How Does Inflation Redistribute Income?*

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(Preliminary. Comments welcome.)

ABSTRACT

This paper investigates how inflation redistributes income, on a sample of 110 countries, for the period 1970-2013. In order to deal with endogeneity, it instruments inflation with oil price movements. Results indicate that exogenous inflation reduces both the Gini coefficient and the top 1 percent share of income. The effects are present when real interest rates are low and when top marginal income tax rates are high. The effects are smaller in more developed countries and have decreased over time, which may be explained by the decline in the marginal tax rates and the financial development.

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I. Introduction

One element of the consensus in macroeconomics prior to the advent of the global financial crisis in 2007 was that inflation should be low and stable (see Goodfriend (2007) and Woodford (2009), for example). Accordingly, many central banks adopted inflation targets of around 2 percent. With the emergence of the crisis, some challenged this consensus. Blanchard, Dell'Ariccia, and Mauro (2010) questioned whether the distortions from higher inflation are really so high, that is, if they are higher than the potential benefits of avoiding the zero interest rate bound. Rogoff (2008) proposed using inflation as one instrument for reducing public debt. Similar narratives are present in Aizenman and Marion (2011), who argued that raising inflation to 6 percent could erode U.S. public indebtedness by 20 percent within four years. Finally, Coibion, Gorodnichenko, Kueng, and Silvia (2012) argued that keeping inflation low has had negative effects on income equality, finding that the disinflationary policies in the U.S. in the early 1980s led to a persistently higher inequality in the 1990s.

Numerous studies had already investigated the relationship between inflation and income inequality before Coibion, Gorodnichenko, Kueng, and Silvia (2012). Beginning with Bach and Ando (1957), different studies have been reaching different conclusions regarding the redistributive effects of inflation. Things have been additionally complicated by the body of literature arguing that inequality may also affect inflation (e.g. Al-Marhubi (2000)), implying that causality may be difficult to establish.

The present paper aims to reassess how inflation affects income inequality, filling in the gaps in the existing literature. To begin with, it will account for the apparent endogeneity between inequality and inflation, by using exogenous variation in inflation, provided by oil price movements. Furthermore, it will acknowledge the possibility that inflation may affect inequality only under certain conditions. Finally, it will be the most comprehensive study on the issue, covering 110 countries, both developed and developing, over a time period of 40 years (1970-2013).

The paper proceeds as follows. Section II gives a brief overview of the existing empirical literature on the relationship between inflation and inequality. Section III presents the

methodology, while section IV the data. Section V provides the basic results, section VI delves into the underlying mechanisms that can explain the relationship and section VII conducts some further investigation and robustness checks. Conclusions are provided in Section VIII.

II. Literature review

The inflation-inequality nexus has attracted researchers' attention for some time. No consensus has been reached on the issue. Studies on the U.S. have usually found that inflation *reduces* inequality. Bach and Ando (1957) analyse the redistributional effects of inflation in the U.S. during 1939-1952, finding that inflation has decreased inequality, by shifting income from business profits to wages and salaries, and from lenders to borrowers. Blinder and Esaki (1978), Blank and Blinder (1985) find that inflation has benefitted the poor in the U.S. Jantti (1994), Bishop, Formby, and Sakano (1995) and Mocan (1999) have also found that inflation improves income equality. Dincer (2014) is an exception. Using panel data for U.S. states, he finds that inflation increases income inequality.

Cross-country studies, on the other hand, predominantly document adverse effects of inflation on equality. Romer and Romer (1998) and Easterly and Fischer (2001) use cross-country data and find that inflation hurts the poor most severely. Blejer and Guerrero (1990) and Silber and Zilberfarb (1994) find that inflation has raised income inequality in the Philippines and Israel, respectively.

Several other studies have pointed out that the effects of inflation on inequality are non-linear. Bulir and Gulde (1995), Bulir (2001), Galli and van der Hoeven (2001) and Monnin (2014) find a U-shaped relationship - when inflation is low, higher inflation lowers inequality, but after inflation reaches some threshold, it begins to increase inequality. Similar findings are presented by Dollar and Kraay (2002) who find that stabilisation from high inflation increases the income share of the poor.

At the same time, several studies have argued that inequality can also affect inflation. As Beetsma and van der Ploeg (1996) argue, in democratic societies with high inequality,

the median voter would prefer pro-poor policies, i.e., policies that redistribute income from the rich to the poor. If inflation is perceived as such a policy, higher inequality will result with higher inflation. A similar mechanism is proposed by Dolmas, Huffman, and Wynne (2000), who argue that with higher inequality, the median voter prefers higher inflation as a way of financing higher government expenditures. Crowe (2006) and Albanesi (2007) also provide models in which higher inequality leads to higher inflation, although for different reasons. In their models, greater income inequality leads to greater inequality in political influence, with the rich having greater political power. If the rich perceive that inflation will favour them, because they may be insulated from the inflation tax, differently from the poor, they may push for inflationary policies. Al-Marhubi (1997) and Al-Marhubi (2000) document empirically that countries with higher inequality have also higher inflation.

Despite this, all studies investigating the redistributional effects of inflation have ignored this potential reverse causality. The main contribution of the present study is to address this shortcoming.

III. Methodology

To address the endogeneity between inflation and income inequality, one needs to find an exogenous source of variation in inflation. Such variation may be provided by the oil prices. Oil prices are largely unpredictable and are likely to be unrelated to income inequality. On the other hand, they are likely to be correlated with inflation, because they are input in the production process for many products. Therefore, oil price movements are likely to satisfy the two conditions required for a good instrument.

To obtain a cross-sectional variability of the instrument, one also needs to find a source of variation across countries in the sensitivity of inflation to movements in oil prices. We proxy this sensitivity by the share of the oil imports in the total imports of the country. To eliminate sudden rapid changes in the share of oil in the total imports, five-years moving average are used. Hence, our instrument is defined as a product of the annual change in the oil prices and the five-year moving average of the share of oil imports in total imports.

Therefore, the model that is used is as follows:

$$inequality_{i,t} = f(inflation, controls_{i,t}) \quad (1)$$

$$inflation_{i,t} = f(oil\_shock_{i,t}, controls_{i,t}) \quad (2)$$

Where subscripts i and t denote countries and years and controls are control variables which are usually found in the literature on income inequality.

IV. Data

Data on oil prices are from the World Bank. The average value of Brent, Dubai Fateh and West Texas Intermediate is used. It is expressed in nominal USD per barrel. Data on imports of oil and total imports are from United Nation's Comtrade, in nominal USD. Imports of oil refer to the category "mineral fuels, mineral oils and products of their distillation" (code 27). Data on inflation are from the World Bank's World Development Indicators (WDI).

Data on income inequality are from the Standardized World Income Inequality Database (SWIID), version 4, of Solt (2013). This is the most comprehensive database on income inequality at the moment, with continuous data series for approximately 150 countries, since 1960. It uses the data from the World Income Inequality Database (WIID) of UNU-WIDER (2008) (previously known as the Deninger and Squire (1996) dataset), which in turn uses numerous different sources. Because of the differences in the inequality measures in the WIID (e.g. some use consumption, some income, some expenditure; some use before taxes, some after; some are based on households, some on individuals etc.), SWIID standardizes them, i.e. adjusts the different measures to the Luxembourg Income Study (LIS) definition. The adjustment is done using regression techniques. The end result is a standardized database on Gini coefficient by countries, calculated on household adult-equivalent income (both market and disposable, i.e. before and after government redistribution), and top 1% share of income, calculated on market income. In addition to standardizing the different data, SWIID also uses

multiple imputation techniques to fill in the missing data points. Consequently, it produces continuous series for all the countries.

Because of the imputation, proper use of the SWIID requires accounting for imputation variability. However, this is not straightforward to combine with the panel instrumental variable (IV) estimator that we use. Consequently, we will just use the mean values of the imputed inequality measures, as Acemoglu, Naidu, Restrepo, and Robinson (2010), Ostry, Berg, and Tsangarides (2013) and Solt (2011) (among others) have done. Reassuringly, Jenkins (2015) (pp. 666-668) finds that ignoring imputation variability and using the mean values of the imputed inequality measures makes little difference.

In addition to these basic variables, the analysis will also include control variables which are usually met in the literature on income inequality. These are: GDP growth, government size, top marginal income tax rate, financial development, openness, real interest rates and stock exchange index. The definitions and sources of the control variables are presented in Table 1 below.

All data are on annual frequency, for the period 1970-2013. 108 countries are included in total. They are shown in Table A4 in the Appendix. Approximately 2000 country-year observations are available in the final sample. To eliminate episodes with hyperinflation, which may contaminate the results, observations corresponding to the highest 30 data points on inflation have been removed. This corresponds to approximately 1.5 percent of the sample and covers country-years when inflation exceeded 125 percent per year.

Summary statistics and correlation matrix are presented in Tables A1 and A2 in the Appendix. Unit root tests, shown in Table A3 in the Appendix, indicate that the main variables (Gini, top 1%, inflation and oil shock) are likely to be stationary, as the null hypothesis of unit root can be rejected at 5 percent level of significance in most of the cases. Most of the control variables seem to be stationary, too, except the tax rate and the credit level, which seem to be trend stationary. Hence, we conclude that the variables are suitable for the panel IV estimator.

Table 1 - Control variables

Variable	Definition
GDP growth	Annual growth of GDP per capita, in %. From World Bank's WDI.
government size	General government final consumption expenditure, as % of GDP. From World Bank's WDI.
tax	Top marginal income tax rate, in %. From Economic Freedom of the World dataset of Gwartney, Lawson, and Hall (2013).
credit	Domestic credit to private sector (% of GDP). From World Bank's WDI.
openness	Exports of goods and services, plus imports of goods and services, as % of GDP. From World Bank's WDI.
interest rate	Real interest rate, calculated as the nominal deposit interest rate, corrected by the inflation, in %. The deposit interest rate is from World Bank's WDI. For US, it is from the OECD statistics (due to unavailability of data on WDI).
stock exchange	Annual change in the S&P 500 index. From Yahoo Finance.

V. Basic results

We first present the results of the OLS estimation of equation 1. They are given in Table 2. The first column shows the results for the Gini coefficient, the second - for the top 1% share of income. Inflation seems to be associated with a decline in both Gini and the top 1% share of income. The effects are rather small, however - increase in inflation by 1 percentage point would be associated with a decline in Gini by 0.03 and in the top 1% share by 0.01 percentage points.

Columns 3 and 4 of the same table show the results when inflation squared is included. Both the linear and quadratic terms of inflation are significant, both for Gini and for the top 1% share of income. The linear terms are negative, the quadratic terms are positive, implying that the effect of inflation on income inequality is U-shaped - inflation initially reduces inequality, but after it reaches some threshold, it starts to increase it. The threshold, in both cases, is around 70 percent. The effects are still small, though. Increase in inflation from 2 to 3 percent, would reduce Gini by 0.09 percentage points and the top 1% share of income by 0.04 percentage points.

Table 2 - OLS results

	(1) Gini	(2) Top 1%	(3) Gini	(4) Top 1%
			inflation2	inflation^2
inflation	-0.031***	-0.014***	-0.092***	-0.039***
	(0.012)	(0.005)	(0.022)	(0.010)
inflation^2			0.0007***	0.0003***
			(0.000)	(0.000)
GDP growth	-0.063**	0.017	-0.067**	0.015
	(0.027)	(0.012)	(0.027)	(0.012)
interest rate	-0.107***	-0.046***	-0.119***	-0.051***
	(0.022)	-0.01	(0.022)	(0.010)
stock exchange	0.009	-0.005*	0.009	-0.005*
	(0.006)	(0.003)	(0.006)	(0.003)
tax	0.019**	-0.009**	0.022**	-0.008*
	(0.009)	(0.004)	(0.010)	(0.004)
government size	0.145***	0.028	0.137***	0.025
	(0.044)	(0.020)	(0.044)	(0.020)
credit	0.027***	0.022***	0.025***	0.021***
	(0.005)	(0.002)	(0.005)	(0.002)
openness	0.000	-0.001	-0.000	-0.001
	(0.006)	(0.003)	(0.006)	(0.003)
constant	34.166***	8.641***	34.763***	8.881***
	(1.051)	(0.472)	(1.065)	(0.479)
Observations	2,083	2,083	2,083	2,083
R squared	0.044	0.103	0.049	0.107
Number of c.s.	112	112	112	112
Threshold			68.21	71.67

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

The results obtained when inflation is instrumented with the oil shocks are presented next, in Table 3. Columns 1 and 2 show the results for the Gini; column 1, the first stage regression (i.e. equation 2 from above), column 2, the second stage regression (i.e. equation 2 from above). Columns 3 and 4 show the same for the top 1% share of income. It can be seen that the instrument is not weak. The F test for its exclusion is 9.24, which is close to the rule-of-thumb value of 10. Somewhat surprisingly, its coefficient is negative, implying that

higher increase in oil prices leads to lower inflation. Moving to the second stage regression, it can be seen that these results are about 10 times stronger than the OLS results from before. Increase in inflation by 1 percentage point now implies a decline in Gini by 0.3 percentage points and in the top 1% share of income by 0.2 points.

Table 3 - IV results

	(1)	(2)	(3)	(4)
	First stage	Second stage	First stage	Second stage
	Inflation	Gini	Inflation	Top 1%
inflation		-0.269		-0.183**
		(0.188)		(0.086)
GDP growth	-0.564***	-0.215*	-0.564***	-0.088*
	(0.050)	(0.113)	(0.050)	(0.048)
interest rate	-1.229***	-0.393*	-1.229***	-0.246**
	(0.033)	(0.229)	(0.033)	(0.108)
stock exchange	0.065***	0.025*	0.065***	0.008
	(0.012)	(0.014)	(0.012)	(0.008)
tax	0.175***	0.060*	0.175***	0.005
	(0.019)	(0.035)	(0.019)	(0.016)
government size	-0.878***	-0.053	-0.878***	-0.056
	(0.085)	(0.172)	(0.085)	(0.057)
credit	-0.021**	0.023***	-0.021**	0.015***
	(0.009)	(0.006)	(0.009)	(0.003)
openness	-0.021**	-0.004	-0.021**	-0.004
	(0.011)	(0.008)	(0.011)	(0.004)
oil shock	-0.104***		-0.104***	
	(0.034)		(0.034)	
Observations		2031		2031
Number of countries		108		108
F test for exclusion of instruments	9.24		9.24	

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Next, we add inflation squared in the IV regression. Following Angrist and Pischke (2009), p. 143 and Wooldridge (2001), p. 237, we instrument the squared inflation with the square of the fitted value for the inflation obtained from the first stage regression. These results are presented in Table 4. Columns 1-3 show the results for the Gini, columns 4-6 for the top 1%

share of income. The instruments are not weak, again, the F value for their exclusion being much higher than 10. The coefficients on the oil shock variable in the first stage regressions are again negative, but they seem to be outweighed by the positive coefficients of the square of the fitted inflation, implying in the end that higher increases in oil prices lead to higher inflation. From the second stage regressions, shown in columns 3 and 6, one can see that both inflation and inflation squared are significant (at 10 percent). The linear term of inflation is again negative, while inflation square is positive, implying a U-shaped effect again. Until inflation of about 75 percent per annum, increase in inflation lowers inequality. Afterwards, it starts to increase it. The effects are now much more stronger than before. Increase in inflation from 2 to 3 percent would be associated with a decline in Gini by 0.9 percentage points and a decline in the top 1% share of income by 0.5 percentage points.

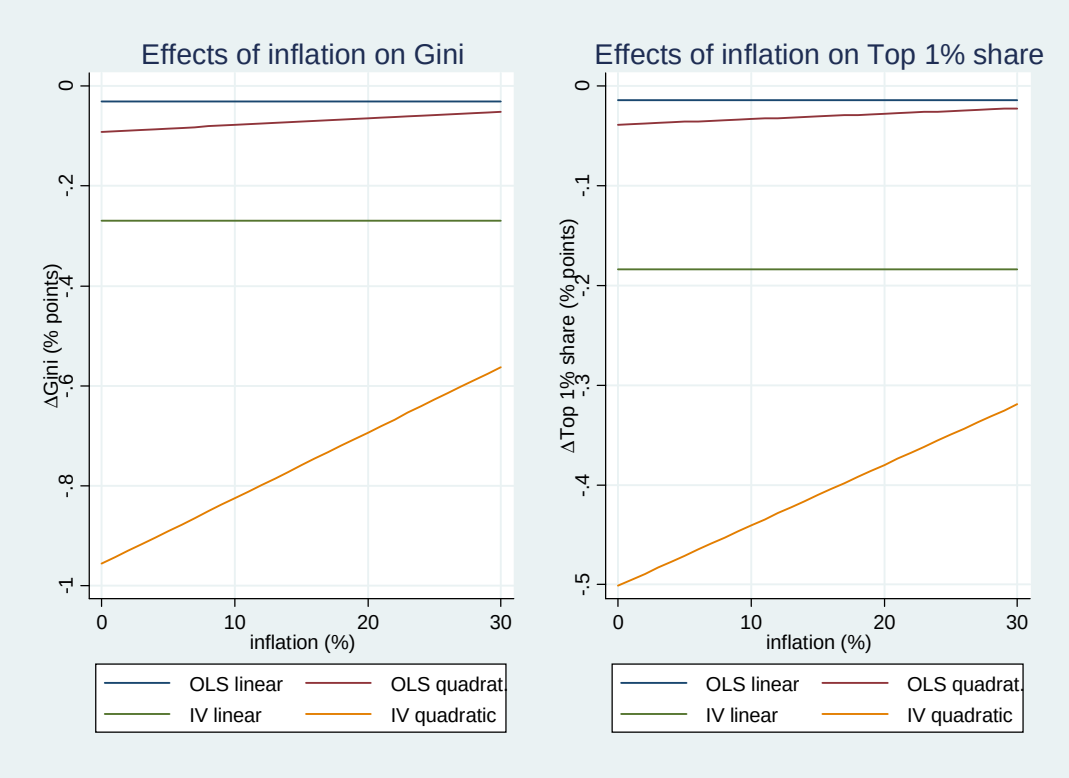
Table 4 - IV results with squared inflation

	(1) First stage Inflation	(2) First stage Inflation^2	(3) Second stage Gini	(4) First stage Inflation	(5) First stage Inflation^2	(6) Second stage Top 1%
inflation			-0.956*			-0.501*
			(0.531)			(0.269)
inflation^2			0.007**			0.003**
			(0.003)			(0.001)
GDP growth	-0.387***	-11.419**	-0.310*	-0.387***	-11.419**	-0.139
	(0.053)	(5.015)	(0.179)	(0.053)	(5.015)	(0.091)
interest rate	-0.784***	-1.824	-0.679*	-0.784***	-1.824	-0.376*
	(0.057)	(5.459)	(0.403)	(0.057)	(5.459)	(0.205)
stock exchange	0.046***	1.957*	0.033*	0.046***	1.957*	0.010
	(0.012)	(1.109)	(0.020)	(0.012)	(1.109)	(0.010)
tax	0.129***	0.654	0.119*	0.129***	0.654	0.041
	(0.019)	(1.801)	(0.068)	(0.019)	(1.801)	(0.034)
government size	-0.679***	-29.070***	-0.221	-0.679***	-29.070***	-0.199
	(0.086)	(8.149)	(0.281)	(0.086)	(8.149)	(0.142)
credit	-0.024***	0.550	0.001	-0.024***	0.550	0.007
	(0.009)	(0.852)	(0.015)	(0.009)	(0.852)	(0.008)
openness	-0.010	1.347	-0.014	-0.010	1.347	-0.010
	(0.011)	(1.023)	(0.012)	(0.011)	(1.023)	(0.006)
oil shock	-0.073**	-5.084		-0.073**	-5.084	
	(0.034)	(3.204)		(0.034)	(3.204)	
(fitted inflation)^2	0.008***	1.546***		0.008***	1.546***	
	(0.001)	(0.084)		(0.001)	(0.084)	
Observations			2,031			2,031
Number of countries			108			108
Turning point			72.8			82.6
F test instruments	49.4	177.2		49.4	177.2	

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

A comparison between the effects from the OLS and IV estimations, for the specifications with and without inflation squared, is given on Figure I. For better clarity, we plot the effects for inflation between 0 and 30 percent per annum. This covers approximately 95 percent of our observations. One can easily see that the IV effects are much bigger than the OLS, and that the effects with inflation squared are much bigger than the effects with just the linear term of inflation.

FIGURE I: EFFECTS OF INFLATION ON INEQUALITY



In the remainder of the paper we will continue with only specifications that include the squared inflation. We prefer this specification for several reasons. First, it is more reasonable that the effect of inflation on inequality is declining with inflation, because a constant effect implies that policy makers can indefinitely lower inequality by raising inflation. Second, both inflation and inflation squared are statistically significant in the second-stage IV regressions (columns 3 and 6 from Table 4). Third, the first-stage regressions are also clearly better in the specifications with inflation squared, because in them oil price increases have a positive effect on inflation, differently from the specifications with just the linear term of inflation.

VI. Channels through which inflation may affect inequality

Why would inflation lower income inequality? The literature identifies several potential channels through which this may occur (see Kane and Morisett (1993), Crowe (2006), Doepke and Schneider (2006), Coibion, Gorodnichenko, Kueng, and Silvia (2012)). The first channel is through the erosion of the real value of the assets people hold, and hence the income from them, which is an important part of the income of the better-off individuals, and a negligible part of the income of the worse-off individuals. The second channel is through the tax bracket effect - inflation raises nominal income, and if taxes are progressive, people may fall into a higher tax group. As a result, higher-income individuals' net income will decline, which may reduce inequality. The third channel is through government expenditure. Inflation may serve as a windfall for the government, due to the higher revenues and the erosion of public debt, which may then lead to higher social transfers, which may reduce income inequality.[1]

We evaluate these three possibilities in turn. We begin by assessing whether redistribution is going through the erosion of the capital income. To assess this, we estimate the above regression for countries with high and low real interest rates. If results turn out to be present only when the interest rates are low, this can be considered as an argument in favour of this channel. Low interest rates are defined as real interest rates below the median value for the

1. It should be noted that this relationship may turn around at very high levels of inflation. If inflation is very high, government revenues may fall, due to time lags in collection, and reduce real government spending (the Olivera-Tanzi effect). This effect is likely to benefit the net tax payers (i.e. the rich).

whole sample, which happens to be 0.9 percent. Table 5 shows these results. It can be seen that the effect is present only when real interest rates are low, supporting the hypothesis that inflation is reducing income inequality through lowering the capital income for higher-income individuals.

Table 5 - Results for interest rate

	High interest rate		Low interest rate	
	Gini	Top 1%	Gini	Top 1%
inflation	-0.005	0.587	-0.524***	-0.182**
	(1.148)	(1.246)	(0.178)	(0.081)
inflation^2	0.009	0.006	0.002***	0.001*
	(0.017)	(0.019)	(0.001)	(0.000)
GDP growth	0.272	0.499	-0.241**	-0.063
	(0.357)	(0.388)	(0.100)	(0.045)
interest rate	-0.076	0.099	-0.709**	-0.260**
	(0.390)	(0.423)	(0.286)	(0.130)
stock exch.	0.023	0.003	0.030	0.010
	(0.021)	(0.023)	(0.020)	(0.009)
tax	-0.051	-0.168	0.059*	0.007
	(0.118)	(0.129)	(0.030)	(0.014)
gov. size	0.996	1.259	-0.002	-0.032
	(0.969)	(1.051)	(0.135)	(0.061)
credit	0.018	0.014	0.007	0.020***
	(0.031)	(0.034)	(0.010)	(0.004)
openness	0.008	-0.005	0.005	0.001
	(0.015)	(0.016)	(0.009)	(0.004)
Observations	1,021	1,021	1,002	1,002
No. countries	98	98	95	95
Turning point	0.253	-50.21	130.9	174.7
F test instr. inf.	0.99	0.99	4.66	4.66
F test instr. inf2.	0.65	0.65	36.82	36.82

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

To evaluate the second possibility, that the redistribution is going through the tax bracket effect, we observe the differences in the results between countries with high and low top marginal income tax rate. If the results are present only with high marginal income taxes, then redistribution is likely to go through this channel. Again, high marginal income taxes

are defined as taxes above the median value. This happens to be 43 percent. These results are shown in Table 6. It can be seen that inflation is significant only for countries with high taxes, and only in the regression for the Gini coefficient. The insignificance in the top 1% regression is likely due to the notion that the data on the top 1% share of income are gross, i.e. before taxes. Hence, there seems to be support for the hypothesis that the redistribution is going through the tax bracket effect.

Table 6 - Results for top marginal tax rate

	High top marginal tax		Low top marginal tax	
	Gini	Top 1%	Gini	Top 1%
inflation	-0.946**	-0.317	0.400	-0.488
	(0.444)	(0.199)	(0.944)	(0.585)
inflation^2	0.005***	0.001	-0.002	0.004
	(0.002)	(0.001)	(0.007)	(0.004)
GDP growth	-0.282	-0.115	0.039	-0.108
	(0.192)	(0.086)	(0.254)	(0.157)
interest rate	-0.720*	-0.296*	0.284	-0.251
	(0.378)	(0.170)	(0.561)	(0.347)
stock exch.	-0.006	-0.005	-0.005	0.009
	(0.011)	(0.005)	(0.034)	(0.021)
tax	0.071**	-0.011	-0.158	0.015
	(0.030)	(0.014)	(0.160)	(0.099)
gov. size	0.008	-0.066	0.287	-0.149
	(0.094)	(0.042)	(0.485)	(0.301)
credit	-0.009	-0.004	0.021	0.004
	(0.023)	(0.010)	(0.027)	(0.017)
openness	0.030	0.013	0.029*	0.006
	(0.022)	(0.010)	(0.015)	(0.010)
Observations	989	989	1,039	1,039
No. countries	70	70	87	87
Turning point	91.81	146.1	112.5	56.52
F test instr. Inf	13.55	13.55	63.01	63.01
F test instr. Inf2	77.15	77.15	310.95	310.95

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Finally, if the redistribution is going through the higher social spending, the effect is likely to be present in countries in which government transfers increased during the inflationary

episode, but not in countries where it decreased. Hence, to evaluate this channel, one needs to compare the results for country-years when government transfers increased and country-years when government transfers decreased. These results are shown in Table 7. It should be noted that the number of observations declines substantially in these estimations (from 2000 to 700), because data on government transfers[2] are available for much fewer country-years. Perhaps because of that the effects appear insignificant both when transfers increase and when transfers decrease. All in all, there is not much evidence that the redistribution is going through the government transfers.

2. Government transfers are proxied by the "subsidies and other transfers" from WDI. It should be noted that apart from the social transfers, these also include government subsidies given to enterprises.

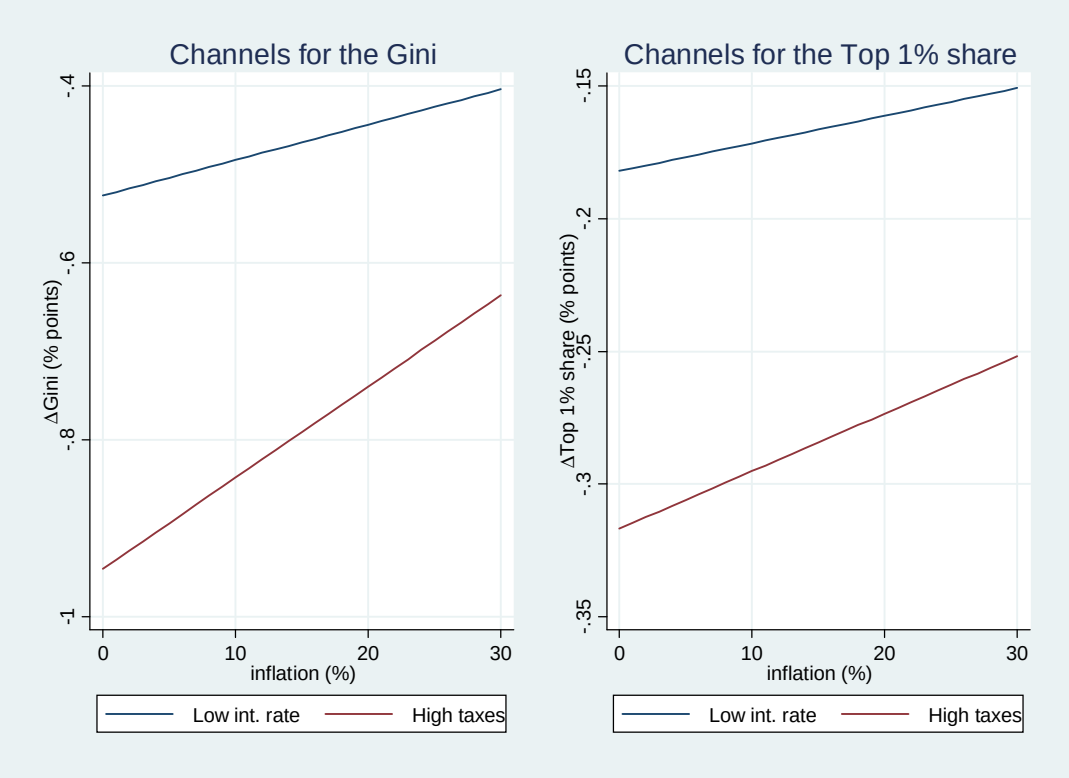
Table 7 - Results for government transfers

	Increase in transfers		Decrease in transfers	
	Gini	Top 1%	Gini	Top 1%
inflation	0.584	7.239	-0.568	-0.659
	(5.545)	(23.641)	(1.041)	(0.809)
inflation2	-0.005	-0.189	0.005	0.006
	(0.148)	(0.631)	(0.009)	(0.007)
GDP growth	0.017	0.416	-0.033	-0.032
	(0.303)	(1.294)	(0.082)	(0.064)
interest rate	0.514	2.891	-0.363	-0.394
	(2.118)	(9.028)	(0.673)	(0.524)
stock exch.	0.008	-0.020	-0.005	-0.007
	(0.014)	(0.058)	(0.013)	(0.010)
tax	-0.073	-0.435	-0.012	-0.013
	(0.301)	(1.285)	(0.045)	(0.035)
gov. size	0.089	1.155	0.042	0.012
	(0.925)	(3.942)	(0.165)	(0.128)
credit	0.016	0.063	-0.018	-0.008
	(0.038)	(0.164)	(0.026)	(0.020)
openness	0.028	0.049	0.002	0.001
	(0.030)	(0.129)	(0.013)	(0.010)
Observations	417	417	305	305
No. countries	78	78	72	72
Turning point	62.56	19.19	53.19	55.88
F test instr. Inf.	11.25	11.25	42.3	42.3
F test instr. Inf2	25.57	25.57	28.53	28.53

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Figure II compares the effects for the two significant channels, lower real interest rates and the tax bracket effects, for the Gini and the top 1% share of income. As on Figure I, we plot the effects for inflation ranging from 0 to 30 percent. It can be seen that the effects are approximately three times stronger for Gini. In addition, the effect of the taxes is approximately twice as strong as the effect of the interest rates.

FIGURE II: COMPARISON OF CHANNELS



VII. Further investigation

We next investigate whether the redistributional effects of inflation are prevalent among countries at different level of development. To do this, we classify the countries into three groups - low income, middle income and high income. We follow the World Bank (WB) classification for this, which classifies countries into four groups - low income, lower-middle income, upper-middle income and high income. To ensure a balance in the size of the groups, we include as low income countries also the countries which the WB treats as lower-middle income, while we treat as middle income countries only WB's upper-middle income countries. We take the WB classification from July 1, 2015. Table A4 in the Appendix shows which country falls into which group.

The results for the three groups of countries are shown in Table 8. For all the three groups, the relationship is U-shaped, as before. The effects increase as one moves down the income ladder - for the middle income countries, they are about twice as high as for the high income countries, while for the low income countries, they are three times higher than for the middle income countries for the Gini, and eight times higher for the top 1% share. This finding may be explained by the notion that more developed countries have more developed financial markets, which allow their higher-income citizens to protect themselves better from the inflation. It should also be noted that the effects are statistically significant only for the middle income group. This may be explained by the poorer data quality for the low income countries.

Table 8 - Results for different groups of countries

	High income		Middle income		Low income	
	Gini	Top 1%	Gini	Top 1%	Gini	Top 1%
inflation	-0.357	-0.140	-0.664***	-0.262**	-2.226	-2.171
	(0.291)	(0.183)	(0.246)	(0.120)	(2.623)	(2.104)
inflation2	0.002	0.001	0.004***	0.001**	0.025	0.024
	(0.002)	(0.001)	(0.001)	(0.001)	(0.029)	(0.024)
GDP growth	-0.069	-0.026	-0.212	-0.094	-0.596	-0.351
	(0.083)	(0.052)	(0.160)	(0.078)	(0.440)	(0.353)
interest rate	-0.239	-0.114	-0.412**	-0.172*	-1.217	-1.127
	(0.237)	(0.149)	(0.186)	(0.091)	(1.328)	(1.065)
stock exch.	0.007	-0.002	0.030	0.003	0.040	0.012
	(0.006)	(0.004)	(0.027)	(0.013)	(0.032)	(0.025)
tax	-0.038	-0.042	0.282***	0.035	0.166	0.156
	(0.042)	(0.027)	(0.066)	(0.032)	(0.177)	(0.142)
gov. size	0.068	-0.051*	-0.472	-0.232	-0.589	-0.662
	(0.044)	(0.028)	(0.402)	(0.195)	(0.865)	(0.694)
credit	-0.002	0.011**	0.075***	0.008	0.008	0.024
	(0.008)	(0.005)	(0.015)	(0.007)	(0.044)	(0.035)
openness	-0.006	0.003	-0.030*	-0.003	0.030	-0.032
	(0.008)	(0.005)	(0.016)	(0.008)	(0.031)	(0.025)
Observations	954	954	531	531	546	546
R-squared	0.111	0.359	-0.246	-0.516	-1.367	-10.636
No. countries	44	44	32	32	32	32
Turning point	72.89	56.78	80.76	94.89	44.53	44.51
F test instr. inf.	51.65	51.65	8.46	8.46	58.43	58.43
F test instr. inf2	482.9	482.9	28.94	28.94	90.33	90.33

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

How has the effect of inflation in inequality changed through time? To assess this, we split the sample into three roughly equal sub-periods and estimate the regression for these three sub-periods. The first sub-period spreads through the 70's and 80's (more precisely, until 1991), the second covers the 90's (more precisely, 1992-2001), the third one covers the 2000's (more precisely, after 2001). The results are presented in Table 9. It can be seen that the effects are present only in the first sub-period. Afterwards, they disappear. This may be explained both by the declining marginal top income tax rates. For illustration, the average

top marginal income tax rate during 70's and 80's was 59 percent, during 90's it declined to 42 percent, while after 2000 it further declined to 32 percent. Additionally, the financial development that has been going on through all this period, may have also contributed.

Table 9 - Results for different time periods

	Gini			Top 1%		
	70's&80's	90's	2000's	70's&80's	90's	2000's
inflation	-1.020*	-1.360	0.233	-0.483	-0.398	0.402**
	(0.609)	(1.845)	(0.256)	(0.326)	(0.561)	(0.173)
inflation2	0.006**	0.008	-0.001	0.002	0.002	-0.004
	(0.003)	(0.009)	(0.003)	(0.001)	(0.003)	(0.002)
GDP growth	-0.257	-0.464	0.036	-0.111	-0.121	0.045**
	(0.200)	(0.560)	(0.030)	(0.107)	(0.170)	(0.020)
interest rate	-0.776	-1.100	0.211	-0.391	-0.325	0.284***
	(0.477)	(1.615)	(0.143)	(0.255)	(0.491)	(0.097)
stock exch.	-0.007	0.058	-0.001	-0.006	0.009	0.012*
	(0.014)	(0.073)	(0.009)	(0.007)	(0.022)	(0.006)
tax	-0.031	0.187	-0.103***	-0.030**	0.038	-0.055***
	(0.026)	(0.234)	(0.022)	(0.014)	(0.071)	(0.015)
gov. size	0.008	-0.319	0.146*	-0.201	-0.070	0.097
	(0.293)	(0.489)	(0.089)	(0.157)	(0.149)	(0.060)
credit	-0.017	0.012	0.010	-0.013	0.010	0.019***
	(0.020)	(0.021)	(0.008)	(0.011)	(0.006)	(0.005)
openness	0.076	-0.002	-0.020*	0.028	0.008	-0.032***
	(0.053)	(0.050)	(0.010)	(0.028)	(0.015)	(0.007)
Observations	618	717	688	618	717	688
R-squared	-0.312	-2.689	0.075	-0.892	-1.359	-0.364
No. countries	60	88	94	60	88	94
F test instr. Inf.	32.2	14.5	50.7	32.2	14.5	50.7
F test instr. Inf2	141.6	51.5	169.8	141.6	51.5	169.8

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

VIII. Robustness

We conduct two robustness checks. In the first one, we eliminate oil producing countries. In these countries, oil price increases may affect income inequality directly, because certain groups may realize direct income from this (see, for instance Mallaye, Timba, and

Yogo (2015)). We treat as oil producers the countries which the International Energy Agency discusses in their Medium Term Oil Market Report (see IEA (2012)). These are the following 24 countries: Iran, Angola, Nigeria, Algeria, Ecuador, Venezuela, United States, Mexico, Canada, China, United Kingdom, Norway, Australia, Russia, Azerbaijan, Kazakhstan, Malaysia, India, Indonesia, Brazil, Argentina, Colombia, Yemen and Egypt. They produce approximately 95 percent of crude oil produced globally[3]. The results for the oil producers and the non-oil producers are given in Table 10. It can be seen that they are very similar amongst themselves, as well as similar to those that are obtained on the whole sample of countries. The only minor difference is that inflation is insignificant in the oil producers sample, but this is likely due to the low number of observations. Hence, we conclude that our findings are not likely to be driven by oil rents.

3. According to data from the CIA World Factbook, available on this link: https://www.cia.gov/library/publications/the-world-factbook/rankorder/2241rank.html#download.

Table 10 - Results for oil producers and non-oil producers

	Oil producers		Non-oil producers	
	Gini	Top 1%	Gini	Top 1%
inflation	-0.732**	-0.471**	-0.994	-0.482
	(0.344)	(0.195)	(1.444)	(0.689)
inflation2	0.005***	0.002***	0.008	0.004
	(0.001)	(0.001)	(0.011)	(0.005)
GDP growth	-0.191	-0.135*	-0.393	-0.132
	(0.125)	(0.071)	(0.396)	(0.189)
interest rate	-0.609*	-0.427**	-0.446	-0.261
	(0.334)	(0.189)	(0.633)	(0.302)
stock exch.	0.027*	0.009	0.035	0.016
	(0.015)	(0.009)	(0.062)	(0.030)
tax	0.091**	0.046*	0.127	0.013
	(0.044)	(0.025)	(0.187)	(0.089)
gov. size	0.106	-0.095	-0.836	-0.401
	(0.141)	(0.080)	(1.043)	(0.497)
credit	0.005	0.002	-0.003	0.023
	(0.011)	(0.006)	(0.050)	(0.024)
openness	-0.015	-0.003	-0.019	-0.050**
	(0.009)	(0.005)	(0.047)	(0.022)
Observations	1,583	1,583	448	448
R-squared	-0.253	-1.075	-0.938	-0.719
No. countries	89	89	19	19
Turning point	78.05	114.2	60.75	64.17
F test instr. Inf.	11.7	11.7	38.4	38.4
F test instr. Inf2	94.5	94.5	66.4	66.4

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

The second robustness check that we do refers to the quality of the data. In light of the criticisms on the SWIID database, laid out by Jenkins (2015), we use alternative database for inequality. We use the World Income Inequality Database of UNU-WIDER (version 3), taking only the observations which they call "high quality". In addition to using only high-quality data, we also try to be as consistent as possible across and within countries. Our preferred definition of the income is - household disposable income, equivalised to adult household members. For some countries, however, this definition is not available, or is available only

for few years, in which case we take other similar definitions, which may differ either in the measurement of income, or in the equivalisation. Importantly, we never take gross measures of income, and we never take different measures of inequality within a country. Understandably, this cherry-picking of the inequality data reduces the sample size substantially and limits it mainly to high-income countries. Furthermore, we are left only with the Gini index, as other measures of inequality are very sparse in this sample.

These results are shown in Table 11. The first thing to note is that the number of observations drops to 700 now. Consequently, the estimated coefficients are much less precise and significant. The results obtained over the whole sample, shown in the first column, although insignificant, imply that the relationship between inflation and inequality is now inverted-U shaped, meaning that inflation first increases inequality, but after it reaches 54 percent, starts to decrease it. This is in stark contrast with the previous results. However, when we break the sample into the three sub-periods from before, some additional insights are obtained. Results from column 2, which refer to 1970's and 1980's, are similar to the main findings from before, in the sense that they suggest that inflation reduces inequality. However, the negative relationship disappears after the 80's, and because there are much more observations after the 80's, they dominate the overall results. The explanation for the change in the effect after the 80's is same as above - declining top marginal income tax rates and financial development.

Table 11 - Results for the WIID database

	Whole period	70's&80's	90's	2000's
inflation	1.071	-1.854	0.200	0.353
	(1.917)	(12.036)	(4.390)	(0.307)
inflation2	-0.010	-0.020	-0.003	-0.002
	(0.019)	(0.070)	(0.019)	(0.004)
GDP growth	0.235	-0.735	-0.099	0.093
	(0.383)	(4.924)	(1.576)	(0.061)
interest rate	0.709	-2.205	0.077	0.360**
	(1.053)	(11.520)	(7.112)	(0.173)
stock exch.	-0.017	-0.086	-0.006	0.003
	(0.031)	(0.487)	(0.326)	(0.012)
tax	-0.235	0.202	0.050	-0.157***
	(0.303)	(1.140)	(0.478)	(0.048)
gov. size	0.287	-0.555	0.093	0.022
	(0.479)	(2.280)	(0.665)	(0.180)
credit	0.028	0.004	-0.008	0.009
	(0.037)	(0.253)	(0.045)	(0.011)
openness	0.043	0.209	0.028	0.003
	(0.045)	(1.535)	(0.371)	(0.019)
Observations	714	111	267	310
R-squared	-2.292	-68.515	-0.120	0.106
No. countries	66	19	46	50
Turning point	54.48	-46.10	31.10	89.62
F test instr. Inf.	23.5	0.1	0.1	22.1
F test instr. Inf2	31.4	0.3	0.8	70

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

IX. Conclusion

How does inflation redistribute income? Does it hurt the poor more than it hurts the rich? Economists have tried to assess this question for a long time. No consensus has emerged yet. This study has tried to contribute to this discussion, by offering several novelties. First, it is the most comprehensive study on the issue so far, covering 110 countries, over 40 years, including both developed and less-developed countries. Second, it has addressed the issue of endogeneity between inflation and income inequality, by using exogenous variation in

inflation, given by the oil price changes. Third, it has analysed the conditions under which inflation is likely to affect income inequality.

Results suggest that exogenous inflation is likely to reduce income inequality and that the effect is sizeable. The effect is stronger at lower levels of inflation, i.e. declines as inflation increases, and becomes positive after inflation reaches 70-80 percent. It is stronger for the Gini coefficient than for the top 1% share of income. It is strongest when top marginal income tax rates are high and the nominal interest rates do not rise enough to offset the inflation. The effect increases as one moves down the income ladder, which is plausible, since less developed countries are less financially developed. The effect has become weaker through time, likely due to the decline in the top marginal income tax rates over time, and the ever-going financial development, which has enabled better-off individuals to shield themselves better from inflation.

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X. Appendix

Table A1 - Summary statistics of variables

	Gini	Top 1%	inflation	Oil inflation	Oil share	oil shock	GDP growth
min	15.37	2.67	-11.69	-47.21	0.00	-11.32	-16.59
max	75.26	23.97	123.40	290.92	0.51	73.97	33.03
p25	29.63	6.39	2.61	-6.12	0.06	-0.68	0.62
p50	37.20	8.45	5.87	8.16	0.10	0.54	2.57
p75	47.01	12.18	11.13	28.25	0.15	2.65	4.53
mean	38.42	9.69	9.67	10.47	0.11	1.31	2.47
st.dev.	10.86	4.22	13.34	30.25	0.08	4.90	3.95
N	2083	2083	2083	2083	1964	2034	2083

	gov. size	tax	int. rate	stock exchange	credit	openness
min	2.98	8.00	-50.12	-23.50	3.14	9.10
max	33.96	89.00	27.70	33.63	250.12	446.75
p25	11.48	30.00	-1.39	-0.25	23.57	48.58
p50	15.56	43.00	0.93	9.15	42.41	67.24
p75	19.37	56.00	3.17	19.21	81.96	100.22
mean	15.70	43.98	0.37	8.49	57.15	81.80
st.dev.	5.33	16.71	5.87	14.22	44.41	58.12
N	2083	2083	2083	2083	2083	2083

Table A2 - Correlation matrix

	Gini	Top 1%	infla tion	oil shock	GDP growth	gov. size	tax	int. rate	stock exch.	credit	open ness
Gini	1										
Top 1%	0.65	1									
inflation	0.23	0.11	1								
oil shock	0.04	0.02	0.00	1							
GDP growth	-0.11	-0.12	-0.16	0.12	1						
gov. size	-0.43	-0.25	-0.20	-0.02	-0.10	1					
tax	-0.26	-0.32	0.08	-0.03	-0.12	0.30	1				
int. rate	-0.07	0.01	-0.57	-0.13	0.03	0.06	-0.04	1			
stock exch.	-0.01	-0.03	0.05	-0.01	0.09	0.00	0.14	0.06	1		
credit	-0.31	-0.09	-0.35	0.00	-0.01	0.23	0.07	0.13	-0.04	1	
openness	-0.02	0.01	-0.19	0.02	0.15	-0.03	-0.26	-0.01	-0.04	0.22	1

Table A3 - Unit root tests

	DF (1 lag)	DF (2 lags)	DF (1 lag, trend)	DF (2 lags, trend)	PP (1 lag)	PP (2 lags)	PP (1 lag, trend)	PP (2 lags, trend)
Gini	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Top 1%	0.79	0.00	0.14	0.00	0.00	0.00	0.00	0.00
inflation	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
oil shock	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GDP growth	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00
gov. size.	0.00	0.00	0.00	0.34	0.00	0.00	0.00	0.00
tax	0.50	0.35	0.00	0.23	0.07	0.03	0.00	0.00
int. rate.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
stock exchange	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
credit	1.00	1.00	0.07	0.35	0.79	0.32	0.00	0.00
openness	0.03	0.02	0.00	0.02	0.23	0.15	0.00	0.00

The null hypothesis in all the tests is that all panels contain unit roots. The values that are shown are the p-values. DF stands for Dickey-Fuller, PP for Phillips-Perron.

Table A4 - Classification of countries

Low income	Middle income	High income
Armenia	Albania	Argentina
Bangladesh	Azerbaijan	Australia
Benin	Belize	Austria
Bolivia	Botswana	Barbados
Cameroon	Brazil	Belgium
Central African Republic	Bulgaria	Canada
Cote d'Ivoire	China	Croatia
Egypt	Colombia	Cyprus
El Salvador	Costa Rica	Czech
Ethiopia	Dominican Rep.	Denmark
Georgia	Ecuador	Estonia
Ghana	Fiji	Finland
Guatemala	Gabon	France
Guyana	Iran	Germany
Honduras	Jamaica	Greece
Indonesia	Jordan	Hong Kong
Kenya	Macedonia	Hungary
Madagascar	Malaysia	Iceland
Malawi	Mauritius	Ireland
Moldova	Mexico	Israel
Morocco	Mongolia	Italy
Mozambique	Montenegro	Japan
Nicaragua	Namibia	Republic of Korea
Nigeria	Panama	Latvia
Pakistan	Paraguay	Lithuania
Papua New Guinea	Peru	Luxembourg
Philippines	Romania	Malta
Senegal	Serbia	Netherlands
Sierra Leone	South Africa	New Zealand
Sri Lanka	Thailand	Norway
Togo	Tunisia	Poland
Uganda	Turkey	Portugal
Ukraine		Russia
Vietnam		Singapore
Zambia		Slovakia
Zimbabwe		Slovenia
		Spain
		Sweden
		Switzerland
		Trinidad and Tobago
		United Kingdom
		United States
		Uruguay
		Venezuela