The Short-Run and Long-Run Effects of Inequality on Inflation

Weinan Yan

Department of Economics

Rutgers University, 75 Hamilton Street

New Brunswick, NJ, 08901

weinan.yan@rutgers.edu

10/14/2019

Abstract

This paper examines the short-run and long-run effects of inequality on inflation. It examines separately data for the United States and several panels of international data. The reason for this strategy is that a variety of measures of inequality are available for the United States for a long period. The panel data sets are limited to a shorter period, but cover a wide range of countries. The cointegration test and the Vector Error Correction Model (VECM) provide evidence that there exists a negative long-run relationship between inequality and inflation in the United States. In the multi-country panels, the Autoregressive Distributed Lag (ARDL) model confirms the negative long-run relationship, and the Arellano-Bond GMM estimator reveals a negative short-run effect. The paper lays out the econometric evidence for this relationship and analyzes the underlying political economy that explains the relationships between inequality and inflation.

1 Introduction

The growth of inequality in the United States and other industrial nations since the 1980s has generated considerable and growing attention from the public, from politicians, and from economists, especially since the publication of Pikettys (2014) *Capital in the Twentieth Century*. Growing inequality raises many questions for economists. How will growth rates of real income be affected? How will unemployment and inflation be affected?

Here I explore the effects of increases or decreases in inequality on inflation. There are many studies that focus on the impact of inflation on inequality but fewer adopt my focus on the impact of inequality on inflation. According to the Median Voter Theorem (Black 1948; Downs 1957), in a democratic society, the median voter has the ability to cast the decisive vote in an election. Melzer and Richard (1981) create a formal model to discuss the relationship between the income inequality and redistribution. When income inequality is high, the mean income will be greater than median income and the median voter will want a greater redistribution. Several economists argue that inequality has a positive effect on inflation (Sachs, 1989; Beetsma and Van Der Ploeg, 1996; Al-Marhubi, 1997). The positive relationship is attributed to populism and political instability. In a democratic society, an increase in inequality causes intense political pressures for governments to raise the income of lower and middle-income groups. These pressures are likely to produce expansionary monetary and fiscal policies. The inflation as a result may well be regarded as a redistribution policy which reduces the real burden of debt and transfers wealth from the wealthy to the poor. According to Doepke and Schneider (2006, p.1) The main losers from inflation are rich, older households, the major bondholders in the economy. The main winners are young, middle-class households with fixed-rate mortgage debt.

However, Kenworthy and Pontusson (2005) compare Europe and the United States and find a negative correlation between inequality and total public expenditures. More equal countries redistribute more, which is often regarded as the Robin Hood Paradox. The Robin Hood Paradox is a challenge to the Median Voter Theorem and the Melzer-Richard model. The wealthy play an important role in the political arena and they have a great influence on macroeconomic policies.

The propensity for political participation is highly correlated with income and education. The most affluent citizens, moreover, have more resources to contribute to political campaigns, and generally, to support their favorite candidates. They work through lobbyists, foundations and think-tanks to dominate the key issues of the public policy (Benabou, 2000; Domhoff, 2014). If this true, an increase in income inequality means the wealthy would have more resources to influence macroeconomic policies. Thus we may see a negative relationship in the long run between inequality and inflation. This will more likely be the case if a substantial share of the resources available to the wealthy are in the hands of old wealth, families whose wealth is in the form of assets fixed in nominal terms such as private and government bonds. The nouveau riche, whose wealth is more likely to be in the form of business ownership, may be less disturbed by inflation.

The following two figures provide a broad-brush picture of the relationship between inequality and inflation. The inequality measure is the share of income going to the richest top 1 percent. It will be discussed in detail in section 3. In Figure 1, we can see that the share of the top 1 percent was generally decreasing from 1920 to 1980 and increasing thereafter. The inflation rate follows the reverse pattern was generally rising from 1920 to late 1970s and falling alter 1980.

To see if the negative long-run relationship exists in other countries, Figure 2 includes six advanced countries and covers the period 1961-2010. Again, we see a negative relationship between inequality and inflation in all six countries.

Can we confirm econometrically that there is a long-run relationship between inequality and inflation as suggested by an inspection of Figures 1 and 2? If there is, what about the short-run relationship? What is missing in the literature is an econometric analysis that identifies both the short-run and long-run relationships between inequality and inflation. This paper attempts to fill this gap in the literature. It studies the United States first and then expands the dataset up to 32 countries.

The remainder of the paper is organized as follows. Section 2 discusses the political debate over

Figure 1: US: 1920-2010

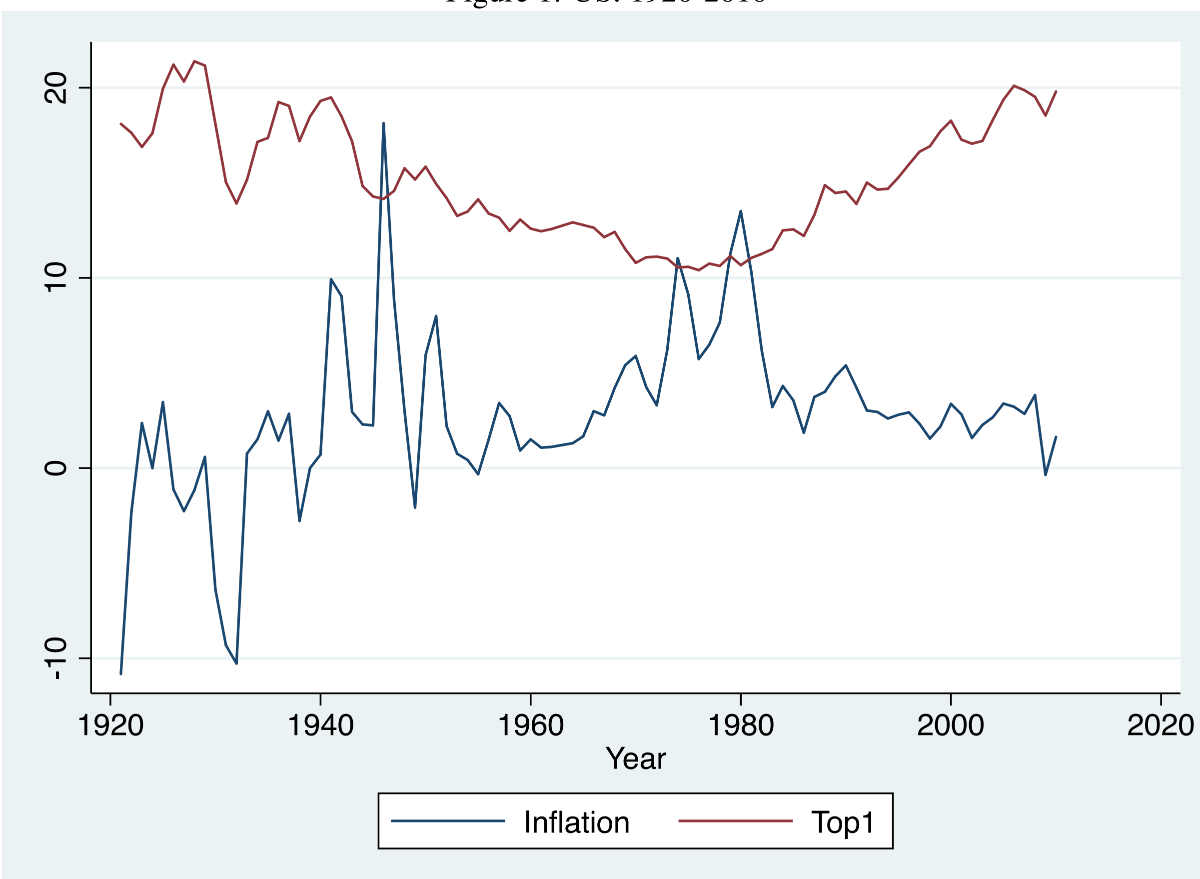
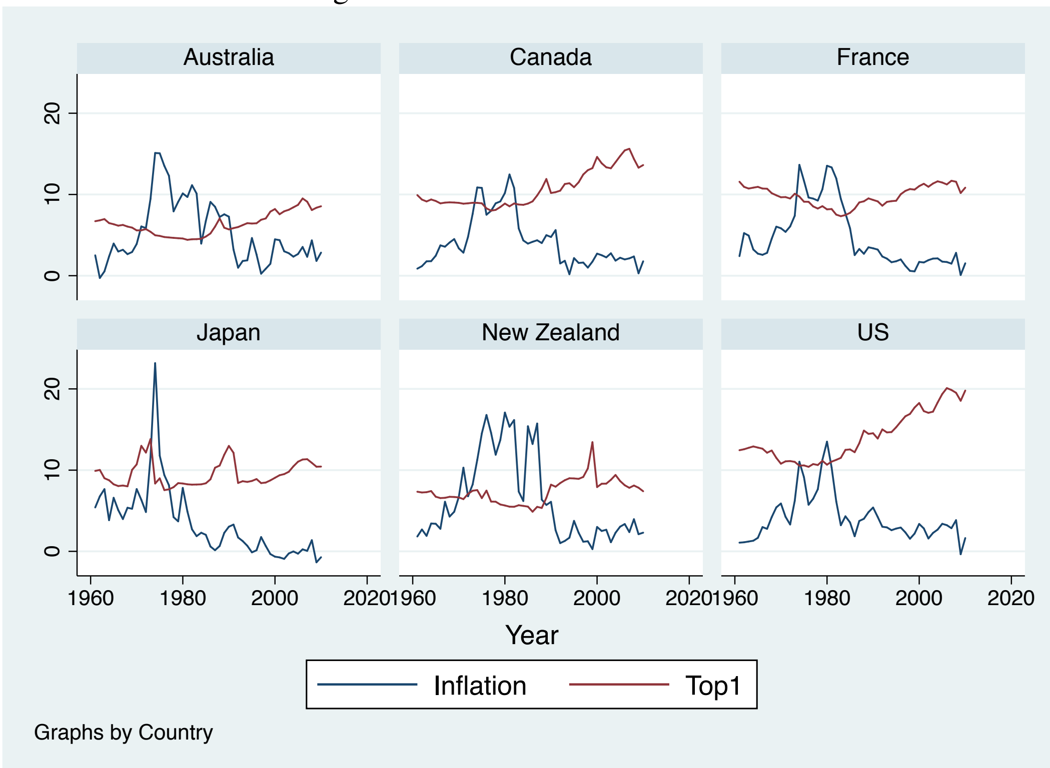


Figure 2: Six countries: 1961-2010



the inflationary policies between the affluent and the poor. Section 3 describes the empirical data. Section 4 provides an empirical study of the United States. The cointegration test and the Vector Error Correction Model suggest that inequality is negatively related to inflation in the long run but the short-run relationship is unclear. In section 5 I expand the dataset and include more countries. The Autoregressive Distributed Lag Model confirms the negative long-run relationship between inequality and inflation, and the Arellano-Bond GMM estimator suggests a negative short-run effect of inequality on inflation. Section 6 summarizes the main conclusions.

2 The Debate over the Inflationary Policies

The attitudes toward expansionary monetary and fiscal policies tend to vary by class. Inflationary policies can stimulate consumption, which in turn promotes production and creates jobs. Unemployment is an ongoing concern for the poor because a large portion are unskilled or low-skilled workers and their jobs are less secure than those of the upper-middle class. A lower unemployment in the short run even at the cost of higher inflation in the long run may seem a worthwhile investment for the poor. The affluent, on the other hand, tend to be more conservative on taxes, economic regulation, and social welfare, and more critical of expansionary monetary and fiscal policies (Page, Bartels and Seawright, 2013). A large fraction of the affluent are rentiers whose income derives mainly from owning financial assets fixed in nominal terms. Inflation erodes the real value of their assets and as a result, redistributes income and wealth from the affluent to the poor. Therefore, the affluent form the main resistance to inflationary policies.

Class conflict over the price level has been a fixture in American politics. One famous case is the debate over bimetallism at the end of the nineteenth century. Prices declined after the United States returned to the gold standard in 1879 until, about, 1896 when increased supplies of gold from South Africa and other parts of the world began to turn a mild deflation into a mild inflation. The GDP deflator, for example, fell about 0.76 percent per year from 1879 to 1896, and then rose about 2.17 percent per year from 1896 to 1906. The Populists, led eventually by the charismatic William Jennings Bryan, blamed the gold standard for producing the initial phase of deflation which they believed hurt poor and indebted farmers. They demanded an end to the gold standard and the adoption of bimetallism (gold and silver) in the hopes of producing inflation and relieving the debt burdens of farmers. The Populists were soon absorbed by the Democratic Party. The 1896 platform of the Democratic Party explained that:

> "The act of 1873 demonetizing silver without the knowledge or approval of the American people has resulted in the appreciation of gold and a corresponding fall in the prices of commodities produced by the people; a heavy increase in the burdens of taxation and of all debts, public and private; the enrichment of the money-lending class at home and abroad; the prostration of industry and impoverishment of the people."

The Republicans, however, representing a wealthier segment of the population, remained supporters of the gold standard, although they softened their position by advocating an international conference.

> "The Republican party is unreservedly for sound money. It caused the enactment of

a law providing for the redemption [resumption] of specie [gold] payments in 1879. Since then every dollar has been as good as gold. We are unalterably opposed to every measure calculated to debase our currency or impair the credit of our country. We are therefore opposed to the free coinage of silver, except by international agreement with the leading commercial nations of the earth, which agreement we pledge ourselves to promote, and until such agreement can be obtained the existing gold standard must be maintained.“

Although Bryan was by far the more charismatic candidate, and although his campaign is considered pivotal by historians, his campaign for bimetallism failed. Republican William McKinley won the election and the United States remained thoroughly committed to the gold standard. Historians have often pointed to the large war chest filled by McKinleys campaign manager Mark Hanna with contributions from major industrialists as a key factor in McKinleys success.

A similar debate over the price level and the gold standard became part of the Presidential campaigns in 1932. The GDP deflator fell a startling 9.04 percent per year between 1929 and 1932. The Republicans were again the staunch supporters of the gold standard.

> “The Republican Party established and will continue to uphold the gold standard and will oppose any measure which will undermine the governments credit or impair the integrity of our national currency. Relief by currency inflation is unsound in principle and dishonest in results. The dollar is impregnable in the marts of the world today and must remain so. An ailing body cannot be cured by quack remedies. This is no time to experiment upon the body politic or financial.“

Many Democrats were now calling for paper money or the old idea of bimetallism to produce inflation. The Democratic Party platform reflected these ideas, but now it was the turn of the Democrats to soften their position by advocating an international conference.

> “We advocate a sound currency to be preserved at all hazards and an international monetary conference called on the invitation of our government to consider the rehabilitation

of silver and related questions.“

Similar debates between the affluent and the poor also happened in France. By 1935, it was still in the great depression. The economy was under terrible pressure from deflation. Domestic demand had fallen dramatically. The main trade partners of France all abandoned the gold standard, and the devaluation brought competitive advantages to those countries. The gold reserve fell by 11 percent in June 1935, and the Prime Minister Pierre-E tienne Flandin, who aimed at economic recovery, was forced to decide between reflation and recovery or deflation and convertibility (Eichengreen, 1996, p.369). He finally chose the latter because of the resistance from the Bank of France. The famous 200 families, who were the largest 200 shareholders, had the right to vote in the Banks annual meeting; and they were able to influence the central banks cooperation with the governments policy. The 200 families became one of the main targets of attacks from left parties in the 1936 election (Moure, 2002, p.123).

In the 1936 election, the Radical party, which represented the middle classes, cooperated with other parties on the left. After intense negotiations, Radical, Socialists and Communists formed a new party, the Popular Front. The Popular Front won the election; and Leon Blum, the head of Popular Front, took office in 1936. Blum weakened the rights of the 200 families and introduced a series of reforms similar to Roosevelts New Deal (Eichengreen, 1996, p.376). Finally, with the pressure of gold losses and broad anticipation of devaluation, France abandoned the gold standard in September 1936.

The implementation of inflationary policies can be seen as a product of the debate between the affluent and the poor, over the distribution of income. When the level of inequality changes because of exogenous factors such as economic crises and globalization, the original balance of power between the wealthy and the poor will be altered, and as a result the inflation rate changes and approaches a new equilibrium. Thus, a clear prima facie case based on the historical narrative can be made that changes in inequality produce changes in the rate of inflation in both the short run and the long. I now turn to the empirical evidence.

3 Data

The two most frequently used measures of inequality are the Gini coefficient and the share of income or wealth going to a top percentage of the population, typically the top 1 percent. The Gini coefficient puts more weight on the middle and low-income groups and describes a general extent of inequality. The share of income or wealth going to the top 1 percent emphasizes, obviously, the income or wealth of the wealthiest group. For this paper, I utilized data from two sources: the Standardized World Income Inequality Database (SWIID) and the World Inequality Database (WID). The SWIID created by Frederick Solt standardizes observations from the OECD Income Distribution Database, the Socio-Economic Database and many other sources (Solt, 2019). Compared to other frequently used databases like Luxembourg Income Study (LIS) and World Income Inequality Database (WIID), it contains more countries and improves compatibility for cross-country study. The SWIID database includes the disposable Gini index (Gini(disp)) and the market Gini index (Gini(mkt)). The disposable Gini index estimates post-tax/post-transfer income of each percentile of the population, and the market Gini index estimates pre-tax/pre-transfer income of each percentile of the population.

The World Inequality Database (WID) was constructed by Thomas Piketty, Emmanuel Saez, Anthony Atkinson and other outstanding economists. There are four major measures of inequality available in the WID: top 1 percent income share (*Top1*), top 10 percent income share (*Top10*), top 1 percent wealth share (*Top1w*) and top 10 percent wealth share (*Top10w*). Top1 and Top10 measure the percentage of pre-tax national income going to the top 1 and top 10 percent population, indicating the level of income inequality. For some countries, the database also includes the fiscal income going to the top 1 percent population. According to the descriptions from the database: Pre-tax national income is the sum of all pre-tax personal income flows accruing to the owners of the production factors, labor and capital, before taking into account the operation of the tax/transfer system, but after taking into account the operation of pension system. Fiscal income is defined as the sum of all income items reported on income tax returns, before any deduction. It includes labor income, capital income and mixed income. The concept of fiscal income varies with national tax legislation, so in order to make international comparisons it is preferable to use the concept of national income. To make international comparisons for income inequality, I use the pre-tax national income share. Similarly, *Top1w* and *Top10w* measure the net wealth owned by the top 1 and 10 percent population, indicating the level of wealth inequality. The inflation rates are calculated based on the Consumer Price Index that is collected from the International Financial Statistics of the IMF, supplemented by the Global Financial Database.[1]

4 The United States

The Gini index from the SWIID database starts in 1961. The *Top1*, *Top10*, *Top1w* and *Top10w* measures, however, start as early as 1913. To cover the longest period, in this section I conduct an analysis of the relationship between inequality and inflation for the United States using these four inequality measures for the period 1921-2010.[2]

4.1 Unit Root Test

It is important when estimating time series models to test the stationarity of the data. The Augmented Dickey-Fuller unit root test was conducted to examine the stationarity of five variables: inflation *Top1*, *Top10*, *Top1w* and *Top10w*. Consider a simple AR(1) process:

$$y_t = \rho y_{t-1} + {x_t}'\delta + \varepsilon_t \tag{1}$$

where x_t are optional exogenous regressors which may consist of constant, or a constant and trend. If the absolute value of $|\rho| < 1$, y is a stationary series, otherwise, nonstationary series.

[1]The GDP deflator is not always available for all countries, and for the countries for which GDP deflator is available, the results are similar to those obtained with CPI.

[2]The inflation rate during the World War I was unusual high, which has a large effect on the test results. For that reason I start dataset with 1921; that is after the return to peacetime economic conditions.

The Augmented Dickey-Fuller (ADF) test constructs a parametric correction for higher-order correlation by assuming that the y series follows an AR(p) process and adding p lagged difference terms of the dependent variable y to the right-hand side of the test regression. After subtracting y_{t-1} from both sides of the equation:

$$\Delta y_t = \alpha y_{t-1} + {x_t}'\delta + \beta_1 y_{t-1} + \beta_2 \Delta y_{t-2} + \cdots + \beta_p \Delta y_{t-p} + \varepsilon_t \tag{2}$$

where $\alpha = \rho - 1$. The null hypothesis is that the variable has a unit root, that is $\alpha = 0$. The alternative hypothesis is $\alpha < 0$. The optimal lag length is selected by the Schwarz Information Criterion and the results are shown in Table 1. The results indicate that all variables are nonstationary in levels but stationary in first differences. Thus we can conclude that all variables are $I(1)$, and we can test for a cointegrating relationship between the variables to see if they are linked to form an equilibrium in the long run. If they are cointegrated, the error correction model is applicable to determine the short-run and long-run correlation between the variables.

Table 1: Augmented Dickey-Fuller unit root tests for the U.S.:1921-2010.

Variable	Level	First difference
Inflation	0.1031	0.0000
Top1	0.6648	0.0000
Top10	0.6777	0.0000
Top1w	0.6831	0.0000
Top10w	0.4701	0.0007

Note: p-values are shown in the table.

4.2 Cointegration Test and Long-Run Cointegrating Equations

The Johansen Cointegration Test was used to examine the cointegrating relationship between inflation and inequality. The methodology was developed in Johansen (1991, 1995), and the setup is as follows. To test the cointegrating relationship of a k-vector $I(1)$ variables Y_t, consider a VAR of order p:

$$y_t = A_1 y_{t-1} + \cdots + A_p y_{t-p} + Bx_t + \varepsilon_t \tag{3}$$

where x_t is a d-vector of deterministic variables and ε_t is a vector of innovations. We can rewrite the VAR as:

$$\Delta y_t = \prod y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + Bx_t + \varepsilon_t \tag{4}$$

where:

$$\prod = \sum_{i=1}^{p-1} A_i - I, \qquad \Gamma_i = -\sum_{j=i+1}^{p} A_j \tag{5}$$

If the coefficient matrix $\prod$ has reduced rank $r < k$, then there exists $k * r$ matrices α and β each with rank r such that $\prod = \alpha\beta'$ and $\beta' y_t$ is $I(0)$. r is the number of cointegrating relations and each column of β is the cointegrating vector. Johansen's method is to estimate the matrix $\prod$ to test whether we can reject the restrictions implied by the reduced rank of $\prod$.

If the variables are cointegrated, we can use the FMOLS (Fully Modified OLS) and the DOLS (Dynamic OLS) methods to estimate the long run equation. The FMOLS is a non-parametric approach that corrects endogeneity among regressors and serial correlation in the errors (Phillips and Hansen, 1990). DOLS is a parametric approach that corrects potential simultaneity bias among regressors and has an outstanding performance in finite samples (Stock and Watson, 1993). The optimal lag length for the DOLS model is selected by the Schwarz Information Criterion.

The results of the Johansen Cointegration Trace and Maximum Eigenvalue tests are shown in Table 2 and 3. If we can reject the hypothesis that there is no cointegrating equation but fail to reject the hypothesis that there is at most one cointegrating equation, we can conclude that there exists cointegrating relationship between inequality and inflation. The tests results show that *Top1*, *Top10*, *Top1w* and *Top10w* are each cointegrated with inflation at the 5 percent significance level.

The long-run cointegrating equations estimated by the FMOLS and DOLS model are shown in Table 4. Each inequality measure has a signicant negative relationship with inflation in the long run. The coefficient of *Top1* in the FMOLS model is -0.627, which means that with one unit

Table 2: Johansen Cointegration Test (trace)

Cointegrating relationship (with inflation)	Hypothesized No. of CE	
	None	At most 1
Top1	0.0000	0.1223
Top10	0.0017	0.2366
Top1w	0.0000	0.1747
Top10w	0.0000	0.1903

Note: P-values are shown in the table.

Table 3: Johansen Cointegration Test (maximum eigenvalue)

Cointegrating relationship (with inflation)	Hypothesized No. of CE	
	None	At most 1
Top1	0.0001	0.1223
Top10	0.0016	0.2366
Top1w	0.0000	0.1747
Top10w	0.0000	0.1903

Note: P-values are shown in the table.

Table 4: Long-run cointegrating equation: dependent variable is inflation

	FMOLS model	DOLS model
Top1	**-0.6266**	**-0.5371**
	(0.0008)	(0.0043)
Constant	**12.4626**	**11.1119**
	(0.0000)	(0.0002)
Top10	**-0.4465**	**-0.4398**
	(0.0001)	(0.0002)
Constant	**20.8784**	**20.6037**
	(0.0000)	(0.0000)
Top1w	**-0.3546**	**-0.3359**
	(0.0000)	(0.0000)
Constant	**14.0421**	**13.4545**
	(0.0000)	(0.0000)
Top10w	**-0.3198**	**-0.3408**
	(0.0000)	(0.0000)
Constant	**25.5811**	**27.0577**
	(0.0000)	(0.0000)

Note: P-values are in parentheses.
Bold letters indicate significant at 5% or better.

increase in the percentage of income going to the richest 1 percent of the population (for example, *Top1* increases from 10% to 11%), in the long run, the inflation will decrease by 0.627 percent (for example, inflation decreases from 5.627% to 5%). The result of the rest of variables can be explained in the same way. In summary, inequality is negatively correlated with inflation in the long run.

4.3 Vector Error Correction Model

Since the variables are cointegrated, we can apply the Vector Error Correction Model which can distinguish the long-run and short-run relationships in variables. For a bivariate panel, the model is set up as follows:

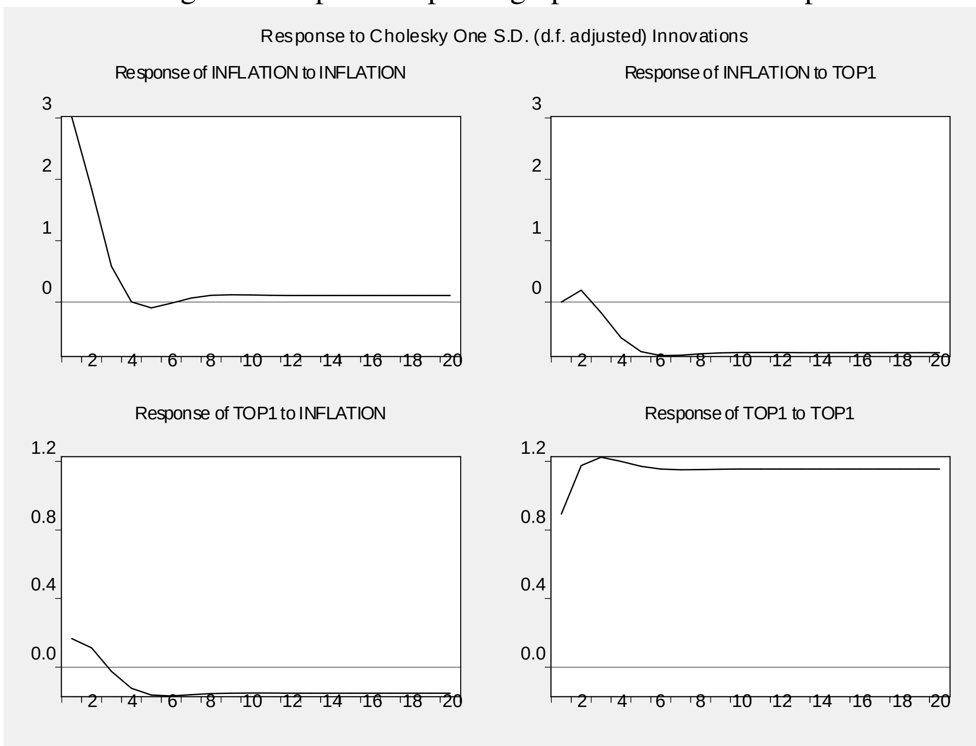
$$\begin{aligned}\Delta y_t = \alpha_1 + \lambda_1 ECT_{t-1} + \sum_{k=1}^{q} \theta_{11k} \Delta y_{t-k} \\ + \sum_{k=1}^{q} \theta_{12k} \Delta x_{t-k} + C_1 + \mu_{1t}\end{aligned} \tag{6a}$$

$$\begin{aligned}\Delta x_t = \alpha_2 + \lambda_2 ECT_{t-1} + \sum_{k=1}^{q} \theta_{21k} \Delta x_{t-k} \\ + \sum_{k=1}^{q} \theta_{22k} \Delta y_{t-k} + C_2 + \mu_{2t}\end{aligned} \tag{6b}$$

where $ECT_{t-1} = y_{t-1} - \beta_0 - \beta_1 x_{t-1}$ is the lagged error correction term derived from long-run cointegrating equation; α is the country fixed effects; λ is the adjustment coefficient; θ represents the short-run relationship; q is the number of lags determined by the SIC (Schwarz Information Criterion), μ is the serially uncorrelated disturbance term.

The results of the Vector Error Correction Model are shown in Table 5. The lagged ECT terms in all four models (except in model 3 when dependent variable is Δ*Top1w*) are negative and significant, which confirms that there exists a long-run relationship between inequality and inflation. However, none of the short-run coefficients are significant, thus, we do not have enough

Figure 3: Impulse response graph: Inflation and Top1



confidence to claim the existence of a short-run relationship between inequality and inflation in the United States.

The graphs of the impulse response function are shown in Figures 3-6. The horizontal axis is time (number of years), and the vertical axis is the unit of change in the response variable. From the top-right graph of the four figures, we can see that in response to an increase in inequality, inflation will decrease and converge to the equilibrium in the long run. From the bottom-left graphs of the four figures, we can see that in response to a positive shock to inflation, inequality will decrease and approach the equilibrium in the long run. In summary, the results of the Vector Error Correction Model and the Impulse Response Function confirms the long-run relationship between inequality and inflation, but the short-run relationship is unclear.

Table 5: Vector Error Correction Model Results

Model 1	ΔInflation	Δ*Top1*
ECT(-1)	**-0.5483**	**-0.0517**
	(0.0000)	(0.0688)
ΔInflation(-1)	0.1477	0.0161
	(0.1341)	(0.5848)
Δ*Top1*(-1)	0.6067	**0.3529**
	(0.0982)	(0.0018)
Constant	0.0243	0.021005
	(0.9400)	(0.8290)
Model 2	**ΔInflation**	**Δ*Top10***
ECT(-1)	**-0.5271**	**-0.0853**
	(0.0000)	(0.0299)
ΔInflation(-1)	0.1787	-0.0276
	(0.1292)	(0.4567)
ΔInflation(-2)	0.0272	0.0310
	(0.8029)	(0.3684)
Δ*Top10*(-1)	0.5506	**0.2833**
	(0.1098)	(0.0102)
Δ*Top10*(-2)	-0.1700	0.0632
	(0.6141)	(0.5534)
Constant	-0.0118	0.0306
	(0.9719)	(0.7721)
Model 3	**ΔInflation**	**Δ*Top1w***
ECT(-1)	**-0.6285**	-0.0625
	(0.0000)	(0.3171)
ΔInflation(-1)	**0.2193**	-0.0156
	(0.0296)	(0.7971)
Δ*Top1w*(-1)	0.1811	0.0235
	(0.3164)	(0.8299)
Constant	0.0202	-0.0090
	(0.9495)	(0.9628)
Model 4	**ΔInflation**	**Δ*Top10w***
ECT(-1)	**-0.5848**	**-0.1261**
	(0.0000)	(0.0020)
ΔInflation(-1)	**0.2248**	0.0309
	(0.0346)	(0.4175)
Δ*Top10w*(-1)	-0.1511	-0.1403
	(0.6059)	(0.1857)
Constant	0.0092	-0.0800
	(0.9778)	(0.5025)

Note: P-values are in parentheses.
Bold letters indicate significant at 5% or better.

Figure 4: Impulse response graph: Inflation and Top10

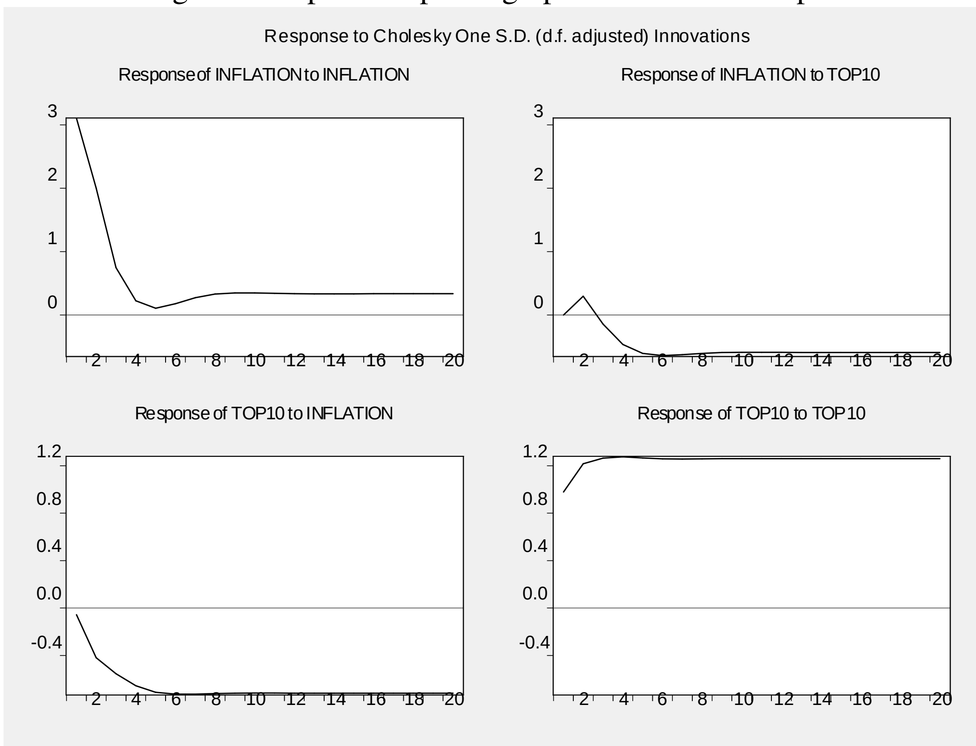


Figure 5: Impulse response graph: Inflation and Top1w

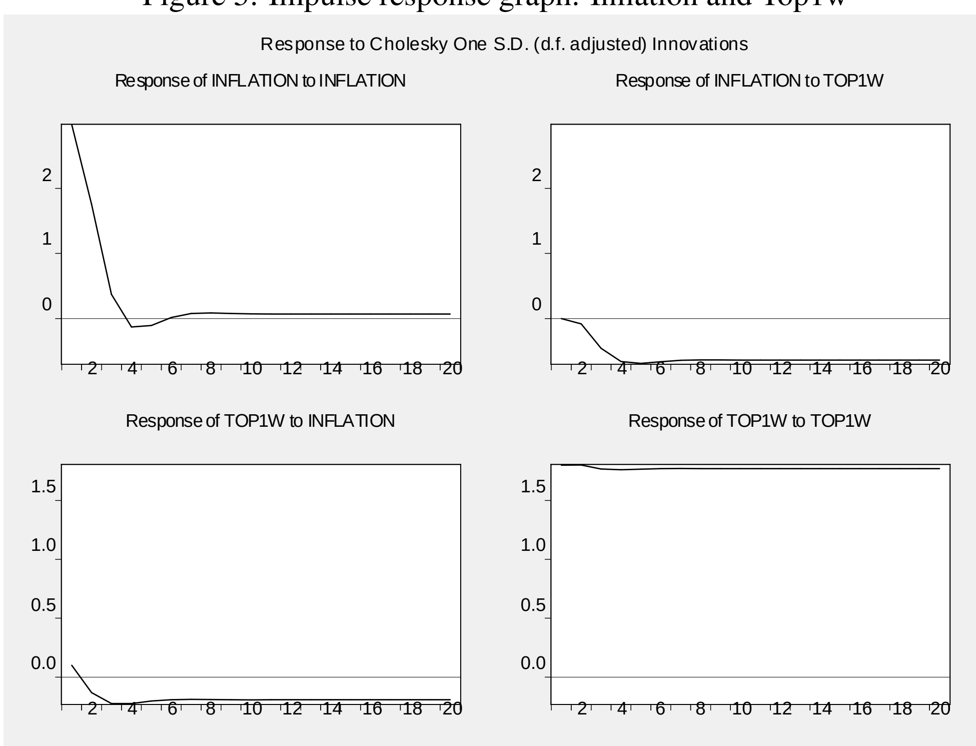
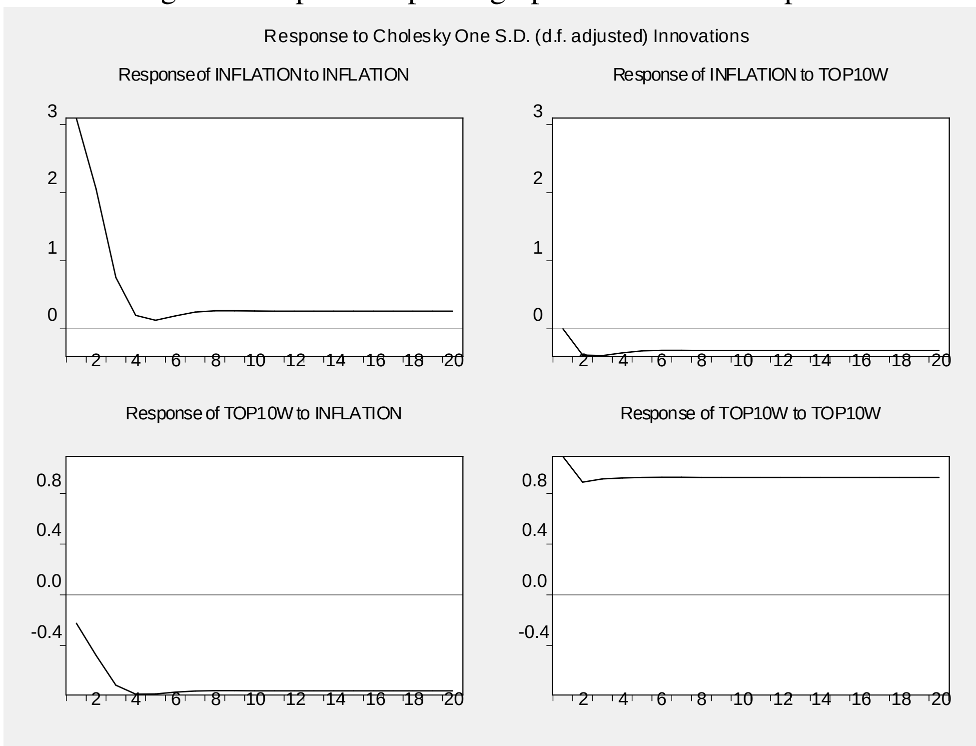


Figure 6: Impulse response graph: Inflation and Top10w



5 The Rest of the World

The previous section provides evidence that there exists a long-run relationship between inequality and inflation in the United States, but what about other countries? In this section I utilize four panel datasets that include up to 32 countries and employ the panel autoregressive distributed lag (ARDL) model and the Arellano-Bond GMM estimator to study the short-run and long-run relationships between inequality and inflation.

5.1 Long-Run Relationship using a ARDL(1,1) model

First I use the panel unit root tests to exmaine the stationarity of the data. For panel data, the panel-based Levin, Lin and Chu test (LLC), Im, Pesaran and Shin test (IPS) Fisher-ADF test and Fisher-PP test are used to examine the degree of integration (Levin, Lin and Chu, 2002; Im, Pesaran and Shin, 2003; Maddala and Wu, 1999 ; Choi, 2001). The tests are based on the ADF test and have the following expression in panel settings:

$$\Delta y_{it} = \alpha_i + \delta_i t + \beta_i y_{i,t-1} + \sum_{j=1}^{p_i} \theta_{ij} \Delta y_{i,t-j} + \varepsilon_{it}, \quad i = 1, \ldots, N, \ t = 1, \ldots, T \tag{7}$$

where α_i and $\delta_i t$ are individual and trend effects which may be set to zero if desired; y_i is the series of observations for country i, p_i is the number of lags selected for the ADF regression, ε_{it} are independently and normally distributed random variables for all i and t with zero means and finite heterogenous variances.

The LLC test assumes that the coefficients of the autoregressive term is homogeneous. That is, $H_0 : \beta_i = \beta = 0 \ \forall i$, against the alternative $H_1 : \beta_i = \beta < 0 \ \forall i$, which requires all individual series to be stationary.

The IPS test allows for the heterogeneity in the autoregressive coefficients. That is, $H_0 : \beta_i = 0$ $\forall i$ against $H_1 : \beta_i < 0, i = 1, \ldots, N_1; \beta_i = 0, i = 1, \ldots, N$, which allows for some of the individual series to be integrated.

The Fisher-ADF and Fisher-PP tests have the same alternative hypothesis as the IPS test and they combine the p-values from individual unit root tests. These tests use π_i to represent the p-value from individual unit root test for each cross-section i, then

$$-2 \sum_{i=1}^{N} ln(\pi_i) \rightarrow \chi^2_{2N} \tag{8}$$

$$Z = \frac{1}{\sqrt{N}} \sum_{i=1}^{N} \Phi^{-1}(\pi_i) \rightarrow N(0,1) \tag{9}$$

where Φ^{-1} is the inverse of the standard normal cumulative distribution fuction.

The first panel dataset I use includes *Top1* of six countries from 1921-2010. The other inequality measures that I did have for the United States are not available. In the second dataset, I expand the number of countries to 13 but it can only cover the period 1981-2010.[3] In the third and fourth

[3] *Top10* is not included in the first two datasets because of data limitation.

dataset, I use the disposable Gini index and the market Gini index as inequality measures. These measures of inequality are available for 32 countries for the period 1976-2015.

The LLC, IPS, Fisher-ADF and Fisher-PP tests results are shown in Table 6. In all datasets, inflation is $I(0)$ and inequality measures *Top1*, Gini(disp) and Gini(mkt) are $I(1)$. Since the variables have mixed order of integration, the error correction model is not appropriate, instead, we can apply the panel Autoregressive Distributed Lag (ARDL) model to the datasets.

Table 6: Panel unit root tests results

Variable	LLC	IPS	Fisher-ADF	Fisher-PP
Dataset 1:				
Inflation (6 countries: 1921-2010)	**-7.3489**	**-8.0337**	**91.0201**	**93.3086**
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Top1 (6 countries: 1921-2010)	**-2.0101**	-1.55279	18.0192	16.6949
	(0.0222)	(0.0602)	(0.1151)	(0.1614)
Δ*Top1* (6 countries: 1921-2010)	**-22.8741**	**-21.5944**	**173.245**	**170.516**
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Dataset 2:				
Inflation (13 countries: 1981-2010)	**-9.8688**	**-8.9184**	**127.265**	**163.238**
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Top1 (13 countries: 1981-2010)	**-2.5560**	-1.54478	35.4249	24.5811
	(0.0053)	(0.0612)	(0.1028)	(0.5428)
Δ*Top1* (13 countries: 1981-2010)	**-12.6621**	**-13.4779**	**203.469**	**258.436**
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Dataset 3:				
Inflation (32 countries: 1976-2015)	**-5.5829**	**-5.3116**	**145.172**	**159.585**
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Gini(disp) (32 countries: 1976-2015)	**-3.2024**	2.0942	56.8921	52.2853
	(0.0007)	(0.9819)	(0.7236)	(0.8523)
ΔGini(disp) (32 countries: 1976-2015)	**-17.4882**	**-11.5568**	**277.380**	**278.795**
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Dataset 4:				
Inflation (32 countries: 1976-2015)	**-5.5829**	**-5.3116**	**145.172**	**159.585**
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Gini(mkt) (32 countries: 1976-2015)	**-3.8687**	1.5753	77.2682	48.7341
	(0.0001)	(0.9424)	(0.1234)	(0.9214)
ΔGini(mkt) (32 countries: 1976-2015)	**-8.7692**	**-10.5858**	**250.001**	**255.751**
	(0.0000)	(0.0000)	(0.0000)	(0.0000)

Note: P-values are in parentheses, and bold letters indicate significant at 5% or better.
The optimal lag length is selected by the Schwarz Information Criterion.

More specificlly, to study the long-run relationship between inflation and inequality, for panel time series data with mixed order of integration, we can apply the ARDL model with the mean group (MG) estimator and the pooled mean group (PMG) estimator introduced by Pesaran, Shin and Smith (1995, 1999).

Consider the following long-run equation:

$$y_{it} = \theta_{0i} + \theta_{1i} x_{it} + \mu_{it} \tag{10}$$

where y_{it} is the rate of inflation, and x_{it} is the measure of income inequality. We expect a negative long-run relationship between inflation and income inequality, thus, we would expect $\theta_{1i} < 0$. The Schwarz Criterion suggests using the ARDL(1,1) model:

$$y_{it} = \mu_i + \beta_i y_{i,t-1} + \alpha_{1i} x_{it} + \alpha_{2i} x_{i,t-1} + \varepsilon_{it} \tag{11}$$

and the error correction equation is:

$$\Delta y_{it} = \phi_i (y_{i,t-1} - \theta_{0i} - \theta_{1i} x_{it}) - \alpha_{2i} \Delta x_{it} + \varepsilon_{it} \tag{12}$$

where

$$\theta_{0i} = \frac{\mu_i}{1 - \beta_i}, \quad \theta_{1i} = \frac{\alpha_{1i} + \alpha_{2i}}{1 - \beta_i}, \quad \phi_i = \beta_i - 1$$

Both the MG and PMG estimations assume there exists a long-run relationship between inflation and income inequality. The MG approach estimates N separate regressions and calculates the means of long-run and short-run coefficients. The PMG estimation constrains the long-run coefficients to be identical but allows short-run coefficients and error variances to differ across groups. The PMG estimation allows us to estimate a homogenous long-run coefficient. The MPG estimation is more efficient but it has the risk of being inconsistent. The Hausman test can be used to evaluate the consistency of the PMG estimator (Hausman,1978). The null hypothesis is that both the MG and the PMG estimators are consistent. The alternative hypothesis is that only the MG estimator is consistent. If we fail to reject the null hypothesis, we can trust the result of the PMG estimator, which is more efficient.

Datasets 1 and 2 use the top 1 percent income share as a measure of inequality. Dataset 1 contains 6 countries for the period 1921-2010. Dataset 2 contains 13 countries for the period 1981-2010. Dataset 3 uses the disposable Gini index to measure inequality and contains 32 countries from 1976-2015. Dataset 4 uses the market Gini index to measure inequality and contains 32 countries from 1976-2015. The long-run coefficients of the measure of inequality, the speed of adjustments and the Hausman test results are shown in Table 7-10.

Table 7: ARDL(1,1) long-run equation: Dataset 1.

Variable	Mean Group Estimator	Pooled Mean Group Estimator
Top1, (θ_1)	**-0.7531**	**-0.5544**
	(0.033)	(0.000)
Speed of adjustment, (ϕ)	**-0.3610**	**-0.3498**
	(0.000)	(0.000)
Hausman Test:	p-value=0.5403	

Note: Bold letters indicate significant at 5% or better.
P-values are in parentheses.

Table 8: ARDL(1,1) long-run equation: Dataset 2.

Variable	Mean Group Estimator	Pooled Mean Group Estimator
Top1, (θ_1)	-0.3320	-0.1232
	(0.247)	(0.218)
Speed of adjustment, (ϕ)	**-0.3946**	**-0.3435**
	(0.000)	(0.000)
Hausman Test:	p-value=0.4776	

Note: Bold letters indicate significant at 5% or better.
P-values are in parentheses.

The Hausman tests indicate that the PMG estimators are consistent in all four datasets, so we trust the results the PMG estimators. In dataset 1, 3 and 4, the long-run coefficients of inequality are negative and significant. In dataset 2, the coefficient of inequality is not significant, but it has the correct sign. Therefore, we can conclude that the negative long-run relationship between inequality and inflation is a near universal rule.

Table 9: ARDL(1,1) long-run equation: Dataset 3.

Variable	Mean Group Estimator	Pooled Mean Group Estimator
Gini(disp), (θ_1)	2.0844	**-0.6856**
	(0.468)	(0.000)
Speed of adjustment, (ϕ)	**-0.3736**	**-0.3315**
	(0.000)	(0.000)
Hausman Test:	p-value=0.3395	

Note: Bold letters indicate significant at 5% or better.
P-values are in parentheses.

Table 10: ARDL(1,1) long-run equation: Dataset 4.

Variable	Mean Group Estimator	Pooled Mean Group Estimator
Gini(mkt), (θ_1)	-0.5725	**-0.7478**
	(0.781)	(0.000)
Speed of adjustment, (ϕ)	**-0.4425**	**-0.3696**
	(0.000)	(0.000)
Hausman Test:	p-value=0.9324	

Note: Bold letters indicate significant at 5% or better.
P-values are in parentheses.

5.2 Short-Run Relationship Using the Arellano-Bond GMM Estimator

The long-run relationship has been proved, but is there a short-run effect running from inequality to inflation? We are interested in estimating the parameters of the following dynamic model:

$$y_{it} = \alpha y_{i,t-1} + \beta x_{it} + \mu_i + \varepsilon_{it} \tag{13}$$

where y_{it} is the dependent variable (inflation), x_{it} is the explanatory variable (income inequality), μ_i is the fixed effect. $y_{i,t-1}$ is correlated with the individual fixed-effect μ_i.

Since inflation may have a reverse effect on inequality, we have an endogeneity problem. Thus the causal effects from inequality to inflation cannot be derived directly from equation 13. If we can find the proper instrumental variables for inequality, the problem will be solved. In this section, I use the Arellano-Bond GMM estimator which uses the lagged values of inequality as instruments to find the short-run effect of inequality on inflation. Differencing the model yields:

$$\Delta y_{it} = \alpha \Delta y_{i,t-1} + \beta \Delta x_{it} + \Delta \varepsilon_{it} \tag{14}$$

The μ_i are gone, but the $y_{i,t-1}$ in $\Delta y_{i,t-1}$ is a function of the $\varepsilon_{i,t-1}$, so $\Delta y_{i,t-1}$ is correlated with ε_{it}. Also, Δx_{it} is correlated with $\Delta \varepsilon_{it}$ if there exists a reverse causality from y_{it} to x_{it}.

Assuming ε_{it} is i.i.d over i and t, Anderson and Hsiao (1981) use lagged values of the variables as instruments to solve the endogeneity problem. For example, $\Delta y_{i,t-2}$ would be a valid instrument for $\Delta y_{i,t-1}$. Arellano and Bond (1991) use GMM framework to construct estimators based on further lagged levels of endogenous variables. For period p, $p-2$ instruments are available for an endogenous variable. For example, in period 3, y_{i1} is a valid instrments for Δy_{i3}; In period 4, y_{i1} and y_{i2} are valid instrments for Δy_{i4} and so on. Treating variables as endogenous quickly increases the size of the instrument matirx, which can cause the GMM estimators to perform poorly. To solve this problem, I set the maximum number of 2 lagged levels of the endogenous variable (inequality) to be included as instruments for $y_{i,t-1}$ and x_{it}.

To get a consistent estimate, we need apply Arellano-Bond test to make sure that there is no autocorrelation in first-differenced errors. A valid instrumental variable should be uncorrelated with the error term. The Sargan test can be used to examine the validity of the instrumental variable. Among the 4 panel datasets, only dataset 2 passes both the Arellano-Bond test and Sargan test. Here we just studies the effect of Δ*Top1* on inflation in the 13 countries from 1980-2010.

The results of the short-run effects using Arellano-Bond GMM estimator are shown in Table 11 below. The Arellano-Bond test indicates there is no autocorrelation in first-differenced errors, and the Sargan test confirms the validation of the instruments. The coefficient of the *Top1* is negative and significant at the 5 percent confidence level, indicating that inequality has a negative short-run effect on inflation. When the top 1 percent income share increases by 1 unit (for example, increase from 10% to 11%), the inflation rate decreases by 0.125 unit (for example, decrease from 5.125%

to 5%).

Table 11: Arellano-Bond GMM estimator results (13 countries: 1980-2010)

Variable	Coefficient	P-value
Inflation(-1)	**0.655**	0.000
Top1	**-0.125**	0.050
Arellano-Bond test:	z(order 2)=0.416	0.677
Sargan test:	chi-square(306)=271.987	0.920

Note: P-values are in parentheses, and bold letters indicate significant at 5% or better.

6 Conclusion

The Median Voter Theorem and the Melzer-Richard model indicate that redistribution policies depend on benefits of the majorities or the median voters. If this is true, we are supposed to see a positive relationship between inequality and inflation since inflation tax redistributes income and wealth from the affluent to the poor. However, the Robin Hood Paradox challenges the Median Voter Theorem and the Melzer-Richard model, and we find that inflation and inequality were moving in the opposite directions in the long run.

What is missing in the literature is a solid econometric analysis about this relationship and the causal effect from inequality to inflation. The major contribution of this paper is examining both the short-run and long-run relationship between inequality and inflation. The vector error correction model finds a negative long-run relationship in the United States. Utilizing four panel datasets that include up to 32 countries and employing the autoregressive lag distributive model, the long-run relationship is confirmed to be near a universal rule. The short-run analysis employing the Arellano-Bond GMM method solves the reverse causality problem by using lagged values of inequality as instruments. The result indicates that there exists a negative causal effect from inequality to inflation in the short run, which provide further evidence against the Median Voter Theorem. The outcome of inflationary policies is the result of the debate between the affluent and the poor. A rise in inequality comes with an increase in the political power of the economic elite since economic inequality and political inequality are closely related. The affluent would use their greater influence to pursue lower inflation.

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