Income Inequality and Mobility: A Nonparametric Decomposition Analysis by Age for Switzerland in the 80s and 90s

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1. Introduction

Income inequality may result from many different sources such as age, education, gender, nationality, occupation, or even luck. Among these, the effect of age is particularly important because income varies substantially over the life-cycle. A stylized income profile might be characterized by a low-income phase in early adulthood, followed by a phase of growing income up to a certain age and finally completed by a phase of declining income after retirement. Computing inequality over the entire cross-section of a population at a point in time neglects the effect of individuals being in different phases of their life-cycle. The pure extent of inequality within a population therefore tends to be overstated.

A second point is that measured inequality usually declines when considering permanent rather than single-year income. Part of the observed inequality in any given year may be due to transitory income variations that are smoothed out over a longer period of time. In fact, as a benchmark, if all characteristics of the household head or equivalently of the entire household were controlled for, the remaining inequality would result from idiosyncratic income shocks only.

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If only part of the characteristics are observed, variations in inequality are due to idiosyncratic income shocks on the one hand, and differences in the unobserved characteristics on the other. The effect of purely transitory income fluctuations is, however, concealed when assessing single-year inequality. A thorough inequality analysis should therefore be complemented by an analysis of the degree of mobility in the sense of inequality reduction when the accounting period is extended.

These two issues, life-cycle effects and inequality in permanent income, are closely related as they refer to the dynamic aspect of the income and earnings process. The first issue corresponds to movements along the income-age profile while the second relates to temporary deviations from it. In this paper we attempt to disentangle these two effects for Swiss income data. Firstly, by conditioning income inequality on age the *within* and the *between* age component are isolated. Secondly, since we have two short panels at hand, both of which are cross-sections at two different points in time covering two years each (1980/82 and 1990/92), mobility in the sense of inequality reduction when the accounting period for incomes is extended, can be studied.

The paper differs in several aspects from previous work. Most importantly we estimate inequality and mobility by means of nonparametric kernel density methods. These allow us to construct continuous and unrestricted relationships between inequality and age on the one hand, and between mobility and age on the other. Unlike conventional inequality decomposition, the use of nonparametric methods overcomes the problem of partitioning the age range in an arbitrary way, and it circumvents the problem arising from too few observations in an age group. We still draw heavily on previous work undertaken in this area, namely by PUDNEY (1993), who estimates nonparametrically age conditional inequality profiles for China, and by TREDE (1998) who estimates age conditional mobility profiles for earnings in Germany. We extend their approach by estimating nonparametrically the decomposition of inequality and mobility into their respective between and within components. The within component delivers age conditional inequality and mobility measures, which seems particularly convenient when carrying out cross-national or intertemporal comparisons, as different countries may exhibit different age structures or the age structure may change over time.

In this paper we carry out the following analysis:
- Total inequality and its between and within components are computed and compared for the years 1982 and 1992.
- Within-inequality profiles are constructed for these two years.

– Total mobility in the sense of inequality reduction, split into its between and within components, is computed and compared for the two periods 1980/82 and 1990/92.
– Within-mobility profiles are constructed for these two periods.
– Inequality and mobility are furthermore analyzed for two income concepts: i) market income, and ii) disposable income.

The interest in studying Swiss data stems from recent investigations carried out by Leu, Burri and Priester (1997), Burri (1998) and Ernst, Gerfin and Leu (2000). Leu et al. find that between 1982 and 1992 inequality increased significantly for the entire population. Burri analyzed a subpopulation aged 60 years and over, and found that inequality for this age group has significantly decreased within the decade spanning the early 80s and early 90s. Ernst et al., by contrast, conducted a comprehensive analysis by decomposing inequality into several of its possibly constituent factors. Their results suggest that the observed increase in inequality is due mainly to a rise of within inequality, particularly so for the age group of the 30 to 40 years old. The increase in the latter age group amounts to about 62 percent while inequality increased by only about 30 percent for the groups aged between 20 and 30, and between 40 and 50 years.

The purpose of this paper is twofold: Firstly we carry out a complementary analysis to the work by Ernst et al. by providing further facts about the increase of inequality in particular age groups. This also justifies our focus on persons in their prime working age. At an international level this paper fits into a series of papers documenting the trends and potential causes in income inequality over the last decade (Gottschalk and Smeeding 1997, 2000) in that we provide further evidence for the case of Switzerland. Secondly, this paper also provides an extension with regard to methodological issues. The introduction of nonparametric kernel density estimation techniques for measuring between and within inequality and mobility builds on work undertaken by Buchinsky and Hunt (1999). They have analyzed wage inequality and mobility in the US, and they have also investigated the respective within and between components, yet within an integer valued framework. Our approach differs from theirs by treating age as a continuous variable for the reasons mentioned above.

The remainder of this paper is organized as follows: The next section presents the data and its source. Section 3 presents the inequality and mobility measures used in this paper. Section 4 contains the results. In section 5 we conclude.

2. Data

The data used in this paper comes from two sources: The 1980/82 data is taken from the Swiss Income and Wealth Survey, and the 1990/92 data is from the Swiss National Poverty Study. Both datasets seem of particular interest because they do not rely on self-reported income, but were collected from official tax records. This means that reported incomes are very detailed and accurate for each household because they were filed for the income tax declarations. Both samples are stratified and need to be weighted to be representative. For the 1990/92 data in particular, low income households were systematically oversampled. Refer to Leu, Buhmann and Frey (1986) and Leu, Burri and Priester (1997) for a detailed description of the sampling designs.[1]

We distinguish two types of income in this paper: market income and disposable income. Market income thereby may be interpreted as measuring income opportunities, while disposable income rather reflects welfare. The two income concepts, of course, are not independent because the tax and transfer system may have (dis)-incentive effects on labor supply and savings decisions. As shown by Schwendener (1990) and Gerfin (1995), this theoretical consideration seems, however, of little practical relevance in the case of Switzerland. Even for married women they find hardly any significant effect of the tax and transfer system on their labor supply.

In defining the income concepts we follow the guidelines of the OECD (1995) report whenever possible. According to these guidelines market income is defined as:

Market Income =		Labor Earnings (before deduction of employee social security contributions)
	+	Gross Self-Employment Income
	+	Realized Wealth Income (excluding rents of owner-occupied housing)

Disposable income in turn is defined as:

Disposable Income =		Market Income
	+	Social Security Cash Transfers
	+	Universal Cash Transfers
	+	Social Assistance
	−	Direct Taxes
	−	Social Security Contributions

1 See also the Luxembourg Income Study homepage: http://www.lisproject.org.

Following these definitions, the difference between market and disposable income thus exactly corresponds to the extent of redistribution.

The datasets contain only Swiss residents aged between 22 and 61. Households reporting zero or negative income were eliminated. The basic entity of the analysis is the real equivalent income of the household head.[2] In order to account for household size we have employed the square root of the household size as the equivalence scale. The incomes were all converted into 1980 CHF using the CPI deflator.

The definition used here differs in one important aspect from the OECD guidelines because wage and salary income are reported net of social security contributions. The two main components of these contributions are old age and survivor insurance and pension fund contributions.[3] Imputing old age and survivor insurance payments does not pose a problem since they represent a fixed proportion of labor income and remained constant over the relevant time period. The situation is different with respect to pension fund contributions. These contributions vary across pension funds and pension schemes respectively, and as we lack the necessary information they cannot be imputed. Moreover, between 1982 and 1992 a change in the institutional setting occurred; while pension fund contributions were voluntary in 1982 they became mandatory as of 1985. The design of the Swiss pension fund system is such that there is a lower bound for earnings below which no contributions have to be made. Prior to 1985 individuals earning higher incomes were more likely to contribute to pension funds because pension plans often were provided by employers as part of fringe benefit packages. Unfortunately, no exact information is available about the age composition of those who contributed prior to 1985. In 1982 about 56 percent of the labor force were contributing to pension funds while membership amounted to almost 90 percent in 1992. It is therefore difficult to determine the distributional effect of this institutional change.

2 The reason for this choice is that we are able to control for the age of the household head only (we lack information about the age of the other household members). We are as well not interested in the income of the household head, but rather of the household.

3 Other components are unemployment insurance, accident and disability insurance. They all are fixed proportions of labor income.

3. Measurement of Inequality and Mobility

Income inequality typically is measured by pooling incomes of individuals with different ages for a particular year. Since income displays a substantial variation over the working life this neglects the effect resulting from individuals being at different stages of their working life. As the interest here lies on isolating the effect of age on income inequality, one somehow needs to partition the age range into groups. The traditional approach in tackling this problem consists in constructing discrete age groups and decomposing inequality into *within*-group and *between*-group inequality. The between-group inequality component subsequently is interpreted as resulting mainly from age effects – it reflects the change in inequality from differences in age. Within-group inequality, in turn, is interpreted as that part of income inequality that is purged of age effects.

This traditional method possesses a serious limitation. Formby et al. (1989) show that the results may be sensitive to the choice of the age group width. For if the age group width is specified too narrowly, the within-group sample size may drastically shrink and cause inaccurate and unreliable estimates. When specifying the age group too large, in turn, much information about the inequality-age relationship is concealed. This is where the use of nonparametric kernel density estimators comes into play. It provides smooth age profiles of inequality and thus removes the arbitrariness of the age range partition. The advantage of this method is that the choice of bandwidths is imposed by statistical theory and, consequently, does not rely on subjective *a priori* judgments as with the partition of the age range when employing a discrete inequality decomposition method.

In the following two sections we construct inequality and mobility measures based on nonparametric kernel density methods serving later on to compute within and between components of inequality and mobility. When constructing the measures for within-inequality and within-mobility we closely follow Pudney (1993) and Trede (1998) respectively.

3.1. Within and Between Inequality

In order to keep the presentation compact we focus here on the class of Generalized Entropy *(GE)* inequality measures only. A major disadvantage of the *GE*-index, by contrast for instance to the Atkinson index (Atkinson, 1970), is that it may not be derived and motivated within a welfare context. Nevertheless, this disadvantage is more than compensated by its highly convenient properties, namely that it is additive by population subgroups. Written in its conditional form the *GE*-index for age a is defined as

$$I_{\alpha}(f(y\,|\,a)) = \left(\frac{1}{\alpha^2 - \alpha}\right)\left\{\frac{\int y^{\alpha} f(y\,|\,a)dy}{\left(\int y\, f(y\,|\,a)dy\right)^{\alpha}} - 1\right\},\ \alpha \neq 0, 1. \tag{1}$$

where y denotes income and f is the density function. Notice, that any other continuous variable than age is conceivable within this setting. α is a parameter reflecting sensitivity towards changes in inequality at different incomes. The *GE*-index with $\alpha = 1$ leads to Theil's first inequality index written in its conditional form as

$$I_{\alpha=1}(f(y\,|\,a)) = \frac{\int y \log(y) f(y\,|\,a)dy}{\int y\, f(y\,|\,a)dy} - \log \int y\, f(y\,|\,a)dy. \tag{2}$$

And finally, the *GE*-index with $\alpha = 0$ leads to the Theil-*L* or the mean logarithmic deviation (MLD) measure

$$I_{\alpha=0}(f(y\,|\,a)) = \log \int y\, f(y\,|\,a)dy - \int \log(y) f(y\,|\,a)\, dy. \tag{3}$$

The *GE*-index encompasses transformations of inequality measures such as the Atkinson index and the coefficient of variation. For α = -0.5 the *GE*-index yields ordinally equivalent results to the Atkinson index with inequality aversion parameter $\varepsilon = 0.5$. The larger α becomes the more sensitive the *GE*-index is to variations of income at the upper part of the income distribution. For $\alpha = 2$ it is equal to half of the squared coefficient of variation. For $\alpha > 2$ it is no longer transfer sensitive, but becomes very sensitive to outliers at the upper tail of the distribution. Again this illustrates that the parameter α explicitly allows for different distributional value judgments. It remains to mention that the *GE*-index is greater than zero and attains zero when incomes are equally distributed. Contrary to the Atkinson index the *GE*-index is thus not bound to be smaller than 1. It, moreover, satisfies the standard restrictions of symmetry, mean-independence and the strong principle of transfers (see Jenkins, 1991 for further details).

Notice, that conditional inequality as computed in (1), (2), and (3) is equivalent to within inequality at each age. As mentioned previously, by contrast to most other inequality measures, the advantage of the *GE*-index consists in its additive decomposability. This means that total inequality is equal to the sum of between and within inequality, i. e.

$$I_\alpha = I_\alpha^w + I_\alpha^b.$$

The average within component may, similarly to the case where the age classes are integer valued, be obtained from

$$I_\alpha^w(f(y)) = \int f(a)\left(\frac{f(y\,|\,a)}{\int y\, f(y)dy}\right)^\alpha I_\alpha(f(y\,|\,a))da,\ \ \alpha \neq 0,1, \tag{4}$$

while the average between inequality component is obtained from

$$I_\alpha^b(f(y)) = \left(\frac{1}{\alpha^2-\alpha}\right)\left\{\int f(a)\left(\frac{f(y\,|\,a)}{\int y\, f(y\,|\,a)dy}\right)^\alpha da - 1\right\},\ \alpha \neq 0,1. \tag{5}$$

According to (4) and (5), the average within component is equal to the within inequality weighted by the age distribution and the conditional income distribution. The average between component, in turn, is equal to inequality between points on the income-age profile weighted by the age distribution. Similar expressions as those in (4) and (5) may be derived for $\alpha \to 1$ and $\alpha \to 0$.

3.2. Within and Between Mobility

Ideally, inequality should be measured in terms of permanent or life-time income. Due to data restrictions this is hardly ever possible. A valuable alternative therefore consists in computing mobility. An extensive overview of the literature and the different ways of conceptualizing mobility is given in ATKINSON, BOURGUIGNON and MORRISSON (1992). In order to assess mobility we use the measure first suggested by SHORROCKS (1978a) and further developed by MAASOUMI (1986) and MAASOUMI and ZANDVAKILI (1990). It builds on the inequality indices presented above and is defined in its conventional form as

$$M_\alpha = 1 - \frac{I_\alpha(f(y_A))}{\sum_{t=1}^{T} s_t I_\alpha(f(y_t))}. \tag{6}$$

y_A is aggregate income over the entire time horizon, y_t is income received in period t, s_t denotes its share of aggregate income and f again denotes the distribution.

In this context, mobility is understood as the relative degree of equalization as the time interval for measuring income inequality is expanded. Its interpretation is thus quite different from the mobility measures based on transition matrices as discussed for instance by Shorrocks (1978b). The basic idea behind it can best be understood when contemplating the above mobility measure. Assume a situation in which a simple permutation of the income vector over two periods occurs. A symmetric and anonymous inequality index would measure the same degree of inequality in both periods. However, when considering aggregate or permanent income the permutation will change the distribution of individual incomes and as a consequence inequality will change as well (unless there is perfect equality to begin with). More specifically, assume that incomes differ across individuals, but they follow the same trend, i. e. they grow at the same rate. Inequality measured at two points in time as well as inequality in aggregate income will then be identical, and hence complete immobility is observed ($M = 0$). By contrast, perfect mobility ($M = 1$) prevails whenever inequality in aggregate (or permanent) income attains zero, regardless of how large inequality is at some point in time. Since M lies between 0 and 1 it can directly be interpreted as the percentage change by which inequality in permanent or aggregate income is lower than the weighted sum of the single-year inequality. A high value of M signifies that inequality reduction is large when considering longer accounting periods, i. e transitory income fluctuations are smoothed out over time. For $M = 1$ mobility or inequality reduction is said to be *complete* and aggregate income over the accounting period is thus equally distributed.

It is interesting to notice that this mobility concept can as well be understood as a measure of income convergence. If we assume that there is a single long-run income path to which all incomes tend to converge, then we should observe a smaller inequality in aggregate or permanent income, regardless of transitory deviations from this long-run income trajectory. This is to say, that provided there is convergence, we should observe a smaller inequality in aggregate income in the long-run than in any period within the time horizon. Within this context it also seems worth mentioning that Shorrocks (1978a) explicitly motivates his mobility index in terms of the permanent income theory.

The derivation of within mobility is now straightforward. Following Trede (1998) one can substitute the conditional inequality measures (1), (2) or (3) for the unconditional inequality $I_\alpha(f(y))$ into (6) and assuming only two periods ($t = 1, 2$) this yields the function $M_\alpha(f(y|a))$ given by

$$M_\alpha(f(y\,|\,a)) = 1 - \frac{\mu_A I_\alpha(f(y_A\,|\,a))}{\mu_1\, I_\alpha(f(y_1\,|\,a)) + \mu_2\, I_\alpha(f(y_2\,|\,a))}, \tag{7}$$

where $\mu_k = \int y_k f(y_k\,|\,a) dy_k$, $k = \{1, 2, A\}$ is the respective average income. Conditioning occurs on age in period t.

In a similar way as with the inequality decomposition we may now decompose mobility. In a integer valued setting this has first been suggested by BUCHINSKY and HUNT (1999). They show that total mobility can be written as the weighted sum of between and within mobility:

$$M_\alpha = M_\alpha^w \phi^w + M_\alpha^b \phi^b.$$

The respective mobility components M_α^w and M_α^b are defined as follows:

$$M_\alpha^w = \left\{1 - \frac{I_\alpha^w(f(y_A))}{\sum_{t=1}^T s_t\, I_\alpha^w(f(y_t))}\right\}, \text{ and} \tag{8}$$

$$M_\alpha^b = \left\{1 - \frac{I_\alpha^b(f(y_A))}{\sum_{t=1}^T s_t\, I_\alpha^b(f(y_t))}\right\}. \tag{9}$$

The weights ϕ^w and ϕ^b reflect the relative importance of within and between inequality reduction in total mobility. They are defined as:

$$\phi^w = \frac{\sum_{t=1}^T s_t\, I_\alpha^w(f(y_t))}{\sum_{t=1}^T s_t\, I_\alpha(f(y_t))} \text{ and}$$

$$\phi^b = \frac{\sum_{t=1}^T s_t\, I_\alpha^b(f(y_t))}{\sum_{t=1}^T s_t\, I_\alpha(f(y_t))}\,.$$

Within mobility is interpreted as the average degree of inequality reduction at all points of the income-age profile while the between mobility is interpreted as the average degree of inequality reduction between all points of the income-

age profile. If the income-age profile was flat for the two periods, the between mobility component would be zero and total mobility would be equal to within mobility. Between mobility thus gives the returns to age over the accounting period and it also gives an indication about the change in the concavity of the income-age profile over time.

3.3. Estimation

To motivate the estimation procedure, we rewrite the definitions (1), (2) and (3) as in Pudney (1993) or Gerfin (1994) in terms of the expectation operator E, which leads to

$$I_\alpha(f(y\,|\,a)) = \left(\frac{1}{\alpha^2-\alpha}\right)\left\{\frac{E[y^\alpha\,|\,a]}{E[y\,|\,a]^\alpha}-1\right\},\quad \alpha\neq 0,1, \tag{10}$$

$$I_{\alpha=1}(f(y\,|\,a)) = \frac{E[y\log(y)\,|\,a]}{E[y\,|\,a]} - \log(E[y\,|\,a])\ , \tag{11}$$

and

$$I_{\alpha=0}(f(y\,|\,a)) = \log(E[y\,|\,a]) - E[\log(y)\,|\,a]\ . \tag{12}$$

This reformulation suggests to interpret the terms $E[y|a]$ as well as the raw moments $E[y^\alpha|a]$ in (10), $E[y\log(y)|a]$ in (11), and $E[\log(y)|a]$ in (12) as regression functions. These regression functions are estimated nonparametrically by the WARP algorithm (Weighted Average of Rounded Points) described for instance in Härdle (1990) and Härdle and Scott (1992). The WARP algorithm is particularly well-suited for large datasets demanding a high computational effort. It requires the data being discretized into bins. The estimation is then carried out with the binned data instead of the original response variables. Refer to the Appendix for a detailed derivation of the simple Nadarya-Watson regression estimator $E[y|a]$ serving as the basis for estimating the above raw moments.

Once the regression estimates are obtained they may be substituted into the formulas of the inequality and mobility indices as well as into the decomposition formulas.

Standard central limit theorems unfortunately cannot be applied to the above expressions because they involve ratios of kernel density estimates. Inference is

therefore carried out by naive bootstrapping (HÄRDLE, 1990). In this way we obtain pointwise as well as simultaneous confidence bands for the inequality and mobility profiles (see as well TREDE, 1998). Since both variables, age and income, are random, resampling can be done from the original data pairs. In the present case we have replicated the estimates a 150 times for each profile we report results of, and we have calculated the 95 percent confidence interval. In order to keep the graphs legible we do not include the confidence bands in each graph and where we include them we consider only the pointwise confidence interval.[4]

4. Results

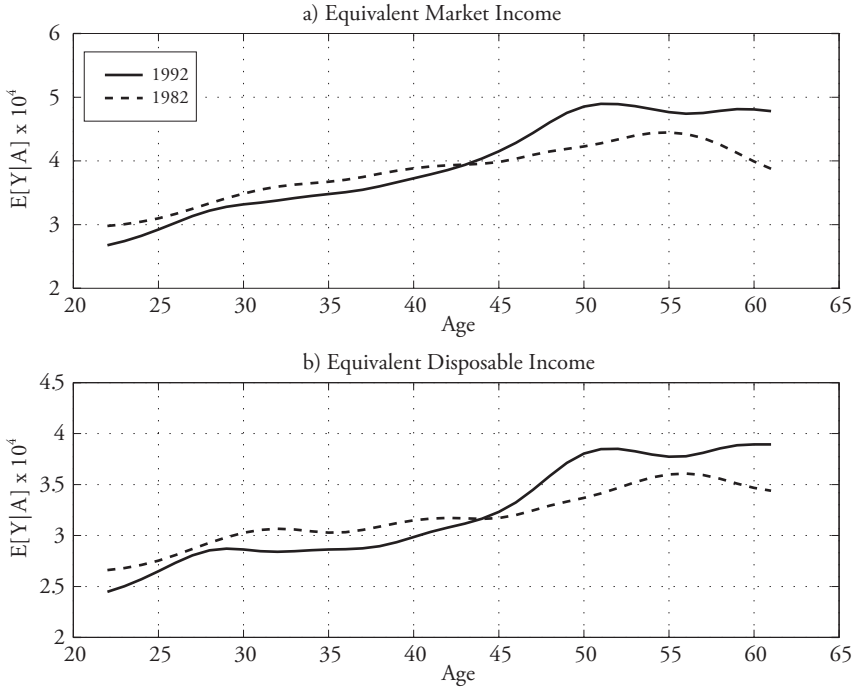
Table 1 in a first step reports some summary measures. One can see that mean income increased by roughly 6 percent between 1982 and 1992. Median income, in turn, grew by about 4 percent. Since the income distribution is skewed this signifies that income growth was biased towards higher incomes. Inequality measured by the traditional Gini-index increased by 8 and 7 percent for market and disposable income respectively.

Table 1: Summary Measures for Real Equivalent Income

	Market Income			Disposable Income		
	1982	1992	Change [%]	1982	1992	Change [%]
# Observation	3923	3767		3923	3767	
Mean [CHF]	37'936	40'270	6.2	31'641	33'440	5.7
Median [CHF]	34'472	35'744	3.7	29'809	30'869	3.6
Mean/ Median	1.10	1.13	2.7	1.06	1.08	2.1
Gini	295	319	8.1	241	258	6.9

4 A short MATLAB code documentation, describing the implementation of these formulas, is available from the author upon request.

Figure 1: Regression of Real Equivalent Income on Age



4.1. Regression Estimates

Figure 1 plots the nonparametric regression of real equivalent income on age, $E[y \mid a]$, for market income and disposable income in 1982 and 1992. Up to the age of about 44 the regression profile of the 1982 income distribution lies above that of the 1992 distribution, the gap is yet statistically insignificant.[5] A striking difference is the relatively steeper increase between the age of 40 and 50 years in 1992. The regression profile of 1982 exhibits a maximum at the age of 56 years while the 1992 profile reaches a local maximum almost five years earlier. This latter difference is statistically significant. It points to a changed return to age and may be indicative

5 By statistically not significant we mean that the confidence bands are overlapping. Normally we have looked at both types of confidence bands. Clearly the pointwise confidence interval is less restrictive than the simultaneous confidence interval (see Trede, 1998 for a discussion).

of some cohort or time effects. Interestingly, these regressions confirm that income growth occurred mainly at the upper tail of the income distribution.

The steeper increase of income between the age of 40 and 50 years of the 1992 regression profile may be explained by some mutually not necessarily exclusive reasons: When discussing the data we have indicated to a potential problem arising if comparing income levels between the early 80s and 90s due to the changed institutional setting with regard to pension fund membership. Since incomes are reported net of these contributions this may be one reason for the observed pattern of income. We believe, however, that this typical time effect due to a policy change is by far not the sole reason for the different shape of the regression profile. The change may as well result from a complicated set of other forces. The most likely causes in our view are a change in the skill composition of the labor force, changes in the returns to capital, an increased labor force participation rate of women, and possibly as well demographic shifts within the labor force. However, with our method we are unfortunately unable to substantiate these hypothetical influences. The situation with respect to the business cycle, in turn, was almost identical in the early 80s compared to the early 90s.[6]

4.2. Inequality

4.2.1. Within-Inequality Profiles

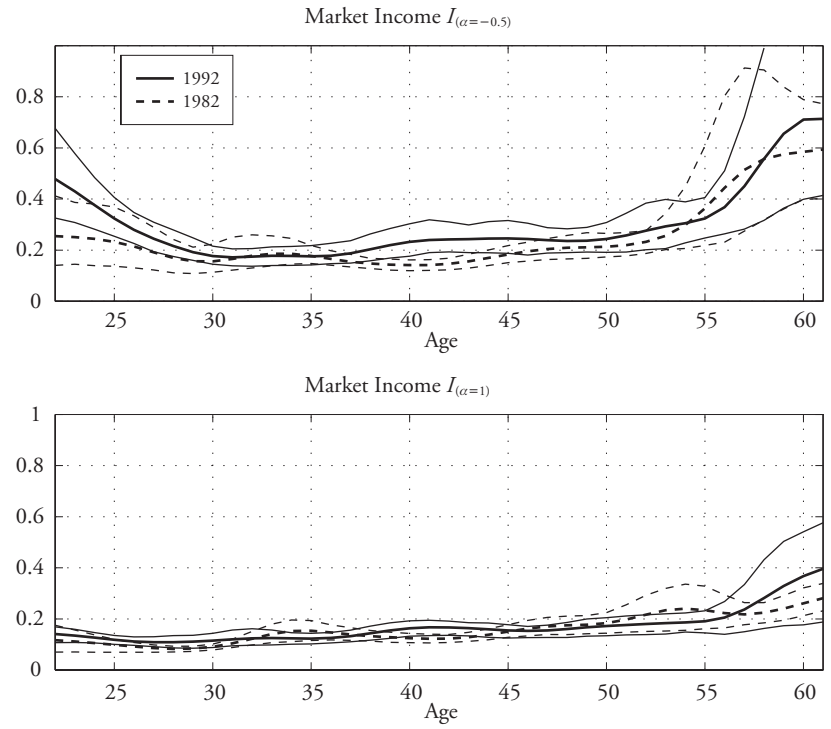
Figures 2 and 3 contrast the within-inequality profiles for 1982 and 1992 for two different values of the inequality aversion parameter α.[7] The different values of α mainly manifest themselves in a level effect. The $GE_{\alpha=1}$ is considerably smaller over the entire age range than the *GE*-index more sensitive to variations of incomes at the lower end of the distribution ($GE_{\alpha=-0.5}$).

As far as market income is concerned, the low income sensitive measure displays a quite pronounced U-shaped profile. It declines to a minimum at the age of about 32 years, remains almost constant up to the age of 50 years, and increases thereafter. The rather high income sensitive *GE*-index seems smallest in early adulthood, moves slightly upwards and also starts to increases at the

6 The unemployment rate was 0.4 percent in 1982. In the course of the recession of the early 80s it increased to 1.1 percent in 1984 and subsequently fell again to 0.6 percent in 1990. At the beginning of the 90s it increased rapidly. In 1992 the unemployment rate was 2.5 percent. It is indeed interesting to notice that both years, 1982 and 1992, were quite similar with respect to the business cycle. Real GDP growth turned negative in both years (-0.9 percent in 1982 and -0.4 percent in 1992). Both years were thus on a brink of a recessional period.

7 Due to space restrictions we do not report the age profiles for the $GE_{\alpha=0}$ (Theil).

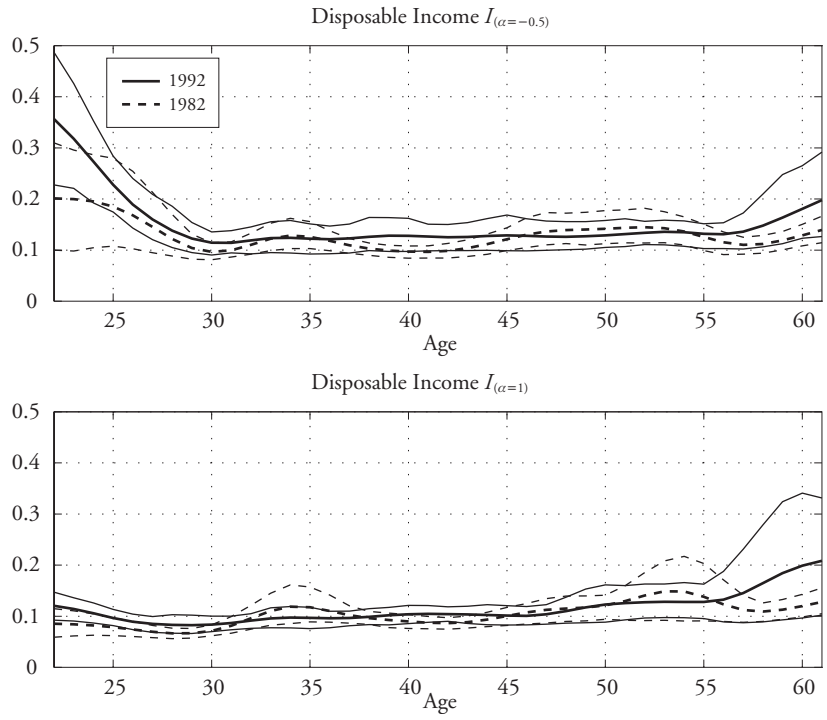
Figure 2: Inequality-Age Profile for Market Income with pointwise confidence bands (Within-group Inequality)



age of approximately 55 years. When comparing the profile of 1982 with that of 1992, significant differences are observed over the age between about 37 and 47 years only. The confidence bands, moreover, are sufficiently narrow to assert that inequality increases significantly with age.

The pattern looks different when considering disposable income. Still, a pronounced level effect is present, but apart from that the profiles are almost completely flat over a wide age range and hardly differ in a significant way in both years. Inequality is, however, still large up to the age of 30 years for the rather low income sensitive *GE*-index. As well, according to the point estimates, inequality is increasing towards the end of the working life. This applies particularly so for the 1992 profile. Moreover, we also find an increase in inequality between the age of 37 and approximately 47 between the 80s and 90s for the low-income sensitive *GE*-index.

Figure 3: Inequality-Age Profile for Disposable Income with pointwise confidence bands (Within-group Inequality)



4.2.2. Inequality Decomposition

Table 2 reports the inequality decomposition for equivalent market and disposable income. Considering first market income, one can see that total inequality increased by 10 to 15 percent between 1982 and 1992. Between inequality more than doubled over these ten years. Its relative contribution to total inequality increased as well by a factor of almost two.

Considering disposable income, we find a quite similar pattern as for market income. The share of total inequality explained by the between component varies between 2 and 3 percent in 1982 compared to 5 and 7 percent in 1992. The overall increase in total inequality varies between 12 and 16 percent.

Table 2: Inequality Decomposition

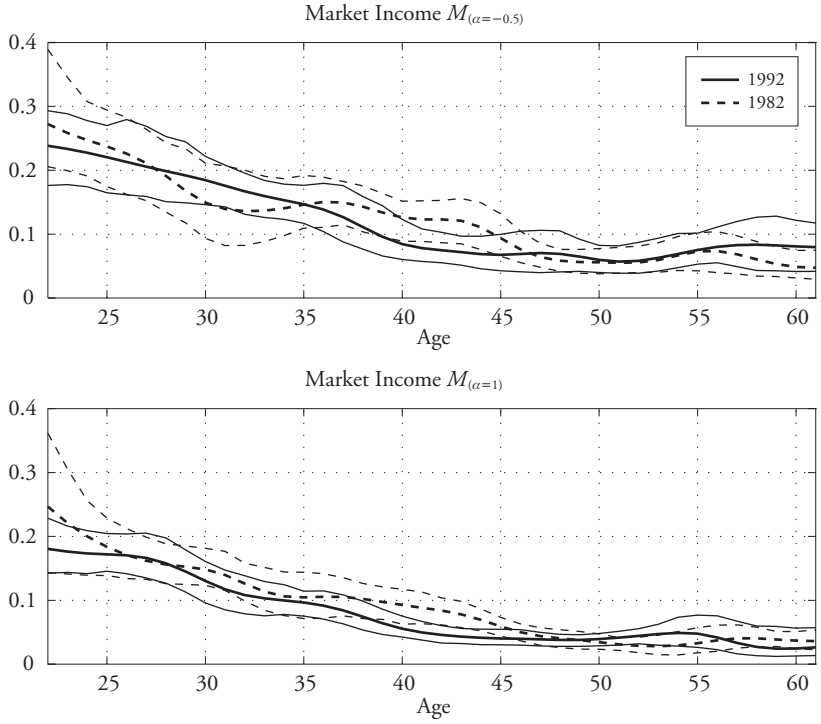
		Market Income			Disposable Income		
		1982	1992	Change [%]	1982	1992	Change [%]
$I_{\alpha=-0.5}$	Between	5.58	13.32	138.7	2.86	8.51	197.6
		1.28	*2.18*		*0.78*	*1.55*	
		(2.28)	(4.64)		(2.17)	(5.65)	
	Within	245.18	274.02	11.8	128.81	142.07	10.3
		22.55	*21.78*		*10.13*	*7.88*	
		(97.72)	(95.36)		(97.83)	(94.35)	
	Total	250.76	287.34	14.6	131.67	150.57	14.4
		22.82	*22.10*		*10.37*	*8.32*	
		(100.00)	(100.00)		(100.00)	(100.00)	
$I_{\alpha=0}$ (Theil-*L*)	Between	5.72	13.29	132.3	3.05	8.64	183.2
		1.20	*2.34*		*0.60*	*1.48*	
		(3.15)	(6.68)		(2.73)	(6.87)	
	Within	176.04	185.70	5.5	108.76	117.05	7.6
		8.73	*8.56*		*4.87*	*5.51*	
		(96.85)	(93.32)		(97.27)	(93.13)	
	Total	181.76	198.99	9.5	111.81	125.69	12.4
		9.09	*9.79*		*5.06*	*6.23*	
		(100.00)	(100.00)		(100.00)	(100.00)	
$I_{\alpha=1}$ (Theil)	Between	6.02	13.33	121.4	3.44	8.93	159.6
		1.10	*2.43*		*0.82*	*1.71*	
		(3.63)	(7.12)		(3.22)	(7.21)	
	Within	159.78	173.88	8.8	103.36	114.85	11.1
		10.11	*15.74*		*6.90*	*10.34*	
		(96.37)	(92.88)		(96.78)	(92.79)	
	Total	165.80	187.21	12.9	106.80	123.78	15.9
		10.65	*17.22*		*7.26*	*11.63*	
		(100.00)	(100.00)		(100.00)	(100.00)	

Note: Own calculations. The first line returns the inequality measure; the second line its bootstrap standard error (italic); the third line shows the share in total inequality (in brackets).

The increase in total inequality for disposable income between 1982 and 1992 is almost equal to that in market income. With regard to the inequality level we note, however, that it is nearly twice as high for market income than for disposable income.

Inequality is usually larger when measured by the low-income sensitive *GE*-index and the *GE* with $\alpha = 1$. However, when considering the standard errors none of these differences between the period 1982 and 1992 are statistically different from zero.

Figure 4: Mobility-Age Profile for Market Income with pointwise confidence bands (Within-group Mobility)



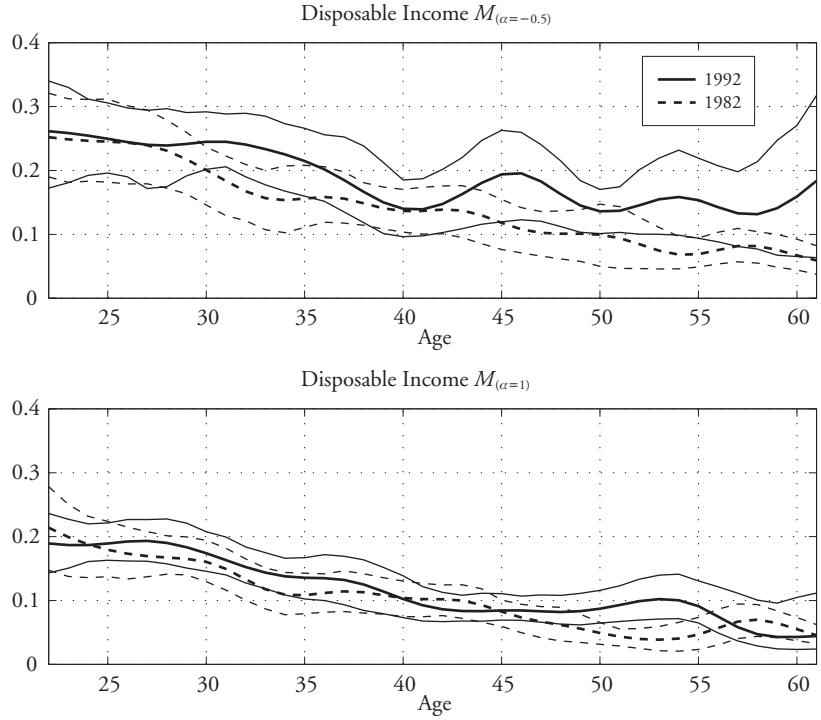
4.3. Mobility

4.3.1. Within Mobility Profiles

The effect of age on mobility is shown in Figures 4 and 5, which plot profiles for equivalent market and disposable income for different values of the inequality aversion parameter.

We can first see that inequality reduction significantly decreases with age. Consequently equalization does not occur at an uniform rate at all points of the

Figure 5: Mobility-Age Profile for Disposable Income with pointwise confidence bands (Within-group Mobility)



age distribution. This also means that income inequality measured at younger ages is less persistent than income inequality measured at higher ages. At least for market income the profiles do not seem to be sensitive with respect to the choice of the inequality aversion parameter. Inequality in aggregate income is lower by 20 to 25 percent than inequality in the average single-year income for the young adults, whereas for the elderly it is lower by only about 5 percent. The point estimates also reveal that mobility between the age of 35 and 45 years is smaller in the 90s than in the 80s. However, this pattern is statistically insignificant as almost all confidence bands of the profiles are overlapping.

A similar pattern as for market income is found for disposable income. An exception to this is the mobility profile for disposable income and the $GE_{\alpha=-0.5}$. In this particular case, mobility exhibits considerable variation in the 1990/92 period over the entire age range. Even though some of this variation might be

due to sampling errors, inequality reduction remains at a high level and almost never drops below 15 percent. The confidence bands are also sufficiently narrow to assign statistical significance to this pattern. This is to say, that at least 15 percent of inequality in the average single-year disposable income is smoothed out when considering aggregate income over a two year period.

4.3.2. Mobility Decomposition

The results of the mobility decomposition are reported in Table 3. We find that overall mobility displays a large variation depending on which income distribution is analyzed and which measure is employed. The range of total mobility over the two years reaches from 5 to 18 percent. This is to say that inequality in aggregate income over two years is at most 18 percent lower than the average single-year inequality.

Considering first market income it is revealed that over the period 1980/82 the between mobility component explains between 4 and 6 percent of total inequality reduction by contrast to 5 to 8 percent in 1990/92. Between mobility is considerably smaller for the period 1990/92 than the decade earlier. Total inequality reduction varies between 7 and 11 percent for the period 1980/82 while it varies between 5 and 11 percent over the 1990/92 period. Comparing levels of mobility, total inequality reduction has declined by about 1.5 percent ($GE_{\alpha=-0.5}$) and almost 25 percent ($GE_{\alpha=1}$). This decline is mainly driven by a decreased between mobility, which means that inequality between age groups has become more persistent in the period 1990/92 compared to the period 1980/82.

Turning next to disposable income, one as well observes substantial changes in the contribution of between mobility to total mobility. While between mobility explained 4 to 5.5 percent of total inequality reduction over the period 1980/82 it explains 6 to 8 percent over the period 1990/92. Total inequality reduction varies between 9 and 15 percent in the 1980/82 period; it varies between 9 and 18 percent in the 1990/92 period. Mobility also seems higher when measured by the rather bottom sensitive *GE*-index. Comparing levels for the 1980/82 and the 1990/92 period reveals that between mobility has decreased significantly while within mobility has increased.

Total mobility has declined for market income, but at the same time it has increased for disposable income. Moreover, inequality reduction for market income is everywhere almost a third lower than for disposable income. This clearly implies that inequality in market income is more persistent than inequality in disposable income.

Table 3: Mobility Decomposition

		Market Income			Disposable Income		
		1982	1992	Change [%]	1982	1992	Change [%]
$M_{\alpha=-0.5}$	Between	5.15 *1.50* (3.65)	1.49 *0.44* (5.31)	-71.1	7.17 *2.15* (4.02)	1.96 *0.67* (6.65)	-72.7
	Within	11.04 *1.05* (96.35)	11.19 *0.81* (94.69)	1.4	15.11 *1.24* (95.98)	19.31 *1.38* (93.35)	27.8
	Total	10.84 *1.00* (100.00)	10.68 *0.78* (100.00)	-1.5	14.81 *1.20* (100.00)	18.23 *1.33* (100.00)	23.1
$M_{\alpha=0}$	Between	4.79 *1.46* (5.29)	1.26 *0.39* (8.00)	-73.7	6.61 *1.49* (5.05)	1.71 *0.53* (7.94)	-74.1
	Within	8.99 *0.66* (94.71)	8.63 *0.65* (92.00)	-4.0	11.63 *0.72* (94.95)	14.39 *1.03* (92.06)	23.7
	Total	8.79 *0.65* (100.00)	8.08 *0.62* (100.00)	-8.1	11.42 *0.70* (100.00)	13.45 *1.01* (100.00)	17.8
$M_{\alpha=1}$	Between	4.21 *1.30* (5.75)	0.93 *0.33* (8.24)	-77.9	5.66 *1.44* (5.44)	1.30 *0.43* (8.07)	-77.0
	Within	7.12 *0.66* (94.25)	5.65 *0.61* (91.76)	-20.6	9.11 *0.77* (94.56)	9.92 *1.04* (91.93)	8.9
	Total	6.98 *0.64* (100.00)	5.29 *0.57* (100.00)	-24.2	8.95 *0.76* (100.00)	9.27 *0.99* (100.00)	3.6

Note: Own calculations. The first line returns the mobility measure; the second line its bootstrap standard error (italic); the third line shows the share ϕ in total mobility (in brackets).

4.3.3. Summary

Summarizing the results so far reveals the following points:

- Mean income increased by about two percentage points more than median income between 1982 and 1992 indicating that income growth was biased towards higher incomes. This finding is confirmed by the regression profile of income on age, where we observe a larger income increase at the upper tail of the distribution. This applies to market as well as to disposable income.
- Total inequality has significantly increased for both market and disposable income. The increase varies between 10 and 15 percent for market income and between 12 and 16 percent for disposable income. The increase seems most pronounced at the tails of the income distribution.
- Inequality in disposable income is considerably smaller than inequality in market income. Inequality in disposable income amounts to between 50 and at most 75 percent of inequality in market income.
- The main contribution to the inequality increase comes from between inequality. Its share in total inequality more than doubled between 1982 and 1992.
- Within inequality is larger at both ends of the age range when evaluated with the *GE*-index rather sensitive to income variations at the lower end of the income distribution. Evaluated by the rather middle to high income sensitive *GE*-index, inequality is largest at the upper age range only.
- The increase in inequality towards retirement age is generally associated with a decreasing inequality reduction. This indicates that income inequality among the elderly tends to be more persistent than for the younger household heads. This feature is observed for the 80s as well as for the 90s and for market income and disposable income.
- Inequality reduction over most of the age range is larger for disposable income than for market income; the difference amounts to approximately 5 percentage points.
- The mobility profile for disposable income decreases less rapidly with age than for market income. The mobility profile for equivalent market income declines up to the age of about 40 years and then remains rather flat on a level of 5 percent. By contrast, the 5 percent level is reached only at the very end of the working life when disposable income is considered.
- Mobility or inequality reduction has generally decreased for market income while it increased for disposable income. This means that inequality in market income has become more persistent between the early 80s and the early 90s.

The main contribution to the increased total mobility in disposable income comes from within inequality reduction.
– The higher between inequality is exacerbated by a decrease of the between mobility. As a main reason for the change in the income profile we identify the emergence of cohort and time effects. The underlying forces giving rise to these effects, yet, remain unclear.

The most important finding is that mobility in disposable income has increased considerably between the early 80s and 90s. Moreover, we find the largest increase at the lower end of the distribution. Contrasting this with the decline of mobility in market income suggests that redistribution seems to work in the intended direction. This is to say that the increased inequality in opportunities is to some extent compensated by a more equal distribution of disposable income. Nevertheless, we also find that between inequality has increased for both types of income and that at the same time mobility decreased. This suggests that inequality between age groups has become more persistent.

Our results with regard to inequality within different age groups conform with those obtained by Ernst et al. (2000). They also find a considerable increase in income inequality for the age group of the 30 to 40 years old. We may add that our results suggest an increase mainly in the age group of the 37 to 47 years old persons. Ernst et al., moreover, show that inequality seems to have increased most at the lower tail of the income distribution which is confirmed by our results. According to our results, inequality reduction is as well largest at the lower tail of the income distribution. This means that inequality reduction is largest for younger household heads.

5. Conclusion

This paper investigates income inequality and mobility for the prime-age working population of Switzerland in the early 80s and the early 90s. Previous studies concentrated on a static analysis of inequality, but such an approach tends to overstate inequality because dynamic aspects of the income distribution are neglected. We focus on disentangling two factors related to the income dynamics. These factors are life-cycle effects and short-term deviations from the life-cycle earnings profile. Life-cycle effects are isolated by conditioning inequality on age. Short-term deviations in turn are studied by means of age conditional mobility. The inequality as well as the mobility measures are estimated by non-parametric kernel density methods.

Two income distributions are analyzed: market income and disposable income. The definitions by and large conform with those in the OECD (1995) report. Equivalent income has been computed by adjusting household income for household size.

This paper provides further evidence about the trend of inequality and mobility as found in other industrialized countries, namely that inequality in market and disposable income has increased over the last decade. In the case of Switzerland income growth of the prime age population has been biased towards higher incomes. This applies for market as well as for disposable income. We also find that mobility in the sense of inequality reduction has decreased for market income while it increased for disposable income. This means that inequality in market income is more persistent than inequality in disposable income. We have asserted that market income may be understood as a measure of income opportunities while disposable income should be seen as a welfare measure. Inequality in income opportunities thus seem to have increased between the 80s and 90s. This trend, however, has been largely compensated by the increased mobility in disposable income over the same period.

Appendix: The WARP Algorithm

Taking our bivariate dataset consisting of age and income we have formed an equally spaced grid along the age axis. The bin width b is chosen to be one, which seems natural as the age data are reported as integer values.[8] This results in an equally spaced vector of bin margins B_j. The bin centers a_j are also set at integer values. In a next step, "bin averages" for income of the form

$$\overline{y}_j = avg\{y_i : i \in B_j\} \text{ for } i = 1, \ldots, n \text{ and } j = 1, \ldots, g$$

are obtained as well as the bin counts

$$c_j = \#\{a_i : i \in B_j\} = \#(B_j)$$

assigned to the bin centers. A further simplification yielding a reduction of computer time is achieved when noting that the bin width is actually independent of j,

8 There is of course a trade-off involved between speed of the estimation algorithm and its accuracy depending on the choice of the binwidth. Small binwidths slow down the algorithm but are more accurate and vice versa.

that is, $\Delta = a_j - a_{j-1}$ and therefore we can write $a_j - a_{j-k} = k\Delta$ (Fan and Marron, 1994). The simple Nadaraya-Watson regression estimator is then obtained as

$$E[y \mid a] = \frac{\sum_{j=1}^{g} K(\Delta(j' - j))c_j \, \bar{y}_j}{\sum_{j=1}^{g} K(\Delta(j' - j)c_j} \tag{A1}$$

where K is the Gaussian kernel function and Δ is defined as gb/h. Calculating the discrete convolution in (A1) becomes a matter of seconds, by contrast to several minutes if each kernel is evaluated separately.

The smoothing parameter h is set according to the normal scale rule derived by Silverman (1986), with $h = 1.06\sigma n^{(-1/5)}$, where n is the sample size and σ the standard deviation.[9] Silverman shows that this delivers asymptotically minimum integrated mean squared errors for standard normal densities. We have not attempted to control for the sensitivity of our estimates with regard to the choice of h. It remains to be noted that the WARP algorithm allows an easy incorporation of sampling weights by appropriately adjusting the bin counts c_j.

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9 This normal scale rule remains valid when computing regression profiles, since the assumption of normality refers to the distribution of observations orthogonal to the regression profiles and not to the shape of the profiles itself.

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SUMMARY

This paper investigates income inequality and mobility for the prime age working population of Switzerland in the early 80s and 90s. The empirical methods applied are based on nonparametric kernel density estimation. Mobility is interpreted here in terms of inequality reduction when the accounting period for income is extended.

We find that income inequality increased between the early 80s and early 90s. The computation of within inequality reveals that age explains a significant fraction of total inequality. An important component of inequality is due to short-term deviations from the long-run income profile. Mobility in the sense of inequality reduction has declined for market income, but in turn increased for disposable income.

ZUSAMMENFASSUNG

In diesem Aufsatz wird die Entwicklung der Einkommensungleichheit und der Einkommensmobilität der erwerbstätigen Bevölkerung zwischen den 80er und 90er Jahren untersucht. Die empirischen Methoden basieren auf nicht-parametrischen Kerndichteschätzungen. Mobilität wird hier als das Ausmass der Ungleichheitsreduktion interpretiert, wenn der Beobachtungszeitraum ausgedehnt wird.

Die Ergebnisse dokumentieren, dass die Ungleichheit zwischen der frühern 80er und 90er Jahren zugenommen hat. Dabei zeigt sich, dass das Alter einen signifikanten Anteil der Gesamtungleichheit erklärt. Die Mobilität im Sinne

einer Ungleichheitsverminderung ist zwischen den 80er und 90er Jahren für das Markteinkommen des Haushaltes zurückgegangen, während sie für das verfügbare Einkommen leicht zugenommen hat.

RÉSUMÉ

L'analyse porte sur l'évolution des inégalités de revenu et de la mobilité des revenus de la population active entre les années 80 et 90. Les méthodes empiriques utilisées recourent à des estimations non paramétriques. Dans ce contexte, la mobilité est interprétée comme la mesure de la réduction des inégalités lorsque la période d'observation est prolongée.

Il ressort de l'analyse que les inégalités de revenu se sont creusées entre le début des années 80 et les années 90. Le calcul des inégalités en fonction de l'âge fait apparaître que cette variable explique une proportion significative des inégalités observées. Entre les années 80 et les années 90, la mobilité au sens d'une réduction des inégalités sur le temps long a diminué pour le revenu de marché des ménages, tandis que la mobilité pour le revenu disponible a légèrement augmenté.