REDI3x3 Working paper 54 April 2019

Education and wage inequality: Prospects for income redistribution

Debra Shephard and Servaas van der Berg

Abstract

Despite significant expansions in educational attainment over the two decades following democracy–particularly amongst the workforce–wage and income inequality in South Africa ranks amongst the highest in the world. The 'paradox of progress', as coined by Bourguignon, Ferreira and Lustig (2005), predicts that under convex returns to education, equalising educational expansion can worsen of wage inequality. This paper aims to provide evidence in support of this paradox in the South African context. We employ comparative-static microeconometric decompositions that isolate the direct 'effect' of observed educational expansion, as well as simulated scenarios, on wage inequality. We find that, over the period 1994 to 2011, educational expansion in South Africa was disequalising and closely linked to the convexity of returns to education. We propose that the convexity in the returns to education is related to technological change that is biased towards high skill jobs. Specifically, shifts in cohort-specific supplies of highly educated labour, combined with a higher relative demand for educated workers, may provide one explanation why wage and income inequality in South Africa is likely to remain stubborn. Therefore, tempering convexity in the returns to education and improving the distribution of income partly requires tackling the problem of dysfunctional and ineffective schooling in order to provide individuals with skills that are compatible with job creation.

The **Research Project on Employment, Income Distribution and Inclusive Growth** is based at SALDRU at the University of Cape Town and supported by the National Treasury. Views expressed in REDI3x3 Working Papers are those of the authors and are not to be attributed to any of these institutions.

REDI3X3
Research Project on Employment, Income Distribution & Inclusive Growth
Towards an integrated response to unemployment, inequality and poverty

Education and wage inequality: Prospects for income redistribution

Debra Shepherd and **Servaas van der Berg**

(ReSEP, University of Stellenbosch)

1. Introduction

Given South Africa's history, much policy attention is focused on reducing income inequality. Attempts at setting future distributional targets – such as those of the National Development Plan – often seem unrealistic. To assess what is realistically achievable, it is useful to consider both past history and factors that influence distributional outcomes.

Earlier decompositions of the Gini coefficient by income source show that he distribution of wages across households (ignoring household size) constitutes the largest source of income inequality between households (Leibbrandt, Bhorat & Woolard, 2001; Armstrong & Burger, 2009; Leibbrandt, Woolard, Finn & Argent, 2010; Leibbrandt, Finn & Woolard, 2012). Leibbrandt et al (2012) show a strong link between the relative success of a household's members to access labour market income and their position in the national household income distribution, with the latter dependent on both a household member's employability and earnings potential, both of which are highly correlated to education. This points to the importance of wages for understanding trends in and prospects for income distribution in South Africa. In virtually all studies investigating the returns to education (conventionally measured, i.e. ignoring ability bias and differences in the quality of education) in South Africa, evidence is found of a convex returns structure (Moll, 1996; Kingdon and Knight, 1999; Mwabu and Schultz, 2000; Rospabe, 2001; Keswell and Poswell, 2004). One explanation offered for this convexity is racial differences in the returns structure: Ten years following the advent of democracy, Keswell (2003) found that whilst the returns to education amongst whites have become fairly linear, the returns to black education remained sharply convex. This may also be related to the weak signal sent by years of education to the labour market in black schools, because of quality concerns and because of erratic progression criteria, as discussed by Lam, Ardington & Leibbrandt (2011) who liken passing or failing to a lottery.

Most Latin American countries also have a long history of high inequality of income distribution and convexity of returns to education, but have recently experienced a strong decline in income inequality, reversing earlier trends of increasing inequality. Central to this was a reduction in wage inequality, caused by reduced convexity in the returns to education. Expansion of in education, on the other hand, was more likely to give rise to Bourguignon's 'paradox of progress', discussed below, where educational improvement sometimes worsens wage inequality.

Can South Africa expect to follow the Latin American example of reduced income inequality stemming from a reduction in the convexity of the return structure to education? This paper builds on existing evidence drawn from South African labour market data to inform scenarios regarding educational expansion, returns to education and wage distribution, thereby providing evidence in support of the ‘paradox of progress’ in the South African context, whereby educational progress in certain circumstances may worsen inequality (as discussed below). We test this by means of basic comparative-static microeconometric decompositions that isolate the direct effect of observed changes in the distribution of education (without considering its quality and the variations in quality that appear to play such a strong role in the observed convexity), as well as alternative simulated educational expansion scenarios, on wage inequality. We find that the direct effect of education expansion in South Africa over the period 1994 to 2011 indeed seemed to be disequalising, given actual levels of educational quality that pertained. This result is closely linked to the convexity of returns to education.

The pattern of technological change observed in developing countries is often considered to be likely to be strongly biased towards high skill jobs as development proceeds (Murphy & Welch, 1994). This is likely to favour even stronger convexity in returns to education, unless educational expansion is rapid enough to ensure that the supply of high skilled labour keeps up with the demand (Goldin & Katz, 1999). Considering the poor quality of education in the majority of South African schools, such a supply shift appears unlikely. However, here we adopt a different methodology, presenting in the final section a multi-level CES production function approach used by Card and Lemieux (2001) to assess the contribution of changes in the relative supply of divergently skilled labour and the demand for skills on the returns to education. Our findings tentatively suggest that shifts in cohort-specific supplies of highly educated labour, combined with a higher relative demand for educated workers, may provide one explanation why wage inequality, and therefore income inequality, in South Africa, is likely to remain stubborn.

The paper proceeds by first briefly discussing the link between education and inequality and the possibility of the paradox of progress. This is followed by a descriptive analysis of trends in the determinants of wage inequality in section 3. Section 4 provides the microsimulation model and results, whilst section 5 concludes and provides policy recommendations.

2. The ‘Paradox of Progress’

Whilst there is general consensus that human capital investment is beneficial for economic growth and poverty reduction, the manner in which education is rewarded is critical for the relevance of education for economic development (Keswell & Poswell, 2004). If, as has been shown by a number of contemporary theoretical models (see Galor & Zeira, 1993; Galor &

Moav, 2004), education matters only once a significant amount of it has been acquired, an unequal distribution of resources and human capital can lead to so-called *multiple equilibria* whereby the majority of the liquidity constrained population will find it difficult to obtain higher levels of skills/education and escape poverty, whilst those with higher skills levels see increasing returns to those skills as the economy develops. Galor and Moav (2004) describe three ways out of this trap: (i) wages rise with increasing returns to human capital, leading to higher savings and investments in education; (ii) the government can subsidise education; or (iii) markets can acknowledge the returns to education and provide finance to liquidity constrained individuals (Branson et al, 2012). Absence to act by either the public or private sectors will perpetuate the status quo of an unequal distribution of wealth and lack of investment in education.

Following Battistón et al (2014), the link between educational expansion and rising inequality may be illustrated using a simple model that relates log earnings to education at period t as follows:

$$lnY_{it} = \alpha_t + \beta_t X_{it} + \varepsilon_{it} \qquad [1]$$

where X_{it} is individual specific years of education and the zero-meaned error term, ε_{it}, summarises all unobservable determinants. Assuming independence between X_{it} and ε_{it}, β can be interpreted as a measure of the returns to education. Suppose further that all earners can be divided into two groups, H and L, with $X_H > X_L$ and $E(ln\, Y_H) > E(ln\, Y_L)$. The expected log earnings gap G can therefore be expressed as:

$$G = E(lnY_{Ht} - lnY_{Lt}) = \beta_t(X_{Ht} - X_{Lt}) \qquad [2]$$

and the change in the earnings gap between t = 1 and t = 2 as:

$$\Delta G = E(lnY_{H2} - lnY_{L2}) - E(lnY_{H1} - lnY_{L1}) = (\beta_2 - \beta_1)(X_{H1} - X_{L1}) + \beta_2(dX_H - dX_L) \qquad [3]$$

where dX_i is the change in education for individuals in $i = H, L$. From the above equation we can see that a change in inequality depends on (i) changes in the returns to education over time, (ii) the initial difference in education levels between the two groups, and (iii) the relative change in education. Therefore, if returns to education are constant over time and the growth in educational levels is similar across groups, $\Delta G = 0$.

Adding convexity in the returns to education to the model:

$$lnY_{it} = \alpha_t + \beta_t X_{it} + \eta_t X_{it}^2 + \varepsilon_{it} \qquad [4]$$

results in the expected change in the earnings gap over time becoming:

$$\Delta G = (\beta_2 - \beta_1)(X_{H1} - X_{L1}) + \beta_2(dX_H - dX_L) + (\eta_2 - \eta_1)(X_{H1}^2 - X_{L1}^2)$$
$$+\eta_2(dX_H^2 - dX_L^2) + 2\eta_2(X_{H1}dX_H - X_{L1}dX_L) \quad [5]$$

In this case, if $\beta_2 = \beta_1, \eta_2 = \eta_1$ and $dX_H = dX_L$, $\Delta G = 2\eta_2(X_{H1} - X_{L1})dX > 0$ under convex returns to education i.e. $\eta_2 = \eta_1 > 0$. Under convexity, Battistón, García-Domench & Gasparini (2014) show that even an expansion of education in favour of the less educated earners can lead to a rise in inequality.

Keswell and Poswell (2004) similarly show that increasing returns to education is related to higher inequality using the coefficient of determination (R^2) from a simple earnings model such as in equation (1), which provides an indication of the proportion of earnings inequality explained by schooling. Taking variances of (1):

$$var(lnY) = var(\alpha + \beta X + \varepsilon)$$
$$= \beta^2 var(X) + var(\varepsilon) + 2\beta cov(X, \varepsilon) \quad [6]$$

Differentiating (6) with respect to the rate of return:

$$\frac{\delta var(lnY)}{\delta \beta} = 2\beta var(X) + 2\beta cov(X, \varepsilon) = 2cov(X, lnY) \quad [7]$$

This expression shows that inequality will necessarily increase when the rate of return increases, as long as $cov(X, lnY) > 0$. Application of the same variance decomposition to equation (4) would imply a more skewed earnings distribution given a convex returns to education.

The following section discusses trends in the determinants of earnings inequality as pointed to in the discussion above. In particular, emphasis is paid to the expansion in education levels amongst groups of the South African population, as well as evolution of the convexity in the returns to education in South Africa over the two decades since democratisation.

3. Trends in the determinants of earnings inequality, 1994-2011

As referred to in the previous section, earnings inequality is affected by two primary factors: first, the distribution of (observable and unobservable) characteristics of workers such as years of education, experience, gender and ability; and secondly the returns to those characteristics. Workers' characteristics, in turn, are affected by decisions such as whether or not to enrol in school (and at which stage to leave formal schooling) as well as policy that has the effect of expanding access to education or how long children remain in school. Returns to labour market characteristics depend on market forces; that is, the demand and supply of workers of different skills (education) and institutional/policy factors such as minimum wages. Both worker characteristics and returns to these characteristics have changed during the two decades after 1994.

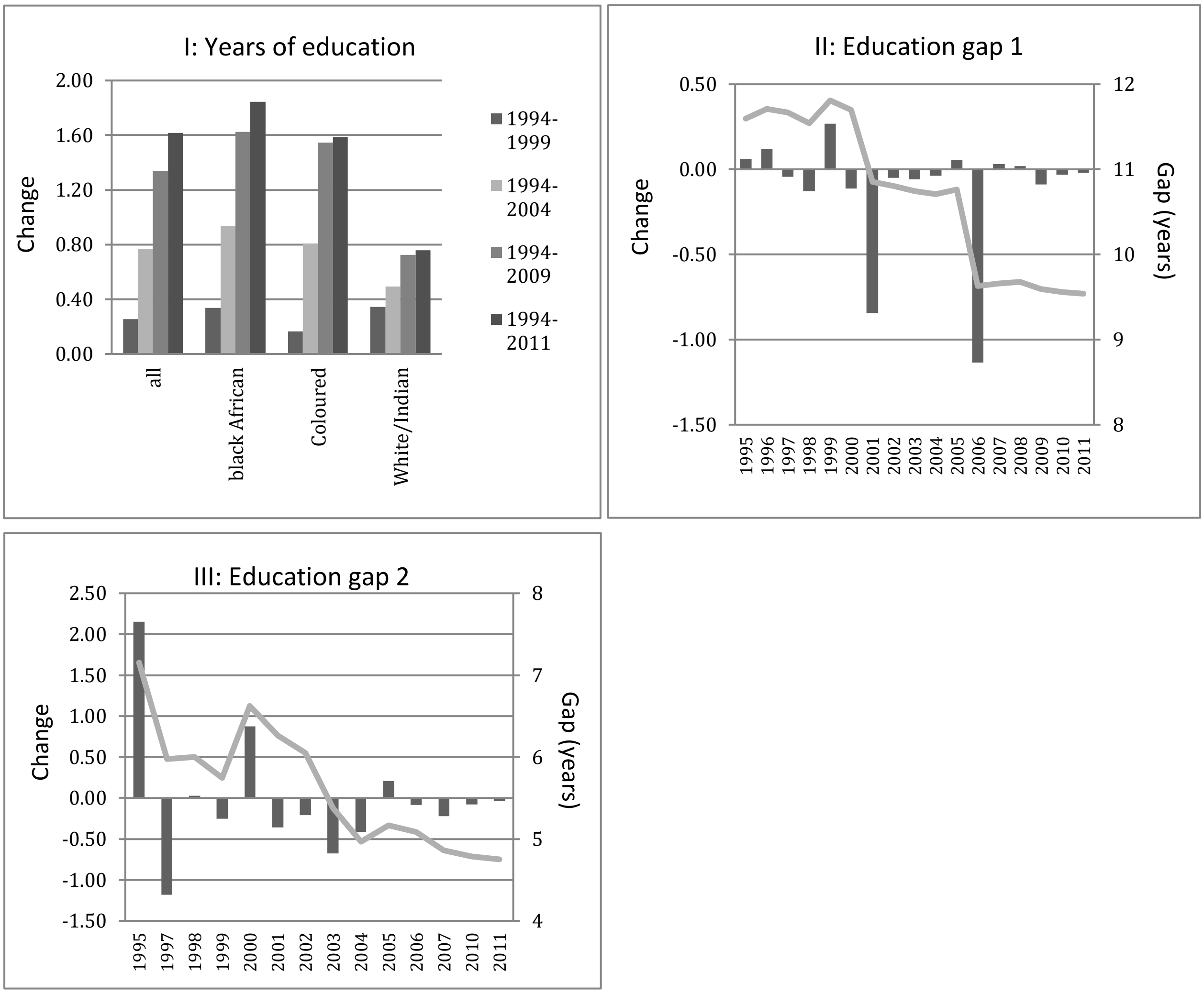
The labour data used in this study is taken from the Post-Apartheid Labour Market Series (PALMS) 1994-2012 compiled by Datafirst[1] from Statistics South Africa's October Household surveys (OHS), Labour Force surveys (LFS) and Quarterly Labour Force surveys (QLFS). The OHSs were administered annually between 1995 and 1999, after which they were replaced by the bi-annual Labour Force Surveys from 2000 to 2007. The quarterly collected QLFS was launched from 2008, and we use this data up to the third quarter of 2011. Given the un-even spacing of the different surveys, only data from the OHS 1995-1999, September LFS 2000-2007 and third quarter QLFS 2008-2011 are utilisied. These surveys include individual responses to questions regarding age, employment status, years of schooling completed, monthly earnings and typical weekly hours worked that can all be used to conduct the microsimulation analysis which will be discussed later.

3.1 Changes in the distribution of education, 1994-2011

South Africa has experienced a notable expansion in educational attainment since democratisation, with average years of education amongst the working age population increasing from 8.2 in 1994 to 9.6 to 2011. This educational expansion was not homogeneous across demographic groups, however, with most of the expansion being driven by the reduction in the educational backlog of the black African and coloured population groups (see Figure 1 panel I). Panels II and III of Figure 1 present the education gap between two groups of individuals over time: gap 1 presents an absolute measure of education inequality through the difference in average years of education between the top 20% and bottom 20% of the education distribution; and gap 2 presents inequality in education relative to earnings through comparing the average years of education between the top 20% and bottom 20% of the earnings distribution. In both cases, the columns represents annual change and the lines the average. It is likely that the data errors in the surveys may influence the annual changes, but the long term patterns are unmistakable. Both education gaps reveal a decline in absolute education inequality over time, most notably since 2000. The education gap between extreme quintiles of the education distribution has dropped consistently over the 17 year period under consideration with the gap currently hovering around 9.5 years of education. Similarly, the education gap between extreme earnings quintiles declined by approximately 2 years over the decade 2001-2011.

[1] This data may be obtained from: http://datafirst.uct.ac.za/dataportal/index.php/catalog/43

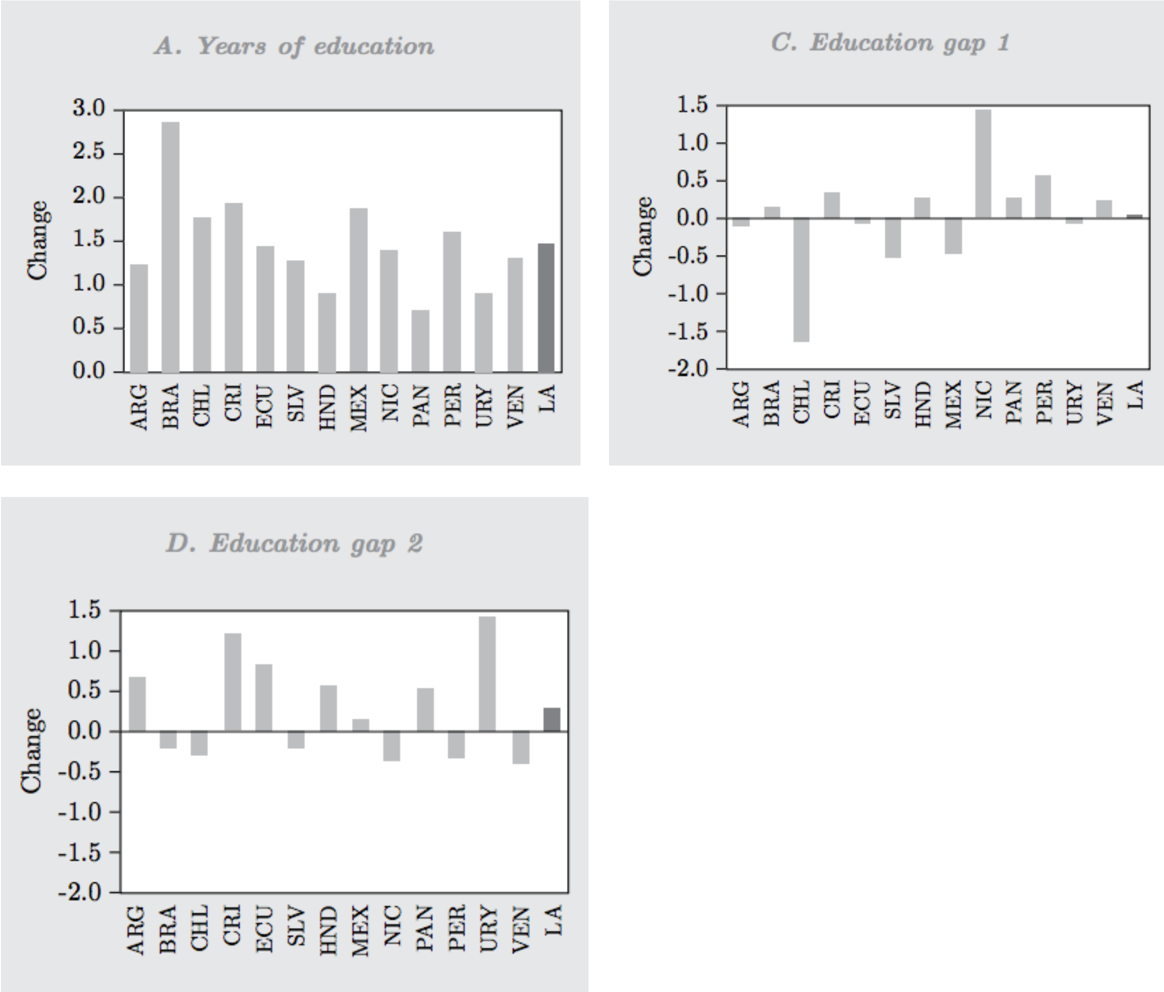
Figure 1: Changes in years of education and educational inequality, 1994-2011



Source: own calculations using PALMS 1994-2012 (Datafirst)

If we make comparisons to similarly calculated gaps in thirteen Latin American (LA) countries by Battistón et al (2014) over a similar time period (1990-2009), the decline in educational inequality in South Africa has been significantly larger (refer to figure 2 below). Whilst the average expansion in the number of years of education was similar across the LA countries (1.5 years), only Chile realised a similarly sized decline in the education gap 1 measure of roughly 1.5 years. In fact, seven of the thirteen countries saw an increase in the education gap between the highest and lowest earners, although this was largely driven by changes in educational inequality during the 1990s. Both education gaps dropped during the period 2002 to 2009, suggesting that whilst the education growth path was biased towards the most educated and higher earners before 2002, this trend subsequently reversed (Battistón et al, 2014: 13). Therefore, as with South Africa, the Latin American region has seen a decline in both relative and absolute inequality in education since the early 2000s.

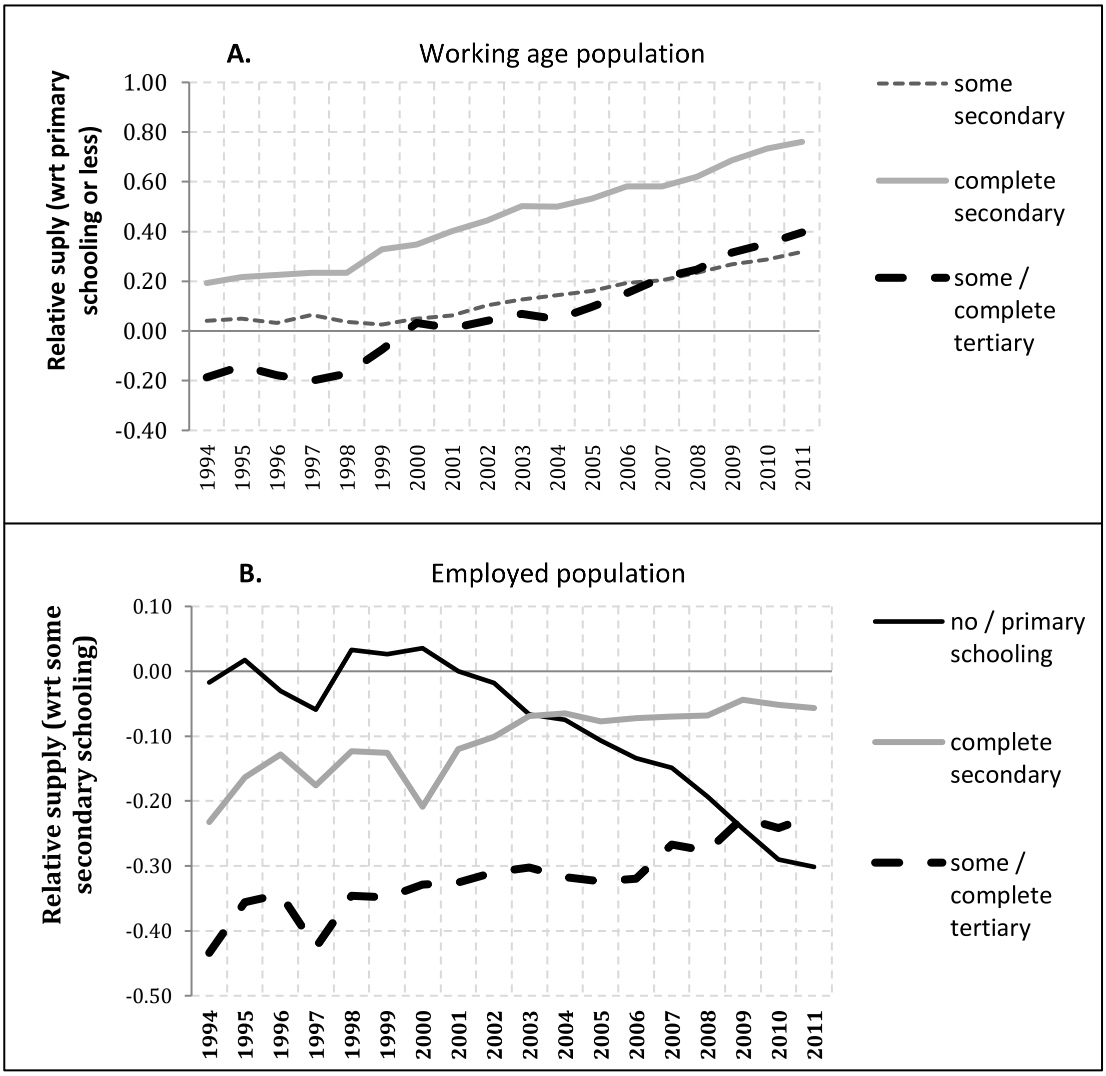
Figure 2: Changes in years of education and educational inequality, 14 Latin American countries 1990-2009



Source: Battiston et al (2014: 12)

Panel A of Figure 3 shows that the proportions of the working age population with some/complete secondary schooling and some/complete tertiary degrees (primary and no education) have steadily risen (declined) since 1994; the relative supply of tertiary educated individuals has risen faster since 2004. Panel B indicates the relative supplies of educated labour amongst the employed. The trends mirror that of the working age population, that is, a more educated workforce over time. Unlike Panel A, the relative labour supplies reflected in Panel B are measured with respect to the proportion of employed individuals with some (but not completed) secondary education. The South African workforce is predominantly comprised of individuals with this level of education, about one-third of all employed individuals, and this proportion was fairly unchanged over the time period.

Figure 3: Relative supply of educated labour, 1994-2011



Source: own calculations using PALMS 1994-2012 (Datafirst)

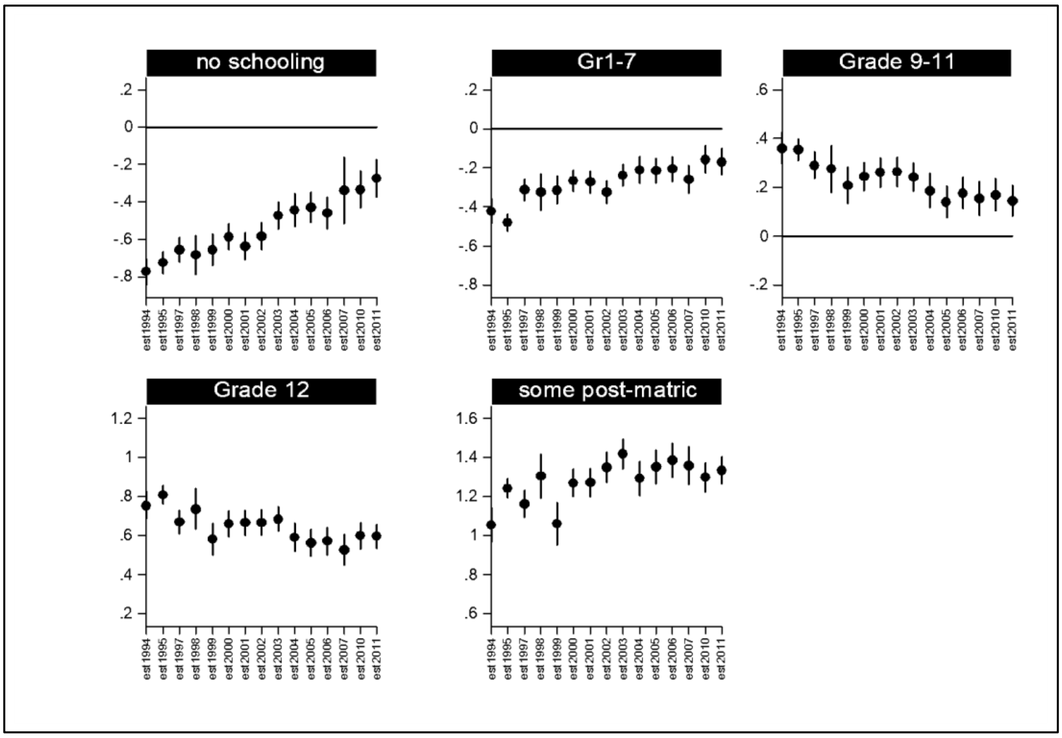
Note: the relative supplies of labour amongst the working age population are calculated as the natural log of the ratio of the proportion of individuals with a given level of education (some secondary, complete secondary or some/complete tertiary) to the proportion of individuals with complete primary education or less. The relative supplies of employed labour are calculated similarly, but relative to employed individuals with some secondary schooling.

Panel B therefore illustrates that the employed are becoming consistently more skilled over time. Whereas roughly similar proportions (one-third) of individuals with no/primary schooling and incomplete secondary education were employed at the commencement of democratisation, the proportion of employed workers with no/primary schooling dropped by roughly 50 percent between 2000 and 2011. Considering the formally employed only, the changes are even more pronounced (not shown here), with an increase in the proportion of tertiary educated (some/complete) and complete secondary former sector workers of 100 percent and 35 percent over the period, respectively.

3.2 Changes in the returns to education, 1994-2011

Figure 4 below shows the conventional returns to different levels of education (no schooling, some/complete primary schooling, some secondary schooling, complete secondary schooling and some/complete tertiary schooling) over the period 1994 to 2011. Note that the returns are estimated relative to 8 years of formal schooling. The figure indicates that the returns to schooling are somewhat modest until completion of secondary school (grade 12). It is also clear that whereas individuals with some secondary schooling were expected to earn significantly higher wages than employed individuals with less than secondary schooling (in the region of 80 percent higher), the returns to schooling below grade 12 have been converging over time with this difference being reduced to approximately 40 percent. Whilst the relative returns to grade 12 have remained fairly constant over time, individuals with post-secondary education have witnessed an increase in their expected wage relative to the returns to grade 8, albeit not significantly so. These findings are similar to those of Branson et al (2012) who focus on earnings over the same period.

Figure 4: Returns to education (levels), 1994-2011

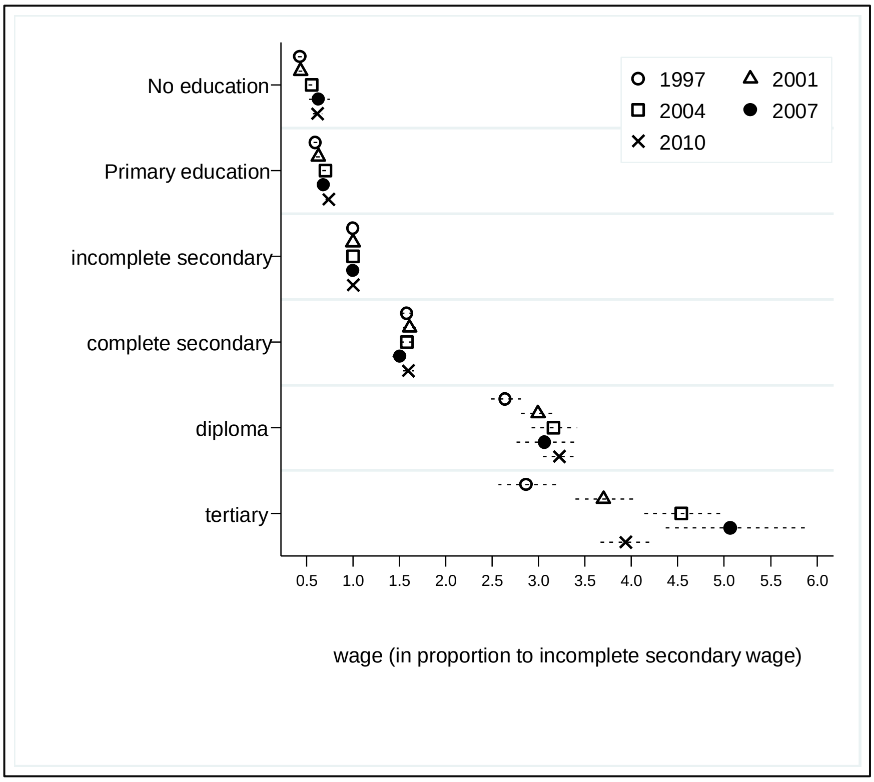


Source: own calculations using PALMS 1994-2012 (datafirst)
Note: Returns to education are normalised to 0 for individuals with highest completed level of education equal to Grade 8. Aside from education (level) dummies, the wage regressions include controls for gender, race and age (quadratic). Here, as throughout, the bars represent 95% confidence levels of the estimates.

Figure 5 illustrates increased convexity in the returns to education over time. Here the expected wage by education level is shown proportional to the expected wage of an individual with incomplete secondary education which is set at 100 percent. Whilst the returns to incomplete and complete secondary education have remained fairly constant over time, the expected wage of paid individuals with primary schooling or less as a proportion of incomplete secondary education has increased from approximately 40-60 percent to 65-75 percent. Paradoxically, the returns to tertiary education, particularly university education, saw an increase over time; whereas workers with university education were expected to earn about 3 times more than workers with incomplete secondary education in 1997 (all else equal), this increased to 5 times in 2007.

From the analysis above it is evident that educational expansion has occurred at the same time as an increase in the premium to higher levels of education. The investigation will now be continued by employing microsimulation analyses that attempt to understand the role that education expansion plays in (i) directly affecting wage inequality in South Africa and (ii) the structure of wages (returns to education). This analysis should not be interpreted as causal, but rather an attempt to obtain a deeper descriptive understanding of the underlying mechanisms driving labour market inequality and convexity in the returns to education, which by association translates into higher levels of income inequality.

Figure 5: Proportional returns to education (levels)



Source: own calculations using PALMS 1994-2012 (datafirst)
Note: Returns to education are normalised to 1 (100 percent) for individuals with highest completed level of education equal to Grade 8-11 (incomplete secondary). Aside from education (level) dummies, the wage regressions include controls for gender, race and age (quadratic).

4. Microsimulations

4.1 Earnings Inequality and Education Expansion

The microsimulation methodology of this paper follows Bourgiugnon, Ferreira & Lustig (2005). Specifically, the counterfactual earnings distribution that would arise in period t if education was distributed as in period t* is estimated, holding all other earnings determinants at their values in period t; that is, the counterfactual log earnings is defined as:

$$lnY_{it}(X_{it}^{*}) = F(X_{it}^{*}, Z_{it}, \varepsilon_{it}, \beta_t, \gamma_t) \qquad [8]$$

where X_{it} is a vector of education-specific characteristics, Z_{it} is a vector of non-education labour market characteristics, ε_{it} is a vector of unobservable characteristics, and β_t and γ_t are the model parameters to be estimated. Using this representation, the difference between the observed earnings distribution and the counterfactual distribution through a measure of inequality such as the Gini coefficient provides an indication of the partial equilibrium, first-round impact of a change in the distribution of education.

In order to calculate (8), we need estimates of β_t, $\gamma_t$and ε_{it}. These are obtained from a standard Mincerian earnings function (Mincer, 1974) where log earnings are modelled as a linear function of observable labour market characteristics:

$$lnY_{it} = \alpha_t + X_{it}\beta_t + Z_{it}\alpha_t + \ \varepsilon_{it} \qquad [9]$$

X_{it} can be modelled either by the number of years of education and its square or a set of dummies for the highest educational level completed. Z_{it} may include characteristics such as age (and age squared), race and gender dummies, and dummies of area type and province. There are well documented issues related to the identification of β_t, in particular omitted variable bias that, according to Card (1999), typically lead to under-estimation of the returns to education. Selection biases (into paid employment) may be corrected for through a Heckman two-stage procedure. Correction for endogeneity bias usually requires access to panel data or suitable instruments for education (Angrist and Krueger, 1991), both of which are not available in our data. Therefore, on this account it may appear as if the simulations produced by this paper are likely to offer lower bound estimates for the simulated change in earnings.

The distribution of education of year t* is replicated using the procedure of Legovini et al (2005). The adult population of year t are divided into homogenous birth-race groups. The following transformation is performed for each individual i within cell j:

$$X_{it}^{*} = \left(X_{ijt} - \mu_{jt}\right)\left(\frac{\sigma_{jt}^{*}}{\sigma_{jt}}\right) + \mu_{jt}^{*} \qquad [10]$$

where μ_{jt} and σ_{jt} are the sample mean and standard deviation within cell j in year t, and similarly for μ^*_{jt} and σ^*_{jt}. This adjustment leads to the distribution of education in each cell in year t having the same mean and variance of the corresponding cell in year t*. Again we emphasise that the results provide a partial equilibrium direct effect on the distribution of earnings through a change in the distribution of education, as it is highly implausible that a change in the educational levels are likely to keep the remaining determinants of earnings unchanged.

Table 1 reports the actual change in earnings (wage) inequality as well as the simulated change by altering the educational structure using equation (10). As the results are path dependent, we report the average change in the Gini from two alternative simulations: (i) the change in the Gini coefficient if the education structure of the earlier year is simulated on the population in the final year; (ii) the change in the Gini coefficient if the education structure of the later year is simulated on the population in the first year. According to table 1 below, the education expansion over the period 1994 to 2011 had direct, first-round disequalising effects on the wage distribution. We split the time period in two in order to match the change in educational expansion as seen from the education gaps of figure 1.

Table 1: Change in educational distribution and wage inequality

	Observed Gini for wages			Education effect
Period	t_1	t_2	Change	(ΔGini)
1994-2000	0.544	0.597	0.052	0.015 (0.0005)***
2001-2010	0.586	0.609	0.023	0.009 (0.0006)***

Source: own calculations using PALMS 1994-2012 (datafirst)
Note: Significance levels are obtained using 200 bootstrap estimations.

Further assessment of the link between educational expansion and earnings inequality is provided in table 2, this time allowing for an educational expansion that assigns an additional year of formal education to each worker. Assuming constant returns to education, the effect of adding one more year of education for every worker is disequalising. Given that the change in education is balanced across all levels of education, this illustrates the role that convex returns to education play in earnings inequality; as can be seen from the final column of table 2, there is a positive relationship between the simulated change in inequality and the convexity of the returns to education.

Table 2: Effect of an extra year of education on wage inequality

Year	Observed Gini for wages	Gini for wages (simulation)	ΔGini	Convexity of returns
1995	0.553	0.560	0.007 (0.0004)***	0.967
1999	0.641	0.652	0.011 (0.0015)***	0.807
2001	0.586	0.599	0.013 (0.0006)***	0.882
2004	0.567	0.585	0.018 (0.0006)***	1.306
2007	0.578	0.604	0.026 (0.0016)***	1.541
2010	0.605	0.620	0.015 (0.0006)***	1.309

Source: own calculations using PALMS 1994-2012
Note: convexity of returns are estimated as the coefficient (x100) of squared years of education from a Mincerian wage equation that also includes controls for race, gender and age (quadratic). Significance levels were obtained using 200 bootstrap estimations.

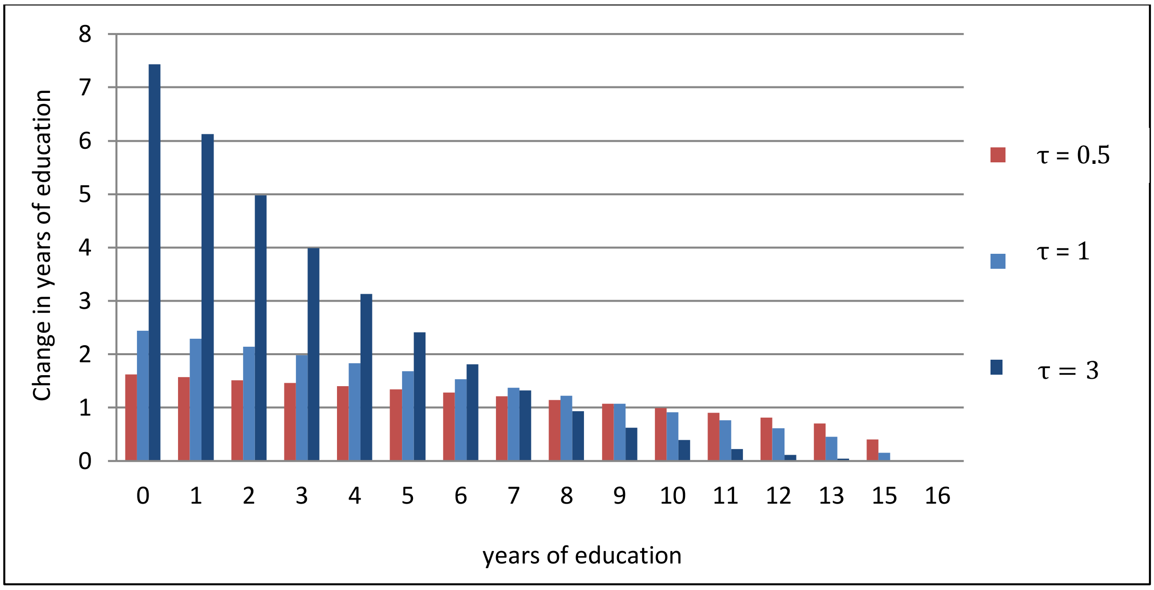
Establishing that educational expansion is related to higher earnings inequality under convex returns, we adopt the approach of Battinos et al (2014) to examine the conditions under which educational expansion might lead to a *decline* in earnings inequality. The following transformation is used to simulate an average increase of one year of education under different educational growth paths:

$$X_i^* = X_i + \theta\left(1 - \frac{X_i}{X_{max}}\right)^{\tau}, \quad \theta > 0 \qquad [11]$$

where τ and θ are two exogenously determined parameters and X_{max} is the highest value of years of education amongst the working age population. For values of $\tau > 0$, the increase in education will be greater for the less educated relative to the more educated. The value of θ is selected according to the restriction that average education increases by only a year as follows:

$$\frac{1}{N}\sum_I X_i + 1 = \frac{1}{N}\sum_I \left[X_i + \theta\left(1 - \frac{X_i}{X_{max}}\right)^{\tau}\right] \qquad [12]$$

Figure 6: Effect of an extra year of education on wage inequality



Source: own calculations using PALMS 1994-2012 (datafirst)

Figure 6 shows the underlying changes in years of education for different values of τ for South Africa; whilst τ = 0.5 and τ = 1 provide for changes in the years of education that on average are somewhat biased toward the less educated population, a value of τ = 3 implies educational advancement that is strongly biased towards the less educated. With τ = 3, we would observe an increase in the education levels of those individuals with less than 8 years of schooling to at least 7 years, or complete primary education. Table 3 reports the simulated changes in wage inequality when the average years of education is increased by one year, assuming different values for τ. The findings suggest that a sufficiently progressive (as opposed to a uniform) expansion in education in favour of the less skilled would be required in order to lower wage inequality. Considering the weak state of education for the poor in South Africa, this seems unlikely to occur in the short to medium term.

Table 3: Effect of an (average) extra year of education on wage inequality

Year	Observed Gini	ΔGini		
		$\tau = \frac{1}{2}$	$\tau = 1$	$\tau = 3$
2001	0.586	-0.0044 (0.00040)***	-0.0104 (0.00040)***	-0.0179 (0.00041)***
2010	0.605	-0.0036 (0.00041)***	-0.0081 (0.00042)***	-0.0100 (0.00043)***

Source: own calculations using PALMS 1994-2012
Note: significance levels were obtained using 200 bootstrap estimations.

4.2 Education Expansion and the Structure of Wages

4.2.1 Theoretical Framework

In this section we present a model of labour demand disaggregated by level of education and age that allows us to estimate the impact of changes in the relative supplies of educated labour on the wage structure. The model follows the approaches of Katz and Murphy (1992), Card and Lemieux (2001) and Manacorda, Manning and Wadsworth (2012). We assume the firms produce according to a typical neoclassical production function that combines labour and capital, and that capital is exogenous to the firms' decision of how much labour to employ; therefore, firms produce output using a combination of labour with different skills (education) levels:

$$Y_t = A_t\left[\sum_{s=1}^{S} \theta_{et} L_{et}^{\rho}\right]^{1/\rho}, \quad e = 0,1,2,3 \qquad [13]$$

where e = 0 represents labour with primary schooling or less, e = 1 represents labour with incomplete secondary education, e = 2 represents labour with complete secondary education and e = 3 represents tertiary educated labour. A_t is a skill-neutral technology parameter and the relative efficiency (represented by θ_{et}) of the different education groups is normalised at $\theta_{0t} = 1$. The elasticity of substitution between the different education groups is measured by $\sigma_E = \frac{1}{1-\rho}$, which for simplicity sake we assume is time invariant and constant over education groups.[2]

The labour input for a given education group *e* is composed of different birth (age) groups as follows:

$$L_{et} = \left(\sum_{a=1}^{A} \lambda_{ea} {L_{eat}}^{\eta}\right)^{1/\eta} \qquad [14]$$

where *a* denotes age group, and λ_{ea} are measures of the relative efficiency of differently aged labour inputs for each level of education; these are assumed to be time invariant (no age-biased technical progress) and normalised at $\lambda_{e1} = 1$. The elasticity of substitution between different age groups, $\sigma_A = 1/(1-\eta)$, is a parameter to be estimated and assumed to be education (skill) invariant.[3]

[2] Although classification of the production function with perfect substition between differently educated labour (although they are allowed to have different efficiency parameters) is quite restrictive, it follows established work in labour economics (ses Katz and Murphy (1992) and Card and Lemieux (2001)).

[3] Battistón et al (2014) assume perfect substitutability across age groups for a given level of education. The assumption of constant elasticity of substitution (CES) production function is restrictive as it assumes that the actual age difference does not matter when workers from one age group are substituted by members of another age group. A fuzzy CES production function is able to take into consideration that members of two neighbouring age groups are better substitutes (Prskawetz, Fent & Guest, 2008). This further allows for workers of some ages to be more flexible (substitutable) than workers from other ages.

Equating relative wages to relative marginal products[4] and assuming competitive markets and normalising output prices to one, log wages are given by:

$$lnw_{eat} = lnA_t + \frac{1}{\sigma_E} lnY_t + ln\theta_{et} + ln\lambda_{ea} + \left(\frac{1}{\sigma_A} - \frac{1}{\sigma_E}\right) lnL_{et} - \frac{1}{\sigma_A} lnL_{eat} \qquad [15]$$

The relative wage of (higher) skilled labour to the lowest education group satisfies:

$$\ln \frac{w_{eat}}{w_{0at}} = \ln \frac{\theta_{et}}{\theta_{0t}} + \ln \frac{\lambda_{ea}}{\lambda_{0a}} - \frac{1}{\sigma_E} \ln\left(\frac{L_{et}}{L_{0t}}\right) - \frac{1}{\sigma_A}\left[\ln\left(\frac{L_{eat}}{L_{0at}}\right) - \ln\left(\frac{L_{et}}{L_{0t}}\right)\right] \qquad [16]$$

According to this model, education wage gaps for a given age group depends on the aggregate relative supply of divergently educated workers as well as the age-specific supply of higher educated labour relative to uneducated labour in period t.

A potential indicator of age-group specific supply effects in the returns to education is the presence of cohort effects. If we assume that workers of different age groups are perfect substitutes, we would expect the returns to higher levels of education for different age groups to rise and fall proportionately over time. If instead we assume that different age groups are imperfect substitutes and that the relative supplies of different age groups are increasing/decreasing at the same rate, we would expect cohort effects to play some role in explaining the pattern of wage gaps across age groups over time. From figure 7 it can be seen that the returns to returns to education for older and younger birth cohorts have not changed proportionately over time. Rather, the returns to lower levels of education has decreased substantially amongst younger age cohorts.

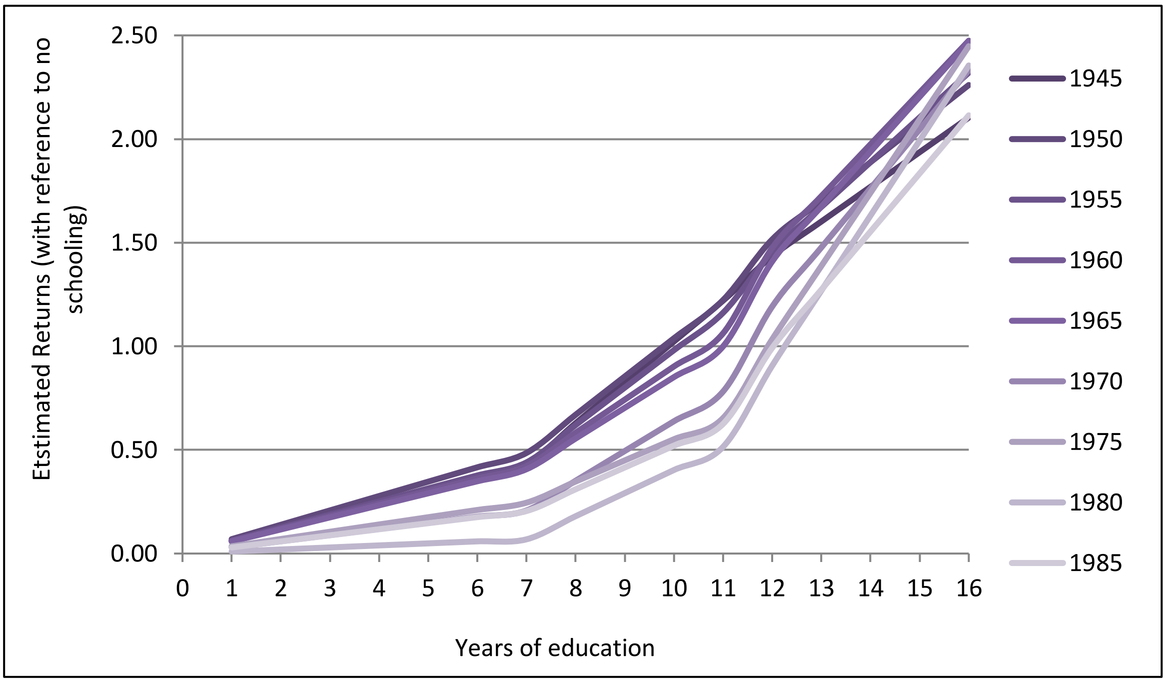
We can therefore consider estimation of the following model:

$$lnw_{eat} - lnw_{e-1,at} = f_a + f_{bc} + f_t + e_{at} \qquad [17]$$

where $lnw_{eat} - lnw_{e-1,at}$ is the estimated wage gap between a higher level of education and a lower level of education for age group a in year t, f_a are a set of three-year age effects, f_{bc} are a set of three-year birth-cohort effects, f_t are three-year time effects and e_{ea} represents sampling and specification error (Card and Lemieux, 2001).

[4] This assumption might be quite limiting within the South African context if we believe wages and productivity to be 'de-linked' or only weakly correlated.

Figure 7: Returns to education by birth cohort



Source: own calculations using PALMS 1994-2012 (datafirst)
Note: Returns to education are normalised to 0 for individuals with no years of formal schooling. The wage regression is estimated on a pooled dataset (including years 1994-2011) with log(wage) as the dependent variable; time effects, age (quadratic) and birth cohort effects are included as controls. Returns to education are calculated as the coefficients on interactions between birth cohort effects and education splines.

4.2.2 Estimation and Identification

Equation (16) is not directly estimable as identification of σ_E requires an estimate of L_{et}, which in turn requires estimates of λ_{ea}. We therefore consider the following iterative process. First, equation (15) is respecified as:

$$lnw_{eat} = f_t + (f_t \times f_e) + (f_e \times f_a) - \frac{1}{\sigma_A} \ln\left(\frac{L_{eat}}{L_{0at}}\right) \qquad [18]$$

where the time fixed effects (f_t) absorb $(lnA_t + \frac{1}{\sigma_E} lnY_t)$ and the time-education interactions $(f_t * f_e)$ absorb $\left(ln\theta_{et} - \frac{1}{\sigma_E} lnL_{et}\right)$. The coefficient on the cell-specific relative supply of semi- and highly skilled[5] workers to unskilled (primary school or less) workers gives an estimate of the elasticity of substitution across age groups, σ_A. The education-age interactions $(f_e * f_a)$ identify $ln\lambda_{ea}$, which allows for estimation of L_{et}. With estimates of L_{et}, (16) can be estimated directly using:

$$ln\left(\frac{w_{eat}}{w_{0at}}\right) = f_t + f_e + (f_e \times f_a) - \frac{1}{\sigma_E} ln\left(\frac{L_{et}}{L_{0t}}\right) - \frac{1}{\sigma_A}\left[\ln\left(\frac{L_{eat}}{L_{0at}}\right) - \ln\left(\frac{L_{et}}{L_{0t}}\right)\right] \qquad [19]$$

[5] Some secondary education, complete secondary education and some/complete tertiary education.

which provides an estimate of the elasticity of substitution between the skills groups (σ_E), skill-biased technological change (f_t), as well as a new estimate of σ_A. The returns to education are therefore affected by changes in the education composition of the population in relation to the elasticities of substitution rooted in labour demand. The elasticity of $ln\frac{w_{eat}}{w_{0at}}$ with respect to the relative labour supply $\frac{L_{et}}{L_{0t}}$ is given by:

$$\kappa_{eat} = (\rho - \eta)/\left(\ln\frac{w_{et}}{w_{0t}}\right) \qquad [20]$$

and the elasticity of $ln\frac{w_{eat}}{w_{0at}}$ with respect to the age-specific relative labour supply $\frac{L_{eat}}{L_{0at}}$ is given by:

$$\pi_{eat} = (\eta - 1)/\left(\ln\frac{w_{eat}}{w_{0at}}\right) \qquad [21]$$

The main sample used for estimation is men and women aged 21-60. Data from the following three-year intervals (2001, 2004, 2007 and 2010) and three-year age cells (24-26, 27-29, 30-32, 33-35, 36-38, 39-41, 42-44, 45-47, 48-50, 51-53, 54-56, 57-59) are used. Our measure of wages is hourly wage.[6] To begin with we adopt a quite narrow classification of wage earner including only private sector, formally employed workers; results for the sample including public sector and informal wage workers are also provided. To derive measures of the returns to education we run Mincerian type wage regressions that control for education dummies and age (quadratic).

4.3.3 Results

The model estimates are shown in table 4. As mentioned, the model is estimated using 4 sub-samples of the data: formal private sector (column 1), whole formal sector (column 2), public sector (column 3) and the entire sample of formal and informal workers (column 4). The first row reports the estimated coefficient on the effect of changes in the relative supply of education (skills) by age and time on the returns to higher levels of education based on equation (18). Rows (2) and (3) report estimates of step 2 (equation (19)) that provide a new estimate of σ_A as well as an estimate of σ_E. The elasticities of the returns to education (relative to primary school or less) to changes in the relative supply of higher educated labour are shown in the final panel of table 4.

When estimation is restricted to the formal private sector only, the estimated coefficient on age-specific relative labour supply ($-\frac{1}{\sigma_A}$) from the first step is 0.171 and statistically significant. The same estimate of $-\frac{1}{\sigma_A}$ is found in the second step estimation together with an

[6] Individuals with outlying wage data are excluded from all analysis.

estimate of $-\frac{1}{\sigma_e}$ of -0.136 (not statistically significant). These results indicate that there is complementarity between workers from different age groups (within the same education category) employed in the private formal sector, whilst higher educated individuals are substitutes for less educated individuals. It is this finding that plays a specific role in how the returns to education levels has changed over the decade 2001 to 2011. The estimation of equation (19) indicates that, at least within the private formal sector, the increase in the aggregate supplies of higher educated (more skilled) workers seems to depress the returns to higher education, whilst increases in age-specific relative supplies of higher educated workers increases the returns to higher education.

In the case of the public sector, the estimate of $(-\frac{1}{\sigma_A})$ is not found to be significantly different from zero, whilst the estimate of $-\frac{1}{\sigma_E}$ is statistically significant at 1.071. This indicates that increases in the relative supplies of higher educated workers as well as the age-specific supplies of higher educated workers is positively related to the returns to higher education. It is unsurprising that the final column which includes both public and private sector workers (informal and formal) provides model estimates that suggest a complementarity between workers of different age groups.

We now use the estimates of table 4 to simulate the effect of changes in the stock and education mix of workers on wages. Following Manacorda et al (2012), we regard equation (13) as an actual production function[7] and use equation (15) to derive the different elements of the decomposition as:

$$dln(w_{ea}^N) = d\frac{1}{\sigma_E}lnY + \left(\frac{1}{\sigma_A} - \frac{1}{\sigma_E}\right)dlnL_e - \frac{1}{\sigma_A}dlnL_{ea} \qquad [22]$$

The components of (22) use the wage bill shares and estimated elasticities of substitution from table 4 to compute the changes in wages for each age-education cell in response to the observed changes in the number and skill composition of the labour force between 2001 and 2010.[8] In line with the earlier analysis, the change in wages is calculated as the average from the simulation of the change in the wages if the education structure of the earlier year is simulated on the sample in the final year, and vice versa. The results are shown in table 5.

The first column of table 5 reports the effect due to changes in the supply of labour in any given age group, $(-\frac{1}{\sigma_A})$, whilst column 2 reports the effect due to changes in the supply of each educational group, $(\frac{1}{\sigma_A} - \frac{1}{\sigma_E})$. Column 3 suggests that an increase in skills levels increases

[7] This further assumes endogenous capital that is in perfectly elastic supply.
[8] See appendix B of Manacorda et al (2012) for a more complete breakdown of this composition.

total output and hence wages. For the most part, the manner in which education levels rose over the 10 year period is associated with higher returns to higher levels of education (relative to primary school or less), with the exception of those with complete secondary (matric) schooling. Whilst a rise in the numbers of higher educated workers lowers the wages of private sector workers (as indicated by negative $\bar{\kappa}_e$), this is countered by a rise in wages due to complementarity of differently aged workers within education cells.

Table 4: Estimated elasticities of substitution by age group and level of education.

		Three year private formal sector	Three year public	Three year all
(1)	First-stage: $\ln\left(\frac{L_{eat}}{L_{0et}}\right)$	0.171** (0.067)	0.123 (0.091)	0.187** (0.078)
	Second stage:			
(2)	$\ln\left(\frac{L_{et}}{L_{0t}}\right)$	-0.136 (0.161)	1.071** (0.452)	0.053 (0.205)
(3)	$\ln\left(\frac{L_{eat}}{L_{0et}}\right) - \ln\left(\frac{L_{et}}{L_{0t}}\right)$	0.171*** (0.059)	0.112 (0.077)	0.162** (0.070)
	χ^2	2816.16	449.51	7061.33
	p-value	0.000	0.000	0.000
	Observations	144	144	144
	R^2	0.951	0.759	0.980
	$\bar{\kappa}_1$	-0.776	1.915	-0.228
	$\bar{\pi}_1$	0.433	0.223	0.339
	$\bar{\kappa}_2$	-0.295	1.017	-0.092
	$\bar{\pi}_2$	0.164	0.119	0.137
	$\bar{\kappa}_3$	-0.165	0.678	0.027
	$\bar{\pi}_3$	0.092	0.079	0.082

Source: PALMS 1994 – 2012 (Datafirst)
Notes: The table reports OLS estimates of equations 18 and 19. All regressions are weighted by the inverse of estimated variance of log wage. *** significant at 1% level, ** significant at 5% level, * significant at 10% level.

Some previous studies in (primarily developed) countries have identified substitution between workers of different ages, with some differences in the degree of substitution (see Card & Lemiuex, 2001;[9] Fitzenberger & Kohn, 2006;[10] Manacorda et al, 2012[11]) whilst other studies such as Hebbink (1993), Kremer & Thomson (1998), Bingley, Gupta & Pedersen (2010)[12] and Kalwij, Kapteyn & de Vos (2009)[13] find, similar to this paper, complementarity between older

[9] Canada, United Kingdom and the United States of America
[10] Germany
[11] United Kingdom
[12] Denmark
[13] 22 OECD countries

and younger workers. Complementarity between young and prime-age workers has also been found in the case of Germany post-2007 where increases in adult employment was accompanied by increases in youth employment during periods of positive growth (O'Higgins, 2012). O'Higgins (2012) argues that differing elasticities of youth-to-adult employment can be "explained in terms of the institutional structure of young labour market", whilst Acemoglu (2002) argues that a continual growth in the skills levels of new workers coupled with technological change bringing with it a bias for certain skills has resulted in groups of younger and older works no longer being good, if at all, substitutes for each other.

The estimated changes in relative wages in South Africa (in both formal private sector employment and employment in general) appear to be primarily driven by changes in the age-specific relative supplies of educated labour. Whilst the relative distribution of differently aged labour remained fairly unchanged over the period, the proportion of labour aged 25-40 years accounted for by complete secondary and tertiary educated individuals increased from approximately 40% to 50%. This trend is particularly noticeable within the public sector where close to half of workers aged 35-45 in 2010 were observed to be tertiary educated. Given the complementarity between younger and older age groups, it is not surpising then that the "upskilling" of the younger and prime-age cohorts have not led to lower returns to education, particularly amongst the tertiary educated, if these skills can be combined with older worker groups with proportionately less education.

Table 5: Simulations of the impact of education expansion on wages

	Total age-education supply (lnL_{eat})	Own education supply (lnL_{et})	Aggregate supply (lnY_t)	Estimated $dln\left(\frac{w_{ea}}{w_{0a}}\right)$
		Formal private sector		
Primary or less	0.013	-0.002	0.029	-
Some secondary	0.050	-0.009	0.029	0.029
Complete secondary	-0.071	0.011	0.029	-0.072
Tertiary	0.082	-0.016	0.029	0.053
		All		
Primary or less	-0.006	0.000	0.004	-
Some secondary	0.032	-0.002	0.004	0.035
Complete secondary	-0.090	0.005	0.004	-0.079
Tertiary	0.014	-0.001	0.004	0.018

Notes: simulations are based on actual wage bill shares in 2001 and 2011 and the estimates of the elasticities of substitution from table 4. The change considered is the change in the relative supplies of differently educated labour in each cell observed over the period 2001–2010.

Directly comparable results for the Latin American region are not available as the methodology adopted by Battison et al (2014) treats differently aged labour as perfect substitutes whereas this study allowed for imperfect substitutability across age groups. However, it is worthwhile comparing the estimated changes in the expected returns to education levels given the observed education expansion in Latin America over the last decade. The estimated changes in the returns to education levels relative to 'no formal schooling' for 14 Latin American countries from Battiston et al (2014) illustrate that changes in the educational levels within the Latin American region are related to declining convexity in the returns to education, and therefore less unequalizing labour market earnings.

In a study of the evolution of Brazilian wages over the 1980s and 1990s that adopts the same methodological framework as this study, Ferreira (2004) finds labour of different age groups (within a given education group) as well as tertiary and secondary educated labour to be substitutes in production. This coupled with the rise in education endowments amongst the Brazilian working age population is argued to have contributed to the reduction in income inequality in Brazil. The findings are in contrast to that estimated by this study for South Africa given the complementarity between labour of different ages (within the same education group). Therefore, whilst a rise in the number of graduates entering the labour market in Brazil during the 1990s may have contributed to a substantial decrease in the college premium, this would not have occurred to the same extent in South Africa.

Table 6: Estimated average (%) changes in the returns to educational level using a CES model, Latin America 1990-2009

	Arg	Bra	Chi	Cri	Ecu	Slv	Hnd	Mex	Nic	Pan	Per	Ury	Ven
$\%\Delta\beta_{primary}$	10.7	-10.4	-45.8	1.2	-54.7	-19.8	-3.8	9.1	-9.4	0.0	-7.0	0.0	25.0
$\%\Delta\beta_{inc.\ secondary}$	0.8	-35.7	-5.9	-2.7	31.7	-35.6	-5.4	-3.8	2.7	0.0	-7.8	0.0	3.8
$\%\Delta\beta_{secondary}$	2.3	-20.1	-3.5	-0.1	-22.9	-17.4	1.2	-0.7	-6.6	0.0	-4.7	0.0	-19.0
$\%\Delta\beta_{iinc\ tertiary}$	-1.6	-13.5	-13.1	-0.7	-22.0	-11.1	2.1	-1.4	-10.9	0.0	-5.7	0.0	-10.5
$\%\Delta\beta_{tertiary}$	-0.8	-5.7	-6.7	-0.2	-5.7	-8.3	-2.1	-0.6	-1.8	0.0	-3.0	0.0	-10.8

Source: Battiston et al (2014: 38)

A study by Gasparini et al (2011) similarly studied the evolution of wage differentials and trends in the supply and demand of workers by educational attainment for 16 Latin American countries over the 1990s and 2000s, specifically adopting Tinbergen's (1975) framework to estimate the relative contribution of supply and demand factors to the observed trends in wage premia. They conclude that in the context of increases in the relative supply of both skilled and semi-skilled workers, the observed trend in the returns to education over the two decades can be explained by a strong shift in the demand for skilled labour in the 1990s (spurred by inter alia technical change, trade openness and privatisation) followed by a deceleration of this relative demand in the 2000s.

5. Conclusion

Labour market inequality, specifically wage inequality, remains the primary determinant of income inequality in South Africa. Understanding the factors that contribute to wage inequality will therefore assist in determining the impediments to income redistribution as well as inform social and economic policy. Whilst improvements in the education level of the South African population is not only desirable but also necessary for poverty alleviation and income distribution, it is known that such expansion can under certain conditions also give rise to the 'paradox of progress'; that is, educational improvement sometimes worsens wage inequality. The last two decades in South Africa have been characterised by significant improvements in the average levels of education. However, a large proportion of the working age population continue to have only incomplete secondary education. This fact combined with rising returns to higher levels of education over the last decade has resulted in the expansion in education levels being disequalising, or at the very least, not equalising. This is in line with the paradox of progress operating.

One of the focuses of this study was to understand the link between educational expansion and the increasing convexity in the returns to education over the period 2001 to 2010. Our finding that differently aged workers are complements in production could be a factor in the rising convexity in the returns to education; specifically, the manner in which educational expansion has occurred may be associated with a reduction in the expected wage gap between individuals with complete secondary education and those with less than complete secondary education, whilst the returns to tertiary education are large and in fact have risen. This might be explained by the current skills bias of the economy favouring high skills, as is often experienced in the development process, and the fact that improvements in education levels have largely occurred amongst the younger and prime-aged members of society. As older, proportionately less educated workers are displaced within the labour market, this may alter the relative complementarity and substitutability across age-education groups, perhaps leading to a decline in the premium to tertiary education in the course of development.

This being said, should educational expansion continue in a manner whereby the less-educated population do not receive a measurable improvement in their skills, we are unlikely to see a reduction in wage inequality, the primary driver of income inequality. Whilst policies aimed at addressing blockages in access to tertiary education are important and could have implications for wage and income inequality reduction, we should not ignore those with less than complete secondary education. The microsimulation analysis of this paper has indicated that with improvements in schooling that are strongly progressive and biased towards the least skilled, wage inequality can fall even after an education expansion. However, as argued by Lam, Leibbrandt, Garlic and Branson (2012), merely accumulating higher levels of schooling is not an end to itself, and emphasis needs to be placed on the quality of education. As long as a significant portion of the education system that serves the poorer parts of the population continues to be dysfunctional, improvements in average schooling levels coupled with job creation that is incompatible with the skills level of these individuals are unlikely to lead to an improved income distribution. Addressing income inequality in South Africa is therefore partly a story of tackling the problem of dysfunctional and ineffective schooling, so that the convexity in the returns to education may be tempered by improved skills levels of the general South African populace.

Appendix

Table A1: Relative labour supplies by age-education group

Year	Supply of primary schooling (or less) relative to:								
	Incomplete secondary schooling			Complete secondary schooling			Tertiary schooling		
	24-29	30-44	45+	24-29	30-44	45+	24-29	30-44	45+
2000	0.272	0.029	-0.198	0.278	-0.180	-0.588	0.030	-0.187	-0.481
2001	0.279	0.066	-0.165	0.363	-0.043	-0.390	0.023	-0.083	-0.394
2002	0.371	0.114	-0.116	0.475	0.067	-0.299	0.244	0.032	-0.277
2003	0.432	0.149	-0.080	0.551	0.156	-0.238	0.252	0.082	-0.208
2004	0.435	0.169	-0.083	0.529	0.220	-0.234	0.203	0.082	-0.232
2005	0.496	0.190	-0.080	0.587	0.178	-0.241	0.264	0.118	-0.224
2006	0.515	0.245	-0.076	0.598	0.246	-0.239	0.274	0.184	-0.202
2007	0.499	0.267	-0.079	0.531	0.268	-0.325	0.318	0.172	-0.113
2010	0.686	0.399	0.005	0.705	0.364	-0.213	0.354	0.196	-0.185
2011	0.668	0.435	0.012	0.693	0.390	-0.178	0.377	0.251	-0.151

Notes: own calculations using PALMS 1994-2012 (Datafirst).

References

Acemoglu, D. (2002). Technical change, inequality and labour market, *Journal of Economic Literature* XL, 7-72.

Armstrong, P. & Burger, C. (2009). *Poverty, inequality and the role of social grants: An analysis using decomposition techniques*. Working Papers 15/2009, Stellenbosch University, Department of Economics

Battistón, D., García-Domench, C. & Gasparini, L. (2014). Could an increase in education raise income inequality?: Evidence for Latin America, *Latin American Journal of Economics* 51(1), 1-39.

Bingley, P., Gupta, N. D., & Pedersen, P. J. (2010). Social Security, Retirement and Employment of the Young in Denmark. In *Social Security Programs and Retirement around the World: The Relationship to Youth Employment* (pp. 99-117). University of Chicago Press.

Bourguignon, F., Ferreira, F. H. & Lustig, N. (Eds.). (2005). *The microeconomics of income distribution dynamics in East Asia and Latin America*. World Bank Publications.

Branson, N., Garlick, J., Lam, D. & Leibbrandt, M. (2012). *Education and inequality: The South African case*. SALDRU Working Paper 75, University of Cape Town

Card, D. & Lemieux, T. (2001). Can falling supply explain the rising return to cllege for younger men? A cohort-based analysis, *The Quarterly Journal of Economics* 116, 705-746.

Ferreira, S.G. (2004). The provision of education and its impacts on college premium in Brazil. *Revista Brasileira de Economia* 58(2), 211-233.

Fitzenberger, B., & Kohn, K. (2006). Skill wage premia, employment, and cohort effects: are workers in Germany all of the same type? ZEW Discussion Papers, No. 06-44

Galor, O. & Zeira, J. (1993). Income distribution and macroeconomics. *The Review of Economic Studies* 60(1), 35-52.

Galor, O. & Moav, O. (2004). From physical to human capital accumulation: Inequality and the process of development. *The Review of Economic Studies* 71(4), 1001-1026.

Gasparini, L., Galiani, S., Cruces, G., & Acosta, P. (2011). Educational upgrading and returns to skills in Latin America: Evidence from a supply-demand framework, 1990-2010. World Bank Policy Research Working Paper, (5921).

Goldin, C. & Katz, L. (1999). *The returns to skills in the United States across the twentieth century.* NBER Working Paper 7126. Cambridge, Mass.: National Bureau of Economic Research.

Hebbink, G.E. (1993). Production factor substitution and employment by age group. *Economic Modelling* 10, 217-224.

Kalwij, A., Kapteyn, A. & De Vos, K. (2009). Early retirement and employment of the young. Rand Working Paper Series No. WR-679.

Katz, L.F. & Murphy, K. M. (1992). Changes in relative wages, 1963-1987: Supply and demand factors. *The Quarterly Journal of Economics* 107(1), 35.

Keswell, M. (2003). Essays on categorical inequality, non-linear income dynamics and social mobility in South Africa.

Keswell, M. & Poswell, L. (2004). Returns to education in South Africa: A retrospective sensitivity analysis of the available evidence. *South African Journal of Economics* 72(4), 834-860.

Kingdon, G. & Knight, J. (1999). *Unemployment and wages in South Africa: A spatial approach.* Centre for the Study of African Economies, Institute of Economics and Statistics, University of Oxford.

Kremer, M., & Thomson, J. (1998). Why isn't convergence instantaneous? Young workers, old workers, and gradual adjustment. *Journal of Economic Growth*, 3(1), 5-28.

Lam, D., Ardington, C. & Leibbrandt, M. (2011). Schooling as a lottery: Racial differences in school advancement in urban South Africa. J*ournal of Development Economics* 95(2)

Leibbrandt, M., Bhorat, H. & Woolard, I. (2001). Household inequality and the labor market in South Africa, *Contemporary Economic Policy* 19(1), 73-86

Leibbrandt, M., Woolard, I., Finn, A. & Argent, J. (2010). *Trends in South African income distribution and poverty since the fall of apartheid.* OECD Social, Employment and Migration Working Papers 101, OECD Publishing

Leibbrandt, M., Finn, A. & Woolard, I. (2012). Describing and decomposing post-apartheid income inequality in South Africa. *Development Southern Africa* 29(1), 19-34

Manacorda, M., Manning, A. & Wadsworth, J. (2012). The impact of immigration on the structure of wages: Theory and evidence from Britain. *Journal of the European Economic Association* 10(1), 120-151.

Mincer, J. (1974). Schooling, Experience, and Earnings. Human Behavior & Social Institutions No. 2.

Moll, P. G. (1996). The collapse of primary schooling returns in South Africa 1960–90. *Oxford Bulletin of Economics and Statistics* 58(1), 185-209.M

Murphy, K. M. & Welch, F. (1994). Industrial change and the rising importance of skills. In: Danziger, S. & Gottschalk, P. (1994). (Eds.). *Uneven tides: Rising inequality in America.* New York: Russel Sage Foundation, 101-132.

Mwabu, G. & Schultz, T. P. (2000). Wage premiums for education and location of South African workers, by gender and race. *Economic Development and Cultural Change* 48(2), 307-334.

O'Higgins, N. (2012). This time it's different: Youth labour markets during 'The Great Recession'. *Comparative Economic Studies* 54(2), 395-412.

Prskawetz, A., Fent, T. & Guest, R. (2008). Workforce aging and labour productivity: The role of supply and demand for labour in the G7 countries. *Population and Development Review* 34, 298-323.

Rospabé, S. (2001). An empirical evaluation of gender discrimination in employment, occupation attainment and wage in South Africa in the late 1990s. In DPRU/FES workshop on "Labour markets and poverty in South Africa", Johannesburg, November.

The **Research Project on Employment, Income Distribution and Inclusive Growth (REDI3x3)** is a multi-year collaborative national research initiative. The project seeks to address South Africa's unemployment, inequality and poverty challenges.

It is aimed at deepening understanding of the dynamics of employment, incomes and economic growth trends, in particular by focusing on the interconnections between these three areas.

The project is designed to promote dialogue across disciplines and paradigms and to forge a stronger engagement between research and policy making. By generating an independent, rich and nuanced knowledge base and expert network, it intends to contribute to integrated and consistent policies and development strategies that will address these three critical problem areas effectively.

Collaboration with researchers at universities and research entities and fostering engagement between researchers and policymakers are key objectives of the initiative.

The project is based at SALDRU at the University of Cape Town and supported by the National Treasury.

Tel: (021) 650-5715

www.REDI3x3.org

REDI3X3

Research Project on Employment, Income Distribution & Inclusive Growth

Towards an integrated response to unemployment, inequality and poverty