Monetary Policy Shocks and Consumer Inflation Expectations: An Empirical Study

by

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Abstract

Economists have become very interested in the relationship between monetary policy and inflation-expectations. However, most research has focused on professional forecasters' rather than consumers' expectations. This paper explores interactions between monetary policy and consumer expectations. Specifically, we estimate the impact of monetary policy shocks on consumer expectations. Using a simple linear regression model and data from the Michigan Survey of Consumers, we found somewhat surprising results. Namely, that consumers adjust their expectations positively in response to an unexpected tightening of monetary policy. This suggests the existence of the "signalling channel" of monetary policy. We control for a host of macroeconomic and demographic variables, and our results are consistent across income and education groups. In line with previous research, we found greater heterogeneity in expectations for lower-income and lower-educated groups. Our research challenges conventional thinking regarding the influence of monetary policy on inflation-expectations, and suggests that this relationship is more complex.

KEYWORDS:

Monetary policy; inflation expectations; policy shock; michigan survey; survey of consumers

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1 Introduction

This paper explores the interaction between monetary policy and consumer inflation expectations. Economists have been increasingly interested in this relationship as there is now a widely accepted belief that expectations play a crucial role in the transmission of monetary policy. This stems from the notion that expectations affect *actual* decision making and inflation. Consequently, for monetary policy to be effective it must influence expectations in ways consistent with the direction of policymaking.

Inflation expectations have been documented and studied in reasonable detail in recent decades. However, the theme is of particular relevance today. The financial crisis caused central banks to exhaust all their conventional options with monetary policy and forced extraordinary policy measures. At the forefront of the discussion at the time was the role of inflation targets and expectations in helping economies fight the contractionary pressures facing them (See Ball [2013, 2014]; Krugman [2014]). Given the lack of policy options available (with nominal interest rates at the zero lower bound), many analysts argued that influencing expectations was virtually the only path to help reinvigorate aggregate demand using conventional monetary policy[1]. In this vein, a number of economists called for inflation targets to be raised to help stimulate expectations.

A natural question that follows is how exactly do unexpected changes in monetary policy affect consumer expectations? The answer to this question has significant implications for policymakers and monetary policy theory in general.

The importance of *consumer* expectations in explaining the evolution of actual inflation in recent years has also been effectively demonstrated. Coibion and Gorodnichenko [2015] demonstrate that the curious patterns in actual inflation post-financial crisis are better explained using household expectations relative to that of professional forecasters. This is an important discovery, as most economic analysis on expectations to date has been on professional forecasters' expectations and not that of households. Such research highlights

[1] Note: The emphasis here is on the lack of *conventional* policy options. A number of unconventional policy options were still available and exercised by the Federal Reserve, such as Quantitative Easing.

the need to understand the behaviour of household expectations in particular, which is part of the motivation for this paper.

While traditional theory suggests countering inflationary/deflationary pressures with a tightening/loosening of policy, some recent research suggests that this relationship is more complex [Melosi, 2014; Tang, 2015]. These papers find evidence of a "signalling channel" of monetary policy, where agents actually respond in unexpected ways relative to what policymakers desire.

This paper seeks to shed more light on this puzzle by using an empirical approach. Specifically, we contribute to existing research by modelling the impact of monetary policy *shocks* on consumer expectations using survey data. The focus on shocks is important as it allows us to sidestep key issues of dual causality between policy and expectations.

Using micro survey data (∼136,000 observations) from the University of Michigan's Survey of Consumers, and exogenous monetary policy shocks derived by Gertler and Karadi [2015], we investigate the impact of monetary policy shocks on consumer inflation expectations. We chose to use data from the Michigan Survey as it is the only source for historical, as well as current, consumer inflation expectations data for the USA.

We include macroeconomic data available online from the Federal Reserve Economic Data (FRED) archive, as well as a host of demographic variables from the Michigan Survey of Consumers, in order to incorporate a number of crucial control variables in our regression analysis. Previous work that employed Michigan Survey data such as Ehrmann et al. [2015], and Coibion and Gorodnichenko [2015] serve as useful leads in creating the basic structure of the model. Upon finding significant patterns in expectations across income and education of respondents, we run separate our by income and education category. This allows us to understand which subgroups in the population respond to shocks in similar/dissimilar ways.

The structure of our model can be described as an 'augmented rational expectations framework', where rational expectations would be a special [albeit unrealistic] case under certain conditions. This is simply a methodological strategy to help understand and guide our modelling approach. We do not focus on rationality itself, and consumer rationality is not tested

for in any way. Our primary interest here is in the expectations responses of consumers to monetary policy shocks.

The results from our model are somewhat surprising. We find that consumers adjust their expectations *positively* in response to an unexpected tightening of monetary policy. This suggests the existence of the "signalling channel" of monetary policy, as documented by Melosi [2014] and Tang [2015]. Moreover, these results are consistent across different income and education groups, removing the possibility that the counter-intuitive nature of our results is due to excessive influence by particular groups within the sample. As one would expect, there is more heterogeneity in expectations for lower income and education groups, leading to drops in significance. These demographic trends in expectations are consistent with previous research on the subject (See Carvalho and Nechio [2014b]), and we explore this further by running our regressions separately for all income and education groups.

The role of crude oil remains pivotal in determining the path of expectations, consistent with the findings of Coibion and Gorodnichenko [2015]. We also include a lagged official measure for inflation expectations, released by the Federal Reserve Bank of Cleveland, to see if consumers incorporate such information in their expectation-formation process. Our results support this premise.

Section 2 of this paper contains a survey on the literature that employs Michigan Survey data, and that has focused on the relationships between policy, demographics, and expectations. Section 3 describes the data used for this paper in more detail, including an extensive look at the monetary policy shock variable. Section 4 explains our model specification, and then proceeds to document our results and interpretations. Section 5 briefly covers some caveats and notes on robustness. Section 6 concludes.

2 Literature Review

Over the years, the Michigan Survey of Consumers has proven to be a rich and useful source of data for researchers on household attitudes and sentiment. Researchers have used this data to analyse a number of different questions; examples of past research include attempts to discern whether consumer expectations are consistent with economic theory, as well as to explain patterns in actual inflation in the economy. Many papers studied the mechanics of measuring consumer confidence (See Curtin [1982]; Dominitz and Manski [2004]).

While this data has been utilised to address a number of issues, the Michigan Survey (MS) in general has not been as widely used as other survey data on expectations. Most economic analysis on expectations focuses primarily on professional forecasters' expectations rather than that of households. However, in recent years, there has been an increasing interest in the role of household expectations in the economy, as well as their influence on current/expected inflation. As a result, the MS is now gaining more recognition as a trusted source for data on household expectations.

In their recent paper, Coibion and Gorodnichenko [2015] explore alternative explanations for why the USA did not experience more persistent disinflation during, and in the immediate aftermath of, the Great Recession of '07-'08. Using a New Keynesian framework and employing data from the MS, they demonstrate that if the expectations of firms track that of *households* rather than that of professional forecasters, the missing disinflation can be explained more satisfactorily than by prevailing arguments. The authors also find that consumer expectations are especially sensitive to changes in highly visible commodity prices such as crude oil.

While inflation up until 2011 remained unusually high compared to historical trends in the USA (relative to earlier comparable recessions), another puzzle arose when inflation remained unusually low despite the economic recovery that gathered momentum from 2012 onwards. Using consumer expectations data helps substantially in explaining both of these puzzles [Friedrich, 2016]. Friedrich [2016] finds that the inclusion of consumer expectations

helps explain recent inflation patterns not just in the USA but also in other OECD countries.

A number of papers have also used the MS to study the relationship between demographics and expectations (See Utsey and Cook [1984]; Bryan and Venkatu [2001]; Souleles [2004]; BruineDeBruine et al. [2010]). These papers find links between survey respondents' demographic characteristics and their expectations. For example, Souleles [2004] finds systematic correlations between household demographic characteristics (such as income) and their inflation forecasts. That is to say, forecast errors were 'systematically heterogeneous'. Snir and Levy [2011] use survey data and evidence from cognitive psychology to demonstrate that financially constrained consumers are more sensitive to price changes in the goods they consume relative to more wealthy consumers.

In his seminal paper from 2003, Carroll illustrates how consumers change their expectations only occasionally, usually in response to media coverage on the expectations of professional forecasters. This led to a number of studies being done on the same topic, with increasing evidence being found that consumer expectations are very susceptible to economic news. (See Doms and Morin [2004]; Curtin [2010]; Lamla and Maag [2012]; Barsky and Sims [2012]; Pfajfar and Santoro [2013]; Lamla and Lein [2014]).

Survey expectations have also been used to gauge sentiment and expectations on asset market returns, such as stocks and real estate. Otoo [1999] studies the relationship between equity market changes and consumer confidence using data from the Michigan Survey. A strong contemporaneous relationship between the two is found at the aggregate level. Piazzesi and Schneider [2009] explore household beliefs with regard to real estate during the recent USA housing boom in the 2000s. They find that consumer optimism, even in relatively small opinion-clusters, can have significant effects on prices. A study covering the measurement of expectations of equity returns can be found in Dominitz and Manski [2010].

Forecasts of energy prices by survey respondents have also provided researchers with new insight into the formation of expectations with regard to energy, most commonly gasoline (See Anderson et al. [2011, 2013]; Allcott [2011].

The [non-]neutrality of monetary policy has been a hotly contested debate within economics for decades. Despite this, not many studies have taken a detailed empirical look at the interplay between monetary policy and consumer expectations. Roberts [1998] does an empirical study on the rationality of expectations and the impact of degrees of rationality (of consumers) on the transmission of monetary policy. His results suggest that inflation expectations are neither perfectly rational nor extremely non-rational. Rather, "survey measures of inflation expectations represent an intermediate degree of rationality" [1998, p. 24]. His argument thus is that the presence of some levels of non-rationality in consumers explains the well-known puzzle of why active inflation reduction by the Central Bank often has adverse *real* costs on the economy in terms of output and unemployment.

Leduc and Sill explore the interplay between surveyed expectations, monetary policy and macroeconomic aggregates. The find significant evidence that expectations "are a quantitatively important driver of economic fluctuations" [2013, p. 1352].

On a somewhat related theme, Ball and Croushore [2003] approach this issue by assessing the impact of monetary policy shifts (changes in the Federal Funds Rate) on output, inflation and expectations. Using data from the Survey of Professional Forecasters, the authors show that respondents systematically underestimate the negative impact of an increase in the funds rate would have on output; this is a direct violation of rational expectations. They are however *unable* to reject rationality of expectations with respect to inflation; a rise in the funds rate leads to roughly equal falls in expected and actual inflation at a horizon of 2 years. By integrating this non-rationality of expectations into a simple macroeconomic model, the authors demonstrate that monetary policy is indeed non-neutral under these conditions. Their theoretical analysis therefore corroborates their empirical findings.

Carvalho and Nechio have done considerable work using Michigan Survey data. Their research includes attempts to understand if households understand the basic tenets of monetary policy in the USA [2014a]. They find large variations in the expectations responses of households over the business cycle, and that *some* households form expectations consistent with a Taylor [1993]-type rule. This is similar to work done by Drager et al. [2015] who explore whether survey expectations are "theory-consistent". Further work on this theme in Carvalho and Nechio [2014b] delves into which pockets of the population have a more coherent understanding of the relationship between interest rates, inflation and unemployment. They find that "households with higher incomes and more education appear to better grasp how interest rates relate to inflation and unemployment" [p. 1]. This finding provides a basis for some of the research done in this paper.

3 Data

The data used in this paper comes from three sources:

1. Inflation expectations and demographic data from the Michigan Survey of Consumers.
2. Monetary policy shock data from Gertler and Karadi [2015].
3. Macroeconomic data available online from the Federal Reserve Economic Data (FRED) archive provided by the Federal Reserve Bank of St. Louis.

The following subsections describe the data used from the above sources in more detail.

3.1 The Michigan Survey of Consumers

The MS consists of roughly 50 core questions and a number of other supplementary questions. The questions address different aspects of household expectations and attitudes. The survey is designed to be representative of all US households, and is conducted over the phone, with a minimum of 500 interviews conducted every month from the university's Ann Arbor facility.

The MS covers the following areas of consumer sentiment: (a) Personal Finances (b) Business Conditions (c) Buying Conditions (See University of Michigan: Survey Description).

Interviewees are asked about both past and expected changes to their personal finances, including changes to nominal and real family income. Furthermore, they are asked about their perceptions regarding the state of the economy and business conditions over the short- and long-term. Included here among more general queries are specific questions on expected changes in the general price level (i.e. inflation) over a 1-year and 5-year horizon. Similar questions on the unemployment rate and interest rates are also included. The final section of the survey involves measuring consumers' buying attitudes for large durables, vehicles and houses. Interviewees are asked to state whether or not current market conditions encourage the purchase of these goods or not, and then face follow-up questions which ask for justifications for their answers. The emphasis on providing justifications illustrates our growing interest in understanding not just *what* decisions consumers make, but also *why* they make them i.e. why they choose to follow certain consumption and spending patterns.

The data used in this paper comes from the University of Michigan's SDA (Survey Documentation and Analysis) online archive. It consists of combined monthly cross-sectional datasets from 1978-2014. In total, there are 251,995 observations, with each observation corresponding to a particular individual's/household's response in a given month. In this paper we only use data from years 1990-2012, to match the range of our shock variable. Furthermore, similar to previous research using this data, we ignore extreme values for self-reported expectations. Specifically, we only include inflation expectations between -25% and +25%[2]. All told, our final dataset consists of ∼136,000 observations.

The MS data illustrates the relationship between consumer expectations and actual events in the economy. The survey description document (University of Michigan: Survey Description) compares expectations with a number of different economic parameters, including interest rates and actual inflation. A strong positive correlation is found between expecta-

[2]The total number of "extreme forecasters" dropped was 521. Interestingly, some brief analysis on this group showed that they come largely from the bottom two income quintiles and education groups; 59% of them lie in the bottom 40% of the income distribution, while 68% have had only some schooling and/or have completed high school.

tions and future trends in these parameters, suggesting that households tend to anticipate these trends fairly accurately in advance.

The data used here is focused on the measures for inflation expectations. Interviewees are asked by how much they expect prices to go up/down over the next 1 year, and also over the next 5-10 years. We focus here only on the 12-month horizon for expectations. The relevant survey questions for this paper are:

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

We are interested in the answers to Question 2, as this gives us a quantitative measure for consumers' inflation expectations. This variable, "PX1", is the dependent variable in our regressions after excluding some outliers. The only other data from the Michigan Survey that is used here is demographic data on survey respondents, such as age, income, education etc. Summary statistics on this data are provided in Tables 1-4.

Table 1 includes summary statistics for the Michigan Survey. Here we can see the mean and range for our inflation expectations variables, as well the age and income of survey respondents. The survey contains a weighting variable which provides us with sampling weights for the household. Since our results incorporate these weights in order to be more representative, we provide information on both the weighted and un-weighted means in columns and 1 and 2. The difference between these two measures are modest across all variables. Tables 2, 3 and 4 show us the un-weighted frequency distributions across income quintiles, education categories, and gender, respectively. These distributions are important as we eventually run our model by income and education groups.

Table 1: **Summary Statistics (Michigan Survey)**

Variable	Un-Weighted Mean	Weighted Mean	Min	Max
Inflation Expectations	3.42 (4.04)	3.45	-23	23
Inflation Expectations (Original Variable)	3.62 (4.94)	3.67	-50	50
Age	48.71 (17.20)	48.90	18	97
Income	59414 (56778)	53966	1	500,000

Table 2: **Income Distribution**

Category	Frequency	Percentage
Bottom 20%	18,970	15
21-40%	22,140	18
41-60%	25,672	21
61-80%	28,511	23
Top 20%	29,640	24
Total	124,933	100

Table 3: **Education Distribution**

Category	Frequency	Percentage
Some Schooling	11,196	8
High School	39,190	29
Some College	33,900	25
College Degree	50,512	37
Total	134,798	100

Table 4: **Gender Distribution**

Item	Number	Percentage
Male	60,588	45
Female	75,077	55
Total	135,665	100

3.2 Monetary Policy Shocks

The core focus of this paper is to analyse the impact of monetary policy *shocks* on consumer expectations. This allows us to sidestep issues of reverse causality when running our regressions.

Arriving at a credible exogenous policy shock has been a challenge for decades. Early work on the topic largely involved traditional vector autoregression (VAR) models [Bernanke and Blinder, 1992; Christiano et al., 1996]. For a comprehensive summary on the early work on this subject, see Christiano et al. [1999].

However, these models have been improved and augmented over time. Some recent approaches have used methods that also account for shocks to communication from the Federal Reserve. Communication, or "forward guidance", has increasingly become one of the most important features of monetary policy. Thus an ideal measure of policy shocks should account for shocks not just to the policy instrument i.e. the short-term interest rate, but also shocks to market expectations regarding the policy instrument through forward guidance.

One approach to account for shocks to forward guidance has been to use high frequency identification (HFI) methods that look at unexpected changes in the policy instrument on days where the Federal Open Market Committee (FOMC) meets and decides on the direction of monetary policy (See Kuttner [2001]; Gurkaynak et al. [2004]; Campbell et al. [2012]). A survey on all of the most prominent methods in identifying macroeconomic shocks can be found in Valerie Ramey's forthcoming chapter in the Handbook of Macroeconomics [2015].

In this paper we use policy shocks generated by Gertler and Karadi [2015]. Their paper identifies shocks using a 'hybrid' method that combines both the traditional Structural VAR (SVAR) methods and the HFI method.

The key identifying assumptions in these two approaches are the following:

- Traditional VAR approaches "impose timing restrictions on both the behaviour and the impact of the policy rate ... A standard set of restrictions is to suppose that within a period the funds rate responds to all the other variables in the VAR but not vice

versa. That is, the impact of the funds rate on the other variables occurs with a lag of at least one period" [Gertler and Karadi, 2015, p. 45].

- For HFI approaches, the key identifying assumption is that "news about the economy on the FOMC day does not affect the policy choice. Only information available the previous day is relevant" [Gertler and Karadi, 2015, p. 46].

Using daily Federal Fund Futures data, the HFI approach addresses the issue of contemporaneous responses of variables to policy changes and vice-versa. The authors are also able to account for shocks to forward guidance. Thus, in these ways, the methodology employed by Gertler and Karadi has certain advantages compared to previous work.

Accounting for forward guidance is important in the context of this paper since we do not explicitly control for the effect of forward guidance on expectations here. Earlier work using the MS had used methods such as creating an index for news on inflation to control for forward guidance [Pfajfar and Santoro, 2013; Ehrmann et al., 2015]. Since this data is not easily available, we used alternative means to solve this puzzle: Specifically, the policy shocks themselves control for forward guidance effects; this is explained below.

To use the authors' words, a monetary policy shock using their framework is "a linear combination of exogenous shocks to the current and expected future path of future rates" [Gertler and Karadi, 2015, p.54]. These shocks are derived using federal fund futures. Futures contracts allow for speculation on what investors suspect the Federal Reserve will do with respect to interest rates. By looking at shocks to Federal Funds Futures, and by including contracts that expire in the future, the authors are able to measure shocks not only to the current rate, but also expected future rates. In order to isolate the effect of *only* central bank decisions on interest rates, the 'shock' is measured within a tight 30-minute window of an FOMC decision/meeting. In monetary policy terms, the interpretation is simple: positive values for the shock correspond to a contractionary shock, while a negative shock values would be typically seen as expansionary.

In order to identify the shocks, the authors use external instruments within a VAR model. This is a variation of the methodology used by Stock and Watson [2012]. The general form of the VAR they use is the following:

$$\vec{A}\vec{Y}_t = \sum_{j=1}^{p} \vec{C}_j \vec{Y}_{t-j} + \vec{\epsilon}_t \tag{1}$$

Where $\vec{Y}_t$ represents a vector of both economic as well as financial variables, $\vec{A}$ and $\vec{C}_j$ are coefficient matrices, while ϵ_t is a "vector of structural white noise shocks" [Gertler and Karadi, 2015, p. 50]. They then multiply equation 1 by $\vec{A}^{-1}$ to arrive at the following reduced form equation:

$$\vec{Y}_t = \sum_{j=1}^{p} \vec{B}_j \vec{Y}_{t-j} + \vec{u}_t \tag{2}$$

where the term $\vec{u}_t$ (reduced form shock) is a function of the structural shocks:

$$\vec{u}_t = \vec{S}\vec{\epsilon}_t \tag{3}$$

with $\vec{B}_j = \vec{A}^{-1}\vec{C}_j$ and $\vec{S} = \vec{A}^{-1}$.

In order to incorporate policy shocks to forward guidance and not just current-period rates, Gertler and Karadi [2015] distinguish between the policy *indicator* and policy *instrument*. In traditional VARs these two measures are the same, since a structural policy shock corresponds to an exogenous variation in the current short rate [p. 50]. However, the policy indicator of choice here is a government bond rate with a longer maturity to that of the current funds rate. The advantage of using the bond rate is that "its innovations incorporate not only the effects of surprises in the current funds rate but also shifts in expectations about the future path of the funds rate, i.e., shocks to forward guidance" [Gertler and Karadi, 2015, p. 50].

Let $\vec{Y}_t^p \in \vec{Y}_t$ be the policy indicator, i.e. the variable in equation 1 that varies exogenously in response to a primitive policy shock ϵ_t^p. The impact of the structural policy shock ϵ_t^p

on on the residuals $\vec{u}_t$ correspond to a particular column in matrix $\vec{S}$; Gertler and Karadi denote this column matrix as $\vec{s}$. They then show that, since we are interested in *only* policy shocks and not any other types of shocks, we can compute impulse responses to monetary shocks using the following equation:

$$\vec{Y}_t = \sum_{j=1}^{p} \vec{B}_j \vec{Y}_{t-j} + \vec{s}\epsilon_t^p. \tag{4}$$

Using a two-stage least squares (2SLS) framework, they are able to identify $\vec{s}$ and thus observe the responses of different market interest rates to exogenous variations in policy indicators, using "interest rate futures surprises on FOMC dates as instruments" [Gertler and Karadi, 2015, p. 55]. Employing the HFI method, the dependent variable here are surprises in daily rates.

The final regression equation estimated by the authors using 2SLS is the following:

$$\Delta R_t = \alpha + \beta(i_t^n)^u + \epsilon_t \tag{5}$$

where i_t^n is the interest rate on an n-month government bond which is the policy indicator. ΔR_t is "the change in an asset return on an FOMC day" [p. 55], and $(i_t^n)^u$ is the unanticipated movement in i_t^n on the same day. Under the identifying assumptions mentioned earlier, the authors' 2SLS estimation identifies the variation in i_t^n that is exclusively due to an exogenous monetary policy surprise. We thus arrive at our measure for policy shocks.

The data used in this paper comes directly from the website for Gertler and Karadi's paper in the American Economic Journal: Macroeconomics. Apart from some of the advantages their methodology has over other alternatives, this data was most suitable for our analysis since it covered most of the sample period of the MS expectations data[3]. Some summary statistics and a graph of the policy shocks can be seen in Table 5 and Figure 1.

[3]In order to demonstrate that their policy surprises are truly exogenous, Gertler and Karadi conduct some analysis on economic forecasts themselves, using survey data. By utilising the official Federal Reserve 'Greenbook' forecasts, and private sector forecasts for the same economic activity using the Blue Chip Economic Indicators Survey, the authors test to see how much of the variation in their shocks can be explained by the Federal Reserve's "private data", and subsequently demonstrate that their policy surprises are indeed orthogonal [2015, p. 72].

The shocks themselves are percentage point deviations in average monthly interest rates. Following the methodology of Kuttner [2001], Gertler and Karadi "measure the surprise in the target rate using the change in the futures rate" [p. 52].

Table 5: **Policy Shock**

	Mean	SD	Min	Max
Shock	-0.0135	0.0484	-0.2903	0.0922

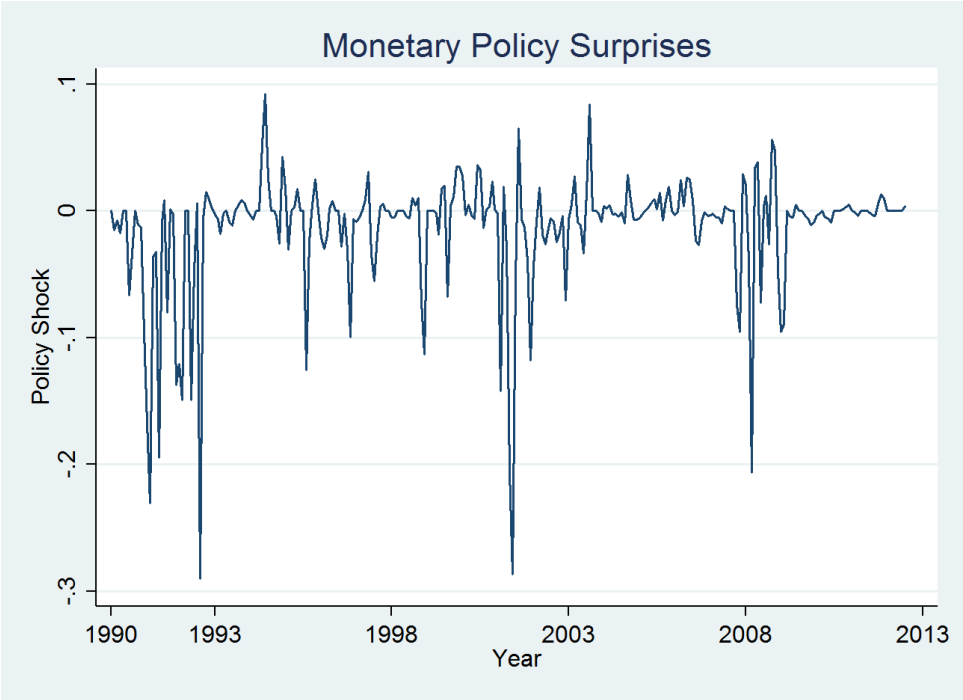

Figure 1: **Plot of Policy Shocks Across Time**

Figure 1 graphs these policy shocks across time. There is a clear asymmetry in the shocks, with the biggest negative shocks being much larger in magnitude than the biggest positive shocks. This implies that interest rates are often adjusted downwards more than what the market expects, or conversely they are not adjusted upwards as much as the market expects.

One possible explanation for this pattern is that central banks typically communicate very clearly in advance when they intend to *raise* interest rates, but don't do so when they plan to *lower* interest rates. Thus the unexpected shocks shown here are skewed more to the negative side.

3.3 Macroeconomic Data

As mentioned in section 3, our model also includes certain relevant macroeconomic variables. These variables include measures for inflation, the Federal Funds Rate, unemployment rate, crude oil prices, as well as an indicator for recessionary periods. All the data were downloaded directly from the online FRED (Federal Reserve Economic Data) archive provided by the Federal Reserve Bank of St. Louis, as monthly data. We then merged this data by month with the MS data.

We also use an official measure for inflation expectations released by the Federal Reserve Bank of Cleveland (FRBC). The FRBC releases data on a host of measures every month, including inflation expectations (combined professional and household measures), nowcasting, and a financial stress index. The data on inflation expectations is derived from a few different sources including inflation swap rates, nominal yields and some survey measures [Haubrich et al., 2012], and can be downloaded directly from the Bank's website.

A table of summary statistics with the various macroeconomic data that are used in this paper is shown below:

4 Model

This paper uses a regression-based framework to examine the relationship between monetary policy shocks and consumer inflation expectations. Using data from the Michigan Survey, and policy shocks derived by Gertler and Karadi [2015], we estimate a simple linear regression model that captures the influence of these policy shocks on expectations. A linear

Table 6: **Summary Statistics (Macro Data)**

Variable	Mean	SD	Min	Max
FRBC Expectations	2.64	0.81	-0.48	5.00
Inflation Rate	2.75	1.27	-2.10	6.30
Federal Funds Rate	3.61	2.28	0.07	8.29
Unemployment Rate	6.03	1.61	3.80	10.00
Crude Oil ($/Barrel)	41.41	28.60	11.35	133.88

regression approach is not unlike the methodology employed by other papers that used MS data (See Ehrmann et al. [2015]), and it is the most appropriate approach in this context given the cross-sectional time-series nature of our data.

A simplified way of assessing the general method used here is to view it as a type of 'augmented' rational expectations framework, where rational expectations would be a special [albeit unrealistic] case in certain conditions. Under rational expectations, agents utilise all available information to form optimal expectations regarding the future. While these expectations are not necessarily always *correct*, they are assumed not to be systematically biased across time. Given that all agents under this scenario have identical information sets, they would all form roughly similar expectations in each period, on average.

A generic structure of the regression model here is as follows:

$$\begin{aligned} Exp = \beta_0 + \beta_1 \cdot (Lagged\ Shocks) + \beta_2 \cdot (Contemporaneous\ Variables) \\ + \beta_3 \cdot (Lagged\ Expectations) + \beta_4 \cdot (Lagged\ Macro\ Variables) \\ + \beta_5 \cdot (Demographic\ Variables) + Error\ Term \end{aligned} \tag{6}$$

where the dependent variable "Exp" represents inflation expectations as recorded in the MS. Hypothetically, under a rational expectations scenario, this would imply that:

- β_3 captures the effect of *all* past information, since this knowledge have been incorporated into forming last-period expectations.
- β_5 would equal zero, since demographic characteristics should not technically be relevant to forming optimal expectations.

It is possible that a lot of information from the lagged macroeconomic variables, β_4, would be captured by the lagged expectations variable that is included. However, it is not necessarily the case that β_4 is irrelevant here, since inflation is being forecasted over a changing 12-month horizon, and also since the model only accounts for one type of economic shock. For obvious reasons, assuming rational expectations would be a questionable assumption to make, and since testing for rationality is not within the scope of this paper, we simply use this framework to help understand our model specification. Our baseline regression model takes the following form:

$$EXP_{it} = \beta_0 + \vec{\beta_1} SHOCK_{t-k} + \beta_2 \overline{EXP}_{t-1} + \vec{\beta_3} INF_{t-k} + \vec{\beta_4} FFR_{t-k} + \vec{\beta_5} \vec{X_{it}} + \epsilon_{it} \quad (7)$$

where β_0 is a constant, β_1 is the coefficient on lagged policy shocks, β_2 is the coefficient on lagged mean expectations (from the previous period), β_3 is the coefficient on lagged inflation and β_4 is the coefficient on lagged interest rates. The vector $\vec{X_t}$ is a vector of demographic variables, including gender, age, income and education à la Ehrmann et al. [2015]. The error term ϵ_{it} is heteroskedasticity-robust. We also control for unobservable common shocks *within* each period across respondents through clustering observations by month. This also helps address the issue of serial correlation in our errors. We assume for the purposes of this paper that these unobservables are independent across periods. This is the "Base Model" in Table 7 on page 20. It includes what one would suspect are the main factors driving consumer inflation expectations. Note that the subscript $k = \{1, 6, 12\}$.

To gain further insight, we augment this "Base Model" with a few more relevant regressors:

1. Lagged FRBC Expectations: this variable contains the lagged measure of inflation expectations released by the Federal Reserve Bank of Cleveland. It is included here to inspect the possibility of whether consumers use official measures of inflation expectations to form their own expectations in the future. Only 6- and 12-month lags are included to avoid issues of multicollinearity with the 1-month lagged MS expectations.

2. Recession Indicator: An indicator variable which signifies recessionary periods.

3. Unemployment Rate: A variable measuring the official unemployment rate. Given that unemployment is one of the key measures of economic performance, one could expect that consumers integrate such information in their expectation-formation process.

4. Log(Crude Oil Prices [$/Barrel]): The price of oil is well documented as having a large and significant impact on consumer inflation expectations [Coibion and Gorodnichenko, 2015]. Given that it is an extremely visible expense that is incurred with such regularity, consumers often react immediately and strongly to changes in oil prices, altering their expectations accordingly.

4.1 Results

Table 7 shows us the results of running both the "Base Model" as well as the "Full Model" including the four variables mentioned above. Focusing here largely on the "Full Model", we can deduce a number of interesting findings from these results:

The coefficients on our lagged shock variables are positive for 1- and 6-month lags. This result challenges conventional wisdom regarding the impact of monetary policy; conventionally, [unexpected] positive movements in interest rates will lead consumers to reduce consumption and increase saving as the opportunity cost of consumption has risen. Thus central banks often choose to increase interest rates in their efforts to curb inflationary pressures. The converse is true for [unexpected] downward movements in the interest rate. Thus,

	Base Model	Full Model
1-Month Lagged Shocks	0.271	0.466
	(0.652)	(0.567)
6-Month Lagged Shocks	0.993	1.049
	(0.769)	(0.742)
12-Month Lagged Shocks	0.492	-0.002
	(0.551)	(0.443)
1-Month Lagged MS Expectations	0.810***	0.576***
	(0.056)	(0.063)
1-Month Lagged Inflation	0.028	0.061
	(0.036)	(0.040)
6-Month Lagged Inflation	-0.028	-0.055
	(0.032)	(0.034)
12-Month Lagged Inflation	0.005	-0.026
	(0.024)	(0.029)
1-Month Lagged FF Rate	-0.123*	-0.065
	(0.064)	(0.068)
6-Month Lagged FF Rate	0.180**	0.130
	(0.088)	(0.083)
12-Month Lagged FF Rate	-0.111***	-0.075*
	(0.042)	(0.043)
Male (=1)	-0.567***	-0.563***
	(0.028)	(0.028)
High School Indicator	-0.214***	-0.222***
	(0.066)	(0.066)
Degree Indicator	-0.607***	-0.604***
	(0.068)	(0.068)
Age	-0.004***	-0.005***
	(0.001)	(0.001)
Log(Income)	-0.381***	-0.419***
	(0.022)	(0.021)
6-Month Lagged FRBC Expectations		-0.014
		(0.086)
12-Month Lagged FRBC Expectations		0.162*
		(0.095)
Recession Indicator		-0.096
		(0.110)
Unemployment Rate		-0.032
		(0.025)
Log(Crude Oil Prices [$/Barrel])		0.533***
		(0.088)
Constant	5.722***	4.803***
	(0.289)	(0.462)
Observations	109367	109367
R^2	.0418	.0437

Robust standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 7: **General Regression Results**

lowering interest rates is seen as a method to provide an additional incentive to spend on current consumption given that the opportunity cost of consuming/borrowing is relatively low. This is why central bankers tend to loosen monetary policy when they wish to generate inflationary pressures.

However, there is an alternative perspective on this issue that has not been explored extensively, which is the "signalling effects" of monetary policy. Under a scenario with rational agents who are perfectly informed, consumers would be able to decipher that the monetary authority chooses to tighten policy in times where inflationary pressures are high and prices are already rising. Similarly, they would expect a loosening of policy in times with deflationary pressure and weak economic performance. In such a situation, consumer expectations would react in the exact opposite manner in which policymakers desire, with inflation expectations reacting *positively* to a rise in the interest rate, and *negatively* to falls in the interest rate. This is the phenomenon that Melosi [2014] and Tang [2015] present their arguments and evidence for, in their research. It would also explain the consistently positive coefficients on monetary policy shocks that we find here using the MS data.

All the coefficients on lagged shocks are positive across both models, except for the 12-month lag in the "Full Model" which is very slightly negative. Note also that the coefficient on 1-month lagged shocks is much smaller than that on the 6-month lags, with a unitary positive shock leading to roughly half a percentage point increase in expectations over a 1-month horizon and a proportional 1 percentage point increase in expectations over a 6-month horizon. Our results here suggest that, on average, a positive shock leads to a correspondingly positive adjustment to future inflation expectations. However, there is some heterogeneity in how respondents react to shocks. Since agents in reality are unlikely to process these policy surprises immediately, this is not unexpected.

The next regressor is "1-Month Lagged MS Expectations". This variable is a lagged version of mean inflation expectations from the MS. We include it here because in order to isolate the effects of shocks on expectations as much as possible, we need to control for all the information that consumers already possess. Including lagged expectations seemed an easy

way to achieve this. We also wondered if past expectations influence current expectations. Considering that the coefficients are positive and highly significant, our premise here is reinforced.

We also include 1-, 6- and 12-month lagged inflation and lagged values of the federal funds rate in the model. Interestingly, while the coefficient on the former is slightly positive, the coefficient on the latter two is slightly negative in the "Full Model". With lagged interest rates again, an interesting pattern emerges. 6-month lagged interest rates having positive coefficients, while the 1- and 12-month lags have negative coefficients. This suggests again that consumers take time to process and incorporate changes in interest rates into their information sets.

The demographic regressors offer some insight into trends in inflation expectations. The coefficients on the gender, education and income regressors are all highly significant and sizeable, while the coefficient on age, although significant, is smaller. The significance of demographic characteristics in the formation of inflation expectations is in line with previous literature (Utsey and Cook [1984]; Souleles [2004]; BruineDeBruine et al. [2010].

We find that consumers who hold a higher education degree, as well as those who have only graduated high school, tend to have more stable inflation expectations on average. The size of the coefficients on the High School Indicator are notably smaller than those on the Degree Indicator, suggesting that as consumers are better educated, their inflation expectations tend to stabilise. Specifically, graduating high school leads to a downward adjustment of average inflation expectations of less than quarter a percentage point, while attaining a college degree leads to an adjustment of more than half a percentage point. This relationship may not be causal, as education is correlated with a number of other individual characteristics, such as income, which could be driving these results. We do find that increases in income tend to significantly stabilise expectations. These patterns in demographics match those found by Carvalho and Nechio [2014b] discussed in Section 2.

Males also tend to have lower and more stable expectations relative to females, with the coefficients suggesting that expectations of males is roughly half a percentage lower than

that of females, on average. In line with the research done by Malmendier and Nagel [2015], we find that older individuals on average tend to have more stable expectations. Income is a particularly striking source for heterogeneity in expectations, with higher income consumers consistently having lower price expectations. These demographic patterns in education and income are consistent across both models and are explored further in the next subsection.

We find evidence that official releases on inflation expectations such as those released by the FRBC are incorporated in consumers' information sets over a longer, 12-month horizon. The coefficient on the 12-month lagged FRBC Expectations is significant and positive, implying that consumers absorb such information over time and adjust their expectations accordingly. The coefficient on the 6-month lag is relatively small and not statistically significant.

Both the recession indicator as well as the unemployment rate have negative coefficients. This suggests that, in line with standard macroeconomic theory, consumers adjust their inflation expectations downward during economic slumps and times of high unemployment (between 1990 and 2012).

The final variable of interest is the estimate for crude oil prices, measured in logs. Highly visible commodity prices such as crude oil have been well documented as having a large influence over the price perceptions of consumers [Coibion and Gorodnichenko, 2015]. The evidence here corroborates that theory, with changes in crude oil price levels having large, highly significant impacts on consumer expectations. A 1% increase in crude oil prices leads to over a 0.5% increase in average inflation expectations.

4.2 Results by Demographic

An interesting question that arises from doing this research is *who* exactly within the population is responding to monetary shocks, and whether particular subgroups of the population respond in systematic ways.

In order to explore this further, we investigated the patterns in expectations by different demographic characteristics, including age, region, income and education. While there were

no discernible relationships between expectations and age or location, we did find evidence of systematic patterns in expectations by education and income à la Carvalho and Nechio [2014b]. This can be seen in Tables 8 and 9.

Table 8: **Expectations by Income**

Quintiles	Mean	Median
Bottom 20%	4.19	3.00
21-40%	3.80	3.00
41-60%	3.51	3.00
61-80%	3.24	3.00
Top 20%	2.84	3.00

Table 9: **Expectations by Education**

Education	Mean	Median
Some Schooling	4.03	3.00
High School	3.72	3.00
Some College	3.51	3.00
College Degree	3.03	3.00

Average inflation expectations decline steadily across income groups as well as education groups. Thus, one could speculate that higher-income and more educated households, on average, tend to have lower inflation expectations. Not only is this the case, but it is also true that the spread on expectations is smaller for these groups. An easy way to see this is by studying Figures 2 and 3.

Figures 2 and 3 show that on average, higher-income and educated households tend to have a 'tighter' distribution of inflation expectations relative to their lower-income and less-educated counterparts. The 'box' in the figures marks the upper and lower quartiles of the distribution, while the whiskers and upper/lower adjacent lines mark the upper/lower adjacent values. These values are calculated by taking the upper and lower quartiles (i.e. 75th and 25th percentiles) and adding 1.5*(Inter-Quartile Range) to each of these values. Note, that while our entire sample on expectations was used to generate these plots, for practical purposes the figures do *not* show values that lie outside the upper and lower adjacent values.

Upon discovering these patterns, and studying the work done by Carvalho and Nechio [2014b], it became clear that income and education are important sources of heterogeneity in the responses of expectations to monetary policy shocks. For these reasons, we ran our

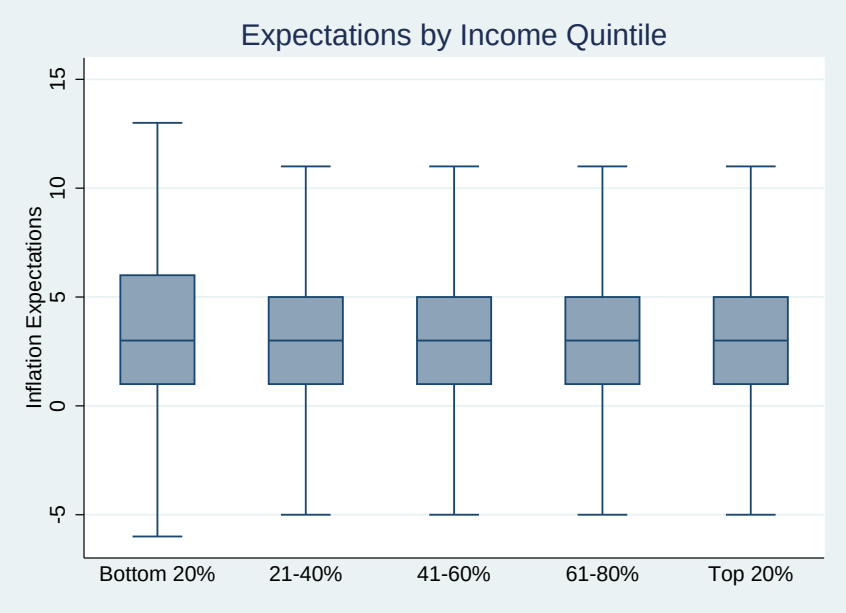

Figure 2: **Box Plot of Expectations by Income**

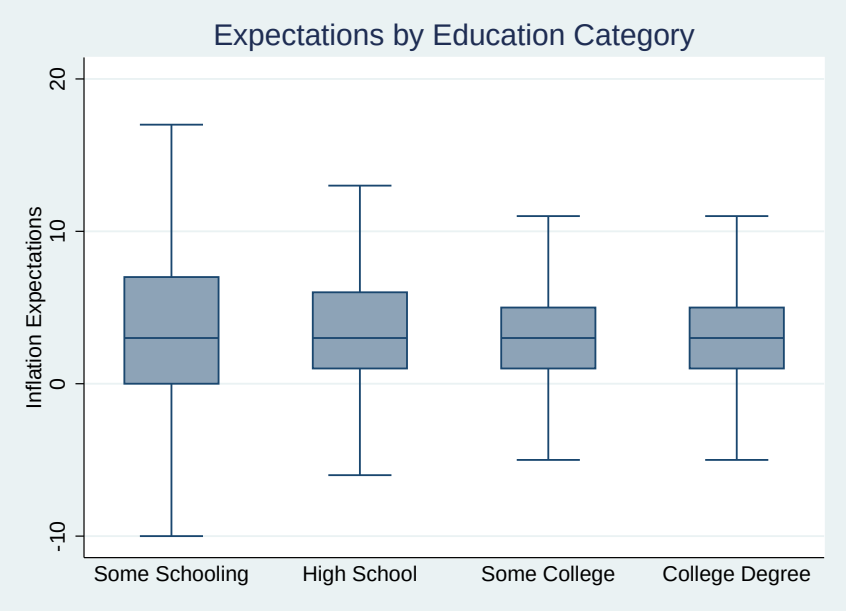

Figure 3: **Box Plot of Expectations by Education**

regressions separately for each education and income category. The following subsections elaborate on our findings.

4.2.1 Income

Table 10 shows the regression results from the same specification as our "Full Model" (Table 7), except here each column (i.e. model) corresponds to an income category. We also include the "Full Model" from earlier in the final column, just for comparison. Supporting the deductions we made by looking at the box plots, the regression results suggest that there is much more heterogeneity in expectation responses at lower income levels.

Interestingly, the coefficients on the contemporaneous shock variable continue to be mostly positive across income groups except the bottom-most quintile, as in Table 7. For the 6-month lagged shocks, the coefficients get steadily larger for each quintile, especially for the 3^{rd}, 4^{th} and 5^{th} quintiles. This implies that respondents in higher income quintiles tend to respond more sharply on average to monetary policy shocks than their lower income counterparts. The standard errors for the top three quintiles also get steadily smaller, suggesting that there is decreasing heterogeneity in expectations responses for higher income quintiles. Similar patterns of significance can be found in the coefficients for 1-month lagged inflation, lagged interest rates, and unemployment. Again, we find evidence that agents respond positively and consistently to official releases on expectations such as FRBC expectations, but over a longer, 12-month horizon.

The top income quintile is the only one for which the coefficient on the recession indicator is significant, implying that the responses of consumer expectations in recessionary periods is relatively homogeneous only within this subgroup. This result is intuitive, since economic slumps are typically associated with downward pressures on prices. Similarly, the upper quintiles respond more systematically to changes in the unemployment rate. Consumer expectations across all income groups respond strongly to changes in logged crude oil prices, corroborating previous research on this topic.

	1st Q	2nd Q	3rd Q	4th Q	5th Q	Full Model
1-Month Lagged Shocks	-0.452	0.579	0.386	0.677	0.937	0.466
	(1.011)	(0.876)	(0.927)	(0.734)	(0.969)	(0.567)
6-Month Lagged Shocks	-0.179	0.609	1.451	1.484	1.557*	1.049
	(1.017)	(0.859)	(1.180)	(0.918)	(0.883)	(0.742)
12-Month Lagged Shocks	-0.140	0.658	-0.759	-0.112	0.320	-0.002
	(0.943)	(0.950)	(0.747)	(0.593)	(0.697)	(0.443)
1-Month Lagged MS Expectations	0.634***	0.591***	0.537***	0.531***	0.565***	0.576***
	(0.109)	(0.092)	(0.110)	(0.079)	(0.069)	(0.063)
1-Month Lagged Inflation	-0.034	0.089	0.014	0.092*	0.093	0.061
	(0.060)	(0.064)	(0.073)	(0.048)	(0.057)	(0.040)
6-Month Lagged Inflation	-0.013	0.004	-0.111**	-0.066	-0.060	-0.055
	(0.055)	(0.056)	(0.056)	(0.042)	(0.055)	(0.034)
12-Month Lagged Inflation	-0.069	-0.029	-0.058	0.010	0.007	-0.026
	(0.042)	(0.044)	(0.049)	(0.037)	(0.033)	(0.029)
1-Month Lagged FF Rate	0.043	-0.080	-0.109	-0.178**	-0.030	-0.065
	(0.094)	(0.096)	(0.112)	(0.076)	(0.089)	(0.068)
6-Month Lagged FF Rate	-0.006	0.233*	0.124	0.214**	0.096	0.130
	(0.136)	(0.125)	(0.132)	(0.104)	(0.117)	(0.083)
12-Month Lagged FF Rate	0.019	-0.126*	-0.101	-0.090	-0.067	-0.075*
	(0.074)	(0.066)	(0.067)	(0.055)	(0.063)	(0.043)
6-Month Lagged FRBC Expectations	0.026	-0.251**	0.141	-0.055	0.019	-0.014
	(0.143)	(0.121)	(0.128)	(0.100)	(0.133)	(0.086)
12-Month Lagged FRBC Expectations	0.156	0.083	0.227	0.113	0.139	0.162*
	(0.161)	(0.124)	(0.145)	(0.102)	(0.125)	(0.095)
Recession Indicator	-0.123	0.068	0.179	-0.064	-0.485***	-0.096
	(0.158)	(0.178)	(0.177)	(0.123)	(0.172)	(0.110)
Unemployment Rate	0.032	-0.032	-0.091**	-0.081**	-0.026	-0.032
	(0.045)	(0.042)	(0.041)	(0.035)	(0.038)	(0.025)
Log(Crude Oil Prices [$/Barrel])	0.579***	0.451***	0.858***	0.636***	0.439***	0.533***
	(0.160)	(0.133)	(0.153)	(0.132)	(0.127)	(0.088)
Male (=1)	-0.721***	-0.603***	-0.623***	-0.580***	-0.358***	-0.563***
	(0.082)	(0.065)	(0.058)	(0.050)	(0.050)	(0.028)
High School Indicator	-0.101	-0.425***	-0.383**	-0.177	-0.522**	-0.222***
	(0.109)	(0.123)	(0.160)	(0.158)	(0.242)	(0.066)
Degree Indicator	-0.811***	-0.809***	-0.808***	-0.436***	-0.704***	-0.604***
	(0.130)	(0.136)	(0.163)	(0.156)	(0.241)	(0.068)
Age	-0.011***	-0.006***	-0.004**	-0.003	-0.000	-0.005***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)
Log(Income)	-0.008	-0.578***	-0.979***	-0.920***	-0.463***	-0.419***
	(0.077)	(0.175)	(0.234)	(0.194)	(0.063)	(0.021)
Constant	0.426	7.441***	10.271***	10.419***	5.281***	4.803***
	(1.020)	(1.828)	(2.426)	(2.094)	(0.955)	(0.462)
Observations	14473	18645	22721	25547	27061	109367
R^2	.0265	.0333	.0357	.0357	.0393	.0437

Robust standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 10: **Regression Results by Income**

With regard to demographics, the trends from the general regression continue to hold true across income groups, with males and more educated individuals having lower expectations on average across all income groups. Interestingly, the difference in expectations responses between genders is especially large for lower quintiles. The negative relationship between income and expectations continues to hold (i.e. the coefficient on Log(Income) continues to be negative) even *within* groups; there is an *intra-group* pattern in expectations by income, as well as the general *inter-group* trend observed earlier. Consumers with higher income levels even *within* their particular quintile tend to have lower inflation expectations, on average. Older individuals continue to have more stable expectations across income groups, however this effect gradually peters out for higher quintiles.

The underlying conclusion from running our model by income group could be stated as follows: while there are no glaring contradictions in the expectations responses of different income groups with relation to each other, there seems to be a distinct lack of coherence and consistency in the lowest quintiles, especially in the bottom 20%. Given that higher income households tend to generally be better educated and have access to more/better information, it is not surprising that there is more uniformity in the way they process information, respond to changes in the economy and adjust their inflation expectations. Higher income quintiles might be forming these more consistent expectations also due to increased communication between members, or from acquiring their information from similar, more credible sources.

4.2.2 Education

Table 11 presents our regression results by education category. We stratify across education in order to understand further where the heterogeneity in expectations across groups is coming from. Previous research suggests that education is an important source for this heterogeneity [Carvalho and Nechio, 2014b]. Table 3 had shown us that there are significant patterns in expectations across education categories, which is explored here in more detail.

While the general pattern is not unlike what we described in the previous subsection, there are some interesting differences. For instance, while the coefficients on 6-month lagged

	Some School	High School	Some College	College Degree	Full Model
1-Month Lagged Shocks	-0.923	0.979	0.059	0.610	0.466
	(1.204)	(0.720)	(0.897)	(0.735)	(0.567)
6-Month Lagged Shocks	-2.571*	1.681*	1.188	1.245	1.049
	(1.337)	(0.858)	(1.025)	(0.852)	(0.742)
12-Month Lagged Shocks	-0.125	0.461	0.336	-0.528	-0.002
	(1.402)	(0.534)	(0.721)	(0.579)	(0.443)
1-Month Lagged MS Expectations	0.455***	0.542***	0.614***	0.574***	0.576***
	(0.147)	(0.093)	(0.089)	(0.070)	(0.063)
1-Month Lagged Inflation	-0.085	-0.003	0.061	0.126***	0.061
	(0.089)	(0.057)	(0.058)	(0.047)	(0.040)
6-Month Lagged Inflation	0.111	-0.045	-0.037	-0.105***	-0.055
	(0.088)	(0.048)	(0.054)	(0.039)	(0.034)
12-Month Lagged Inflation	-0.178**	-0.050	-0.010	0.008	-0.026
	(0.079)	(0.033)	(0.043)	(0.035)	(0.029)
1-Month Lagged FF Rate	-0.025	-0.096	-0.110	-0.024	-0.065
	(0.139)	(0.085)	(0.101)	(0.077)	(0.068)
6-Month Lagged FF Rate	0.335*	0.050	0.247*	0.075	0.130
	(0.199)	(0.111)	(0.126)	(0.098)	(0.083)
12-Month Lagged FF Rate	-0.081	-0.019	-0.174***	-0.061	-0.075*
	(0.111)	(0.058)	(0.062)	(0.051)	(0.043)
6-Month Lagged FRBC Expectations	-0.424*	0.203*	-0.114	-0.013	-0.014
	(0.222)	(0.114)	(0.135)	(0.098)	(0.086)
12-Month Lagged FRBC Expectations	0.212	0.144	0.190	0.173	0.162*
	(0.233)	(0.116)	(0.128)	(0.109)	(0.095)
Recession Indicator	-0.404	0.032	-0.089	-0.098	-0.096
	(0.267)	(0.147)	(0.169)	(0.141)	(0.110)
Unemployment Rate	0.014	-0.048	-0.003	-0.052*	-0.032
	(0.076)	(0.036)	(0.042)	(0.028)	(0.025)
Log(Crude Oil Prices [$/Barrel])	0.743***	0.686***	0.495***	0.438***	0.533***
	(0.229)	(0.118)	(0.125)	(0.103)	(0.088)
Male (=1)	-0.833***	-0.810***	-0.539***	-0.388***	-0.563***
	(0.117)	(0.054)	(0.060)	(0.037)	(0.028)
Age	-0.023***	-0.012***	-0.005***	0.005***	-0.005***
	(0.004)	(0.002)	(0.002)	(0.001)	(0.001)
Log(Income)	-0.209**	-0.507***	-0.391***	-0.406***	-0.419***
	(0.088)	(0.038)	(0.037)	(0.029)	(0.021)
High School Indicator					-0.222***
					(0.066)
Degree Indicator					-0.604***
					(0.068)
Constant	3.678***	5.564***	4.187***	3.836***	4.803***
	(1.413)	(0.636)	(0.715)	(0.538)	(0.462)
Observations	7260	30573	28172	42935	109367
R^2	.0323	.0395	.0395	.043	.0437

Robust standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 11: **Regression Results by Education**

shocks continue to be positive across most groups, there is a contradiction here; lower-educated consumers adjust their expectations in precisely the opposite direction relative to their more educated counterparts. The magnitude of this coefficient is also large for the lowest category. This could be due to an asymmetry in the two groups' information sets. Alternatively, it might be a sign of a "wealth effect", where unexpectedly high interest rates cause creditor households to spend more due to having more savings, while debtor households cut consumption due to higher borrowing costs, which would change their inflation expectations in opposite directions.

The coefficients on lagged inflation are significant only for the highest education group, suggesting that consumers within the other education categories do not tend to have consistent expectations responses. This could imply that those who are more educated tend to process changes in monetary policy more actively and hence respond in similar ways. There is general lack of consistency in responses to lagged interest rates across groups.

Our results here are similar to Table 10 in relation to official expectations data, with positive coefficients on 12-month lagged FRBC expectations across education groups. This similarity continues across the recession and unemployment regressors as well.

All groups continue to be extremely perceptive of changes in crude oil prices. The size of the coefficients on crude oil prices are especially large for lower educated groups. This makes intuitive sense as you would expect higher educated/income households to have a relatively more inelastic demand for crucial commodities such as gasoline etc.

Patterns in demographics such as gender, age and income continue to hold across all groups similar to our previous regressions and in line with earlier literature. An interesting point is that even *within* education categories, increases in income tend to stabilise inflation expectations. Thus, rising incomes is one way to 'offset' the volatility in expectations that arises from being less educated.

To summarise our results: we reinforce our premise mentioned earlier, namely that higher educated consumers adjust their expectations in more coherent and consistent ways relative to their less educated counterparts.

5 Robustness and Caveats

Given the time and resources available at hand for this MA Paper, there are certainly limitations to the research conducted here. For instance, we did not explore the possibility of non-linearities in the relationships between expectations and shocks etc. Furthermore, the length of time-series data on the policy shocks was too limited to conduct any sort of non-parametric analysis. Future research on this topic might find further insight by investigating these dimensions.

To check the robustness of our results, we split the sample into two time periods: Pre-2007 and 2007-Onwards. The reason for this is simple; the financial crisis marked a clear shift in the way central banks approached monetary policy. For this reason, we check if our results are markedly different for these two periods. The results are presented in Table 12. As can be seen, there is definitely more 'noise' in the 2007-2012 period, which is to be expected. This does affect levels of significance on some regressors, and changes the signs on others. The drops in significance could be due to the fact that inflation remained extremely low over this period, and thus expectations of inflation did not vary much relative to other times. The coefficients on the 6-month lagged shocks are positive pre-2007, although there is too much heterogeneity in expectations between 2007-2012 resulting in much lower significance, and a negative coefficient. The fact that the signs on the lagged shock variables have changed suggests that the financial crisis did alter the ways in which people form their expectations.

That said, lagged inflation and interest rates continue to be important determinants of expectations as before. One interesting change is that lagged inflation becomes relatively more significant during and immediately following the financial crisis. One reason for this could be that people are more responsive to 'recent inflation experiences' rather than 'lagged inflation'. A similar pattern can be seen in the coefficients on lagged interest rates and FRBC expectations.

As with all previous research that has focused on monetary policy shocks, the question of exogeneity is of primary importance here. Perfect exogeneity is virtually an impossibility

	1990-2006	2007-2012	Full Model
1-Month Lagged Shocks	-0.127	0.864	0.466
	(0.454)	(1.583)	(0.567)
6-Month Lagged Shocks	1.153*	-0.177	1.049
	(0.678)	(1.133)	(0.742)
12-Month Lagged Shocks	-0.201	1.133	-0.002
	(0.421)	(1.177)	(0.443)
1-Month Lagged MS Expectations	0.460***	0.409***	0.576***
	(0.081)	(0.094)	(0.063)
1-Month Lagged Inflation	0.044	0.083	0.061
	(0.061)	(0.073)	(0.040)
6-Month Lagged Inflation	-0.006	0.107*	-0.055
	(0.048)	(0.059)	(0.034)
12-Month Lagged Inflation	-0.078	0.075**	-0.026
	(0.048)	(0.034)	(0.029)
1-Month Lagged FF Rate	0.097	-0.220	-0.065
	(0.065)	(0.208)	(0.068)
6-Month Lagged FF Rate	-0.033	0.769***	0.130
	(0.073)	(0.207)	(0.083)
12-Month Lagged FF Rate	-0.026	-0.197*	-0.075*
	(0.040)	(0.105)	(0.043)
6-Month Lagged FBC Expectations	0.035	-0.391**	-0.014
	(0.106)	(0.175)	(0.086)
12-Month Lagged FBC Expectations	0.036	-0.152	0.162*
	(0.137)	(0.135)	(0.095)
Recession Indicator	-0.112	-0.060	-0.096
	(0.162)	(0.327)	(0.110)
Unemployment Rate	0.043	0.288	-0.032
	(0.077)	(0.194)	(0.025)
Log(Crude Oil Prices [$/Barrel])	0.492***	1.675***	0.533***
	(0.108)	(0.382)	(0.088)
Male (=1)	-0.596***	-0.483***	-0.563***
	(0.030)	(0.062)	(0.028)
High School Indicator	-0.300***	-0.029	-0.222***
	(0.073)	(0.145)	(0.066)
Degree Indicator	-0.638***	-0.530***	-0.604***
	(0.075)	(0.153)	(0.068)
Age	-0.006***	-0.001	-0.005***
	(0.001)	(0.002)	(0.001)
Log(Income)	-0.365***	-0.529***	-0.419***
	(0.022)	(0.044)	(0.021)
Constant	4.545***	-1.183	4.803***
	(0.583)	(2.793)	(0.462)
Observations	81416	27951	109367
R^2	.0342	.06	.0437

Robust standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 12: **Regression Results (Split by Time Period)**

in the context of macroeconomic data, however we are convinced that our analysis comes as close as possible to address this issue. Gertler and Karadi [2015] subjected their results to a number of robustness checks in order to demonstrate the exogeneity of their policy surprises. While their derivation is not without limitations, it is the most contemporary measure of policy surprises that addresses many of the issues with previous VAR estimates.

In our analysis, the possibility of a feedback loop between the central bank's decisions and household expectations presents a problem for the validity of our results. We argue here that our policy shocks are driven primarily by professional investors and not households, since the shocks are derived from federal fund futures markets. Under this assumption, our policy shocks will remain exogenous to *households*. Since our analysis pertains to consumer (i.e. household) expectations, we can sidestep this problem of a feedback loop.

Another variable we chose not to include in our primary regressions was a measure for aggregate demand. The proxy we use is Log(Aggregate Personal Consumption Expenditure) downloaded directly from the FRED archive. We now include this variable and run our same regressions as before. The results are presented in Tables 13, 14 and 15 in the Appendix. Our main result of significant, positive expectations responses to our lagged shock variable, persists.

Furthermore, we ran our regressions including contemporaneous shocks along with lagged shocks, and also using a slightly different shock measure derived again by Gertler and Karadi [2015]. Our primary results remained robust to these different specifications.

6 Conclusion

The relationship between inflation expectations and actual inflation has rarely been as important as in recent years. The financial crisis led to interest rates falling to the zero lower bound in most western countries including the USA, effectively exhausting all conventional monetary policy measures. Apart from unconventional measures such as quantitative easing, central banks had to rely on raising inflation expectations in the economy as a means

to stimulate aggregate demand.

These events raised questions on what the impacts of policy actually are on inflation expectations. While much work had been done on understanding the interplay between professional forecasters' expectations and actual inflation, few had paid much attention to *consumer/household* expectations. Recent papers such as Coibion and Gorodnichenko [2015] highlighted the importance of household expectations in explaining actual economic phenomena.

This paper contributes to existing literature by exploring the impacts of monetary policy *shocks* on consumer inflation expectations using micro survey data from the University of Michigan. Using a simple linear regression framework and shocks derived by Gertler and Karadi [2015], we obtained some interesting results. Namely, we find some evidence of the "signalling channel" of monetary policy à la Melosi [2014] and Tang [2015], where contractionary policy shocks actually lead to an upward adjustment of consumer inflation expectations in the future. Furthermore, we find that income and education are the most prominent demographic sources of heterogeneity in expectations, in line with Carvalho and Nechio [2014b]. By running our regressions separately for each income and education category, we could clearly observe that higher-income and more educated households tend to adjust their expectations more coherently and consistently. This could be due to a lack of both quality and quantity of information for those at the bottom of the income and education distributions.

Far from being a conclusive piece of research in itself, this paper raises a number of interesting questions going forward. Specifically, it challenges the conventional, almost universally accepted notion regarding the operating channels of monetary policy. While perhaps there is not enough proven research yet to warrant a revamp of central banks' approach to influencing expectations, it is increasingly clear that the relationship between inflation expectations and policy is more complex than what was once imagined. Understanding this relationship more thoroughly would be a fruitful endeavour for both economists and policymakers alike.

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A Appendix

	Base Model	Full Model
1-Month Lagged Shocks	0.187	0.222
	(0.642)	(0.467)
6-Month Lagged Shocks	0.863	1.026
	(0.838)	(0.645)
12-Month Lagged Shocks	0.118	0.185
	(0.507)	(0.432)
1-Month Lagged MS Expectations	0.722***	0.544***
	(0.063)	(0.059)
1-Month Lagged Inflation	0.069*	-0.043
	(0.037)	(0.046)
6-Month Lagged Inflation	-0.033	-0.010
	(0.031)	(0.033)
12-Month Lagged Inflation	0.020	-0.051*
	(0.023)	(0.029)
1-Month Lagged FF Rate	-0.052	-0.152**
	(0.066)	(0.066)
6-Month Lagged FF Rate	0.109	0.214***
	(0.089)	(0.079)
12-Month Lagged FF Rate	-0.070	-0.089**
	(0.043)	(0.038)
Log(PCE)	0.536***	-1.771***
	(0.109)	(0.409)
6-Month Lagged FRBC Expectations		-0.142*
		(0.085)
12-Month Lagged FRBC Expectations		-0.025
		(0.093)
Recession Indicator		-0.047
		(0.102)
Unemployment Rate		-0.141***
		(0.036)
Log(Crude Oil Prices [$/Barrel])		1.169***
		(0.189)
Demographic Variables	Yes	Yes
Constant	1.348	19.979***
	(0.989)	(3.429)
Observations	109367	109367
R^2	.0425	.0445

Robust standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 13: **General Regression Results [Including Log(PCE)]**

	1st Q	2nd Q	3rd Q	4th Q	5th Q	Full Model
1-Month Lagged Shocks	-0.473	0.461	0.195	0.390	0.481	0.222
	(1.025)	(0.853)	(0.869)	(0.646)	(0.815)	(0.467)
6-Month Lagged Shocks	-0.181	0.596	1.480	1.496*	1.539**	1.026
	(1.013)	(0.846)	(1.091)	(0.817)	(0.732)	(0.645)
12-Month Lagged Shocks	-0.123	0.765	-0.554	0.096	0.621	0.185
	(0.938)	(0.958)	(0.741)	(0.603)	(0.655)	(0.432)
1-Month Lagged MS Expectations	0.632***	0.574***	0.513***	0.502***	0.507***	0.544***
	(0.109)	(0.091)	(0.106)	(0.073)	(0.068)	(0.059)
1-Month Lagged Inflation	-0.043	0.034	-0.082	-0.023	-0.091	-0.043
	(0.072)	(0.071)	(0.082)	(0.054)	(0.060)	(0.046)
6-Month Lagged Inflation	-0.009	0.029	-0.066	-0.018	0.021	-0.010
	(0.057)	(0.057)	(0.055)	(0.040)	(0.050)	(0.033)
12-Month Lagged Inflation	-0.071	-0.043	-0.082*	-0.019	-0.037	-0.051*
	(0.043)	(0.044)	(0.050)	(0.038)	(0.031)	(0.029)
1-Month Lagged FF Rate	0.035	-0.127	-0.190	-0.268***	-0.179**	-0.152**
	(0.098)	(0.103)	(0.120)	(0.074)	(0.079)	(0.066)
6-Month Lagged FF Rate	0.002	0.280**	0.205	0.301***	0.242**	0.214***
	(0.137)	(0.130)	(0.139)	(0.100)	(0.108)	(0.079)
12-Month Lagged FF Rate	0.018	-0.134**	-0.116*	-0.104**	-0.091	-0.089**
	(0.073)	(0.065)	(0.065)	(0.052)	(0.057)	(0.038)
6-Month Lagged FRBC Expectations	0.015	-0.322**	0.020	-0.193*	-0.210	-0.142*
	(0.149)	(0.132)	(0.127)	(0.101)	(0.132)	(0.085)
12-Month Lagged FRBC Expectations	0.140	-0.017	0.054	-0.088	-0.193	-0.025
	(0.181)	(0.130)	(0.142)	(0.102)	(0.121)	(0.093)
Recession Indicator	-0.119	0.090	0.214	-0.016	-0.400**	-0.047
	(0.160)	(0.174)	(0.174)	(0.117)	(0.154)	(0.102)
Unemployment Rate	0.022	-0.091	-0.191***	-0.200***	-0.220***	-0.141***
	(0.060)	(0.057)	(0.061)	(0.048)	(0.048)	(0.036)
Log(Crude Oil Prices [$/Barrel])	0.635**	0.794***	1.453***	1.335***	1.566***	1.169***
	(0.288)	(0.255)	(0.302)	(0.242)	(0.257)	(0.189)
Male (=1)	-0.721***	-0.604***	-0.625***	-0.578***	-0.362***	-0.564***
	(0.082)	(0.065)	(0.058)	(0.050)	(0.050)	(0.028)
High School Indicator	-0.101	-0.424***	-0.383**	-0.169	-0.502**	-0.220***
	(0.109)	(0.123)	(0.160)	(0.158)	(0.242)	(0.066)
Degree Indicator	-0.811***	-0.810***	-0.807***	-0.431***	-0.681***	-0.603***
	(0.130)	(0.136)	(0.163)	(0.155)	(0.241)	(0.068)
Age	-0.011***	-0.006***	-0.004**	-0.002	0.000	-0.005***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)
Log(Income)	-0.005	-0.477***	-0.639***	-0.544***	-0.387***	-0.410***
	(0.077)	(0.175)	(0.234)	(0.199)	(0.064)	(0.021)
Log(PCE)	-0.156	-1.027	-1.940***	-2.251***	-3.191***	-1.771***
	(0.664)	(0.655)	(0.721)	(0.562)	(0.565)	(0.409)
Constant	1.748	15.282***	23.431***	25.701***	31.922***	19.979***
	(5.719)	(5.581)	(5.813)	(4.515)	(4.675)	(3.429)
Observations	14473	18645	22721	25547	27061	109367
R^2	.0265	.0335	.0364	.0368	.0425	.0445

Robust standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 14: **Regression Results by Income [Including Log(PCE)]**

	Some School	High School	Some College	College Degree	Full Model
1-Month Lagged Shocks	-1.226	0.907	-0.179	0.245	0.222
	(1.239)	(0.691)	(0.793)	(0.594)	(0.467)
6-Month Lagged Shocks	-2.620*	1.675**	1.165	1.210*	1.026
	(1.340)	(0.838)	(0.914)	(0.715)	(0.645)
12-Month Lagged Shocks	0.140	0.517	0.513	-0.261	0.185
	(1.327)	(0.530)	(0.714)	(0.570)	(0.432)
1-Month Lagged MS Expectations	0.416***	0.532***	0.581***	0.527***	0.544***
	(0.152)	(0.093)	(0.087)	(0.058)	(0.059)
1-Month Lagged Inflation	-0.205*	-0.032	-0.048	-0.031	-0.043
	(0.115)	(0.069)	(0.067)	(0.046)	(0.046)
6-Month Lagged Inflation	0.155*	-0.034	0.014	-0.034	-0.010
	(0.089)	(0.048)	(0.053)	(0.035)	(0.033)
12-Month Lagged Inflation	-0.208**	-0.057	-0.035	-0.030	-0.051*
	(0.080)	(0.036)	(0.043)	(0.030)	(0.029)
1-Month Lagged FF Rate	-0.120	-0.120	-0.197*	-0.159**	-0.152**
	(0.147)	(0.093)	(0.102)	(0.069)	(0.066)
6-Month Lagged FF Rate	0.439**	0.074	0.330***	0.201**	0.214***
	(0.203)	(0.118)	(0.122)	(0.090)	(0.079)
12-Month Lagged FF Rate	-0.101	-0.024	-0.185***	-0.081*	-0.089**
	(0.109)	(0.058)	(0.057)	(0.045)	(0.038)
6-Month Lagged FRBC Expectations	-0.555**	0.168	-0.253*	-0.208**	-0.142*
	(0.229)	(0.119)	(0.134)	(0.096)	(0.085)
12-Month Lagged FRBC Expectations	0.024	0.095	-0.017	-0.115	-0.025
	(0.258)	(0.118)	(0.127)	(0.102)	(0.093)
Recession Indicator	-0.345	0.045	-0.035	-0.025	-0.047
	(0.267)	(0.148)	(0.166)	(0.126)	(0.102)
Unemployment Rate	-0.106	-0.078	-0.114**	-0.221***	-0.141***
	(0.102)	(0.055)	(0.056)	(0.036)	(0.036)
Log(Crude Oil Prices [$/Barrel])	1.443***	0.862***	1.159***	1.412***	1.169***
	(0.462)	(0.272)	(0.240)	(0.198)	(0.189)
Male (=1)	-0.835***	-0.810***	-0.539***	-0.394***	-0.564***
	(0.117)	(0.054)	(0.060)	(0.037)	(0.028)
Age	-0.022***	-0.011***	-0.004**	0.005***	-0.005***
	(0.004)	(0.002)	(0.002)	(0.001)	(0.001)
Log(Income)	-0.203**	-0.505***	-0.382***	-0.389***	-0.410***
	(0.088)	(0.038)	(0.037)	(0.029)	(0.021)
Log(PCE)	-1.865*	-0.480	-1.881***	-2.747***	-1.771***
	(1.031)	(0.583)	(0.558)	(0.433)	(0.409)
High School Indicator					-0.220***
					(0.066)
Degree Indicator					-0.603***
					(0.068)
Constant	19.653**	9.677*	20.327***	27.368***	19.979***
	(8.947)	(4.931)	(4.810)	(3.680)	(3.429)
Observations	7260	30573	28172	42935	109367
R^2	.0328	.0396	.0403	.0452	.0445

Robust standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 15: **Regression Results by Education [Including Log(PCE)]**