Inflation Volatility and Economic Growth: A Disaggregated Analysis

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Abstract

Inflation volatility has been theorized to negatively affect real economic growth, but empirical analyses have returned somewhat mixed results. Constructing my own dataset of household group inflation rates by disaggregating and linking Consumer Expenditure Survey data with Consumer Price Index data, I analyze inflation volatility and economic growth from the ground-up. Calculating inflation volatility using a moving-window methodology, I find: 1) significant heterogeneity of inflation volatility across household groups; 2) a negative correlation between inflation volatility and economic growth from 2000-2012 for all household groups, with a stronger negative correlation at lower income levels; 3) a positive correlation between volatility and growth during expansions and a negative correlation between volatility and growth during recessions. Results suggest reducing inflation volatility and refining policymaking to account for the heterogeneity of inflation volatility could improve growth over the longrun. Further analysis is warranted.

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I. Introduction

It is well known that inflation can dramatically affect a household's well-being. Stories of Zimbabwean citizens rushing to buy food with their paycheck before it became insufficient to buy a sandwich likely serves as a reminder to central bankers of the dangers of rampant inflation. While such hyperinflation is uncommon, central banks are often tasked with controlling the rate of inflation. In the United States, we are constantly bombarded with news about the current *rate* of inflation. But, inflation *volatility* can also significantly affect a household's well-being. If prices are constantly changing, planning for future consumption may be more difficult because real household income is fluctuating. If this leads risk-averse households to delay or decide against purchasing big-ticket items such as cars or houses, this can have a significant negative effect on their lives.

In the aggregate, thousands of people delaying or deciding against purchasing goods and services could have a drag on the economy. As a result, inflation volatility could significantly reduce economic growth in that time period. Economic theory also suggests that inflation volatility and uncertainty could negatively affect economic growth by reducing economic efficiency. Empirical analyses of overall inflation volatility, however, have not unilaterally supported this theory. I believe that disaggregating inflation volatilities for different groups of households may be useful in reconciling some of the inconsistencies between the theoretical and empirical literature. If

different households experience different inflation volatility, there are potential implications for economic growth.

Most of the work on the link between inflation volatility and economic growth has focused on analyzing aggregate data (such as the Consumer Price Index) to look for broad relationships. Mullineaux (1980) finds a negative link between inflation volatility and growth using aggregate data, but Jansen (1989) finds no evidence of a link. Economists have studied inflation volatility and growth in the United States and across the world, and successive work has tried to control for observable fixed effects and macroeconomic factors. After controlling for such factors, Hnatkovska and Loayza (2005) find that inflation volatility negatively affects growth. However, successive analyses have not evaluated inflation volatility and growth using disaggregated inflation volatility data.

Limited work has been done analyzing the extent to which there are different inflation rates within different income levels or age groups. Hobijn and Lagakos (2005) observe the existence of different inflation rates for different household groups when analyzing expenditure data, but only differentiate between poor and non-poor households. Additionally, the Federal Reserve Bank of Chicago (2014) has calculated inflation rates for United States households of different incomes and ages, but their data is not finely disaggregated and it combines dramatically different household groups into a single cohort. Analyzing at a finer level of differentiation could provide new evidence of the link between inflation volatility and economic growth. Because of this, I construct finely disaggregated household inflation rate data for my own analyses.

I accomplish this by disaggregating expenditure patterns from the Consumer Expenditure Survey (CEX) and disaggregating goods and services price changes from the Consumer Price Index (CPI). The CEX tracks household expenditures and relevant demographic information of each surveyed household. Based on the survey data, I develop different consumer baskets of goods and services for households of different ages and income levels.

Employing methodology consistent with the relevant economic literature, I create a dataset from the ground up to investigate whether the link between inflation volatility and economic growth varies across household groups. This paper begins by calculating the market baskets of goods and services for 1999-2013 for different groups of households based on their expenditure patterns. By disaggregating expenditure patterns from the Consumer Expenditure Survey and linking them to price changes from the Consumer Price Index, I compute inflation rates across household groups of varying ages and incomes. I assume households purchase goods in any of 27 expenditure categories, and abstract away from price differences between goods within a given category. I then compute the standard deviations of inflation for different household groups to determine inflation volatility.

With a ground-up approach to computing inflation volatility, I find significant heterogeneity of inflation volatility across household groups. Linking the computed volatilities to U.S. real economic growth rate data, I find that lower and middle-income households exhibit the strongest negative correlation between inflation volatility and U.S. economic growth from 2000-2012. After conducting separate analyses for the expansions and recessions during the time period, I find that inflation volatility is positively correlated with growth during expansion and negatively

correlated with growth during recession. Despite this, all household groups exhibit negative correlations between inflation volatility and economic growth over the entire time period. The implication for public policy is that inflation volatility exhibits heterogeneity across households and that volatility among low and middle-income households has the strongest link to economic growth. Refining policymaking to account for the heterogeneity of inflation volatility or focusing policymaking to reduce the level of volatility (particularly for low and middle-income households) could improve economic growth.

In Section II, I review the relevant literature. In Section III, I describe the datasets I use to compute household inflation volatilities and assess their correlations with growth. In Section IV, I present the model I use to calculate household inflation rates and volatilities. In Section V, I delineate how I link the datasets and present the results of my analysis.[1] Section VI concludes the paper with further discussion of the results.

II. Literature Review

Two main strands of literature inform the research questions of whether different household groups experience different inflation rates and volatilities and whether inflation volatility and uncertainty reduce economic growth. In this section, I will review the literature on household inflation experiences and the link between inflation volatility and economic growth.

[1] All code is available upon request.

A. Household Inflation Experiences

Previous literature has shown that the inflation varies between and within household groups. Hagemann (1982) finds statistically significant differences between inflation rates experienced by different household groups. In fact, he finds statistically significant differences when disaggregating household groups on almost all possible variables (age, race, education, income, etc.).

Easterly and Fischer (2001) explore the impact of inflation on low-income households using comprehensive polling data and direct measures of inequality. They find that the poor view inflation as more of a pressing concern than the wealthy do. More significantly (and perhaps explaining the survey findings), they determine that inflation increases are inversely related to key measures of well-being, including reduced poverty, higher minimum wages, and a larger share of national income owned by the poor. As a result, inflation increases can hurt or even increase the number of low-income households, potentially reducing real consumption.

Crawford and Smith (2002) use United Kingdom expenditure data to investigate the inflation rates for different households from 1976-2000. They find great variation over time in the inflation rates experienced by low and high-income households. Importantly, they also find that roughly one third of households experience an inflation rate within 1 percentage point of the calculated United Kingdom headline average (conceptually equivalent to the U.S. Consumer Price Index). Levell and Oldfield (2011) also use survey data to calculate United Kingdom inflation rates for different household groups and different goods and services. They conclude

that low-income and high-income households experience different inflation rates because they have different spending patterns.

Johannsen (2014) finds that household groups experience different inflation rates partially because of the differences in expenditure weights for different household groups. Food and energy make up a larger proportion of household expenditures in less wealthy households, and thus they contribute more to their experienced inflation.

Consistent with Levell and Oldfield, McGranahan and Paulson (2005) find that, from 1983 to 2005, U.S. households below the poverty line experienced a slightly higher inflation rate than the typical household (using Chicago Fed data). According to updated Chicago Fed IBEX data, from 2002 to 2012 households in poverty experienced an inflation rate of 2.65 percent while the typical household only experienced an inflation rate of 2.43 percent. While this 10 percent difference may seem small, this can have large ramifications for real wealth.

Hobijn and Lagakos (2005) also find that different United States household groups experience different inflation. From 1987-2001, they find considerable differences in inflation rates between different household groups. Their analysis indicates that much of the difference in experienced inflation results from prices changes in education, healthcare, and gasoline prices. Their conclusions suggest that using the CPI-U (urban) as a measure of inflation for different household groups may not be the best idea. The reality is that different household groups face different inflation rates due to the composition of their consumption bundle.

B. Inflation Volatility and Economic Growth

In the classical dichotomy, nominal variables do not affect real variables. In this school of thought, inflation volatility does not affect real variables such as output. However, prominent economists have questioned this notion. Okun (1971) hypothesizes that inflation volatility and uncertainty could reduce output and affect growth. Volatile inflation exposes households to large variations in their real net worth. If households are risk-averse, they may reduce their consumption of goods and services to protect themselves if their income or net worth cannot keep up with the changing price level (perhaps due to wage-stickiness). This reduction of consumption could reduce output and dampen economic growth.

Friedman (1977) theorizes that inflation volatility and uncertainty could affect real variables in two ways. First, inflation volatility can increase the likelihood of distortionary sub-optimal policies by the government. Essentially, Friedman states that increased inflation volatility means that the government's policy decisions are being made on uncertain trends, reducing the likelihood of the most efficient policies being chosen. Second, like Okun, Friedman posits that inflation volatility can affect real variables because prices and wages can be sticky in the short run. Price and wage stickiness can result in distortions of the price mechanism, leading to inefficient allocations of resources. This inefficiency results in reduced real economic output.

Empirical analyses have returned inconsistent results. Mullineaux (1980) finds that inflation volatility reduces industrial production, suggesting that inflation volatility and real output are negatively related. Conversely, Jansen (1989) finds no evidence that inflation uncertainty reduces real output growth. He uses an autoregressive conditional heteroskedasticity (ARCH)

model to estimate the effect of inflation uncertainty on output. However, Jansen cautions that the ARCH inflation model may not perfectly measure the effect of inflation volatility on output growth due to the lack of variability in his model.

Fischer (1993) also finds no empirical support for the hypothesis, though he notes that previous work has found a link between inflation volatility and growth. Using chained[2] inflation volatilities as a proxy for uncertainty, he finds no correlation between economic growth and uncertainty. However, he cautions that separating the level of inflation from the volatility of inflation is difficult in his data, and thus his results may be missing a possible relationship.

By using a logarithmic specification for inflation and inflation volatility, Judson and Orphanides (1999) try to account for possible error in Fischer (1993). In their analysis, they use intra-year inflation data (quarterly) as a proxy for inflation uncertainty. Unlike Fischer, they find that inflation volatility is negatively correlated with economic growth across the world, even when controlling for different levels of inflation. Hnatkovska and Loayza (2005) try to control for more factors that could be biasing results. After controlling for nations' institutional strength, wealth, and financial depth, they find that inflation volatility negatively affects growth. They also find that this effect is magnified in countries with weak institutions, low wealth, and limited financial depth.

From this brief literature review, it is clear that economists have not yet reached complete agreement about the effect of inflation volatility on economic growth, though recent work and

[2] Chained inflation measures account for households substituting away from some goods and into others in their "basket" of goods and services used to calculate the inflation rate.

economic theory suggest there may be a negative relationship. I suspect that the lack of empirical consensus regarding the effect of inflation volatility on real GDP growth may stem from the lack of disaggregated inflation volatility data. If inflation volatility heterogeneously affects different household groups, aggregate data could be masking an underlying empirical relationship. Thus, data selection and methodological sensitivity could explain the disagreement. Though more recent work has controlled for macroeconomic factors that could be clouding the relationship, the literature has not focused on household disaggregation as a possible approach to analyzing this link. I believe this could significantly assist in the pursuit of greater consensus.

To my knowledge, no study has computed inflation rates and volatilities for United States household groups finely disaggregated by age and income to investigate inflation volatility and economic growth. This lack of research has clear policy and economic relevance. Economic research has strong potential to better inform policymakers of how to design policies to reduce inflation volatility, and the literature has yet to reach a clear consensus on the impact of inflation volatility on economic growth. This paper disaggregates and links the relevant data in order to calculate the different groups' inflation rates and volatilities. This paper thus sheds light on the empirical evidence for the hypotheses originating from Okun (1971) and Friedman (1977) by analyzing the link between inflation volatility and growth across household groups.

Disaggregating and linking the U.S. household expenditure and price data provides a new, rich dataset for understanding volatility and growth. Consistent with the literature, I use the standard deviation of inflation to measure inflation volatility. Different from the literature, I analyze a volatility dataset disaggregated by household income and age instead of analyzing an aggregate

dataset. This freshly constructed dataset provides new insight into whether inflation volatility is negatively related to economic growth.

III. Data

This paper uses data drawn from four data sources: the Consumer Expenditure Survey (CEX), the Consumer Price Index (CPI), the Bureau of Economic Analysis's Gross Domestic Product (GDP) data, and the Chicago Fed Income-Based Economic Index (IBEX) data. The CEX collects data on household goods and services expenditures, as well as demographic information such as age and income. The CPI measures the average change in prices of the typical basket of goods and services purchased by U.S. consumers. The BEA's GDP data provides quarterly and annual data of percent changes to U.S. real GDP. The IBEX data presents inflation data partially disaggregated by age and income.

This paper disaggregates and links the CEX and the CPI in order to determine the extent to which inflation rates and volatilities differ between income and age demographic groups. This paper eschews the IBEX data and uses my own more disaggregated, newly constructed dataset to investigate the extent to which inflation volatility is negatively correlated with real economic growth. In this section, I discuss each data source individually.

A. Consumer Expenditure Survey

The Consumer Expenditure Survey interview raw data encompasses thousands of households' expenditures each quarter from 1999 to 2013. It is a quarterly survey of households conducted by the Bureau of Labor Statistics. Table 1 presents a subset of raw CEX data downloaded from the

Bureau of Labor Statistics[3]. The newid variable is a code delineating the specific household that corresponds to this set of expenditure data. The age_ref variable denotes the age of the reference person of the household (the homeowner or renter). The fincbtax variable lists the household's annual income before taxes.

Table 1 US Consumer Expenditure Survey Data

newid	age_ref	fincbtax	totexppq	sheltpq	ntlgaspq	telephpq	apparpq	gasmopq
1651855	49	102000	42985	2551	0	240	339.0001	1344
1651865	50	266336	33269.676	7531.524	300	564	1600	1500
1651895	54	202000	10329.456	2881	72	76	234	530
1651955	44	22700	10216.5	1800	0	764	0	1850
1651995	60	122866	11730	968.0001	0	141	70.0001	840

The variable totexppq indicates the household's total expenditures over the previous quarter. The totexppq variable can be separated into hundreds of different variables, several of which are seen in Table 1. Sheltpq indicates how much of the total expenditures were spent on shelter (mortgage payment, rent, etc.) and ntlgaspq indicates how much was spent on natural gas during the previous quarter. The variables telephpq, apparpq, and gasmopq denote spending on telephone service, apparel, and gasoline and motor oil by the household.

The variables sheltpq, ntlgaspq, and others (representing household expenditures on various goods and services) can be mapped to price index changes in the Consumer Price Index data.

A clear strength of Consumer Expenditure Survey is that the survey tracks relevant household demographic and characteristic information in addition to tracking expenditures. While the CEX

[3] The complete raw data contains hundreds more variables (including flag variables describing the quality of each observation), but they are not all relevant for this brief discussion.

is the most complete dataset of household expenditures, the fact that it also collects household demographic and characteristic information is vital to answering the research question. Without this information, any attempt to determine expenditure patterns for different household groups would be enormously more difficult. Though it might be possible to determine the patterns by combining multiple survey datasets, such a result would be statistically suspect due to differences in survey methodology and biases.

The clear weakness of the Consumer Expenditure Survey is that survey results are susceptible to sampling and non-sampling error. Sampling error arises because the CEX surveys only a small sample of households relative to the total population. As a result, the CEX may be slightly different than it would be if it surveyed all households. Sampling error is largely unavoidable in survey data, and ultimately is not that large of a concern because the sampling is randomized. Non-sampling error arises from things such as data processing mistakes or respondents providing inaccurate or false information. The Bureau of Labor Statistics takes great care to limit the error in their survey, and they expanded the scope of the CEX in 1999 in order to further reduce bias and variance in the estimates. I use only the expanded, more detailed data to maintain accuracy. We can be confident that these data are the most accurate available.

B. Consumer Price Index

The Consumer Price Index raw data encompasses millions of observations of monthly price indices of various goods and services from 1947 to 2014. The Bureau of Labor Statistics uses the Consumer Expenditure Survey data to construct the CPI (BLS 2007). The CPI has a tiered item classification system. Eight high-level categories are separated into 70 lower-level classes that

are further divided into 211 strata. The lowest-level (micro-level) publicly available CPI data subcategorizes items in each stratum into one of 305 entry-level items.[4]

Table 2 illustrates an example of raw CPI data downloaded from the Bureau of Labor Statistics. In this dataset, the year and period variables indicate the year and month of each observation. The value variable is the price index for that particular good or service. The price index is the price level for a good or service in a particular year and month relative to the base price level in June 1983. A value of 101.6 means that the price of the good in that time period was 1.6% higher than in the base period (which is assigned a value of 100).

Table 2 US Food and Beverage Data

series_id	year	period	value
CUSR0000SEFN01	1983	M04	99.4
CUSR0000SEFN01	1983	M05	99.5
CUSR0000SEFN01	1983	M06	100
CUSR0000SEFN01	1983	M07	100.3
CUSR0000SEFN01	1983	M08	100.6
CUSR0000SEFN01	1983	M09	100.7
CUSR0000SEFN01	1983	M10	101.6

Source: Bureau of Labor Statistics 2014

The series_id variable can be separated into five parts. The first two letters (CU) denote this series as part of the Consumer Price Index. The next letter (S) indicates that the data are seasonally adjusted. The next four characters (0000) uniquely identify the geographic region from which the price data were collected. The final six characters (SEFN01) identify the specific

[4] A finer level data can be obtained by visiting the BLS in Washington, D.C., but that ultra low-level detail is not necessary for drawing conclusions about differential inflation rates and volatilities.

good or service for which the price level is recorded. In this example, the code SEFN01 indicates that these data represent price level changes for carbonated drinks (BLS 2014).

The Consumer Price Index measures the typical consumer's market basket of goods and services.[5] The Bureau of Labor Statistics releases millions of observations of price data spanning multiple decades. The CPI series variable is detailed enough to allow for specific good or service mapping, which allows the CPI data to be seamlessly integrated with the CEX.

The chief weakness of the Consumer Price Index is that it does not capture the true experience of any specific household because each family purchases different goods and services (BLS 2007). As a result, the CPI measure cannot accurately be read as the inflation rate for any particular household. Additionally, the CPI cannot measure cost-of-living differences between households. The CPI tracks changes in prices over time. It does not track the relative prices between geographic areas. Comparing CPI measures between regions shows which regions experienced faster changes in prices, not which areas have higher or lower prices.

To the extent that cost-of-living differences are correlated with inflation rates or inflation volatility, disaggregating the CPI data may not perfectly capture the correct inflation rates and volatilities. Accounting for cost-of-living differences is beyond the scope of this paper. As a result, my estimates for inflation rates and volatilities abstract from cost-of-living differences. Assessing the degree to which cost-of-living differences would meaningfully change the inflation rate and volatility estimates is a possible topic of further research.

[5] The Bureau of Economic Analysis releases the Personal Consumption Expenditures (PCE) price index, which also measures consumer prices. The decision to use the CPI instead of the PCE comes from the sheer volume of CPI data available.

C. Bureau of Economic Analysis GDP Data

The Bureau of Economic Analysis provides quarterly and annual United States economic growth rate data from 1947 to 2014 (BEA 2014). Table 3 provides a brief sample of the data. The clear strength of this dataset is that it provides quarterly economic growth observations. Quarterly data enables the use of quarterly inflation volatility, instead of annual inflation volatility (because I can compare intra-year inflation to intra-year growth rates), which allows for more data points. More data points results in more precise volatility-growth correlations.

Table 3 U.S. Real Economic Growth (Percentage)

Quarter	Growth (Chained 2009)
1983q1	5.3
1983q2	9.4
1983q3	8.1
1983q4	8.5
1984q1	8.2
1984q2	7.2
1984q3	4.0
1984q4	3.2
1985q1	4.0
1985q2	3.7
1985q3	6.4
1985q4	3.0
1986q1	3.8
1986q2	1.9
1986q3	4.1
1986q4	2.1
1987q1	2.8
1987q2	4.6
1987q3	3.7
1987q4	6.8
1988q1	2.3
1988q2	5.4
1988q3	2.3
1988q4	5.4
1989q1	4.1
1989q2	3.2

1989q3	3.0
1989q4	0.9
1990q1	4.5
1990q2	1.6
1990q3	0.1

Source: Bureau of Economic Analysis 2014

Because I am interested in real economic growth, I will focus on the BEA data indicating percent changes to real GDP. The data are chain weighted[6], and thus are a more accurate representation of GDP growth rates than standard percent change data. Consistent with the limitations from the other data sources, I will focus on growth rates from 1999 to 2013. A potential weakness of the data is that GDP growth may not perfectly capture real economic growth. GDP calculation does not take into account the underground economy, nor does it account for the depletion or degradation of natural capital such as lakes and wetlands. However, shortcomings are present in every possible measurement of economic activity; GDP does an excellent job of capturing economic activity, and its ubiquity in the developed world makes it the best candidate for assessing growth.

D. Chicago Fed Income-Based Economic Index

The IBEX data measure monthly inflation rates for different U.S. household groups from 1983 to 2012 (Chicago Fed 2014). The inflation rates are calculated by using data from the Consumer Expenditure Survey and the Consumer Price Index. By disaggregating and linking these surveys, the Chicago Fed has created informative datasets that shed light on the different inflation rates of U.S. household groups. In particular, they illustrate the different inflation experiences of households at or near the poverty line and the experience of households of different ages and

[6] See footnote 1 for an explanation of chain weighting.

incomes. While the IBEX data provides new information, it has two clear weaknesses: it does not finely disaggregate by age, nor does it compute inflation rates for different age-income combinations.

The IBEX age dataset measures different inflation rates for elderly and non-elderly households, where households with the primary reference person over the age of 65 are considered elderly. The IBEX income dataset measures inflation rates for households of different income levels, disaggregating by income quartiles. For some analyses, these distinctions might be sufficient. But, because I suspect that aggregated inflation data may be masking an underlying relationship between volatility and growth, these data are not disaggregated finely enough for me to thoroughly investigate the research question.

Table 4 provides a brief summary of my preliminary analysis on the IBEX age dataset. A cursory look illustrates that elderly and non-elderly households experience very different quarterly inflation volatilities. I find that non-elderly households experience more volatile inflation, which is consistent with the literature. However, I believe this degree of disaggregation may not be fine enough. Households aged 55-65 and households below age 25, which are considered non-elderly, are *very* different households. This likely plays out in significantly different expenditure patterns, which might result in a different correlation between inflation volatility and economic growth. Using the IBEX data could bias an analysis of inflation volatility and economic growth. Combining such vastly differently household groups could be neutralizing a link between one of the groups and economic growth.

Table 4 U.S. Elderly and Non-Elderly Inflation Volatility

Quarter	Std. Deviation Elderly	Std. Deviation Non-Elderly
2000q1	0.667082135	0.723630055
2000q2	0.576185759	0.689840396
2000q3	0.484353771	0.505373688
2000q4	0.543877605	0.723671196
2001q1	0.776704815	0.985913607
2001q2	0.869042765	1.068566151
2001q3	0.876757982	1.05235606
2001q4	0.852403005	0.97689038
2002q1	0.856063508	0.98097675
2002q2	0.722646489	0.839618011
2002q3	0.617318667	0.732620866
2002q4	0.60036907	0.709100992
2003q1	0.619391761	0.704532538
2003q2	0.592139633	0.679592219
2003q3	0.55507167	0.625408812
2003q4	0.587072509	0.699134589
2004q1	0.616038719	0.751405141
2004q2	0.578615599	0.739029162
2004q3	0.759261525	0.934795253
2004q4	0.82908988	0.985631098
2005q1	0.788796191	0.917493799
2005q2	0.651365648	0.79606153
2005q3	0.648742593	0.779176093
2005q4	0.682740414	0.869855573
2006q1	0.720267044	0.932935049
2006q2	0.744581758	0.969556835
2006q3	0.788456785	1.012420304
2006q4	0.760187973	0.9869509
2007q1	0.802123784	1.056857676
2007q2	0.82913455	1.102090994
2007q3	0.976577546	1.27382033
2007q4	1.113341522	1.520660094
2008q1	1.468611279	1.907820911
2008q2	1.88515531	2.410471281
2008q3	2.217020407	2.73877013
2008q4	2.263314515	2.781582796
2009q1	2.178063779	2.721855984
2009q2	2.02332749	2.579840981
2009q3	1.817850238	2.37485876
2009q4	1.226513484	1.849106506
2010q1	1.159904333	1.809055884

2010q2	1.302612759	1.893252376
2010q3	1.297056826	1.69833478
2010q4	0.952314021	1.128336016
2011q1	0.836460457	0.958105919
2011q2	0.836954185	0.971721238
Average	0.968499169	1.220632167

Source: Federal Reserve Bank of Chicago and author's calculations.

Because of these two weaknesses, I will supplement the IBEX data by creating a richer, more comprehensive dataset by disaggregating more finely by income and age. To better evaluate if inflation volatility is related to growth, I need to construct disaggregated age-income combinations. This allows for the detection of possible underlying heterogeneous relationships. The following section details my inflation volatility dataset construction methodology.

IV. Model Specification

To calculate household-group inflation rates, I use the model employed by Johannsen (2014) that is consistent with how the Bureau of Labor Statistics calculates the CPI. The model is also similar to Hobijn and Lagakos (2005), who construct an alternative model of the CPI. As such, this model is thoroughly grounded in the literature. To begin, I define the price index for each household at a specified time:

$$I_t^i \equiv \sum_{j \in J} w_j^i \frac{P_{j,t}}{P_{j,b}},$$

where I^i_t is the price index for household i at time t. W^i_j is the proportion of household income spent on good/service j (J is the set of all goods/services). $P_{j,t}$ is the price of good/service j at time t, and $P_{j,b}$ is the price of good/service j at time b, which represents the base year. The summation

of each good/services' adjusted price * expenditure share results in the price index for that household in that time period. Next, I define the household inflation rate in period k:

$$\pi^i_{t-k,t} \equiv \frac{I^i_t}{I^i_{t-k}} - 1.$$

In this equation, the household inflation rate is defined as the percent change in price indices. For example, If I^i_t is 111 and I^i_{t-k} is 107, then the inflation rate during period k is 111/107 – 1, a rate of 0.03738.

Following Johannsen (2014), I define the base period as *t – k*. With this as a base, we can manipulate the equations to derive an equation for the good/service weighted average inflation rate:

$$\pi^i_{t-k,t} = \sum_{j \in J} w^i_j \frac{P_{j,t}}{P_{j,t-k}} - 1 = \sum_{j \in J} w^i_j \frac{P_{j,t} - P_{j,t-k}}{P_{j,t-k}} = \sum_{j \in J} w^i_j \pi_{j,t-k,t}$$

This equation comes from substituting *t – k* for *b* in the price index equation. By substitution, $\pi_{j,t-k,t}$ is the inflation rate (change in prices) of good/service j during period k. With this substitution, the inflation rate of each good/service, π_j, is multiplied by that good/service's proportion of total expenditures. These values are then summed across the set of all goods/services *J* to calculate the household inflation rate for that time period, $\pi^i_{t-k,t}$. As Johannsen (2014) notes, this model calculates inflation rates as a weighted average of individual goods/services' inflation rates.

After calculating household inflation rates, I calculate the household group rate as a weighted average of each household's inflation rate (weighting based on that individual household's share of the group's expenditures). I then compute the quarterly standard deviations, σ^g_t, of each

household group's inflation rate, $\pi^g_{t-k,t}$, where *g* is the household group. If inflation volatility dampens growth because households do not make purchases they would make under less volatility or because inflation volatility distorts the price mechanism (as suggested by Okun and Friedman), then there should be a negative correlation between volatility and economic growth. With that in mind, I investigate the link between inflation volatility and economic growth. To do this, I utilize a moving-window methodology to compute inflation volatility over time. With this methodology, the volatility of a given quarter σ^g_t is given by the standard deviation of inflation over the period beginning four quarters before quarter *t* and ending four quarters after time *t*. This technique, using preceding and future data, is a standard method for computing standard deviations in the literature.[7] Employing this methodology reduces the noise in the measure of inflation volatility by expanding the time horizon. After computing σ^g_t for each quarter from 2000q1 to 2012q4, I determine the correlation between the set of all σ^g_t and U.S. real economic growth rates over the period.

V. Results

In this section, I describe how I link the Consumer Expenditure Survey and the Consumer Price Index, and discuss the results of my volatility-growth analyses. I first present the results of my analysis of the entire time period. Then, I present the results of my analysis of the time period separated into expansions and recessions. Though the Bureau of Labor Statistics handles both the CEX and the CPI, the two data sources use different classification codes for goods and services.

[7] Using preceding and leading quarters to calculate a moving volatility from historical data is done to create more reliable results. The choice of four quarters is driven by the desire to capture quarterly changes in inflation volatility but also reduce the noise in the calculation. See da Silva Filho and Figueiredo (2015).

To merge the datasets, I write Stata and Python programs to match the goods and services categories and the item classification codes from the CEX and the CPI. After matching the categories to price changes, I merge the disaggregated datasets on the uniquely identified, matched categories. The result is a fully identified, rich dataset of both inflation and expenditure data individually mapped to the desired household groups. After conducting my analysis, I find sizable inflation volatility heterogeneity across household groups. I also find that from 2000-2012, volatility and economic growth are negatively correlated for all household groups (with stronger correlations at lower income levels), but the trend is not uniform across the period. Inflation volatility and growth are positively linked during expansion and negatively linked during recession.

Table 5 shows the 27 categories into which I break down household consumption in order to calculate inflation rates and volatilities, consistent with Johannsen (2014) but updated to include goods such as vehicles and tobacco. For each category, I match the CEX data with the corresponding price index from the CPI data. To calculate the inflation volatilities, I compute the standard deviations of each household group's inflation rates by disaggregating the monthly price data within the CPI. Because of data constraints, I calculate inflation rates from 1999-2013 and volatilities for U.S. household groups from 2000 to 2012[8]. To calculate the household group inflation rates, I adopt the methodology of Johannsen (2014). For each household group, I re-weight the formula according to that group's typical basket of goods and services that I have determined by disaggregating the Consumer Expenditure Survey. Consistent with the literature, I

[8] Because I calculate volatility using a moving window, inflation and expenditure data from 1999-2013 results in volatility data for 2000-2012.

normalize the household expenditure weights to the relevant data in the selected categories (about 90-95% of total household expenditures) prior to conducting analyses.

Table 5 CEX Consumption Categories and CPI Price Indices[9]

Category	Price Index (CUUR0000)
Food at Home	SAF11
Food Away From Home	SEFV
Alcoholic Beverages	SAF116
Shelter	SAH1
Natural Gas	SEHF02
Electricity	SEHF01
Other Fuel	SEHE
Phone	SEED
Water	SEHG
Household Operations	SEHP
Household Furnishings	SEHL
Apparel	SAA
Gasoline and Motor Oil	SETB
Cars and Trucks (Old)	SETA
Cars and Trucks (New)	SETA
Other Vehicles	SETA
Vehicle Insurance	SETD
Vehicle Finance	SETA
Vehicle Maintenance and Repairs	SETD
Public Transportation	SETG
Health	SAM
Entertainment	SAR
Personal Care	SAG1
Reading	SERG
Education	SAE
Tobacco	SEGA
Miscellaneous	SAG

Source: Johannsen (2014) and author's updates

A. 1999-2013 Analysis

To put the inflation volatility and economic growth analysis in context, I begin by describing the inflation experience of U.S. household groups over the entire time period. Table 6 presents the average quarterly inflation rates by household group from 1999 to 2013. Consistent with

[9] Adapted from Johannsen (2014).

Crawford and Smith (2002), I find significant heterogeneity of inflation rates across household groups. Additionally, similar to Levell and Oldfield (2011) and McGranahan and Paulson (2005), I find that lower income households experience higher inflation rates than wealthier households. I also find no clear trend in inflation rates across age groups.

Table 6 Average Inflation Rates by Household Group, 1999-2013

Age	Under 25	25-34	35-44	45-54	55-64	65-74	75 and over	Average by Income
Income ($)								
Less than 40K	0.0043	0.0040	0.0043	0.0043	0.0043	0.0042	0.0043	0.0042
40K - 80K	0.0039	0.0038	0.0041	0.0041	0.0040	0.0039	0.0040	0.0040
80K - 120K	0.0040	0.0036	0.0038	0.0040	0.0037	0.0036	0.0035	0.0037
More than 120K	0.0040	0.0033	0.0034	0.0036	0.0037	0.0035	0.0039	0.0036
Average by Age	0.0040	0.0037	0.0039	0.0040	0.0039	0.0038	0.0039	

Source: Bureau of Labor Statistics and author's calculations

Table 7 presents the average quarterly inflation volatility by household group from 2000-2012 computed using the moving window methodology. Consistent with McGranahan and Paulson (2005), I find that inflation volatility is higher for lower income households than wealthier households. I also find great variation in volatility across age groups. In particular, younger households experience greater inflation volatility than older households. Looking at households two-dimensionally, households under 25 of all income levels and households aged 35-54 with lower and middle-incomes experience the greatest volatility.

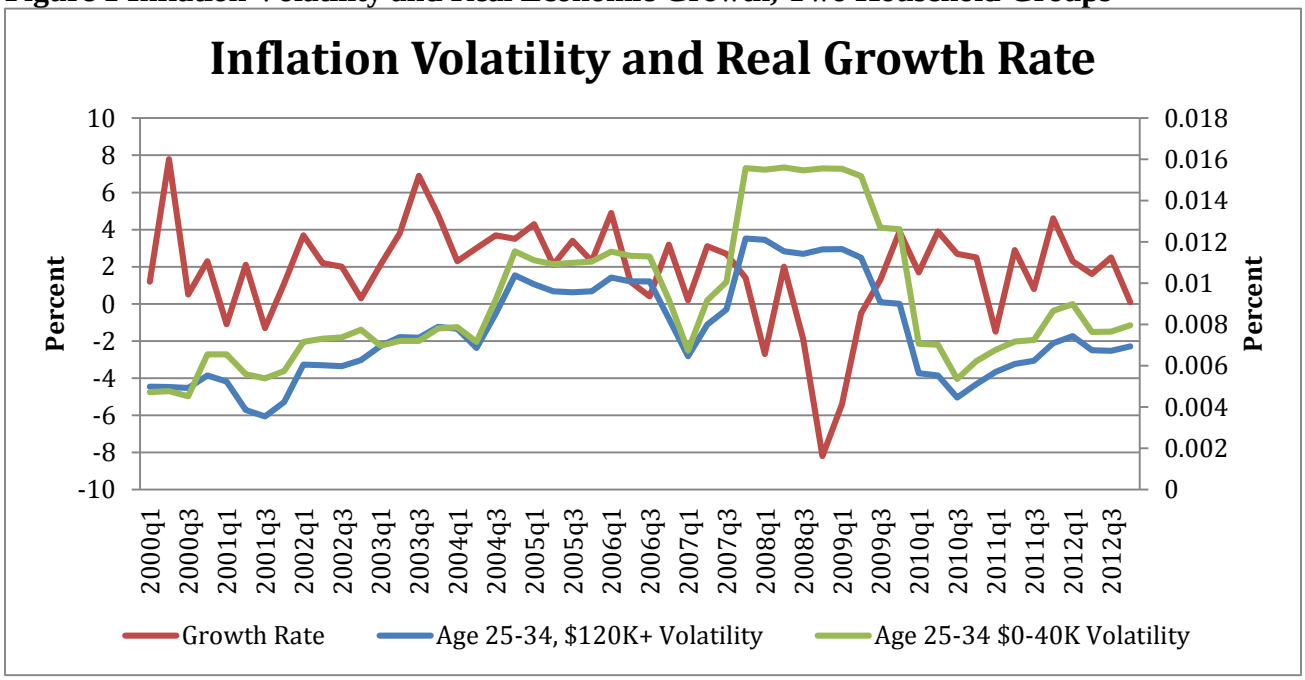
Table 7 Average Inflation Volatility by Household Group, 2000-2012

Age	Under 25	25-34	35-44	45-54	55-64	65-74	75 and over	Average by Income
Income ($)								
Less than 40K	0.0090	0.0089	0.0093	0.0089	0.0085	0.0078	0.0062	0.0084
40K - 80K	0.0096	0.0085	0.0089	0.0091	0.0084	0.0080	0.0067	0.0085
80K - 120K	0.0095	0.0080	0.0082	0.0088	0.0086	0.0075	0.0072	0.0082
More than 120K	0.0104	0.0075	0.0075	0.0075	0.0079	0.0077	0.0058	0.0078
Average by Age	0.0096	0.0082	0.0085	0.0086	0.0083	0.0077	0.0065	

Source: Bureau of Labor Statistics and author's calculations

Tables 6 and 7 illustrate that inflation rates and volatilities vary across income and age groups. The heterogeneity of inflation volatility across household groups implies that there are different correlations between inflation volatility and growth across household groups. Figure 1 shows inflation volatilities for two household groups (households aged 25-34 with incomes under $40,000 and over $120,000) and U.S. real economic growth rates, with growth rate on the primary Y-axis and volatility on the secondary Y-axis.[10]

Figure 1 Inflation Volatility and Real Economic Growth, Two Household Groups



Source: Bureau of Labor Statistics, Bureau of Economic Analysis, and author's calculations

As seen in Figure 1, lower levels of inflation volatility are associated with higher economic growth rates from 2000-2012. Figure 1 also illustrates that different household groups do in fact experience different inflation volatilities. Additionally, real economic growth rate and inflation

[10] In this figure, and all following figures, inflation volatility refers to the standard deviation of the inflation rate.

volatility appear to move together for both household groups. However, the figure suggests a negative correlation between volatility and real growth rates for both age-income combinations during some periods but a positive correlation during other periods.

Table 8 presents a matrix of the correlation between U.S. real economic growth rates and inflation volatility for different income-age combinations from 2000-2012. If inflation volatility does reduce economic growth, then the volatility-growth correlation matrix should be populated with negative values for household groups whose inflation volatility is negatively related to growth.

Table 8 U.S. Inflation Volatility - Growth Correlation Matrix[11]

Age	Under 25	25-34	35-44	45-54	55-64	65-74	75 and over	Average by Income
Income ($)								
Less than 40K	-0.3933	-0.3943	-0.3947	-0.3889	-0.3935	-0.3982	-0.4449	-0.4011
40K - 80K	-0.3998	-0.3790	-0.3931	-0.3798	-0.3690	-0.4274	-0.4373	-0.3979
80K - 120K	-0.3415	-0.3757	-0.3772	-0.3958	-0.4012	-0.3676	-0.4983	-0.3939
More than 120K	-0.0700	-0.2623	-0.4093	-0.3156	-0.3995	-0.4317	-0.1700	-0.2941
Average by Age	-0.3012	-0.3528	-0.3936	-0.3700	-0.3908	-0.4062	-0.3876	

Source: Bureau of Labor Statistics, Bureau of Economic Analysis, and author's calculations

As seen in Table 8, there is a negative correlation between inflation volatility and real economic growth for every household group. These results are consistent with Okun and Friedman's intuitions and with some of the literature. While Jansen (1989) and Fischer (1993) find no link between aggregate volatility and growth, Judson and Orphanides (1999) and Hnatkovska and Loayza (2005) find aggregate inflation volatility to be robustly negatively correlated with

[11] Correlations in this table (and subsequent figures) are computed from volatility-growth rate pairs for years 2000-2012 using data from 1999-2013.

economic growth. This disaggregated, ground-up analysis finds results consistent with recent work in this strand of literature, suggesting that recent work should be given more weight in further research and policymaking.

Table 8 also presents the average correlations by age and income group, respectively. The strongest correlations between inflation volatility and economic growth rates exist in middle and lower-income households. Looking at households of different incomes within the same age group, there are often sizable differences between correlations but no clear trend across all age cohorts. Additionally, households over 35 years old exhibit stronger correlations than younger households. These results confirm that the heterogeneity of inflation volatility matters in determining the correlation between inflation volatility and economic growth. They also suggest that inflation volatility may have a greater effect on lower and middle-income households than wealthier households.

B. Expansion and Recession Analysis

While the overall results suggest that low and middle-income households' inflation volatilities are more linked to overall economic growth than wealthier households' volatilities, the relationship may not be uniform over time. In this section, I present the results of my analysis of inflation volatility and economic growth during the 2001q4 - 2007q3 expansion, the Great Recession, and the 2009q3-2012q4 expansion.

Table 9 presents the average quarterly inflation volatility by household group from 2001q4 to 2007q3. Like over the entire time period, during the mid-2000s expansion there is heterogeneous inflation volatility across households. Lower income households experience higher inflation volatility (though the difference is smaller) and younger households also tend to experience higher inflation volatility. The heterogeneity is far greater across ages than income levels, with households under 25 experiencing nearly 60% more volatile inflation than households over 75 years old.

Table 9 Average Inflation Volatility by Household Group, 2001q4 – 2007q3 Expansion

Age	**Under 25**	**25-34**	**35-44**	**45-54**	**55-64**	**65-74**	**75 and over**	**Average by Income**
Income ($)								
Less than 40K	0.0094	0.0089	0.0090	0.0089	0.0084	0.0079	0.0060	0.0084
40K - 80K	0.0094	0.0085	0.0086	0.0091	0.0086	0.0076	0.0064	0.0083
80K - 120K	0.0100	0.0079	0.0082	0.0086	0.0083	0.0074	0.0065	0.0082
More than 120K	0.0115	0.0080	0.0075	0.0078	0.0082	0.0076	0.0065	0.0082
Average by Age	0.0101	0.0083	0.0083	0.0086	0.0084	0.0076	0.0064	

Source: Bureau of Labor Statistics and author's calculations

Table 10 illustrates the correlations between U.S. real economic growth rates and household inflation volatility during the expansion. Notably, the correlations are dramatically different. In fact, during this expansion, there is a positive correlation between every household group's inflation volatility and U.S economic growth. Additionally, the stronger link between lower-income households' volatility and growth disappears. Instead, during the expansion, wealthy households (those earning more than $120,000) have the strongest correlation between volatility and growth at 0.1642.

Table 10 U.S. Inflation Volatility - Growth Correlation Matrix, 2001q4 – 2007q3 Expansion

Age	Under 25	25-34	35-44	45-54	55-64	65-74	75 and over	Average by Income
Income ($)								
Less than 40K	0.1440	0.0759	0.1269	0.1241	0.1001	0.0865	0.0925	0.1071
40K - 80K	0.0832	0.1108	0.1056	0.1069	0.0666	0.0409	0.1276	0.0916
80K - 120K	0.0464	0.1421	0.0730	0.1013	0.0583	0.1510	0.1315	0.1005
More than 120K	0.1474	0.2164	0.1510	0.1584	0.0379	0.2441	0.1939	0.1642
Average by Age	0.1053	0.1363	0.1141	0.1227	0.0657	0.1306	0.1364	

Source: Bureau of Labor Statistics, Bureau of Economic Analysis, and author's calculations

Given the stark difference between the correlations during the expansion and the overall time period, there appears to be something more complex going on under the surface of the entire period data. Table 11 presents the average quarterly inflation volatilities across households during the Great Recession (2008q1 – 2009q2). Inflation volatility is significantly higher during the recession than during the preceding expansion, with every income and age group experiencing about two-to-three times as volatile inflation. Interestingly, the difference in inflation volatility between lower income households and wealthy households increases significantly during the recession. Across age groups, households under 25 years old and households between 35 and 54 years old experienced the highest levels of volatility. Like during the expansion and over the entire time period, lower and middle-income households experienced greater inflation volatility than wealthier households.

Table 11 Average Inflation Volatility by Household Group, Great Recession

Age	Under 25	25-34	35-44	45-54	55-64	65-74	75 and over	Average by Income
Income ($)								
Less than 40K	0.0188	0.0194	0.0206	0.0195	0.0186	0.0165	0.0141	0.0182
40K - 80K	0.0213	0.0184	0.0193	0.0200	0.0176	0.0180	0.0148	0.0185
80K - 120K	0.0192	0.0170	0.0173	0.0190	0.0190	0.0158	0.0148	0.0174
More than 120K	0.0185	0.0143	0.0156	0.0147	0.0160	0.0169	0.0092	0.0150
Average by Age	0.0195	0.0173	0.0182	0.0183	0.0178	0.0168	0.0132	

Source: Bureau of Labor Statistics and author's calculations

Table 12 lists the correlations between inflation volatility and real economic growth during the Great Recession. As shown in table 12, during the recession inflation volatility and economic growth were negatively correlated for almost every household group. Like in the 2001-2007 expansionary period, wealthy households exhibit the strongest correlation between inflation volatility and economic growth. However, during the recession, the correlation is negative. Additionally, prime aged households (25-44) exhibit the strongest negative correlation between inflation volatility and economic growth.

Table 12 U.S. Inflation Volatility - Growth Correlation Matrix, Great Recession

Age	Under 25	25-34	35-44	45-54	55-64	65-74	75 and over	Average by Income
Income ($)								
Less than 40K	-0.4755	-0.2569	-0.1287	-0.0305	0.0161	-0.0365	-0.0692	-0.1402
40K - 80K	-0.3059	-0.1355	-0.1594	-0.0754	-0.0629	0.0314	-0.3763	-0.1549
80K - 120K	0.5022	-0.2383	-0.3106	-0.2061	-0.1397	-0.1459	-0.0811	-0.0885
More than 120K	-0.1492	-0.3042	-0.3549	-0.3787	-0.3741	-0.2674	-0.2026	-0.2902
Average by Age	-0.1071	-0.2337	-0.2384	-0.1727	-0.1402	-0.1046	-0.1823	

Source: Bureau of Labor Statistics, Bureau of Economic Analysis, and author's calculations

The clear outlier is the correlation of 0.5022 for households under 25 with incomes of $80K-120K. This outlier seems to be due to the high number of vehicle purchases relative to the number of observations in the survey data for this household group during the time period (biasing the correlation). Without this outlier, the average volatility for the $80K-120K income group is -0.1869. This would be consistent with the fact that the wealthiest households had the strongest correlation between volatility and growth.

From Table 10 and Table 12, it seems that the link between inflation volatility and growth may be different during recessions and expansions. Table 13 presents the quarterly inflation volatilities across household groups during the expansion after the Great Recession (2009q3 – 2012q4). Similar to prior time periods, lower and middle-income households experience greater inflation volatility than wealthier households. Middle-aged and young households also experience greater inflation volatility than elderly households.

Table 13 Average Inflation Volatility by Household Group, 2009q3 – 2012q4 Expansion

Age	**Under 25**	**25-34**	**35-44**	**45-54**	**55-64**	**65-74**	**75 and over**	**Average by Income**
Income ($)								
Less than 40K	0.0079	0.0077	0.0082	0.0078	0.0072	0.0065	0.0048	0.0071
40K - 80K	0.0079	0.0075	0.0083	0.0078	0.0072	0.0067	0.0054	0.0073
80K - 120K	0.0081	0.0073	0.0071	0.0078	0.0072	0.0057	0.0055	0.0070
More than 120K	0.0105	0.0063	0.0064	0.0068	0.0067	0.0056	0.0044	0.0067
Average by Age	0.0086	0.0072	0.0075	0.0075	0.0071	0.0061	0.0050	

Source: Bureau of Labor Statistics and author's calculations

Table 14 shows inflation volatility and economic growth correlations for households during the post-recession expansion. Like during the mid-2000s expansion, inflation volatility and U.S.

economic growth are positively correlated for almost every household group during the 2009-2012 expansion. Within age cohorts, lower income households tend to be more correlated with growth than higher income households. The table indicates that inflation volatility and U.S. economic growth are more correlated for lower and middle-income households and non-elderly households during this expansion, unlike during the previous expansion.

Table 14 U.S. Inflation Volatility - Growth Correlation Matrix, Post-Great Recession Expansion

Age	Under 25	25-34	35-44	45-54	55-64	65-74	75 and over	Average by Income
Income ($)								
Less than 40K	0.2131	0.1694	0.1706	0.1826	0.1943	0.1528	0.1844	0.1810
40K - 80K	0.1904	0.1511	0.1569	0.1602	0.1357	0.1751	0.1554	0.1607
80K - 120K	0.1003	0.1217	0.1538	0.1573	0.1498	0.0947	0.0763	0.1220
More than 120K	0.3354	0.1040	0.0989	0.1196	0.1426	0.0966	-0.0869	0.1158
Average by Age	0.2098	0.1366	0.1451	0.1549	0.1556	0.1298	0.0823	

Source: Bureau of Labor Statistics, Bureau of Economic Analysis, and author's calculations

Across the entire period of 2000-2012, lower and middle-income households generally experience greater inflation volatility than wealthier households and younger households generally experience greater inflation volatility than older households. Additionally, inflation is roughly two-to-three times as volatile for all household groups during the Great Recession than during the expansionary periods. During the expansions, inflation volatility and economic growth were positively correlated across almost every household group. However, during the recession, volatility and growth were negatively correlated across almost every household group. Over the entire time period, I find a negative correlation between inflation volatility and real economic growth, with stronger correlations as income decreases. The increasingly strong

negative correlation at lower income levels suggests that inflation volatility may be more linked to economic growth among low and middle-income households.

VI. Conclusion

This paper has investigated the extent to which inflation volatility is linked to reduced real economic growth by analyzing inflation volatility for households of different ages and incomes. By disaggregating and linking the Consumer Expenditure Survey and the Consumer Price Index, I constructed a comprehensive, rich dataset. This manually constructed dataset was used to determine the extent to which increased U.S. inflation volatility is correlated with lower economic growth, as suggested by the theories of Friedman and Okun. Previous empirical literature has returned somewhat mixed results, which may have been the result of using aggregate inflation data.

Analyzing a dataset previously unused in the volatility-growth literature, I find that disaggregating inflation volatility shows great heterogeneity of inflation volatility across household groups. I also find that all household groups have negative correlations between their inflation volatility and U.S. economic growth from 2000-2012. In particular, I determine that low and middle-income households exhibit the strongest negative correlation between inflation volatility and growth. A possible explanation is that lower and middle-income households are not as protected from inflation induced fluctuations in net income due to their lower income level. However, the negative correlation between volatility and growth is not consistent over the time period; I find positive correlations between inflation volatility and growth during expansions and

a negative correlation between inflation volatility and growth during the Great Recession. A possible explanation could be that the negative link between inflation volatility and economic growth stems from short periods of highly volatile inflation.

Inflation volatility heterogeneity is widespread and it seems to matter, which may have implications for further research and policymaking. This paper has shown that analyzing inflation volatility by using aggregate data masks differences in volatility across household groups. My results, computed from the ground-up (in contrast to the previous literature), support recent work that finds a negative relationship between inflation volatility and real economic growth over a 10-plus year time horizon.[12] When looking at the entire time period of 2000-2012, the strongest negative correlations between inflation volatility and U.S. economic growth are found in lower and middle-income groups. Future analyses of inflation volatility and economic growth should account for the heterogeneity of inflation volatility experienced by households, perhaps focusing on low and middle-income households. My analysis does not determine which household groups are driving growth, but it does suggest new avenues to look at this question.

Another avenue for further research would be to expand the analysis to include additional countries. To the extent that a causal relationship exists between inflation volatility and growth, it is conceivable that it is only present empirically at high levels of volatility (which are less likely to be observed in a developed country like the United States). This would be consistent with my analysis of inflation volatility and growth during the Great Recession and consistent

[12] This study abstracts away from price differences between goods within a given expenditure category. Though all households buy from the same categories, they may buy different goods (I might buy a Toyota while my professor might buy a Ferrari). However, this assumption is very reasonable, as the changes in prices of various goods within the same category are usually very close together.

with results from Hnatkovska and Loayza (2005). However, as developing nations and emerging market economies may not have the robust economic measurement data necessary to construct as detailed disaggregated inflation volatility estimates, this could be difficult to overcome.

Finally, there are policy implications of my inflation volatility analysis. Because inflation volatility among low and middle-income households has a stronger link to economic growth over the longrun, focusing policymaking to reduce the level of volatility for these households could improve economic growth. Additionally, the disparity in inflation volatility between lower income and wealthy households increased during the recession. Central banks and governments should consider these results when setting inflation targets or designing policies aimed at limiting inflation volatility and increasing growth.

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