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Macroeconomic determinants of inequality of opportunity and effort in the US: 1970-2009*

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Abstract

Conventional wisdom predicts that changes in macroeconomic conditions significantly affect income inequality. In this paper we hypothesize that the way in which macroeconomic conditions affect inequality depends on how these conditions influence the constituents of total inequality: inequality of opportunity (IO) and inequality of effort (IE). Using the PSID database for the U.S. (1970-2009), we first decompose total inequality into these components. Then, we specify a dynamic model that relates each inequality component to a set of macroeconomic factors. Apart from real GDP and inflation rates, the most widely used factors in the literature, we also consider outstanding consumer credits and public welfare and health care expenditures. We find that real GDP and outstanding credits have a negative and significant effect upon IO and IE, while inflation has a positive and significant effect only on IE, and welfare expenditures have a negative and significant effect only on IO.

Keywords: income inequality, inequality of opportunity, inequality of effort, growth cycle, outstanding consumer credit.
JEL Classification: D63, E32, O16, O51.

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1. Introduction

A surge of literature on the macroeconomic determinants of inequality has suggested two main channels through which macroeconomic conditions could affect the economic performance of individuals and, consequently, income distribution: the unemployment rate (or real GDP growth) and inflation.[2] Empirical studies have found that the unemployment rate (or real GDP growth) has significant and positive (negative) effects on income inequality. A feasible explanation for this result is that aggregate growth reduces exclusion in the labor market and, as a result, reduces inequality (Metcalf, 1969, Mirer, 1973, Nolan, 1987 and Powers, 1995). As regards inflation, the results are inconclusive. While income inequality may decrease when input costs increase faster than profits (i.e., inflation originates from the supply side), inequality tends to increase when inflation arises from tensions on the demand side (Schultz, 1969, Gramlich, 1974, Blinder and Esaki, 1978 and Buse, 1982). Although these models performed reasonably well in foreseeing changes in inequality until mid 80's, they became less accurate in the 90's and 00's, which reopened the debate on the macroeconomic determinants of inequality (Meyer and Sullivan, 2011).[3]

Our paper attempts to open a new line of enquiry in the empirical literature so as to gain a better understanding of the macroeconomic-inequality relationship. We hypothesize that the way macroeconomic conditions affect inequality depends on how these factors

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[2] See, among others, Metcalf (1969), Thurow (1970), Blinder and Esaki (1978), Blank and Blinder (1986), Björklund (1990), Cutler and Katz (1991), Bishop et al. (1994), Freeman (2003) and Smeeding et al. (2011).

[3] Recently, a number of reasons have been proposed in the literature. For example, the decline in real wages among less-skilled workers (Atkinson, 1996) due to the process of trade liberalization (Wood and Ridao-Cano, 1999) and technological change biased towards high-skilled workers (Aghion et al., 2002) has deteriorated the relationship between inequality and macroeconomic determinants. Additional explanations are that the unemployment rate as an indicator of employment conditions might be limited, because the intra-household distribution of unemployment is also an important factor to explain changes in inequality (Ayala et al., 2011); and models do not consider asymmetries, i.e., inequality could be more sensitive to increases in unemployment rates (recessions) than to reductions (expansions) (Hines et al., 2001 and Ayala et al., 2011).

influence the components of total inequality. The modern theories of justice emphasize that income inequality is actually a composite measure of inequality of opportunity (IO) and inequality of effort (IE).[4] In keeping with Roemer (1993), IO refers to that inequality stemming from factors, called *circumstances*, beyond the scope of individual responsibility, like race and socioeconomic background (i.e., commonly proxy by parental education), while IE defines the income inequality caused by individual responsible choices, like the number of hours worked or the occupational choice.[5] In this manner, whenever the relationship between macroeconomic conditions and overall inequality is characterized, this could be hiding different – even opposite – effects upon its components, and overall conclusions might be misleading. Addressing this distinction is this paper's main contribution.

To this end, we update the time series for overall inequality, IO and IE, for the U.S. (1970-2007) in Marrero and Rodríguez (2011) to 2009, in order to include the Great Recession of 2008-2009.[6] Among the different alternatives, we focus on the IO and IE estimates using the Björklund et al. (2011) approach, because it also takes into account the correlation between observed circumstances (parental education and race) and effort. The estimated time series provide information for a long period of time, which allows us to characterize their cyclical behavior and trends.

Traditionally, the relationship between macroeconomic factors and inequality has been studied by considering short-term fluctuations.[7] However, inequality series typically

[4] See Roemer (1993), Van de Gaer (1993), Bourguignon et al. (2007), Fleurbaey (2008), Checchi and Peragine (2010), Marrero and Rodríguez (2010), Ferreira and Gignoux, (2011) and Björklund et al. (2011).

[5] The overall effect of family and community factors on economic status for the United States is analyzed in Björklund et al. (2002).

[6] See Bishop et al. (1990) and (1994) for an evaluation of changes in the U.S distribution of income from the 50's through the 80's.

[7] Models in this literature usually include a linear time trend in the regression, which characterizes the relationship between variables in terms of their deviations with respect to that trend (Blinder and Esaki, 1978, Blank and Blinder, 1986 and Björklund, 1990).

present a high inertia. In addition, annual incomes always include transitory variations and measurement errors (Pistolesi, 2009 and Marrero and Rodriguez, 2011). As a result, short-term fluctuations of estimated IO and IE may suffer from significant noise, which would mislead short-term regression results. To avoid this, we adopt an alternative approach by focusing on the variable's smoothed trend growth rates, which we refer to as the growth cycle (Young et al., 1999; García-Ferrer et al., 2001).[8]

With all these ingredients, we estimate a dynamic time series model for total inequality, IO and IE. In addition to real GDP growth and inflation rates, we also consider as macroeconomic factors the level of outstanding consumer credit and the welfare and public health care expenditure. We have included consumer credits as an explanatory variable because the presence of credit restrictions particularly affects people with low income and/or in dire circumstances. As noted by Galor and Zeira (1993), low income individuals are confronted by considerable difficulties when attempting to develop their investment projects because of the barriers they face to access credit.[9] We have also included welfare and public health care expenditure in the model because these expenditure concepts have been shown by a large number of authors to affect mainly low income households.

Our results highlight that macroeconomic conditions affect the components of inequality differently. With respect to real GDP and outstanding consumer credit, the results for IO and IE share the same negative sign and significance, though the magnitude of their coefficients is clearly different. A less unequivocal result is found for the other two explanatory variables: inflation shows a positive and significant coefficient for IE, while the coefficient is negative but insignificant for IO; and welfare

[8] The business cycle is measured in terms of the output level, while the growth cycle is computed in terms of the output growth rate.

[9] In fact, poor agents, unlike high-income agents, allocate less time to schooling and so are less able to increase their human capital even if the education system is public (see Sylwester, 2002).

expenditures have a significant and negative effect on IO, but a positive and insignificant incidence on IE. In all cases, the estimates for overall inequality fall between those for IO and IE.

Section 2 presents the inequality, IO and IE time series plus the explanatory macroeconomic variables considered in this paper. Section 3 summarizes the methodology used to estimate the growth cycles of annual time series and shows the main pairwise growth cycle comparisons. Section 4 presents the dynamic model and discusses our main findings. Finally, Section 5 concludes.

2. Variables and data

In this section, we introduce all of the variables used in the dynamic model (Section 4). First, we present the variables of inequality (overall, IO and IE) and next we show the macroeconomic factors: real GDP, GDP deflator, outstanding consumer credit and public welfare and health spending.

2.1. Overall inequality, IO and IE

In keeping with the literature on inequality of opportunity (see footnote 5), overall inequality can be seen, in reality, as a combination of IE and IO. The reason lies in the fact that an individual's outcome (income, welfare, health, etc.) can be interpreted as a function of variables *within* and *beyond* the individual's control, called effort (occupational choice, number of hours worked or investment in human capital) and circumstances (socioeconomic and cultural background or race), respectively.

Thus, following the ex-ante approach used by Van de Gaer (1993), Checchi and Peragine (2010) and Ferreira and Gignoux (2011), among others, a population can be partitioned into types according to its individuals' circumstances. Then, the IO term would be associated with the between-group inequality component, while the IE term would be related to the within-group inequality component.[10]

Marrero and Rodríguez (2011) have estimated the series of overall inequality, IO and IE for the U.S. from 1970-2007 from the Panel Study of Income Dynamics (PSID). They used the PSID database because it is the only database that provides information on parental education over a long period of time. In order to estimate these inequality indexes, they follow the common practice in the inequality–of–opportunity literature to remove the so–called life-cycle composition effect: restrict the samples to household heads between 25 and 50 years old. Moreover, they considered two circumstances, the father's education and race, and used the mean logarithmic deviation or Theil 0 inequality index.[11] Following the same procedure, we have extended their series of inequality, IO and IE to 2009 in order to include the Great Recession of 2008-2009, thus allowing us to analyze the cyclical evolution and macroeconomic determinants of IO and IE over four decades.

Among the alternative methods considered by Marrero and Rodríguez (2011), we focus on the decomposition approach proposed by Björklund et al. (2011). Most estimation methods assume that effort and circumstances are uncorrelated, but this is clearly an important shortcoming. For example, Roemer (1998) observes that an individual's extra effort may be explained by characteristics beyond her control (i.e. students that work harder in school and thereby do better because their parents pressure them to do so). For

[10] In the alternative ex-post approach (Roemer, 1993 and Checchi and Peragine, 2010), population is also partitioned into types according to individuals' circumstances, but then each type is further subdivided according to personal effort. Accordingly, IO and IE are represented by the *within-group* and *between-group* components of overall inequality, respectively. As in Marrero and Rodríguez (2011), we adopt in this paper the ex-ante approach. See any reference in footnote 5 for further details on these methods.

[11] For the father's education, they assumed four groups: no education, primary, secondary and tertiary education. For race, they considered two groups: white and non-white. At this point, it must be noted that the circumstance vector observed is, by definition, a subset of the vector of all possible circumstances. The estimated IO values, then, will be a lower bound of the true IO and will increase with the number of circumstances observed (Ferreira and Gignoux, 2011 and Luongo, 2011).

these cases, an equal-opportunity policy should somehow distance individuals from their circumstances in order to respect an individual's effort. On this, we follow Björklund et al. (2011), who recently proposed an empirical approach to consider the correlation between observed circumstances and effort, a term that is included in the IO component.

For illustrative purposes, we show the evolution of overall inequality, IO and IE between 1970 and 2009 in Figure 1 and Table 1. We first notice that the IO component yielded between 10% (1990) through 4% (2007) of total inequality. Despite the fact that only two circumstances were used (parental education and race), these percentages are at the same level as those obtained by other studies for countries with a similar degree of development as the U.S.[12] Given the range of these percentages, the evolution of overall inequality and IE was similar (see Figure 1).

Considering the trends in more detail, overall inequality increased slightly between 1970 and 1977. The uneven evolution between 1970 and 1977 of IO (slight decrease) and overall inequality reflects a significant increase in IE during this period. As for IO, we observe a moderate increment in IE and total inequality between 1977 and 1985. However, the rise between 1985 and 1995-1997 in total inequality (a growth rate lower than 25%) is clearly less intensive than the increase in the IO component (a growth rate higher than 35%), which indicates a decline in IE as a part of overall inequality. The major difference in the trend in IO and IE is observed between 1997 and 2005. In this period, IE continued rising at a moderate rate (around 18%), while the IO component dropped significantly (more than 40%). Finally, with the advent of the 2008-2009 crisis, the significant increase in overall inequality (a growth rate of 6%) was overcome by a more rapid increase in IO (a growth rate of 34%).

[12] Checchi and Peragine (2010) computed an IO percentage below 10% for Italy, while Marrero and Rodríguez (2010b) found percentages between 2% (Denmark) and 22% (Portugal) for 23 European countries.

INSERT FIGURE 1 ABOUT HERE

INSERT TABLE 1 ABOUT HERE

2.2. Macroeconomic factors

In addition to real GDP (base 2000) and inflation (GDP deflator), the macroeconomic variables commonly used in the literature as determinants of inequality, we also consider the welfare and public health care expenditure and the level of outstanding consumer credit.[13]

Public spending may significantly affect the income of the poor and, by doing so, total inequality. Of all public expenses, 'Welfare' and 'Health Care' are the items most related to low incomes. Welfare spending includes: family and children (food and nutrition assistance, aid programs, etc.); unemployment and workers compensation (general retirement and disability insurance); housing (housing assistance, housing and community development programs); and, social exclusion and R&D on social protection. In terms of health care, two basic programs have been in effect in the U.S. since 1960 - Medicare and Medicaid. Medicare is a program for individuals 65 and over, while Medicaid is the largest source of funding for medical and health-related services for people with limited income in the U.S. (mainly low-income adults, their children, and people with certain disabilities). Apart from these two programs, medical care outlays also include spending on hospitals, medical R&D, and consumer and occupational health and safety. As our explanatory variable, we consider welfare expenditure plus public health care expenditure (both adjusted by the GDP deflator), though spending on the Medicare program is excluded because our inequality measures

[13] Real GDP and GDP deflator are obtained from the U.S. Dept. of Commerce (BEA) and the Bureau of Labor Statistics (BLS) web site databases. Public welfare and health care data are obtained from http://www.usgovernmentspending.com/welfare_spending. Outstanding consumer credit data are obtained from http://www.federalreserve.gov/releases/g19/hist/.

(overall, IO and IE) are based exclusively on those persons between 25 and 50 years old (recall from above).

Liquidity and credit constrains are regarded as important factors affecting low-income individuals. The main idea is that relatively poor individuals do not have the means to finance the accumulation of human capital, and, because they are credit constrained, they end up investing little, if anything, on human capital. If, in addition, there are decreasing returns to the accumulation of human capital, the redistribution of resources from rich to poor individuals could reallocate resources towards more profitable investments which, in turn, could increase the size of the pie.[14] Therefore, total outstanding consumer credit (including revolving and non-revolving credits, adjusted by the GDP deflator) will be used in this paper as an overall measure of credit availability (i.e., contrary to financial constraints).[15]

We summarize in Table 2 the evolution of these four macroeconomic factors by decades. Comparing consecutive decades, real GDP has steadily grown since the 80's: each decade shows an overall growth rate of about 35%. Meanwhile, inflation has exhibited a clear downward trend since the two consecutive oil crises in the 70's, with the US GDP deflator growing at 83% in the 80's, 34% in the 90's and 24% in the 00's. Although not as stable as real GDP, welfare and total public health care spending have grown steadily since 1980. The former grew at 39% in the 80's, 42% in the 90's and 32% in the 00's, while the latter grew at 81% in the 80's, 69% in the 90's and 78% in the 00's. At this point, it is worth noting that when the Medicare program is excluded, the growth rate of health care spending in the 80's drops to 50%. An acceleration pattern is also shown for real outstanding consumer credit. This variable grew at 40% in

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[14] See Aghion et al. (1999) for a thorough review of this literature. Empirical evidence has been found in De Gregorio (1996) and Flug et al. (1998).

[15] Non-revolving credits include automobile loans and all other loans not included in revolving credit, such as loans for mobile homes, education, boats, trailers and vacations.

the 80%, 50% in the 90% and 66% in the 00's. With the advent of the Great Recession (2007-2009), the growth rates of these four macroeconomic factors have dropped dramatically. In fact, the growth rates of two macroeconomic variables, real GDP and consumer outstanding credit, have become negative.

INSERT TABLE 2 ABOUT HERE

3. The cyclical evolution of inequality and macroeconomic variables

As mentioned in the introduction, we focus in this paper on the growth cycle so as to avoid the strong fluctuations and high volatility typically present in short-term fluctuations. In short, the growth cycle of a variable can be defined as the smoothed non-inflationary growth performance of that variable (García-Ferrer et al., 2001; Marrero, 2007). Thus, the first step in measuring the growth cycle is to distinguish between the two components of a time series; namely, the low-frequency or trend-cycle component and the high-frequency or noise component. A full description of the estimation procedure is given in the Appendix. Once those components are estimated, the growth cycle is computed as the smoothed growth rate of the trend-cycle component. In this section we analyze and compare the growth cycles of all the variables considered in the dynamic model presented in Section 4.

To characterize the mid-term cyclical properties of the variables, we compare in Figure 2 (a-f) the growth cycle of real GDP with the growth cycles of the remaining variables. The five recessionary periods that have taken place in the U.S. between 1970 and 2009 – 1974-75, 1981-83, 1990-91, 2000-01 and the recent 2008-09 – are shaded in. In Figures 2a and 2b, we observe that overall inequality and IE behave counter cyclically because the peaks and troughs of real GDP coincide with the corresponding troughs and peaks of overall inequality and IE, though with some delay (one or two years, depending on the turning point). The large proportion of the IE component in total income inequality explains the similar cyclical pattern of both time series.

With respect to IO, Figure 2c shows that IO cycles are less regular than those of IE and total inequality. In fact, the general pattern of IO is also counter-cyclical, though its synchronicity with GDP is less clear than that between IE and GDP. For example, most recessionary periods are followed by an intense increase in IO; however, its acceleration during the eighties does not correspond with the regular cycle of GDP. In this respect, the existence of different macroeconomic determinants for IO than for IE and overall inequality could explain the lower synchrony between the IO and GDP growth cycles.

In Figures 2d-2f, the growth cycle of inflation, outstanding consumer credit and public welfare and health care expenditure are compared with the GDP growth cycle. We first observe that inflation exhibited a very smooth cyclical evolution over the entire period, one in which growth rates dropped significantly since the early 80's. We also note the close cyclical relationship between GDP and outstanding consumer credit (pro-cyclical) and GDP and welfare and health spending (counter-cyclical). This tight cyclical correspondence between GDP and the other two macroeconomic factors (outstanding credit and welfare spending) will cause significant collinearity problems in the model presented in Section 4 that will need to be addressed.

INSERT FIGURE 2(a)-(f) ABOUT HERE

4. The model

Traditionally, models that study determinants of inequality have considered a measure of economic activity, such as the unemployment rate or real GDP growth rate, and the inflation rate. In this paper, as noted in the introduction, in addition to these variables we consider two new ones. The first variable, welfare expenditure plus public health care spending, tries to represent the governmental spending most directly related to low incomes. The second variable, the outstanding consumer credit, tries to estimate the effect of credit markets, in line with the imperfect credit market hypothesis (see above).

Since the growth cycle – GC – of the variables is non-stationary (as evidenced by Figure 2 in Section 3), we estimate a growth cycle model in first-differences, where the inequality variables (total, IE and IO) – I – are related to the four explanatory variables mentioned above and some dynamic terms.[16] Therefore, the basic model can be written as follows:

$$\begin{aligned} &\Delta I_t^{GC} = \alpha + \beta_1 \Delta GDP_{t-1}^{GC} + \beta_2 \Delta P_{t-1}^{GC} + \beta_3 \Delta C_{t-1}^{GC} + \beta_4 \Delta S_t^{GC} + \varepsilon_t \\ &\varepsilon_t (1 - \phi_1 B - \phi_2 B) = a_t \quad a_t \sim N(0, \sigma^2) \end{aligned} \tag{1}$$

where P, C and S denote the inflation rate measured by the GDP deflator (base 2000), the outstanding consumer credit variable and the welfare and health expenditure, respectively. The term Δ denotes the first difference operator, i.e., $\Delta(x_t) = x_t - x_{t-1}$. In addition, we impose an AR(2) to capture the cyclical behavior of the variables.[17]

A direct estimation of model (1) is still problematic because real GDP is highly correlated with welfare spending and outstanding consumer credit, as noted earlier. The correlation matrix for all of the variables in model (1) is shown in Table 3. We observe that correlations between the three variables mentioned above are around 0.7 in magnitude, which might give rise to a collinearity problem between these variables.

INSERT TABLE 3 ABOUT HERE

[16] Because the variables under consideration are not cointegrated (test results are available upon request), a specification in first-differences is appropriate. Otherwise, we would have needed to estimate an error correction model.

[17] A standard specification exercise á la Box-Jenkins also supports the AR(2) specification.

To address this collinearity problem, we ran auxiliary pairwise regressions once we had carried out a pairwise Granger causality analysis between real GDP, welfare spending and credit variables (Table 4). According to the test results, GDP is causing the other two variables, while the pairwise comparison between welfare spending and consumer credit does not reveal any causal relationship. Therefore, given this empirical evidence, we can correct the collinearity problem by first running the following auxiliary pairwise regressions:

$$\Delta C_t^{GC} = \delta_0 + \delta_1 \Delta GDP_t^{GC} + v_t^{Credit}$$

$$\Delta S_t^{GC} = \lambda_0 + \lambda_1 \Delta GDP_t^{GC} + v_t^{Spending} \tag{2}$$

and then include as regressors in (1) the corresponding error terms, which are orthogonal to the GDP growth cycle. Hence, the final results are based on the following dynamic regression:

$$\begin{aligned} &\Delta I_t^{GC} = \alpha + \beta_1 \Delta GDP_{t-1}^{GC} + \beta_2 \Delta P_{t-1}^{GC} + \beta_3 \Delta v_{t-1}^{Credit} + \beta_4 \Delta v_t^{Spending} + \varepsilon_t \\ &\varepsilon_t (1 - \phi_1 B - \phi_2 B) = a_t \quad a_t \sim N(0, \sigma^2) \end{aligned} \tag{3}$$

INSERT TABLE 4 ABOUT HERE

The results are shown in Table 5, where inequality indices are taken in levels, and Table 6, where inequality indices are taken in logs. The coefficients can thus be interpreted as elasticities.

First, we note that the estimates of the autorregresive coefficients are always highly significant.[18] Second, we will comment on the estimated coefficients related to the different macroeconomic factors considered. We observe that real GDP and outstanding

[18] The roots of an AR(2) polynomial are imaginary numbers, which is why the estimates can be interpreted in terms of the average period of the cycle (in years), denoted by *p* and given by $2\pi / \arccos\left(\phi_1 / 2\cdot\sqrt{-\phi_2}\right)$, and the damping factor of the cycle, denoted by *d* and given by $d = \sqrt{-\phi_2}$. The estimated period and damping factor are always higher for IO than for IE. For example, looking at Table 6, the estimated period and damping factor are 6.16 and 0.85 for IE, while they are 6.64 and 0.88 for IO.

consumer credit have a negative and significant effect on overall inequality, IE and IO. Focusing on the specification in logs, we observe that the GDP variable has a larger negative effect on IO than on overall inequality and IE. It seems that the evolution of GDP in the medium- and long-run has a clear impact on inequality of effort and, above all, on IO. The functioning of financial markets has also an impact on the three variables of inequality, though the negative effect of consumer credits on IO is almost five times the effect on IE. Therefore, we find support for the imperfect credit markets hypothesis and show that credit constraints would affect mainly the IO component of total inequality.

The inflation rate is shown to have a positive and significant effect on IE, but a negative and insignificant impact on IO. When both kinds of inequality are considered together under the overall inequality indicator, inflation has a positive effect, which is significant only when inequality is measured in levels. This result agrees with previous studies, which show that inflation has a weak effect on overall inequality.

INSERT TABLES 5 AND 6 ABOUT HERE

Welfare and health expenditure has a significant and negative effect on IO, but a positive and insignificant effect on IE. As a result, the impact on overall inequality is negative but not significant. Therefore, for the last two explanatory variables we find opposite effects on the IO and IE components. This fact would have not been observed if a total indicator of income inequality had been used.

5. Concluding remarks

This paper has estimated a growth cycle model for income inequality, inequality of opportunity and inequality of effort in order to characterize their main cyclical determinants in the U.S. between 1970 and 2009. For this task, we have considered as explanatory variables real GDP, inflation, outstanding consumer credit and welfare and health expenditure.

We focused on the growth cycle so as to avoid the strong fluctuations and high volatility typically present in short-term fluctuations. Moreover, we decomposed overall inequality into IO and IE to study whether macroeconomic conditions have different effects on inequality components. In this respect, we found that inflation rates and welfare expenditures have opposite effects on IO and IE, negative on the former and positive on the latter.

Apart from these effects, we have also found that real GDP and outstanding consumer credit have a negative and significant effect on the three alternative inequality measures. However, the evolution of GDP in the medium- and long-run has a larger effect on IO than IE, and the existence of credit constraints in the financial markets affects mainly the IO component.

These findings suggest the need to reconsider those results obtained using traditional procedures for the macroeconomic determinants of income inequality, and show the relevance of considering a suitable estimation model. More importantly, the empirical evidence obtained in this paper should be useful in future research for developing a formal theoretical model that explicitly specifies the channels through which macroeconomic conditions cause inequality of opportunity and inequality of effort.

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APPENDIX

In this Appendix we briefly present the methodology to estimate the growth cycle for annual time series. Based on works by Young (1984) and Harvey (1989), an unobserved component (UC) model of a time series *y(t)* can be specified as follows:

$$y(t) = \tau(t) + \eta(t) \tag{A1}$$

where τ is the low-frequency or trend-cycle component and η is the high-frequency or noise component, with constant variance σ_η^2. Because we deal with annual data, no seasonal component is modeled in (A1). To be estimated, the UC model above requires a particular specification for the unobserved components. In this respect, the majority of applications (see among others, Young et al., 1999, García-Ferrer et al., 2001 and Marrero, 2007) use the following local linear trend (LLT) model for the trend-cycle component:

$$\begin{aligned} \tau_t &= \tau_{t-1} + d_{t-1} + \varepsilon_t, \\ d_t &= d_{t-1} + v_t \end{aligned} \tag{A2}$$

where d measures the change (or derivative) of the trend-cycle component, and v and ε are serially and mutually uncorrelated white noise errors with variance σ_v^2 and σ_ε^2, respectively. If variables are taken in logs, then the trend derivative d represents a growth rate. By setting σ_v^2>0 and σ_ε^2=0 we obtain the so-called Integrated Random Walk (IRW) trend, which gives us a smoothed trend (Young et al., 1999). Since all parameters in (A1)-(A2) are constrained to unity or zero, the IRW representation can indeed be uniquely defined by the ratio $\sigma_v^2 / \sigma_\eta^2$, which is referred as to the Noise Variance Ratio (NVR) of the model.

In order to estimate the NVR, the most obvious approach is to formulate model (A1)-(A2) in maximum likelihood terms (Harvey, 1989), however, the optimization tends to be very complex because of the flatness of the likelihood function around the optimum.

As a result, the estimated growth cycle becomes too noisy (Young et al., 1999). Alternatively, we can apply the manual tuning approach proposed in Pedregal and Young (1996) and García Ferrer and Queralt (1998). This method gives the NVR for which the estimated trend includes those cycles consistent with the historical growth-cycle record of the economy being analyzed. In this respect, it is worth to recall that Pedregal and Young (1996) found an exact relationship between the NVR of model (A1)-(A2) with the average frequency of the cycles in $\tau(t)$:

$$F_{\alpha} = \frac{\arccos\left[1 - \sqrt{NVR(1-\alpha)/4\alpha}\right]}{2\pi}, \tag{A3}$$

where α is an attenuation factor that is commonly set to 0.5 and F is the average frequency of the cycles (number of cycles per year).[19]

For our data, we find that the average amplitude of the real US GDP cycles between 1970 and 2009 is about 8-10 years and, consequently, the number of entire cycles is 4. Correspondingly, the frequency is about 0.09-0.10 and the NVR should be chosen to be around 0.2 according to (A3). After the NVR is obtained, the trend-cycle and noise components are estimated by applying to the State Space formulation of model (A1)-(A2) the Kalman filter and fixed interval smoothing techniques (see Pedregal and Young, 1996 and García Ferrer and Queralt, 1998). As an example, we show in Figures A1 and A2 the estimated smoothed trend and the growth rate for real GDP in U.S. between 1970 and 2009, respectively. The shadow areas highlight the five recession periods taken place in U.S. throughout that period of time: 1974-75, 1981-83, 1990-91, 200-01 and the recent 2008-09.

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[19] It can also be proved that, for model (A1)-(A2), the parameter λ used in the Hodrick and Prescott (1997) filter is precisely equal to 1/NVR.

Although not shown in the paper, setting a much lower NVR (for example, 0.01) would have generated too smoothed cycles because the variance of the low-frequency component would have been very low in comparison with the variance of the high-frequency component. On the contrary, setting a much higher NVR (for example, 1) would have led to a high noisy cycles. For consistency reasons, we apply the NVR obtained for real GDP (0.02) to the rest of variables in Section 3.

INSERT FIGURE A1 AND A2 ABOUT HERE

TABLES

Table 1. Overall inequality, IE and IO in U.S. (1970-2009) by decades

	Overall Inequality	**Inequality of Effort**	**Inequality of Opportunity**
1970-79	0.2509	0.2303	0.0205
1980-89	0.3145	0.2870	0.0276
1990-99	0.3862	0.3385	0.0477
2000-09	0.4320	0.4028	0.0292
		Growth rate (%)	
1970-79	--	--	--
1980-89	25.4	24.6	34.2
1990-99	22.8	17.9	73.2
2000-09	11.9	19.0	-38.9
2007-09	6.0	4.6	33.8

Note: estimates from the PSID database using the Theil 0 inequality index.

Table 2. Macroeconomic factors in U.S. (1970-2009) by decades

	Real GDP, (2000 US$), billions	**GDP deflactor**, Index, 2000=100	**Public welfare**, excluded Health care (2000 US$, GDP deflac.), billions	**Health care**, total (2000 US$, GDP deflac.), billions	**Health care**, excluded Medicare (2000 US$, GDP deflac.), billions	**Consumer outstanding credit** (2000 US $, GDP deflac.), billions
1970-79	4401.1	36.8	143.1	115.3	80.6	980.6
1980-89	5910.4	67.5	198.8	208.4	120.8	777.2
1990-99	8024.2	90.4	282.7	352.6	205.2	1161.4
2000-09	10865.5	111.7	372.8	628.2	364.1	1927.5
			Growth rates in the whole period			
1970-79	--	--	--	--	--	--
1980-89	34.3	83.5	38.9	80.8	49.9	-20.7
1990-99	35.8	33.9	42.2	69.2	69.9	49.4
2000-09	35.4	23.6	31.9	78.2	77.4	66.0
2007-09	-2.7	3.1	45.5	10.7	10.5	-1.2

Table 3. The correlation matrix

	ΔI^{GC}	ΔIO^{GC}	ΔGDP^{GC}	ΔP^{GC}	ΔC^{GC}	ΔS^{GC}
ΔI^{GC}	1.0000	0.0851	-0.4909	-0.5767	-0.4539	0.5272
ΔIO^{GC}	0.0851	1.0000	-0.0658	0.0115	-0.0711	-0.3131
ΔGDP^{GC}	-0.4909	-0.0658	1.0000	0.2435	0.7666	-0.7086
ΔP^{GC}	-0.5767	0.0115	0.2435	1.0000	0.2116	-0.4522
ΔC^{GC}	-0.4539	-0.0711	0.7666	0.2116	1.0000	-0.6689
ΔS^{GC}	0.5272	-0.3131	-0.7086	-0.4522	-0.6689	1.0000

Table 4. The pairwise Granger causality tests.

Null Hypothesis:	**Obs**	**F-Statistic**	**P-value**
ΔC^{GC} does not Granger cause ΔGDP^{GC}	36	4.30384	0.0224
ΔGDP^{GC} does not Granger cause ΔC^{GC}		11.1921	0.0002
ΔS^{GC} does not Granger cause ΔGDP^{GC}	36	2.80030	0.0762
ΔGDP^{GC} does not Granger cause ΔS^{GC}		6.23409	0.0053
ΔS^{GC} does not Granger cause ΔC^{GC}	36	0.45813	0.6367
ΔC^{GC} does not Granger cause ΔS^{GC}		0.70143	0.5036

Note: we do not reject the null hypothesis if the probability value is higher than 0.1. For those cases we reject the null hypothesis, we accept the causality for which the probability value is lowest.

Table 5. Overall inequality, IE and IO determinants in U.S. (1970-2009), levels

	Theil 0		**IE-Theil 0**		**IO-Theil 0**	
	estimate	**std**	**estimate**	**std**	**estimate**	**std**
GDP(-1)	-0.4302***	0.1090	-0.2569**	0.1222	-0.1598***	0.0448
Deflactor (-1)	0.1479*	0.0855	0.2123*	0.1107	-0.0619	0.0568
Credit (-1)	-0.1604***	0.0430	-0.1026*	0.0603	-0.0594**	0.0239
Spending	-0.0065	0.0212	0.0308	0.0246	-0.0339***	0.0072
C	-0.0001	0.0004	0.0000	0.0004	-0.0001	0.0002
Estimates of the autorregressive structure						
AR(1)	1.2479***	0.1655	1.2742***	0.1352	1.3494***	0.0994
AR(2)	-0.7558***	0.1574	-0.7724***	0.1245	-0.7937***	0.0672
p	6.2992		6.4344		6.7858	
d	0.8694		0.8789		0.8909	
	estimate	**p-value**	**estimate**	**p-value**	**estimate**	**p-value**
R2	0.9137	--	0.8989	--	0.8812	--
S.E. of regression	0.0012	--	0.0014	--	0.0004	--
F-stat	49.3971	0.0000	41.4715	0.0000	34.6293	0.0000
Durbin-Watson	2.0103	--	2.0973	--	2.0957	--
Q-Stat(10)	5.0394	0.7530	8.2328	0.4110	6.0378	0.6430

(***) significance at a 1% level, (**) 5% level or (*) 10% level.

p: the period (years/cycle) of the cycle: $p = 2\pi / \arccos\left(\phi_1 / 2\cdot\sqrt{-\phi_2}\right)$; **d**: the damping factor: $d = \sqrt{-\phi_2}$

Table 6. Overall inequality, IE and IO determinants in U.S. (1970-2009), logs

	log Theil 0		log IE-Theil 0		log IO-Theil 0	
	estimate	std	estimate	std	estimate	std
GDP(-1)	-1.4108***	0.3664	-1.0210**	0.42939	-4.0384**	1.5525
Deflactor (-1)	0.4572	0.3189	0.6816*	0.42333	-0.8156	2.3044
Credit (-1)	-0.4560***	0.1460	-0.3571*	0.20513	-1.5799**	0.6386
Spending	-0.0235	0.0587	0.0898	0.07858	-0.8837***	0.3062
C	-0.0006	0.0011	-0.0004	0.00138	0.0002	0.0070
Estimates of the autorregressive structure						
AR(1)	1.1845***	0.1626	1.2296***	0.12630	1.3267***	0.1359
AR(2)	-0.6724***	0.1728	-0.7247***	0.12219	-0.7778***	0.1007
p	5.9070		6.1601		6.6427	
d	0.8200		0.8513		0.8819	
	estimate	p-value	estimate	p-value	estimate	p-value
R2	0.9151	--	0.9025	--	0.8555	--
S.E. of regression	0.0036	--	0.0043	--	0.0120	--
F-stat	50.2854	0.0000	43.1781	0.0000	27.6211	0.0000
Durbin-Watson	2.2293	--	2.3050	--	2.0447	--
Q-Stat(10)	7.7372	0.4600	10.8180	0.2120	5.6818	0.6830

(***) significance at a 1% level, (**) 5% level or (*) 10% level.

p: the period (years/cycle) of the cycle: $p = 2\pi / \arccos\left(\varphi_1 / 2\cdot\sqrt{-\varphi_2}\right)$; d: the damping factor: $d = \sqrt{-\varphi_2}$

FIGURES

Figure 1. Overall inequality, IE and IO in U.S. (1970-2009)

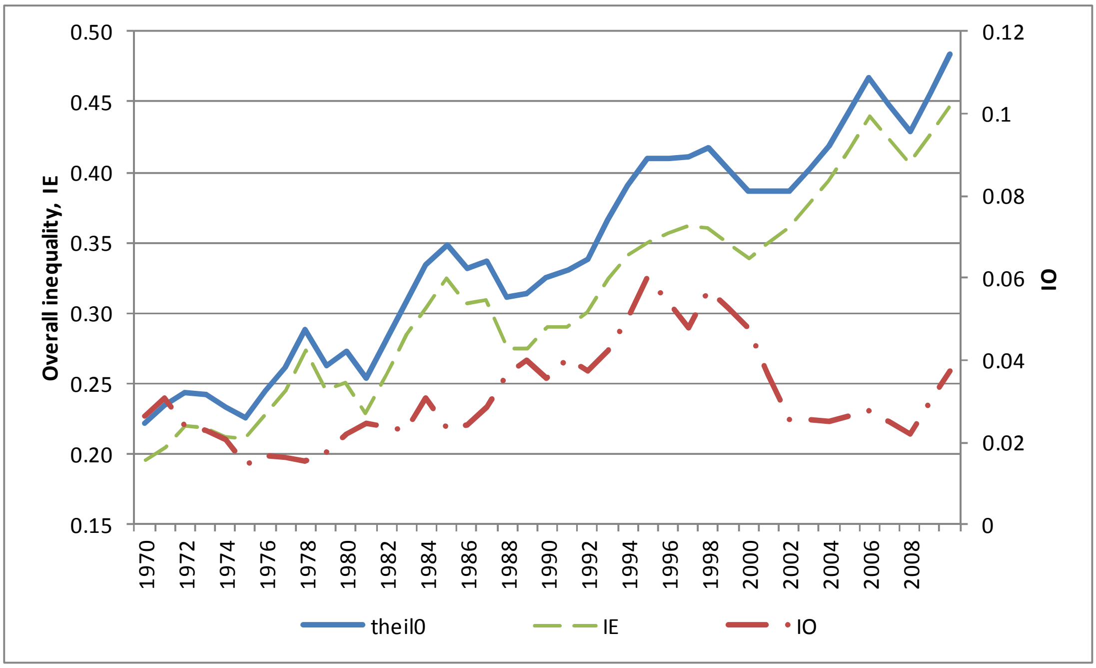
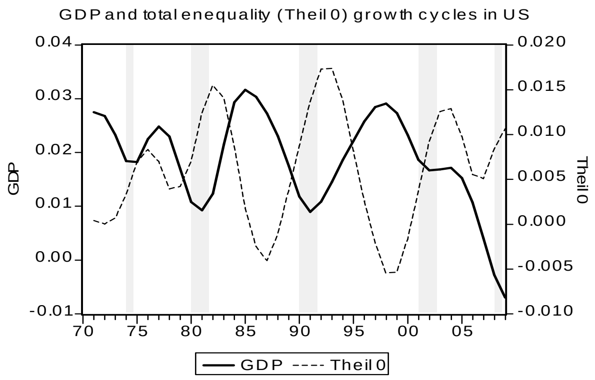
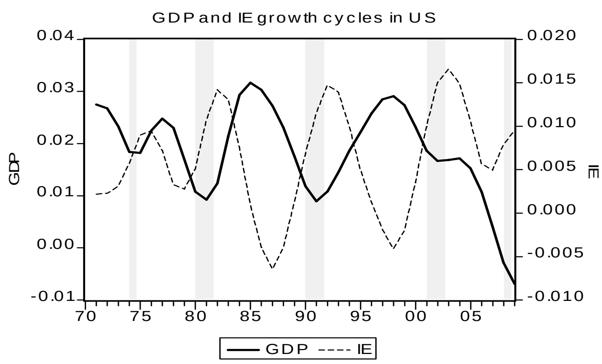


Figure 2. The growth cycle of real GDP and all the rest variables in U.S. (1970-2009)

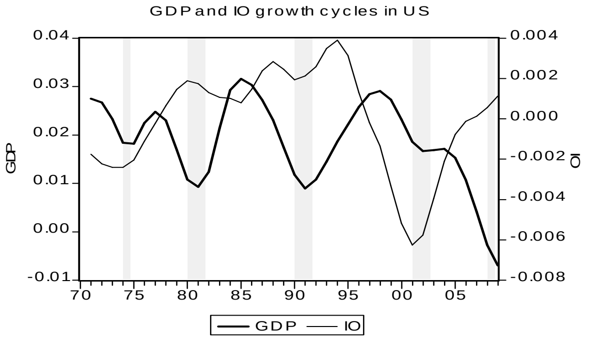
(a)



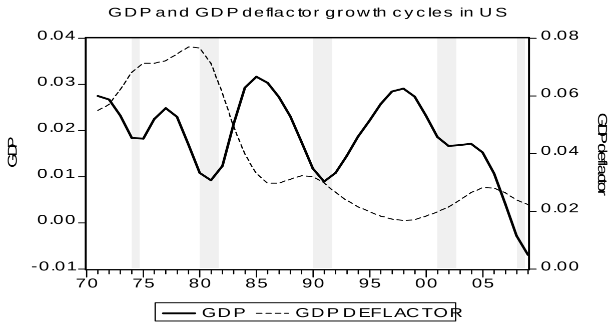
(b)



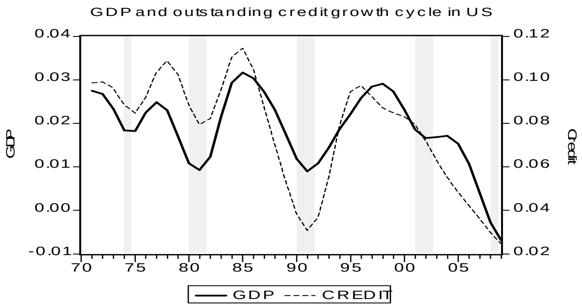
(c)


GDP and IO growth cycles in US
GDP
IO
0.04
0.03
0.02
0.01
0.00
-0.01
0.004
0.002
0.000
-0.002
-0.004
-0.006
-0.008
70 75 80 85 90 95 00 05
GDP IO

(d)


GDP and GDP deflactor growth cycles in US
GDP
GDP deflactor
0.04
0.03
0.02
0.01
0.00
-0.01
0.08
0.06
0.04
0.02
0.00
70 75 80 85 90 95 00 05
GDP GDP DEFLACTOR

(e)


GDP and outstanding credit growth cycle in US
GDP
Credit
0.04
0.03
0.02
0.01
0.00
-0.01
0.12
0.10
0.08
0.06
0.04
0.02
70 75 80 85 90 95 00 05
GDP CREDIT

(f)

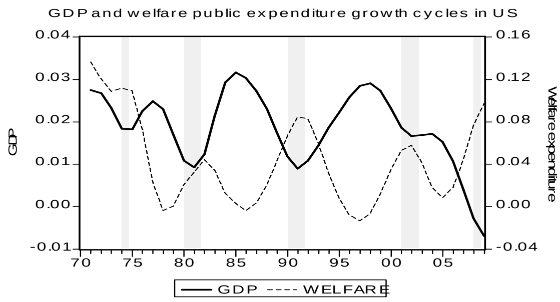

GDP and welfare public expenditure growth cycles in US
GDP
Welfare expenditure
0.04
0.03
0.02
0.01
0.00
-0.01
0.16
0.12
0.08
0.04
0.00
-0.04
70 75 80 85 90 95 00 05
GDP WELFARE

Figure A1. GDP (real and smoothed) in U.S. (1970-2009)

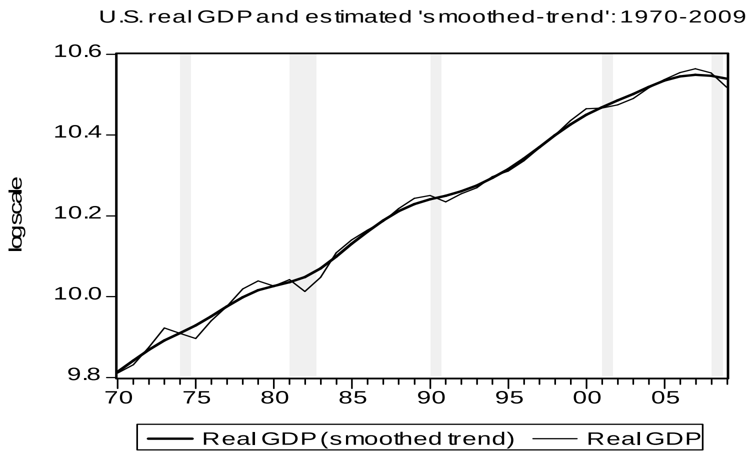


Figure A2. GDP (real and smoothed) growth rates in U.S. (1970-2009)