

# Income distribution, human capital and economic growth in Colombia

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## Abstract

Colombian income distribution has followed a clear path during the last two decades: in the second half of the 1970s, human capital accumulation reduced the dispersion of income distribution, and led to a period of stagnation between 1983 and 1990, when mobility declined. After the structural reforms (a skill-bias technological change), the wage differential for skilled workers increased inequality by a polarization in the bi-modal distribution of income. These topics are discussed in the paper along some dynamic aspects of income and educational mobility in Colombia. © 2001 Published by Elsevier Science B.V.

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## 1. Introduction

Colombia, as well as in the majority of Latin American economies, has experienced a recent and accelerated process of structural reforms based on trade liberalization.<sup>1</sup> Simultaneously, the traditional indicators of income distribution point to a sharp decay in income equality, making it advisable to question the positive relation between the trade liberalization process and the decay in income

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<sup>1</sup> The most important facts of the process of reforms have to do with trade liberalization, labor reforms and a new role of the state. For example, from February 1990 to August 1991, non-tariff barriers were eliminated, and tariffs sharply cut, from an average of 43.7% to 14.3%.

distribution. Fig. 1 presents a smooth version of the traditional Gini's coefficient, Nuñez and Jiménez (1997). The analysis of episodes clearly shows a huge reduction of inequality during the second half of the 1970s, followed by stagnation after 1983, when the Colombian economy experienced major macroeconomic imbalances: an increasing fiscal and current account deficit, a crisis of the domestic financial system, and a cyclical downturn in the business cycle (Ocampo et al., 1997 deals with those aspects). After the structural reforms of the 1990s, the Gini's coefficient shows the increasing trend we referred in the last paragraph.

The majority of research on the Colombian case concentrates on the static characteristics of income distribution, neglecting a great number of dynamic implications. The aim of this paper is to fill in some blank spaces by applying a more dynamic analysis, especially because an important part of the change in distribution can be the result of a temporary phenomena that will have no long-run effects on the status of society, or because the deterioration in the situation is a necessary initial phase in the improvement process of income distribution. In fact, mobility and persistence are fundamental aspects of income distribution that have been ignored up to now by the Colombian empirical literature; when dynamic aspects are considered, the deterioration in the income distribution attributed to the trade liberalization process (through a skill-bias technological change) must be seen from a different perspective, since higher income mobility associated with structural reforms can assure improvements in income distribution and efficiency, and also provides better economic incentives for sustained growth.

We believe that the relevant question of the consequences of the structural reforms on income distribution rests on the mobility and temporary character of the structural adjustment effects. The analytical role of mobility in processes of

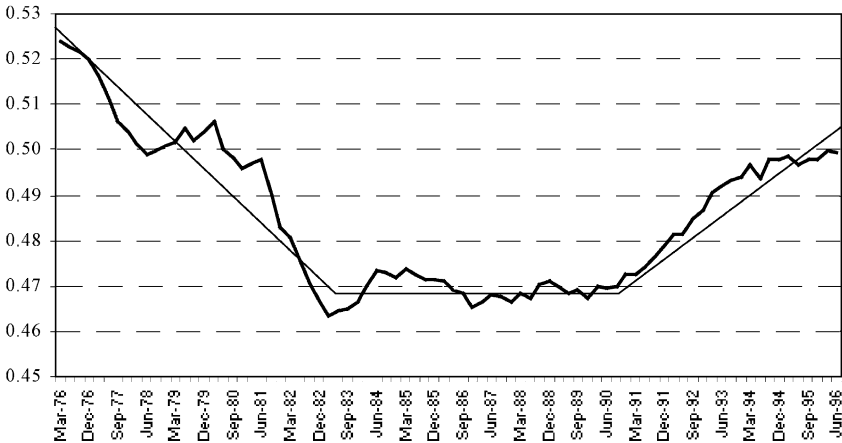


Fig. 1. Per capita household Gini's coefficient (eight periods moving average).

structural change can be established from the perspective of political economy, an example being Fernández and Rodrik (1991), or by the general approach of Galor and Zeira (1993) concerning the long-run effect on human capital of credit constraints.

We must emphasize two important dynamic implications (developed by Galor and Tsiddon, 1997): initial conditions determine the evolution of the distribution of human capital among dynasties, creating a tendency to inequality in the distribution of human capital; and interactions between dynasties, and their impact on the productive structure, can lead to a qualitative transformation of the dynamics of a system with multiple equilibria to one with a single globally stable equilibrium. Income distribution is transformed into a state variable that evolves dynamically. From the empirical point of view, these two implications are condensed in the determination of mobility between different generations (overlapped) coexisting in every time period, as a status measure, and the mobility of distribution as a whole through time.<sup>2</sup> We evaluate those aspects with mobility indices developed by Shorrocks (1978) and Geweke et al. (1986) in Section 4. Finally, we present some concluding remarks in Section 5.

## 2. A simple framework

The model we have in mind follows some previously mentioned methodological aspects based on Galor and Zeira (1993) and Galor and Tsiddon (1997). We assume a continuum of overlapping generations that live two periods with constant population. Each agent has a unit endowment of time that is rented to firms to receive a wage income in the second period and a bequest coming from the previous generation, which reports capital earnings; these two terms compose the income (wealth) of each agent. Agents are born unskilled, but they decide whether to remain unskilled or to acquire skills that increase their future earnings. The agent receives the income generated by his (her) work and the earnings of his bequest of the previous period, and makes a decision on how much to consume and how much to bequeath to the son that has been born unskilled and must face the same decision his parent made. Without education, the agent ( $i$ ) behaves as an unskilled worker and receives the following income:

$$y(i)_{u,t} = w + (1 + r)k(i)_t \quad (1)$$

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<sup>2</sup> This aspect has not been analyzed in Colombia due to the lack of information from surveys with longitudinal data. To solve this, we propose a method based on the estimate of the transition probabilities between the different classes of distribution.

If he decides to invest in education he must face a fixed cost ( $e$ ) in the initial period, but will receive a higher wage represented by a premium ( $h$ ) obtained from the higher productivity.

$$y(i)_{s,t} = wh_t(H_t, K_t) + (1 + r)[k(i)_t - e] \tag{2}$$

where  $H_t$  and  $K_t$ , represents aggregate human and physical capital. An individual decides to acquire education when the expected income of doing so is higher than the one earned without education; but there are two separate cases. In the first one, we assume that the bequest is enough to cover the cost of education ( $e$ ) in such a way that the agent is a net lender. In the second case, with a small bequest, the agent may obtains loans to finance his education paying a higher interest rate  $r^* > r$ . At this point, it is clear that the education decision depends on two elements: the received bequest, and the education premium. If the bequest is high enough (at least covers the cost of education), the agent will always choose to be educated; in this case, only the education premium determines the education decision. If the premium is above a threshold given by a non-arbitrage condition, he will always invest in education. Now, when the agent acquires loans, the premium ceases to be the only determinant of the education decision; so, for an agent to become educated, the lower premium must be compensated by higher inherited wealth.

If we represent the problem of the second period through some Cobb–Douglas function, the agent will assign his wealth in fixed proportions between current consumption and bequests. In this case, the dynamics of each generation can be represented by Fig. 2.

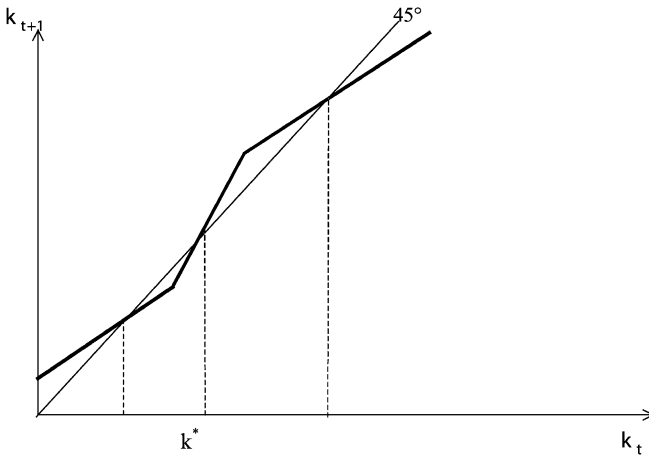


Fig. 2. Capital dynamics.

Dynamics are very interesting since there are three equilibrium points and two of them are stable. Agents that begin in an initial condition, which is less than  $k^*$ , work as unskilled workers, as do their descendants in all future generations. Agents that begin in an initial condition greater than  $k^*$  may or may not reach higher income levels depending on the access to education. Those who begin with higher bequests converge at a higher wealth level and all of their descendants can invest in education. Income distribution tends to be non-ergodic and to polarize into two modes, one for the rich and another for the poor.

If we wish to establish a link between the analytical framework and the processes of structural change, we might conclude that the structural reforms cause a rise in the relative demand for skilled labor and an increase in the premium for skilled workers through an increase in the demand for physical and human capital. The estimates of labor demand in manufacturing by Cárdenas and Gutiérrez (1996) and Ramírez (1995) confirm our hypothesis. Certainly, the precise contribution of trade liberalization has been debated, and other links associated with trade liberalization have been proposed, notably that technical change has been biased towards skilled labor after the introduction of automation and information technology (those aspects are part of the global environment, discussed later). However, trade and technical change interact in developing countries.

Under skill-biased technological progress, the relative demand for skilled labor would increase the earnings premium. Because the unskilled are subject to the bequest constraint, poor people remain poor and would become trapped (polarized). We could think, as an analytical input, that the process of structural reforms leads to a polarization of income distribution and, therefore, to a systematic deterioration. Nonetheless, we must consider the role of  $h$  in the determination of the decision to be educated because, as we mentioned, there is a trade-off between these variables.

To analyze the economy's growth, we must recall that population is distributed into two groups, skilled and unskilled workers. Despite the assumption of constant population, the densities of the two groups depend on time since there are agents that move between groups, and for whom it is optimal to be educated or to fall into poverty traps. Similarly, we can calculate the income distribution for every time period as:

$$Y_t = \int_{[0, k^*]} g_u(t, z) dz + \int_{[k^*, \infty]} g_s(t, z) dz \quad (8)$$

where  $g$  is the density of each group of agents. To consider the growth implications of the reforms, we can make the human capital depend on a proportion of skilled workers, and on some complementarity effect of aggregate physical capital by  $h_t = h_t(H_t, K_t)$ . Under this scheme, the human capital stock could be sufficiently high (by a huge expansion of skills or physical capital) to ensure that the non-ergodic pattern of growth can be reverted and, as time goes by, an improvement in income distribution can be reached similar to the one presented

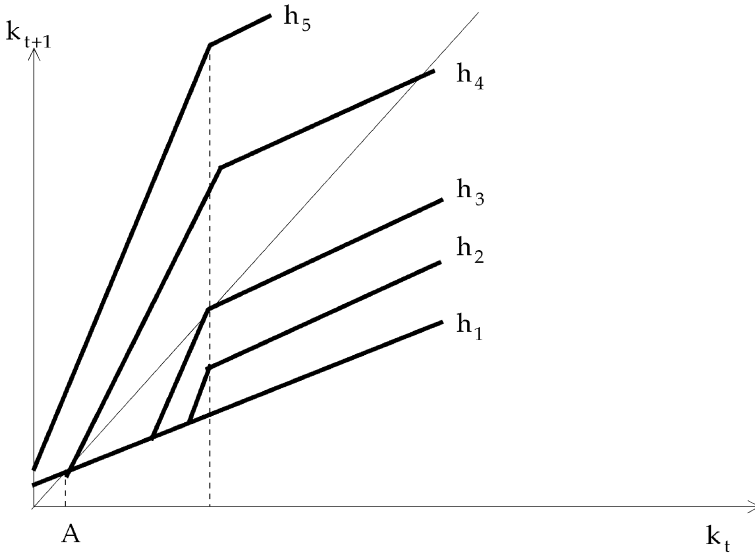


Fig. 3. Human capital and income dynamics.

during the second half of 1970s in Colombia.<sup>3</sup> To see the effect this variable has on agents’ decisions regarding education, we have plotted several levels of  $h$  in Fig. 3.

It is interesting to note that the incentives inherent in higher human capital provoke a substantial change in education decisions. When the human capital stock is less than  $h_1$ , there is no incentive to be educated, and later on generations will reach a capital level ( $A$ ). For a stock  $h_2$ , despite the fact that some members decide to study, in the long run, generations converge at the same steady state observed previously, because the incentive is not sufficiently high to maintain bequests that ensure education for all generations; the economy then falls into a poverty trap. In case three, agents with sufficient initial endowment chose to study, in the steady state. Case four presents a situation in which the incentive to be educated leads to a steady state, where the entire population decides to be educated, despite the fact that such was not their parent’s decision in the initial period. In case five, human capital is so big that the decision does not depend on

<sup>3</sup> For this convergence to occur, an initial deterioration of the distribution was necessary. For example, Londoño (1995) finds that during industrialization after the second war, Colombia faced an increase in the demand for skilled workers, which made wage differences more acute. This fact initially concentrated income distribution until the supply of skilled labor increased through higher education, which in time did improve income distribution. From our point of view, the recent evolution of income distribution has some similarities with this case.

their initial wealth level. In this scenario, the long-run distribution of human capital loses its dependence on initial conditions and overcomes the family effect.

In summary, in periods of major technological progress, the relative importance of parental–environmental conditions increases, and inequality rise because there is an increasing demand for skilled workers. After that increase in the high-skilled workers premium, mobility increase and inequality is (slowly) reduced. In other words: inequality can induce more educated agents to deteriorate the distribution, but at the same time to eliminate less educated agents through technical progress.

### 3. The shape of the income distribution

Our analysis of the evolution of income distribution centers on two main points: static aspects, like the change in shape of the distribution, and the distributional dynamics inside income distribution. The mechanism that we will use is a stochastic Kernel, for it captures the essential characteristics of the distributional shape. The area under the density function between two income levels is the proportion of the population with incomes within that income range, so that the total area enclosed in the function equals 1 (100% of the population). Formally, we can define the Kernel as a function  $K$  where:

$$\int_{[0,\infty]} K(v)dv = 1. \quad (4)$$

In Fig. 4, we present the result of adjusting income distribution in the years 1976, 1983, 1990 and 1996, as turning points in the Gini's behavior under this probability function.

The stochastic Kernels are estimated using the Epanechnikov window<sup>4</sup> to analyze the joint density of relative income (relative to income average) and its logarithmic transformation, choosing window width according to a normal scale, as suggested in Silverman (1986). The left-hand side figure plots the frontal view of the joint density. The contour plots on the right side of the figures are obtained by projecting onto the horizontal plane the Kernel of the relative income and the log-relative income. The contour levels were chosen to be 0.25, 0.50 and 0.75, to be informative of some structure on the left side figures. Zero on the horizontal axis indicates an income equal to the population average, because our logarithmic scale and negative numbers represent incomes below the income average. Symmetrically, positive numbers represent incomes above the income average.

<sup>4</sup> For the statistical properties in Silverman (1986), we take  $K$  to be the Epanechnikov kernel function. The band width was selected according to the Gaussian criteria used by Quah (1996), because as Silverman (1986) proves, it minimizes the mean integrated square error (MISE). Additionally, the Kernel estimates implement local adaptive smooth parameters allowed to vary with the data. Further empirical discussions can be found in Silverman (1986).

Looking across two decades, we see in 1976 an almost unimodal distribution, at a little under 0. The Gini's coefficient in this period was 0.52, consistent with an increasing dispersion around the unique modal income. By 1983, the September survey shows the lowest Gini's coefficient in the preceding 20 years, around 0.45. This improvement in equality comes from a reduced dispersion along the income scale (as the contour plots suggest). When we look at the distribution for the 1990s, the bi-modality property surfaces, and in 1996, this (increasing) aspect clearly identifies the most recent income distribution. This picture gives us an important clue to understand the nature of the change in overall income distribu-

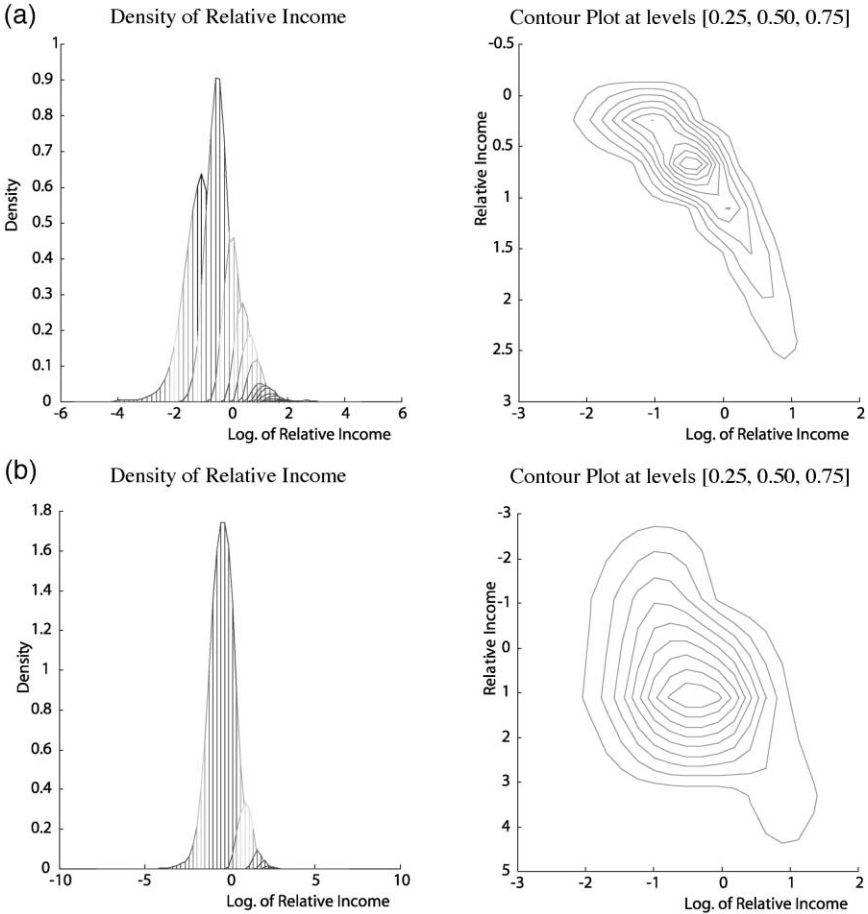


Fig. 4. (a) Densities and contour Plot (September 1976), (b) densities and contour Plot (September 1983), (c) densities and contour plot (September 1990), (d) densities and contour plot (September 1996).

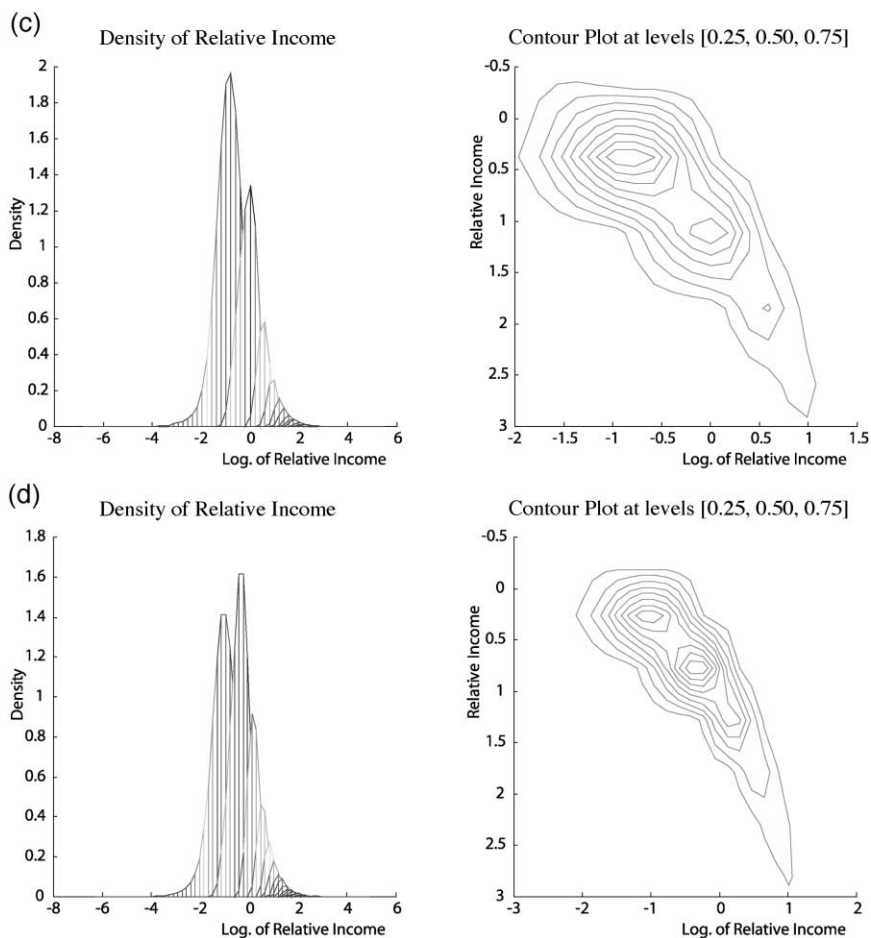


Fig. 4 (continued).

tion in Colombia in the period of the structural reform. Our plots suggest that the income distribution results from mixing two (or more) separate underlying income distributions, in turn arising from wage inequality generated from a skill-biased technological change. Thus, the effect of structural transformation during this decade is a polarization of incomes into two groups: low-income levels (close to half of relative income), and middle-income level (almost equal to relative income).<sup>5</sup>

<sup>5</sup> Our findings are similar to those of Cowell et al. (1996) for the United Kingdom.

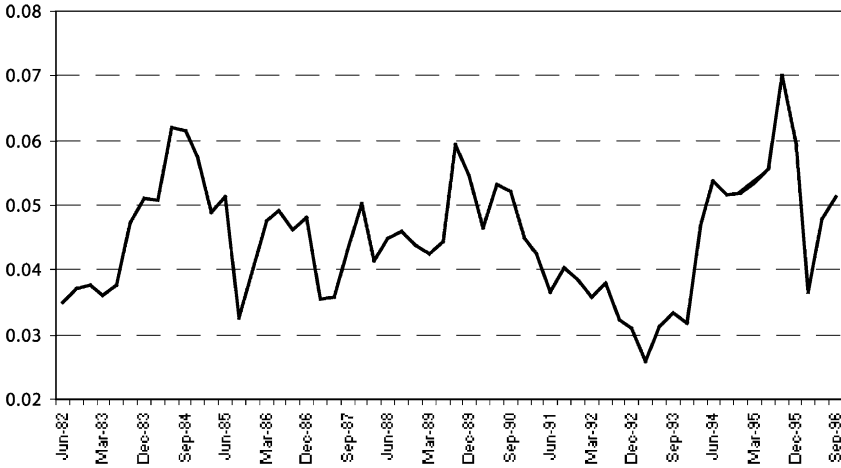


Fig. 5. Quarterly per capita household polarization index ( $\alpha = 1.5$ ).

Another important aspect that we would like to consider more explicitly, in light of our previous finding, is the possibility of clustering around a greater number of modes on a wider notion of polarization. The knowledge of the degree of polarization and stratification can be more telling (in terms of our preceding model, this is clear) than any measure of inequality and may be derived using parametric tools. To study the clustering of income distribution in Colombia parametrically, we follow Esteban and Ray (1994).<sup>6</sup> Our polarization measure  $P$  is of the form:

$$P = N \sum_{i=1}^n \sum_{j=1}^n \pi_i^{1+\alpha} \pi_j |y_i - y_j| \tag{5}$$

where  $\pi_i$  is the population frequency in every class,  $N$  is used for population normalization (zero degree homogeneity) according to  $N = [\sum_{i=1}^n \pi_i]^{-(2+\alpha)}$ ,  $y$  is the logarithm of household income, and  $\alpha$  represents the opposition effect that must be restricted to belong to  $[1, 1.6]$  as Esteban and Ray prove.

Fig. 5 plots the polarization index for quarterly data from 1982-I. It is interesting to observe that after 1993, there was an episode of sustained increase.

<sup>6</sup> The differences between inequality and polarization measures are discussed on Jenkins (1996) and Wolfson (1994).

Table 1

Exclusion restriction (Granger-causality) tests; marginal significance levels<sup>a</sup>

Left-hand-side variable	Right-hand-side bloc			
	Gini	$P (\alpha = 1.5)$	Inv. Growth	GDP Growth
Gini's coefficient	(0.000/0.000)	(0.316/0.086)	(0.126/0.096)	(0.077/0.166)
$P (\alpha = 1.5)$	(0.003/0.082)	(0.000/0.000)	(0.702/0.664)	(0.699/0.517)
Fixed investment growth	(0.005/0.134)	(0.250/0.446)	(0.000/0.002)	(0.119/0.281)
GDP growth	(0.060/0.201)	(0.004/0.019)	(0.298/0.082)	(0.000/0.002)

Source: author's calculations.

<sup>a</sup>All VARs include seasonal dummies and were estimated using quarterly data from 1977-I through 1996-IV.  $\chi$ -square statistic (marginal significance levels) in parentheses.

This evidence is consistent with our view that polarization provides an explanation of the current situation in the Colombian income distribution.

Table 1 provides Granger-causality tests. This table gives a compact description of tests of exclusion restriction in four-variable VARs in Gini, polarization index, fixed investment growth and aggregate income growth.<sup>7</sup> Results are presented for 4 and 8 lags; in each cell entry, there is a pair of numbers giving marginal significance levels for excluding the right-hand set from the named left-hand variable. The first number is the marginal significance level in the 4-lag VAR and the second in the 8-lag VAR. The results suggest that the polarization of income is the variable most strongly and dynamically correlated with income inequality and GDP growth.

Roughly speaking, polarization Granger causes inequality (and vice versa), and GDP growth in long term; the marginal significance level for excluding the polarization measure in the equation for GDP growth is between 0.4% and 2%, and is the smallest of the table's off-diagonal entries. In longer-lag systems, the polarization measure appears to help predict the Gini's inequality coefficient; however, this relation is unstable and disappears once we consider shorter-lag systems. The opposite direction is present in the relation between the Gini's coefficient and GDP growth: in the short term, there is a strong relation, while in longer systems, there is none. To conclude, the relation between inequality (measured as Gini's) and polarization is dynamically mutual, and in the long run seems to be bi-directional. The effect of fixed investment growth is stable and significant in the long run in the economy's growth rate and in income inequality; however, it seems to have little effect on polarization.

<sup>7</sup> Quarterly information originated in DNP-Umacro.

## 4. Some dynamics

The most important and innovative points to be analyzed are the dynamic aspects of income distribution. We consider two different aspects of mobility because low inequality among different families in the same generation is consistent with highly stable rankings of families in different generations, and an unstable ranking is consistent with sizable inequality in the same generation. Thus, our main task is to describe the behavior of income mobility in addition to inter-generational education mobility in the long-run.

### 4.1. Income mobility

To perform this analysis, we concentrate on determining the probability of transition between states in every possible class of income levels. Due to the type of information reported in the household surveys, the classification of individuals regarding their possible state would require a division of the space of the variables in ( $n$ ) discrete regions  $q$  (quintiles), to count the transitions of entering and exiting each one of these categories or classes. This means that the transition probability can be defined as  $\text{Prob}(Y_{t+s} \in q_j | Y_t \in q_i) = M_{ij}(t) = M_{ij}$ ; where  $s$  is the difference in time between observations and  $M$  is a Markov's chain describing the agents' movements between the different classes (or quintiles) under stationary probabilities of transition, or time homogeneity.

The main problem in building  $M$  is that, as opposed to panel data, household surveys in Colombia present only the frequency distributions of the number of individuals in each class, but do not provide information on each agent. In fact, individuals in the sample change, and we have access only to the proportion in each group for every period. To compensate for this gap in the Colombian information, we have estimated econometrically the possibilities of transition between states the agents in the economy face, so every probability reflects the behavior of unobservable individuals. The estimation procedure is based on Lee et al. (1970).<sup>8</sup> Our main result is the estimation of probabilities of transition between income distribution quintiles between 1976 and 1995, using information on the annual shares (to September). The result is (upper left-hand for transitions from poor to poor)<sup>9</sup> in Table 2.

<sup>8</sup> Due to the nature of the data, the estimation must include a heteroskedasticity correction in a restricted estimator. The procedure is based on a GLS estimator with an iterative procedure of quadratic primal-dual programming. The objective is to find a consistent estimator, which satisfy all the restrictions placed on the transition matrix. Further technical details can be found in Lee et al. (1970).

<sup>9</sup> We have employed a macro-Bayesian transition-probability-estimator based on different priori distributions. One exercise was to consider the US transition matrix of Gottschalk (1997) for 17-year mobility, and an egalitarian prior. The results are similar at the extremes of the distribution. The general discussion of this procedure can be found in Lee et al. (1970).

Table 2  
Nineteen-year mobility (1976–1995)

		1995 Quintiles					
		[0.2]	[0.4]	[0.6]	[0.8]	[1.0]	Total
1976 Quintiles	[0.2]	0.372	0.238	0.153	0.145	0.092	1.000
	[0.4]	0.214	0.376	0.214	0.109	0.087	1.000
	[0.6]	0.073	0.195	0.337	0.235	0.160	1.000
	[0.8]	0.009	0.097	0.232	0.356	0.307	1.000
	[1.0]	0.000	0.000	0.022	0.144	0.834	1.000

Source: author’s estimates based on Lee et al. (1970).

From those who started in the highest quintile in 1976, 97.8% found themselves in the two highest quintiles in 1995. Of those who did exit the bottom quintile, most of them did not make much progress with the largest group staying in the same quintile. The richest remain so, with a probability of 0.98; and the poorest remain poor, with a probability of 0.60. It is interesting to note that the interior diagonal is greater than the off-diagonal entries; this means that middle-income families are likely to remain where they are in the distribution, also facing almost equal probabilities of rising or falling.

From the construction of these transition probabilities, we get different mobility indices from Geweke et al. (1986) and Shorrocks (1978). The basis of the analysis is the relation established by the diagonal of the matrix as a persistence measure: the measures tell us how close the present position of income distribution is with respect to perfect equality; so, these measures can be interpreted as the difference between the observed matrix and the limit matrix of Markov’s process, taking into account the speed of convergence. The indices are based on the decomposition of the matrix in its eigenvalues ( $\lambda$ ), as shown in Table 3.

The description of these measures can be related to the persistence of the matrix and the convergence speed to the limit distribution (Shorrocks, 1978). In general, if  $\mu$  equals 0,  $M$  is the identity matrix, and there is no mobility. If  $\mu$  equals 1, there is perfect mobility. As an example, the indices for the last Markovian matrix are shown in Table 4.

Table 3  
Income mobility indices

$\mu_T$	$\mu_A$	$\mu_L$	$\mu_D$
$\frac{n - \text{trace}(M)}{n - 1} = \frac{n - \sum_j \lambda_j}{n - 1}$	$\frac{n - \sum_j  \lambda_j }{n - 1}$	$1 -  \lambda_2 $	$1 -  \prod_j \lambda_j ^{\frac{1}{n-1}}$

Source: Geweke et al. (1986) and Shorrocks (1978).

Table 4  
Intra-distribution mobility: US–Colombia

	US (1974–1991)	Colombia (1976–1995)
$\mu_T$	0.7587	0.6813
$\mu_A$	0.7587	0.6813
$\mu_L$	0.4779	0.2822
$\mu_D$	0.1796	0.2286

Source: author's calculations based on Table 2 and Gottschalk (1997).

The main result from the last table is the presence of high persistence in the Colombian income distribution, especially at higher levels. But we cannot regard these results as conclusive, because low inequality among different families in the same generation is consistent with highly stable rankings of families in different generations, and an unstable ranking is consistent with sizable inequality in the same generation.

#### 4.2. Long-run educational mobility

To determine family dynamics, we define a 4-year limit on an experience index (age less years of schooling less six years) assuming that high level of experience are related to people not returning to formal education. With this restriction, our transition probability matrix can be calculated in every survey because we have educational information for every household head, and for every son. Thus, for September of 1976, the transition matrix takes the form shown in Table 5.

The interpretation is similar to Table 2, the diagonal shows the phenomenon of persistence in education. In 1976, persistence at the lowest educational level for every generation was 69%, while in 1993, it dropped to 50%. At the other extreme, persistence at the highest educational level increased during the most recent years, and if we observe the entire data set (Fig. 6), it suggests that persistence at the highest level is the cause of the recent higher mobility. Mobility in highly educated people is clear enough such that it suggests a structural transformation toward a less stratified society carrying short-term increase in

Table 5  
Inter-generational educational mobility (September 1976)

		Son's educational level			
		Primary	Secondary	Higher	Total
Father's educational level	Primary (0–5)	0.690	0.290	0.020	1.000
	Secondary (6–11)	0.331	0.606	0.063	1.000
	Higher (12+)	0.080	0.673	0.247	1.000

Source: author's calculations.

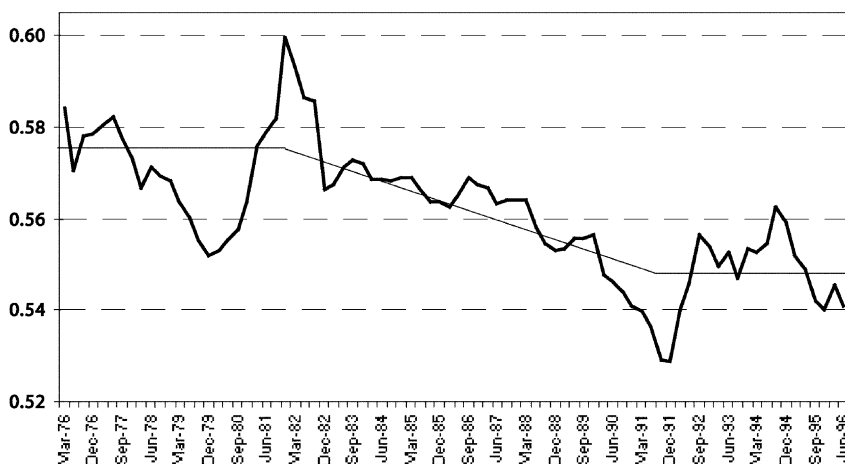


Fig. 6. Inter-generational mobility.  $\mu_T$  index (four periods moving average).

inequality. Dynamically, we can analyze the evolution of mobility using the latest indices for every household survey. Fig. 6 plots one of these.

In Fig. 6, we observe the declining trend in mobility since 1976 (a high-status society); as of 1992, the increasing persistence stopped. The episodes are highly relevant to our analytical proposals on the recent evolution of income distribution. Despite it being too early to state conclusive results, it seems that the stagnation of income distribution during the 1980s was accompanied by a reduction in mobility. During the 1990s, the process of declining mobilization stopped, consistent with the increasing importance of the educational premium conditions.

To sum up, in periods of slow technological progress, the dominant factor is the local environment; inequality declines, but becomes more persistent. However, in periods of major technological progress, the importance of local conditions declines, enhances mobility, increases short-term inequality and generates poles in the distribution of income.

## 5. Conclusions

This paper has provided a framework for analyzing the recent increase in income inequality in Colombia. It has applied new tools for modeling evolving income distribution dynamically, using polarization measures and mobility indices. In the Colombian case, we can interpret the liberalization as a skill-biased technological change, which increases wage inequality and induces polarization, and also leads to high mobility. In this sense, the unequal and immobile conditions of the Colombian economy lead to slow growth and more equality during the late

1970s and 1980s; and later on, the structural change makes the economy less equal but more mobile.

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