Cuadernos de Economía (2018) 41, 291-300

Asociación Cuadernos de economía

Cuadernos de economía

www.cude.es

ARTÍCULO

Linearity and causality on the dynamic relationship between income inequality and economic growth: evidence from a high income Latin American country

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JEL CODES
C22; O11; O47; O54

KEYWORDS:
Economic growth;
Income inequality;
Cointegration analysis;
Causality tests;
Uruguay

Abstract: This paper studies the long-run relationship between income inequality and economic growth in Uruguay, a high income Latin American country. Cointegration techniques are applied by using nonparametric tests and data for the period 1986 to 2014. Linearity of the relationship is tested previously to the estimation of the functional of the relationship between these variables which shows a negative linear long-run relationship between real GDP growth and inequality is obtained. To test causality, the procedure suggested by Holmes and Hutton (1990) is performed. The results find that causality is unidirectional and the effect goes from economic growth to inequality. When the test is performed in differences, significant effects can be identified in both directions. A shock (an unexpected rise or decrease) on the variation of inequality cause effects on growth variation. It follows that in the short-run inequality may affect growth, but not in the long-run, implying that the effect in this direction is transitory.

CÓDIGOS JEL
C22; O11; O47; O54

PALABRAS CLAVE
Crecimiento económico;
Desigualdad de ingresos;
Análisis de cointegración;
Pruebas de causalidad;
Uruguay

Resumen: Este trabajo estudia la relación a largo plazo entre la desigualdad de ingresos y el crecimiento económico en Uruguay, un país latinoamericano de altos ingresos. Con este fin, se aplican técnicas de cointegración mediante el uso de test y datos no paramétricos para el período de 1986 a 2014. La linealidad de la relación se prueba previamente a la estimación de la función que relaciona estas variables, la cual muestra que se obtiene una relación lineal negativa de largo plazo entre el crecimiento del PIB real y la desigualdad. Para probar la causalidad, se realiza el procedimiento sugerido por Holmes y Hutton (1990). Los resultados encuentran que la causalidad es unidireccional y el efecto va del crecimiento económico a la desigualdad. Cuando la prueba se realiza en diferencias, se pueden identificar efectos significativos en ambas direcciones. Un shock (un aumento o disminución inesperados) en la variación de la desigualdad causa efectos en la variación del crecimiento. Se sigue que, en el corto plazo, la desigualdad puede afectar el crecimiento, pero no a largo plazo, lo que implica que el efecto en esta dirección es transitorio.

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I. Introduction

The relationship between income inequality and economic growth has been discussed extensively. Kuznets (1955) suggested that the relationship between these variables seems to be U-shaped, and this hypothesis has been tested and confirmed in several studies based on both personal income and regional income distributions. Recent studies test the dynamic relationship for several countries by using panel-data time series of good quality and length, but researches for specific countries are scarce. The study of individual countries could reveal alternative results than those for panel data.

Some particularities of Uruguay encourages choosing this country as an interesting case of study. First, the country stands out in the Latin-American region (the most unequal one in the world) because of a large tradition of publicly provided education and social inclusion. Also, it ranks among the highest in the region in terms of its economic indicators, presenting the lowest poverty rate and income inequality (IMF, 2015). In addition, in contrast to other countries of the region, income inequality evolved differently in Uruguay (see Amarante, 2014 for an empirical review). Intensity in the Uruguayan process of economic liberalization, such as gradual openness of the economy, no privatization of the main public firms, and institutional factors –mainly in the labor market– could be in part explaining these divergences across countries.

These are the reasons why this paper aims to study to what extent income inequality and economic growth are dynamically related in the long-run in Uruguay over the period 1986 to 2014. Specifically, the study tests whether a long-run relationship between economic growth and income inequality exists, and if it does, it examines to what extent a causal relationship between these variables takes place. In this sense this paper is a first attempt to explore the dynamic long-run relationship between these variables in Uruguay. It is worth noting that cointegration techniques only attempt to analyze if long-run relationship between key variables exists, and do not account for the alternative mechanism that could be affecting both variables (such as distributive policies, investment policies, etc.).

Since classical authors, the economic science has focused on understanding the relationship between income distribution and economic development. Both theoretical and empirical studies have found opposite results, without final conclusive answers. While early studies based on cross-sectional databases find a negative relationship between income inequality and economic growth, studies based on panel datasets find mixed results (see Herzer and Vollmer, 2012). For instance, Li and Zou (1998) and Forbes (2000) report a positive effect of overall income inequality on subsequent economic growth, using a diverse sample of developed and developing countries. Conversely, Barro (2000) finds that inequality appears to encourage growth only within rich countries, and to slow it down in poorer countries. For Latin-American countries, Janvry and Saudolet (2000) find that growth doesn't reduce inequality (the study extends from 1970 to 1994), nevertheless they show that great recessions have a significant and negative impact on it. Since different studies analyze the causal relationship between inequality and economic growth for different set of countries, ranging from cross-countries databases to panel database analysis, they are subject to several criticisms (see Banerjee and Duflo, 2003). Moreover, allowing for non-linearity of the effect of inequality suggests that a change in inequality *in any direction* may be detrimental to growth (Banerjee and Duflo, 2003).

By contrast, the study of a single country could shed light on the relationship between income inequality and economic growth, at the time that overcomes different issues pointed by the literature (Banerjee and Duflo, 2003; Risso et al., 2013). Gobbyn and Rayp (2008) argue that a country-specific analysis through a vector autorregresive (VAR) model is the most suitable framework for the analysis of the relationship between inequality and economic growth. By exploring the cases of Belgium, Finland and US, the authors stress that different inequality-growth models hold for different countries, which may in turn explain the mixed effects found in previous cross-section and panel studies. Few country case studies tackling the long-run relationship between income inequality and economic growth through cointegration analysis are provided in Risso et al. (2013) for the Mexican case, Risso and Sánchez Carrera (2012) for China; Policardo et al., (2015) addressing the cases of Brazil and China, and Andrade et al. (2014) for the Portuguese case.

This paper aims to contribute to the empirical literature in two ways. First, it provides new country case evidence on the relationship between inequality and economic growth for a high income country such as Uruguay.[1] Second, in order to avoid restricting the analysis and due to neither theory nor previous research indicates that the relation between inequality and growth is linear or not, linearity assumption previously to the estimation of the cointegration relationship is tested. The linearity assumption was previously pointed by Banerjee and Duflo (2003) as a possible explanation of why alternative studies find mixed results.

For the purpose of the paper, cointegration techniques are applied by using nonparametric tests and data for the period 1986 to 2014.[2] These techniques allow to consider both variables, inequality and GDP growth as endogenous, avoiding assuming causality in any direction. After testing linearity for the functional form between inequality and economic growth, a negative linear long-run relationship between real GDP growth and inequality is found. To test causality, in the sense of the predictive capability, a test suggested by Holmes and Hutton (1990), more robust than Granger non-causality test, is performed. The result suggests that the effect goes from economic growth to inequality. When the test is performed in differences, significant effects are identified in both directions. A shock (an unexpected rise or decrease) on the variation of inequality cause effects on growth variation. It follows that in the short-run inequality may affect growth, but not in the long-run. Then, the effect in this direction is transitory.

[1] Uruguay has recently been classified as a High income country by the World Bank (July 2016).

[2] The consideration of different periods of analysis (as in Risso and Sanchez Carrera, 2012) should be of interest. However a unique period was considered because of the limitation of the number of observations.

After this introduction, Section 2 reviews the theoretical and empirical literature on the relationship between economic growth and inequality. Section 3 summarizes the evolution of income inequality and economic growth in Uruguay over the period 1986 - 2014. Next, we introduce the methodological framework, and present the data used in this study. Section 5 shows the main results found in this study. Finally, the last section concludes and indicates lines of future research.

II. Literature review on inequality and economic growth

The relationship between economic growth and wealth distribution is and old question targeted by the economic literature. Despite the large development from a theoretical and empirical point of view in the literature, the answer is still far from being conclusive. Over time, different perspectives on the relationship between development and income distribution had emerged. Classical economists believed that income inequality fosters economic growth, on the understanding that inequality promotes savings from those wealthier individuals, whose marginal propensity to save is higher, increasing aggregate savings, capital accumulation, and economic growth (Kaldor, 1956).

The neoclassical perspective, which had subsequently dominated the field of macroeconomics, dismissed the significance of income distribution on economic growth. As a consequence, income inequality became irrelevant as a subject of study in the economic literature. For instance, the hypothesis advanced by Kuznets (1955) reflects the neoclassical point of view, in which an inverted U relationship between inequality and economic development reflects the causation from the process of development to the distribution of income.

Over the last decades there has been a resurgence of studies in the economic development literature focusing on the persistency of inequality and economic status within and between countries. On the one hand, the great income differences observed between as well as within countries, has turned economic literature's attention to explain why countries differ in their economic growth.

On the other hand, the recognition of the negative effects of income inequality on individuals' wellbeing such as happiness, health, education, violence, etc., has turned economic research to analyze the mechanisms through which economic status and inequality perpetuates over time. Then, insightful theories on alternative sources of inequality were developed focusing on the alternative channels explaining persistency in inequality and its relationship with economic growth.

In challenge to the representative agent framework dominating the neoclassical viewpoint, the modern perspective that states that inequality is harmful for development has emerged. Two main channels are explored within this literature: credit constraints and political economy channels.[3] The first approach states that under plausible conditions, such as credit market imperfections and fixed costs associated with investments, individuals' occupational choice and long-run development depend on the initial wealth distribution.

The pioneer works of Galor and Zeira (1993) and Banerjee and Newman (1993) show that credit market imperfections could prevent poor people from undertaking the efficient amount of investment. These models broadly states that, under the presence of credit market imperfections, up-front investment is available only to wealthy people who can provide a collateral, while poorer and credit constrained individuals are prevented to invest in human capital (Galor and Zeira, 1993) or physical capital (Banerjee and Newman, 1993). Then, only wealthier people can choose to become employed in skilled jobs (Galor and Zeira, 1993), or to become entrepreneurs (Banerjee and Newman, 1993). Poorer people, instead, can only obtain unskilled jobs (Galor and Zeira, 1993) or can only choose to work for a wage (Banerjee and Newman, 1993); giving rise to a new distribution of wealth. In the long-run, in countries with a low rate of rich to poor people, more people can choose their occupation in the creation and development of profitable firms, or occupations paying larger wages. A contrasting equilibrium could be reached if a country starts with a relatively high number of wealthy to poor people. In this case development runs out of steam (Aghion and Bolton, 1997; Matsuyama. 2002; Aghion et al, 2007).

The second vein within the modern perspective, focuses on the political economy channel which advances the idea that inequality is harmful for development. This framework stresses that income distribution influences on the level of taxation and redistribution through the political system (Alesina and Rodrik 1994; Persson and Tabellini 1994). Higher initial inequality leads to higher redistribution. Inequality may generate an incentive for better endowed agents to lobby against redistribution, preventing efficient redistribution policies from being implemented, such as the implementation of institutional changes and policies that promote human capital formation and thus economic growth (Acemoglu, 1995; Mehlum et al., 2003; Engerman and Sokoloff, 2005; Easterly, 2001). Also, if redistribution is attained via higher taxes on investment returns, it ends up reducing economic growth (García-Peñalosa and Wen, 2008).

Galor and Moav (2004) claim to provide theoretical evidence which reconciles different viewpoints found in the literature. The authors suggest that the positive or negative relationship between inequality and economic growth reflects the state of the world in early stages of industrialization, when physical capital accumulation is the motor of economic growth. Conversely, when human capital accumulation fosters economic growth, in later stages of development, the credit market imperfections approach explains the negative effect of inequality on development.

Empirical research on economic growth and income distribution has shown no conclusive results (see the recent surveys Neves et al. 2014; 2016). Banerjee and Duflo (2003) argue that disagreements in empirical studies reflects different econometrics techniques, control variables chosen, countries covered, and the quality of databases used in different studies. Also, the authors find that the data strongly supports the case for taking non-linear relationships

[3] See Benabou (1996) and Galor (2011) for a complete literature review.

between income distribution and economic growth. Moreover, they conclude that "(...) *in particular the non-linearities in those relationships (and not differences in the control variables, the sample, and the lag structure), explain why different variants of the basic linear model (OLS, fixed effects, random effects) have generated very different conclusions: In many cases, it turns out that the differences arise out of giving different structural interpretations to the same reduced-form evidence* " (pp. 268). In turn, Voichovsky (2005) highlights the importance of income inequality measures, suggesting that the relationship between income distribution and economic growth depends on the part of the distribution considered, with top end inequality encouraging growth and bottom end inequality retarding growth.

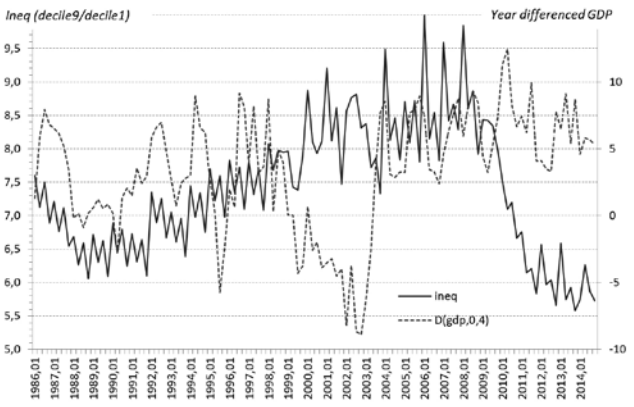
Studies that address the association between income distribution and economic growth are relatively scarce in the literature. For instance, Risso et al. (2013) analyze the long-run relationship between economic growth and income inequality in Mexico. Using cointegration analysis, the authors find that a negative long-run relationship between inequality and economic growth for the period 1968-2010. Also, that unidirectional causality goes from economic growth to income inequality.

Risso and Sánchez Carrera (2012) study the long-run relationship between inequality and growth in China during the pre-reform (1952-1978) and post-reform (1979-2007) periods by using cointegration analysis. The authors find a positive relationship between these variables for both periods of analysis. Also, the study points out that causality goes from inequality to growth in the pre-reform period, while for the post-reform period no directional causality is found. Also, Policardo et al. (2015) analyze the long-run relationship for Brazil and China separately, for the period 1980 to 2009, through cointegration analysis. In line with Risso and Sánchez-Carrera (2012), a positive relationship between inequality and economic growth is found for China. Conversely, this relationship is negative for the Brazilian case. Moreover, this study concludes that, for China, causality runs from economic growth to inequality; while for Brazil, causality goes the other way round, from income inequality to economic growth. Finally, Andrade et al. (2014) focus on the long-run relationship between inequality and growth for the Portuguese case, considering the period 1985-2007. By applying structural model (SVAR analysis), the study concludes that income inequality is detrimental to economic growth for the period considered. In addition, the authors conclude that the causality seems to run from inequality to economic growth.

III. Economic growth and income inequality in Uruguay over 1986-2014

The joint evolution of economic growth and income inequality in Uruguay shows periods in which both variables evolved in a similar way, and periods in which both variables move in opposite directions (Figure 1). A priori, there is no clear pattern of evolution of these variables.

Figure 1. Economic growth and income inequality. Quarterly data 1986 - 2014.



Source: own elaboration based on ECH and BCU.

During the eighties, the Uruguayan economy was signed by an increase in its exports, mainly to Argentina and Brazil, and the restoration of the centralized bargaining wage process after the end of the dictatorial regime, generating a significant increase in real wages, mainly of those unskilled workers (Alves et al., 2012).

Over the nineties, the Uruguayan economy was characterized by a deepening in its trade and financial liberalization process, a regional integration process with Argentina, Brazil and Paraguay creating the MERCOSUR, and the implementation of macroeconomic stabilization policies; factors that produced changes on economic growth and income distribution patterns' prevailing in the eighties. As a consequence of the international openness, the economy expanded fostered by an increase in its exports and a greater dynamism in the service sector. However, the country experienced an important reduction of the industrial sector on the total economy, giving place to structural changes of the economy (Arim and Furtado, 2000).

According to different authors (Amarante and Arim, 2005; Alves et al., 2012) the economic growth observed over the nineties, coexists with different evolutions of income inequality. Changes in the labor market and on the mechanisms of income adjustment affected the evolution of social groups' income per capita. Retirement pensions and social security benefits were readjusted since 1990, implying an indexation of passivity's to the medium wage index. This change in the pattern of adjustment of social security benefits, plus an increasing participation of household members in the labor market, mainly female labor participation, increased households' income per capita.

In 1990-1991, a new change in the bargaining wage process took place. Decentralization and retirement of the State in wage and labor conditions' bargaining, and a reduction in labor unions' power, gave place to a decrease in labor conflicts, which jointly to an increasing unemployment rate, made labor unions to focus on employment maintenance instead of wage increasing negotiations. Alves et al. (2012) describes the period 1986-1994 as a relatively stable one, in which income inequality does not present significant changes. According to these authors, this period can be considered as "pro-poor" on the understanding that income

of the bottom percentiles of the distribution grew more than the one observed in the top of the distribution. At the same time, income in the top of the distribution increased at a larger rate than the average growth rate, then total inequality does not substantially changes.

Since 1994, income inequality raises until 2007, mainly explained by the increasing returns of education, which enlarged wage gaps between skilled and unskilled workers. Overall, the fall of employment in the industrial sector, largely due to trade liberalization, and the fall of public employment, as consequence of state reform carried on the nineties, and changes in the mechanisms in wage bargaining, explains the concentration of income distribution observed over the nineties. At the end of the decade, the regional instability provoked recession in the Uruguayan economy, which ended in the deepest economic crisis of the country in 2002. In particular, the GDP per capita fall by 11% that year, and unemployment rate reached 17%.

After 2003 a new expansion of the economy takes place, led by a favorable international context of increasing demand of raw materials, and the boom of international prices of primary goods. In addition, since 2005 different reforms were implemented in the economy; a greater intervention of the State in the labor market, such as centralization of wage and labor conditions' bargaining, periodic increases in the minimum wage; tax and health reforms were implemented; and a large deployment of social policies such as cash transfers focused on the poorest people. As a consequence of these reforms (Amarante, 2016),[4] and after a large period of increases in income concentration, inequality rates fall since 2007 (Alves et al., 2012).

IV. Methodological framework

The present paper follows the procedure described in Breitung (2001), Holmes and Hutton (1990) and Ye Lim et al. (2011) to test and estimate the relationship between inequality and growth. The procedure suggested is: (i) test the existence of cointegration by using nonparametric tests (ii) test linearity, (iii) estimation of the corresponding relationship (iv) perform the rank-causality test. In what follows a summarized overview of these tests are presented.

Rank test for cointegration

Breitung (2001) introduces a nonparametric test procedure based on ranks to test the hypothesis of a cointegration relationship (linear or not) and to identify whether this link is nonlinear. The idea of that residual based cointegration test (the rank test) is that the sequences of the ranked series tend to diverge if there is no cointegration between the variables. Breitung rank test checks whether the ranked series move together over time towards a linear or nonlinear long-term cointegrating equilibrium. The procedure first checks for cointegration by using the rank test. If cointegration is accepted, then linearity in the cointegration relationship is examined by using a scoring test.

[4] In Amarante (2016) is shown that contributive transfers are a key factor in explaining the fall in inequality in Uruguay.

Let $f(x_t) \sim I(1)$ and $g(y_t) \sim I(1)$ nonlinear increasing functions of x_t and y_t, and $\mu_t \sim I(0)$. Let suppose that a nonlinear cointegration relationship between x_t and y_t is given by:

$$\mu_t = g(y_t) - f(x_t) \tag{1}$$

The rank statistic is constructed by replacing *f(xt)* and *g(yt)* by the ranked series

$$R_T[f(x_t)] = R_T(x_t) \tag{2}$$

and

$$R_T[g(y_t)] = R_T(y_t) \tag{3}$$

Given that the sequence of ranks is invariant under monotonic transformations of the variables, if x_t or y_t are random walk process then $R_T[f(x_t)]$ and $R_T[g(y_t)]$ behaves like the ranked random walks as $R_T(x_t)$ and $R_T(y_t)$.The rank test procedure is based on two "distance measures" between the sequences of $R_T(x_t)$ and $R_T(y_t)$.

The cointegration test is based on the difference between the sequences on the ranks that can be detected by the bivariate statistics K_T^* and ξ_T^*:

$$K_T^* = T^{-1} \max_t |d_t| / \hat{\sigma}_{\Delta d} \tag{4}$$

$$\xi_T^* = T^{-3} \sum_{t=1}^{T} d_t^2 / \hat{\sigma}_{\Delta d}^2, \tag{5}$$

where

$$d_t = R_T(y_t) - R_T(x_t), \tag{6}$$

for $R_T(y_t)$ = Rank [of y_t among $y_1,\ldots,y_T$] and $R_T(x_t)$ = Rank [of x_t among $x_1,\ldots,x_T$].

The $\max_t |d_t|$ is the maximum value of $|d_t|$ over t=1, 2, …, T and

$$\hat{\sigma}_{\Delta d}^2 = T^{-2} \sum_{t=2}^{T} (d_t - d_{t-1})^2 \tag{7}$$

adjusts for possible correlation between the series of interest.

Rank test for neglected nonlinearity

If cointegration exists in the first step, then the linearity of the cointegration relationship is examined in a second step.

For a convenient representation of the alternative and null hypothesis Bretuing (2002) follows Granger (1995) and represents the nonlinear relationship as:

$$y_t = \gamma_0 + \gamma_1 x_t + f^*(x_t) + u_t \ , \tag{8}$$

where $\gamma_0 + \gamma_1 x_t$ is the linear part of the relationship. Only when $f^*(x_t) = 0$ there is a linear relationship between the variables. In this test the multiple of the rank transformation is used instead of $f^*(x_t)$.

If it is assumed that x_t is exogenous and *ut* is a white noise with $u_t \sim N(0,\sigma^2)$ a *score test* is obtained as the T^*R^2 statistic of the MCO:

$$\tilde{u_t} = c_0 + c_1 x_t + c_2 R_t(x_t) + e_t. \tag{9}$$

Bretuing (2001) generalizes the score test for the ECM representation and applies it to contrast the null hypothesis of

linear cointegration against the alternative hypothesis of nonlinear cointegration.

To compute the score statistic, the following two multiple regressions are run consecutively:

$$y_t = \alpha_0 + \sum_{i=1}^{p} \alpha_{1i} y_{t-i} + \alpha_2 x_t + \sum_{i=-p}^{p} \alpha_{3i} \Delta x_{t-i} + u_t \quad (10)$$

$$u_t = \beta_0 + \sum_{i=1}^{p} \beta_{1i} y_{t-i} + \beta_2 x_t + \sum_{i=-p}^{p} \beta_{3i} \Delta x_{t-i} + +\theta_1 R_T(x_t) + +v_t, \quad (11)$$

where $\beta_0 + \sum_{i=1}^{p} \beta_{1i} y_{t-i} + \beta_2 x_t + \sum_{i=-p}^{p} \beta_{3i} \Delta x_{t-i} +$ is the linear part of the relationship and it involves the ranked series $R_T\left(x_{jt}\right)$.

Under the null hypothesis, it is assumed that the coefficients for the ranked series are equal to zero, θ_1=0. The appropriate value of p is selected based on Akaike Information Criterion, such that serial correlation $\tilde{u}_t$ and possible endogeneity are adjusted based on Stock and Watson (1993). The *score statistic* $T \cdot R^2$, is distributed asymptotically as a χ^2 distribution, where T is the number of observations and R^2 is the coefficient of determination of the second equation. The null hypothesis is rejected and a nonlinear relationship is accepted, if the score statistic value exceeds the χ^2 critical values with one degree of freedom.[5]

Causality Rank Test

To examine causality (not in the strict sense but in the sense of predictability capability), conventional Granger test uses Vector Autoregression (VAR) or Vector Error Correction Model (VECM). However, results from the conventional parametric tests are limited by the augmenting hypothesis of the specific functional forms of the variables and the assumptions of homoscedasticity and normality of the error terms. As pointed by Ye Lim et al. (2011), violation of these conditions can cause spurious causality conclusions. If one of these conditions is violated, Holmes and Hutton (1990) multiple rank F-test is more robust than the standard Granger causality test. Moreover, if the conditions of Granger estimations are satisfied, the multiple rank F-test results are alike the Granger results.

Holmes and Hutton (1990) analyzed the small sample properties of the multiple rank F-test, showing that with non-normal error distributions the test has significant power advantages both in small and in large sample. This is also true for weak and strong relationships between the variables.

The Holmes and Hutton (1990) multiple rank F-test is based on rank ordering of each variable. In this test, the causal relationship between y_t and x_t involves a test of a subset of q coefficients in the Autoregressive Distributed Lag (ARDL) model. The multiple rank F-test in ARDL (p,q) model can be written in the following framework:

$$R\left(y_t\right) = a_0 + \sum_{i=1}^{p} a_{1i} R\left(y_{t-i}\right) + \sum_{i=1}^{q} a_{2i} R\left(x_{t-i}\right) + e_t \quad (12)$$

$$R\left(x_t\right) = b_0 + \sum_{i=1}^{p} b_{1i} R\left(x_{t-i}\right) + \sum_{i=1}^{q} b_{2i} R\left(y_{t-i}\right) + \varepsilon_t \quad (13)$$

where $R(\cdot)$ represents a rank order transformation and each lagged values of the series in each model are treated as separate variables when calculating their ranks, for example, $R(Y_t)$ and $R(Y_{t-1})$. The residuals e_t and ε_t are assumed to be serially uncorrelated. The values of p and q may differ in each equation. When choosing p and q, two things need to be considered: the significance of the estimated coefficients and the serial correlation of resulting residuals. From the first equation, rejection of the null hypothesis $(a_{2i} = 0)$ implies causality from X to Y; whereas in the second one, rejection of the null hypothesis $(a_{2i} = 0)$ implies the reverse causality from Y to X. The null hypothesis is rejected if the F-test statistic is significant with respective q´s value and $N\text{-}K\ (K=p+q+1)$ degrees of freedom.

V. Data

Data used in this study are time series of quarterly data, ranging from the first quarter of 1986 through the last quarter of 2014. Inter-annual variation of Real Gross Domestic Product (year differenced GDP) represents economic growth (which source is the Uruguayan Central Bank, BCU). Since there are no official population quarterly data, estimates with quarterly GDP per capita variable it not used. However, as the population growth rate in Uruguay is very low, there are no significant differences in the evolution of both indicators (GDP and GDP per capita).

Income inequality is proxied by using the 90/10 ratio, which measures the ratio of the income share on the top 9th decile to the bottom 1st decile.[6] This ratio is estimated based on Continuous Household Surveys (ECH *Encuesta Continua de Hogares*) conducted by the National Statistic Institute (INE). Microdata provided by the ECH is continuously available since 1986. In order to obtain consistent series for the whole period, per capita household income after taxes and transfers to the urban population is considered (representing 85% of the total population).[7]

VI. Empirical Results

After testing the order of integration, which indicates that both variables are integrated of order 1 (i.e. the series are I (1)), the rank cointegration test is performed. As we mentioned before, neither theoretical nor empirical literature is conclusive with respect to the specification of the relationship between economic growth and inequality.

[5] We consider 1 degree of freedom because the score test is applied using 2 variables.

[6] Other studies use the Gini index as a proxy of income inequality. In this study the 90-10 ratio was chosen in order to obtain more variability of income inequality measure. As we consider quarterly data, it can be expected that the Gini index would move slower than the 90-10 ratio, as the first one reflects changes in inequality for the whole distribution; while the second one shows changes only if income shares in the percentiles considered changes. Then, one disadvantage of the income share rates is that they only reflect changes in the percentiles considered. As a consequence, if income shares in other parts of the distribution changes, then changes in inequality are not reflected.

[7] Since 2006 the ECH is representative at the national level, including urban and rural areas.

Breitung (2001) states that when theory does not provide a precise specification of the functional form is desirable to have nonparametric tools for estimation and inference, and proposes a rank test to detect cointegration. Once the existence of the cointegration relationship is confirmed, then proceeds its identification, investigating whether it is linear or not.

Table I resumes the empirical results of the non-parametric cointegration test and the linearity test performed between real GDP growth and inequality. The non-parametric cointegration test shows that there is a cointegration relationship between real GDP growth and inequality, at 10% of level of confidence. On the other hand, linearity test indicates that it cannot be rejected this hypothesis (at all levels of confidence).

Table I. Results of nonparametric cointegration test and linearity test

	Test Statistics	
	$\Xi_T^*[1]$	$T \cdot R^2$
Coint. Ineq-growth	0.0226*	0.0257
Significance Level	Critical values	
10%	0.0248	2.7055
5%	0.0197	3.8415
1%	0.0136	6.6349

Notes: The hypothesis of no cointegration is rejected if the rank statistic, $\Xi_T^*[2]$, is below the respective critical value and the hypothesis of linearity is rejected if the score statistic, $T{\cdot}R^2$, exceeds the χ^2 critical values with two degree of freedom. *, ** and *** denote significance at 10%, 5%.

Once linearity is accepted, the analysis of the cointegrated relationship is analyzed in a linear context following Johansen procedures (Johansen, 1988; 1995)[8]. The methodology involves the joint analysis of long and short term dynamics, by estimating a vector autoregressive with error correction mechanism (VECM) between inequality (denoted by *ineq*) and inter annual real GDP variation (year differenced GDP, denoted by *d4pib*). The maximum likelihood procedure of Johansen provides two different tests to determine the number of cointegrating equations. One is based on the trace statistic and the other on the maximum eigenvalue. As seen in Table II, both tests detect the existence of one cointegrated equation at 5%.

Table II. Johansen cointegration test

[*ineq*, *d4pib*] No. of Eq.	Eigen value	Trace			Max. eigenvalue		
		Statistic	Value Crítico	Prob.	Statistic	Value Crítico	Prob.
None	0.142986	19.4197	15.49471	0.0121	17.12745	14.26460	0.0172
At most 1	0.020439	2.29223	3.841466	0.1300	2.292231	3.841466	0.1300

Note. The rejection of the null hypothesis is indicated at 95% confidence level (*).

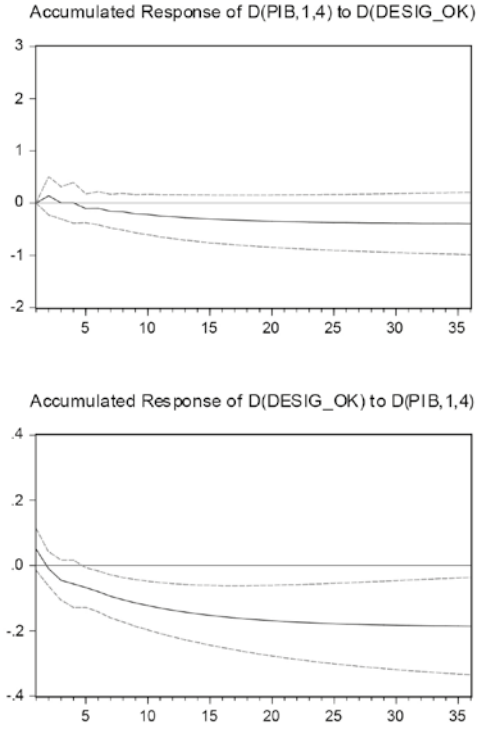
The exogeneity contrast performed show that economic growth economic growth (inter-annual variation of real GDP) is weakly exogenous and inequality is endogenous within the long run relationship. In addition, exclusion tests confirm that both variables are significant in the long run relationship. The final restricted cointegration equation (imposing the exogeneity of GDP growth, previously tested) estimated is:

$$ineq = +8.006 - 0.183 * d4gdp \quad (14)$$
$$(0.073)$$

Equation (14) indicates, as expected, that in the long run, inequality (proxied by the 90/10 ratio) is negatively related to inter-annual growth of GDP in Uruguay.

In order to investigate about the dynamic of adjustment within the estimated relationship between inequality and economic growth, impulse response analysis is performed. Monte Carlo simulations are ran by shocking the variables with 1 standard innovation and applying Cholesky decomposition method. Results are presented in Figure 2.

Figure 2. Impulse-response analyses



Note: confidence interval $\pm 2sd$

Impulse response analysis shows that a positive shock on economic growth (1 *sd* shock, i.e. 2 p.p innovation on d(gdp,1,4)) causes a very quick, negative and significant response on inequality. The accumulated response of inequality to 1 *sd* of GDP growth is a decrease of 0.2 p.p. The impact is 50% absorbed in 8 quarters (i.e. 2 years). On the contrary, a positive shock on inequality (a 0.3 p.p innovation) leads to a negative response on economic growth but this is no significant.

Finally, following Brida et al. (2015), causality (in the sense of predictability), between both variables is tested

[8] A general approach is provided by Johansen and Juselius, 1990.

by applying the rank test proposed by Holmes and Hutton (1990), which is more robust than the conventional parametric causality tests usually applied in the literature.[9]

Table III shows the results of Holmes and Hutton test (H-H).[10] The statistics $(F, \chi 2)$ confirm that the effect goes from economic growth towards inequality. On the contrary, the test rejects causality (more precisely, predictability) of inequality towards economic growth in the long- run. These results are consistent with what can be seen in impulse-response simulations previously discussed.

Table III. Causality test (H-H)

		Dependent Variable	
		R(ineq)	R(d4gdp)
Levels	Optimal model (p,q)	(1 5,3 4 7 6)	(1 2 4 5, -)
	F-statistic (d.f.)	2.772** (3,100)	-
	$\chi 2$ statistic (d)	8.316** (3)	-
	Conclusion	d4gdp $\rightarrow$ ineq	ineq $\not\rightarrow$ d4gdp
		R(d(ineq))	R(d(d4gdp))
Diffs	Optimal model (p,q)	(1 3 8 8,1 1 5 5)	(1 1 4 4 8 8, 4 4)
	F-statistic (d.f.)	4.693** (2,100)	3.849* (1,102)
	$\chi 2$ statistic (d)	9.386*** (2)	3.849** (1)
	Conclusion	D(d4gdp) $\rightarrow$ d(ineq)	d(ineq) $\rightarrow$ d(d4gdp)

When the test is performed in differences, statistic causality cannot be rejected in any direction. A shock (an unexpected rise or decrease) on the variation of inequality cause effects on growth variation. It follows that in the short-run inequality affects growth, but not in the long-run. The effect is transitory.

VII. Conclusions

This paper aimed to contribute to the empirical literature on economic growth and income inequality by providing evidence on the dynamic relationship between income distribution and economic growth in the long-run in a high income country such as Uruguay. In addition, the study contributes to this literature by testing if linearity is the best specification to represent the long-run relationship between inequality and economic growth, an issue rarely considered in previous empirical studies. By testing linearity, the paper takes into account some of the main issues pointed by the literature as the main factors in explaining no conclusive results in empirical studies.

First, cointegration tests were conducted between inter-annual real GDP variation and income inequality proxied by the ratio of the income share on the top 9th decile to the bottom 1st decile, for the period 1986 - 2014. This test does not previously assumes any hypothesis about the specification of the relationship (linear or not). The results of applying the test show that linearity is a plausible specification for the dynamic relationship between the involved variables. Note that this issue opens a line of future research by including the introduction of alternative dynamic relationships between the variables for the cases where the linear test shows that the specification in nonlinear.

Secondly, once linearity of the functional form is accepted, a negative long-run relationship between economic growth and income distribution was found. Finally, based on impulse response analysis, the results showed that a positive shock on economic growth causes inequality reduction, and that half of the shock is absorbed in 8 quarters. In turn, after causality tests were performed, causality uni-directionally goes from economic growth to inequality.

In sum, the relationship between income distribution and economic growth seems to be an empirical matter, which in turn reflects specific country characteristics, such as institutional factors that may affect the inequality-growth relationship. For the Uruguayan case, the results showed a negative linear relationship between income distribution and economic growth in the long-run. Similar long-run relationships are found in Mexico (Risso et al., 2013), Brazil (Policardo et al., 2015) and Portugal (Andrade et al., 2014). However, differences across studies are found in relation to the causality between inequality and economic growth. Causality is found to go from economic growth to inequality in the Uruguayan and Mexican cases. Conversely, for Brazil and Portugal, inequality causes economic growth (Policardo et al., 2015; and Andrade et al, 2014; respectively). A positive relationship between inequality and growth for the pre and post reforms periods is found in China, and causality goes from inequality to growth in the pre-reform period (Risso and Sánchez-Carrera, 2012). Conversely, a positive relationship is observed for the Chinese case, for the period 1980-2009, at the time that causality runs from economic growth to inequality (Policardo et al., 2015).

The fact that the empirical results are not homogeneous, with countries presenting a negative relationship while others show a positive association, indicates that country specific factors determine the final dynamic relationship between economic growth and inequality. Therefore, single countries case studies seem to be relevant and necessary to complement the several studies using pools of countries. Future research may explore alternative country case

[9] To examine the casual linkage, conventional Granger causality test uses Vector Autoregression (VAR) or Vector Error Correction Model (VECM). However, results from the parametric tests are limited by the augmenting hypothesis of the specific functional forms of the variables and the assumptions of homoscedasticity and normality of the error terms. Violation of these conditions can cause spurious causality conclusions, as signaled by Ye Lim et al (2011). If one of these conditions is violated, the Holmes and Hutton (1990) multiple rank F-test is shown to be more robust than the standard Granger causality test. Moreover, if the conditions of Granger estimations are satisfied, the multiple rank F-test results are similar to the Granger results. Holmes and Hutton (1990) analyzed the small sample properties of the multiple rank F-test, and found that with non-normal error distributions, the test has significant power advantages both in small and large sample as well as with weak and strong relationships between the variables.

[10] Granger causality test does not show evidence of causality between these variables.

studies in order to understand the different specifications (and economic models that are behind) for economies with different fundamentals. In this sense, Janvry and Saudolet (2000) suggest that there's some kind of asymmetries in the impact of growth on inequality in Latin American countries, with recession having strong negative effects on it. In addition, it seems that time period of study could be relevant to understand the different dynamic relationships. In the present study the test of linearity is an argument to justify the use of a unique time period.

Mixed empirical studies are also stressed in Risso and Sánchez-Carrera (2013), who point out that some countries have recently experienced a redistribution of the benefits of growth, while the opposite is observed in economies that until recently have shown a more equalitarian income and wealth distribution. Then, the authors argue that it is possible to identify "clubs of countries" in which each club shares a model of growth defined in terms of the relationship distribution-growth. Thus, according to the results presented for the Brazilian and Mexican cases (in Policardo et al., 2008 and in Risso and Sánchez-Carrera, 2013; respectively), and with similar periods of analysis as the one considered in this study, it could be stated that these countries share similar economic growth models in the sense that economic growth reduced income inequality.

In this line, Risso and Sánchez-Carrera (2012), Policardo et al. (2008) identifies two different growth countries models. One which describes the Brazilian experience as a moderate growth with income redistribution, "consumption" supported model; and a second one, characterized by fast growth and income concentration, "investment" supported model which is observed in China. Specially, the authors suggest that Brazil's redistributive and integrative income policies in the last decade have financed a stronger consumption demand, especially with the birth and growth of a low middle and middle class, reducing in turn, income inequality.

Similar policies can be found in Uruguay over the last decade. Overall, the several reforms that took place in the Uruguayan labor market, in the tax system, the health system, jointly with cash transfer policies aiming to reduce poverty, seems to channel economic growth to poorest people in the society, thus reducing inequality. Alternative mechanisms that caused economic growth on the period, and on the mechanisms through which economic growth reduced inequality deserves further research.

Overall, results seems to show that economic growth is not a sufficient condition to reduce inequality; and then gives support to those theories that recommend public policy interventions in which income-distribution efforts are implemented to foster economic growth.

It is worth to note that all findings presented in this paper are based on one inequality indicator, the 90/10 ratio. Future research can include testing the robustness of results to alternative inequality measures. Note that it may also be the case that different income groups may be sensitive to the growth process (see Rubin and Segal, 2015). Finally, testing the robustness of results to the exclusion of the last expansion period (growth and inequality decline from 2007 on) can also be material for future research.

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