The Relationship between the Inflation Rate and Inequality across US States: A Semiparametric Approach

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Abstract

This paper uses a cross-state panel for the United States over the 1976 to 2007 period to assess the relationship between income inequality and the inflation rate. Employing a semiparametric instrument variable (IV) estimator, we find that the relationship depends on the level of the inflation rate. A positive relationship occurs only if the states exceed a threshold level of inflation rate. Below this value, inflation rate lowers income inequality. The results suggest that a nonlinear relationship exists between income inequality and the inflation rate.

JEL Codes: E31, D31, C14.

Keywords: Income inequality, Inflation rate, Semiparametric instrumental variable estimator.

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1. Introduction

Over the last 30 years, the U.S economy has experienced an increasing income inequality. Researchers consider many possible explanations for this trend, yet no political/economic instrument seems to explain this long-run trend. In this paper, we investigate the effects of the inflation rate on income inequality to see whether monetary policy and the resulting inflation rate can affect income inequality and improve well-being of individuals. In the political economy arguments, the redistribution of income commonly reflects changes in fiscal policy by government spending, taxation, or transfer payments. Monetary policy and its effect on the inflation rate can also redistribute income as households differ in many dimensions. First, the inflation rate affects different sources of income differently. Different prices change at different rates. For example, the prices of commodities change every day and others, such as wages, adjust much more slowly. Second, each households' income source differs. For instance, income can come from capital or labour, or both. Thus, the effect of the inflation rate on the total household income is heterogeneous. By affecting each household's income in a different way, the inflation rate affects the income distribution.

Theoretically, monetary policy affects income inequality both in the short and long run. In short-run, a lower inflation rate slows down the relative loss in purchasing power of non-indexed nominal fixed incomes, such as pensions and transfers, relative to indexed nominal incomes, such as capital income. Because the poor receive a larger proportion of their income from transfers than the rich, lower inflation slows the rise in income inequality (Albanesi, 2007; Erosa and Ventura, 2000; Easterly and Fischer, 2001). Therefore, in the short-run, the inflation rate affects income inequality through the cycle in economic activity generated by the policy change (Romer and Romer, 1998). In long-run, through various channels, inflation can affect income inequality (See for example, Jin, 2009; Camera and Chien, 2012; Areosa and Areosa, 2016). Rising inflation can decrease the real value of nominal, non-indexed assets and the real value of non-indexed transfers. The poor probably cannot protect themselves from rising inflation due to the existence of entry barriers in markets for real, indexed financial assets (Easterly and Fischer, 2001). In this case, rising inflation enhances income inequality (Cysne et al., 2005). On the other hand, rising inflation can decrease the real value of private debt, which can reduce income inequality. In the long-run, the relationship between inflation and income inequality can depend on the initial level of inflation.[1] For instance, lower long-run inflation positively affects growth for countries with initially high inflation (Funk and Kromen, 2010; Vaona and Schiavo, 2007). In low and moderate inflation economics, however, inflation does not affect economic instability which can discourage investment and restrain long-run growth. The trade-off between inflation and unemployment provides another example of the relationship between inflation and income inequality, which depends on the initial level of inflation. Downward rigidities in nominal wages imply that reducing inflation from low to lower levels could lead to a larger increase in unemployment (Wyplosz, 2000; Ribba, 2006). Jin (2009) shows that inflation and inequality can exhibit a positive or negative relationship. By incorporating inflation, growth, and income inequality in a consistently specified framework and introducing two types of heterogeneity -- skill endowments and initial capital holdings -- across households, the author shows that along the balanced growth path wealthier households that experience higher capital shares tend to work less, whereas more skilled households that exhibit higher skill shares tend to work more. Consequently, the relative income share of each household represents a convex combination of its relative capital and skill shares (Jin, 2009). Areosa and Areosa (2016) examine optimal monetary policy in the presence of inequality by introducing unskilled labour with no access to the financial system into a DSGE model with sticky prices. The authors find a contractionary interest rate shock increases inequality, while inflation and

[1] For non-linear effect of inflation on economic growth, see Hess and Morris (1996), Barro (1996), Fischer (1993), Sarel (1996), and Kremer et al. (2013).

the output gap decrease. Also, they find that a higher proportion of unskilled labour weakens monetary policy while fiscal policy produces a more relevant effect on the economy.

Thus, these studies suggest that the net long-run effect of inflation on income inequality depends on the initial rate of inflation. When a country experiences low inflation, no clear relationship exists between inflation and income inequality. Whereas when a country experiences high inflation, higher inflation leads to higher income inequality.

A number of empirical studies examine the relationship between inflation and inequality, yielding inconsistent results. Some authors find a positive or negative relationship between inflation and income inequality, while others find no relationship. Thus, the pre-2000 literature generates an inflation-inequality puzzle. Galli and van der Hoeven, 2001 provide a review of the empirical literature. Post-2000 empirical studies also add to this inconsistency. Scully (2002), Albanesi (2007), and Beck et al. (2007) find a positive relationship between inflation and the income inequality. Erosa and Ventura (2002) find inflation acts like a regressive tax in the United States, implying that inflation increases income inequality as lower-income households hold a larger fraction of their assets in cash. Maussner (2004), Sun (2011), Maestri and Roventini (2012), and Coibion et al., (2012) find that inflation decreases income inequality. Whereas these empirical studies focus on linear relationship between inflation and inequality, Romer and Romer (1998) find that the slope of income distribution varies with inflation. Bulir (2001) finds a non-linear relationship between inflation and inequality. By dividing the dataset into low, middle, and high inflation sections, the author shows that inflation and inequality exhibit a negative relationship from low to middle inflation and exhibit a positive relationship from middle to high inflation sections. That is, the initial decline in inflation from a hyperinflation situation reduces inequality, whereas further declines in lower levels of inflation increases inequality. Bulir (2001) finds a threshold of five percent inflation, where below the threshold reducing inflation causes income inequality to rise and above the threshold reducing inflation causes income inequality to fall. Galli and van der Hoeven (2001) also find a non-linear relationship between inflation and income inequality and estimate the inequality minimizing rate of inflation at around six percent in the United States The authors show that increasing inflation reduces inequality with low initial inflation and boosts inequality with high initial inflation rate.

In this paper, we use a semiparametric instrument variable (IV) estimator to assess the relationship between the inflation rate and income inequality. The semiparametric estimator proves extremely sensitive to outliers. By using cross-state panel data, we minimize the problems associated with data comparability often encountered in cross-country studies related to income inequality. That is, cross-state data are more comparable than those for different countries. Also, states form a group of observations with minimal differences in institutions and political regimes.

Analysts generally agree that economic policies aimed at stimulating growth need to consider effects on inequality and poverty, emphasising equitable growth policies and explicit redistributive policies (Gali and van der Hoeven, 2001). The use of monetary policy, as an instrument of economic policy, is important not only for growth but also for reducing inequality.

The plan of the paper is as follows. We discuss the methodology for empirical analysis in section 2. Discussion of data and results are presented in section 3. Conclusions appear in section 4.

2. Methodology

A semiparametric estimator proves useful for situations when the researcher expects a nonlinear relationship between two variable and controls for the effect of other covariates. Also, the semiparametric model allows the data to uncover a more realistic functional form. By employing the semiparametric IV estimator of Vaona and Schiavo (2007) and Park (2003), we also can account for the potential endogeneity of the inflation rate.

In the first stage, we determine the validity of the instrumental variable. We use a F-test to decide whether the instrument should enter the first-stage regression. The auxiliary instrumental variable regressions take the following form:

$$\pi_t = \mu + \theta z_t + \varepsilon_t \qquad (1)$$

where π_t is the inflation rate, $z_t = \pi_{t-1}$ (instrumental variable), and $\varepsilon_t \sim iid(0, \sigma^2)$ is the error term.

The semiparametric specification can be expressed as follow:

$$g_t = \phi x_t + f(\pi_t) + \varepsilon_t, \qquad (2)$$

where $f(\pi_t)$ is a nonlinear function and x_t is a set of exogenous variables. We account for the possibility that $E[\varepsilon_t|\pi_t] \neq 0$ by estimating (2) using the model with a valid instrumental variable. Following Vaona and Schiavo (2007) and Balcilar et al. (2014), we estimate the model in equation (2) using the semiparametric IV estimation approach of Park (2003). We determine the bandwidth, using the least-square cross-validation method of Li *et al.* (2013). We use a Gaussian kernel for semiparametric model.

3. Data and Empirical Results

3.1. Data

The analysis relies on a cross-state panel from 1976 to 2007, which includes the U.S. state Consumer Price Index, U.S. per capita income, human capital attainment measures, unemployment, and six income inequality measures - Atkinson Index, Gini Coefficient, the

Relative Mean Deviation, Theil's entropy Index, as well as the Top 10%, and the Top 1% income shares.[2] The income inequality measures, income share measures, and human capital attainment measures come from the online data segment of Professor Mark W. Frank's website.[3] We employ the revised 2009 version of the Berry-Fording-Hanson state cost of living index of Berry et al. (2000), who construct a panel from 1960 to 2009.[4] U.S per capita income is from the Bureau of Economic Analysis (BEA). Unemployment rate is from the Federal Reserve Economic Data (FRED). We create a dummy variable that equals one for less than 6 percent of inflation and zero otherwise to avoid the bias results as the semiparametric estimator is sensitive to outliers.

3.2. Empirical results

3.2.1. Preliminary results

Since our approach requires the use of mean reverting data, we ensure that all variables are stationary. Hence, before considering the empirical link between inflation and income inequality, we examine the stationarity properties of the variables. For this, we perform the Im, Pesaran, and Shin (2003, IPS) unit-root test, which assumes individual unit roots across each cross-section. The IPS test has the null hypothesis of a unit root. Table 1 presents the results. The results show that all variables used are I(1), but the growth rate (first-difference of the natural logarithm) of all the variables are stationary, which, in turn, are what we use in the model specifications. Since we use growth rates of the variables, we lose the observations corresponding to 1976.

[2] Leigh (2009) finds that these measures are useful proxies for inequality across the income distribution.

[3] See http://www.shsu.edu/eco_mwf/inequality.html. Professor Frank constructed his dataset based on the Internal Revenue Service (IRS), which has a limitation of omission of some individual earning less than a threshold level of gross income. For this reason, we focus more on top income shares as primary indicators of inequality measures.

[4] See http://dvn.iq.harvard.edu/dvn/.

Table 1. Panel Unit root tests

IPS	Test Statistics	
	Level	First difference
Atkinson Index	7.972	-29.302***
Gini Coefficient	4.594	-26.935***
the Relative Mean Deviation	4.804	-26.276***
Theil's entropy Index	4.532	-21.193***
Top 10% income shares	7.390	-38.905***
Top 1% income shares	5.920	-33.431***
Consumer Price Index	-0.654	-2.597***
Real per capita income	4.373	-8.759***
High school attainment	7.281	-31.931***
College attainment	4.193	-33.234***
Unemployment rate	0.475	-20.838***

Note: Variables are in natural logarithms. *, ** and *** denote rejection of the null hypothesis of unit root at the 10%, 5% and 1% significance levels. IPS test assume asymptotic normality.

Table 2. Linear Relationship between Income Inequality and Inflation by OLS regression and IV Estimates

Atkin05	Intercept[α]	Inflation[β]
OLS regression	0.0235*** (0.0021)	-0.1976*** (0.0418)
OLS regression on lagged inflation	0.0280*** (0.0020)	-0.3021*** (0.0413)
IV Model	0.0310*** (0.0020)	-0.3700*** (0.0510)
Gini	Intercept[α]	Inflation[β]
OLS regression	0.0068*** (0.0011)	0.0343 (0.0222)
OLS regression on lagged inflation	0.0095*** (0.0011)	-0.0280 (0.0221)
IV Model	0.0100*** (0.0010)	-0.0340 (0.0270)
Rmeandev	Intercept[α]	Inflation[β]
OLS regression	0.0075*** (0.0009)	0.0024 (0.0191)
OLS regression on lagged inflation	0.0082*** (0.0009)	-0.0155 (0.0191)
IV Model	0.0080*** (0.0010)	-0.0190 (0.0230)
Theil	Intercept[α]	Inflation[β]
OLS regression	0.0278*** (0.0037)	-0.0464 (0.0751)
OLS regression on lagged inflation	0.0469*** (0.0036)	-0.4972*** (0.0739)

IV Model	0.0520*** (0.0040)	-0.6090*** (0.0930)
Top 10%	Intercept[α]	Inflation[β]
OLS regression	0.0124*** (0.0015)	-0.0294 (0.0309)
OLS regression on lagged inflation	0.0132*** (0.0015)	-0.0480 (0.0308)
IV Model	0.0140*** (0.0020)	-0.0590 (0.0380)
Top 1%	Intercept[α]	Inflation[β]
OLS regression	0.0498*** (0.0052)	-0.4310*** (0.1063)
OLS regression on lagged inflation	0.0349*** (0.0052)	-0.0786 (0.1065)
IV Model	0.0360*** (0.0060)	-0.0960 (0.1300)
F-statistics		
3128.0347***		

Note: OLS model is the estimate of $g_t = \alpha + \beta\pi_t + \varepsilon_t$ while OLS-lagged estimates $g_t = \alpha + \beta\pi_{t-1} + \varepsilon_t$using non-instrumental OLS estimation. IV models are estimated by two stage least squares using the first lag of inflation as an instrument. F-statistic is from the estimates of the IV auxiliary regression and indicates that the first lag of inflation is valid as an instrument. *, ** and *** denote significance at the 10%, 5% and 1%, respectively.

We use the first lag of inflation as our instrumental variable. Table 2 reports results indicating that the instrumental variable is valid and should enter the first stage regression.

3.2.2. Main results

We choose variables that previous studies use (e.g., Johnson and Shipp, 1999; Romer and Romer, 1998; Cutler and Katz, 1991; Bulir, 2001; Easterly and Fischer, 2001; Chu, Davoodi, and Gupta, 2000). The dependent variable is the growth of inequality measures. We control for the growth rates of human capital attainment, of real per capita income, and of the unemployment rate. The inflation rate is instrumented by its first lag.

Figure 1 plot the results for the semiparametric IV estimator, which we estimate without dummy variables[5], and show the functional relationships between income inequality and inflation. This relationship is nonlinear, mostly U-shaped, for the six inequality measures. Figure 2 plots the results when we include dummy variables, since the semiparametric estimator proves sensitive to outliers and the inflation is mostly high in the oil shock periods.[6]

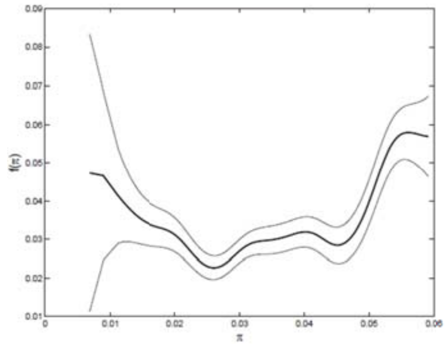
We find that increasing inflation coincides with decreasing income inequality for low inflation levels and that increasing inflation coincides with increasing income inequality for high inflation levels (i.e., negative relationship between inequality and inflation below the threshold; positive relationship above the threshold). Figures 2.a, 2.c, 2.e show that the threshold level falls around 0.035. That is, below 3.5 percent, inflation exerts a negative relationship on income inequality, while the relationship becomes positive above the

[5] The inflation rates were mostly high during the oil shock and Volcker's disinflationary periods. Since the semiparametric estimator is sensitive to outliers, we created a dummy variable that equals one when the inflation rate was less than 6 percent and zero otherwise to avoid biasing the results.

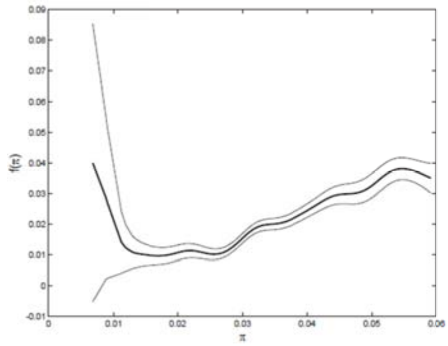
[6] Given possible endogeneity issues, we also use the first lag of the control variables in the model – the growth rates of real per capita income, of high school attainment, of college attainment, and of the unemployment rate. Our results here are qualitatively similar to the model that does not address possible endogeneity issues..

Figure1. Semiparametric IV estimates (without dummy variable)

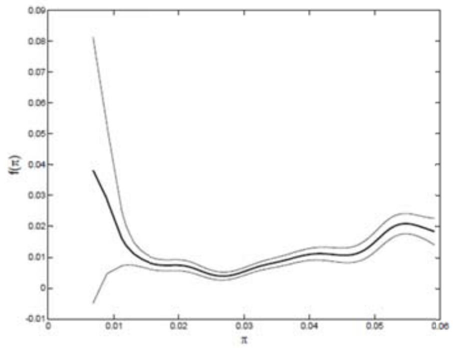
(a) Atkinson Index



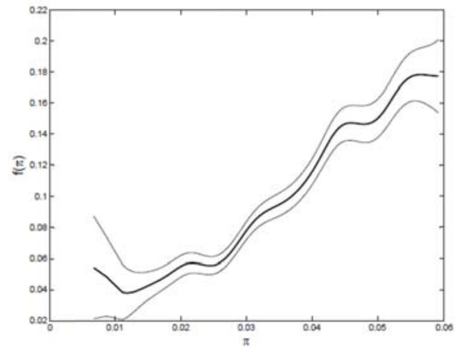
(b) Gini Coefficient



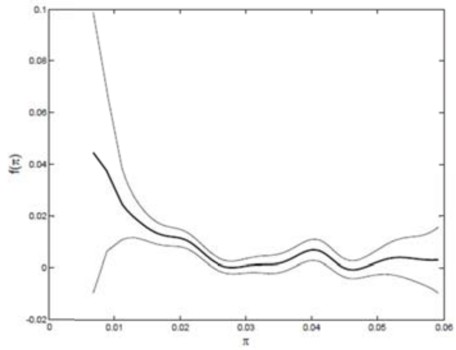
(c) The Relative Mean Deviation



(d) Theil's entropy **I**ndex



(e) Top 10% income share



(f) Top1% income share

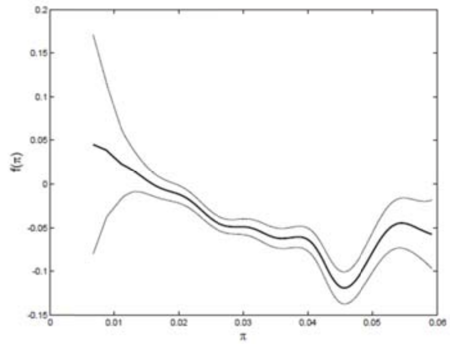
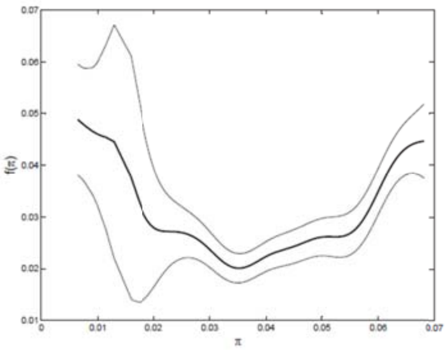
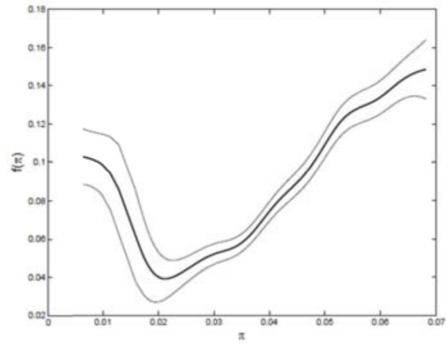


Figure2. Semiparametric IV estimates (with dummy variable)

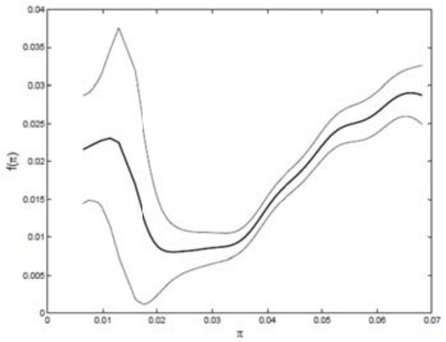
(a) Atkinson Index



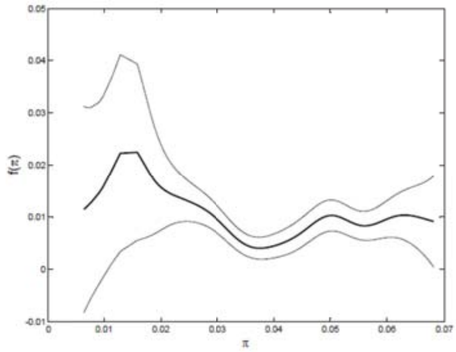
(d) Theil's entropy **I**ndex



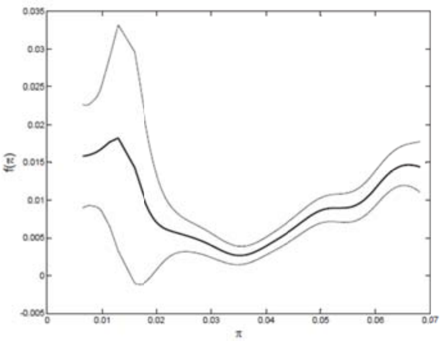
(b) Gini Coefficient



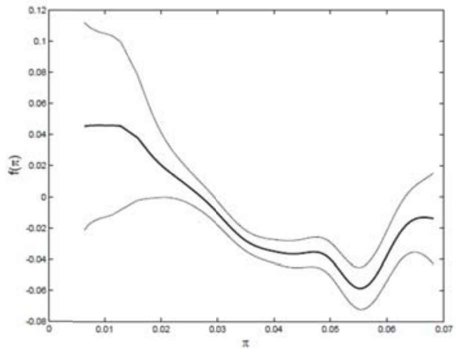
(e) Top 10% income share



(c) The Relative Mean Deviation



(f) Top1% income share



threshold. Figures 2.b and 2.d show that the threshold level falls around 0.02, or 2 percent. The threshold level falls around 0.056, or 5.6 percent, in Figure 2.f. In the United States, the dynamics of income inequality mostly reflects variation in the upper end of income distribution since the early 1980's. Thus, the estimated effect of monetary policy could depend on the inequality measure used in the empirical analysis. That is, the estimated effects can differ if it does not represent the whole income share of the population, particularly the top 1-percent income share. Our results fall in line with Bulir (2001) and Galli and van der Hoeven (2001) who find a U-shaped relationship between inflation and income inequality with a threshold of around five and six percent, respectively, in the United States.

Our finding, the existence of the threshold, implies that inflation affects the income distribution due to its effect on economic growth, wage income, and the debtor-creditor relationship. When inflation falls below the threshold, reducing inflation could lead to a larger increase in the unemployment rate as downward rigidities hold for the nominal wage rate (Wyplosz, 2000; Ribba, 2006) and, consequently, this effect increases income inequality. When inflation is above the threshold of 2 percent, it negatively affects economic growth and increases inequality (Balcilar et al., 2014). Also, when inflation is above the threshold of 2.8 percent, it affects relative prices and increases income inequality (Kremer et al., 2013). Furthermore, when inflation is adjusted, the speed of adjustment differs as wages usually lag behind inflation. In addition, our results relate to skill-biased technological transition, which affects income inequality in the United States (Autor et al., 2008). The Federal Reserve wants to stimulate employment. When the Federal Reserve tries to maximize employment, it may affect different segments of the population differently, as the risk of unemployment differs. Also, our results relate to the level of development of the United States and the sophistication of the financial structure (Bulir and Gulde, 1995; Bulir, 2001; and Doepke and Schneider, 2006). Financial structure influences the ability to hedge against shocks and to loosen spending constraints. Higher inflation lowers the consumption of those who experience a tight budget and who cannot borrow. The continuance of the shock positively affects inequality.

4. Conclusion

One important, ongoing political issue in the United States is income inequality, which has increased over the past 30 years. In the political economy argument, the redistribution of income typically comes through fiscal policy.. Yet, economic activity responds to both fiscal and monetary policy. Though fiscal and monetary policies are used for comparatively different macroeconomic objectives, both policies can affect the income distribution. Fiscal policy can affect income inequality through taxes, public sector employment, government spending, and other fiscal policy instruments. Monetary policy can affect income inequality through its effect on inflation, which then can affect income distribution through the inflation rate's heterogeneous effect on sources of income.

In this study, we analyse the relationship between the inflation and income inequality for the United States Empirically, the results show that a non-linear relationship exists between inflation and income inequality for the 50 U.S. states over 1976 to 2007. This result matches Bulir and Gulde (1995), where they conclude that the inflation rate affects the inequality relationship in a non-monotonic manner. Also, Easterly and Fischer (2001) find that the well-being of the poor negatively correlates with inflation and higher inflation reduces the well-being of the poor with a non-linear factor. Bulir (2001) and Galli and van der Hoeven (2001) find that the inflation rate and inequality relationship is nonlinear and that pushing inflation below a certain threshold reverses the correlation.

Since the financial crisis, the Federal Reserve has used monetary policy aggressively to promote economic growth and regain economic stability. When the Federal Reserve conducted such aggressive monetary policy, such as cutting the federal funds rate to zero and purchasing large amount of U.S. Treasury securities and mortgage-backed securities, the possible redistributive results of monetary policy can play an important role. In spite of their effort, inequality has worsened in recent years.

In our sample period, inequality has widened and became a long-term trend relationship. Unfortunately, in current monetary system, a tendency exists for income to flow to the rich.

Each household owns different combinations of assets/debts, which makes it almost impossible to avoid the redistributive effects of monetary policy. Policymakers should explicitly consider the possible redistributive effects of monetary policy. Also, more research can determine the optimal average level of inflation as well as the redistribution effects of unconventional monetary policy, such as forward guidance and quantitative easing.

As discussed in Bulir and Gulde (1995) and Bulir (2001), the results pertain to the United States and may not extend to an international analysis.

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Appendix

Appendix 1

Park (2003) considers a semiparametric regression model in which the error term is correlated with the nonparametric part. Although the model cannot eliminate the nonparametric part in the two-step estimation procedure, the author can still obtain a semiparametric estimator with consistency and asymptotic normality with two existing sets of instrumental variables which meet an orthogonality conditions.
The regression model takes the form

$$g_t = \phi x_t + f\left(\pi_t\right) + \varepsilon_t, t = 1, \ldots, T$$

with

$$E[\varepsilon_t | \pi_t] \neq 0$$

The author considers a case in which an error term, $\varepsilon_t \in R$, is correlated with a nonparametric part, say $f\left(\pi_t\right)$, where f is an unknown function from R^1 to R.

Appendix 2

See Table 3.

Table 3 Results of Hansen (1999) threshold method

	Estimate	95% confidence interval
Estimate of threshold with dummy		
Atkinson index	0.0240	[0.0223 0.0240]
Gini coefficient	0.0291	[0.0287 0.0292]
The relative mean deviation	0.0327	[0.0308 0.0328]
Theil's entropy index	0.0286	[0.0281 0.0287]
Top 10% income shares	0.0240	[0.0238 0.0242]
Top 1% income shares	0.0476	[0.0473 0.0478]
Estimate of threshold without dummy		
Atkinson index	0.0240	[0.0240 0.0240]
Gini coefficient	0.0291	[0.0287 0.0292]
The relative mean deviation	0.0661	[0.0634 0.0676]
Theil's entropy index	0.0661	[0.0623 0.0676]
Top 10% income shares	0.0240	[0.0238 0.0242]
Top 1% income shares	0.0476	[0.0472 0.0478]

The estimation method is suggested by Hansen (1999)