

# How do people interpret macroeconomic shocks? Evidence from U.S. survey data\*

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## Abstract

We study the revision of survey expectations in response to macroeconomic shocks, which we identify in vector autoregressive models with sign restrictions. We find that survey respondents distinguish between movements along the Phillips curve and shifts of the Phillips curve, depending on the type of shock that hits the economy. In addition, interest rate expectations are revised broadly in line with a Taylor rule. Consistent with models of rational inattention, macroeconomic shocks account for a small share of the forecast error variance of survey measures elicited from consumers, while they are more relevant for the expectations of professional forecasters.

Keywords: Macroeconomic Expectations, Michigan Survey, Structural Vector Autoregression, Zero and Sign Restrictions

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# 1 Introduction

How do people interpret macroeconomic developments and form expectations? To the extent that views about current and future developments influence decision making, macroeconomic outcomes themselves should depend on agents' perceptions.<sup>1</sup> In other words, people's perceptions should be an integral element of the propagation mechanism for shocks. In fact, macroeconomic models assign a key role to expectations and forward-looking behavior.<sup>2</sup> Yet, empirically, relatively little is known about how people interpret shocks.

We estimate vector autoregressive (VAR) models with U.S. macroeconomic data and survey data from the University of Michigan's Surveys of Consumers (Michigan Survey) and from the Survey of Professional Forecasters (SPF) to study how expectations are revised in response to structural macroeconomic shocks. To identify shocks, we impose zero and sign restrictions on the impulse responses of the macroeconomic variables. Specifically, we identify aggregate demand (AD) shocks, aggregate supply (AS) shocks, and monetary policy (MP) shocks. To disentangle AD and AS shocks, we restrict the unemployment rate and the inflation rate to move in the same direction in case of an AD shock, and in opposite directions following an AS shock. In addition, we assume that a restrictive policy shock gives rise to the same dynamics of the unemployment rate and the inflation rate as an adverse AD shock, but with the additional restriction that the interest rate increases. These restrictions are a standard characterization of the shocks that we are interested in and are consistent with a wide range of macroeconomic models (see e.g. Smets and Wouters, 2005; Peersman, 2005; Smets and Wouters, 2007; Fry and Pagan, 2011).

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<sup>1</sup>Armantier et al. (2015) find that expectations elicited from surveys and choices in a laboratory experiment are correlated. Barnes and Olivei (2017) show empirically that information about consumers' attitudes obtained from the University of Michigan's Survey of Consumers has forecasting power for consumption.

<sup>2</sup>For an overview on the role of expectations in macroeconomic models and the propagation of shocks see e.g. Evans and Honkapohja (2001). A related, albeit distinct, issue is the modeling of expectations (see, among others, Carroll, 2003; Milani, 2007; Coibion and Gorodnichenko, 2015a).

Our analysis is closely related to Carvalho and Nechio (2014) who analyze whether expectations are consistent with a Taylor rule relationship and argue that a better understanding of monetary policy enhances its effectiveness. Along similar lines, Dräger et al. (2016) find that central bank communication increases the understanding of key macroeconomic concepts.

The VAR approach allows us to study dynamic responses of the survey measures, while the existing literature focuses on contemporaneous relationships. Since expectations may not be updated instantaneously, the contemporaneous relationship may not capture all relevant information. In addition, and perhaps more importantly, the identified shocks are orthogonal by construction, which simplifies the interpretation of the results. For instance, analyzing whether expectations are consistent with a Phillips curve is complicated by the fact that the Phillips curve may shift due to AS shocks. Dräger et al. (2016) assume that short-run fluctuations are either predominantly due to AD shocks when comparing people's expectations with the predictions of a Phillips curve relationship,<sup>3</sup> or that AS shocks are adequately captured by oil price movements. In our analysis, we explicitly distinguish between AD and AS shocks and characterize the responses of the survey measures accordingly. Similarly, when analyzing whether expectations are consistent with a Taylor rule, Carvalho and Nechio (2014) and Dräger et al. (2016) assume that movements in the interest rate are due to systematic monetary policy rather than shocks to the Taylor rule. Our identification approach, in contrast, ensures that policy shocks are orthogonal to AS and AD shocks. Therefore, we can explicitly disentangle systematic policy responses and policy shocks.

We find that in response to an adverse AD shock, survey respondents expect unemployment to increase and inflation to decrease, which is consistent with a Phillips curve relationship. At the same time, interest rate expectations decrease, which is in line with a Taylor rule. These findings

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<sup>3</sup>There is some empirical evidence indicating that AS shocks are quantitatively important sources of business cycle fluctuations (see e.g. Smets and Wouters, 2005, 2007).

corroborate the results reported in Carvalho and Nechio (2014) and Dräger et al. (2016). For adverse AS shocks, we find that unemployment and inflation are both expected to increase. Thus, survey respondents correctly distinguish between AD and AS shocks. In other words, they distinguish between movements along the Phillips curve and shifts of the Phillips curve. Following an adverse AS shock, the interest rate expectation increases, which indicates that survey respondents expect the Fed to put more weight on inflation than on real economic developments in the aftermath of an AS shock. Overall, these results suggest that survey answers are consistent with the propagation mechanisms for AD and AS shocks in standard macroeconomic models. Concerning MP shocks, the evidence is less conclusive. The responses of the expectation measures are characterized by a high degree of dispersion and the effects are less persistent. Thus, while survey respondents interpret the effects of AD and AS shocks on interest rates in line with the systematic monetary policy reaction incorporated in standard models, our results indicate that the interpretation of the effects of MP shocks is less clear.

We also study how consumption plans are adjusted and find that survey respondents increasingly plan to reduce consumption in response to adverse AS shocks, which is in line with the pronounced responses of the expectation measures. Following AD shocks, we find a modest decline of our measure of planned purchases of larger household items.

To complement the VAR estimation, we conduct a regression analysis that allows us to use the rotating panel design of the Michigan Survey, and to control for individual characteristics of the survey respondents. This additional analysis shows that although heterogeneities across respondents play some role in how consumers update expectations, our conclusions concerning the revisions in expectations induced by macroeconomic shocks are unaffected when we control for individual characteristics.

When we compare the results obtained with the Michigan Survey data to those obtained using the SPF, we find that consumers and professional forecasters interpret shocks in a remarkably similar way. However, with respect to how important the macroeconomic shocks are in shaping the dynamics of the survey expectations, pronounced differences emerge between consumers and professional forecasters. While the identified shocks explain only small shares of the forecast error variance of consumer expectations, they account for a sizable fraction of the forecast error variance of the SPF expectation measures. Since consumers are likely to have weaker incentives to collect and analyze information about macroeconomic conditions, this outcome is consistent with models of rational inattention (e.g. Sims, 2003).

The remainder of this paper is structured as follows: Section 2 describes the survey data from the Michigan Survey and the SPF. In Section 3 we discuss the estimation and the identification strategy. In Sections 4 we present the results based on Michigan Survey data and in Section 5 for SPF data. Section 6 explores the robustness of our results and Section 7 concludes the paper.

## 2 Survey Data

We use survey data from the Michigan Survey and from the SPF.<sup>4</sup> In the Michigan Survey the respondents are households and the survey answers should therefore be indicative for how consumers view economic developments.<sup>5</sup> While we primarily consider data obtained from the Michigan Survey, we also conduct the analysis using data from the SPF to see how consumers perceive macroeconomic developments in comparison to financial and economic experts.

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<sup>4</sup>These data are widely used to study expectations in a macroeconomic context. See e.g. Carvalho and Nechio (2014); Coibion and Gorodnichenko (2015b); Wong (2015); Bachmann et al. (2015); Dräger et al. (2016).

<sup>5</sup>Coibion and Gorodnichenko (2015b) argue that firms' expectations about economic activity and inflation are better approximated by household answers compared to answers from professional forecasters, since small and medium-sized enterprises usually have no professional forecasters on staff and are not likely to use professional forecasting services.

## 2.1 The Michigan Survey

A minimum of 500 telephone interviews are documented each month by the Survey Research Center at the University of Michigan. The households are selected to ensure that the sample is representative for the U.S. population (Alaska and Hawaii are excluded from the surveys). Survey questions cover three areas: demographics, how survey respondents assess the prospects for their own financial situation, and how they view prospects for the economy in general.

To evaluate how survey respondents interpret shocks, we focus on questions about the future developments of inflation, the interest rate, and real developments. The Michigan Survey contains quantitative as well as qualitative questions. For expected inflation we use point estimates obtained from answers to the following two questions:<sup>6</sup>

(A12) *‘During the next 12 months, do you think that prices in general will go up, or go down, or stay where they are now? (A12b) By about what percent do you expect prices to go (up/down) on the average, during the next 12 months?’*

The remaining questions that we use in our analysis are qualitative. To capture expectations about interest rates we consider the following question:<sup>7</sup>

(A11) *‘No one can say for sure, but what do you think will happen to interest rates for borrowing money during the next 12 months – will they go up, stay the same, or go down?’*

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<sup>6</sup>In fact, the point estimates of the expected inflation rate are a combination of answers to questions A12 and A12b. For all respondents that reach question A12b, we consider the point estimates, but not all respondents reach question A12b. Respondents indicating that prices stay the same in question A12 are asked a follow up question clarifying whether they mean that prices or that inflation stays the same. Those who specify that they mean that inflation remains the same, then have to provide the quantitative point estimate (i.e. they have to answer question A12b). Those respondents who confirm that they believe that prices stay constant are not asked for their point estimate and do not reach question A12b. They are automatically assigned a quantitative point estimate of 0.

<sup>7</sup>It has to be noted that this question does not refer to a specific interest rate and respondents may not specifically have the monetary policy rate in mind.

To infer expectations about real economic activity, we use the following question:

(A10) *‘How about people out of work during the coming 12 months – do you think that there will be more unemployment than now, about the same, or less?’*

In addition to expectations about the macroeconomic environment, we also study how survey respondents plan to adjust consumption in response to structural shocks. We study the adjustment of consumption plans using the question:<sup>8</sup>

(A18) *‘About the big things people buy for their homes – such as furniture, a refrigerator, stove, television, and things like that. Generally speaking, do you think now is a good or bad time for people to buy major household items?’*

To include the survey data in our VAR analysis, we aggregate the answers across respondents for each month  $t$ . Specifically, for the question about the expected inflation rate (question A12b), we simply average over the estimates provided by respondents. For the qualitative questions (A11, A10, and A18), we use balance scores (see e.g. Leduc and Sill, 2013). As an example for the construction of the balance scores, consider question A11. We calculate the balance score as the share of respondents indicating that interest rates for borrowing money during the next 12 months will go up minus the share of respondents indicating that interest rates go down and multiply this difference by 100 to allow for an interpretation in percentage points. Finally, we add 100 so that the balance score fluctuates around 100, as it is standard in the literature. Balance scores for the answers to questions A10 and A18 are obtained analogously.

Figure 1 displays the time series for the aggregated survey answers from January 1978 to July 2016. Shaded areas indicate NBER recessions. Panel A shows that expected inflation declined

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<sup>8</sup>Bachmann et al. (2015) use this question to study the influence of expected inflation on consumption plans at the zero-lower-bound.

strongly during the early 1980s along with the onset of the Great Moderation. According to Panel B and Panel C, the balance scores for interest rate expectations and unemployment developments exceed the level of 100 in most periods. Thus, survey respondents have a tendency to expect that borrowing becomes more expensive and that unemployment will increase. Panel D shows that people, on average, plan to increase current consumption spending despite the pessimistic overall outlook for the economy. These results are consistent with the view that borrowing costs are currently perceived as favorable relative to expected future developments. An alternative explanation is the so-called illusion of control fallacy, which states that people have a tendency to view their individual situation and things that depend on their own decisions optimistically, ignoring available information that paints a less optimistic picture (Langer, 1975).

We also see that the expectation measures fluctuate over the business cycle. As recessions set in, respondents tend to expect a lower inflation rate and lower interest rates, while relatively more respondents expect unemployment to increase. With respect to planned consumption, a relatively lower share of respondents states that it is a good time to consume.

## **2.2 The Survey of Professional Forecasters**

The SPF elicits survey answers from a group of approximately 40 private sector economists from financial and research institutions who generate forecasts about key macroeconomic variables. Respondents fill out a questionnaire form and provide point estimates for a number of variables and various forecasting horizons ranging from one quarter to 10 years. In contrast to the Michigan Survey, the SPF is conducted with a quarterly frequency. Another difference is that the SPF elicits point estimates, whereas the Michigan Survey asks for qualitative forecasts of the unemployment rate and the interest rate.



For our analysis, we use the cross-sectional averages provided by the Federal Reserve Bank of Philadelphia. Specifically, we use forecasts for the current quarter and for three quarter ahead for the consumer price index (CPI) inflation rate (denoted CPI5 in the SPF dataset), the three-month Treasury bill rate (TBILL5), and the unemployment rate (UNEMP5). Data for the expected T-Bill rate and the expected CPI inflation rate are available from the third quarter of 1981 while the expected unemployment rate is available since 1968.<sup>9</sup>

Figure 2 shows the time series for these survey measures from the third quarter of 1981 until the third quarter of 2016 together with the NBER recession dates indicated by shaded areas. During recessions, respondents expect the unemployment rate to go up and the inflation rate and the T-Bill rate to go down. These dynamics correspond to the pattern that we have obtained with consumer data from the Michigan Survey, discussed above.

### 3 Estimation and Identification

#### 3.1 Estimation

We estimate reduced-form VAR models of the type

$$x_t = c + \sum_{l=1}^L B_l x_{t-l} + e_t,$$

where  $x_t$  is a vector of endogenous variables,  $c$  is a vector of constants,  $B_l$  is the matrix of reduced-form coefficients at lag  $l$ , and  $e_t$  is a vector of residuals with covariance matrix  $\Sigma_e = E(e_t e_t')$ . We

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<sup>9</sup>The SPF also asks to forecast real consumption expenditures (RCONSUM) at different horizons. Although this question could be related to consumption plans and could therefore be used analogously to Question A18 from the Michigan Survey, we do not use this question for the analysis. The reason is that while Question A18 in the Michigan Survey asks consumers about their own consumption plans, the consumption question in the SPF asks professionals to forecast aggregate consumption. Thus, the answers to these two questions have rather different interpretations.

estimate the reduced-form VAR using Bayesian methods with the Normal-Wishart distribution as an uninformative prior density for the reduced-form coefficients. The posterior density of the reduced form coefficients is therefore Normal-Wishart with the location parameters  $B = [B_1, \dots, B_L]'$  and the covariance matrix  $\Sigma_e$  (Uhlig, 1994).

The vector of endogenous variables,  $x_t$ , contains survey measures from either the Michigan Survey or the SPF along with macroeconomic data. In our baseline specification, the macroeconomic variables are the seasonally adjusted civilian unemployment rate, the annual growth rate of the seasonally adjusted CPI for urban consumers (i.e. inflation rate), and the Federal Funds rate (FFR) provided by the Federal Reserve Economic Data (FRED) database of the Federal Reserve Bank of St. Louis. We have chosen these variables to correspond closely to the variables for which survey respondents provide forecasts. Using the unemployment rate as a proxy for economic activity also has the advantage that it is usually not revised ex post (see also Leduc and Sill, 2013). In an additional analysis, we use industrial production and the CPI, both in logs, to identify macroeconomic shocks.

When we estimate the VAR with Michigan Survey data,  $x_t$  contains the three macroeconomic variables plus balance scores summarizing unemployment expectations, interest rate expectations and consumption plans, and average point estimates of future inflation rates. When we use SPF data, the vector of endogenous variables contains the three macroeconomic variables plus the expected unemployment rate, the expected inflation rate, and the expected interest rate. Since the SPF does not have a suitable counterpart to consumption plans,  $x_t$  contains only six variables in this case.

To ensure that we do not pick up major structural breaks, we only consider the sample starting with the beginning of the Great Moderation, which we date with January 1985, until the onset of

the Great Recession in June 2007, in the baseline estimations. In additional estimations, we explore the robustness of our results by extending the sample until July 2016. Given the availability of data discussed in Section 2, we estimate the VAR with monthly data when using the Michigan Survey data, and with quarterly data when using data from the SPF. Despite the different data frequencies, the Akaike information criterion suggests a lag length of  $L = 2$  for both estimations.<sup>10</sup>

### 3.2 Identification

We impose a combination of zero and sign restrictions on the impulse response functions to identify AD, AS and MP shocks. Table 1 summarizes our identification scheme. In response to an adverse AD shock, economic activity and inflation decline. Hence, we restrict the unemployment rate to increase and the inflation rate to decrease.<sup>11</sup> According to a Taylor rule, the central bank responds to this shock by lowering the interest rate. Consequently, we restrict the policy rate to go down.<sup>12</sup> Standard macroeconomic models predict that AS shocks, such as price mark-up shocks, wage mark-up shocks, or technology shocks (see e.g. Smets and Wouters, 2007), move economic activity and inflation in the same directions. Consistent with these predictions, we restrict the unemployment rate and the inflation rate to go up. In addition, we restrict the policy rate to increase. Here we essentially assume that the central bank puts relatively more weight on price stability in its objective function. Finally, to identify MP shocks we impose the restrictions that along with an increase in the interest rate, the unemployment rate rises and the inflation rate decreases. These restrictions are consistent with standard macroeconomic models (e.g. Smets and Wouters, 2005,

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<sup>10</sup>In a robustness analysis, we estimate the VAR with 12 lags.

<sup>11</sup>To explore the robustness of our results, we replicate the baseline estimations using industrial production as a measure for output and impose the opposite signs compared to the unemployment rate.

<sup>12</sup>Since the sample for our baseline estimation ends in June 2007, the zero-lower-bound does not complicate our identification scheme. In the robustness analysis we extend the sample period and replace the FFR by a shadow rate as an alternative measures for the monetary policy.

2007) and are used widely in the empirical literature (Fry and Pagan, 2011). The sign restrictions are imposed on impact plus three consecutive months when we use the Michigan Survey data and on impact plus the consecutive quarter for SPF data.

Although the sign restrictions ensure that the macroeconomic shocks are orthogonal, it is still conceivable that the identified shocks are not orthogonal to exogenous changes in expectations. Suppose, for instance, that aggregate demand changes due to a change in the private sectors's assessment of future economic activity that is not induced by changes in the economic situation itself. Also suppose that these effects are strong enough to influence economic activity.<sup>13</sup> Relying exclusively on the sign restrictions, we would falsely classify these dynamics as the endogenous responses of expectation variables to exogenous macroeconomic shocks, rather than the other way around.

To address this issue, we impose additional zero restrictions that render the macroeconomic shocks orthogonal to expectations shocks. Specifically, we restrict the expectation measures respond to macroeconomic shocks only with a lag of one period. In other words, we assume that the expectation measures are predetermined. Since expectation shocks should be quickly visible in the survey variables, these additional restrictions allow us to disentangle exogenous macroeconomic shocks from exogenous expectation shocks.

Although the restriction that survey measures only respond with a lag to macroeconomic shocks may at first glance appear rather restrictive, it is in fact consistent with the timing of the Michigan Survey. The survey is conducted during each month and data on the unemployment rate and the inflation rate are published with a delay in the first half of the following month. Hence, data about contemporaneous macroeconomic developments have not yet been published at the time the

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<sup>13</sup>Leduc and Sill (2013) find that expectation shocks are a quantitatively important source of business cycle fluctuations.

survey is conducted. Consequently, survey respondents should respond to macroeconomic data and developments only with a lag. It has to be noted, however, that survey respondents may still have some contemporaneous information about interest rate developments at the time the survey is conducted.<sup>14</sup>

The SPF is conducted with a quarterly frequency and the response deadline is generally the third week of the second month of the quarter. At this time, respondents are able to observe macroeconomic data, which are relevant for the current quarter, through releases of monthly data. Thus, the zero restrictions would be less plausible with SPF data. Therefore, we follow Leduc and Sill (2013) and redefine quarters such that the first month of a quarter is the month in which respondents provide forecasts. Following this logic, the redefined first quarter consists of February, March, April. The second quarter consists of May, June, July, and so on.<sup>15</sup>

To implement the identification approach, we apply a zero-and-sign-restrictions algorithm based on Rubio-Ramirez et al. (2010) and Arias et al. (2018), which works as follows: For each draw from the distribution of the reduced form parameters, we take the Choleski factor of  $\Sigma_e = PP'$  and use random orthogonal matrices  $Q$  to obtain alternative decompositions  $\Sigma_e = PQQ'P'$ , and orthogonal shocks  $u_t = (PQ)^{-1}e_t$ . The matrix  $Q$  is constructed such that the zero restrictions are fulfilled. To obtain the distribution of permissible models we iterate the algorithm 1,000 times using the following steps. We draw one set of parameters from the posterior distribution of the reduced-form VAR. For this set of parameters we check whether we can find a transformation that is admissible in terms of the sign restrictions. Specifically, we keep drawing  $Q$  matrices until either a permissible transformation is found (then we retain the candidate model and proceed with the next iteration of

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<sup>14</sup>See also the discussion in Leduc and Sill (2013).

<sup>15</sup>To generate the macroeconomic data for the redefined quarters we consider quarterly averages of the monthly data described above.

the algorithm) or a maximum number of 1,000 draws is reached (then we proceed without retaining any model). In most cases we find a permissible model for each draw from the posterior distribution of the reduced-form models, which is reassuring in terms of the empirical plausibility of the imposed sign restrictions (Giacomini and Kitagawa, 2015).

Since the system is set-identified, the prior is only flat over the reduced-form coefficients but not necessarily over the structural coefficients as the decomposition of the variance-covariance matrix  $\Sigma$  using random orthogonal matrices  $Q$  (where  $Q'Q = I$ ) incorporates an implicit prior distribution (Baumeister and Hamilton, 2015, 2018). However, as shown in Giacomini and Kitagawa (2015), inference is less sensitive to the distribution of the  $Q$  matrices if zero restrictions are imposed.

## 4 Results for Consumers

### 4.1 VAR Results

Figure 3 shows the responses of the endogenous variables to an AD shock in the first column, to an AS shock in the second column, and to a MP shock in the third column. The responses of the macroeconomic variables are shown in Panel A and the responses of the expectation measures, which are either a balance score (for unemployment and interest rate expectations), or an average point estimate (for the expected inflation rate), are displayed in Panel B. In Panel C, we present the responses of the balance score of consumption plans.

The solid lines represent the pointwise-median responses and the dashed lines are the closest-to-median responses as suggested in Fry and Pagan (2011).<sup>16</sup> For ready comparisons across the different shocks, all responses are normalized such that the unemployment rate rises by one per-

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<sup>16</sup>The closest-to-median responses are the responses from a single model that is selected such that the responses associated with this model exhibit the minimum deviations from the pointwise-median responses among all set-identified models.

centage point on impact. Each subfigure also shows bands corresponding to the 5th and the 16th percentiles (lower limits of the shaded areas) as well as the 84th and the 95th percentiles (upper limits of the shaded areas) of the distribution of the set-identified models.

We display responses for the macroeconomic variables in Panel A and the responses of planned consumption in Panel C for horizons of up to 24 months. In the Michigan Survey, the respondents are asked to provide an assessment of macroeconomic developments during the next 12 months. Therefore, we show the responses of the expectation variables in Panel B only for horizons of up to 12 months. Although we impose the sign restrictions only on impact plus 3 periods, the responses of the macroeconomic variables, which are shown in Panel A, are rather persistent. This indicates that the restrictions are generally well supported by the data.

We see from the responses shown in the first column in Panel B that the balance score of unemployment expectations increases in response to the AD shock. The average expected inflation rate declines in response to the shock. Hence, we conclude that survey respondents interpret AD shocks in a way consistent with a Phillips curve relationship, or more precisely, as a movement along the Phillips curve. In other words, expectations are revised in line with how standard macroeconomic models characterize the propagation of AD shocks. We also see that survey respondents expect lower interest rates, which is consistent with the interest rate dynamics suggested by a Taylor rule.

The second column of Panel B shows that the balance score of unemployment expectations and the average expected inflation rate increase after an adverse AS shock. These dynamics are again consistent with the predictions of standard theory as AS shocks are viewed as shifts of the Phillips curve, rather than movements along the Phillips curve. Thus, survey respondents correctly distinguish between AD and AS shocks. Although the responses of the balance score summarizing interest rate expectations are initially largely positive, they are less persistent than for the other

expectation variables and turn negative 4 months after the shock. This may, however, reflect the rather muted response of the FFR itself (shown in Panel A).

Finally, the last column shows the responses of the expectation measures to a MP shock. We see that the balance score of unemployment expectations increases on impact and the average expected inflation rate declines. While these responses are consistent with the effects that a monetary contraction exerts in standard models, the increase in the balance score of unemployment expectations is only short-lived. Interestingly, survey respondents predominantly expect lower interest rates after an adverse policy shock, even though the Federal Funds rate, according to Panel A, remains persistently positive following a contractionary policy shock. One interpretation is that survey respondents underestimate the persistence of the shock and expect a stronger degree of mean-reversion. Alternatively, survey respondents may confuse the monetary policy shock with an AD shock to which the central bank responds endogenously. Also note that the responses of the survey expectations to MP shocks are generally less systematic as the distribution of permissible models is relatively wide.

Overall, the interpretation of AD and AS shocks is largely in line with the propagation mechanisms for AD and AS shocks in standard macroeconomic models. In the event of AD shocks, respondents expect a movement along the Phillips curve and future interest rates to respond as suggested by a Taylor rule relationship. These results support the findings in Carvalho and Nechio (2014) and Dräger et al. (2016), who report that people generally tend to form expectations consistent with a Phillips curve and a Taylor rule. Following an AS shock, unemployment and inflation expectations are revised in the same direction indicating that people expect a shift of the Phillips curve. Thus, survey respondents correctly distinguish between AD and AS shocks. Interest rate expectations increase following a contractionary AS shock, which suggests that survey respondents



expect the Fed to react more strongly to inflation than to real economic developments in the aftermath of an AS shock. Following an MP shock, the responses of the expectation variables are generally characterized by a high degree of dispersion and the effects are less persistent. While survey respondents appear to interpret the effects of AD and AS shocks on interest rates in line with the usual systematic monetary policy reaction, they seem to have a less clear interpretation of the macroeconomic effects of MP shocks.

We also see that the responses of the expectation variables build up over the first few months after a shock in most cases. While this hump-shaped pattern is partly due to the imposed zero restrictions, it also suggests that survey participants update expectations only gradually, which may be due to informational rigidities (see e.g. Mankiw and Reis, 2002; Coibion and Gorodnichenko, 2012, 2015a).

Having analyzed how consumers interpret macroeconomic developments, we now turn to the question if and how they adjust consumption plans in response to the shocks.<sup>17</sup> Panel C of Figure 3 shows the responses of the balance score associated with planned consumption. This measure of consumption plans drops strongly and persistently after an AS shock, whereas the decline is only short-lived following an AD shock. This pattern is consistent with the less pronounced and less persistent response of the unemployment expectation and the declining interest rate expectation in case of the AD shock. In addition, higher actual and expected inflation may drag on the perceived purchasing power of income resulting in lower consumption plans in case of the AS shock. Interestingly, the contractionary MP shock does not lead to a reduction in the balance score of consumption plans.<sup>18</sup>

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<sup>17</sup>In the Online Appendix, we consider automobile purchases as an alternative measure of consumption plans.

<sup>18</sup>In the Online Appendix, we also consider how forecaster disagreement reacts to macroeconomic shocks and show responses of cross-sectional standard deviations and interquartile ranges of the survey answers.

While we find that survey answers are broadly consistent with the propagation mechanisms captured in standard macroeconomic models, the question arises how people arrive at their answers to the survey questions. On the one hand, survey answers should mirror how perceived macroeconomic developments are interpreted in light of the respondents' views about macroeconomic relationships. In this case, survey answers reveal how people interpret macroeconomic developments. On the other hand, it is also conceivable that survey respondents simply use the latest observations of the unemployment rate, the inflation rate, and the interest rate, and extrapolate these developments into the future without having any views about their interconnectedness. We argue that simple extrapolation is unlikely for at least two reasons. First, if survey answers were mainly the result of univariate extrapolation, and given that the responses of the macroeconomic variables are fairly persistent, the responses of the expectation measures should replicate the responses of the macro variables fairly closely. While we find this to be the case in most instances, there are exceptions. For instance, survey respondents expect the interest rate to decline in response to a monetary policy shock, although the actual interest rate increases persistently. And second, we re-estimate the VAR with the annual growth rate of industrial production as a proxy for real economic activity instead of the unemployment rate and modify the sign restrictions accordingly.<sup>19</sup> Thus, we identify the shocks using industrial production growth and study the response of expectations about unemployment. Although we interpret industrial production growth and unemployment both as proxies for economic activity, the link between the macroeconomic variables and the expectation variables is less tight in this specification and extrapolation should become harder.<sup>20</sup> Nevertheless the impulse responses of the survey measures exhibit patterns that are similar to those found with

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<sup>19</sup>The results are shown in the Online Appendix.

<sup>20</sup>The contemporaneous correlation between the annual growth rate of industrial production and the unemployment rate is -0.23 for the period from January 1985 until June 2007.

the baseline specification.

To understand how important macroeconomic shocks are for the dynamics of the survey measures, we compute forecast error variance decompositions (FEVD) for the set-identified models. Table 2 shows the median of contributions of the macroeconomic shocks at horizon  $h$ , together with the 16th and the 84th percentile of the distributions. We again show the contributions of the macroeconomic shocks to the forecast errors of the expectation measures for horizons up to 12 months, while we show contributions for the macroeconomic variables and planned consumption for 24 months.

From Panel A of Table 2 we see that the structural shocks explain large shares of the forecast error variance of the macroeconomic variables. While the AD shock generally dominates the dynamics of the unemployment rate and the Federal Funds rate, the AS shock captures the largest share of the forecast error variance of the inflation rate. The MP shock explains the forecast error variance of the macroeconomic data to a smaller extent. Overall, the shares of the forecast error variance accounted for by the shocks are of an order of magnitude similar to what other studies find (see e.g. Smets and Wouters, 2007; Ramey, 2016).

In contrast to the macroeconomic variables, the structural shocks generally explain only small shares of the forecast error variance of the expectation measures, as shown in Panel B of Table 2. The AD shock accounts for only up to roughly 3 percent of the forecast error variance associated with the expectation variables, regardless of the horizon. A similar conclusion emerges for the MP shock. The AS shock plays a somewhat more prominent role and accounts for up to roughly 10 percent of the forecast error variance of the expected inflation rate. Nevertheless it also accounts for only up to approximately 1 percent of the forecast error variance of the interest rate expectation for most horizons considered. Panel C shows the FEVD for consumption plans. While AD and MP

shocks play only a limited role in shaping the dynamics in this variable, the AS shock explains a somewhat larger share of the forecast error variance, especially at longer horizons.

Overall, we conclude that although survey respondents react to macroeconomic fluctuations in a way that is broadly consistent with theory, the structural shocks play only a minor role for the dynamics of the survey measures. In particular, the rather small contributions of AD shocks suggest that consumers are aware of their importance for the business cycle only to a limited extent. In addition, we observe that the structural shocks tend to be more important for inflation expectations than for unemployment expectations. This finding is consistent with Coibion et al. (2018) who report that survey respondents adjust expectations about inflation more readily than expectations about unemployment when exposed to news about these variables.

## 4.2 Micro-Level Regression Analysis

In the Michigan Survey, approximately 40% of the respondents are interviewed a second time six months after the initial interview. We now use these repeated interviews to study how individual survey respondents update their expectations by regressing the changes in the survey responses on measures of macroeconomic shocks. This analysis has the advantage that we are able to control for individual characteristics and it therefore complements the VAR analysis that uses aggregated data.<sup>21</sup>

We estimate regressions of the type:

$$\Delta r_i = \alpha + \beta_1 shock_i^{AD} + \beta_2 shock_i^{AS} + \beta_3 shock_i^{MP} + \mathbf{X}_i' \delta + \epsilon_i, \quad (1)$$

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<sup>21</sup>Pfajfar and Santoro (2013) use a similar approach to study the influence of news on inflation expectations. While they focus on the propensity to update, we also take the sign of the update into account.

where  $\Delta r_i$  is the change in the response of respondent  $i$  between the first and the second interview, with respect to either inflation, interest rate, unemployment developments, or consumption plans. Since individuals are only observed twice, we avoid time-subscripts. In case of inflation expectations, we construct  $\Delta r_i$  by subtracting the point estimate elicited in the first interview from the point estimate elicited in the second interview for each respondent  $i$ . For the qualitative answers we code the responses as 1 (goes up), 0 (stays the same), or  $-1$  (goes down) and take the difference between the two interviews.  $shock_i^{AD}$ ,  $shock_i^{AS}$ ,  $shock_i^{MP}$  are six month, backward-looking moving averages of the pointwise medians of the shock series from the baseline VAR.<sup>22</sup> To allow for an easy comparison with the VAR results, we normalize the shock variables such that positive values indicate adverse shocks. Although the shocks are aggregate shocks, they are still individual-specific in the sense that the survey respondents are interviewed at different points in time and are therefore exposed to different shocks.  $\mathbf{X}_i$  is a column vector of dummy variables indicating education (with college degree), age (age>65), income (below the median), and gender (female).  $\alpha$  is a constant and  $\epsilon_i$  is an error term.

Pfajfar and Santoro (2013) note that although the first interviews are a random subsample of the population, this is not necessarily true for the second interviews, resulting in potentially biased estimates. To address this point, we estimate Equation (1) using the Heckman (1979) method. We estimate the selection equation using the dummy variables indicating education, age, income, and gender.

Table 3 shows the results for the change in unemployment expectations as the dependent variable in Columns (I) to (III), inflation expectations in Columns (IV) to (VI), interest rate expectations

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<sup>22</sup>The moving averages take into account shocks that hit the economy in the month in which the first interview takes place until the month immediately preceding the second interview since interviews are conducted within the months and shocks may therefore not be observed contemporaneously (see Section 3).

in Columns (VII) to (IX), and consumption plans in Columns (X) to (XII). For each expectation measure we estimate three different variants of Equation (1): only with the shock variables, the shock variables and a set of control variable, and finally with the shock variables, the controls, and a dummy variable indicating NBER recessions.

We see that regardless of the regression specification, contractionary, macroeconomic shocks lead to significant increases in unemployment expectations. For the changes in inflation expectations the type of shock matters. While inflation expectations decline in response to contractionary AD and MP shocks, they increase when the economy is hit by an adverse AS shock. Although we observe a similar pattern for interest rate expectations, the effects are not always statistically significant. Turning to consumption plans, we see that survey respondents reduce planned consumption in response to adverse shocks, where the results for the MP shock are only significant when we explicitly control for recessions. Overall, these results suggest that respondents revise their expectations in line with a movement along the Phillips curve after AD shocks and that AS shocks are viewed as shifts of the Phillips curve. Revisions in interest rate expectations are consistent with a standard Taylor rule. Thus, our main conclusions remain unchanged when we control for the respondents' individual characteristics.

The demographic variables exert significant effects only in case of inflation expectations. Female survey respondents generally tend to revise their expectations downward more than male respondents and survey respondents with a degree tend to expect higher inflation in the second interview. Lower income respondents generally expect lower inflation. Overall, adding the individual characteristics leaves the estimated coefficients of the shock variables largely unchanged. Thus, although individual characteristics play some role in how expectations are revised, in particular inflation expectations, they do not confound the average effects of the macroeconomic shocks.

Finally, the dummy variable indicating NBER recessions enters significantly with a positive sign for unemployment expectations and with negative signs for the remaining expectation measures. Although the effects associated with the AD shock become smaller and, in some cases, less significant, when we include the recession dummy, the signs of the coefficients of the shock variables are largely unaffected.

### 4.3 Theory-Consistency and Individual Level Data

So far, we have not taken into account how survey respondents interpret the joint dynamics of macroeconomic variables. Consider for instance an AD shock and suppose that a group of respondents expects that unemployment will increase and that prices will remain stable. Another group indicates that unemployment will remain stable and that prices will decrease. At an individual level, these expectations are not consistent with standard theory. Nevertheless, when we aggregate the responses across groups, the balance score summarizing expected unemployment increases, while the average expected inflation rate decreases, indicating that the shock is interpreted in a theory-consistent way.

To address this issue, we now aggregate the survey data taking into account whether the joint responses of individual respondents are theory-consistent. A respondent is classified as interpreting a contractionary AD shock, for instance, as theory-consistent, if the associated survey answers indicate that unemployment is expected to go up while the inflation rate and the interest rates are expected to decline (and vice versa for expansionary AD shocks). We classify respondents with expectations consistent with contractionary and expansionary AS and MP shocks analogously.<sup>23</sup>

Based on these classifications we compute shares of respondents having expectations consistent

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<sup>23</sup>Note that only responses indicating future changes can be potentially consistent with either expansionary or contractionary shocks.

with contractionary and expansionary AD, AS, and MP shocks and use balance scores to summarize contractionary and expansionary shares for each shock. Consider for instance expectations consistent with an AD shock. We subtract the share of respondents having expectations consistent with an expansionary AD shock from the share of respondents having expectations consistent with a contractionary AD shock, multiply this relative score by 100 and add 100. Balance scores for expectations consistent with AS and MP shocks are constructed analogously.

A complication arises since survey respondents provide a point estimate for the expected inflation rate. Therefore, we first need to transform the quantitative answers into an ordinal measure indicating whether the expected inflation rate goes down, remains constant or goes up. To do so, we subtract the past realized inflation rate from the inflation rate forecast (which is provided in integers), where we calculate the past realized CPI inflation rate as the 12-month backward-looking moving average up to period  $t-1$ . Next, we round this difference to the nearest integer and, according to the sign of the difference, generate the ordinal variable indicating the expected direction of change. If the rounded difference is equal to zero, the respondent is classified as expecting constant inflation (see Carvalho and Nechio, 2014; Dräger et al., 2016).

Figure 4 shows the fractions of respondents having expectations consistent with contractionary and expansionary AD, AS, and MP shocks together with NBER recessions. We see that especially the fractions associated with contractionary shocks respond to the business cycle, as they tend to increase during recessions.

Figure 5 displays the impulse response functions obtained with our baseline specification where we replace the aggregated expectation measures with the balance scores indicating theory-consistency at the individual level. We estimate the VAR again with two lags of the endogenous variables as suggested by the Akaike information criterion. We see from Panel A that the responses of the



macroeconomic variables are almost identical to the baseline results. The responses of the balance scores are shown in Panel B. Since we consider responses to contractionary shocks, an increase in the balance score indicates that the share of respondents having a theory-consistent interpretation goes up.

The top subfigure in the first column shows that the share of respondents interpreting the shock in a theory-consistent way increases after an adverse AD shock. Similarly, we see from the middle subfigure in the second column that the share of respondents that evaluate the macroeconomic environment correctly as being the result of an AS shock increases. The third column shows the responses to MP shocks. In line with our baseline analysis, we find that respondents have a less clear interpretation of MP shocks.

In short, we conclude that taking theory-consistency at the level of individual survey respondents into account supports our main results.<sup>24</sup>

## 5 Results for Professional Forecasters

### 5.1 VAR Results

Do professional forecasters process and interpret shocks the same way households do?<sup>25</sup> To address this question, we re-estimate the VAR with survey data obtained from the SPF and identify shocks using the same identification scheme as in the baseline specification with the consumer data (see Table 1). We impose the sign restrictions on impact plus one quarter.

Figure 6 shows the responses to contractionary AD, AS, and MP shocks. Responses are nor-

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<sup>24</sup>A related, albeit distinct, question is whether individuals who have theory-consistent expectations also have more accurate expectations. We address this issue in the Online Appendix.

<sup>25</sup>It is well documented that household forecasts tend to be less efficient and more disperse. Moreover, forecasts by professionals may lead those made by households (Mankiw et al., 2004; Carroll, 2006). Carvalho and Nechio (2014) and Dräger et al. (2016) find that a larger fraction of survey responses by professional forecaster tends to be theory consistent.

malized so that on impact, the unemployment rate rises by one percentage point. Recall that the data frequency is quarterly now and that the forecasting horizon in the SPF is three quarters. Due to the forecasting lead, we show impulse response functions for 8 quarters for the macroeconomic variables in Panel A, and for 4 quarters for the survey measures for in Panel B.

The responses of the macroeconomic variables are largely similar to those obtained with consumer data, although the unemployment rate responds slightly more persistently to AD and AS shocks and also more strongly to MP shocks. The impact response of the inflation rate to an AS shocks is also somewhat more pronounced when we consider quarterly data.

The first column in Panel B shows that professional forecasters expect the unemployment rate to increase, and the inflation rate as well as the interest rate to decrease in response to an adverse AD shock. Thus, professional forecasters interpret AD shocks in a way consistent with standard theory. The second column shows that professional forecasters expect the unemployment rate and the expected inflation rate to increase after an AS shocks. In other words, professional forecasters also correctly distinguish between movements along the Phillips curve and shifts of the Phillips curve. We also see that professional forecasters initially expect the interest rate to increase after an AS shock, indicating that they expect the Fed to respond with a policy tightening to the shock. Although the actual FFR increases slightly in response to an AS shock, it does so only temporarily. Overall, these patterns again match what we found with consumer expectations. Finally, the responses in the third column show that professional forecasters expect the unemployment rate to increase and the inflation rate to decrease after a MP shock. These findings match the responses of the macroeconomic counterparts and is consistent with standard models. Although responses of interest rate expectations are less systematic, they tend to go down, which is similar to our results for consumer data.

Although the impulse response analysis shows that professional forecasters and consumers interpret shocks similarly, we see from the FEVD of the expectation variables, shown in Panel B of Table 4, that stark differences arise in terms of the extent to which shocks are taken into account when expectations are revised.<sup>26</sup> For the forecasting horizons considered, the AD shock accounts for up to 38 percent of the forecast error variance of the unemployment expectation and for up to approximately 18 percent of the forecast error variance of the interest rate expectation. Hence, professional forecasters are influenced more strongly by AD shocks than consumers. For the inflation expectation, the AD shock plays a smaller role, accounting for only up to slightly less than 5 percent of the forecast error variance. However, the lower contribution is consistent with the result that the AD shock accounts for a smaller fraction of the forecast error variance of the realized inflation rate (see Panel A). The contributions of the AS shock to the forecast error variance of the expectation measures are generally lower than the contributions of the AD shock. While the AS shock still accounts for up to 11 percent of the forecast error variance of the unemployment expectation, it accounts for less than 5 percent of the variation in the inflation expectation and for less than 1 percent in case of the interest rate expectation. The MP shock, in contrast, contributes relatively little to the forecast error variance of the expectation measures.

Although the contributions vary across the expectation measures and across shocks, we find that the share of forecast error variance that can be attributed to the identified shocks is substantially higher when we use data from the SPF. Overall, we conclude that although professional forecasters interpret macroeconomic shocks in a similar way as consumers, they pay more attention to macroeconomic developments than consumers. Since professional forecasters have stronger incentives to keep track of macroeconomic developments, this outcome is in line with models of

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<sup>26</sup>Panel A of Table 4 shows the FEVDs of the macroeconomic variables. The shares are of similar orders of magnitude as in the baseline estimation with the consumer data.

rational inattention (Sims, 2003; Coibion and Gorodnichenko, 2015a; Maćkowiak and Wiederholt, 2015).

## 5.2 VARs with Individual Respondent Data

The aggregation of survey answers may again hide potential heterogeneities. In contrast to the Michigan Survey, longer time series are available for the majority of SPF respondents, since they are usually surveyed over several years. Therefore, we are able to estimate VAR models with data from single respondents. We consider respondents with at least 40 consecutive quarters of forecasts for the unemployment rate, the inflation rate, and the three-month Treasury bill rate. This leaves us with 20 respondents with an average observation period of approximately 61 quarters, where sample periods vary across the respondents. The VAR specification and the identification scheme correspond to the analysis of the aggregated SPF data.

Figure 7 shows the point-wise median responses of the macroeconomic variables and the expectation measures for each of the 20 VARs. The point-wise median responses from each VAR are scaled such that the unemployment rate increases by one percentage point on impact to facilitate comparisons across models. Panel A shows that although the responses of the macroeconomic variables are quite disperse, which is not unexpected given the differences in the sample periods, the general patterns obtained from the different models are similar to what we found with aggregated data.

The first column of Panel B shows that the vast majority of SPF respondents expects a rise in the unemployment rate together with a decline in the inflation rate in response to an AD shock, which is consistent with a movement along the Phillips curve. Note that the responses of inflation expectations are less pronounced and less systematic, which is similar to what we find with the

aggregated survey data. Consistent with a Taylor rule relationship, all respondents revise interest rate expectations downward in response to an AD shock. The responses of the expectation measures to an AS shock, which are displayed in the second column of Panel B, indicate that the majority of the respondents revise their expectations in line with a shift of the Phillips curve, and most respondents expect higher interest rates. The responses to an MP shock, shown in the last column, are more dispersed, which is in line with the less systematic responses of the aggregated survey measures.

Overall, we conclude that although there is some heterogeneity in how individual respondents update their expectations, the results of the VAR estimation with individual level data support our findings obtained with aggregated data.<sup>27</sup>

## 6 Robustness Analysis

In this section, we support our results by a series of robustness checks.<sup>28</sup> To include more recent macroeconomic developments, we re-estimate the baseline VAR model with data from November 1985 until July 2016. We use the Shadow Short rate (SSR), suggested by Krippner (2015), instead of the FFR in this estimation.<sup>29</sup> Figure 8 shows that the estimation with the longer sample generally supports our main results. The responses of the survey measures to AD and AS shocks are similar to our baseline results. Although the positive response of the interest rate expectation in case of MP shocks contrasts with our baseline results, it is in line with the more persistent response of the SSR. The wide bands associated with the responses to policy shocks again suggest that survey

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<sup>27</sup>The SPF provides information on whether respondents are from financial or non-financial institutions, starting in the third quarter of 1990. In the Online Appendix we show group-specific impulse response functions for these two subgroups of respondents. The responses are similar across groups, which suggests that economic and financial experts comprise a relatively homogenous sample.

<sup>28</sup>In the Online Appendix, we present several additional robustness checks.

<sup>29</sup>For this estimation the sample starts in November 1985 due the limited availability of the SSR.

respondents are relatively uncertain about how to process MP shocks.

The aggregation of survey answers may hide potential heterogeneities among respondents. In fact, several studies have documented that people update expectations and forecast macroeconomic variables differently depending on demographic characteristics such as education, income, age, and gender.<sup>30</sup> To address this issue, we now divide the Michigan Survey sample along education, depending on whether respondents have a college degree, and depending on whether the respondent's income is below or above the median income. For each sub-sample we aggregate the survey data as in the baseline analysis and estimate the VAR with the resulting eight (instead of four) aggregated survey variables.<sup>31</sup>

We find that the two education groups respond in a similar way, regardless of the shock. In particular, the dynamics of the impulse response functions for both groups are largely in line with the baseline results. Although the responses across income groups are generally also similar, only respondents with lower levels of income revise unemployment expectations systematically following an AD shock. Overall, we conclude that differences across demographic groups are relatively small and that the results for specific groups of respondents are largely in line with our baseline results.<sup>32</sup> These findings are in line with Curtin (2019), who shows that, although subgroups of Michigan Survey respondents differ in terms of their average expectations, changes in expectations over time are highly correlated across groups.

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<sup>30</sup>E.g. Souleles (2004) finds that forecast errors by consumers are systematically correlated with demographic characteristics. Easaw et al. (2013) report that people with higher education levels tend to have lower inflation expectations and absorb new information faster suggesting less pronounced informational rigidities for this subset of respondents. Malmendier and Nagel (2016) find that younger people react stronger to inflation surprises, which is consistent with the idea that recent experiences account for a larger share of accumulated lifetime experiences. Coibion et al. (2018), in contrast, study survey data elicited from firms and report that inflation nowcast errors are not systematically affected by demographic characteristics once firm-specific variables are controlled for.

<sup>31</sup>The impulse response functions, and tables showing the corresponding FEVDs are presented in the Online Appendix.

<sup>32</sup>This is also the case when we group respondents according to age or gender, as shown in the Online Appendix.

## 7 Conclusion

How do people interpret macroeconomic shocks? We find that survey respondents interpret AD and AS shocks largely in line with the predictions of standard theory. AS shocks are viewed as shifts of the Phillips curve while AD shocks are interpreted as movements along the Phillips curve. In addition, expectations about future interest rates in the aftermath of AD and AS shocks are revised broadly in line with a Taylor rule. The interpretation of monetary policy shocks is less systematic, however, and not necessarily consistent with standard theory.

A large literature argues that central bank communication strongly influences the transmission of monetary policy (see e.g. Woodford, 2001; Blinder et al., 2008; Hoyerichts et al., 2009). For the most part, this literature focuses almost exclusively on how central banks provide information and takes it for granted that people interpret macroeconomic developments in a similar way as central banks. In this respect, our results are reassuring. In fact, our results indicate that survey respondents anticipate systematic monetary policy response to AD and AS shocks in line with the propagation mechanism in standard models. As it is argued in e.g. Bernanke (2013), this should enhance the effectiveness of monetary policy. Nevertheless, we also find that standard macroeconomic shocks play only a limited role in shaping the dynamics of the expectations of the general public.

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Table 1: Restrictions on impulse response functions

|          | unempl.<br>rate | inflation<br>rate | FFR | unempl.<br>expect. | inflation<br>expect. | interest<br>rate<br>expect. | consum.<br>plans |
|----------|-----------------|-------------------|-----|--------------------|----------------------|-----------------------------|------------------|
| AD shock | ↑               | ↓                 | ↓   | 0                  | 0                    | 0                           | 0                |
| AS shock | ↑               | ↑                 | ↑   | 0                  | 0                    | 0                           | 0                |
| MP shock | ↑               | ↓                 | ↑   | 0                  | 0                    | 0                           | 0                |

Notes: Sign restrictions correspond to contractionary shocks and are imposed on impact plus three months for the estimations using monthly data, and on impact plus one quarter for the estimations using quarterly data.

Table 2: Forecast error variance decomposition (in percent): Michigan Survey

|                                  | $h$ | AD shock             | AS shock             | MP shock            |
|----------------------------------|-----|----------------------|----------------------|---------------------|
| Panel A: macroeconomic variables |     |                      |                      |                     |
| unempl.<br>rate                  | 1   | 46.12 (24.26, 67.51) | 30.06 (12.98, 53.98) | 8.94 (3.26, 24.40)  |
|                                  | 6   | 31.39 (17.30, 47.67) | 24.43 (11.60, 40.25) | 3.73 (1.16, 12.72)  |
|                                  | 12  | 20.32 (10.04, 32.79) | 22.97 (11.34, 35.86) | 2.37 (0.85, 8.07)   |
|                                  | 24  | 12.33 (5.58, 21.97)  | 25.86 (14.01, 38.12) | 2.40 (0.74, 6.58)   |
| inflation<br>rate                | 1   | 2.39 (0.44, 9.34)    | 47.48 (24.69, 67.03) | 25.89 (8.44, 49.37) |
|                                  | 6   | 4.50 (1.44, 11.53)   | 37.37 (19.42, 53.36) | 16.68 (4.78, 34.98) |
|                                  | 12  | 5.37 (1.93, 12.06)   | 31.81 (16.66, 47.06) | 13.06 (3.65, 29.04) |
|                                  | 24  | 5.81 (2.13, 12.26)   | 27.83 (14.85, 42.07) | 11.28 (3.62, 25.53) |
| FFR                              | 1   | 42.61 (23.66, 56.70) | 2.83 (0.57, 10.27)   | 20.41 (7.41, 39.74) |
|                                  | 6   | 24.25 (14.54, 33.45) | 1.84 (0.34, 6.41)    | 7.64 (1.90, 16.74)  |
|                                  | 12  | 15.57 (9.20, 23.52)  | 1.24 (0.32, 4.43)    | 4.83 (1.15, 11.79)  |
|                                  | 24  | 10.35 (5.66, 17.76)  | 1.48 (0.41, 4.38)    | 4.97 (1.12, 11.80)  |
| Panel B: expectation variables   |     |                      |                      |                     |
| unempl.<br>expect.               | 1   | 0.41 (0.04, 1.45)    | 1.46 (0.51, 2.85)    | 0.29 (0.02, 1.07)   |
|                                  | 6   | 0.60 (0.15, 1.68)    | 3.24 (1.22, 6.23)    | 0.70 (0.23, 1.84)   |
|                                  | 12  | 1.08 (0.40, 2.23)    | 4.16 (1.62, 8.18)    | 1.00 (0.33, 2.96)   |
| inflation<br>expect.             | 1   | 1.26 (0.38, 2.71)    | 1.97 (0.58, 4.02)    | 0.75 (0.09, 2.26)   |
|                                  | 6   | 2.91 (0.99, 5.98)    | 9.94 (5.09, 15.70)   | 1.83 (0.35, 6.27)   |
|                                  | 12  | 3.10 (1.10, 6.36)    | 9.87 (5.11, 16.33)   | 1.97 (0.58, 5.90)   |
| int. rate<br>expect.             | 1   | 1.08 (0.41, 2.18)    | 0.19 (0.02, 0.80)    | 0.22 (0.02, 0.87)   |
|                                  | 6   | 1.76 (0.59, 3.79)    | 0.64 (0.19, 1.66)    | 0.76 (0.18, 2.20)   |
|                                  | 12  | 1.99 (0.94, 3.79)    | 1.57 (0.55, 3.53)    | 1.09 (0.29, 2.94)   |
| Panel C: consumption plans       |     |                      |                      |                     |
|                                  | 1   | 0.52 (0.07, 1.40)    | 0.80 (0.16, 1.83)    | 0.11 (0.01, 0.53)   |
|                                  | 6   | 0.86 (0.20, 2.52)    | 5.90 (2.92, 9.77)    | 0.98 (0.23, 2.96)   |
|                                  | 12  | 0.95 (0.28, 2.73)    | 8.32 (4.13, 13.99)   | 1.47 (0.29, 4.78)   |
|                                  | 24  | 1.34 (0.44, 3.17)    | 9.96 (4.67, 17.24)   | 1.79 (0.42, 5.90)   |

Notes: The table shows the median of the contributions to the forecast error variance computed for each set-identified model for horizon  $h$  in months, together with the 16th and the 84th percentile of the distribution of the contributions.

Table 3: Regressions controlling for individual characteristics

|                    | (I)                       | (II)              | (III)             | (IV)                   | (V)                 | (VI)                | (VII)                      | (VIII)              | (IX)                 | (X)                 | (XI)                | (XII)                |
|--------------------|---------------------------|-------------------|-------------------|------------------------|---------------------|---------------------|----------------------------|---------------------|----------------------|---------------------|---------------------|----------------------|
|                    | Unemployment expectations |                   |                   | Inflation expectations |                     |                     | Interest rate expectations |                     |                      | Consumption plans   |                     |                      |
| <i>AD shock</i>    | 0.040**<br>(4.33)         | 0.040**<br>(4.35) | 0.028**<br>(3.06) | -0.141*<br>(-1.99)     | -0.144*<br>(-1.98)  | -0.095<br>(-1.32)   | -0.035**<br>(-3.36)        | -0.035**<br>(-3.35) | -0.012<br>(-1.14)    | -0.060**<br>(-5.32) | -0.060**<br>(-5.32) | -0.040**<br>(-3.49)  |
| <i>AS shock</i>    | 0.059**<br>(5.96)         | 0.059**<br>(5.98) | 0.038**<br>(3.76) | 0.306**<br>(3.98)      | 0.311**<br>(3.95)   | 0.400**<br>(5.01)   | 0.004<br>(0.40)            | 0.005<br>(0.40)     | 0.046**<br>(4.00)    | -0.091**<br>(-7.55) | -0.091**<br>(-7.56) | -0.055**<br>(-4.42)  |
| <i>MP shock</i>    | 0.028**<br>(3.04)         | 0.028**<br>(3.05) | 0.040**<br>(4.30) | -0.202**<br>(-2.83)    | -0.195**<br>(-2.67) | -0.242**<br>(-3.34) | -0.052**<br>(-4.90)        | -0.051**<br>(-4.87) | -0.075**<br>(-7.08)  | -0.003<br>(-0.23)   | -0.003<br>(-0.23)   | -0.023*<br>(-2.05)   |
| <i>Female</i>      |                           | -0.010<br>(-1.01) | -0.010<br>(-1.02) |                        | -0.299**<br>(-3.69) | -0.298**<br>(-3.76) |                            | -0.004<br>(-0.35)   | -0.004<br>(-0.34)    |                     | -0.007<br>(-0.61)   | -0.007<br>(-0.57)    |
| <i>Degree</i>      |                           | -0.006<br>(-0.68) | -0.006<br>(-0.66) |                        | 0.264**<br>(3.79)   | 0.263**<br>(3.86)   |                            | 0.011<br>(1.11)     | 0.011<br>(1.11)      |                     | -0.000<br>(-0.04)   | -0.001<br>(-0.06)    |
| <i>Old</i>         |                           | 0.041<br>(0.65)   | 0.037<br>(0.59)   |                        | -0.346<br>(-0.83)   | -0.332<br>(-0.81)   |                            | -0.055<br>(-0.79)   | -0.051<br>(-0.74)    |                     | -0.026<br>(-0.32)   | -0.019<br>(-0.25)    |
| <i>LowerIncome</i> |                           | -0.012<br>(-0.82) | -0.013<br>(-0.86) |                        | -0.347**<br>(-3.32) | -0.344**<br>(-3.37) |                            | -0.018<br>(-1.13)   | -0.018<br>(-1.11)    |                     | -0.000<br>(-0.00)   | 0.001<br>(0.07)      |
| <i>Recession</i>   |                           |                   | 0.125**<br>(8.29) |                        |                     | -0.503**<br>(-4.24) |                            |                     | -0.251**<br>(-14.54) |                     |                     | -0.216**<br>(-11.71) |
| <i>Constant</i>    | -0.028**<br>(-4.49)       | -0.005<br>(-0.24) | -0.014<br>(-0.70) | -0.297**<br>(-6.63)    | -0.361**<br>(-3.14) | -0.325**<br>(-2.88) | -0.034**<br>(-4.99)        | -0.052*<br>(-2.52)  | -0.035<br>(-1.67)    | 0.049**<br>(6.63)   | 0.044<br>(1.85)     | 0.059*<br>(2.51)     |
| $\hat{\lambda}$    | 0.175<br>(1.55)           | -0.171<br>(-0.21) | -0.127<br>(-0.15) | -0.619<br>(-0.84)      | 6.323<br>(1.43)     | 6.189<br>(1.43)     | 0.206<br>(1.68)            | 0.945<br>(1.12)     | 0.899<br>(1.07)      | -0.141<br>(-1.14)   | 0.124<br>(0.14)     | 0.057<br>(0.06)      |
| Obs                | 51240                     | 51240             | 51240             | 45761                  | 45761               | 45761               | 49878                      | 49878               | 49878                | 46523               | 46523               | 46523                |

Notes: Survey data are from the Michigan Survey. The dependent variable is either the change in unemployment expectations, Columns (I) to (III), the change in inflation expectations, Columns (IV) to (VI), the change in interest rate expectations, Columns (VII) to (IX), or the change in consumption plans, Columns (X) to (XII). Coefficients are estimated with OLS. The  $t$  statistics are in parentheses, and \*, and \*\* indicate significance at the 5 percent, and 1 percent level. All regressions are estimated using the two-step Heckman (1979) correction, the estimated inverse Mills ratio from the selection equation is denoted by  $\hat{\lambda}$ .

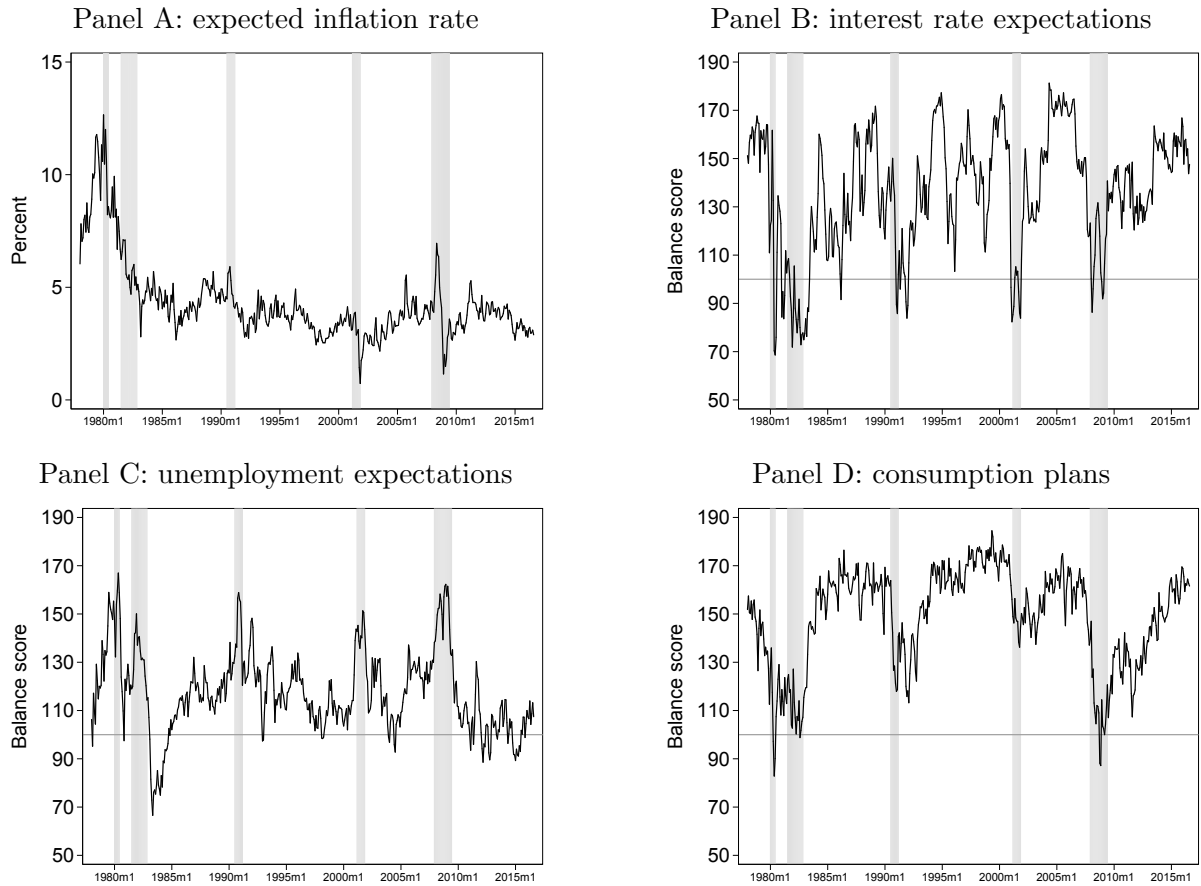
Table 4: Forecast error variance decomposition (in percent): SPF

|                                  | $h$ | AD shock             | AS shock             | MP shock            |
|----------------------------------|-----|----------------------|----------------------|---------------------|
| Panel A: macroeconomic variables |     |                      |                      |                     |
| unempl.<br>rate                  | 1   | 55.58 (44.15, 66.88) | 9.09 (3.14, 16.47)   | 2.51 (0.75, 7.18)   |
|                                  | 2   | 52.85 (41.17, 64.66) | 9.53 (3.55, 16.41)   | 1.62 (0.57, 4.69)   |
|                                  | 4   | 46.87 (34.07, 59.42) | 14.04 (5.93, 23.75)  | 1.87 (0.64, 4.01)   |
|                                  | 8   | 36.28 (23.91, 50.75) | 23.44 (10.54, 39.07) | 2.34 (0.76, 7.21)   |
| inflation<br>rate                | 1   | 4.13 (1.15, 10.35)   | 67.70 (48.61, 80.01) | 12.13 (2.55, 30.66) |
|                                  | 2   | 5.24 (1.54, 12.32)   | 61.28 (43.05, 74.14) | 10.44 (2.21, 26.99) |
|                                  | 4   | 7.18 (2.56, 15.57)   | 49.32 (33.36, 63.59) | 8.69 (2.12, 21.81)  |
|                                  | 8   | 8.25 (3.46, 17.87)   | 39.42 (25.08, 53.18) | 7.44 (2.08, 18.30)  |
| FFR                              | 1   | 23.29 (17.40, 30.13) | 1.34 (0.38, 3.22)    | 3.07 (1.45, 5.31)   |
|                                  | 2   | 23.44 (16.99, 31.63) | 0.93 (0.35, 2.11)    | 1.75 (0.82, 3.21)   |
|                                  | 4   | 23.60 (15.30, 33.25) | 1.34 (0.49, 3.46)    | 1.19 (0.56, 2.76)   |
|                                  | 8   | 21.39 (12.62, 32.06) | 3.74 (0.88, 11.52)   | 1.65 (0.57, 4.93)   |
| Panel B: expectation variables   |     |                      |                      |                     |
| unempl.<br>expect.               | 1   | 22.72 (16.15, 30.71) | 4.59 (1.38, 9.16)    | 1.82 (0.36, 4.93)   |
|                                  | 2   | 34.37 (24.35, 44.45) | 7.39 (2.83, 13.38)   | 1.49 (0.35, 4.52)   |
|                                  | 4   | 38.31 (26.58, 50.26) | 11.51 (4.82, 19.60)  | 1.58 (0.62, 3.70)   |
| inflation<br>expect.             | 1   | 0.58 (0.06, 2.39)    | 4.39 (1.71, 8.56)    | 1.87 (0.37, 4.72)   |
|                                  | 2   | 3.40 (1.09, 7.44)    | 4.92 (1.85, 9.10)    | 1.65 (0.55, 3.99)   |
|                                  | 4   | 4.64 (1.41, 10.31)   | 4.48 (1.69, 9.16)    | 1.79 (0.74, 3.71)   |
| int. rate<br>expect.             | 1   | 7.25 (4.36, 11.32)   | 0.75 (0.12, 2.01)    | 0.26 (0.02, 0.96)   |
|                                  | 2   | 14.73 (9.33, 21.33)  | 0.66 (0.19, 1.96)    | 0.36 (0.07, 1.14)   |
|                                  | 4   | 18.48 (11.08, 28.00) | 1.01 (0.34, 2.96)    | 0.54 (0.18, 1.49)   |

Notes: The table shows the median of the contributions to the forecast error variance computed for each set-identified model for horizon  $h$  in months, together with the 16th and the 84th percentile of the distribution of the contributions.

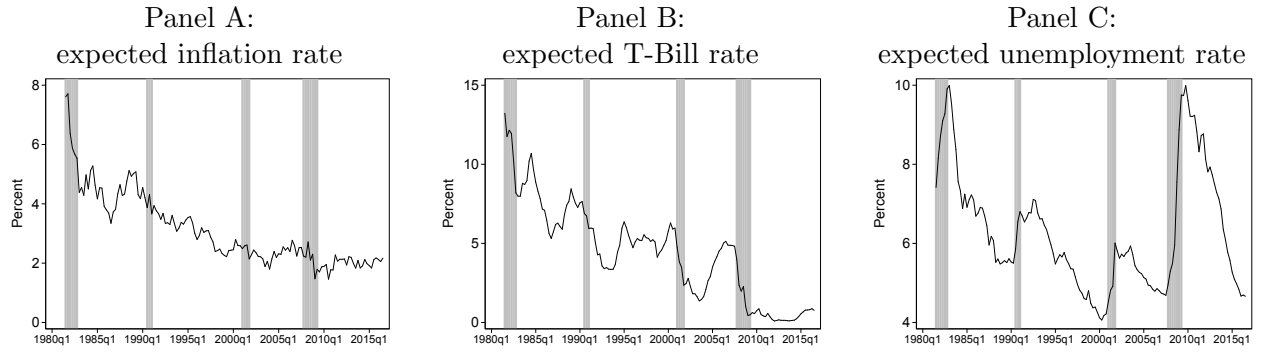


Figure 1: Time series of the aggregated survey measures from the Michigan Survey



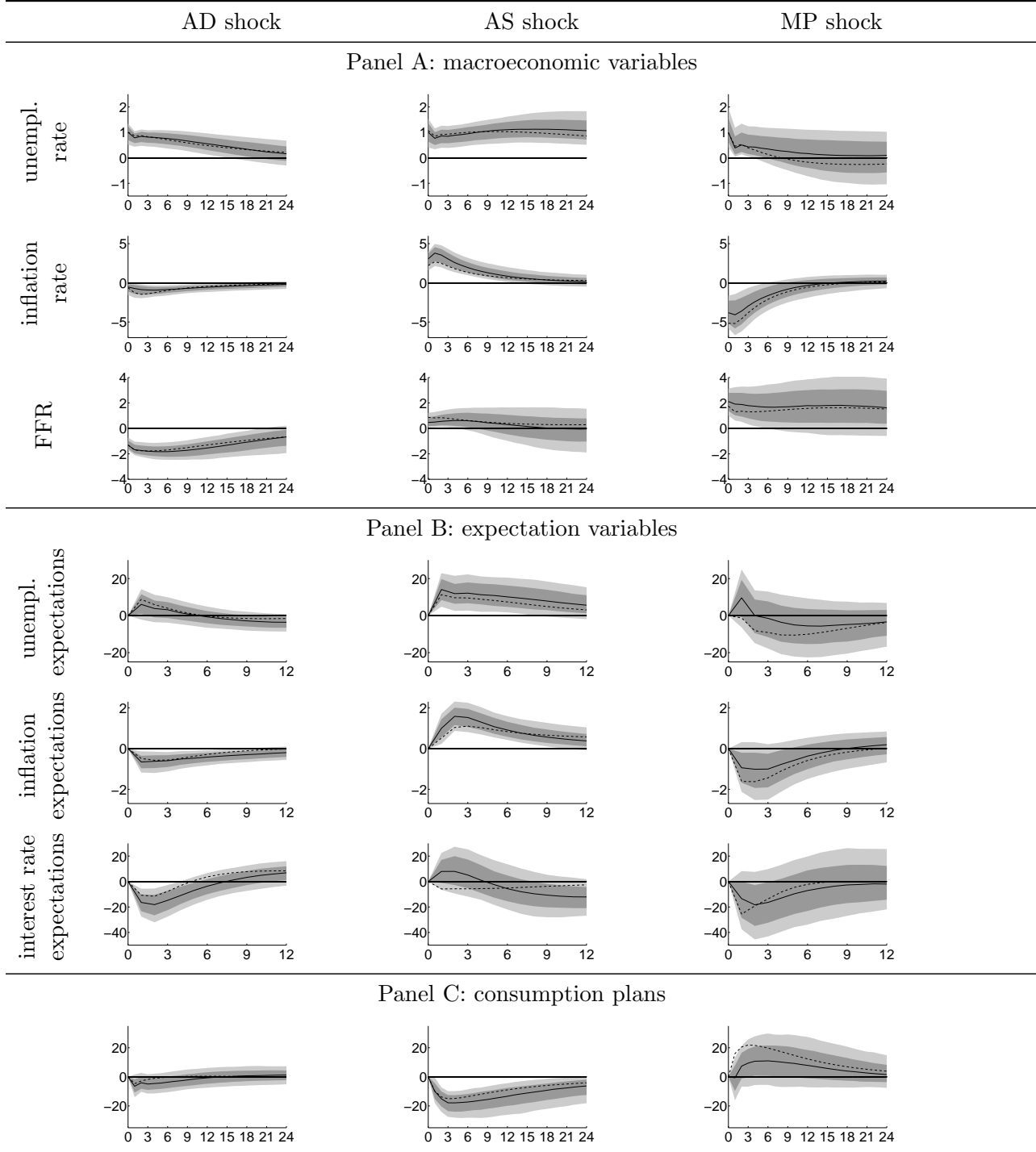
Notes: Shaded areas indicate economic downturns as classified by the NBER Business Cycle Dating Committee.

Figure 2: Time series of average point estimates from SPF respondents



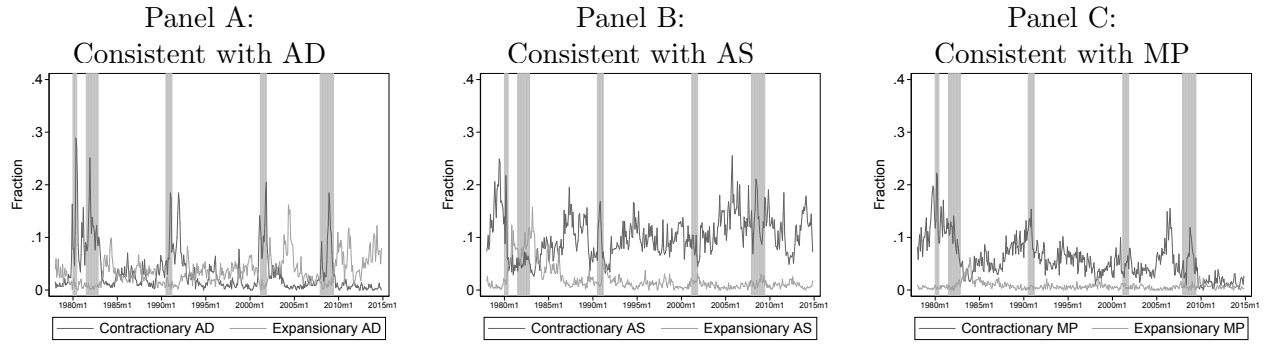
Notes: Shaded areas indicate economic downturns as classified by the NBER Business Cycle Dating Committee.

Figure 3: Impulse responses for the baseline estimation with Michigan Survey data



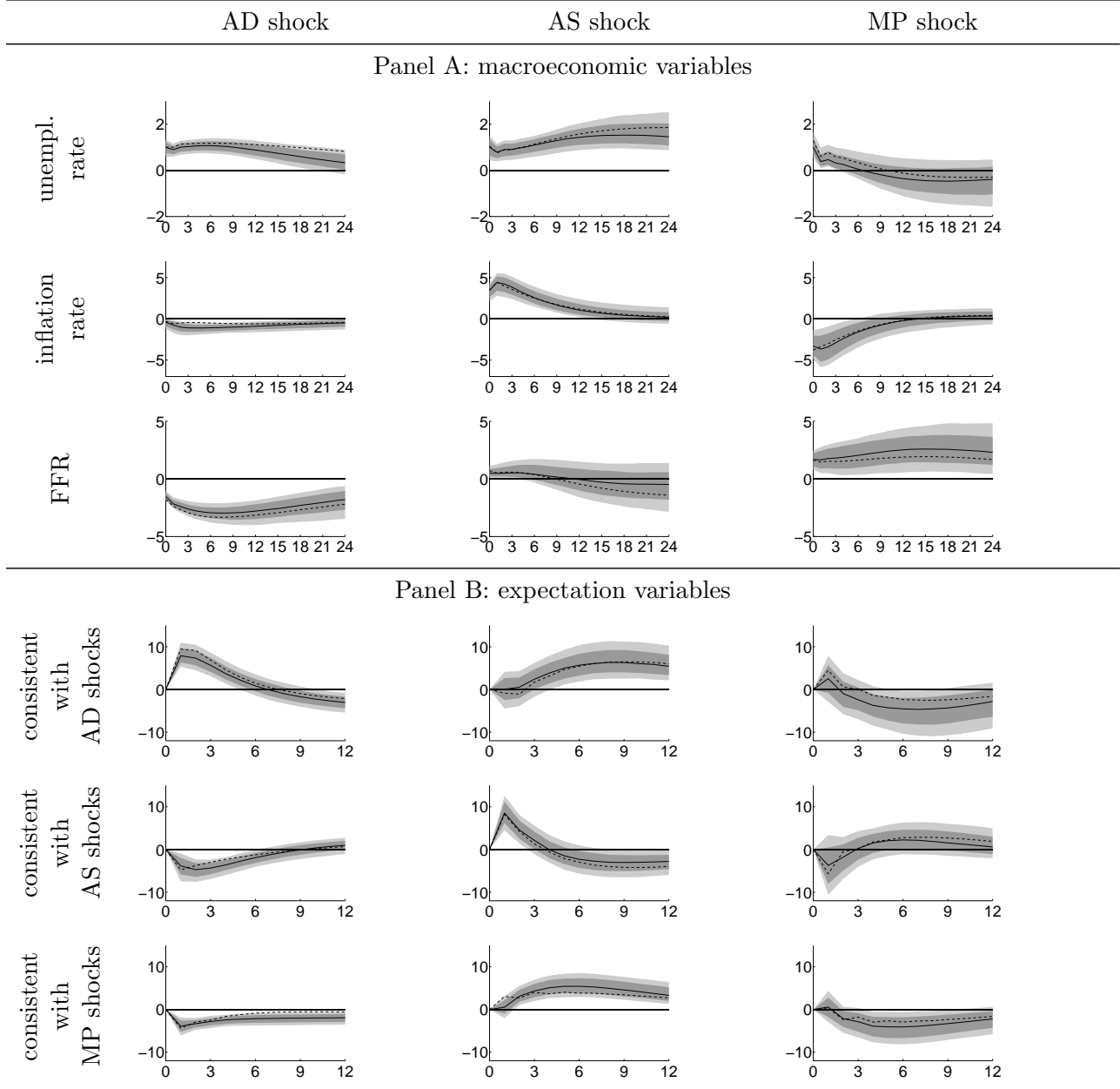
Notes: Inflation expectations are average point estimates of the future inflation rate while the other survey measures are summarized using balance scores. Solid lines represent the pointwise median responses. Dashed lines show the responses of the closest-to-median model selected as proposed in Fry and Pagan (2011). The bands represent the distribution of set-identified models in the impulse response function representation (5th and 16th percentiles as well as the 84th and 95th percentiles).

Figure 4: Fractions of respondents having expectations consistent with AD, AS and MP shocks



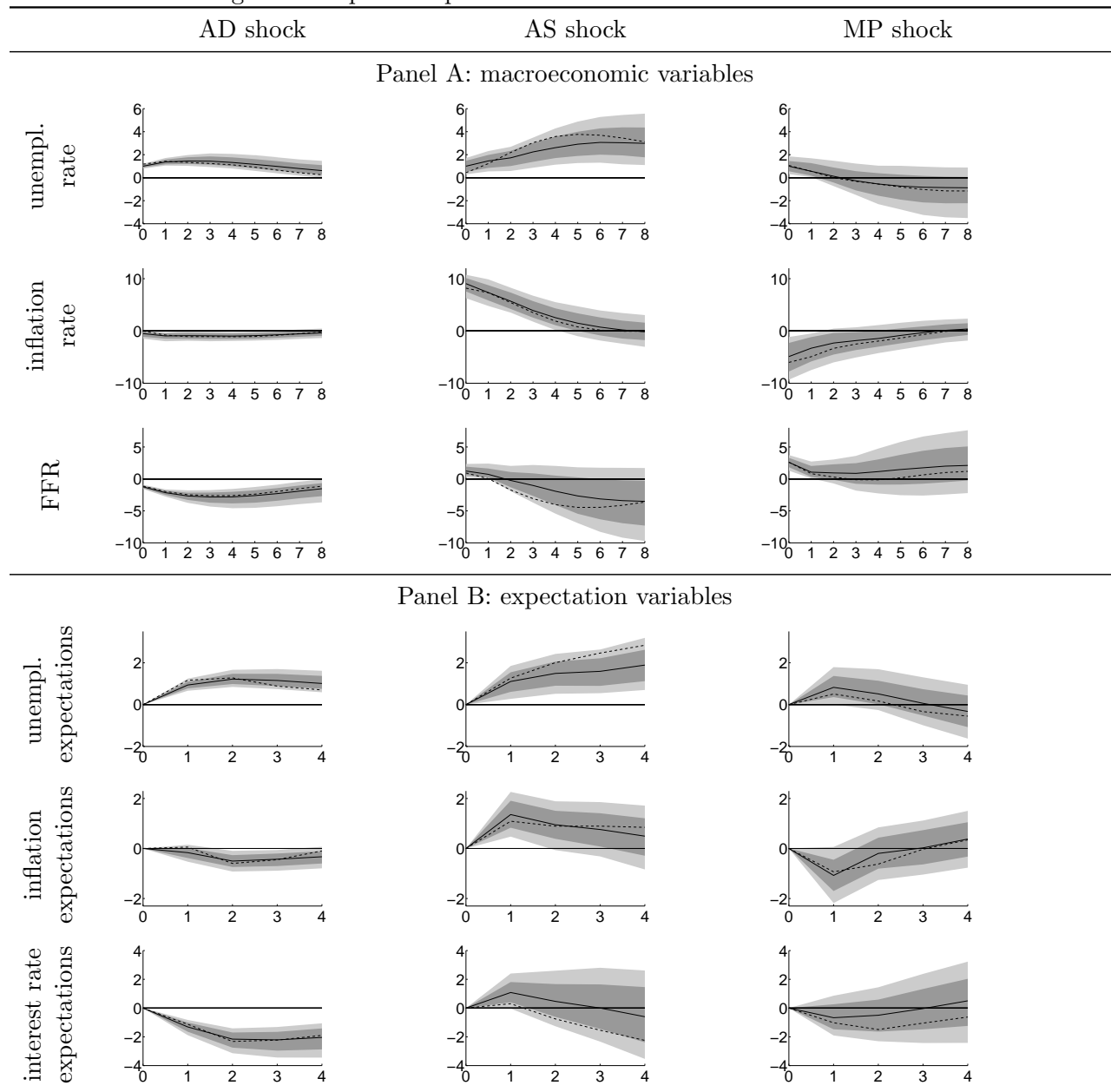
Notes: Survey data are from the Michigan Survey. Shaded areas indicate economic downturns as classified by the NBER Business Cycle Dating Committee.

Figure 5: Theory-consistency on the individual level



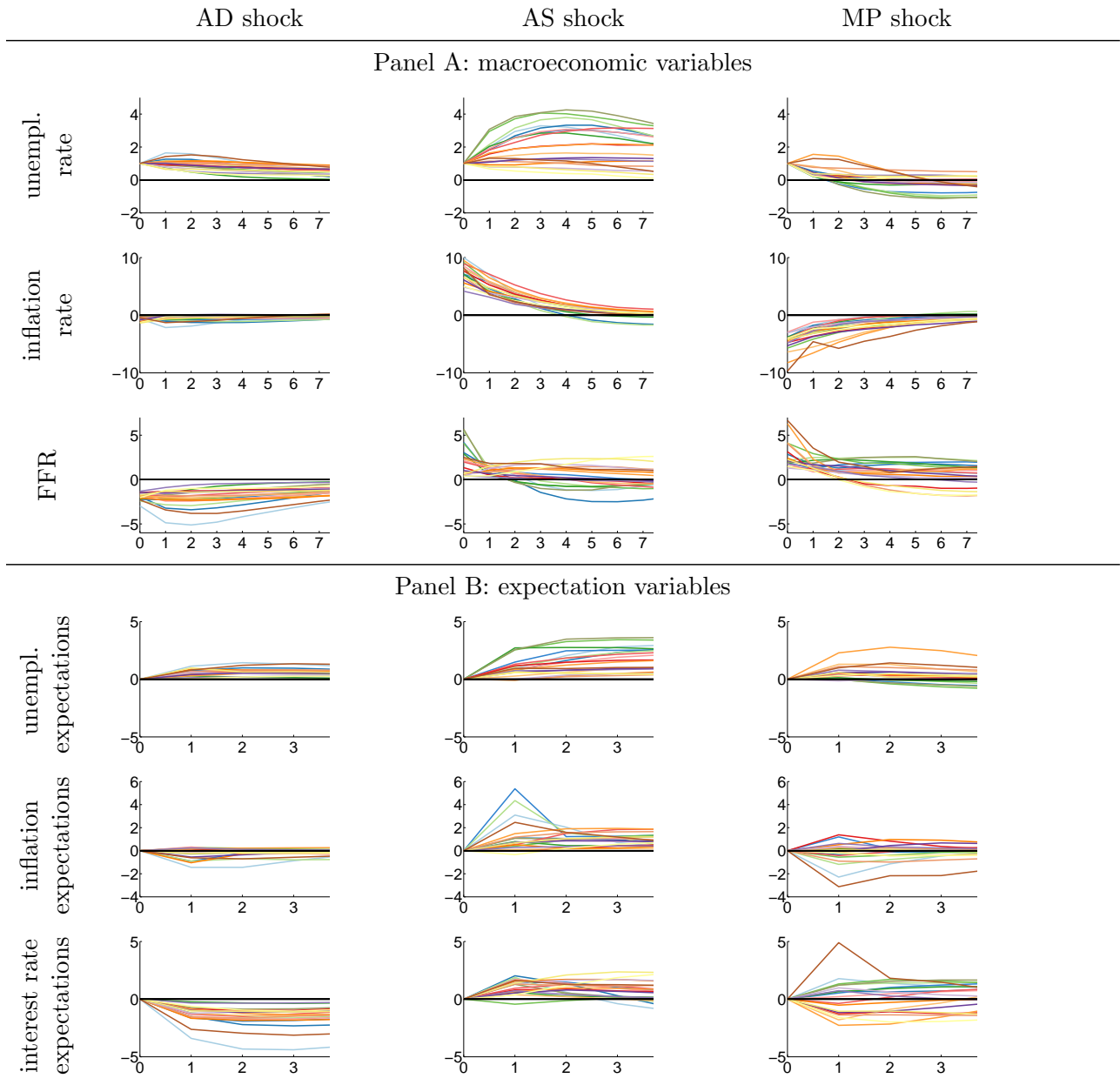
Notes: Survey data are from the Michigan Survey. Expectations consistent with the macroeconomic shocks are summarized by balance scores. Solid lines represent the point-wise median responses. Dashed lines show the responses of the closest-to-median model selected as proposed in Fry and Pagan (2011). The bands represent the distribution of set-identified models in the impulse response function representation (5th and 16th percentiles as well as the 84th and 95th percentiles).

Figure 6: Impulse responses for the estimation with SPF data



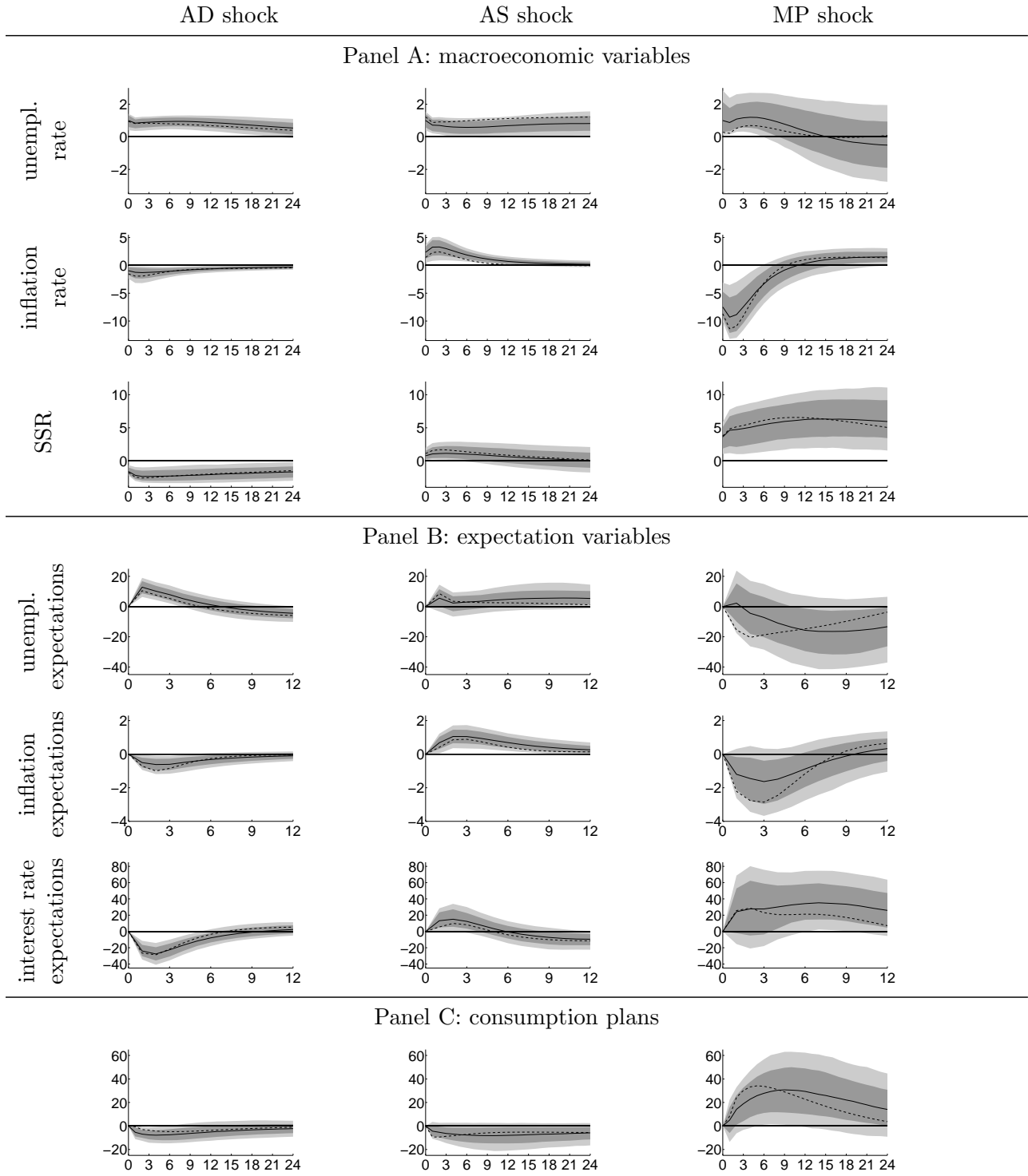
Notes: The expectation measures are average point estimates of the unemployment rate, the inflation rate and the three-month Treasury bill rate. Solid lines represent the point-wise median responses. Dashed lines show the responses of the closest-to-median model selected as proposed in Fry and Pagan (2011). The bands represent the distribution of set-identified models in the impulse response function representation (5th and 16th percentiles as well as the 84th and 95th percentiles).

Figure 7: Impulse responses for the estimation with individual SPF respondents



Notes: The expectation measures are average point estimates of the unemployment rate, the inflation rate and the three-month Treasury bill rate. Colored lines represent the point-wise median responses from the VARs estimated with survey answers from individual respondents.

Figure 8: Impulse responses for the estimation including data from the zero-lower-bound period



Notes: Survey data are from the Michigan Survey. Inflation expectations are average point estimates of the future inflation rate while the other survey measures are summarized using balance scores. Solid lines represent the pointwise median responses. Dashed lines show the responses of the closest-to-median model selected as proposed in Fry and Pagan (2011). The bands represent the distribution of set-identified models in the impulse response function representation (5th and 16th percentiles as well as the 84th and 95th percentiles).