Income Inequality in Côte d'Ivoire: 1985-2014

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Abstract

Data on income/consumption distributions in Sub-Saharan Africa have been mainly used to study the welfare of the poorest. Yet, the rapid growth experienced by several countries in the last decades has drawn the attention towards higher earnings groups in the income/consumption distributions. However, due to under-reporting and non-response, surveys often fail to accurately measure the income of the wealthiest. Little is known about the size of such biases as it requires to have access to more reliable sources of information. In this paper we confront the 2014-2015 household survey with first-hand income tax files in the case of Côte d'Ivoire, 2014. We first identify, within the survey, a sub-sample corresponding to the one for which we have fiscal data. Comparing the earning distribution of this sub-sample with the one extrapolated from the fiscal data, we are able to measure the magnitude and the distribution of the bias among top earners in the survey. We then use this estimation to adjust the pre-tax and pre-transfer income distribution of the entire survey sample and thus recover corrected nationally representative inequality statistics. Our results show that the 2014-2015 survey significantly underestimates income inequalities. After our correction, the top 1 % share increases from 11.57 % to 17.15 %, the top 10 % share from 40.34 % to 48.28 %, and the Gini coefficient from 0.53 to 0.59. We compare our estimates with more commonly used consumption inequality measures and discuss the potential sources of differences. Making the assumption that the bias is constant over time for a given level of income, we also extend our correction to previous surveys. After correction, top 1 % shares increase by 5-6 percentage points, top 10 % shares by 7-8 percentage points and Gini coefficients increase by 6 points, making Côte d'Ivoire's inequality levels comparable to that of the US.

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1 Introduction

Since the large decrease in poverty rates in South and East Asia in the 1990s, Sub-Saharan Africa has become the poorest region in the world. Its absolute poverty rate is still about 43 % while in the developing world as a whole it is now below 20 % (Beegle et al., 2016). Perhaps not surprisingly, research on income and consumption distribution in this region has mainly focused on the living standards of the poorest.

Nevertheless, in the recent decades, several African countries experienced very high growth rates, making Sub-Saharan Africa the fastest growing region since the 2000s. Regional poverty rate has decreased by about 15 percentage points between 1999 and 2012 (Beegle et al., 2016). In Ncube et al. (2011) the African Bank of Development advocated that a substantial middle class was emerging and, as anecdotal as it may be, Forbes identified 50 Africans with a wealth superior or equal to $ 400 millions in 2013. More attention is

now given to higher income groups, but robust evidence about the dynamics of income distribution and the level of income concentration remains scarce.

One major limitation to properly study inequalities in African countries is the availability of reliable data. With the exception of South Africa (Alvaredo and Atkinson, 2010), and Mauritius (Atkinson, 2011), all studies on the recent decades rely on survey data only. While appropriate to measure consumption level at the bottom/middle of the distribution, survey instruments are likely to suffer from under-reporting and non-response biases at very high income levels (Deaton, 2005). A reliable way to remedy such measurement issues is to use administrative fiscal data (see Atkinson and Piketty (2007) for related methodological issues). Thus, comparing fiscal and survey estimates in Colombia, Alvaredo and Londoño (2013) find that survey data underestimated top 1 % income share by about 5 to 6.5 percentage points over the period 2007-2010. Unfortunately, fiscal sources are by definition incomplete as they provide information only about individual paying taxes. This feature is particularly problematic in Sub-Saharan countries where the tax base often represents less than 10 % of the working age population.

In this paper, we combine the 2014 wage tax data with the 2014-2015 household survey in Côte d'Ivoire, to compute corrected and nationally representative inequality statistics. First we identify a sub-sample, within the survey, corresponding to the population for which we also have administrative data. Comparing the distribution of their wages to the distribution we can extract from our fiscal source allows us to measure the magnitude of the survey bias due to under-reporting and/or non-response. Assuming under-estimation rate is a function of income level only, then we exploit this information to adjust the distribution of wages and other types of income across the entire population in the survey.

2 Comparing Fiscal and Survey Data

2.1 Fiscal Data

Our income tax data was compiled by the Direction générale des impôts in Côte d'Ivoire. It consists of tabulations describing the distribution of wages within two sectors : the **public sector** (180,669 individuals) and **the formal private sector**, i.e all wage earners working for companies registered to the social security institute Caisse Nationale de Prévoyance Sociale (180,503 individuals).

Individuals are grouped into 34 different wage brackets ranging from "less than 1,000,000 FCFA" (€1,520) to "more than 200,000,000 FCFA"(€304,000). For each bracket and by sector, the data reports the total number of individuals whose *gross yearly wage* fall into the brackets, as well as their average wage (see column (1) and (4), (5) of Table 1). Throughout the paper, we will consider that, by convention, an individual belongs

to the **formal Sector** if she belongs to either of the aforementioned categories, namely, if she pays wage tax.

The formal sector forms a very unequal group, with a rather concentrated public sector and private wages reaching levels comparable to top earnings in developed countries (see Table 1). For instance : in 2014 the threshold to enter the top 1 % of the wage distribution in France (full-time equivalent, net of withholding taxes) was €97,956. [1]. From our fiscal data we can estimate that about 0,3 % of the individuals working in the formal sector (i.e ≈ 1,100 individuals) earned more than this in Côte d'Ivoire.

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[1]see https://www.insee.fr/

Table 1: Distributional Statistics from Fiscal Data

Wage Brackets (in FCFA)	Formal Sector (Public + Private)					Decomposing by sector			
	Population	Pop. Share	Wage Share	Average		Pop. Share		Wage Share	
				Euros	$PPP 2011	public	private	public	private
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Below 1	50,227	13.90	2.55	1,098	2,929	0.651	13.25	0.128	2.43
1 - 2	76,121	21.07	7.67	2,172	5,793	6.66	14.40	2.44	5.22
2 - 3	75,177	20.81	12.52	3,592	9,576	14.41	6.39	8.51	4.00
3 - 4	71,470	19.78	17.11	5,163	13,766	16.25	3.52	14.00	3.11
4 - 5	31,729	8.78	10.13	6,888	18,365	6.39	2.38	7.40	2.73
5 - 6	13,032	3.60	5.07	8,390	22,369	1.86	1.74	2.63	2.43
6 - 7	12,647	3.50	5.86	10,004	26,674	2.15	1.34	3.63	2.23
7 - 8	5,481	1.51	2.91	11,454	30,540	0.471	1.04	0.915	1.99
8 - 9	4,833	1.33	2.88	12,862	34,293	0.542	0.795	1.16	1.72
9 - 10	2,381	0.659	1.59	14,429	38,470	0.067	0.591	0.159	1.43
10 - 15	7,537	2.08	6.47	18,521	49,381	0.353	1.73	1.09	5.37
15 - 20	3,995	1.10	4.96	26,774	71,384	0.053	1.05	0.230	4.72
20 - 25	1,983	0.549	3.12	34,011	90,677	0.061	0.487	0.352	2.77
25 - 30	1,231	0.340	2.37	41,574	110,841	0.034	0.306	0.235	2.13
30 - 35	727	0.201	1.66	49,374	131,638	0.005	0.196	0.043	1.62
35 - 40	485	0.134	1.28	56,985	151,929	0.004	0.130	0.039	1.24
40 - 45	364	0.100	1.09	64,571	172,154	0.003	0.097	0.032	1.05
45 - 60	688	0.190	2.52	79,244	211,275	0.010	0.180	0.145	2.38
60 - 90	593	0.164	3.03	110,501	294,610	0.004	0.159	0.077	2.96
90 - 100	87	0.024	0.585	145,125	386,922	0	0.024	0	0.585
100 - 110	70	0.019	0.520	160,435	427,739	0	0.019	0	0.520
110 - 120	57	0.015	0.461	174,521	465,294	0	0.015	0	0.461
120 - 130	48	0.013	0.424	190,526	507,964	0	0.013	0	0.424
130 - 140	26	0.007	0.247	205,218	547,137	0	0.007	0	0.247
140 - 150	28	0.007	0.284	219,328	584,755	0	0.007	0	0.284
150 - 160	24	0.006	0.262	235,784	628,629	0	0.006	0	0.262
160 - 170	10	0.002	0.116	252,183	672,349	0	0.002	0	0.116
170 - 180	19	0.005	0.234	265,726	708,457	0	0.005	0	0.234
180 - 200	17	0.004	0.229	290,649	774,904	0	0.004	0	0.229
Above 200	85	0.023	1.76	447,445	1,929,940	0	0.023	0	1.76

Notes : For anonymity reasons there is at least 10 individuals per brackets. *Reading :* Individuals from the top bracket represent 0.023 % of the population in the formal sector (column (2)). Individuals working in the public sector who earn between 1 and 2 millions FCFA represent 6.66 % of the formal sector population (column (7)), and their total wage represent 2.44 % of the sum of all formal wages (column (9)).

We can compute wage shares by brackets directly from the fiscal data (1 column (3)). However, income brackets are defined with respect to round thresholds in the local currency so our analysis to the raw tabulations would prevent us from measuring comparable indicators such as top 1 % and top 10 % income shares.

To go beyond this, we use interpolation techniques developed by Blanchet et al. (2017). Contrary to other extrapolating strategy this method makes no parametric assumption regarding the model underlying the income distribution such as Lognormal or Pareto curve. It consists essentially in reconstructing a generalized Pareto curve based on empirical Pareto coefficients and corresponding quantiles of the distribution. Recovering the generalized Pareto curve allows to estimate Lorenz curve of the income distribution, and therefore to compute cumulative income share $L(p)$ for any percentile p.

Like in most developing countries only, a very small share of the working population is registered in income tax files. In 2014, these 361,172 individuals paying wage taxes represent approximately 3 % of the working age population and about 5 % of the active population (as calculated in the 2014-2015 survey). In developed countries, income tax files are sufficient to estimate nationally representative inequality statistics when controlling for total population and income. But in countries where the tax base is so narrow, the use of survey data is crucial to derive information about the entire population.

2.2 Survey Data

Collected from a nationally representative sample of 12,885 households, the 2014-2015 household survey has been essentially designed to measure the living standards in Côte d'Ivoire. It contains a wide range of information including detailed data at the individual level about employment, income and consumption expenditures. Data collection took place from January 2015 to March 2015, so the reference period for the questions regarding income ("last 12 months" from interview day) almost perfectly matches our fiscal data.

To use this second source as a complement of the fiscal data, we first needed to make a distinction in the survey sample between the individuals paying taxes (so those likely to correspond to either of the sector for which we obtained fiscal data), and others. As explained above, to be submitted to labour income tax, an individual must either work in the public sector, or be employed by an enterprise registered at the CNPS. Fortunately, respondents were asked precise questions about this regarding their main professional activity. On the basis of their responses to these questions, we assigned them to either the public sector, or the formal private sector. These two groups add up to 778 individuals (435 civil servants and 343 at the CNPS). However 26 belonged to both sectors which, by construction, is impossible. For these ones only we carried out a one-by-one assignment on the basis of their type of activity.

The second step to combine fiscal and survey sources was to extract, from the survey, an income concept corresponding to that of the fiscal source. Our fiscal data contains information about yearly wage before tax. On the other hand, surveyed people were asked how much they earned in the last 12 months from their main professional activity : they needed to give an amount and a time rate (day, week, month, trimester or year) but we have no information telling whether the amount they gave is before or after tax.

In Côte d'Ivoire, three different taxes are levied on wages : the *Impôt Général sur le Revenu* (IGR, or General Income Tax), the *Impôt sur les Salaires et Traitements* (ITS, or Tax on Wages and Salaries), and the *Contribution Nationale* (CN, National Contribution) [2]. The first tax is progressive and declarative : by the end of each fiscal year, individuals who earn a wage must declare how much they earned during the year and will be taxed accordingly (see *livre premier, chapitre cinquième* of the Code Général des Taxes). The last two are flat and withholding taxes. The rate is 1.5 % of 80 % of the gross wage, both for the ITS and the CN (see L1, Chap.1 Section III Art 120; and L1 Chap.2 Section III Art. 146 respectively). We assume that, during the survey, respondents paying taxes probably gave their income after the two withholding taxes but before the declarative one. We thus adjusted the earnings of individuals working in the formal sector by adding back the CN and the ITS.

2.3 Comparison

In our fiscal data we observe the entire universe of what we defined as the formal sector. In contrast, the survey data is a randomly selected sub-sample only, and is likely to misrepresent the very top of the earning distribution given that the empirical probability to select and manage to interview the richest individuals is extremely small. Therefore income tax files should be more accurate than the survey to capture earning distribution within the formal sector.

To analyze how large the discrepancy is between the two sources, we compare estimates computed from the survey data restricted to the formal sector, to those computed from the income tax file. Table 2 displays some key figures calculated by sector and data source.

The survey seems to very well capture the public sector. Weighted population figures are almost equal to the total population from the tax data (Table 2) and the wage distribution closely follows the one that can be extrapolated from tabulations of the public sector (Figure A2). The picture is somewhat different regarding the private sector. First, its weighted population is greater than the total private population from our fiscal source by about 18 %. Second, top shares and averages are significantly lower in the survey than

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[2]see Code General des Impots

Table 2: Distributions of Yearly Earnings in the Formal Sector

	public		private		public and private	
	Survey	*Fiscal*	*Survey*	*Fiscal*	*Survey*	*Fiscal*
Mean	14,320	13,765	11,694	18,071	12,924	15,917
Top 1 % average	85,575	69,217	117,324	344,265	114,237	243,872
	(14,920)		(10,576)		(9,056)	
Top 10 % average	36,846	31,599	49,166	97,748	43,703	66,279
	(3,651)		(5,602)		(3,397)	
Middle 40 % average	12,311	12,308	7,332	7,564	10,254	10,642
	(105)		(159)		(102)	
Bottom 50 % average	9,115	8,759	4,045	4,066	5,943	5,951
	(161)		(128)		(138)	
Poverty Line (yearly)	693.5	693.5	693.5	693.5	693.5	693.5
Gini coefficient	0.286	0.272	0.516	0.640	0.420	0.503
Top 1 % share	6.82	5.02	13.61	19.04	9.44	15.32
Top 10 % share	25.95	22.95	42.89	54.08	33.93	41.63
Middle 40 % share	34.42	35.76	24.98	16.74	31.67	26.74
Bottom 50 % share	31.67	31.81	17.27	11.25	22.88	18.69
Population	186,906	180,699	212,163	180,503	399,070	361,172
No. Obs (survey)	435		343		778	

Notes : Wage shares are computed with respect to total earnings within each sector. Standard errors in are in parentheses. Individuals are the statistical unit. Authors calculation.

in the fiscal data. The average wage of the top 10 % within the private sector is almost 2 times greater in the fiscal source than in the survey (Table 2). The highest wage from the formal private sector in the survey (before withholding taxes) is equal to €56,906, but we know from the fiscal data that a "missing top" of about 2,200 individuals from the private sector received higher salaries this year. Figure A1, A2 and A3 and further illustrate the gap between the sources by comparing logarithms of percentile average wage by source and by sector. They strongly suggest that from low to moderately high earning levels, the survey instrument has correctly approximated the real distribution of wages in the formal sector, but that, as expected, high earnings from the private sector (the top 36-38 %) are under-estimated.

Although the effects of under-reporting versus non-response cannot be disentangled here, we may have some evidence that the survey suffers at least from a non-response bias. Guénard and Mesplé-Somps (2010) show that French and Lebanese expatriates are absent from the sample of the 1998 survey in Côte d'Ivoire, and that adding observations to account for their weight in total population increases per capita income Gini coefficient by 4-10 points if we assume they enjoy living standards comparable to that of their country of origin. That said, French and Lebanese are also completely absent from the 2014 survey – a repetition which suggests that such communities might be deliberately discarded from the sampling methodology. Yet according to the French government, 15,212 French nationals had their residency in Côte d'Ivoire in 2014 [3]. In Table 3 we estimate what proportion of the so called "missing top" could be French expatriates conditional on their share in the formal private sector and their wage level.

Table 3: Percentage of French Expatriates in the missing top : an estimation

		Pct. of French expatriates working in the formal sector								
		90%	80%	70%	60%	50%	40%	30%	20%	10%
Pct. among French expatriates	25%	155	138	121	103	86	69	51	34	17
working in the formal sector,	20%	124	110	96	82	69	55	41	27	13
who earn a wage above the	15%	93	82	72	62	51	41	31	20	10
maximum wage in the survey	10%	62	55	48	41	34	27	20	13	6
(i.e > €55,198 per year)	5%	31	27	24	20	17	13	10	6	3
	1%	6	5	4	4	3	2	2	1	0

Notes : The maximum wage in the formal sector of the 2014 survey is equal to €55,198. According to our fiscal data, about 2,200 individuals had higher earnings this year. This table estimates what percentage of this "missing top" could be French expatriates (absent from the survey).
Reading : Assuming 50 % of the 15,212 French expatriates worked in the private formal sector in 2014, and 10 % of these earned more than €55,198. then 34 % of the missing top would be French expatriates.

Not all 15,212 French expatriates work in the formal sector. First, because this number includes children

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[3]see https://ci.ambafrance.org

as well as unemployed (but we ignore in which proportion). Second, because those working for an international organizations are unlikely to declare their revenue to the Ivorian fiscal administration. Considering this, we believe that figures from column 1 and 2 in Table 3 (where it is assumed that 90 % and 80 % of French residents work in the private formal sector) should be regarded as very unlikely cases.

We do not have data on the distribution of expatriates' wages, but we know that the maximum survey wage from the private formal sector (€55,198) is slightly higher than the top 5 % threshold of the French wage distribution in 2014 (€55,068) [4]. Therefore to appreciate the likelihood of Table 3's hypotheses, one should keep in mind that line 5 roughly assumes that the wage distribution among French expatriates is the same as the one among French living in France. Restricting to what we consider as the most likely assumptions (line 3-4 and column 4-7) about 38 % of the "missing top" could be French expatriates.

Lebanese are also completely absent from the 2014-2015 survey sample, although they constitute a rather large community [5], with at least some very wealthy individuals [6]. Assuming some of them work in the formal private sector, the absence of Lebanese in the survey could also explain, at least partly, the underestimation of formal wages in the survey.

3   Correcting the 2014-2015 Survey

We defined the formal sector as the population paying income tax. The rest of the individuals in age of working will be considered as part of the informal sector. Furthermore, a household will be considered as part of the formal (informal) sector if the highest earnings from main activity in this household goes to an individual from the formal (informal) sector.

In Table 4, we use the survey to compare the population and income shares of both sectors. Households from the formal sector represent 6.82 % of the total population. While they are almost absent from the bottom 50 % of the population, they represent about a third of the population within the top 1 % and quarter of the top 10 %. As expected, the formal sector is therefore a small but wealthy sub-sample of the population. On the other hand, the informal sector is poorer on average, but still represents the largest population share among the top groups.

Given the importance of the informal sector, our fiscal data is of very limited scope. Furthermore, it gives information on wages only and thus does not include other sources of income such as rents, dividends or auto-production. Demographic characteristics such as age and household size are also absent. To compute

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[4]see both are calculated net of withholding taxes https://www.insee.fr/

[5]About 60,000 individuals according to http://www.diploweb.com

[6]The SwissLeaks scandal revealed in February 2015 shed a bit of light on the large wealth detained in fiscal heavens by Ivorian residents and showed that around two third of the 382 of these bank accounts belonged to Syrio-Lebanese expatriates. According to the International Consortium of Investigative Journalism, the sum of Ivorian deposits was equal to US$190,500,000 (in 2007 US$), some accounts sheltering more than US$ 35,000,000 (see www.connectionivoirienne.net and lemonde.fr)

Table 4: Income and Population Distribution by Sector Before Correction

| | | Full Population | | Decomposing by | | |
| | | | Top 1 % | Top 10 % | Middle 40 % | Bottom 50 % |
		(1)	(2)	(3)	(4)	(5)
Population Share	*Formal*	6.82	0.34	2.75	1.45	0.70
	Informal	93.17	0.65	7.25	38.55	49.29
	Total	100	1	10	40	50
Income Share	*Formal*	17.12	4.51	12.39	1.06	0.28
(hh per adult)	*Informal*	82.87	7.06	27.94	24.49	15.38
	Total	100	11.57	40.34	25.56	15.66
Average	*Formal*	7687	39766	13814	2244	1238
(hh per adult)	*Informal*	2725	32996	11809	1947	956
	Total	3064	35340	12360	1967	956

Notes : Authors calculation from the 2014-2015 household survey. Household is the statistical unit.
Reading : Household from the formal sector (i.e highest earning comes from an individual working in the formal sector) represent 6.82 % of the total population, their income share equals 17.12 % of total income, and their average yearly income per adult is $7,687 (PPP 2011). Among the top 1 %, their population represent 0.34 % of the total population.

income inequality statistics at the *national* level, we therefore need to use the household survey. But as section 2.3 shows, the 2014-2015 survey fail to properly capture the top of the earnings distribution in the private formal sector, so using the survey only to compute income inequality statistics would lead to an underestimation of inequalities.

To correct for this bias, we first replace survey earnings in the private formal sector by the ones retrieved from the fiscal data. But this correction is likely to be insufficient. If the top earnings are missing from the private formal sector of the survey, it cannot be excluded that under-reporting and non-responses biases may also affect the rest of the population and other income sources. To account for this, we make the most of the information retrieved from the comparison of fiscal and survey data to adjust all income sources for the entire survey population. The following section explains step by step how we proceed.

3.1 Method

Step 1 : individual earnings in the formal private sector

As suggested by figures of Table 2 and Figure A2, we assume that the public sector has been properly captured by the survey and apply no correction to it.

The discrepancy between fiscal and survey wages in the top of the distribution of the private formal

sector might come from non-reporting and/or non-response biases. Here the optimal correction of the survey would therefore consist in adjusting under-reported wages and/or re-weighting survey observations to give more weight to under-sampled groups. But this strategy is unfeasible given that we cannot distinguish the two effects. For lack of a better option, our correction consists in raising top survey earnings from the private sector to fiscal levels using a simple proportional upgrading rule.

We first divide survey and fiscal earnings distributions of the formal private sector into percentile groups. For each n such that $1 \leq n \leq 100$, let P_n^f (P_n^s) be the nth-percentile group of the distribution of earnings from the fiscal (survey) source. We then compute the corresponding correction coefficients $c_n = \bar{y}_n^f / \bar{y}_n^s$, where $\bar{y}_n^f$ and $\bar{y}_n^s$ are average earnings in P_n^f and P_n^s respectively.

Figure A3 suggests that the discrepancy between the two sources starts to be significant around percentile 62-64. Therefore we apply our correction to the top 37 % of the survey earnings, leaving the bottom 62 % unchanged. For each $n \geq 63$, we correct each survey earnings y^s in top percentile group P_n^s by replacing it by $y^s \times c_n$. Figure 1 (left) shows the magnitude of the correcting coefficients we use.

We operate as if the entire bias would be due to under-reporting only. But by probably over-correcting under-reporting bias, we indirectly correct for non-response, and, by construction, the quantile function of the survey wage distribution from the private formal sector after correction is identical to that of its fiscal counterpart. Our correction therefore is equivalent to the optimal one (correcting for under-reporting and non-response separately) providing that the characteristics (household size, other source of income, income of other members ...) of the individuals in the top of the survey are representative of those of individuals in the top of the fiscal data.

Step 2 : individual earnings in the informal sector

To correct also the informal sector we assume that, *conditional on income*, under-reporting and non-response biases in the *informal* sector are the same as those measured in the *formal private* sector. Our correction method for the earnings of the informal sector then consists in increasing top earnings in the survey by multiplying them by a smoothed version of the factors we used to correct formal private earnings of *similar level*.

First we smooth the distribution of correction coefficients c_n, using Kernel-weighted local polynomial method (Figure 1, left). Let c_n^{smth} be the resulting coefficients (Figure 1, right). For each n such that $63 \leq n \leq 100$, let q_n^s be the minimum threshold to enter into percentile group P_n^s as defined in step 1 (we also set $q_{101}^s = \infty$). Then we simply replace each survey earning y_{inf}^s from the informal sector by $y_{inf}^s \times c_n^{smth}$, if $q_n^s \leq y_{inf}^s < q_{n+1}^s$ (for each $n \geq 63$). Again, this correction assumes that under-reporting and non-responses

Figure 1: Correction Coefficients used for 2014 - Measured and Smoothed
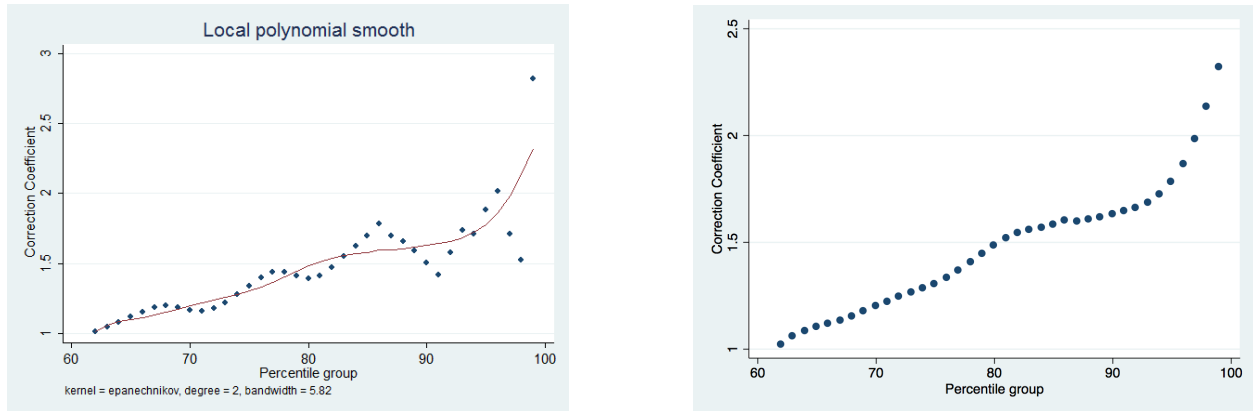
Notes: On the left we display empirical correction coefficients measured by comparing percentile group averages in the fiscal and survey source (formal private sector only) together with the local polynomial smoothing line. On the right we display the correction coefficients by percentile group, after smoothing.

biases are the same in the formal and informal private sector for any given brackets $[q_n^s; q_{n+1}^s]$.

Step 3 : other income source

To correct other sources of income we assume that, *conditional on income*, under-reporting and non-response biases for complementary income sources are the same as those for wages in the formal private sector. We apply the same methodology as the one defined in step 2 for each other income components, using the same correction coefficients and the same income brackets. Some components are reported individually, some others at the household level only (see Appendix C for a complete description of the method we use to compute total income). To apply our correction to the latter, we first split them among all adults in the household.

3.2   Results

The 2014-2015 survey is a *household* survey, so income earned by household members who were absent during the interview had to be reported by the available respondents. In a country like Côte d'Ivoire where individuals often have multiple sources of income, it might be complicated for a respondent to accurately detail all earnings of other members. This design may lead to an overestimation of within household inequality and thus overall individual inequality. To avoid this, we compute inequality statistics at the household level (total income equally split among adults aged 20 or above). The income concept we use is pre-tax pre-transfer income as defined in the DINA guidelines (Alvaredo et al., 2017). For a complete description of

our methodology to compute household income and the related measuring issues, see Appendix C.

Table 5: Inequality Statistics Before and After Correction - hh Income per Adult

	Gini	Top 1 %	Top 10 %	Middle 40 %	Bottom 50 %	Mean	Pop. Share Affected by the correction	Pct. Increase of the mean
(0) Before Correction	0.530	11.57	40.34	25.56	15.66	3064	—	—
(1) Correcting wages of the formal sector only (procedure defined in step 1)	0.546	13.64	42.48	24.59	15.13	3187	1.79	4.03
(2) Adding Correction on informal wages (procedure defined in step 2)	0.585	16.52	47.55	22.24	13.64	3532	8.01	15.29
(3) Adding Correction on all other income (procedure defined in step 3)	0.590	17.15	48.28	21.91	13.44	3586	8.44	17.05

Notes : We increment corrections step by step and measure its impact on overall income inequalities. Income is pre-tax, pre-transfer household income equally split among adults (>20 y.o) Household is the statistical unit. Authors' calculation based on 2014-2015 household survey and fiscal data

Table 5 displays inequality statistics before and after each of the three adjustments defined in section 3.1. The minimum individual income from which we start applying our correction is equal to $9,833 PPP 2011, i.e 3.2 times the overall mean income in our sample before any correction, and 14 times the yearly absolute poverty line (see Table B2). The correction we operate entails a non negligible increase in measured inequalities. Gini coefficient increases by 6 points in total and the income shares of the top 1 % and the top 10 % increase by 5.5 and 8 percentage points respectively. We adjust the income of less than 10 % of the adult population, but the overall mean increases by 17 %. Interestingly, the magnitude of our results is consistent with findings in Alvaredo and Londoño (2013) for the Colombian case, although the method they use is different.

3.3 Income, Consumption and Measurement Issues

In comparison to figures from the PovcalNet database (the most cited database when it comes to measuring inequalities in Sub-Sahara African countries), our estimates may seem remarkably high. Indeed, according to this source the average Gini coefficients in Côte d'Ivoire over the last 2 decades was 0.404 (computed from 9 surveys, from 1985 to 2008). Naturally, part of the difference comes from our correction, but an even larger share comes from the difference between income versus consumption inequalities (see Table B1). Apart from two isolated cases (namely Namibia 2014 and Seychelles 2013), inequality statistics from the PovcalNet (2017) database for Sub-Saharan African countries are extracted from consumption dis-

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tribution. In line with this, most of the literature on inequalities in this region is based on consumption and international comparisons are sometimes made disregarding the essential difference between income and consumption inequalities. Yet, there is a large body of evidence showing it is crucial. Fisher et al. (2013) for instance show that, from 1985 to 2010, income Gini coefficient was greater than consumption Gini by 10-14 points in the US. Similar differences can be found in the PovcalNet database [7]. Last, comparing income and consumption inequalities in 5 African countries (Uganda, Madagascar, Ghana, Côte d'Ivoire and Guinea), Cogneau et al. (2006) estimate that the gap can vary from 5 to 14 points.

We estimate consumption inequality statistics in Côte d'Ivoire for the year 2014 using consumption aggregates computed by the National Statistic Institute. As expected, income inequalities are more pronounced (see Table B1). We further compare the logarithm of percentile average for consumption and income in 2014 (Figure 2) and show that households at the bottom (top) of the income distribution are poorer (richer) than households at the bottom (top) of the consumption distribution. The intuitive interpretation to explain the difference between income and consumption distributions is that rich households save, while poorest ones borrow. Some of that should be true, but we find little support for this hypothesis in the data. The questionnaire contains one question about the amount of yearly savings and another one about yearly borrowings. But savings and borrowings as declared in the survey are very poor predictors of the residual savings we can estimate by taking the difference between income and consumption. Part of the issue might come from the fact that households are more reluctant to report what they earn than what they spend. That said, such situation is quite common with household surveys, and particularly salient in developing countries, to the extent that consumption is sometimes regarded as the only sound aggregate to measure living standards in such regions (Deaton, 1997).

Another plausible explanation for the difference between income and consumption inequalities is that individuals may smooth their consumption more easily than their income. Along the interview, respondents were asked, for each income component, how much they earned in the last twelve months. It is clear that such question is easy to answer for someone who signed a proper contract, for a long term period, associated with a monthly wage. However in Côte d'Ivoire, as in many developing countries, these individuals are the exception and total income over 12 months can become very difficult to recollect properly for individuals having several informal sources of income with irregular payments. Errors in recollection might therefore add some noise. Assuming such noise is random, it would contribute to make measured income inequalities

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[7]For some country-year both income and consumption data are available. The size of the gap between income and consumption Ginis varies greatly from one country to another : +2-5 in Mexico (1992-2012, every 2 years); +7-8 in Romania (2006-2012) and + 7-15 in Nicaragua (1993, 1998, 2001, 2005)

Figure 2: Comparing Income and Consumption Distributions - hh per adult
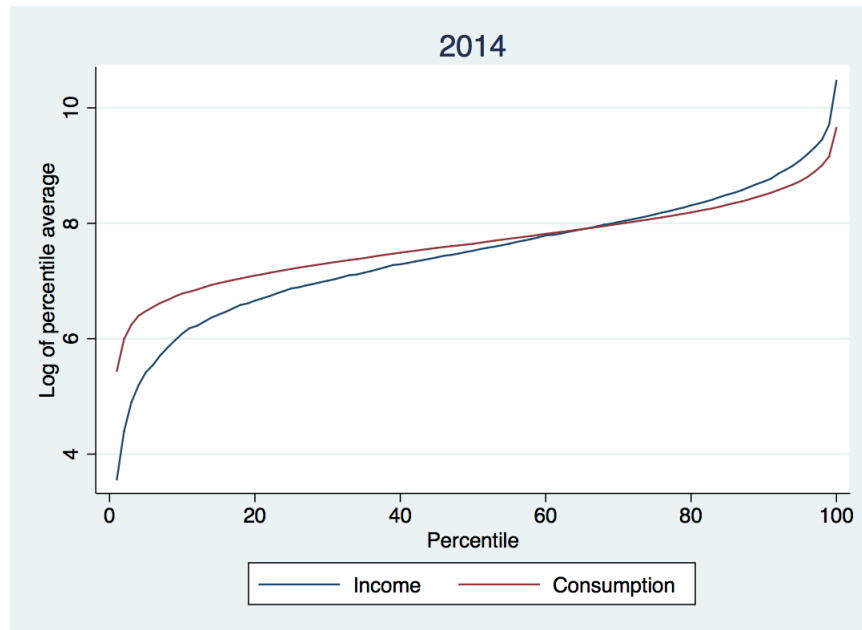
Notes: Logarithm of percentile average for consumption and income, ranking households with respect to consumption and income respectively. Authors' calculation based on 2014–2015 household survey. The average residual saving is equal to -4.9 % and about 67 % of households have negative savings.

higher than true income inequalities. The questionnaire suggests otherwise to make an average for a given time period (day, week, months or trimester), then to be extrapolated to recover the yearly income. But answers might be downward/upward biased depending on how bad/well the most recent period was for the respondent. Again, if bad and good times are randomly distributed among households, this would also contribute to upward bias our measure of income inequalities. On the other side, if consumption is smoothed, it is also more regular and thus easier to recollect, and safer to extrapolate over a yearly period [8].

In light of this, it should be acknowledged that measured income inequalities may be upward biased and therefore our estimates should be taken with caution. However there is no solution to this issue, other than improving our instruments of measures.

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[8]However consumption is not exempt from similar reporting biases, Jones (1997) showed for instance that cash crop producers report higher expenditures just after harvests.

4 Extending the correction to previous years

4.1 Method

Fiscal data for years prior to 2014 was not accessible. Nevertheless, we extrapolated our correction method to all years for which surveys similar to that of 2014 had been conducted. We therefore computed household income distribution for all previous years (see Appendix C for a thorough examination of the method applied). Then to compare income level across years we deflated household income by the national consumer price index (CPI) retrieved from the World Development Indicators, taking 2011 as a base year, and used the purchasing power parity converting factor for the year 2011 to translate it into international dollars.

The correction methods used for the year 2014 operates at the individual level, by income sources, which then translates into an adjustment of total household income. However, important differences in the definition of income components across surveys prevent us from using the same coefficients as the ones computed for the year 2014-2015 to adjust the income distribution of previous years. To circumvent this, we compare total household income distribution for the entire 2014 sample before and after the adjustment, and extract correction factors at the household level.

For each n, such that $1 \leq n \leq 99$, let $P_n^{b,2014}$ ($P_n^{a,2014}$) be the nth-percentile group of the full sample distribution of equivalized household income before (after) correction in 2014. Sample size here allows us to further divide the top 1 percentile group in 10 tenth-of-a -percentile : $P_{100}^{b,2014}$, $P_{101}^{b,2014}$ ... $P_{109}^{b,2014}$ ($P_{100}^{a,2014}$, $P_{101}^{a,2014}$ ... $P_{109}^{a,2014}$), for a finer adjustment. For each n, such that $1 \leq n \leq 109$, we then compute the correction coefficients $coef_n^{All} = \bar{y}_n^a / \bar{y}_n^b$, where $\bar{y}_n^a$ and $\bar{y}_n^b$ are average income in $P_n^{a,2014}$ and $P_n^{b,2014}$ respectively. We eventually replace each household income y_t in some survey year t by $y_t \times coef_n^{All}$, whenever there is an $n \geq 84$ such that $y_t \in P_n^{b,t}$, where $P_n^{b,t}$ is the $nth-$percentile group in year t before correction. We opt for 84 as a threshold given that the difference between the income distribution before and after our correction starts to be significant at percentile 84 (see coefficients in Figure 3).

Some rather well off individuals might live together with other adults receiving little or no income, therefore some individuals whose income has been raised by the correction for the year 2014 live in households whose equivalized income lies below the threshold q_{84}^b. Inversely, there are also individuals living in households above q_{84}^b, whose personal income has not been modified after the correction. Due to this, the correction coefficients $coef_n^{All}$ computed for the entire sample are smaller than the ones computed in section 3.1, but their distribution is also smoother and they affect a larger proportion of the population when applied to previous years (Table B2).

All resulting estimates for corrected income distributions (from year 1988 on) are included in the World

Figure 3: Correction coefficients to correct income distributions in years prior to 2014
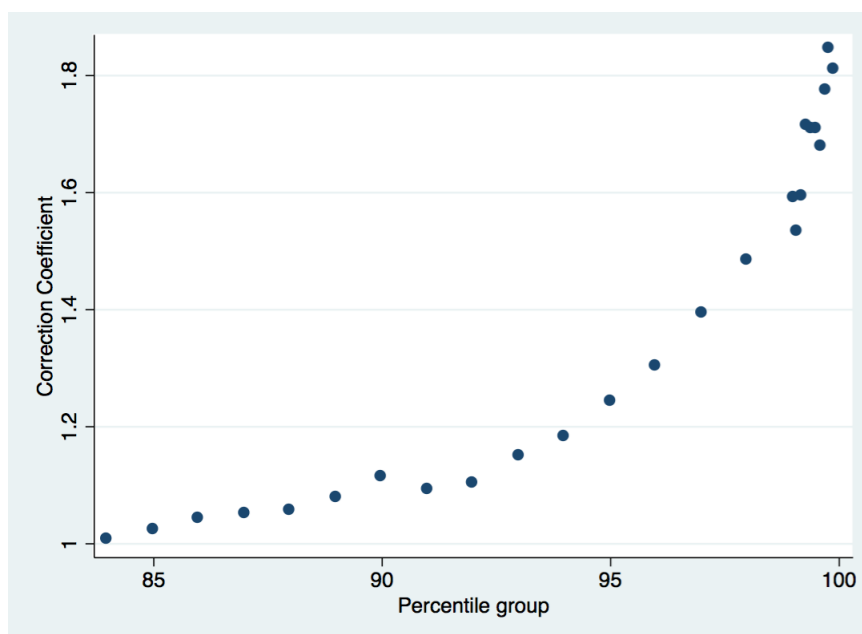
Notes: Coefficients below the 100-nth percentile group are ratios between percentile averages before and after the correction for the full sample in 2014. Above, ratios are computed within tenth-of-percentiles. Household pre-tax pre-transfer Income per adult.

Wealth and Income Database[9].

4.2   Results and International Comparison

Following independence (1960) Côte d'Ivoire enjoyed two decades of political stability and rapid growth. The production of cocoa, coffee and cotton intensified rapidly, boosted by stable and later increasing prices. Côte d'Ivoire then became a land of immigration for its neighboring countries, and new fiscal revenues together with important aid from France allowed the government to invest in transportation infrastructures and to increase the number of schools. Unfortunately the sudden fall in commodity price in the late 1970s marked the end of the so called "Ivorian miracle". The Ivorian economy did not recover from this shock : GDP per capita steadily declined until 1993 and never reached back its level of the 1970s (Figure 4). By the end of the downfall, the founding father Houphouët-Boigny died, and Henri Konan Bédié was elected president in 1995. Benefiting from the devaluation of the CFA, a bounce back in commodity price, large amount of foreign aid and significant private investment, the situation started to improve in the mid 1990s. However with the election coming in 2000, competition for power escalated, with Bédié reviving ethnicity

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[9]Note that standard errors for the top 0.1 % income shares/averages and the top 0.01 % income shares/averages are rather large given the sample size of the household surveys (see Table C1), so these figures should be taken with caution.

debate to rule out his main opponent Alassane Ouattara. In 1999 Robert Guëi overthrew the president by a military coup which marked the beginning of long period of civil unrest from which the country would escape only in 2011 with the help of foreign intervention. Our micro data span over a period which starts in the middle of the downfall following the price shock and ends 3 years after the political stabilization of the country (Figure 4).

Our extrapolation from the 2014 correction yields consistent results across all years. Surveys tend to underestimate Gini coefficients by about 6 points, top 1 % share by about 5-6 percentage points, and top 10 % shares by 7-8 % points (Figures B1, B2, B5 and Table B1). As one could expect, trends in income inequalities before and after our adjustment are parallel. Interestingly, from 1993 on, the evolution of income inequalities and consumption inequalities follow very similar pattern (we use consumption data from Cogneau et al. (2014a) and Cogneau et al. (2014b) for years prior to 2014). However, the large variations from 1985 to 1986 (the top 1% and 10 % income shares decrease by 5 and 10 percentage points respectively) cast some doubt on data quality of these early years as we cannot think of any event which could reasonably explain variations of that magnitude in such a short time period. Then, consistently with consumption inequalities, income inequalities for the period 1986-1988 remain rather stable, but then sharply decreases in 1993, while consumption inequalities decrease only slightly. We believe the intensity of this downfall in income inequalities may be the consequence of two measurement issues. First, Jones (1997) showed evidence suggesting that samples selected during the survey CILSS 1-4, might be too rich on average to be nationally representative. These findings are consistent with the comparison we make in Figure 4 between survey and macroeconomic estimates of average income per adult. Indeed, from 1993 on, average income per adult in the survey is equal to 65 % of household final consumption aggregates on average, but during the 1985-1988 period this ratio goes up to 85 %. This suggests that income inequalities could be overestimated in these early years. Second, during the 1993 survey, respondents were not asked the precise amount earned from their main activity, but the range in which it would fall (out of 10 brackets). For lack of better option, we imputed respondents earnings equal to the median of the range they declared, a solution which could have contributed to artificially lower our inequality estimates in 1993.

During this tumultuous period, income inequality varied significantly. As Cogneau et al. (2014a) already well documented : between 1988 and 1993, the economic consequences of the price shock eventually affected everybody and reduced income disparities across regions and social classes; the income growth between 1993 and 1998 mostly benefited the upper middle class, such as large crop growers, and induced a slight increase in inequalities; the evolution from 1998 to 2002 deepened the divide between rural and urban areas as the absolute poverty rate increased among farmers and civil servants saw their salaries increasing significantly; from 2002 to 2008, civil war reached its climax and contributed to reduce inequalities by more strongly

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affecting regions previously better off. Finally, income growth over the last period (2008-2014) was evenly distributed B6.

Figure 4: Comparing survey mean consumption/income per adult with macroeconomic aggregates
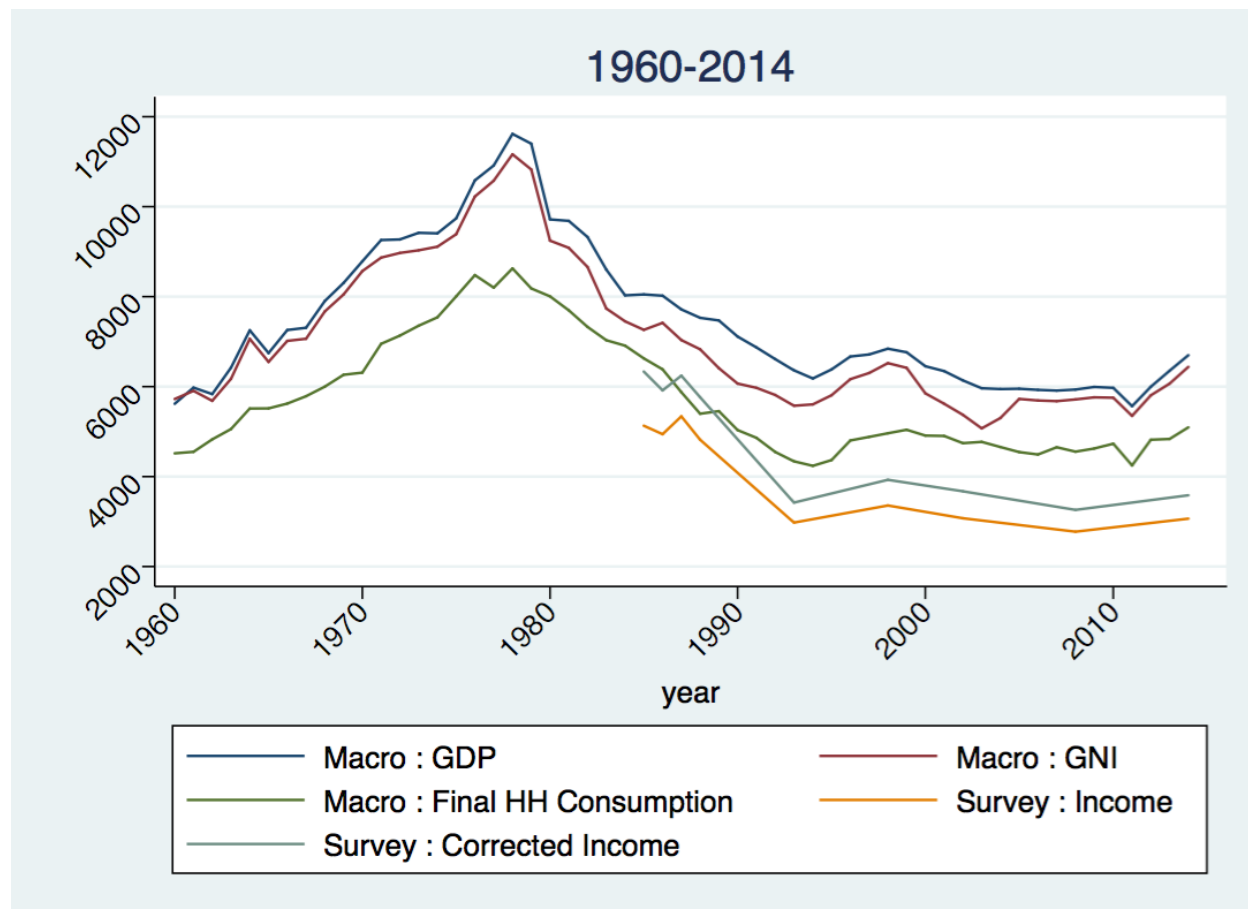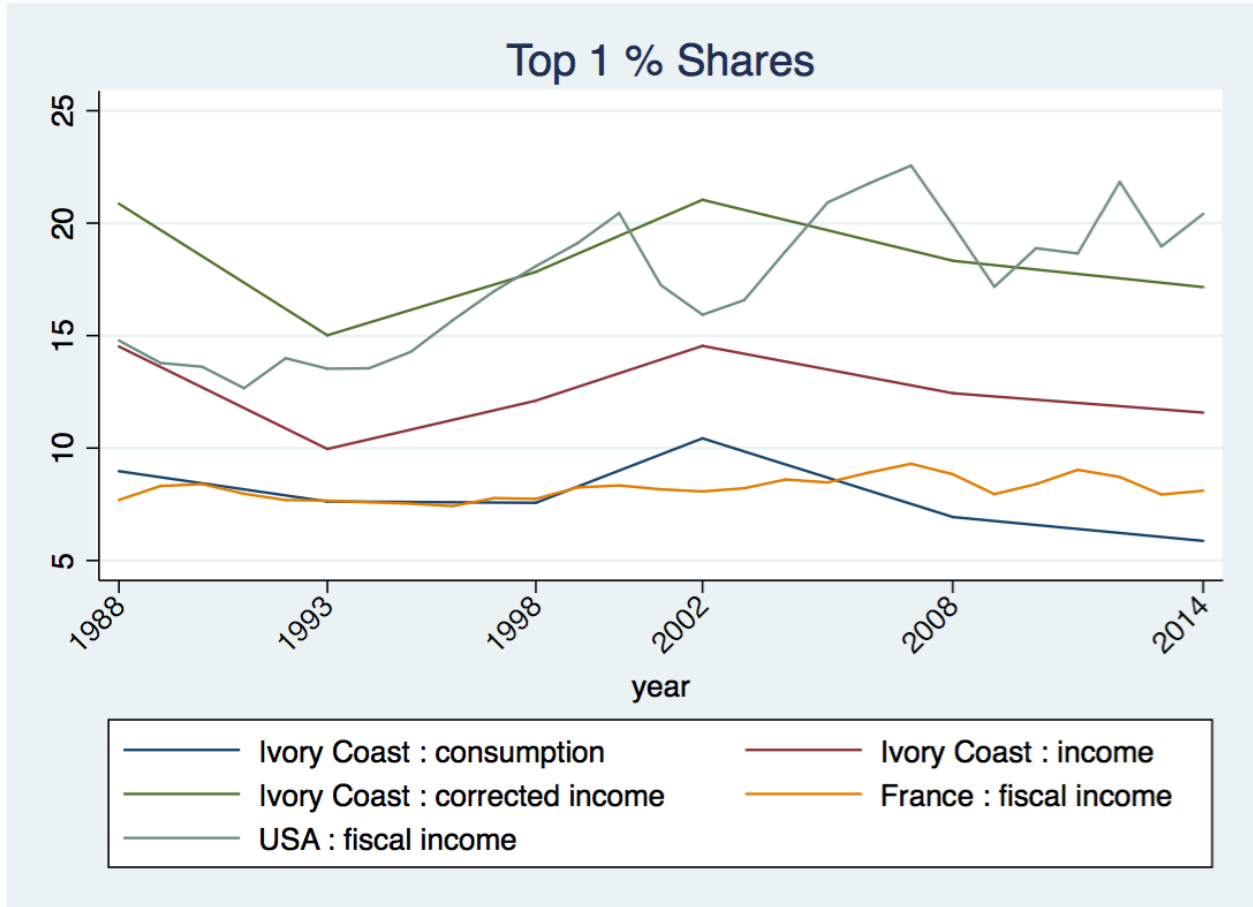

Notes: Authors' elaboration from World Development Indicator (2017) and the CILSS 1-4; ENV1-5 survey data (with and without correction). Survey income (with and without correction) is pre-tax pre-transfer household income per adult (>20 y.o). Constant international dollar 2011 PPP.

In Figure 5 and 6, we compare top 1 % and top 10 % shares in Côte d'Ivoire together with that of France and the USA over the same period. Consumption inequality in Côte d'Ivoire is about as high as income inequality in France. Switching to income inequality *before correction*, the top 1 % share in Côte d'Ivoire now lies clearly above the French top 1 %, but still below that of the USA. Finally, after our correction, income inequality in Côte d'Ivoire reaches levels comparable, if not higher (Figure 6) to the one measured in the United States.

This demonstrates that when comparing inequality levels across countries, one should always be extremely cautious regarding the different concepts at use. In particular, given that inequalities in Sub-Saharan Africa have been measured so far from consumption distributions exclusively, using surveys similar to the ones
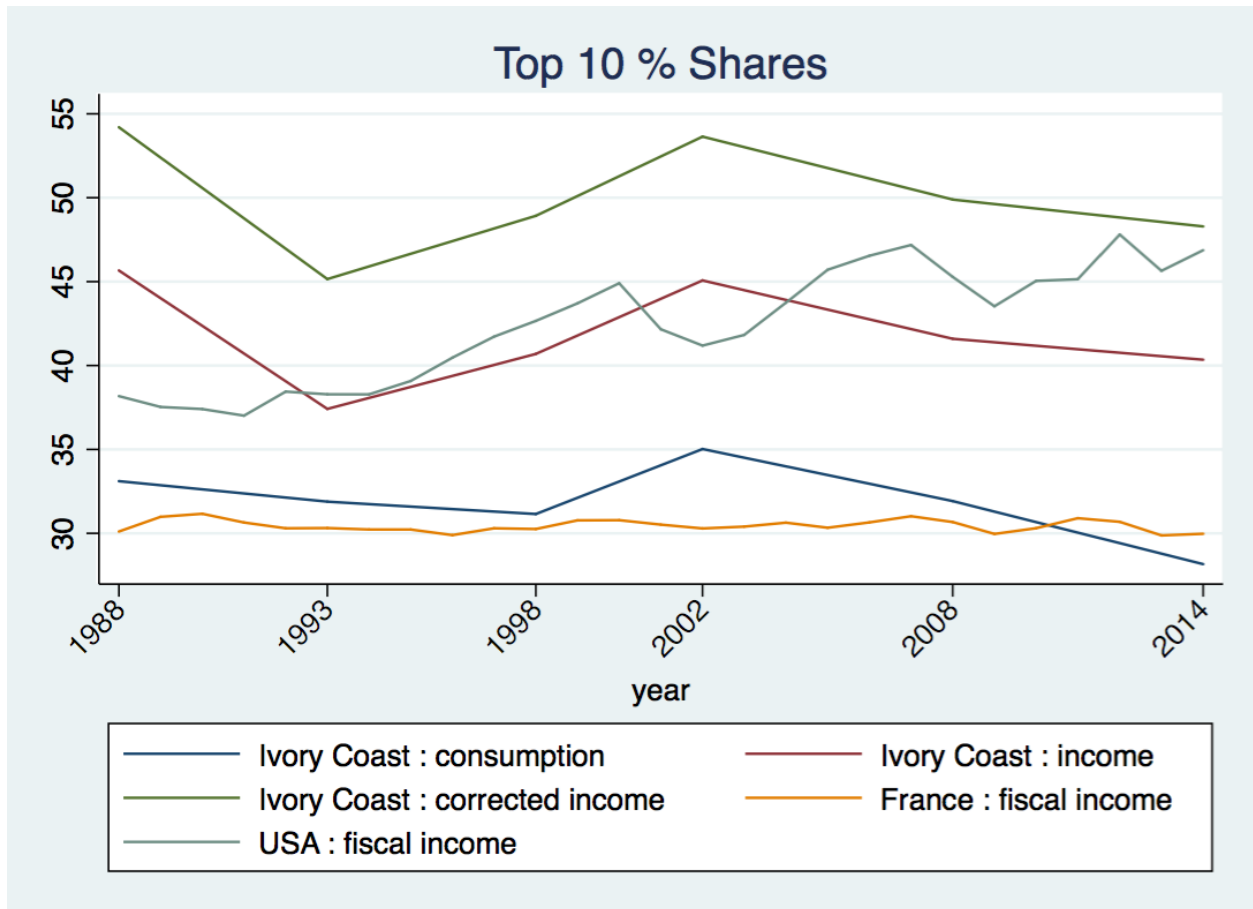
explored here but without any upward revision of the top, our results suggest that inequalities in this region may have been significantly underestimated compared to other regions.

Figure 5: Comparing top 1 % in Côte d'Ivoire, France and the USA

Notes: Authors' elaboration from World Wealth and Income Database (2017) data and CILSS 1-4; ENV1-5 survey data (with and without correction). Survey income (with and without correction) is pre-tax pre-transfer household yearly income equally split among adults (>20 y.o). Fiscal income is at the tax unit level, equal split among adults.

Figure 6: Comparing top 10 % in Côte d'Ivoire, France and the USA

Top 10 % Shares

Legend:
- Ivory Coast : consumption
- Ivory Coast : corrected income
- USA : fiscal income
- Ivory Coast : income
- France : fiscal income

Notes: Authors' elaboration from World Wealth and Income Database (2017) data and CILSS 1-4; ENV1-5 survey data (with and without correction). Survey income (with and without correction) is pre-tax pre-transfer household yearly income equally split among adults (>20 y.o). Fiscal income is at the tax unit level, equal split among adults.

5   Conclusion

This paper combines wage tabulations and household survey data from Côte d'Ivoire in 2014 to estimate corrected nationally representative income inequality statistics. Tax data has proven to be a reliable source to measure inequalities while avoiding non response and under-reporting issues related to survey data, but has seldom been used to estimate income distribution in Sub-Saharan Africa. Apart from Mauritius (Atkinson, 2011) and South Africa (Alvaredo and Atkinson, 2010), the literature regarding the recent evolution of inequalities in Sub-Saharan Africa mostly concentrates on the distribution of consumption rather than income, and relies only on surveys.

Comparing tax data with a well identified sub-sample of the survey we show that the survey significantly underestimates wages from the formal private sector. We provide evidence suggesting that part of the discrepancy between the two sources may be due to the absence of expatriates in the survey. As advocated in Guénard and Mesplé-Somps (2010), these exclusions from the sampling design are likely to be intentional, given the size of some communities (as the French or Lebanese). Our results however show that their absence are likely to lower inequality estimates, and therefore goes in support of including them in the sampling design.

We correct the wages observed in the survey using a simple upgrading rule. Assuming non-response rates and under-reporting are a function of income level only, we then apply the same correction coefficients used to correct the formal private sector to adjust earnings in the informal sector, as well as other income components for the entire sample. The income concept we use is household income per adult before taxes and transfers as per the DINA guidelines (Alvaredo et al., 2017). After our correction, the top 1% income share increases from 11.57% to 17.15%, the top 10% income shares from 40.34% to 48.28%, and the Gini coefficient from 0.53 to 0.59. Most of the effect of our correction comes from the adjustment of earnings in the informal sector. We extrapolate our adjustment method to other years for which relatively comparable surveys were available and obtain consistent results.

Finally, we illustrate the importance of this adjustment by comparing inequality levels with that of the US and France. Depending on whether we use the distribution of consumption, income or adjusted income, inequalities in Côte d'Ivoire are roughly equal to inequalities in France or closer, if not above those in the US. As inequalities in Sub-Saharan Africa are mostly measured in terms of consumption, this suggest that they may have been largely underestimated in international comparisons.

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A Comparison between Fiscal and Survey Sources

Figure A1: Logarithm of yearly average individual wage by percentile in the formal sector (public+private) : comparing fiscal and survey data
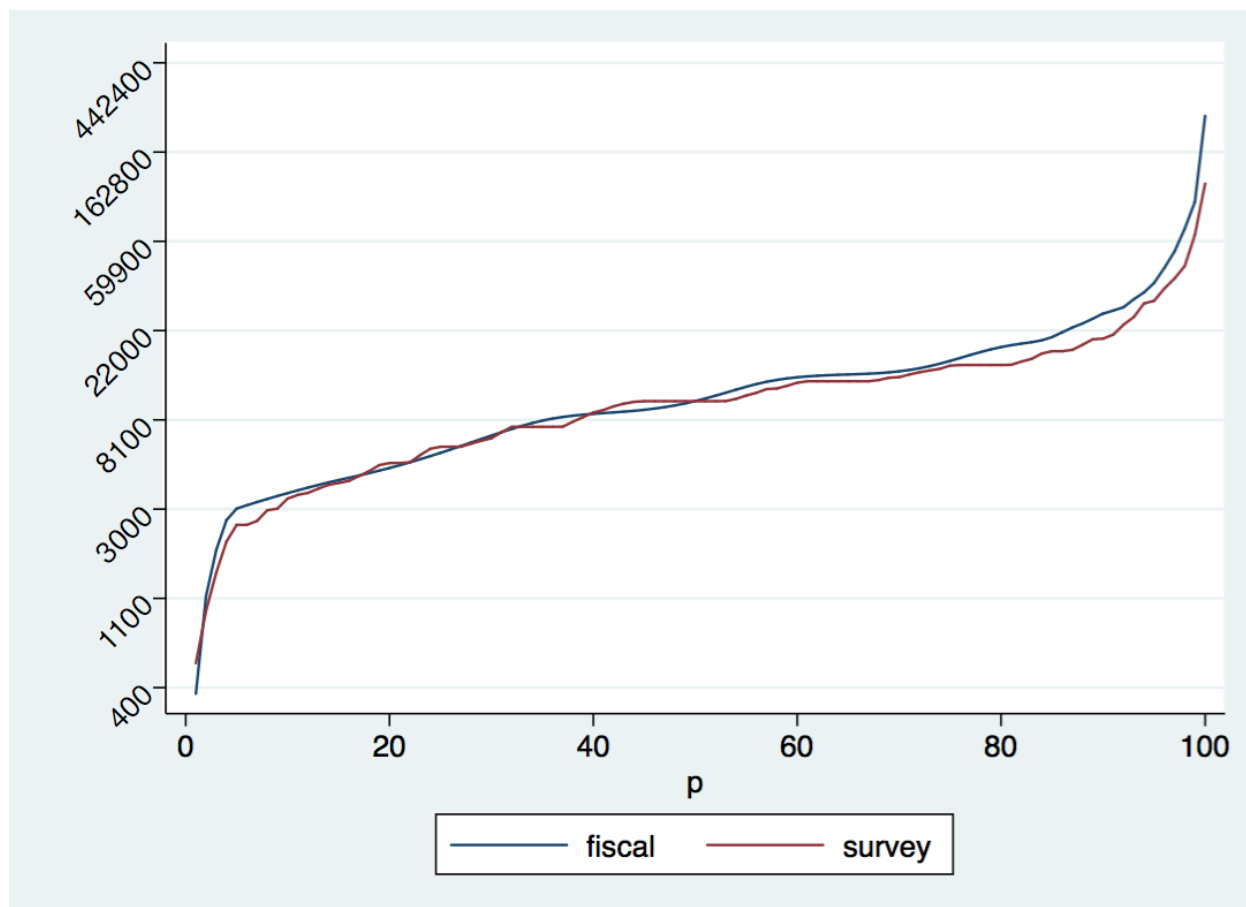
Notes: We plot the logarithm of average individual wages, but the label on the y-axis indicate corresponding wage level in $PPP 2011. Percentile distribution of the fiscal data is obtained by applying interpolation techniques. Individual is the statistical unit.

Figure A2: Logarithm of average individual wage by percentile in the private formal sector : comparing fiscal and survey data
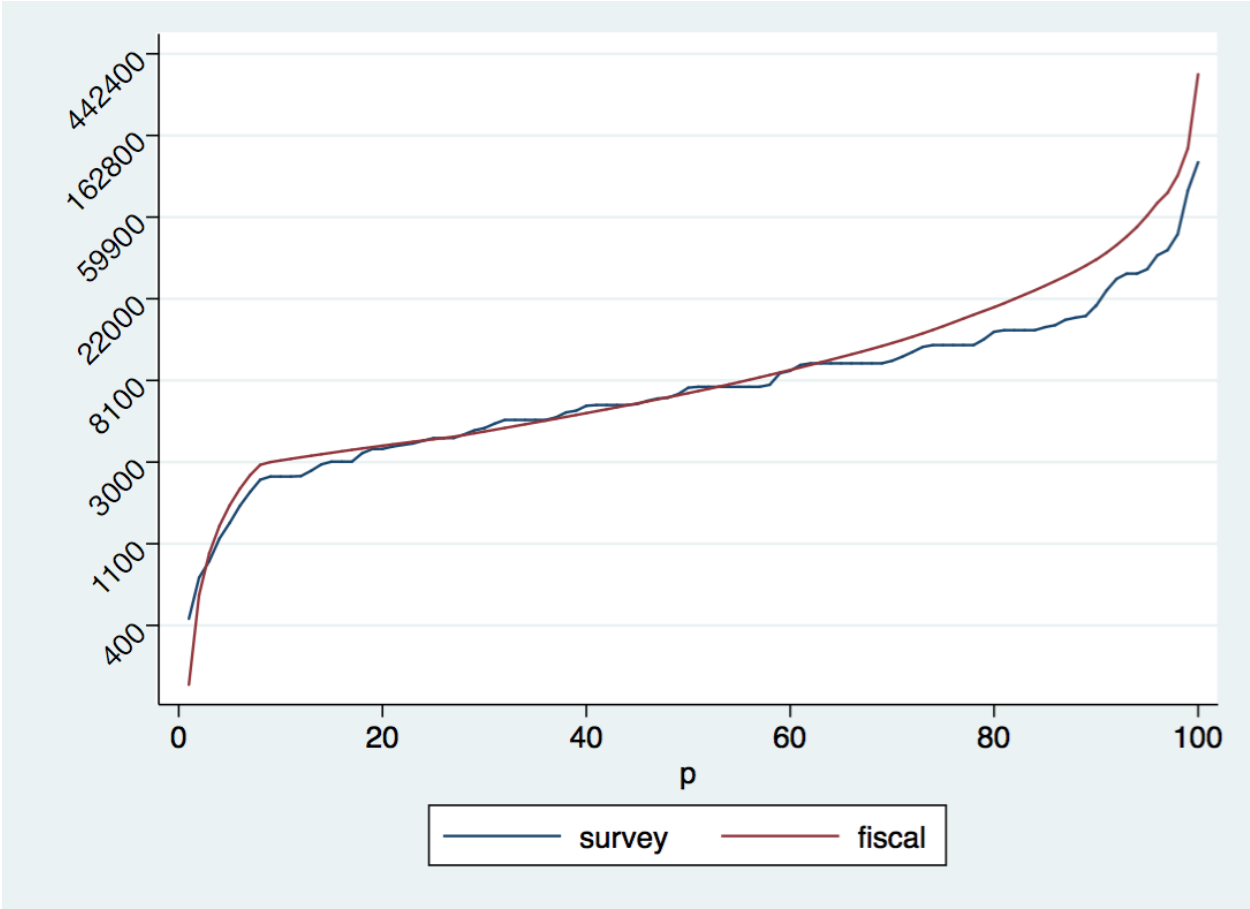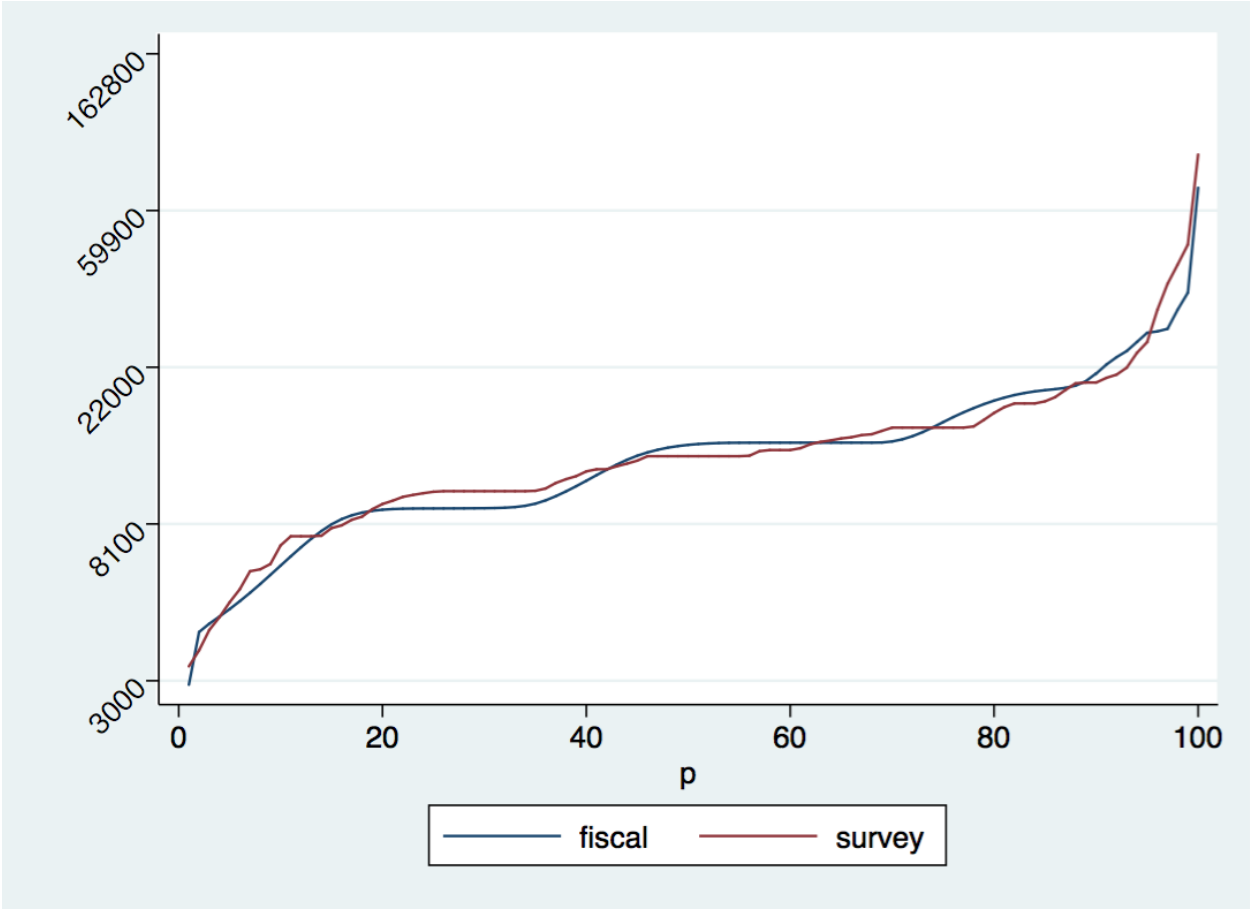

Notes: We plot the logarithm of average individual wages, but the label on the y-axis indicate corresponding wage level in $PPP 2011. Percentile distribution of the fiscal data is obtained by applying interpolation techniques. Individual is the statistical unit

Figure A3: Logarithm of average individual wage by percentile in the public sector : comparing fiscal and survey data

Notes: We plot the logarithm of average individual wages, but the label on the y-axis indicate corresponding wage level in $PPP 2011. Percentile distribution of the fiscal data is obtained by applying interpolation techniques. Individual is the statistical unit
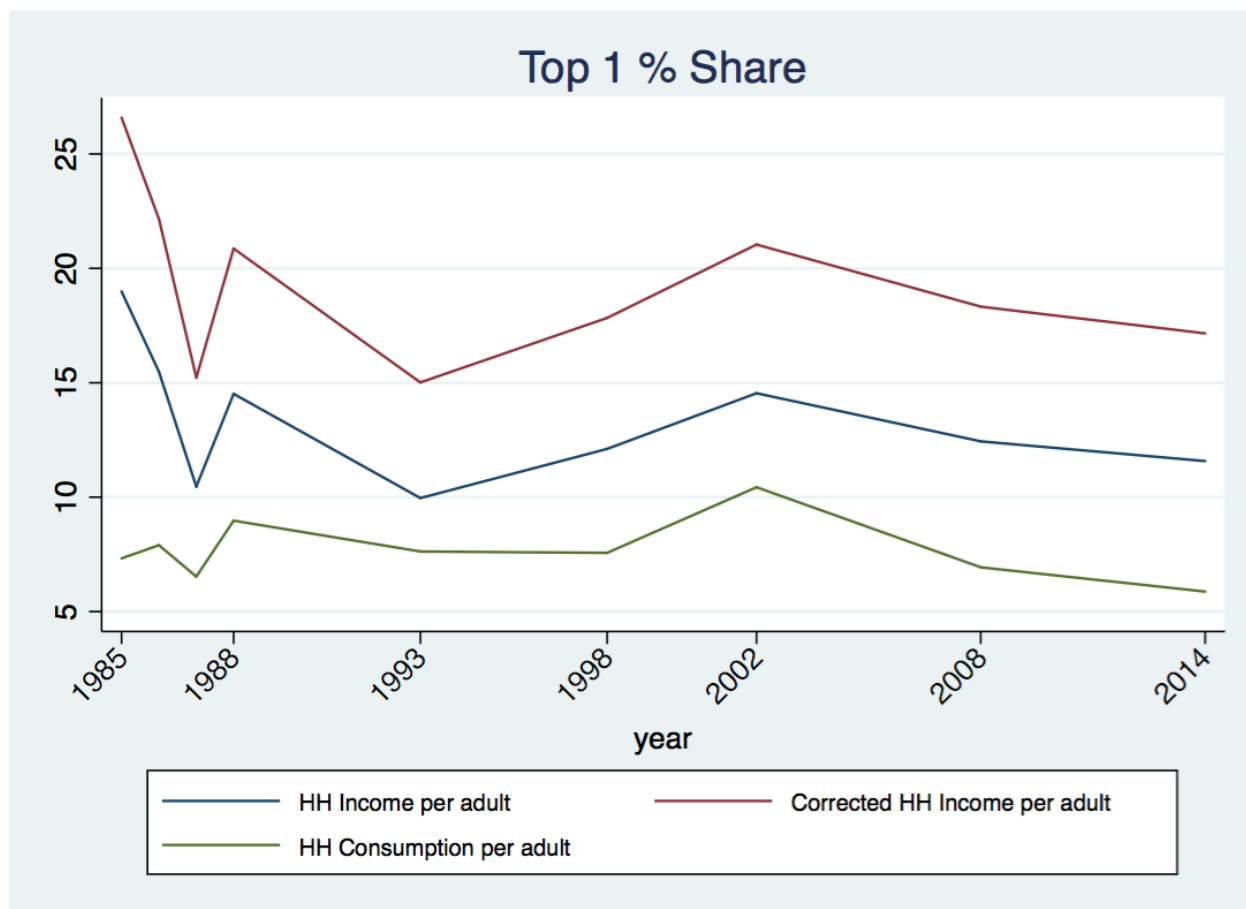
B Results

Figure B1: Evolution of top 1 % share - comparing consumption and income before and after correction

Notes: Authors' elaboration combining 2014 fiscal data and CILSS 1-4; ENV1-5 survey data. The correction we apply for 2014 is described in section 3.1, for previous years, see section 4.1. Income (with and without correction) is pre-tax pre-transfer household yearly income equally split among adults (>20 y.o).

Figure B2: Evolution of top 10 % share - comparing consumption and income before and after correction

Notes: Authors' elaboration combining 2014 fiscal data and CILSS 1-4; ENV1-5 survey data. The correction we apply for 2014 is described in section 3.1, for previous years, see section 4.1. Income (with and without correction) is pre-tax pre-transfer household yearly income equally split among adults (>20 y.o).
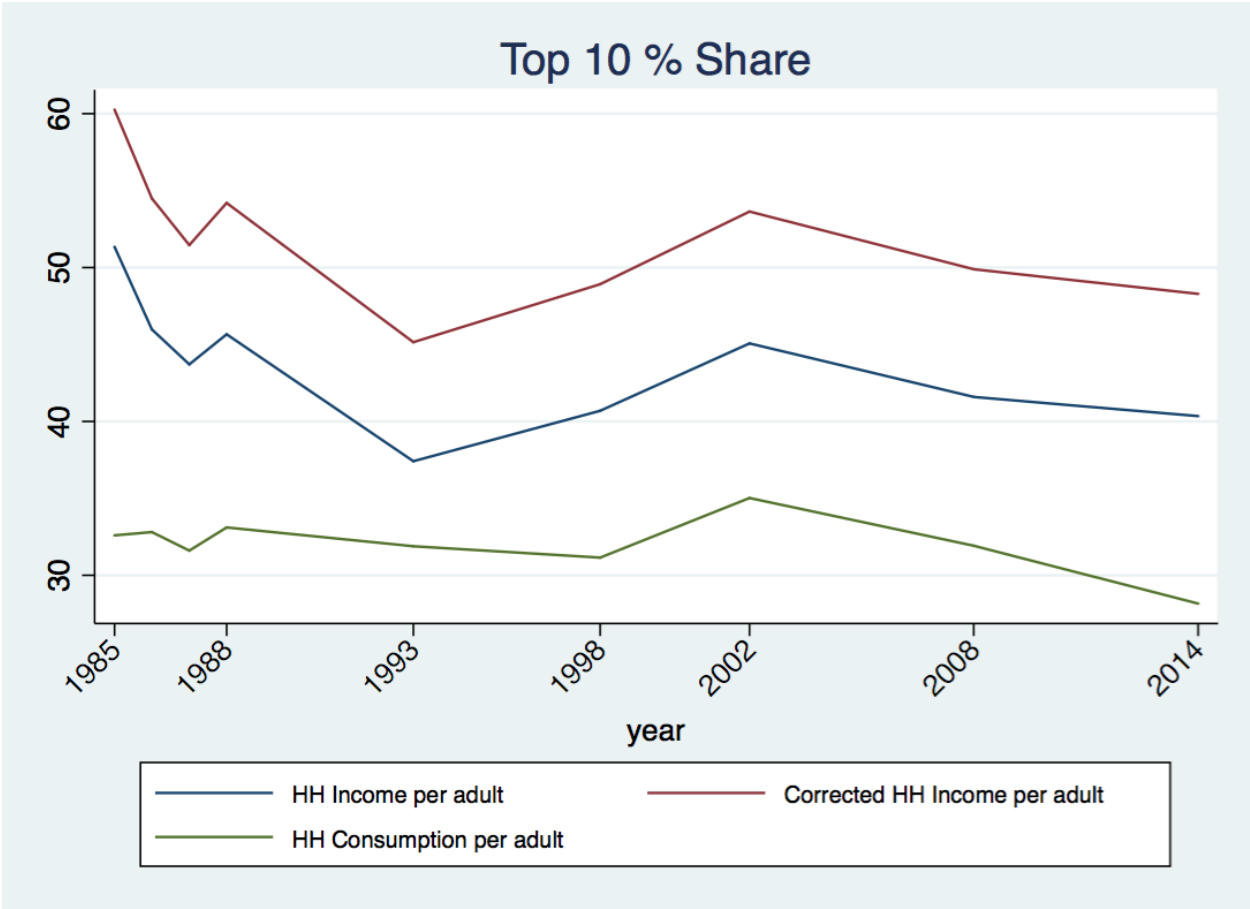
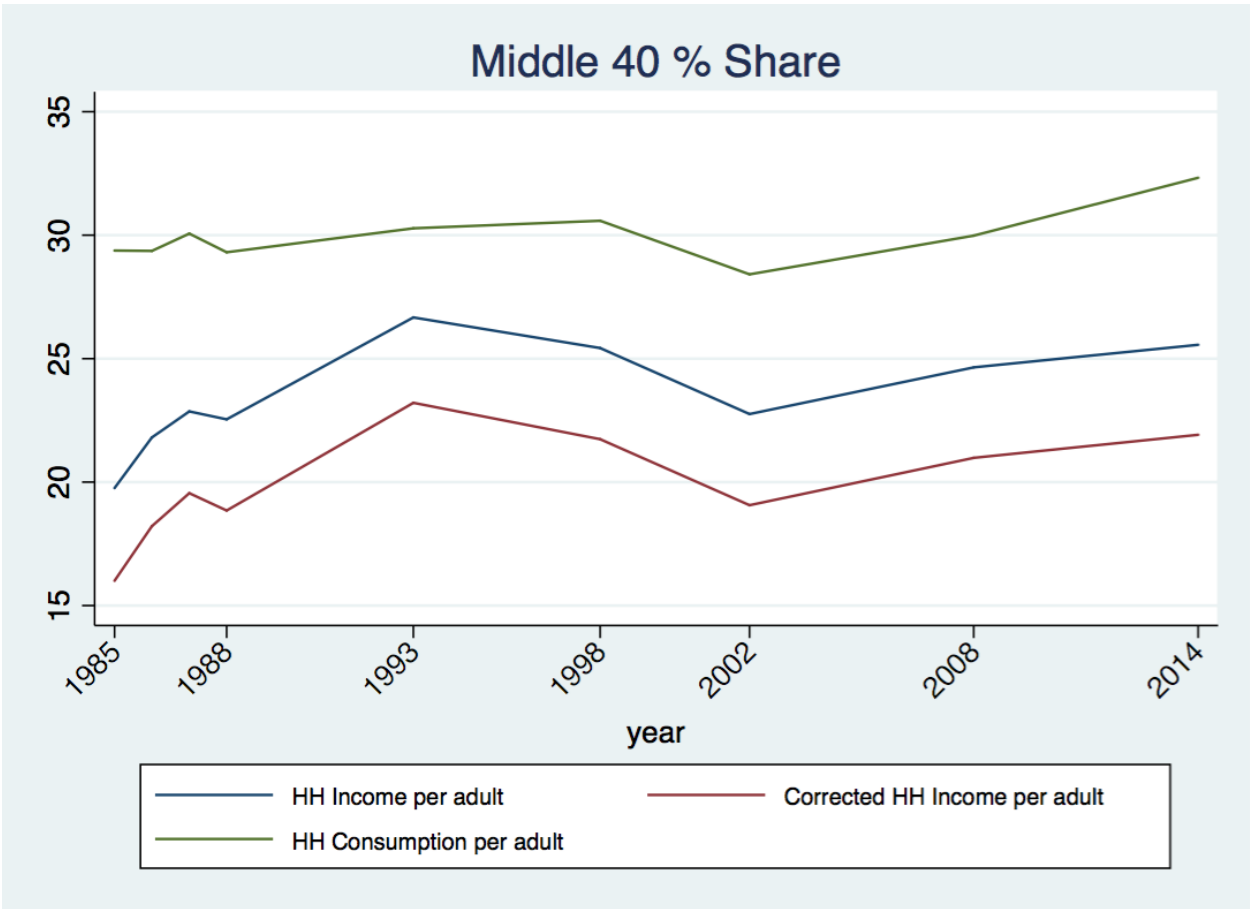Figure B3: Evolution of middle 40 % share - comparing consumption and income before and after correction

Notes: Authors' elaboration combining 2014 fiscal data and CILSS 1-4; ENV1-5 survey data. The correction we apply for 2014 is described in section 3.1, for previous years, see section 4.1. Income (with and without correction) is pre-tax pre-transfer household yearly income equally split among adults (>20 y.o).

Figure B4: Evolution of bottom 50 % share - comparing consumption and income before and after correction
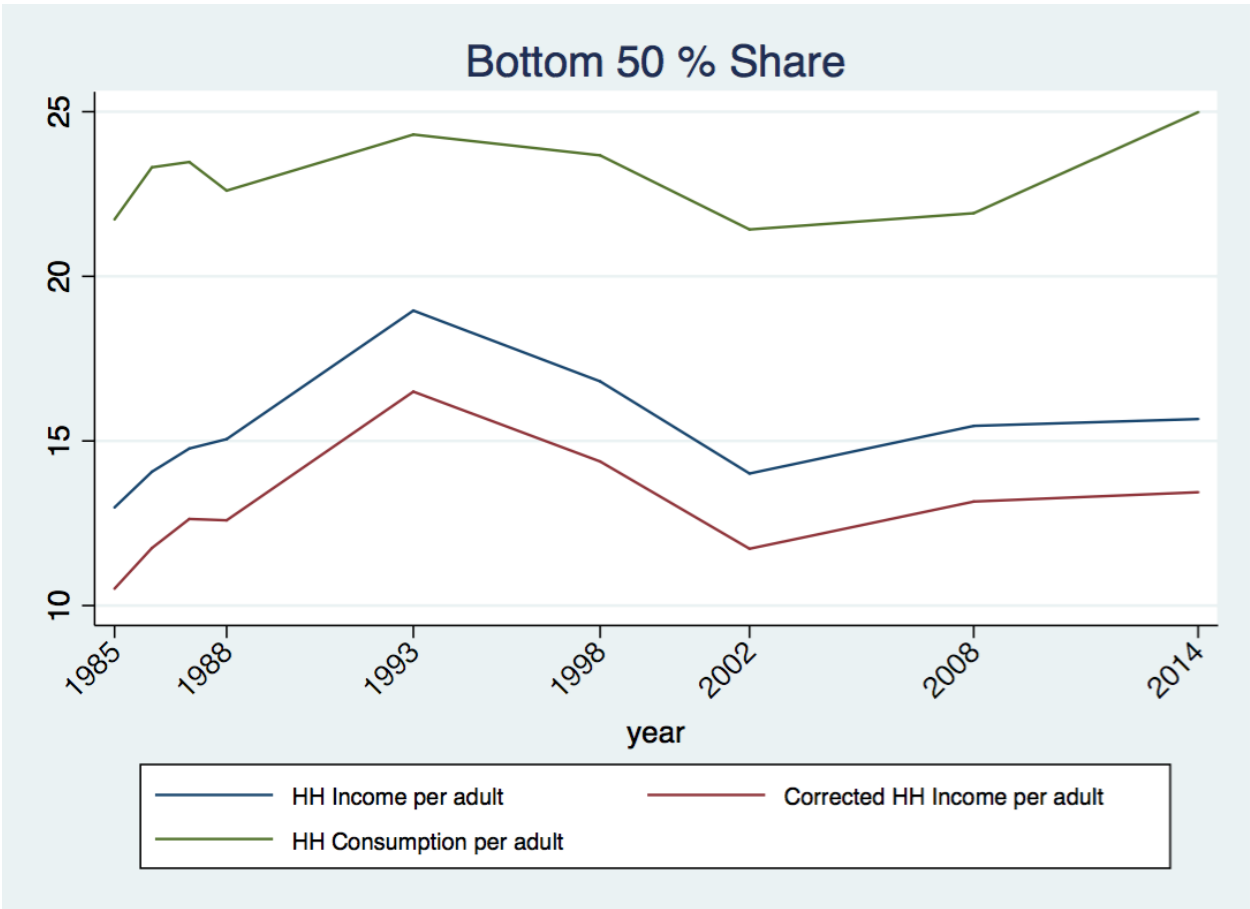
Notes: Authors' elaboration combining 2014 fiscal data and CILSS 1-4; ENV1-5 survey data. The correction we apply for 2014 is described in section 3.1, for previous years, see section 4.1. Income (with and without correction) is pre-tax pre-transfer household yearly income equally split among adults (>20 y.o).

Figure B5: Evolution of Gini coefficients - comparing consumption and income before and after correction

Notes: Authors' elaboration combining 2014 fiscal data and CILSS 1-4; ENV1-5 survey data. The correction we apply for 2014 is described in section 3.1, for previous years, see section 4.1. Income (with and without correction) is pre-tax pre-transfer household yearly income equally split among adults (>20 y.o).
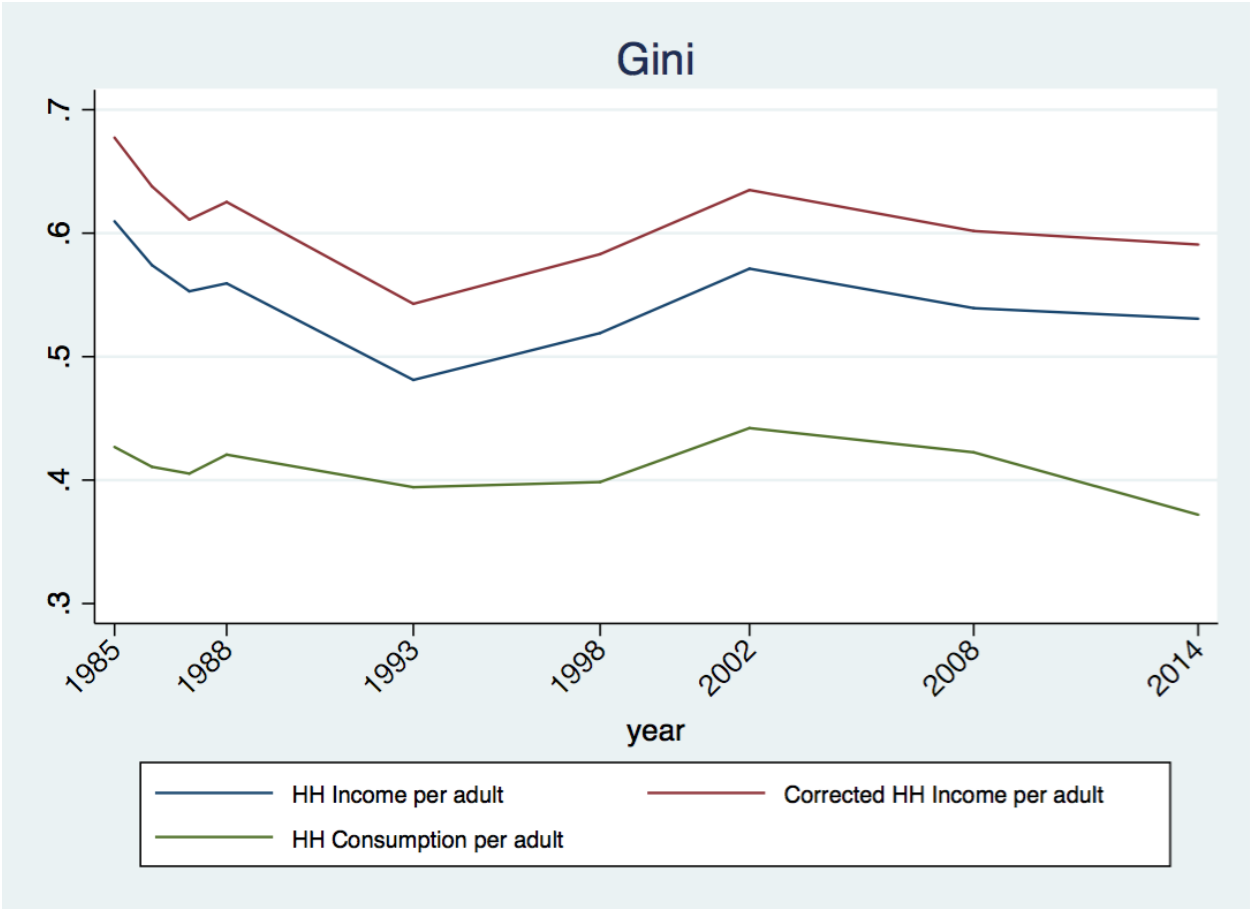
Inequality Statistics - Before and After Correction

		Gini (1)	Top 1 % (2)	Top 10 % (3)	Middle 40 % (4)	Bottom 50 % (5)
1985	Consumption	0.426	7.32	32.59	29.37	21.72
	Income	0.609	18.98	51.34	19.75	12.98
	Corrected Income	0.677	26.58	60.25	16.00	10.51
1986	Consumption	0.410	7.89	32.80	29.36	23.31
	Income	0.574	15.48	45.97	21.80	14.06
	Corrected Income	0.637	22.16	54.49	18.21	11.74
1987	Consumption	0.405	6.52	31.60	30.06	23.47
	Income	0.552	10.46	43.70	22.86	14.76
	Corrected Income	0.610	15.22	51.45	19.55	12.62
1988	Consumption	0.420	8.97	33.10	29.30	22.60
	Income	0.559	14.51	45.66	22.54	15.05
	Corrected Income	0.625	20.86	54.19	18.84	12.59
1993	Consumption	0.394	7.62	31.88	30.27	24.30
	Income	0.481	9.95	37.41	26.66	18.95
	Corrected Income	0.542	15.01	45.14	23.21	16.49
1998	Consumption	0.398	7.56	31.15	30.58	23.67
	Income	0.519	12.10	40.69	25.42	16.80
	Corrected Income	0.583	17.83	48.91	21.73	14.37
2002	Consumption	0.442	10.43	35.02	28.41	21.42
	Income	0.571	14.54	45.07	22.75	14.01
	Corrected Income	0.634	21.04	53.64	19.06	11.72
2008	Consumption	0.422	6.93	31.92	29.98	21.91
	Income	0.539	12.43	41.59	24.64	15.45
	Corrected Income	0.601	18.32	49.89	20.98	13.15
2014	Consumption	0.371	5.87	28.16	32.32	24.98
	Income	0.530	11.57	40.34	25.56	15.66
	Corrected Income	0.590	17.15	48.28	21.91	13.44

Notes : Authors' elaboration combining 2014 fiscal data and CILSS 1-4; ENV1-5 survey data. The correction we apply for 2014 is described in section 3.1, for previous years, see section 4.1. Income (with and without correction) is pre-tax pre-transfer household yearly income equally split among adults (>20 y.o).

Table B2: Population affected and Mean

|	Population share affected by the correction	Percentage increase of the mean after correction	Mean ($2011 PPP)	Income threshold from which starts the correction	(4) as a pct. of the mean	(4) as a pct. of the poverty line
	(1)	(2)	(3)	(4)	(5)	(6)
1985	17	23.46	6334	6822	132	983
1986	17	19.73	5916	7528	152	1085
1987	17	16.93	6242	8105	151	1168
1988	17	19.56	5762	6994	145	1008
1993	17	14.91	3421	4670	156	673
1998	17	16.97	3927	5065	150	730
2002	17	19.49	3672	4658	151	671
2008	17	17.48	3259	4327	155	623
2014	8	17.03	3586	9833	320	1417

Notes : Authors' elaboration combining 2014 fiscal data and CILSS 1-4; ENV1-5 survey data. The correction we apply for 2014 operates at the individual level and is described in section 3.1, for previous years it is implemented at the household level, see section 4.1. Income (with and without correction) is pre-tax pre-transfer household yearly income equally split among adults (>20 y.o). *Reading :* In 2014, the minimum individual income from which we start applying our correction is equal to $9,956 PPP 2011, i.e 3.24 times the overall mean income in our sample before any correction, and 14.35 times the yearly poverty line.

Table B3: Average per Population Share - HH per adult 2011 PPP

		1985	1986	1987	1988	1993	1998	2002	2008	2014
Top 1	Consumption	39427	37897	30194	35485	21399	23198	31434	18784	15615
	Income	94666	63873	54953	69418	29541	39460	44637	34360	35340
	Corrected Income	163630	109460	93528	119319	51178	67997	77169	59466	60932
Top 10	Consumption	18089	15853	15005	13588	9002	9532	10947	8697	7520
	Income	26331	22695	23314	21798	11132	13660	13849	11534	12360
	Corrected Income	38152	3 n2203	32099	30938	15438	19214	19695	16251	17310
Middle 40	Consumption	4111	3571	3644	3040	2164	2377	2243	2073	2168
	Income	2580	2700	3101	2775	2022	2145	1773	1732	1967
	Corrected Income	2580	2700	3101	2775	2022	2145	1772	1731	1979
Bottom 50	Consumption	2544	2356	2295	1901	1406	1497	1379	1217	1352
	Income	1367	1438	1613	1440	1141	1160	874	862	956
	Corrected Income	1367	1438	1613	1440	1141	1160	874	862	956

Notes : Authors' elaboration combining 2014 fiscal data and CILSS 1-4; ENV1-5 survey data. The correction we apply for 2014 is described in section 3.1, for previous years, see section 4.1. Income (with and without correction) is pre-tax pre-transfer household yearly income equally split among adults (>20 y.o).

Figure B6: Annualized Growth Rates by Percentile Groups : 1988-2014
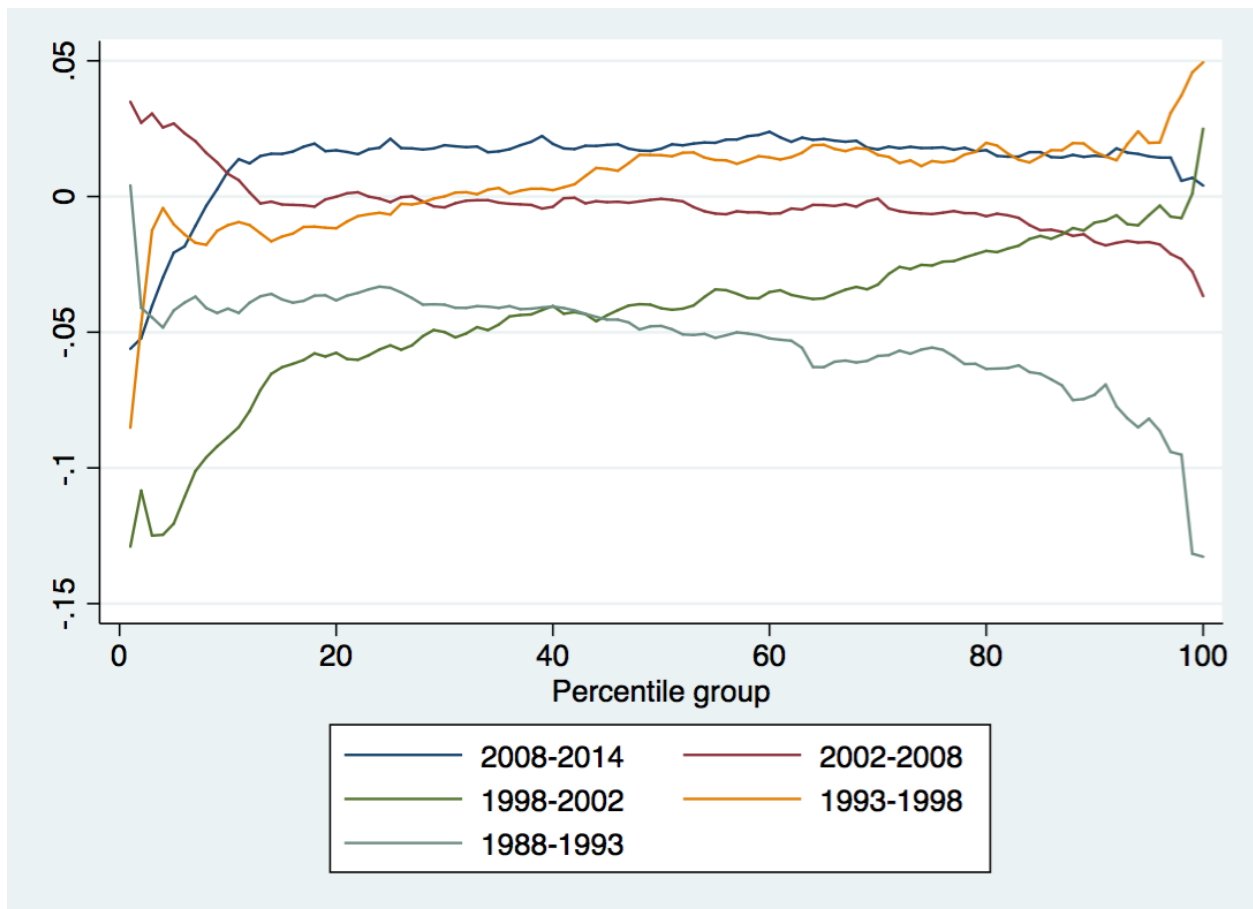
Notes: Authors' elaboration combining 2014 fiscal data and CILSS4; ENV1-5 survey data. Income is pre-tax pre-transfer household yearly income equally split among adults (>20 y.o), after correction.

C   Measurement of Income

Working on the first three waves of the 1985-1987 panel in Côte d'Ivoire, A. Deaton acknowledged that "The measurement of consumption is relatively straightforward [but] the definition and measurement of income is a good deal more complex. [...] The code that generates the income figures is many hundreds of line long, and embodies many difficult decisions, both about conceptual matter, and about likely measurement errors." (Deaton, 1992). In line with this, computing income aggregates was by far the most complex step of our work. The task was all the more difficult as we needed to make the different surveys comparable and avoid related measurement biases. While some difficulties can be overcome, perfect comparability can never be achieved. In this section we provide a detailed description of the methodology we follow to estimate income aggregates in the most consistent way across years.

General Definition

Our variable of interest is pre-tax, pre-transfer household income divided by the number of adults in the household. We therefore do not take into account transfers made to/received from the government/other households. "Adult" is always defined as being 20 or older. The questions regarding income can be split into 5 different categories, following the structures of the questionnaires :

1. **Individual income from main and secondary activities :** This part of the questionnaire details all income retrieved by each member of the household from what they (or the main respondent) identified as their main activity/secondary activities. It is always at the individual level.

2. **Agricultural Income :** This section targets self-employed farmers or sharecroppers. It contains information on income generated by selling agricultural products, and on the cost incurred to generate these profits. It is always at the household level.

3. **Other farming Income :** All income, at the household level, retrieved from selling animal product, hunting, fishing and beekeeping. Cost incurred for such activities are rarely measured.

4. **Auto-production :** Food produced by the household for consumption, valued at market price by the main respondent.

5. **Miscellaneous :** Another section gives the rental income, dividends, *other* income ... The nature and number of components varies from one survey to another, as well as the unit of analysis (it can be household or individual).

From this description, it is clear that the income concept we use should be the sum of at least 1, 4 and 5. Now, producing the food valued in the auto-consumption part should come with some agricultural costs. Agricultural costs are reported in the agriculture section but related to the entire production, part of which is sold and not consumed. If the sum of income reported in part 1 by self-employed farmers or sharecroppers was roughly equal to the net income calculated in part 2, then we could leave the costs of part 2 unaccounted in our calculation. But, in the case that the sum was roughly equal to the gross income of part 2, then we would simply have to subtract the cost of part 2 from total household income. Yet, neither is the case: the sum of individual income reported from self-employed farmers or sharecroppers in part 1 does not match at all the income from part 2, may it be net or gross. In the 2014-2015 survey for instance, about 23 % of the households declaring some agricultural income had a higher income in part 2 than in part 1 (and most of these had actually reported no agricultural income in part 1), 75 % are in the opposite situation, while only 2 % display consistent aggregates. Which information then is most reliable ? Part 2 is very detailed (sales and costs are reported by crop, sometimes by crop × field/individual), but it also known as being very noisy (Deaton, 1997). On the other side it is not clear whether respondents reported net versus gross income in part 1. Finally, to avoid potential double counting, we assumed that agricultural income from part 1 is net, and did not include income from part 2.

Part 3 was designed as a complement, activity specific, section for least regular, but still common, activities. In some surveys (2014 for instance), if one would truly stick to questions about secondary activities, income from hunting, fishing and breeding should already be included in part 1. But the questionnaires were relatively ambiguous here : in a section on employment, respondents were asked about their secondary activit*y*, then later they were asked about income retrieved from their secondary activit*ies*. In some other years (1993 for instance), it is clear that we always consider only 1 secondary activity. The information on the type of secondary activities is insufficient to precisely analyse whether household aggregates in part 1 equal that in part 3. However we take little risk assuming income from part 3 was at best strongly under-reported, at worst not reported at all in part 1. Following this we add it to total income.

Even though there was sometimes a section devoted to income retrieved from non farming enterprises we systematically discarded it from our methodology. First, as for agricultural income, adding revenue streams coming from other self-employed activities would induce some double counting with part 1. Second, even if one would deem such *enterprise section* more reliable to estimate the net income of the self-employed, the questionnaires are too different from one year to another and often not complete enough to allow any sound comparison : in 2014 there was only one question about last month net profit; in 2008, there was no enterprise section; in 2002 the exact amount retrieved for the benefit of the household was reported together with several details about incurred costs; in 1998 there was only one question about total gross profit in the

last 12 months.

Main changes in the general frames

We categorize the 9 households surveys into 4 groups :

1. **1985-1988** : The 1985 survey was actually the first LSMS survey ever made. Unlike the other surveys, main and secondary activities are defined with respect to two time periods : last 7 days and last 12 months. We used the last 7 days period as the reference (much less missing values) and extrapolated it to one year, then completed it eventually with data measured with respect to the activities of the last 12 months.

2. **1993** : This survey stands alone in our series. Income from the main activity comes in brackets (the highest threshold being 500 000 fcfa). Contrary to all other surveys also, only the two main members of the households had to report their income from main and secondary activities. Income from other members were recovered, as a sum, in section F (see Table C3)

3. **1998-2002** : Both surveys are quite similar, 2002 significantly differs from 1998 only regarding the list of agricultural costs, which should not matter given our methodology to compute income.

4. **2008-2014** : The two surveys are a continuation of the frame used for year 2002, aside of 3 important changes. Contrary to all other surveys, questions about miscellaneous income (rents, dividends, interests, pensions ...) were reported at the individual level (before they were summed up for the entire household by the enumerator). The auto-consumption section was also augmented with one question about food given by other households. Last, the question about the main activity was divided into two questions, one about the salary, the other about related bonus or allowances.

Missing values and imputation :

A non negligible share of households had 0 pre-tax pre-transfer income, especially in the most recent surveys (Table C1). To some extent, this could be explained by the fact that some individuals may live only from transfers received from the government and/or from other households and therefore have 0 pre-tax/pre-transfer income. However a significant percentage of the households also had 0 post transfer income. Now, given the structures of the questionnaires, all households should have positive post-transfer incomes unless they live on savings and/or loans. But most households with zero post transfer income also have no loans nor savings. On the other side, their consumption is always positive. Therefore either income or

Survey name, period and sample size

Survey	Period	Sample size (households)	Pct. with no income
CILSS 1	May 85-April 86	1595	1.94
CILSS 2	May 86-April 87	1601	1.18
CILSS 3	May 87-April 88	1600	1.87
CILSS 4	May 88-April 89	1600	1.31
ENV1	April 92-October 93	9600	3.61
ENV2	September 98-December 98	4200	4.21
ENV3	May 02-July 02	10801	7.25
ENV4	June 08-August 08	12600	6.08
ENV5	January-15-March 15	12891	7.69

*Notes :* Household income per adult. Authors' calculation.

loans/savings have been mis-measured. On the income side : this inconsistency could be the illustration that some respondents are less reluctant to report their expenditures than their income (as discussed in section 3.3). Otherwise the inconsistency could be attributed to weaknesses of the questionnaires in terms of measuring savings and especially loans. Respondents are asked *how much* they could save by the end of last year, but when banking services are rare, savings could take non-monetary forms such as investment in livestock. Besides, the section devoted to loans is always very modest, and the main question often consists in a simple "Have you contracted any loan in the last 12 months ?". Phrased as such, we fear that the question might have induced some respondents not to declare less formal loans, through which they simply borrowed money to neighbors or relatives. As shown in section 3.3, the bottom 60 % of the population is much poorer in terms of income than in terms of consumption, a discrepancy which cannot be attributed only to negative savings. Considering all this, we decided to use consumption as a proxy for income, whenever income is null.

Outliers :

We removed observations whose total income was greater/lower than the average total income by at least 4 standard deviations. For the year 2008 and 2014, we also performed an additional trimming step prior to the one on total income. We apply this special treatment due to the difference in reporting options. Indeed, to declare their income from main and secondary activities, as well as from each other income of the so called "miscellaneous" section, in 2008 and 2014 respondents were asked : "How much did you get from [income source] in the last 12 months ?"; and had to answer something of the form : "[some amount Y] per [some period X]", where the period could be :*day, week, month, trimester, semester* or *year*. To then scale it up to a yearly income, we had to multiply Y by some factors depending on X (253 for days, 52 for weeks, 12

for months ... and 1 for year). Inevitably, such design yields a correlation between annualized income and time period (see Figure C1). This pattern is less salient in previous surveys, as they use somewhat different methodology. Miscellaneous incomes were declared at the household level and most importantly neither "day", nor "week" were optional periods. As for the main and secondary activities : in the 1985-1988 surveys very few respondents answered "day", in 1998-2002 answering "day" was not even an option, and in 1993 information about total work duration over the last 12 months were available and sufficiently consistent to calculate yearly income in a finer way. For the year 2008 and 2014 only, we therefore trimmed each income component separately. This led to very few deletions (9 observations in total for 2008 and 8 for 2014). Further, we replaced all income figures whose average recalling period is "day" and whose estimated log of annualized income is 2 standard deviations higher than the mean, by the $Y \times 104$ (instead of $Y \times 253$).

Figure C1: Correlation between time unit chosen by respondents and annualized earnings
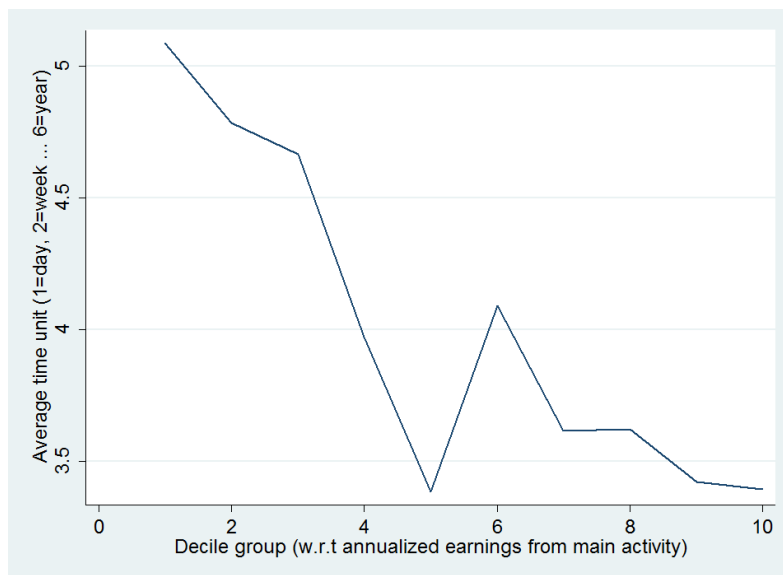
Notes: To estimate yearly earnings from their main activity, respondents reported how much they earn per day, week, months, trimester, semesters or year. Here we plot decile average time unit declared (given that 1=day, 2=week ... 6= year) with decile average annualized earnings.

Table C2: Income Component for the year 1985-1988

Main activity	Main act. of the last 7 days : Sect. 5B1-3. Q10 (salary), Q21-31 (bonus, allowances and in-kind benefits) Main act. of the last 12 months : Sect. 5E1-3. Q11 (salary), Q21-31 (bonus, allowances and in-kind benefits)
Secondary activities	Sec. act. of the last 7 days : Sect. 5C1-2. Q9 (salary), Q12 (other income), Q20 (all other inc. from other act.) Sec. act. of the last 12 months : Sect. 5G1-2. Q10 (salary), Q19 (all other inc. from other act.)
Miscellaneous income	Sect. 14A : Q201-217 : social grant, pension, unemployment benefits, medical insurance, dividends, interests, scholarships, gifts, inheritage, lottery gain, rental income, other
agricultural	Sect 9B : Q5 (sales), Sect. 9E : Q501-510 (derived product) Sect 9D : Q3 (seeds), Q9 (fertilizer), Q15 (manure), Q20 (insecticide), Q26 (transport), Q30 (bags), Q36 (stocking), Q39 (labor), Q41 (other input)
Farming	Sect 9F : Q8 (selling animals); Sect. 9G : Q301-305 (derived products); Sect 9J : Q201-Q210 (cost from breeding)
Auto Consumption	Sect 12B : Q501-532 (daily price of auto-consumed food)

Notes : Authors' elaboration.

Table C3: Income Component for the year 1993

Main activity	Sect. 4 : Q3 (salary, bonus, in-kind benefits and other) Top coded brackets, only to the 2 main members
Secondary activities	Sect. 4 : Q12 (all income) only to the 2 main members
Miscellaneous income	Sect 9 : Q101-114 : breeding products, occasional hunting or fishing, other salaries, rental income, monetary and non-monetary help from other households, social transfers (pension, insurance, scholarships) other
Agriculture	Sect 6D1 : Q8 (sales) Sect. 6B : Q4 (labor cost)
Farming	Sect 6 : Q7 (selling farm animals), Q11 (veterinary cost), Q14 (selling fish), Q16 (auto-consumption of fish)
Auto Consumption	Sect 8H123 : Q801-822 (daily price of auto-consumed food)

Notes : Authors' elaboration.

Table C4: Income Component for the year 1998

Main activity	Sect 1B4 : Q67 (salary)
Secondary activities	Sect 1C : Q12 (salary)
Miscellaneous income	Sect. 6 : other breeding products, occasional hunting or fishing, other agricultural product, other salaries, rents, monetary and non-monetary help from other households, transferts (pension, insurance etc ...), other
Agriculture	Sect 3B2 : Q8 (sales), Sect 3B1 : Q11 (cost labor)
Farming	Sect 3A : Q8 (selling farm animal), Q10 (cost of breeding), Q13 (auto-conso farming product). Sect 3B1 : Q2 (selling fishes), Q4 (auto-conso fish), Q6 (sales from hunting), Q8 (auto-conso hunt)
Auto Consumption	Sect H: Q9 (daily price of auto-consumed food)

Notes : Authors' elaboration.

Table C5: Income Component for the year 2002

Main activity	Sect 2B2 : Q26 (salary)
Secondary activities	Sect 2C : Q12 (salary)
Miscellaneous income	Sect. 6 : Q201-213 : other breeding products, occasional hunting or fishing, other agricultural product, other salaries, rents, monetary and non-monetary help from other households, transferts (pension, insurance etc ...) other
Agriculture	Sect 3B2 : Q8 (sells) Sect 3B1 : Q16 (labor cost) Q18-23 (cost from fertilizer, insecticides, seeds)
Farming	Sect 3A : Q8 (selling farm animals), Q12 (conso derivate prod). Sect 3B1 : Q2 (sell fish), Q4 (conso fishing), Q6-9 (beekeeping), Q11 (sell hunt), Q13 (conso hunt)
Auto Consumption	Sect G: Q10 (daily price of auto-consumed food)

Notes : Authors' elaboration.

Table C6: Income Component for the year 2008

Main activity	Sect F : Q1 (salary), Q2 (other inc)
Secondary activities	Sect F : Q3 (all inc)
Miscellaneous income	Sect F : Q4-11 (pension, rent, dividends and interests, official grants monetary and non-monetary help from other households, other)
Agriculture Income	Sect K : Q7 (sales) Sect K : Q19-22 (labor cost, fertilizer, insecticide, seeds)
Farming	Sect EB : Q3 (fish sales), Q4 (auto-conso fish), Q10 (hunt sales) Q11 (auto-conso hunt). Sect J : Q8 (sales of farm animal), Q13 (auto-conso animal prod), Q15 (sales animal product)
Auto Consumption	Sect L: Q10 (daily price of given food), Q15 (daily price of auto-produced food)

Notes : Authors' elaboration.

Table C7: Income Component for the year 2014

Main activity	Sect I : Q1 (salary), Q2 (other income)
Secondary activities	Sect I : Q3 (all inc)
Miscellaneous income	Sect F : Q4-11 (pension, rent, dividends and interests, official grants monetary and non-monetary help from other households, other)
Agriculture	Sect H : Q26 (sales) Sect H : Q20 (cost of seeds, fertilizer, pesticides)
Farming	Sect G : Q10 (net sales farm animal), Q12 (net sales farming product), G15 (fishing), G18 (beekeeping), G21 (hunting), G24 (drinks making)
Auto Consumption	Sect M: Q18 (daily price of given food), Q13 (daily price of auto-produced food)

Notes : Authors' elaboration.