be the mirror image of expansionary policy[1] — or state dependent, in that the transmission mechanism might differ depending on the stage of the business cycle. Put another way, the consequences of a monetary policy shock might depend both on the sign of that shock and on the history of other macroeconomic shocks that preceded it.

Identifying these types of non-linearities is difficult in aggregate time series variables: in a given sample, how does one distinguish similarly-sized policy shocks that have differential effects from differently-sized shocks, if one must estimate the nature of both the shock and the subsequent dynamic effects? Due to changes in the practice of monetary policy and the nature of the economy, even a long time series may not be sufficient to recover the true nature of the impulse and propagation mechanisms.

In the United States, monetary policy is determined at the national level in response to national events. Yet it does not necessarily have uniform effects throughout the country.[2] Recently, several authors have documented differential effects of monetary policy on U.S. regions and states. Our work complements that literature, suggesting that monetary policy can have important distributional consequences. However, in our approach the main distinguishing characteristic is not a fixed attribute of the state or region, such as the industrial mix, but rather the relative position of economic activity within the state prior to the policy change. By examining the effects on the cross-sectional distribution of state activity of common monetary policy actions through time, we can better ascertain the extent and import of history dependence for the monetary transmission mechanism.

Any distributional consequences are likely to be of interest not only to U.S. politicians and policy makers; such an investigation also may be informative for the design of institutions in the Euro zone. The U.S. states can be thought of as small open economies with their exchange rates fixed through a currency

[1] Such asymmetry is implicit in another oft-repeated quip: "monetary policy cannot push on a string."

[2] Although policy could be a function of regional data instead of, or in addition to, national aggregates, rarely is U.S. Federal Reserve policy conceptualized in such a manner. Indeed, Frantantoni and Schuh (2003) make note of a video game in the visitors' lobby at the Board of Governors called "You Are the Chairman." In that simulation the suggested monetary policy response to a rise in unemployment in only one region of the country (several farm-belt states) is "no change." (See endnote 7 of Frantantoni and Schuh, 2003.)

union that eliminates monetary independence. While there are some important differences between the U.S. states and members of EMU — fiscal federalism, factor mobility, etc. — the broad similarities may allow useful inference from the U.S. states' experiences for current and future participants in EMU.

Our empirical estimates on a panel of U.S. state-level data suggest a resoundingly affirmative answer to the question proposed by the title of this paper: monetary policy is less beneficial for areas that are depressed relative to the average position of states at the time of the policy shock. Moreover, we find that the strength of this effect may differ depending on whether policy is expansionary or contractionary, thus introducing an additional asymmetry into the transmission of monetary policy.

Finally, while the regional consequences are interesting and important in their own right, we view the implications for the modeling of monetary policy more generally to be particularly significant. The existence of non-linearities in the transmission of monetary policy shocks suggests a misspecification of policy in aggregate, linear models. We interpret the existence of these asymmetric, history-dependent results as suggestive of the importance of the credit channel, broadly construed.

In section 2 we discuss related research; our approach can be viewed as merging concepts from different literatures, notably on the regional effects of monetary policy and on asymmetric policy models, with an emphasis on a lending or credit channel. Section 3 discusses how and why state dependence of monetary policy might arise at the sub-national level, and motivates the search for differential effects of expansionary versus contractionary policy. Section 4 incorporates these considerations into a statistical model, and section 5 reports the empirical results from U.S. state-level data. Section 6 concludes.

2 Literature Review

Recently, several authors have investigated whether the effects of monetary policy might differ across U.S. regions or states. Because estimation with a state-level panel would quickly use up degrees of freedom, especially in a vector autoregressive (VAR) or simultaneous-equations framework, many authors aggregate to a smaller number of regions. For example, Carlino and DeFina (1998) estimate a regional VAR model for the eight Bureau of Economic Analysis regions.[3] They find that contractionary shocks to the Federal Funds rate affect states in the Great Lakes region more, and states in the Rocky Mountain

[3] The BEA's eight U.S. regions are: New England (CT, ME, MA, NH, RI, VT), Mideast (DE, DC, MD, NJ, NY, PA), Southeast (AL, AR, FL, GA, KY, LA, MS, NC, SC, TN, VA, WV), Great Lakes (IL, IN, MI, OH, WI), Plains (IA, KS, MN, MO, NE, ND, SD), Rocky Mountain (CO, ID, MT, UT, WY), Southwest (AZ, OK, NM, TX), and Far West (AK, CA, HI, OR, NV, WA).

and Southwest regions less, than the remaining regions or the country as a whole. Their results are robust to common alternative monetary policy variables, and to using employment growth instead of real personal income growth as the activity measure. While such aggregation might be thought to mask some important aspects of the local economic relationships or to confound others, Carlino and DeFina (1999) find similar results with separately estimated VARs for the lower 48 states.

More recently, Owyang and Wall (2004) report evidence of structural breaks in the regional impacts of monetary policy by estimating a single large regional VAR specification separately over pre-Volcker (1960Q1 – 1978Q4 in their paper) and post-Volcker (1983Q1 – 2002Q4) sub-samples. Our model generalizes this idea by investigating the state dependent nature of monetary policy conditional on the prior distribution of local shocks, rather than on a finite set of discrete changes in the propagation mechanism.

In a paper close in spirit to our own investigation, Frantantoni and Schuh (2003) investigate the effects of monetary policy through regional housing markets. They develop a "heterogenous agent VAR" approach which allows them to estimate a two-stage model: first the regional dynamics are estimated taking the national variables as given, then the aggregated regional variables are incorporated into a VAR estimation with national data. As the dynamics at the aggregate national stage are influenced by the distribution and history of shocks in the regional stage, their approach embodies a particular kind of state dependence for monetary policy. They use their estimates to simulate how the monetary transmission mechanism changes in the midst of a coastal housing boom versus a more homogeneous regional distribution. Due to constraints on the scope of available data (they collect a balanced panel of 27 U.S. metropolitan statistical areas observed quarterly from 1986Q3 to 1996Q2), they present their results as suggestive of the potential consequences of ignoring regional heterogeneity and state dependence for monetary policy.

Both Frantantoni and Schuh (2003) and Owyang and Wall (2004) find that the average length of monetary-induced downturns generally are much shorter at the regional level than are those estimated with national data. They both posit that aggregation bias may cause national VARs to over-estimate the actual duration of the response of the activity variable. Consistent with our approach, each pair of authors hypothesizes that non-linearities in the relationship between the policy variable and local activity measures might explain this apparent bias.

In addition, we allow the magnitude and duration of the responses of activity to a monetary shock to differ between expansionary and contractionary actions. Our approach to modeling these asymmetric effects is related to earlier work by Cover (1992), in which innovations to the policy instrument are separated into positive and negative components that are entered jointly into the estimation. Alternative approaches, such as threshold VAR models (see, e.g., Choi, 1999), place even greater demands on the data and therefore are not practical for our panel of state observations.[4] Details of the treatment of the asymmetries in the model are presented in sections 4 and 5.

3 Policy Transmission at the Sub-National Level

Several of the papers cited previously establish significant variation in business cycles across U.S. regions. Asynchronous fluctuations in real economic activity could be due to idiosyncratic shocks or to common shocks with different propagation mechanisms. State-level differences in the industrial mix or structure of the financial sector are often cited as potential sources of this variation, although differences in local labor markets, natural resource endowments, expenditure and tax policies, regulatory environments, or other attributes could also be contributing factors. As we explain below, we suspect that the banking sector plays an important role in the differential transmission of monetary policy among subnational areas as well.

At the national level, numerous authors have found evidence supporting the importance of the banking sector for the transmission of monetary policy; Bernanke and Gertler (1995) provide an overview.[5] Carlino and DeFina (1998, 1999) and Owyang and Wall (2004) use proxies for a traditional interest rate channel of monetary policy as well as for various definitions of the credit channel to test which are systematically related to the cross-regional (or state) differences in the response to monetary shocks.[6] Their results are decided mixed. Carlino and DeFina (1998, 1999) report only weak support for the broad credit channel and none for the narrow credit channel in their sample. Owyang and Wall (2004), by contrast, find that the narrow credit channel can account for the depth of the income response to monetary shocks, but not their cumulative cost (income loss), during their post-Volcker sample. For their full sample, all three channel proxies have significant explanatory power for the cumulative loss, but none

[4] Choi (1999) also focuses on distinct policy regimes, whereas we consider differential effects of policy actions.

[5] Hanson McPherson and Waller (2000) provide evidence that bank lending is more a local than national activity, so complete smoothing across regions is not possible.

[6] For the interest rate channel, the fraction of employment in manufacturing is used as the proxy. For the broad credit channel — that small firms have more limited access to non-bank sources of funds — some measure of the concentration of firms by size (usually employment) is used. For the narrow credit (or bank lending) channel — that smaller banks have difficulty adjusting their balance sheets and thus constrain loans more during tight monetary policy, as in Kashyap and Stein (2000) — a measure of bank deposit or loan shares is employed.

for the depth of monetary-induced recessions. Reconciling these differences is difficult, as the studies investigate different sample periods, regional definitions, and policy experiments.

Frantantoni and Schuh (2003) examine mortgage interest rates as their link between aggregate activity and regional heterogeneity, and find evidence of state dependence in monetary transmission via the housing market. Our approach is less direct, but arguably more general. Like Frantantoni and Schuh (2003), we seek to determine how the monetary transmission mechanism changes over the business cycle. While there are likely numerous possible interactions, we focus on the credit channel (broadly construed) as a potential rationale for both asymmetric and state-dependent effects of monetary policy. Changes in the value of collateral held by borrowers — or, equivalently, the asset side of banks' balance sheets — will affect the level of lending activity in a region.[7] Such changes are likely to be highly correlated with the rate of local economic activity; consider the value of residential real estate, for example. From the lender's perspective, the distribution of potential borrowers — or the expected return on investment projects — may also vary over the business cycle. If banks tend to ration the supply of loans when such adverse selection or moral hazard problems are more prevalent, then areas growing more slowly are more likely to suffer as a result. Our approach does not require us to separately identify loan supply and demand shocks, which arguably represents an advantage.[8]

These effects describe the conditions existing in local markets prior to a change in monetary policy. In this environment, contractionary monetary policy should disproportionally affect those localities already growing more slowly. As has been emphasized in the lending channel literature (see, e.g., Bernanke and Gertler, 1995), contractionary monetary policy is likely to result in a reduction of lending activity due to the asymmetric information or balance sheet issues raised above. For regions that are growing relatively quickly, such effects are likely to be less drastic than for areas in which collateral values are falling or banks are already nervous about lending. As a concrete example, contractionary policy might be expected to depress activity even more in a relatively slow growth area such as the Midwest in the mid-1980s, whereas the impact on the booming coasts might be proportionally smaller.

The same logic should hold for expansionary policy as well: for regions already growing relatively quickly, a loosening of policy should result in a greater expansion of lending activity (many more consumers who can benefit from mortgage refinancing, for example) relative to regions growing sluggishly (or shrinking). Thus, for a region that is growing relatively quickly, the positive effects of expansionary

[7] Notice that this scenario has aspects of both the broad and narrow credit channels.

[8] For perspectives on the challenges of identifying changes in loan supply, see, e.g., Peek et al. (2003) and Driscoll (2004).

monetary policy changes are amplified while the negative effects of contractionary changes are mitigated. The converse is true for regions that are growing more slowly (or contracting more quickly) than average. As a result, the logic of the state-dependent nature of policy also suggests an important asymmetry between expansionary and contractionary policy changes. Our goal in this paper is to quantify the impact of monetary policy changes in these four potentially different cases. In section 4 we formalize the above discussion into an econometric specification, which is then estimated on a panel of U.S. state data. Those results are discussed in section 5.

4 Empirical Model

Let y_{it} represent observations on the endogenous measure of economic activity for state i in time period t. Note that y_{it} could be a vector, although in our estimates below we use a single series. Let z_t be a vector of national variables, including the monetary policy instrument. A general dynamic representation for y_{it} can be written as

$$y_{it} = \sum_{j=1}^{q} \alpha_j y_{it-j} + \sum_{k=0}^{p} \beta_k z_{t-k} + \sum_{k=0}^{p} \sum_{j=k+1}^{q} \gamma_{jk} (y_{it-j} \cdot z_{t-k}) + \varepsilon_i + \mu_t + \nu_{it} \tag{1}$$

where the composite error term includes state fixed effects (ε_i), a stochastic time trend (μ_t), and idiosyncratic state-level shocks (ν_{it}).

Notice that we have included the interaction of the lagged endogenous variable with the vector of national variables. These terms allow for the possibility of state dependence in the effects of the aggregate variables on the local activity measure. Based on our discussion above, we are most interested in the γ_{jk} terms that measure the importance of the interaction with the monetary policy instrument in z_t.

As written, equation (1) is likely to suffer from endogenous regressors. As in Frantantoni and Schuh (2003), we could presume the national variables are predetermined with respect to the state-level dynamics. The dimensionality of our data set prohibits applying their HAVAR approach, in which an aggregation equation transmits the cumulative effects of changes in the local endogenous variables back to the national level. Alternatively, like much of the regional VAR literature, we could assume that monetary policy only affects activity variables with a lag, and replace $k = 0$ with $k = 1$ in the above specification. However, our interaction terms are not conducive to standard VAR estimation techniques, which presume a linear model.

Therefore we take an alternative approach. As we are interested in the differential effects of policy across geographical areas, we subtract the cross-sectional average of the endogenous activity variable from each state observation at every point in time: $\widetilde{y}_{it} = y_{it} - \frac{1}{N}\sum_{i=1}^{N} y_{it}$. This geographically de-meaned variable captures the cross-state dispersion of the activity measures.

Transforming the other variables in equation (1) in a similar manner yields:

$$\widetilde{y}_{it} = \sum_{j=1}^{q} \alpha_j \, \widetilde{y}_{it-j} + \sum_{k=0}^{p} \sum_{j=k+1}^{q} \gamma_{jk} \, (\widetilde{y}_{it-j} \cdot z_{t-k}) + \widetilde{\varepsilon}_i + \widetilde{v}_{it} \tag{2}$$

Notice that this transformation eliminates all terms that do not vary across location (namely z_t and μ_t). As these variables are the source of the potential endogeneity problem for equation (1), the transformation results in a specification that can be estimated by OLS — provided the central bank does not set policy in response to the dispersion of regional activity. Based on the discussion in section 2, we find this assumption both plausible and consistent with Federal Reserve behavior. Thus, while equation (2) still includes the contemporaneous macroeconomic variables interacted with the vector of lagged endogenous variables, OLS estimation will be consistent. Put another way, even if z_t were correlated with v_{it}, it is unlikely to be correlated with $\widetilde{v}_{it}$. Equation (2) is the basis for our empirical results in section 5. Notice that, relative to the regional VAR models discussed in section 2, our approach can consistently estimate the effects of contemporaneous policy innovations on the cross-sectional distribution of state economic activity.[9]

4.1 Computation of Responses to Monetary Shocks

To estimate the dynamic effects of a monetary policy shock for the dispersion of real state activity, we start by assuming that the local economy is in its steady-state. Then, in the absence of any changes to monetary policy, state-specific shocks ($\widetilde{v}_{it}$) lead to temporary business cycle effects as the state economy converges back to the steady state. These cycles are protracted, however, so that a state that experiences an idiosyncratic shock can expect to remain away from trend for several quarters. In section 5 we shock our model with a one standard deviation shock (positive or negative) one or more quarters prior to the change in monetary policy to create a low growth (negative shock) or high growth (positive shock) local

[9] In section 5 we generally cannot reject that null hypothesis that the interaction terms involving the contemporaneous funds rate are jointly zero, nor the null that they sum to zero. These results provide some support for the common practice in VAR models of using the lagged response of activity variables to a monetary policy as an identifying assumption.

environment, relative to the average state.[10]

So long as the central bank does not respond to regional dispersion in economic activity, as argued above, conceptually we can employ a two-step procedure: we can recover the dynamics of an exogenous monetary policy shock to the policy instrument from a model estimated with national data (such as a VAR), then feed the response of the instrument into the moving average representation of the de-meaned state activity variable to find its dynamics.[11]

From the first stage we can recover the policy instrument as a function of all the structural shocks at the national level, including the monetary policy shock. For the purposes of measuring the impact of monetary policy shocks, we normalize the other shocks to zero at all horizons. Then the policy variable can be written as

$$z_t = \Theta(L)\,\mu_t = \sum_{m=0}^{\infty} \theta_m\,\mu_{t-m}\,, \tag{3}$$

where μ_t is the structural shock to monetary policy. The impulse response to a one-time monetary shock then can be expressed simply as

$$\frac{\partial z_{t+h}}{\partial \mu_t} = \theta_h\,. \tag{4}$$

To find the impact of a one-time shock to monetary policy on the cross-sectionally demeaned state activity variable, $\widetilde{y}_{it}$, we first lead equation (2) by h periods (after normalizing the steady state and leads of the idiosyncratic shock to zero):

$$\widetilde{y}_{it+h} = \sum_{j=1}^{q} \alpha_j\,\widetilde{y}_{it-j+h} + \sum_{k=0}^{p}\sum_{j=k+1}^{q} \gamma_{jk}\,(\widetilde{y}_{it-j+h}\cdot z_{t-k+h})\,. \tag{5}$$

From equation (3), a one-time monetary shock at time $h = 0$ implies

$$z_{t-k+h} = \begin{cases} \theta_{h-k} & \text{for } h \geq k \\ 0 & \text{for } h < k \end{cases} \tag{6}$$

[10] Recall that the monetary policy shock is orthogonal to the state idiosyncratic shock by construction.

[11] This technique accounts for national non-monetary factors in one of two ways: those that have no distributional consequences are eliminated by geographically de-meaning the data as in equation (2); those that do are captured by the regional shocks, $\widetilde{v}_{it}$.

Thus, equation (4) can be written as

$$\widetilde{y}_{it+h} = \sum_{j=1}^{q} \alpha_j \widetilde{y}_{it-j+h} + \mu_t \sum_{k=0}^{\min(p,h)} \theta_{h-k} \left(\sum_{j=k+1}^{q} \gamma_{jk} \widetilde{y}_{it-j+h} \right)$$

Collecting common terms for $\widetilde{y}_{it+h}$ yields a recursive formula for the impulse responses to a one-time monetary policy shock (μ_t), given the previously estimated lag polynominal $\Theta(L)$ for the dynamics of the Fed Funds rate with respect to the policy shock from equation (3) and the estimates of α_j and γ_{jk} from equation (2).

$$\widetilde{y}_{it+h} = \sum_{j=1}^{q} \left(\alpha_j + \left[\sum_{k=0}^{j-1} \theta_{h-k} \gamma_{jk} \right] \cdot \mu_t \right) \cdot \widetilde{y}_{it+h-j} \tag{7}$$

Equation (7) forms the basis for the simulation of the impulse responses. With multiple observations at the same point in time, one can hold constant the nature of the monetary impulse and monitor how different localities react as a function of their current economic conditions. Conditional on this information, systematically different effects from similar shocks would provide evidence that monetary policy is state dependent.

5 Results

5.1 Data Measurement and Transformations

The raw data for the state activity variable used in the estimates below is personal income for all 50 states since 1969Q1, as reported by the U.S. Bureau of Economic Analysis. Because price indexes are not available for individual states, we convert these data into real 2000 dollars by the U.S. implicit price deflator for GDP. We further divide by quarterly state population to produce per capita real income.[12] Our measure of state economic activity, y_{it}, is the annualized one-quarter growth rate of real per capita personal income. Our preferred measure of the monetary policy instrument is the effective Federal Funds rate; we use the final month of each quarter as our quarterly observation. After accounting for lags and the computation of the income growth rate, our base model is estimated over the period 1970Q2 – 2003Q4. In total, our sample consists of a balanced panel of 6,550 observations.

[12]Annual state population estimates come from the U.S. Census Bureau. We linearly interpolate a quarterly series with the third quarter observation set to the value reported by Census each July, save for the decadal observations of 1970, 1980 and 1990; these are reported in April and coded as the second quarter observation for those years.

Figure 1 plots the cross-sectional average of the growth rate of real per capita personal income, along with the corresponding one standard deviation interval (the grey shaded region) computed per quarter. For our full sample, the annualized mean quarterly growth rate of real per capita income for the country as a whole is 2.1% with an annualized standard deviation of 2.3%. However, some of the smaller states (in terms of population) exhibit far more volatile quarterly growth rates. For example, the average annual rate of income growth for South Dakota is 2.4% in our sample, while the standard deviation is 13%. By contrast, California (the largest state by population) has an average annual income growth of 2.1% with a standard deviation of 1.9%, closely mirroring the national figures. To avoid having the observations from the smaller states unduly influence our results, we use a weighted estimation technique. The weights are each state's population as a proportion of the total national population in period t.[13]

5.2 Quantifying the State Dependence Effect

We begin by estimating equation (2) above. The geographically de-meaned activity measure, $\widetilde{y}_{it}$, is the one-quarter income growth rate in state i at date t less the average growth rate across all 50 states at time t. We use $p = 4$ lags of demeaned income growth and $q = 3$ lags of the Funds rate (plus the contemporaneous observation) in our estimation. Notice that the monetary policy instrument only enters equation (2) interacted with lagged observations of the dependent variable.

Our main hypothesis is that states that are doing relatively worse than the national average will have a larger negative response to a monetary contraction than the average state. In other words, a "depressed" state will move farther away from the average following a negative monetary policy shock. For our specification, this hypothesis implies a positive sum of the γ_{jk} terms in equations (1) and (2).[14] Collectively, the $\widehat{\gamma}_{jk}$ sum to -0.01 (p-value = 0.39). However, the coefficients on the more recent lags of the Fed Funds rate interactions are larger and highly significant. Specifically, the sum of $\widehat{\gamma}_{10}$ through $\widehat{\gamma}_{51}$ is 0.06 (p-value = 0.02) and the sum of $\widehat{\gamma}_{10}$ through $\widehat{\gamma}_{62}$ is 0.03 (p-value = 0.17). We conclude that increases in the Federal Funds rate during the contemporaneous or immediately previous quarter cause states with relatively low growth rates in the recent past to diverge even more from the national average.

[13] We also experimented with excluding the most volatile states from the sample entirely (usually Montana, North Dakota, and South Dakota) and with an unbalanced panel formed by truncating the top and bottom 1% of the individual observations on demeaned state income growth. In the majority of these cases the truncation and exclusion methods made our results below stronger and more statistically significant. For exposition, we only report the results from the weighted regressions.

[14] Each interaction term is the product $\gamma_{jk} \times \widetilde{y}_{it-j} \times z_{t-k}$. A contractionary Funds rate shock (positive z_{t-k}) interacting with a "depressed" state (negative $\widetilde{y}_{it-j}$) yields a lower than average impulse response if $\gamma_{jk} > 0$.

As in the VAR literature, the large number of coefficient estimates in equation (2) are difficult to interpret individually, or even jointly. To really uncover the dynamic effects of a monetary policy shock on the distribution of state income growth in our model, we compute dynamic responses for $\tilde{y}_{it}$. Due to the state dependency represented by the interaction terms, the magnitude and duration of the computed responses depends on the assumed initial lagged values of $\tilde{y}_{it-j}$, which in turn are a function of the history of cross-sectionally demeaned idiosyncratic shocks, $\tilde{v}_{it-j}$.[15]

Therefore, we presume a state first experiences a one-time exogenous shock to $\tilde{v}_{it-j}$. This deviation from the steady-state can then give rise to non-trivial effects of a monetary policy change working through the interaction terms. It is important to recognize that the time $t-j$ idiosyncratic shock and the time t monetary policy shock are independent; this framework merely permits a straight-forward way to quantify the significance of the state dependence terms. In the figures shown below, we let $j = 4$ and $\tilde{v}_{it-j}$ equal one standard deviation below the average state income growth rate in our sample.

To further isolate the quantitative significance of the interaction terms, we can simulate the impulse response to the $\tilde{v}_{it-j}$ shock alone, without any subsequent monetary policy shock. This response is a function solely of the $\hat{\alpha}_j$ parameters, and provides the baseline dynamics for a state that is shocked away from its steady-state growth rate (normalized to zero). These natural "business cycle" dynamics of the endogenous activity variable will eventually return state i to its long-run average growth rate; in our sample the initial shock is approximately 5 percentage points and the own response of $\tilde{y}_{it-j+h}$ persists for about $h = 12$ quarters on average.[16]

What is the additional impact of a contractionary shock to monetary policy for a state that experienced a negative idiosyncratic shock four quarters ago? To measure this effect, we compute the impulse responses from a one-time 25 basis point increase in the Fed Funds rate and subtract the underlying dynamics as specified in the previous paragraph. The resulting response is shown in figure 2. Note that this response is not exactly the one given by equation (7), as it ignores the persistence of the Funds rate (the θ_h terms for $h \geq 1$). As it turns out, a one-time 25 basis point shock to the Fed Funds rate has nearly the same quantitative effect as simulating a persistent response of the Funds rate to a exogenous monetary policy shock, as represented by equation (3).[17] Therefore, to simplify the exposition we focus our

[15] Notice that if a state with $\tilde{y}_{it-j} = 0$ for all $j > 0$ were to experience a monetary policy shock, there would be no distributional consequences: the h-period ahead interaction terms all would still be zero.

[16] Figure 8 plots the impulse response of a one-standard deviation negative shock to $\tilde{v}_{it-4}$ over the subsequent 20 quarters.

[17] The $\hat{\theta}_h$ estimates are generated by a 6-variable structural VAR on U.S. macroeconomic data as in Christiano et al. (1999).

discussion on the impulse responses from the one-time shock.

Like Carlino and DeFina (1998, 1999), we report the cumulative responses of the state activity variable to a one-time monetary policy shock. Figure 2 shows the cumulative effect of the contractionary monetary policy shock on the growth rate of a "depressed" state — one that experienced a negative shock to $\tilde{v}_{it}$ four quarters earlier. To reiterate, this response has been purged of the underlying natural dynamics of the system and thus plots the incremental dynamic response due to the policy interaction terms only. The shaded region represents the bias-corrected bootstrapped 90% confidence interval for the estimated response.[18]

Recall that by virtue of the earlier negative shock to $\tilde{v}_{it+h}$, the "depressed" state in this experiment will be growing more slowly than the average state. The one-time contractionary policy shock at $h = 0$ further slows growth in this state, as shown in figure 2. By $h = 8$ quarters after the innovation to the Funds rate, most of the impact has been felt, and the cumulative additional reduction in the "depressed" state's growth rate is nearly −0.11 percentage points. This response is statistically discernible from zero at all forecast horizons greater than zero.

Carlino and DeFina (1999) estimate state-by-state VARs and report an average cumulative reduction in state personal income growth from a 100-basis point contractionary shock to be 1.16 percentage points at an 8-quarter forecast horizon.[19] Scaling proportionally, our 25 basis point shock should imply a 0.29 percentage point cumulative fall in state income growth after 8 quarters for a state at the mean cross-sectional growth rate. For a state that was growing more slowly than average when the 25 basis point shock occurred, output growth slowed an additional 0.11 percentage points, or 0.40 percentage points overall. We interpret this additional state-dependent effect as sizable relative to the established results in the literature.

Conversely, the specification of our model implies that a state that starts out one standard deviation above the mean growth rate four quarters prior to the contractionary policy shock experiences a *positive* incremental response of 0.11 percentage points. Again taking the Carlino and DeFina (1999) estimates as our baseline, such a state would still experience a reduction in its growth rate from the contractionary policy shock, but the net cumulative effect would be only a $0.29 - 0.11 = 0.18$ percentage point decline.

[18]Our bootstrap program re-estimates equation (2) 1000 times by re-sampling our original data with replacement. After the regression is estimated, we re-compute the incremental effect of a 25 basis point increase in the Federal Funds rate as described above.

[19]Conceptually, they embedded our equation (1) in a VAR framework and estimate under the assumption that all γ_{jk} are identically zero. Their sample period is 1958Q1 – 1992Q4.

Notice that the 0.22 percentage point disparity between states with "high" and "low" initial conditions relative to the average is comparable in magnitude to the estimated average response itself.

In summary, monetary contractions lead to larger declines in income growth for states experiencing relatively worse economic growth in the recent past as compared with the average state. By contrast, states experiencing relatively better economic growth in the recent past have smaller declines in income growth as compared with the average state.

5.3 Asymmetric Policy Effects

Equation (2), like most linear dynamic models (including VARs), also is symmetric in the policy shock: the model specification implies that a 25 basis point expansionary policy shock should result in an identical impulse response, opposite in sign, to that shown in figure 2. Yet as explored in sections 2 and 3, both theory and some related evidence support the proposition that contractionary policy might have different effects than expansionary policy for a state away from the cross-sectional average. To test this conjecture, we divide the policy innovations into positive and negative changes in the Funds rate, and re-estimate equation (2) with separate coefficients on the interaction terms for positive innovations as for negative ones:

$$\tilde{y}_{it} = \sum_{j=1}^{q} \alpha_j \tilde{y}_{it-j} + \sum_{k=0}^{p} \sum_{j=k+1}^{q} \gamma_{jk}^{+} (\tilde{y}_{it-j} \cdot z_{t-k}^{+}) + \sum_{k=0}^{p} \sum_{j=k+1}^{q} \gamma_{jk}^{-} (\tilde{y}_{it-j} \cdot z_{t-k}^{-}) + \tilde{\varepsilon}_i + \tilde{\nu}_{it} \tag{8}$$

where z_{t-k}^{+} and z_{t-k}^{-} are the contractionary and expansionary changes to monetary policy, respectively, and γ_{jk}^{+} and γ_{jk}^{-} are the corresponding coefficients on the interaction terms to be estimated.[20]

The sum of the estimated coefficients on the interaction terms for contractionary policy shocks (i.e. increases in the Fed Funds rate) is similar to the above results: $\sum\sum_{j,k} \hat{\gamma}_{jk}^{+} = 0.04$ (p-value of 0.16). However, for the expansionary shocks (i.e. decreases in the Fed Funds rate) the sum of the estimated coefficients on the interaction terms is $\sum\sum_{j,k} \hat{\gamma}_{jk}^{-} = -0.05$ (p-value = 0.02). The sign of these accumulated coefficients confirms our intuition about the nature of the effect: an expansionary shock ($\Delta z_t < 0$) for a relatively slow-growing state ($\tilde{y}_{it} < 0$) still results in a *fall* in income growth relative to the average state. Moreover, the magnitude is larger than the estimated effect for negative shocks or the overall effect reported for the previous symmetric model, and is strongly statistically significant. Interestingly, these

[20] Cover (1992) uses a similar econometric approach.

results contradict the old saw that "monetary policy cannot push on a string" — at least when it comes to the impact on the regional distribution of economic activity.[21]

We conduct additional policy experiments for our hypothetically "depressed" state, defined as above, to compute separate dynamic responses for contractionary and expansionary policy shocks, respectively. Figure 3 shows the cumulative effect on the "depressed" state's growth in per capita income in response to a 25 basis points increase in the Fed Funds rate, along with the bootstrapped bias-corrected 90% confidence region. Figure 4 plots the cumulative response for the "depressed" state following a Fed Funds decrease of 25 basis points. The figures look very similar, yet have the striking interpretation that expansionary shocks are not the mirror image of contractionary shocks — in fact, the economic performance of relatively "depressed" states worsens in response to *both* expansionary and contractionary shocks! Put another way, compared to the average state, states initially in a "low" position (i.e. recently have experienced negative idiosyncratic shocks) experience larger economic contractions in response to Federal Fund rate increases and smaller economic expansions in response to Fund rate declines. Likewise, states that start in a "high" position (i.e. recently have experienced negative idiosyncratic shocks) experience larger economic expansions in response to rate declines and smaller economic contractions in response to rate increases.

5.4 Robustness: Sample Period

Owyang and Wall (2004) document much smaller effects of monetary policy on US regions following the Volcker disinflation.[22] Estimation of equation (2) for the post-Volker sample, 1984Q1 – 2003Q4, generates similar impulse responses as in the full sample (1970Q2 – 2003Q4). Figure 5 is analogous to figure 2, corresponding to the model with state dependency but symmetric policy effects. Figures 6 and 7 show the estimates from our asymmetric model estimated over the post-Volcker sub-sample. States performing below average still experience greater output declines in response to monetary contractions and smaller output gains in response to monetary expansions. The cumulative effects estimated with the post-Volker sample are larger than those estimated over the full sample. However, given the confidence bands, we cannot reject the null that the estimated magnitudes across the two samples are the same. These results imply that the relative importance of the distributional effects of monetary policy studied herein has

[21] We conjecture that the consumer credit channel, particularly mortgage refinancing, plays an important role in the transmission of expansionary monetary policy at this level of disaggregation.

[22] Hanson (2004) reports similar results in VARs estimated with aggregate U.S. data.

increased over time as the mean response to policy shocks has fallen.

These sub-sample results may seem surprising in light of changes in U.S. interstate banking regulations since the mid-1908s, which likely reduced the reliance on local credit providers. Our results suggest the possibility that any dampening of the regional variation in loan supply that may have followed from these changes in the structure of the banking sector are less important than regional contributions to fluctuations in loan demand. Most collateral, such as houses or physical plant and equipment, cannot be easily relocated in the face of regional shocks. The rise of home equity loans and mortgage refinancing in the latter part of our sample may have significantly increased the importance of this particular channel. Based on our results, this issue deserves further empirical investigation.

6 Conclusion

In this paper we establish a new set of stylized facts about the effects of monetary policy at the state level in the U.S. Unlike other research on the regional effects of monetary policy, our approach focuses on how policy affects the distribution of real economic activity in the cross-section of U.S. states over time. State business cycles are not synchronized: at any given point in time, some states are growing much faster and some much slower than the average. The Federal Reserve, however, conducts monetary policy to stabilize the national business cycle. In this paper we investigate whether this environment leads a common change in Fed policy to have differential effects across states, conditional on their initial business cycle position.

Our results are both sizable and striking. In our estimates, monetary contractions lead to larger declines in economic activity for states experiencing relatively worse economic growth in the recent past, as compared to the average state. Other authors have estimated the average state-level effect of the same contractionary policy experiment to be around a 0.29 percentage point cumulative reduction in real state income growth. Taking that value as a baseline, our results imply that a 25 basis point increase in the Fed Funds rate widens the dispersion in state income growth by 22 basis points. This distributional effect is on the same order of magnitude as the estimated mean effects in previously published research.

We also provide evidence against symmetry in the impacts of expansionary and contractionary monetary policy in our specification. Relatively low-growth states experience smaller increases in economic activity in response to a monetary expansion than does the average state. Collectively, we conclude that monetary policy has large distributional implications across regions of the United States. Our results suggest that monetary policy does, in fact, help least those areas that need it the most, in that their local economic conditions already were worse relative to a national average when the policy was enacted. Put another way, while expansionary monetary policy may lead to an overall increase in aggregate output, the majority of that increase will occur in the parts of the country that were already performing better than average. There will be much less stimulus in those parts of the country that had been performing relatively worse than average.

Our approach is distinct from existing research that estimates the effect of monetary policy to vary systematically across states — say, to have a greater effect in Michigan than in Arizona. While others have posited that banking structure and industrial mix determine a given state's responsiveness to monetary policy, we investigate the interaction between the recent business conditions in a state and changes in monetary policy after controlling for these state fixed effects. Speaking loosely, our research addresses the differential effects of monetary policy when a state — be it Michigan or Arizona — is booming (relative to the national average) in comparison with the effects when that same state is in a slow down (again, relative to average).

This research has several broader implications as well. First, our results suggest an important role for history-dependence and asymmetries in the impact of monetary policy. State-level data provide a natural environment to investigate such components, which commonly are absent from estimates with national data — as well as existing regional research. Second, these distributional effects likely generalize to other locations. One specific case is the European Monetary Union: as with the U.S. states, members of EMU face a common monetary policy implemented at the aggregate Euro-zone level. As the cross-country disparities in growth among the EMU member countries appear to be larger on average than those for the U.S. states, the effects identified by our research are likely to be even stronger within the Euro area. Finally, while our work in this area is still preliminary, we believe our results provide additional evidence for the importance of the credit channel, broadly defined, in the transmission of monetary policy. We intend to explore this issue further in subsequent research.

References

Bernanke, Ben S. and Mark Gertler, "Inside the Black Box: The Credit Channel of Monetary Policy Transmission," *Journal of Economic Perspectives*, Fall 1995, *9* (4), 27–48.

Carlino, Gerald and Robert DeFina, "The Differential Regional Effects of Monetary Policy," *Review of Economics and Statistics*, November 1998, *80* (4), 572–587.

__ **and** __ , "The Differential Regional Effects of Monetary Policy: Evidence from the U.S. States," *Journal of Regional Science*, 1999, *39* (2), 339–358.

Choi, Woon Gyu, "Asymmetric Monetary Effects on Interest Rates across Monetary Policy Stances," *Journal of Money, Credit and Banking*, August 1999, *31* (3), 386–416.

Christiano, Lawrence J., Martin Eichenbaum, and Charles Evans, "Monetary Policy Shocks: What Have We Learned and to What End?," in Michael Woodford and John Taylor, eds., *Handbook of Macroeconomics*, Vol. 1A, New York: Elsevier Science, North-Holland, 1999, pp. 65–148.

Cover, James Peery, "Asymmetric Effects of Positive and Negative Money-Supply Shocks," *The Quarterly Journal of Economics*, November 1992, *107* (4), 1261–1282.

Driscoll, John C., "Does Bank Lending Affect Output? Evidence from the U.S. States," *Journal of Monetary Economics*, April 2004, *51* (3), 451–471.

Frantantoni, Michael and Scott Schuh, "Monetary Policy, Housing, and Heterogeneous Regional Markets," *Journal of Money, Credit and Banking*, August 2003, *35* (4), 557–589.

Hanson McPherson, Sandra and Christopher J. Waller, "Do Local Banks Matter for the Local Economy? In Search of a Regional Credit Channel," in Gregory D. Hess and Eric van Wincoop, eds., *Intranational Macroeconomics*, Cambridge University Press, 2000, chapter 12, pp. 295–316.

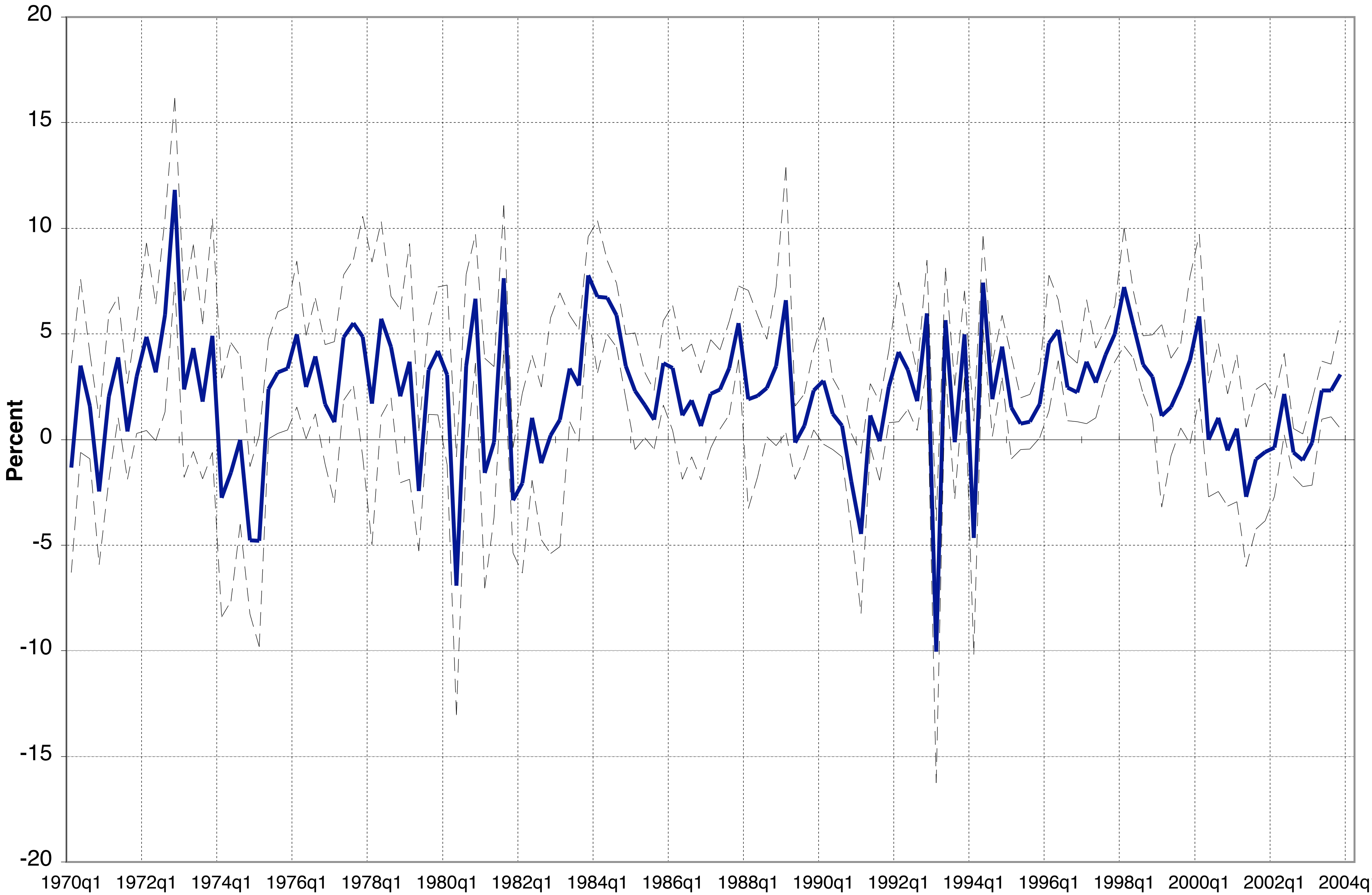
Hanson, Michael S., "The 'Price Puzzle' Reconsidered," *Journal of Monetary Economics*, October 2004, *51* (7), 1385–1413.

Kashyap, Anil and Jeremy C. Stein, "What Do a Million Observations on Banks Say About the Transmission of Monetary Policy?," *American Economic Review*, June 2000, *90* (3), 407–428.

Owyang, Michael T. and Howard J. Wall, "Structural Breaks and Regional Disparities in the Transmission of Monetary Policy," June 2004. Federal Reserve Bank of St. Louis working paper.

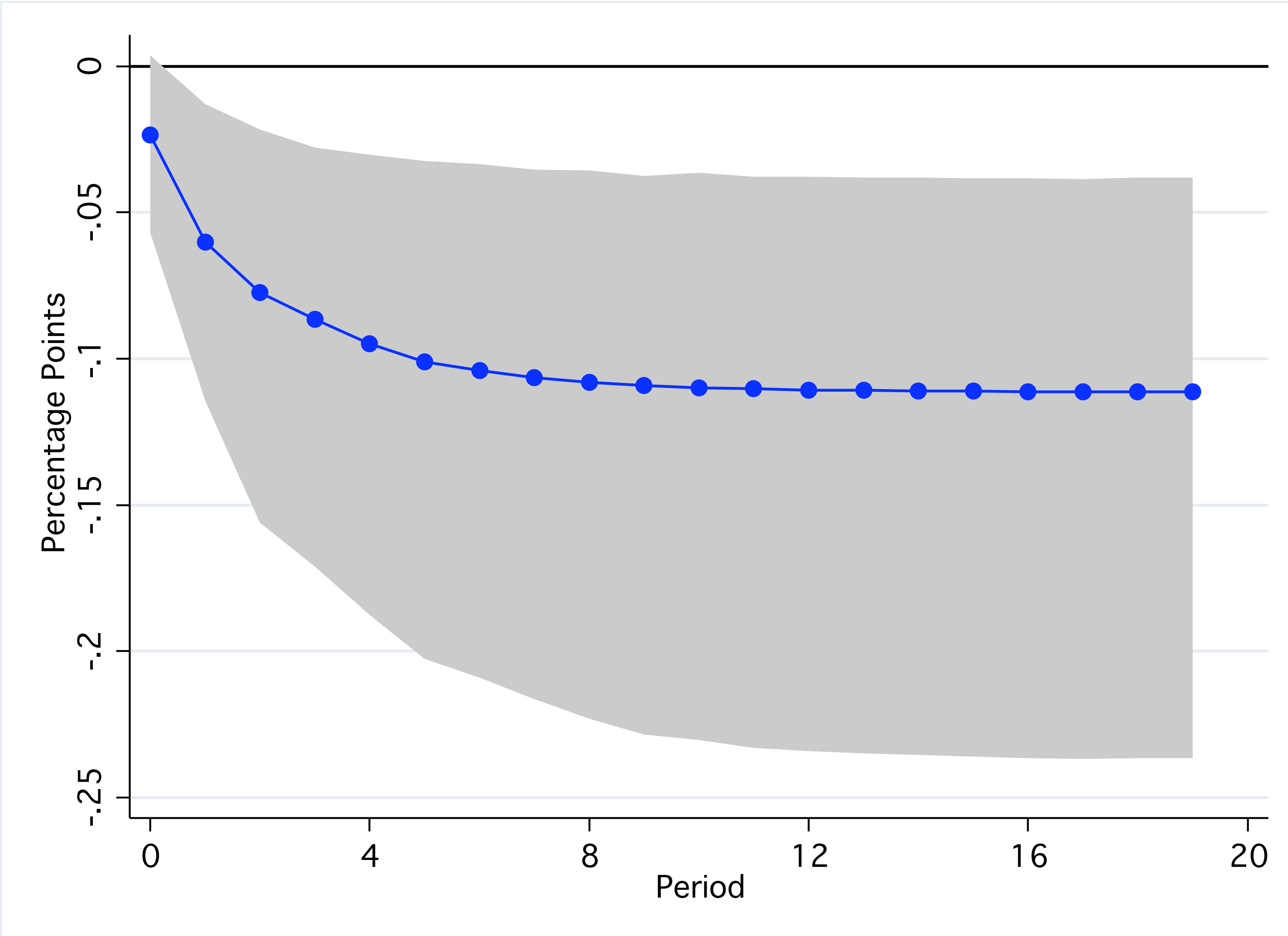
Peek, Joe, Eric S. Rosengren, and Geoffrey M.B. Tootell, "Identifying the Macroeconomic Effect of Loan Supply Shocks," *Journal of Money, Credit and Banking*, December 2003, *35* (6), 931–946.

Figure 1: Distribution of Annualized Quarterly Growth Rate of Real State Per Capita Personal Income



Cross-Sectional Mean Growth Rate per Period (with One Standard Deviation Bands)

Figure 2: Cumulative Response of Growth in State Income Per Capita, Relatively Poorly Performing State

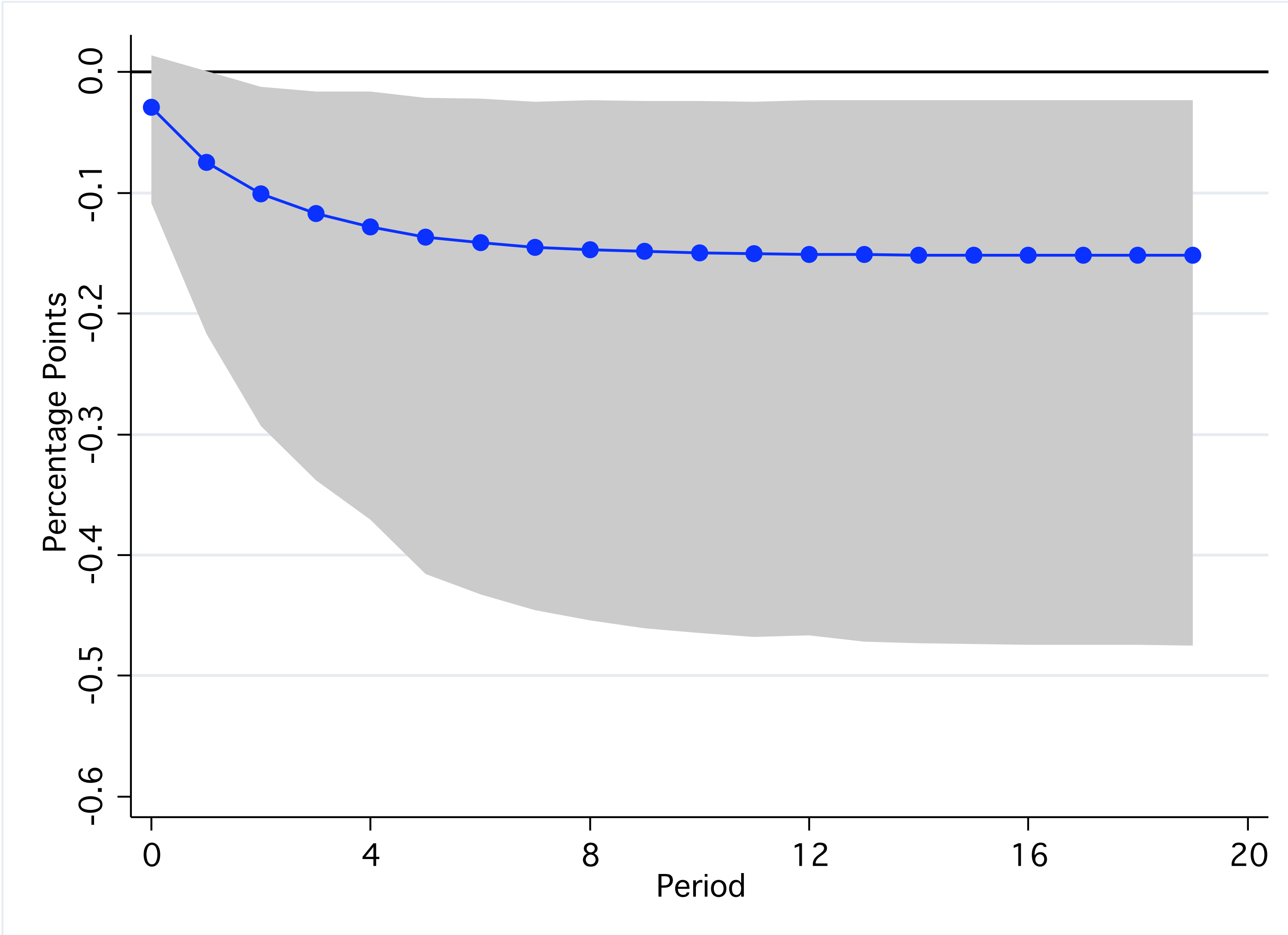


Model: **Symmetric Policy Response**

Sample: **1970Q1 – 2003Q4**

Experiment: **25 Basis Points Increase in Funds Rate**

Figure 3: Cumulative Response of Growth in State Income Per Capita, Relatively Poorly Performing State

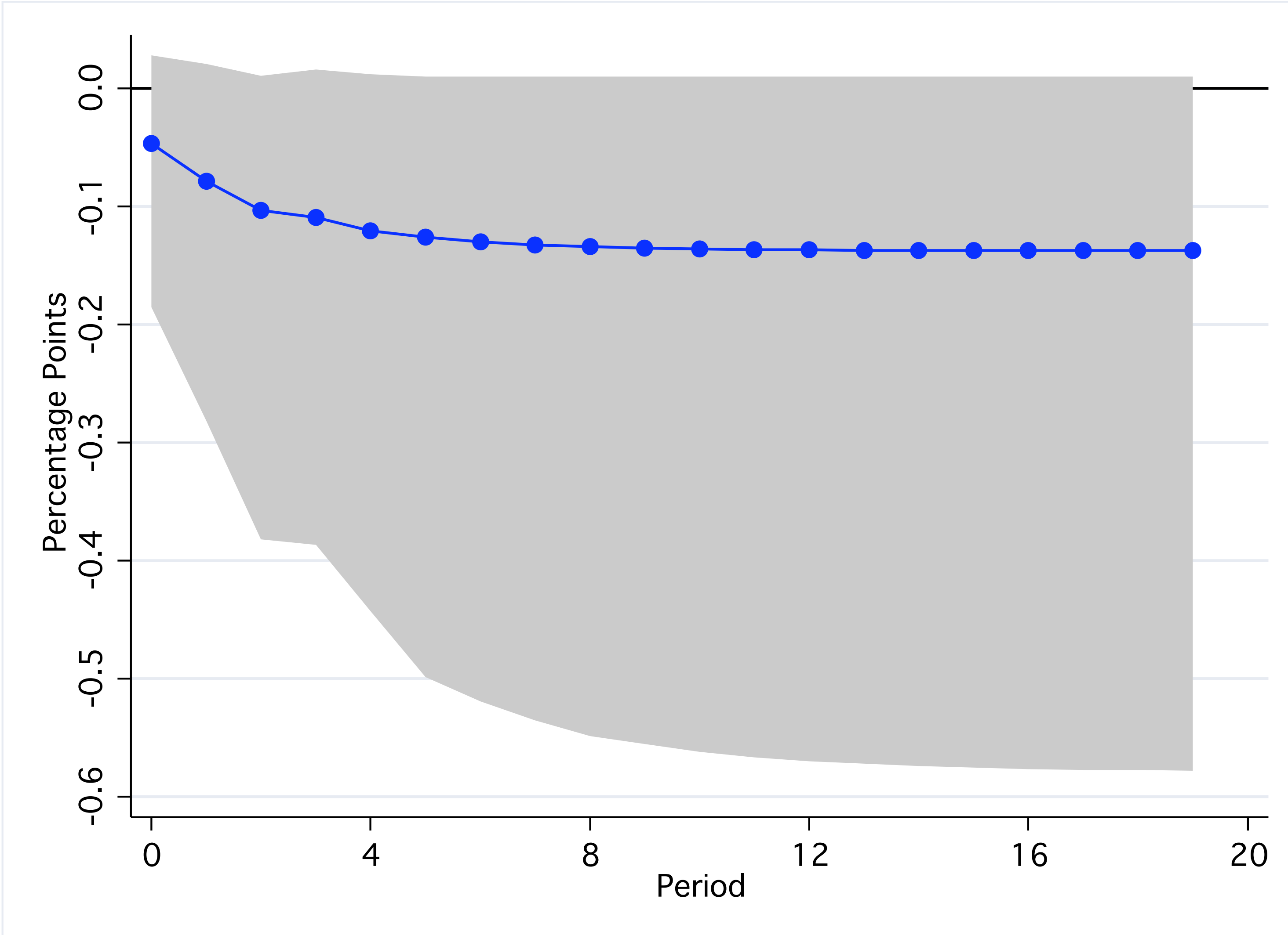


Model: **Asymmetric Policy Response**

Sample: **1970Q1 – 2003Q4**

Experiment: **25 Basis Points Increase in Funds Rate**

Figure 4: Cumulative Response of Growth in State Income Per Capita, Relatively Poorly Performing State

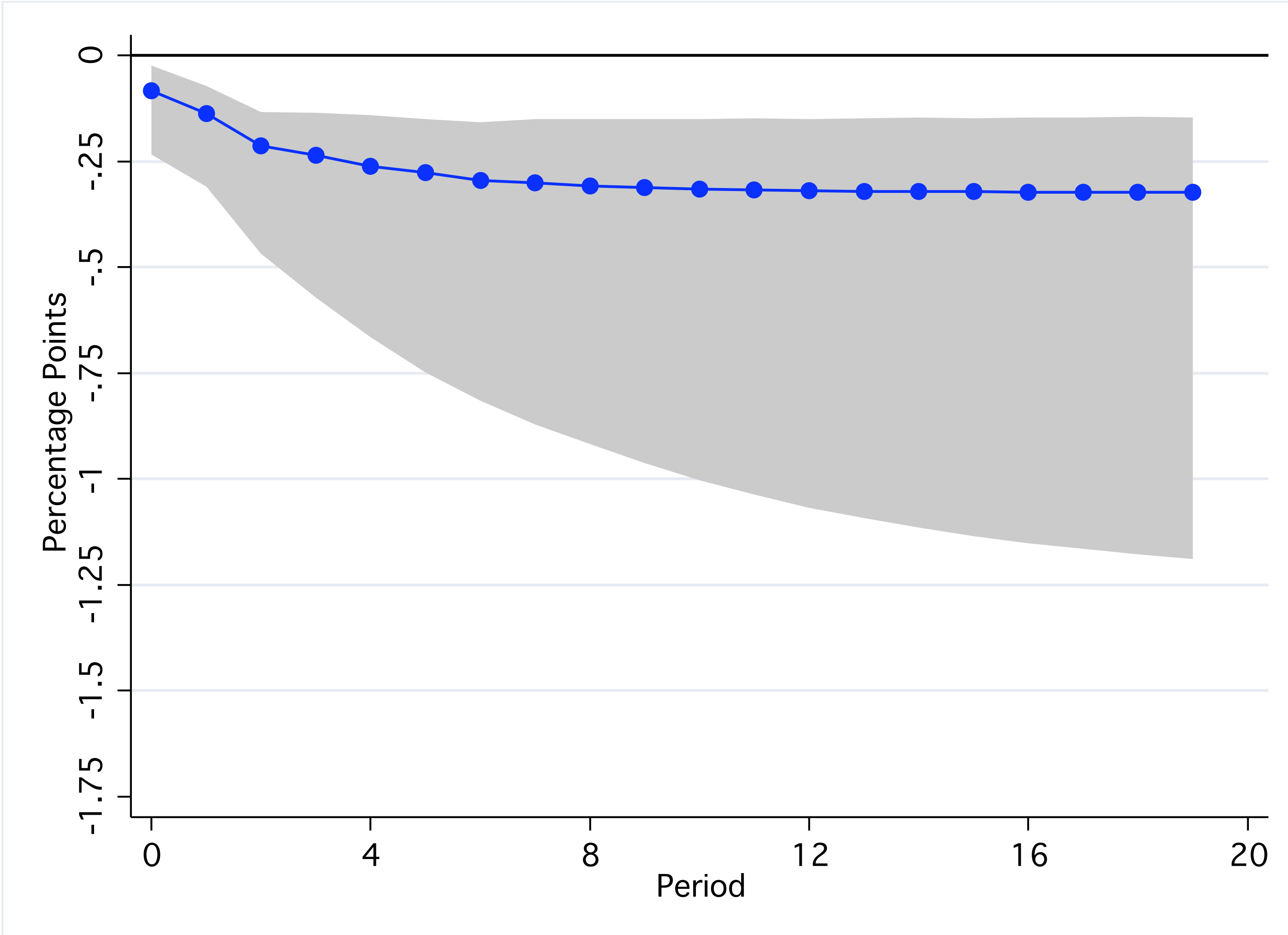


Model: **Asymmetric Policy Response**

Sample: **1970Q1 – 2003Q4**

Experiment: **25 Basis Points Decrease in Funds Rate**

Figure 5: Cumulative Response of Growth in State Income Per Capita, Relatively Poorly Performing State

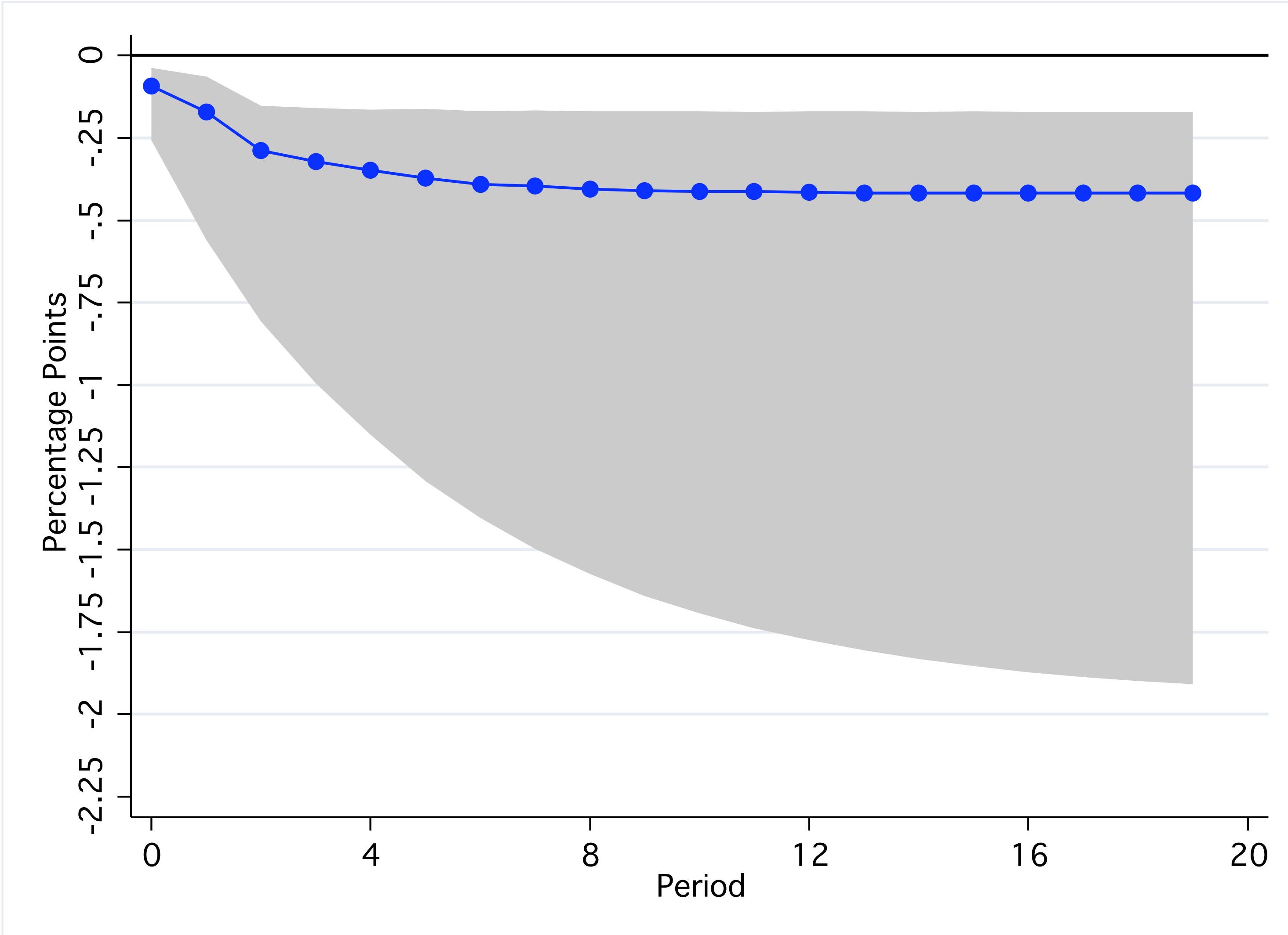


Model: **Symmetric Policy Response**

Sample: **1983Q1 – 2003Q4**

Experiment: **25 Basis Points Increase in Funds Rate**

Figure 6: Cumulative Response of Growth in State Income Per Capita, Relatively Poorly Performing State

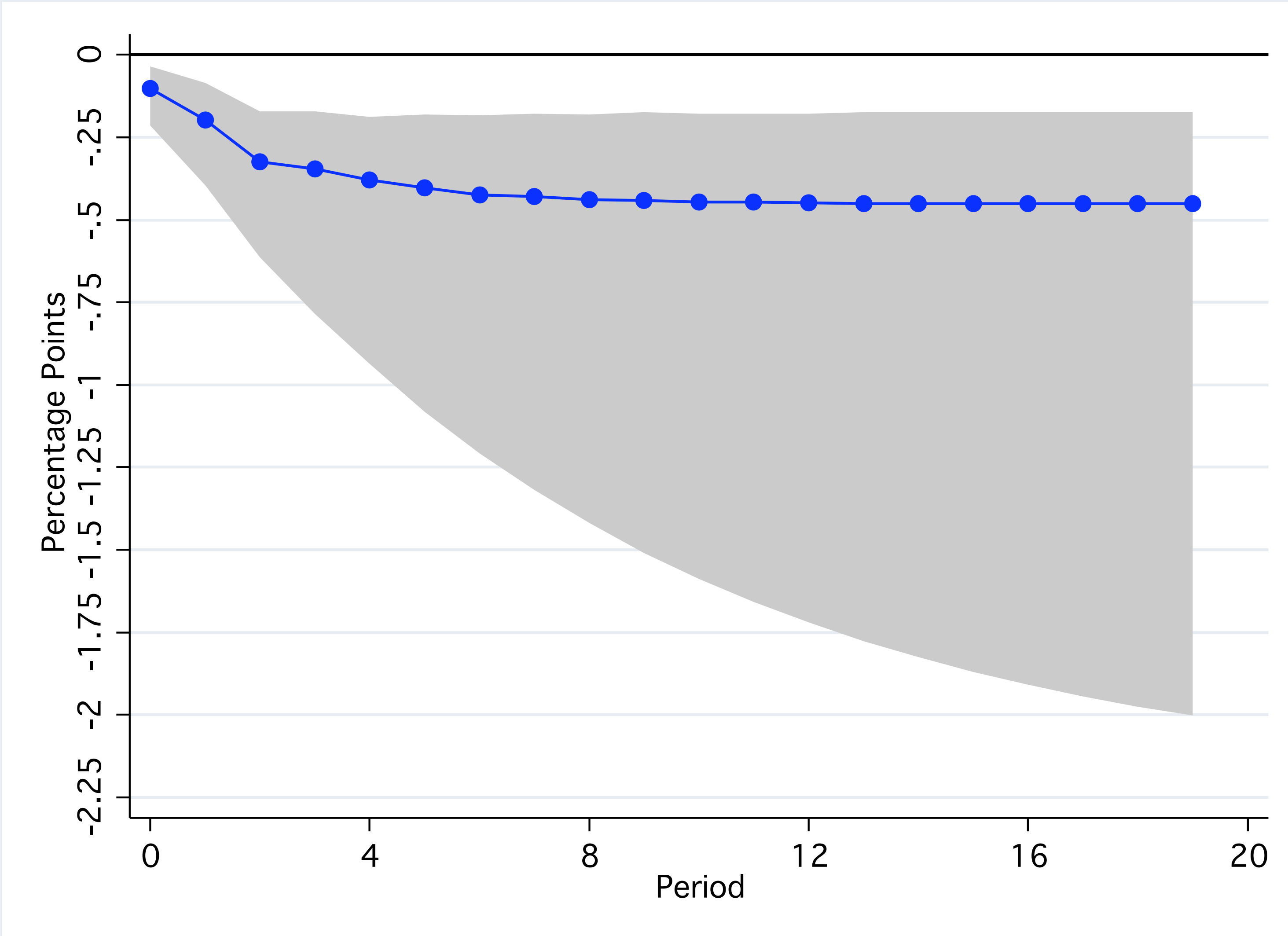


Model: **Asymmetric Policy Response**

Sample: **1983Q1 – 2003Q4**

Experiment: **25 Basis Points Increase in Funds Rate**

Figure 7: Cumulative Response of Growth in State Income Per Capita, Relatively Poorly Performing State

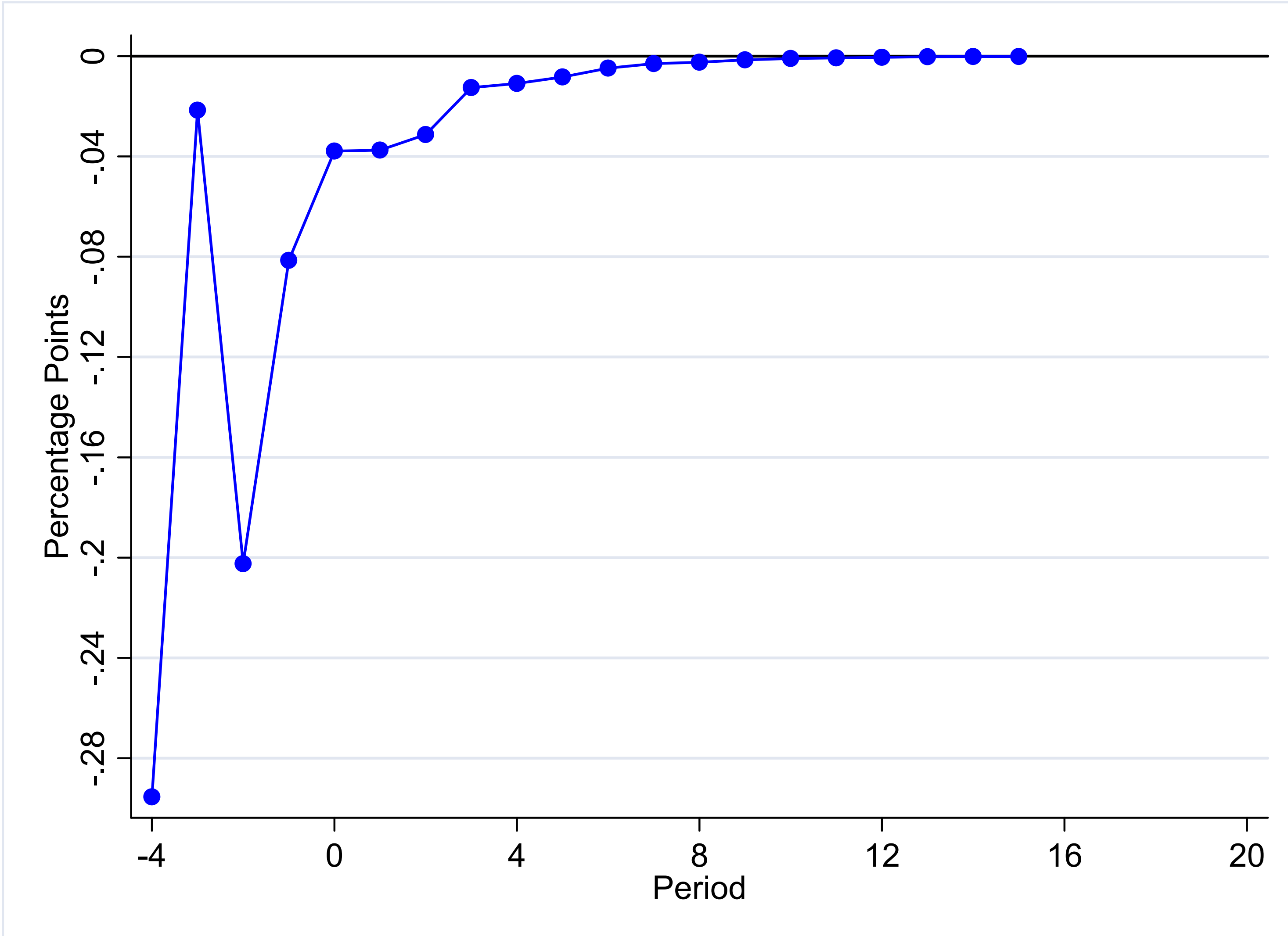


Model: **Asymmetric Policy Response**

Sample: **1983Q1 – 2003Q4**

Experiment: **25 Basis Points Decrease in Funds Rate**

Figure 8: Impulse Response of Growth in State Income Per Capita, Relatively Poorly Performing State



Sample: **1970Q1 – 2003Q4**

Experiment: **No Policy Innovations**