How information on minimum and maximum food prices affect measured monetary poverty ?

Evidence from Niger[1]

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Abstract

Does households facing an interval of prices rather than a simple price changes the perspective in poverty analysis? To deal with that question, we exploit a unique dataset from Niger in which agro-pastoral households state the *minimum and the maximum price* they have paid for each consumed product in each season. We estimate poverty measures based on these alternatives price information and several absolute poverty line methodologies. Prices are used for valuing household consumption bundles, estimating household-specific price indices, valuing minimal calorie requirements, and extrapolating food poverty lines to the whole consumption.

The results in Niger show statistically significant differences in the estimated chronic and dynamic poverties with these alternative approaches, especially for international poverty comparison and seasonal transient poverty monitoring. In particular, using in turn minimum and maximum prices generates gaps in the estimated poverty rates for Niger agro-pastoralists that exceed regional poverty disparities. This implies that regional targeting priorities in poverty alleviation policies would be reversed by using these alternative prices.

This suggests that typically estimated poverty statistics, which assume that each household, or even cluster, faces a unique price for each product at a given period, may be less accurate for policy monitoring than usually believed.

Keywords: Poverty, Prices, Niger, Social Policies.

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1. Introduction

Price deflation is a major component of the analyses of living standard and poverty in developing economies, and elsewhere. This is notably the case in countries for which spatial and time price differences that households face can be substantial. In this context, pioneer authors[2] stressed that accounting for price differences is essential in assessing deprivation and wealth, especially for the poor. Price discrepancies are typically corrected by dividing household income or household total consumption by price indices. In this work, we examine an issue that has been much overlooked in the literature: the fact that any given household can, on the top of this, face an interval of prices for the same product at the same period, instead of a unique price. Does this change the perspective in poverty analysis ?

Spatial and time price differences have been scrutinized in the literature. Focusing on price differences in Rwanda for several seasons, Muller (2002) exhibited substantial spatial price differences, and price discrimination against the poor, even in a small rural country. The poor may sometimes be relegated in areas remote from market places, hence with higher prices. Instead, they may consume lower quality products, and hence appear to pay lower prices in data insufficiently accounting for parities. However, Muller (2005) shows that, under weak association of prices and nominal living standards, price dispersion should be globally beneficial to social welfare, thanks to the shape of the price deflation in living standard indicators. On this ground, neutral price dispersion across households could reduce aggregate poverty. A consequence of these conflicting

[2] Such as Sen (1981), Pinstrup-Andersen (1985) and Stern (1989).

mechanisms is that the effect of price correction on poverty is theoretically ambiguous and stands as an issue to be decided empirically.

Deflation has been found to be crucial in estimating poverty lines and poverty indicators, with special attention devoted to rural-urban price gaps[3]. Purchasing power parities within countries have been particularly studied in large countries[4] and found to substantially influence poverty assessment. Even for smaller countries, precise spatial deflators have been found to matter for poverty analysis (e.g., in Vietnam, Gibson et al. 2016). Typically, in these absolute poverty studies, food Engel curve adjustments are used to convert a minimal calorie requirement into a poverty line level that can be compared to household total consumption expenditure, or to income, in distinct places and periods. This raises the question of how price data affect the estimation of poverty statistics, including through this poverty line estimation method. Not correcting precisely enough for price dispersion generally leads to biased estimates of chronic and transient poverty. For example, sizable biases have been found to emerge from seasonal and geographical price gaps across households in Rwanda (Muller, 2008).

Unfortunately, accurate seasonal and local price information is rarely available. However, when such price information can be obtained, this can improve poverty alleviation policies, for example for focused anti-poverty transfer schemes as they were introduced by Muller and Bibi (2010) for Tunisia with living standards deflated by estimated true price indices. In that case, more precise price

[3] See Black (1952), Ravallion and Bidani (1994) and Rao (2000).
[4] E.g, in India and China, by Deaton and Dupriez (2011), Majumder et al. (2012), Li and Gibson (2014).

information can enhance the targeting efficiency of social policies and save on social funds.

However, an issue with price correction in poverty analysis is that a household may pay different prices for the same product at the same period. These differences may correspond to differences in qualities of products, which can, or not, be taken into account by the used estimation methods. These 'intra-individual' differences may also emerge from the social relationship between buyers and sellers that would incite some of them to adjust the asked or given price in favor or in detriment to their transaction partner. Furthermore, the prices can vary with the timing of the transaction during the market day, with sellers readier to offer bargains at the closing time of the market. Besides, buyers and sellers may learn about prices during the day, and they may make mistakes. Other transaction costs, such as for bulk purchases, transport, or packaging cost, or purchases in distinct days, may contribute to idiosyncratic price dispersion. These individual-specific price differences may finally be generated by other unobserved reasons. In all these cases, rather than a unique price for a given product at a given time, each household faces an interval of prices, empirically bounded by a minimum price and a maximum price. Significant variations in the mean prices paid by different buyers, and even the same buyer, have been found in studies of specific markets, such as for the Marseille fish market, which suggests that the notion of unique price may sometimes be misleading (Kirman, 2010, Chapter 3).

In developing countries, for which market price data are rarely available, observations of unit-values are often used to proxy prices. A unit-value is a ratio of value over quantity for a given good, calculated from records of purchases of this

good in a household survey. Sophisticated estimation methods, for example for demand systems, have been developed to account for household choices of varieties, often of different qualities, involved in the unit value data, starting with Deaton (1987, 1988). [5] The simplest of these methods use the spatial location to identify price variability, which may be a strong assumption if there are local, and even individual, dispersions in prices. Moreover, purging the quality choice by households also throw over the information about price dispersion that each given household may face.

Whatever the source of these individual-specific price dispersion – quality choice, social relations, transaction constraints or mere randomness, the question of the impact of the gap between minimal and maximum prices paid by the same household remains. If this impact is large, this may change the way price deflation is considered in social welfare and poverty analysis and policy. If it is small, this has to be known to remove concerns about it, and better establish the analysis methods.

Does this residual price dispersion, possibly occurring for each individual separately, affects poverty measurement? The aim of this study is to investigate this question in the case of agro-pastoral households in Niger. Using alternatively information on maximum and minimum food prices, may potentially generate a substantial interval of (partially identified) poverty estimates. To the best of our knowledge, this is the first time these issues are tackled with precise economic and statistical methods.

[5] See also Deaton (1990, 1997), Crawford, Laisney and Preston (2003), Ayadi et al (2003).

In Niger, Backiny-Yetna et al. (2017) found that the collection method, particularly the recall period used for the survey, may generate significant gaps in poverty measurement. We complement this local interest in observation issues by turning our attention to the interval of individual prices used for poverty measurement. Our study is based on a unique dataset from Niger in which agro-pastoral households state the minimum and the maximum prices they have paid for each food product that they consumed. Using these data, we estimate poverty by considering three alternative poverty lines (and three associated real living standard variables): The World Bank international poverty line of 1.90 PPP US $ a day, an absolute poverty line based on a minimal calorie requirement and minimum prices, and a similar poverty line based on maximum prices instead. Using the 1.90 dollar a day poverty line will bring a complementary perspective on how international poverty lines that mostly account for country price difference perform when compared to more precise cost-of-basic-needs methods that account for within-country price differences, and here even accounting for the interval of prices faced by any individual. All these variants are extended to chronic and transient poverty measures across seasons.

Our results will exhibit statistically significant differences in poverty levels measured with these three approaches. The found gaps in poverty that are caused by using minimum instead of maximum prices are considerable with the international poverty line that is typically used for international poverty comparisons. They are also substantial for seasonal transient poverty, even with the estimated absolute poverty lines based on nutritional basic needs. In that case, the impact of using one type of prices rather than the other is small for annual or

chronic poverty. However, these changes remain large enough to reverse the North vs South targeting priority in poverty alleviation policies that would be derived from estimated poverty profiles. Therefore, at least in the studied case, the usually estimated poverty statistics, which overlook price intervals for each household, and consider that each household, or cluster, face identical and uniform prices, may be misleading , for some typical poverty analyses. Moreover, using the 1.90 dollar a day poverty line not only produces a clearly distinct picture of poverty, but also of the consequences of the price interval. In that case, poverty estimated with maximum prices is about one tenth lower than poverty estimated with minimum prices, which is substantial.

The rest of the paper is organized as follows. In Section 2, we present the context of Niger and the data used. Section 3 discusses the methods used to compute the poverty indices. Section 4 reports the estimation results. Finally, Section 5 concludes.

2. Context and Data

Niger is a large landlocked country with a population of 17 million in 2014. The country's economy is essentially based on agriculture (40 per cent of GDP), with a large contribution from the livestock sector (11 per cent of GDP, Ministère de l'Elevage, 2016). As a matter of fact, the livestock sector is a mainstay of the country's economy, since 87 per cent of the population is involved in this sector as a primary or secondary activity. Moreover, 10 per cent of rural households' income, and up to 43 per cent for households in pastoral zones, directly come from livestock.

In a survey conducted in 2011 by the National Institute of Statistics in Niger on living standards and agriculture, 77 per cent of the 4,000 households interviewed raised livestock as a source of income or to compensate for low agricultural income. However, agro-pastoral households are far from being the poorest in Niger, as noted for example in Gueye et al (2008). In particular, they have generally been able to preserve at least part of their animal capital, sometimes over several drought periods.

Nonetheless, raising cattle and sheep is not enough to lift these households out of poverty. Between 2008 and 2013, on the basis of their income or expenditure levels, up to 30 per cent of the pastoral and agro-pastoral populations have been considered to be "very poor", 30 percent "poor", 20 per cent "middle" and 20 per cent to be "better-off" by Haan (2016).

The data used is taken from a specialized survey collected by the Ministry of Livestock in Niger. This survey was conducted in the framework of two development projects in Niger: The "PRAPS: Projet Régional D'appui au Pastoralism au Sahel", and the "PASEL: Programme d'Appui au Secteur de l'Elevage". We have access to the first round of this survey which was conducted in October 2016 and is the only round useful for our purpose. The survey covered all the seven regions of the country. 90 villages were first selected proportionally to their size. Then, within each of these villages, pastoral and agro-pastoral households were drawn randomly. We first truncate the sample to eliminate urban and peri-urban households that do not really fall into our population of interest : the true pastoral and agro-pastorale households. The excluded households are often too rich for being included in estimations of nutrient subsistence minima and

of consumption habits of the poor. Most excluded households do not produce milk and live in urban communes of Dosso region. We checked that, once controlled for peri-urban characteristics, this truncation step does not significantly affect the balance of the sample across regions, and cattle sizes.

After cleaning and removing obvious outliers in household's caloric consumption, total expenditures, and food prices, we end up with 671 observations. Our sample is mainly (more than 85 per cent) composed by households who owns cattle and sheep. Appendix 7 provides details on how these variables are calculated.

The surveyed households were asked about their socio-demographics characteristics, budget, food consumption, agro-pastoral activities, and crucially the minimum and maximum prices they face individually for each food product at each season. Specifically, in order to obtain the minimum price paid by a household during a given season s for a given product p, the following question was asked: "*During season s, what is the lowest price at which you bought product p?*". For the maximum price, the corresponding question was: "*During season s, what is the highest price at which you bought product p*?". The collected price[6] information reflects the instability of price at some periods when they can vary for each day or each week. This price instability, especially for cereals, is partly related to the seasonality of production. Araujo et al (2012) have shown that for Niger, Mali and Burkina Faso, cereal price fluctuations are a determining factor in the prevention of food crises.

This detailed information on the food prices faced by each household enables us to compute household's food expenditure using alternatively the minimum and

[6] The information collected are prices paid by households in the market and not unit values.

maximum prices collected at household level. However, mean, or median prices cannot be computed for each household from these data.

The individual price indices are constructed by using the same price information than the one used for computing the nominal living standards. That is: minimum prices, and alternatively maximum prices, are used to calculate both variables. Therefore, the measure of the real living standard variables depends on the chosen price information in a complex fashion that may be less elementary than a mere normalization by a typical price index based on village-level mean prices.

The estimate of the caloric price, for calculating the food poverty line will also depend on choosing to use minimum prices versus maximum prices. Moreover, as we will discuss later, the extrapolation step in the estimation of the absolute poverty line, which is driven by a food Engel curve estimation, may generate an additional wedge between the poverty statistics based on the two kinds of different price information, notably when prices are included as regressors in the Engel curve equation.

Finally, we construct the price and living standard indicators not only at the year level, as is customary for poverty statistics, but also separately for three distinct seasons. This mitigates the cases of observed minimum and maximum prices for the same product that would correspond to far apart prices.

By convention in the questionnaire, three seasons have been distinguished. The hot and dry season lasts from March to June; the rainy season begins in July and ends in October; finally, the dry season ranges from November to February. Most

harvests take place between October and December. Of course, these patterns can fit more or less well the diverse local circumstances in such large country.

The hot and dry season and the rainy seasons are both lean seasons for the agro-pastoralists. The hot and dry season negatively affects their livestock activity, while the rainy season is a planting period with empty cereal stocks. During the hot and dry season, agro-pastoralist households are confronted with a lack of pasture and water for their animals, resulting in weight loss and lower market value. However, four fifth of their total consumption is still made of food at this time in the year.

In the rainy season, agro-pastoralist households work on their fields, and they progressively exhausted their cereal stock. Moreover, even if the first rains in this season benefit animals, some of the mentioned negative effects of the hot and dry season may persist in the rainy season. The market value of animals may not be sufficient to buy enough cereals, which are costly in that period. Food account for 87 per cent of total consumption, almost as much as the 86 per cent in the cold and dry season. Finally, the strong seasonality of food prices is well acknowledged, in particular for millet for which recurrent price spikes have been studied (Araujo-Bonjean and Simonet, 2016)

3. Food Expenditure and Food Prices

This study is based on a unique survey for which, for each of the consumed food products, each surveyed household stated the lowest and highest prices at which it had bought them, and this for the three seasons of the year. However, as in most consumption surveys, price information was occasionally missing for some products consumed by some households. In that case, we applied an imputation algorithm to replace them with median values of prices observed at the closest geographical levels (see the Appendix for details).

Moreover, for some households and some products, the stated minimum and maximum prices are identical. Table 1 indicates the proportions of these households, for each product used to construct the price index and by season. The proportions range from 1 per cent (cowpea in the hot and dry season) to 60 per cent (tobacco) per cent depending on the product and the season. Although these proportions are high for some products in some seasons, it is fair to say that, overall, and for a high proportion of households, the stated minimum and maximum prices differ, and this for all seasons. During the cold and dry season, for ten of these products, more than one third of households state a unique price; this is the case for seven products in the hot and dry season; while, only for five products in the rainy season. Additionally, these data do not obviously suggest that the occurrence of the differences between minimum and maximum prices would come from quality differences. Finally, household price dispersion is supported by the results of a survey conducted by the Institut National de la Statistique (2015) that show that, in each of eight[7] regions of the country, the respondents hugely

[7] Seven regions (Agadez, Diffa, Dosso, Maradi, Tahoua, Tilabéri, and Zinder) plus Niamey, the capital.

vary in their assessment of price changes for cereals. These responses are hard to reconcile with the usual fiction of a unique price, at village level at least. In these conditions, it seems clear that the so far overlooked issue of individual-specific price dispersion should be taken seriously.

Table 1: Percentage of Households with Identical Minimum and Maximum Prices

Products	Cold and dry season	Hot and dry season	Rainy season
Millet	26.53	16.39	8.94
Sorghum	17.88	19.67	6.26
Cowpea	31.15	1.04	2.53
Maize	49.18	14.75	25.19
Groundnut	30.25	49.03	71.39
Butter	59.17	59.02	42.32
Kola nut	23.40	11.17	9.24
Okra	7.45	25.48	25.63
Oil	33.83	28.02	21.01
Fresh milk	42.92	42.62	30.10
Curdled milk	15.05	48.29	15.35
Bread	41.13	41.13	41.13
Edible pasta	24.74	25.04	7.15
Fish	42.03	42.03	42.03
Sugar	15.80	14.61	27.27
Tobacco	36.36	59.91	21.76
Tea	17.59	9.69	9.99
Condiments	34.28	33.68	23.99
Meat	27.42	28.46	21.61
Poultry	23.25	4.92	23.85

The seasonal means of these minimum and maximum prices values are presented in Table 2. The mean gap between the minimum price and the maximum price (see Diff column) greatly varies from one product to another, and from one season to another for the same product. For most products and seasons, this gap is significant. In the cold and dry season, for 8 products out of 20, the gap exceeds 100 CFA per kg or per liter, compared to 11 products in the hot and dry season and 12 products in the rainy season, that satisfy the same conditions. Broadly, the products with the greatest relative gap between minimum and maximum prices are : sorghum, okra, cowpea, fresh and curdled milks, fish, tobacco, meat, and poultry. In contrast, maize, butter, and kola correspond to products with the smallest gaps.

Moreover, for some products this gap varies much according to the season, while for others, even when huge, it is stable across seasons as for meat. For millet or maize, the difference between the maximum and minimum price can vary by three to four times from one season to another (e.g. ,for millet, from 15 CFA/kg in the cold dry season to 54 CFA/kg in the rainy season).

Table 2 : Mean Seasonal Prices (CFA)

Products	Cold and dry season				Hot and dry season				Rainy season			
	N	Pmax	Pmin	Diff	N	Pmax	Pmin	Diff	N	Pmax	Pmin	Diff
Millet (kg)	671	246.4 (.639)	230.5 (.643)	15.9 (.907)	671	239.1 (.310)	211.7 (.080)	27.4 (.320)	671	268 (.545)	213.3 (.076)	54.7 (.550)
Sorghum (kg)	671	187 (.080)	163.8 (.069)	23.2 (.105)	671	227.9 (.383)	208.9 (.383)	19 (.542)	671	230.3 (.077)	210.1 (.068)	20.3 (.103)
Cowpea (kg)	671	342 (.289)	309.8 (.256)	32.2 (.387)	671	361.8 (.416)	318.6 (.259)	43.2 (.491)	671	378.9 (.234)	333.3 (.196)	45.6 (.306)
Maize (kg)	559	197.6 (.083)	188 (.068)	9.6 (.108)	671	244.6 (.161)	227.5 (.079)	17.1 (.180)	559	242.2 (.324)	217 (.078)	25.2 (.334)
Groundnut (kg)	470	440.5 (.290)	390.9 (.286)	49.6 (.408)	470	472.9 (.161)	383.4 (.200)	89.5 (.257)	470	604.5 (1.21)	470.5 (.245)	134 (1.23)
Butter (kg)	402	1301.4 (.714)	1024.2 (.377)	277.3 (.807)	275	1563.9 (1.37)	1157 (.755)	406.9 (1.57)	387	1309.8 (.936)	1002.9 (.908)	306.6 (1.30)
Kola nut (kg)	630	561.2 (2.36)	506.7 (2.25)	54.4 (3.27)	630	501.1 (1.90)	377.5 (1.45)	123.6 (2.39)	630	590.6 (2.35)	451.3 (1.80)	139.2 (2.96)
Okra (kg)	630	967.5 (1.03)	781.5 (.89)	185.9 (1.37)	630	1075.7 (1.27)	938.7 (1.07)	136.9 (1.66)	503	1161 (1.88)	984 (1.58)	177 (2.46)
Oil (l)	671	869.6 (.641)	802.6 (.466)	67.1 (.792)	671	882.5 (1.23)	779.2 (.477)	103.2 (1.32)	671	902.6 (.908)	803.8 (.469)	98.8 (1.02)
Fresh milk (l)	514	362.3 (.470)	288.9 (.202)	73.4 (.512)	514	455.1 (.348)	334.8 (.278)	120.3 (.446)	597	417.1 (.273)	296.5 (.177)	120.7 (.325)
Curdled milk (l)	630	312.5 (.941)	235.8 (.647)	76.7 (1.14)	597	373.71 (2.28)	343.1 (2.28)	30.6 (3.23)	630	453 (4.48)	310.5 (2.26)	142.4 (5.02)
Bread (kg)	630	350.8 (.330)	304.9 (.311)	45.9 (.453)	630	394.5 (.510)	342 (.485)	52.5 (.704)	630	378.6 (.464)	331.4 (.404)	47.3 (.615)
Pasta (kg)	671	520.8 (.369)	467.1 (.318)	53.7 (.487)	671	522.4 (.371)	468.8 (.319)	53.6 (.489)	671	526.3 (.359)	469.4 (.320)	56.9 (.481)
Fish (kg)	559	1299.5 (1.69)	1080.6 (1.45)	218.9 (2.23)	559	917.1 (1.45)	774.2 (1.14)	142.9 (1.85)	518	1306.4 (2.15)	1110.7 (1.87)	195.7 (2.85)
Sugar (kg)	671	617.8 (.472)	555.7 (.428)	62.1 (.637)	671	602.5 (.456)	541.1 (.420)	61.4 (.620)	671	632.1 (.625)	570.9 (.414)	61.2 (.750)
Tobacco (kg)	638	2012.9 (3.54)	1665.8 (2.60)	347.1 (4.40)	638	1971.7 (3.37)	1767.4 (2.50)	204.3 (4.20)	638	2994.6 (5.71)	2520.9 (4.47)	473.7 (7.26)
Tea (kg)	671	1018.6 (2.65)	883.1 (2.07)	135.5 (3.36)	671	1089.3 (2.49)	907.5 (1.97)	181.9 (3.18)	671	1078 (2.08)	942.7 (1.92)	135.3 (2.83)
Condiments (kg)	671	1014.4 (2.22)	880.9 (1.68)	133.5 (2.79)	671	1040.9 (2.07)	924.8 (1.78)	116.1 (2.73)	671	1046.8 (2.03)	914.1 (1.74)	132.7 (2.68)
Meat (kg)	671	1932.3 (2.09)	1560.9 (1.52)	371.5 (2.58)	671	1958.6 (2.03)	1713.7 (1.72)	244.9 (2.67)	671	1981.8 (1.87)	1730.6 (1.68)	251.2 (2.52)
Poultry (kg)	638	2100.7 (2.58)	1513.7 (1.37)	587 (2.92)	638	1987.8 (2.57)	1441.7 (1.34)	546.1 (2.90)	638	2123 (2.45)	1527.6 (1.32)	595.4 (2.78)

Notes : Pmin=Minimum price, Pmax=Maximum price. Values in parentheses are standard errors. The values presented in this table are means weighted by the sample weights.

The significant differences observed between the maximum and minimum food prices faced by the same household generate a corresponding gap in the valuation of food expenditure. In Table 3, mean food expenditure per adult-equivalent, evaluated at maximum prices, is respectively in the cold and dry, hot and dry and rainy seasons, 14, 14.3 and 24.6 per cent greater than that evaluated at minimum prices. Over the year, on average, the measured consumption increases by 17 per cent as minimum prices are substituted with maximum prices.

Table 3: Nominal Food Expenditure, and Laspeyres Food Price Index under the Alternative Prices

Variables	Prices	Cold and dry season (N=671)		Hot and dry season (N=671)		Rainy season (N=671)		Year (N=671)	
		Mean	Std	Mean	Std	Mean	Std	Mean	Std
Food expenditure (CFA/day/adult-equivalent)	Pmax	588.82	1223.70	509.71	892.87	639.14	1139.39	579.23	960.55
	Pmin	527.21	1144.21	455.53	869.19	520.26	971	501	896.13
	R.Diff	.140	.209	.143	.458	.246	.794	.173	.303
Food Price Index	Pmax	1.00	.504	.977	.258	1.017	.595	.921	.701
	Pmin	1.01	.529	.986	.211	1.00	.230	.917	.674
	R.Diff	.001	.092	-.009	.164	.008	.501	.015	.270
Real Food expenditure (CFA/day/adult-equivalent)	Pmax	583.51	1390.77	530.81	1106.76	656.73	1423.58	768.07	1957.05
	Pmin	509.41	1228.75	466.51	1032.36	535.98	1253.65	665.28	1722.24
	R.Diff	.137	.102	.145	.206	.230	.186	.161	.117

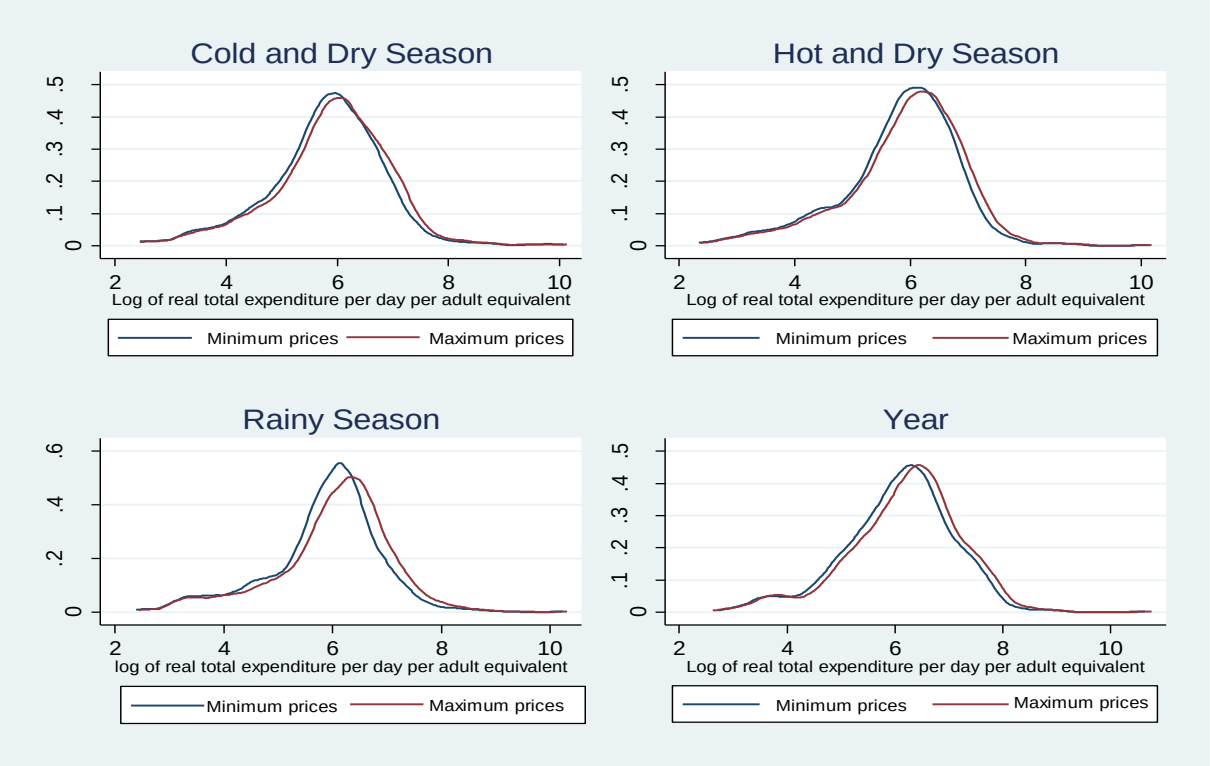
Note: See Appendix 7 for details on how the adult equivalent scale is calculated. The mean values presented in the table are sample means. The three seasonal food expenditure are summed up to obtain its annual value. The base of the seasonal food price indexes is the mean national price of the corresponding season. The annual food price index is computed using the weighted average of seasonal food prices, where the weights are the quantity of food consumed by the household. As for seasonal food price indices, the base of the annual food price index is the national average price of the year. Pmin=Minimum prices, Pmax=Maximum prices, R.Diff= Relative Difference between maximum and minimum prices.

Figure 1 presents the estimated densities of the log of living standards variables, yearly, and at each season, calculated with minimum and maximum prices. It seems fair to say that the shifts in these curves caused by changing the kind of price used do not seem dramatic. However, this is partly due to the logarithmic transformation that dampens income differences.

The Laspeyres food price index is also slightly sensitive to the choice of using minimum or maximum prices. However, due to the national average used as the

index base, the mean price index changes by less than one half percent when substituting minimum prices by maximum prices, at each season. We now turn to the estimation of poverty measures.

Figure 1: Density of the Real Total Expenditure per Day and per Adult-Equivalent (Epachenikov kernel estimator)



4. Results

We first examine poverty estimates for the whole year and based on the $ 1.90 a day international poverty line, then yearly and seasonal poverty estimates based on the estimated cost-of-basics-needs poverty lines.

4.1. Poverty estimates with the World Bank international poverty line

The current World Bank international poverty line is $ 1.90 per day per capita at the 2011 purchasing power parity (Jolliffe and Beer Prydz, 2016). This poverty line

is equivalent to 3.08 $ per adult-equivalent per day in our case[8]. It is applied to all regions of the country that are regrouped in two larger regions: the North and the South. The North is formed by the regions of Agadez, Diffa, Maradi and Zinder; and the South by the regions of Tahoua, Dosso and Tillabery.

Table 4: Poverty Measures with Minimum and Maximum Prices with the International Poverty Line

	National (N=671)			North (N=284)			South (N=387)			Difference between the North and the South (T-test)		
	FGT_0	FGT_1	FGT_2	FGT_0	FGT_1	FGT_2	FGT_0	FGT_1	FGT_2	FGT_0	FGT_1	FGT_2
Using maximum food prices	.735*** (.0004)	.375** (.0003)	.246*** (.0002)	.713*** (.0006)	.347*** (.0004)	.214*** (.0003)	.749*** (.0005)	.394*** (.0004)	.268*** (.0003)	-.036*** (.0007)	-.047*** (.0005)	-.054*** (.0004)
Using minimum food prices	.823*** (.0003)	.425*** (.0003)	.279*** (.0002)	.819** (.0005)	.402*** (.0004)	.249*** (.0003)	.826*** (.0004)	.441*** (.0003)	.300*** (.0003)	-.006*** (.0006)	-.039*** (.0005)	-.050*** (.0005)
Differences	-.088*** (.0002)	-.050*** (.00005)	-.032*** (.00003)	-.106** (.0004)	-.054** (.0001)	-.035** (.00004)	-.076** (.0003)	-.047** (.0001)	-.031** (.00004)	-.029*** (.0005)	-.007*** (.0001)	-.003*** (.00006)
Relative difference	-.11	-.12	-.11	-.13	-.13	-.14	-.09	-.11	-.10	4.83	.18	.06

Note: Values in parentheses are standard errors. ** and *** implies significant at the 5 and the 1 per cent level, respectively. The North is formed by the regions of Agadez, Diffa, Maradi and Zinder; and the South by the regions of Tahoua, Dosso and Tillabery. FGT_0 is the poverty head count ratio, FGT_1 is the poverty gap index and FGT_2 is the poverty severity index.

As can be seen from Table 4, the poverty estimates obtained under the two types of food prices are significantly different. Of course, since in that case the poverty line level does not change with using either type of price, the poverty measures obtained with the maximum prices are smaller than those obtained with the minimum prices. At national level and for the North, the incidence of poverty measured with maximum prices (respectively, 73.5 per cent and 71.3 per cent) is almost one-tenth smaller than that obtained with minimum prices (respectively, 82.3 per cent and 81.9 per cent), which is substantial. This difference is less pronounced for the South, where poverty incidence estimated with the minimum

[8] This number is obtained by multiplying the $ 1.90 per capita per day poverty line by the average households' size (7.11) and dividing it the average adult-equivalent scale (4.39). The conversion rate of the purchasing power parities (PPP) used for 2016 is FCFA 220.6 for $ 1 PPP for private consumption.(source: https://data.worldbank.org/indicator/PA.NUS.PRVT.PP?locations=NE, consulted 14 March 2020).

prices (82.6 per cent) is only 7.6 per cent greater than that obtained with maximum prices (74.9 per cent). As a consequence, the ranking of regions according to poverty is reversed by substituting the type of price information used. Indeed, the differences in the estimated poverty rates caused by this change in price information are greater than the poverty difference between North and South, that is only of almost 1 per cent with minimum prices, and 4 per cent with maximum prices. This matter if, as usually, the national poverty alleviation strategy tends to target the regions where poverty is found to be more severe.

When moving to poverty measures that are sensitive to living standard differences among the poor, the same substantial impact of choosing minimum vs maximum prices emerges. Poverty intensity and poverty severity estimated with minimum food prices are respectively 4 to 5 per cent and 3 per cent significantly greater than those estimated with maximum food prices, depending on the region. However, this impact is now smaller than the North-South gaps in poverty, and therefore there is no reversal of the ranking of regions. Let us now turn to poverty estimates based on a poverty line stipulated from minimal nutritional requirement.

4.2 Poverty estimates with cost-of-basic-needs poverty lines

The sign of the effect of using minimum prices instead of maximum prices for estimating poverty is theoretically ambiguous. Indeed, prices intervene at four stages of the estimation process: (1) the construction of the consumption aggregate for each household, (2) the construction of each household price index, (3) valuing minimal calorie requirement and finally (4) the extrapolation of the poverty line with an estimated Engel curve that also involve price effects.

We estimated three types of poverty indicators: annual poverty, which is defined as the arithmetic average of the three seasonal poverty indices; chronic poverty, which comes from the formulae of the poverty measures applied to total annual consumption expenditure, and therefore assumes that households smooth their consumption over the year; and finally transient poverty, which is specified as the residual poverty after accounting for chronic poverty in the annual poverty (see the Appendix for more details on how these poverty measure are computed). Ravallion (1988) proposes to use this dynamic decomposition, and Muller (2008) extended it to seasonal variations, as a convenient device to assess the basic magnitudes of the contribution of transient well-being variations to poverty. Of course, more sophisticated measures can be based on modelling consumption smoothing and risk sharing behavior of households, as in Deaton and Paxson (1994) for example. However, this would clearly be beyond the possibilities offered by these data, and besides, we prefer to stick to methods that do not depend on specific hypotheses about behavior models.

Absolute poverty lines

Table 5: Seasonal Food and Absolute Poverty Lines in Real Terms (CFA/day/adult-equivalent)

Poverty lines	Geographic level	Cold and dry season		Hot and dry season		Rainy season		Year	
		Pmin	Pmax	Pmin	Pmax	Pmin	Pmax	Pmin	Pmax
Food poverty line	North	107.7	121.2	130.2	142.1	130.8	151.7	118.6	134.6
	South	138.7	150.2	137.5	150.8	160.7	197.4	140.4	162.4
	National	124.9	137.2	134.5	147.1	147.5	176.9	130.8	150
Absolute poverty line	North	219.7	246.8	260.6	284.5	261.7	301.7	239.6	270.9
	South	241.8	259.7	240	260.6	276.2	333.2	244.5	278.7
	National	232.5	254.2	248.8	270.7	270.1	319.9	242.4	275.4

Note : Pmin=Minimum prices, Pmax=Maximum prices. The national poverty line is composed of the two regional poverty lines. It takes the value of the North poverty line if the household live in the North and the South poverty line if the household live in the South. The National poverty line presented in this table are mean of the national poverty line.

The absolute poverty lines are estimated using the cost-of-basic-needs method (see the Appendix for details). Table 5 shows that the estimated poverty lines are substantially higher with maximum prices than with minimum prices, for all seasons and all regions. Over the year, the poverty lines with maximum prices are greater than those with the minimum food prices by almost 14 per cent and they slightly vary between regions. The gaps between these two kinds of estimated poverty lines are more pronounced in the rainy season (between 15 and 20 percent) and the hot and dry season (8 and 9 percent), than in the cold and dry season (7 and 12 percent).

The seasonal variations in the diverse poverty lines are greater than their regional variations. The seasonal absolute poverty lines lie between 220 and 333 CFA per day per adult equivalent, while over the year, its values lie between 240 and 279 CFA per day per adult equivalent, depending on the region. Besides, the gap between the poverty lines alternatively estimated with minimal and maximal prices also dominates the variation of poverty lines between the two regions. This

is another hint about potential influence of the household specific price interval for poverty monitoring. Moreover, if this influence is patent and sizable for mean living standards or poverty with the international poverty line, this is less obvious for poverty estimated with the absolute poverty line. Indeed, there may be compensation between changes in the poverty line and changes in living standards.

Seasonal poverty

The results of the seasonal poverty estimates are presented in Tables 6a to 6c. For all the three seasons, the two seasonal poverty estimates with alternative prices always significantly differ at the 1 per cent level. However, not only these differences due to using alternative prices are always relatively moderate, with a magnitude reaching at most a little more than a 7 per cent variation, but also these differences can be positive or negative, with no obvious structure determining these signs. It seems that, in that case, the poverty line estimation has partly compensated the changes in living standards measure computed by using alternative prices.

For the cold and dry season (see Table 6a), the impact of using minimum versus maximum prices is more pronounced for North and the South, than when considering the country as a whole. During this season, the poverty rate varies from 27.7 to 33.5 per cent, while the poverty intensity and the poverty severity varies from 10 to 16 per cent, and from 5 to 10 per cent, respectively, depending on the region and the alternative prices. Moreover, the differences in poverty rates between the North and the South are larger when they are assessed with minimum prices than with maximum prices, while they are larger for poverty intensity and poverty severity when using maximum prices than minimum prices.

Table 6a: Poverty with the Absolute Poverty Line (for the Cold and Dry Season with Minimum and Maximum Prices)

	National (N=671)			North (N=284)			South (N=387)			Difference between the North and the South (T-test)		
	FGT_0	FGT_1	FGT_2	FGT_0	FGT_1	FGT_2	FGT_0	FGT_1	FGT_2	FGT_0	FGT_1	FGT_2
Using maximum food prices	.312*** (.0004)	.136*** (.0002)	.083*** (.0002)	.277*** (.0006)	.103*** (.0003)	.053*** (.0002)	.335*** (.0005)	.159*** (.0003)	.104*** (.0002)	-.057*** (.0008)	-.055*** (.0004)	-.050*** (.0003)
Using minimum food prices	.307*** (.0004)	.136*** (.0002)	.083*** (.0001)	.292*** (.0006)	.102*** (.0003)	.052*** (.0002)	.317*** (.0005)	.160*** (.0003)	.104*** (.0002)	-.025*** (.0008)	-.058*** (.0004)	-.052*** (.0003)
Differences	.005*** (.0001)	.000 (.00002)	.000 (.00001)	-.014*** (.0002)	.001*** (.00002)	.001*** (.00001)	.018*** (.0001)	-.001*** (.00002)	.000 (.00002)	-.032*** (.0002)	.003*** (.00003)	.002*** (.00002)
Relative difference	.016	.000	.000	-.051	.009	.019	.056	-.006	.000	1.28	-.051	-.038

Note: Values in parentheses are standard errors and *** means significant at the 1 per cent level. The National poverty measures are computed with the regional poverty lines.

Table 6b: Poverty with the Absolute Poverty Line (for the Hot and Dry Season with Minimum and Maximum Prices)

	National (N=671)			North (N=284)			South (N=387)			Difference between the North and the South		
	FGT_0	FGT_1	FGT_2	FGT_0	FGT_1	FGT_2	FGT_0	FGT_1	FGT_2	FGT_0	FGT_1	FGT_2
Using maximum food prices	.306*** (.0004)	.144*** (.0002)	.088*** (.0002)	.291*** (.0006)	.118*** (.0003)	.061*** (.0002)	.315*** (.0005)	.162*** (.0003)	.107*** (.0002)	-.024*** (.0008)	-.043*** (.0004)	-.046*** (.0003)
Using minimum food prices	.310*** (.0004)	.146*** (.0002)	.090*** (.0002)	.293*** (.0006)	.116*** (.0003)	.060*** (.0002)	.321*** (.0005)	.167*** (.0003)	.111*** (.0002)	-.028*** (.0008)	-.050*** (.0004)	-.051*** (.0003)
Differences	-.004*** (.00005)	-.002*** (.00001)	-.002*** (.00001)	-.002*** (.00006)	.002*** (.00001)	.001*** (.00001)	-.006*** (.00008)	-.005*** (.00002)	-.004*** (.00002)	.004*** (.0001)	.007*** (.00003)	.005*** (.00003)
Relative difference	-.013	-.014	-.022	-.007	.017	.017	-.019	-.030	-.036	-.142	-.140	-.098

The poverty rates estimated for the hot and dry season (see Table 6b) are generally higher than those obtained for the cold and dry season, in all regions. The poverty rate extends from 29 to 32 per cent, while the poverty severity and the poverty gap vary from 6 to 11 per cent, and from 11.6 to 16.7 per cent, respectively, depending on the region and the prices used. The regional discrepancy in poverty is more pronounced than the gap between the two poverty estimates with the alternative prices.

Table 6c: Poverty with the Absolute Poverty Line (for the Rainy Season with Minimum and Maximum Prices)

	National (N=671)			North (N=284)			South (N=387)			Difference between the North and the South		
	FGT_0	FGT_1	FGT_2	FGT_0	FGT_1	FGT_2	FGT_0	FGT_1	FGT_2	FGT_0	FGT_1	FGT_2
Using maximum food prices	.332*** (.0004)	.157*** (.0002)	.102*** (.0002)	.317*** (.0006)	.116*** (.0003)	.066*** (.0002)	.342*** (.0005)	.185*** (.0003)	.126*** (.0002)	-.025*** (.0007)	-.069*** (.0004)	-.060*** (.0003)
Using minimum food prices	.337*** (.0004)	.157*** (.0002)	.101*** (.0002)	.343*** (.0006)	.120*** (.0003)	.067*** (.0002)	.333*** (.0005)	.182*** (.0003)	.124*** (.0002)	.01*** (.0007)	-.062*** (.0004)	-.057*** (.0003)
Differences	-.005*** (.0001)	.000 (.00002)	.001*** (.00002)	-.026*** (.0003)	-.004*** (.00002)	-.001*** (.00001)	.009*** (.0001)	.003*** (.00003)	.002*** (.00003)	-.035*** (.0002)	-.007*** (.00004)	-.003*** (.00003)
Relative difference	-.015	.000	.009	-.075	-.033	-.015	.027	.016	.016	-3.5	.11	.053

Finally, the poverty measures estimated for the rainy season are higher than those estimated for the two other seasons. This may be because this is a lean period for agro-pastoralists. Indeed, during this season, the head-count index of poor moves from 31 to 34 per cent, while the poverty severity and the poverty gap vary from 6.6 to 12.6 per cent, and from 12 to 18 per cent, respectively, depending on the region and the prices used. In all seasons, poverty is higher in the South than in the North, except for poverty incidence at the raining season, which follows an opposite pattern.

Annual, Chronic, and Transient Poverty

As mentioned before, the annual poverty measures are defined as the arithmetic means of the seasonal poverty measures (see the Appendix for details). Table 7 shows that the annual poverty rates among agro-pastoralist remain stable for all regions and price type at 31.7 and 31.8 per cent for the whole country, 29 and 31 per cent for the North, and 32 to 33 per cent for the South. Moreover, the annual poverty severity, which lies between 14.6 and 14.7 per cent for the whole country, is higher in the South than in the North. The estimated poverty measures are

generally lower (or almost equal) when using maximum food prices than when using minimum food prices. The only exception is the head-count index of the North that is about five percent higher with minimum prices. However, the differences in annual poverty intensity and poverty severity using alternative prices are always very small, and even non-significant in half of the cases.

Table 7: Annual Poverty with the Absolute Poverty Line (with Minimum and Maximum Prices)

	National (N=671)			North (N=284)			South (N=387)			Difference between the North and the South		
	FGT_0	FGT_1	FGT_2	FGT_0	FGT_1	FGT_2	FGT_0	FGT_1	FGT_2	FGT_0	FGT_1	FGT_2
Using maximum food prices	.317*** (.0004)	.146*** (.0002)	.091*** (.0002)	.295*** (.0005)	.113*** (.0003)	.060*** (.0002)	.331*** (.0005)	.168*** (.0003)	.112*** (.0002)	-.036*** (.0007)	-.056*** (.0004)	-.052*** (.0003)
Using minimum food prices	.318*** (.0004)	.147*** (.0002)	.091*** (.0002)	.309*** (.0005)	.113*** (.0003)	.060*** (.0002)	.324*** (.0005)	.169*** (.0003)	.113*** (.0002)	-.014*** (.0007)	-.057*** (.0004)	-.053*** (.0003)
Differences	-.001*** (.00006)	-.001*** (.00001)	.000 (.00001)	-.014*** (.0001)	.000 (.00003)	.000 (.00001)	.007*** (.00007)	-.001*** (.00002)	-.001*** (.00002)	-.021*** (.0001)	.001*** (.00002)	.001*** (.00002)
Relative difference	-.003	-.006	.000	-.045	.000	.000	.021	-.006	-.009	1.5	-.017	-.019

Table 8: Chronic Poverty with the Absolute Poverty Line (with Minimum and Maximum Prices)

	National (N=671)			North (N=284)			South (N=387)			Difference between the North and the South		
	FGT_0	FGT_1	FGT_2	FGT_0	FGT_1	FGT_2	FGT_0	FGT_1	FGT_2	FGT_0	FGT_1	FGT_2
Using maximum food prices	.265*** (.0004)	.112*** (.0002)	.063*** (.0001)	.270*** (.0006)	.095*** (.0002)	.044*** (.0001)	.262*** (.0005)	.123*** (.0003)	.076*** (.0002)	.007*** (.0007)	-.028*** (.0004)	-.032*** (.0003)
Using minimum food prices	.273*** (.0004)	.109*** (.0002)	.061*** (.0001)	.270*** (.0006)	.098*** (.0002)	.047*** (.0001)	.275*** (.0005)	.117*** (.0003)	.070*** (.0002)	-.005*** (.0007)	-.018*** (.0004)	-.023*** (.0003)
Differences	-.008*** (.0001)	.003*** (.00002)	.002*** (.00002)	.000 (.0002)	-.003*** (.00002)	-.003*** (.00001)	-.013*** (.0002)	.006*** (.00004)	.006*** (.00002)	.013*** (.0003)	-.009*** (.00004)	-.009*** (.00003)
Relative difference	-.029	.027	.033	.000	-.03	-.064	-.047	.051	.085	-2.6	.5	.39

Table 8 displays the estimates of chronic poverty, which is the closest estimation to typically published poverty statistics, which are based on annual consumption indicators. The results elicit moderate poverty levels among agro-pastoralist, around 27 per cent for the head-count index, as expected with households deemed

to be generally better-off than most other Nigerien households. The results show again that poverty is more severe in the South than in the North, even though there may appear to be lower proportion of the poor in the South when using maximum prices. This is consistent with the published national statistics on poverty in 2011, which also indicates that 52.2 per cent of the poor live in the South, while 47.8 per cent live in the North (Institut National de la Statistique, 2013). Moreover, according to the Institut National de la Statistique (2017), in 2011, the agropastoral areas amount to 29.9 per cent of the poor, in Niger, and 19.7 per cent of the non-poor.

Defining instead chronic poverty from the mean of living standards across seasons change little the national head-count index results (27.3 per cent with maximum prices and 26.8 per cent with minimum prices). Even though these changes are larger for the poverty gap (12.4 per cent with maximum prices vs 12.3 per cent with minimum prices) and the poverty severity (7.5 per cent with maximum prices vs 7.4 per cent with minimum prices), the impact of choosing one type of prices remains negligible.

On the whole, distinguishing minimum from maximum prices only little, even if significantly, affects the estimate of chronic poverty at national level that is only slightly higher with minimum prices. Similar marginal effects can be found for each region, with again an opposition of patterns. Poverty gap or poverty severity are slightly higher in the North when using minimum prices, and in the South when using maximum prices.

Table 9: Transient Poverty with the Absolute Poverty Line (with Minimum and Maximum Prices)

	National (N=671)			North (N=284)			South (N=387)			Difference between the North and the South		
	FGT_0	FGT_1	FGT_2	FGT_0	FGT_1	FGT_2	FGT_0	FGT_1	FGT_2	FGT_0	FGT_1	FGT_2
Using maximum food prices	.051*** (.0003)	.034*** (.0001)	.028*** (.0001)	.025*** (.0006)	.017*** (.0003)	.015*** (.0002)	.068*** (.0003)	.045*** (.0001)	.036*** (.0001)	-.043*** (.0006)	-.028*** (.0003)	-.020*** (.0002)
Using minimum food prices	.044*** (.0003)	.037*** (.0001)	.030*** (.0001)	.038*** (.0006)	.014*** (.0003)	.012*** (.0002)	.048*** (.0003)	.052*** (.0001)	.042*** (.0001)	-.009*** (.0006)	-.038*** (.0003)	-.030*** (.0002)
Differences	.007*** (.0001)	-.003*** (.00002)	-.003*** (.00002)	-.013*** (.0002)	.003*** (.00002)	.003*** (.00001)	.020*** (.0002)	-.007*** (.00003)	-.006*** (.00002)	-.034*** (.0003)	.010*** (.00004)	.010*** (.00003)
Relative difference	.16	-.081	-.10	-.34	.21	.25	.42	-.13	-.14	3.78	-.26	-.33

Table 10: Share in Percent of Transient Poverty in Annual Poverty (%)

	National (N=671)			North (N=284)			South (N=387)			Difference between the North and the South		
	FGT_0	FGT_1	FGT_2	FGT_0	FGT_1	FGT_2	FGT_0	FGT_1	FGT_2	FGT_0	FGT_1	FGT_2
Using maximum food prices	15.77	23.29	30.77	8.47	15.04	25	20.54	26.78	32.14	-12.07	-11.74	-7.14
Using minimum food prices	13.84	25.17	32.97	12.30	12.40	20	14.81	30.77	37.17	-2.51	-18.37	-17.17
Differences	1.93	-1.88	-2.2	-3.83	2.64	5	5.73	-3.99	-5.03	-9.56	6.63	10.03
Relative difference	.12	-.08	-.07	-.45	.17	.2	.28	-.15	-.16	.79	-.56	-1.40

Finally, Tables 9 and 10 show that using one kind of prices is found to have greater consequences for the estimated transient poverty. The seasonal transient poverty rates are significantly higher at national level (5.1 per cent vs 4.4 per cent), and in the South (6.8 per cent vs 4.8 per cent), when using maximum prices, and lower in the North (2.5 per cent vs 3.8 per cent). An opposite pattern is observed for the transient poverty severity and poverty gap across regions. Note that, again, the ranking of the two regions is reversed for the poverty rates. This hints at numerous crossings of the poverty line by households in some seasons, in a context of high chronic poverty. However, the share of transient poverty in annual poverty remains relatively modest, nationally or for each season.

With maximum prices, for the poverty rate (respectively, poverty severity), it ranges from 8 per cent in the North up to 20 per cent in the South, (respectively 25 and 32 per cent). This suggest that pastoral activities are particularly good at smoothing seasonal consumption shocks, and thereby limiting the role of transient poverty. Besides, these moderate fluctuations of poverty over seasons are relatively robust to the choice of the type of prices used, especially from a national perspective.

5 Conclusion

Price deflation is a fundamental stage in the construction of living standard indicators for poverty analyses. However, rather than a unique price for each given product, as typically assumed, each household rather faces an interval of prices at a given period. We show that this specific price information can be used to generate an interval of poverty estimates, as a case of partial identification of poverty levels, and that this can affect poverty alleviation policies.

To do so, we use a unique dataset from Niger in which the surveyed agropastoral households state the minimum and the maximum prices they had paid at each season for each consumed food product. Then, we estimate poverty measures based on these alternative price data. For this, we consider three alternative poverty lines: The World Bank international poverty line of 1.90 PPP US $, an estimated absolute poverty line based on minimum prices, and a similar poverty line based on maximum prices.

The results show statistically significant differences in the estimated poverty levels obtained with these three approaches in the study case, mostly for international annual poverty comparisons, or for seasonal transient poverty analyses . This suggests that typically estimated poverty statistics, which consider that each household, cluster, or region, face a unique price for each product at a given period, may be less accurate than often believed, at least for the latter two type of analyses. In particular, the impact of using alternatively minimum and maximum prices for computing real living standards is found to generate gaps in estimated poverty rates for Niger agro-pastoralists that are greater than the corresponding gaps between estimated poverty for the South and the North regions. A policy consequence of this is that: the targeting priorities of regions, for food aid or cash transfer programs for poverty alleviation policies, would be reversed between the South and the North by using maximum prices instead of minimum prices when monitoring poverty.

The consequences for poverty alleviation policies are therefore substantial. First, caution must be applied when using typical poverty statistics that do not account for the dispersion of prices that each household faces, which is the standard and only practice nowadays. The found estimated gaps between results based on using minimal and maximal prices, in the case of agro-pastoralists in Niger, are large enough to invite to prudence in this regard. Second, policies changing price distributions may affect measured poverty in complex ways, for example when their impacts are different for the minimum, maximum, and mean prices faced by each household. The latter may be the case for public price subsidies that may put

more pressure on the maximum prices paid by consumers than on the minimum prices if these are below the subsidies legal price level.

A few issues remain that have to be resolved in a broader context. First, richer data covering whole countries and detailed consumption and price information over several years would better allow the exploration of the exhibited issues. Second, one would need to better understand theoretically and empirically the respective determinants of maximum and minimum prices.

Some avenues of research could be developed from this initial exploration. First, poverty estimators based on partial identification could be thoroughly developed and implemented, including for accounting not only for individual price dispersion, but also for measurement errors in consumption quantities and frequencies. Second, one would like to know more about the economic determinants of the observed gaps in minimum and maximum prices paid by the same household at the same period. Third, one should more systematically investigate the distributions of prices faced by typical households. Fourth, minimum and maximum prices could be used to something else than estimating poverty. For example, they can be alternatively included in demand system estimation. Fifth, one may wonder if minimum and maximum prices have the same economic and normative importance. For example, maximum prices may sometimes correspond to emergency circumstances, or even to forced purchases, which points to monitoring high degree of priority to social relief.

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7 Appendix: Construction of poverty indicators

The poverty measures employed in this work are widely used in the literature on poverty and are typically based on household income or total consumption expenditure. Monetary poverty is defined as a shortfall in income or total expenditure, given a poverty line to specify. In the literature, the most widely used monetary poverty indicators are from the Foster-Greer-Thorbecke (FGT) family (Foster, Greer & Thorbecke, 1984).

$$FGT_\alpha = \frac{1}{\sum_{i=1}^{N} w_i \times T_i} \left[\sum_{i=1}^{N} w_i \times T_i \times \left(\frac{z - y_i}{z} \right)^\alpha \times I(y_i < z) \right]$$

where N is the number of households in our sample, y_i the living standards of each household i, w_i is the household sample weight, T_i its size, a is a parameter that can be viewed as describing poverty aversion, and z is the poverty line . The three values of $a = 0$, 1 and 2 correspond respectively to: the headcount ratio, the poverty gap index, and the square poverty gap (poverty severity index). These indices are calculated at aggregate level for the whole population and for each of three seasons of the same studied agricultural year. The three seasons have the same length of four months and are denoted by the *cold and dry season*, the *hot and dry season,* and the *rainy season*.

We denote by $y_{it} = c_{it} / (E \times FPI_{it})$ the real living standards for household i at season t, where c_{it} is its total consumption expenditure in season t, E the adult equivalent scale and FPI_{it} its Laspeyres food price index in season t calculated with the annual budget shares and with the mean household over the year and the whole population as its base. Seasonal poverty is estimated by replacing y_i by y_{it} with the corresponding seasonal poverty line z_t in the above FGT_α formulae. CPI price indices covering the whole consumption would be better, but in our case, there is no price information for non-food product.

The annual living standard of a household i over the studied agricultural year is equal to $y_i = c_i / (E \times FPI_i)$, where c_i represents household total annual consumption (the sum of the three seasonal consumption) and FPI_i its Laspeyres food price index over the year. When computing these living standards, we neglected the discount factor between the three seasons because of a short observation period.
In addition to seasonal poverty, three other poverty measure namely: an annual poverty, a chronic poverty, and a transient poverty are estimated. Following Muller (2008), the annual poverty (AP) is defined as the arithmetic mean of the three seasonal poverty indices, that is : AP=(P_1 + P_2 + P_3)/3; while the chronic poverty (CP) is the obtained poverty measure applied to the annual living standard. CP corresponds to a situation where households could have smoothed their consumption if they had desired following (Muller, 2008). The transient poverty(TP), over the studied agricultural year, is the residual poverty after once chronic poverty is taken into account in the annual poverty : TP= AP-CP.

All these poverty estimators are estimated using alternatively the minimum and maximum prices faced by each household.

7.1 Construction of the consumption aggregate

As stated before, the monetary living standard variable indicator is the household's total consumption per adult-equivalent and per day in real terms. In Niger, it is hard to avail of accurate data on household income. Instead in our data, we have information on household's expenditures and consumption. The steps used to compute the total consumption variable are as follows.

Database preparation and missing values processing

To construct this aggregate, we needed data on prices and quantities for each product consumed by the household. In the database, the quantities of food consumed by households had sometimes been evaluated in local units of measurement (*lum*), for which equivalents rates in kg or liter had been measured. The same applies to the prices given by *lum*. An initial task therefore consisted in converting these quantities into kg or liter and the prices into CFA/kg or CFA/liter. However, for some *lum*, the equivalent conversion rates were missing. These missing *lum* values were replaced as follows. First of all, *lums* were divided into two categories: *lums* that we call "conventional", like the 50kg or 100kg bag, the 25g pack of millet, and those "non-conventional" lums which are local, like tia and tongolo. The latter are often used as weighting measures for the purchase of cereals in local markets in West Africa. The equivalent rates for the "conventional" *lum* are known and standard. On the other hand, for "non-conventional" *lum*, we used equivalents rates provided in the database. Given that for this type of *lum*, the equivalent rates in kg or in liter vary over regions, we built a database containing, for each of these *lum,* equivalent rates by geographical zone (region, department, commune, and locality or village). In practice, we retained the smallest geographical level for which we had a sufficient number of observations of equivalent rates. Then, for each *lum*, the missing equivalent rates were replaced with the median value of equivalent rates observed for that *lum* in that geographical level, so as to ensure robustness to outliers.

A second task was to deal with the missing values observed for the prices of the consumed goods. As a reminder, the observed prices are purchase prices as stated by households, and not unit values. However, not all households buy all the products that they consume at the market. In particular for these households, some observations on prices are missing.

The algorithm proposed by Muller (2005b) to estimate non-monetary consumption in household surveys was used. For each product, and for a given geographical area, the missing values were replaced by the median value of all its observed purchase prices. The procedure started with the village level, the lowest geographical level, assuming that households belonging to the same village are likely to face the same purchase prices. At the village level, the median was calculated for a given product using samples of prices with at least 10 observations. If at the village level, there are less than 10 observations, one moved to the next

higher geographical level, which is the commune, and the same procedure is repeated. Whenever the constraint of the minimal number of price observations was not satisfied, one moved to the next upper geographical level, thus neglecting the price variation at this geographical scale. If, finally, at the highest scale, the regional level, one cannot replace all the missing or zero values, the constraint on the number of observations is relaxed, by making it less than 10.

The following table shows the outcome of this algorithm for the products used to compute the price index, and for each season. As shown in this table, the percentage of households for which missing price values have been replaced by median values, varies between 5 per cent and 71 per cent depending on the type of product and the season. Moreover, in most cases, missing values have been replaced with median price values at regional level, a geographical level for which there is a sufficient number of observations. Note that village or communal replacement would often fit well the typical practices to generate price data. However , it seems reasonable to consider that the gaps elicited in this paper that are due to the differences between minimal and maximal prices should be seen as conservative as some of these differences may be attenuated in the aggregation process of this algorithm.

Table 11: Percentage of Seasonal Prices Replaced by Median Values by Area Type for Minimum and Maximum Prices

Products	Cold and dry season					Hot and dry season					Rainy season				
	V	C	D	R	All	V	C	D	R	All	V	C	D	R	All
Millet	8.08	28.95	11.33	9.17	**57.53**	7.07	23.32	6.5	5.99	**42.88**	6.86	28.01	8.95	6.21	**50.03**
Sorghum	0.86	6.71	5.85	58.3	**71.72**	0.72	17.72	8.80	40.9	**68.14**	1.66	14.3	5.63	42.82	**64.41**
Cowpea	2.02	4.04	1.08	57.25	**64.39**	1.01	10.61	1.15	51.19	**63.96**	1.37	10.83	5.41	45.48	**63.09**
Maize	0.14	0.21	12.27	37.03	**49.65**	0.14	7.5	8.95	42.23	**58.82**	0.5	4.33	13.2	28.88	**46.91**
Groundnut	0	0	0	49.89	**49.89**	0	0	0	50.10	**50.10**	0	0	0	49.89	**49.89**
Butter	0	0	0	19.20	**19.20**	0	0	0	5.04	**5.04**	0	0	0	38.62	**38.62**
Kola nut	0.07	5.41	0	51.33	**56.81**	0.14	5.41	0	51.55	**57.1**	0.14	5.48	0	51.33	**56.95**
Okra	0.72	4.47	2.38	46.42	**53.99**	0.28	4.25	2.45	46.64	**53.62**	0.64	3.97	2.52	33.28	**40.41**
Oil	1.73	5.48	5.34	13.72	**26.27**	2.16	8.23	4.90	7.65	**22.94**	1.66	7.14	4.18	15.88	**28.86**
Fresh milk	0.28	4.25	0	40.57	**45.1**	0.07	4.54	0	22.23	**26.84**	0.36	4.40	0	29.45	**34.21**
Curdled milk	0.86	11.84	2.16	18.98	**33.84**	0.64	8.59	2.31	23.68	**35.22**	0.64	12.12	2.16	18.19	**33.11**
Bread	0	0	0	28.30	**28.30**	0	0	0	28.51	**28.51**	0	0	0	28.51	**28.51**
Pasta	0.5	5.63	1.66	30.32	**38.11**	0.43	6.13	1.44	30.54	**38.54**	0.5	6.42	1.66	30.03	**38.61**
Fish	0	0	0	29.96	**29.96**	0	0	0	10.25	**10.25**	0	0	0	17.54	**17.54**
Sugar	1.73	6.85	2.52	11.55	**22.65**	1.87	5.27	5.19	11.69	**24.02**	1.80	9.09	2.52	8.44	**21.85**
Tobacco	0.144	1.29	0	36.75	**38.18**	0.14	1.29	0	36.67	**38.1**	0.14	1.29	0	36.75	**38.18**
Tea	1.37	5.99	0	19.35	**26.71**	1.22	6.71	0	19.56	**27.49**	1.22	6.71	0	19.13	**27.06**
Condiments	0.64	3.17	6.93	3.68	**14.42**	0.72	3.10	6.85	3.68	**14.35**	0.43	3.97	7.0	3.89	**15.29**
Meat	0.21	5.27	3.46	14.15	**23.09**	0.28	5.12	3.24	15.02	**23.66**	0.36	5.55	3.24	14.22	**23.37**
Poultry	0.28	0	0	24.83	**25.11**	0.07	0	0	6.64	**6.71**	0.14	0	0	14.44	**14.58**

Notes: Values presented in this table are in percent. They represent the proportion of missing value replaced with the median price value at village (V), communal (C), departmental (D) and regional (R) levels. And "All" is the total of these proportions for a given product.

Goods included in the consumption aggregate

All food products are included in the consumption aggregate for each household. For non-food products, following the recommendations of Deaton and Zaidi (2002), health expenditures are excluded, but expenditures on water, energy, telecommunications, transportation, education, and personal care are included.

Finally, transitory expenses, as for holidays or ceremonies are not included in the aggregate.

The food consumption expenditure is evaluated for each season and alternatively with the minimum and maximum prices faced by each household. The non-food expenses are given for the whole year, and therefore they were divided by three in order to estimate their value for each of the three seasons. Finally, the total consumption aggregate for each season is obtained by adding up food consumption expenditure and non-food expenses. The annual consumption aggregate for a given household is therefore the sum of its three seasonal consumption aggregates. The value of the consumption aggregates, in each case, were calculated using alternatively minimum and maximum food prices. Then, they were deflated with the Laspeyres price index calculated at household level, and with an equivalent scale that reflects the household demographic composition.

The price index and the equivalence scale

Laspeyres price indices were calculated for each of the three seasons as in Muller (2008). In the basket of goods used to calculate them, we kept only those products (mainly food) for which the number of price observations is at least 20 as suggested by Deaton & Tarozzi (2005). The food price index (FPI) was calculated at the household level.

$FPI_{it} = \sum_g S^g \times (p_{it}^g / P_t^g)$, where $S^g = \frac{\sum_t \sum_i w_i \times p_{it}^g \times q_{it}^g}{\sum_t \sum_g \sum_i w_i \times p_{it}^g \times q_{it}^g}$ and $P_t^g = \frac{\sum_i w_i \times p_{it}^g}{\sum_i w_i}$

S^g is the weight of good g in the price index yearly, w_i is the sample weight of household i, p_{it}^g is the price faced by household i in the season t for the good g, q_{it}^g is the quantity consumed of good g by household i, and P_t^g is a consistent estimate of the mean price for all consumed quantities of good g at national level in season t. The household annual price for a good g is $p_i^g = \frac{\sum_t q_{it}^g \times p_{it}^g}{\sum_t q_{it}^g}$, which is used to compute annual food price index. In the food price index formulae, the prices are weighted by both sampling weights and consumption quantities. These food price indexes are calculated using alternatively the minimum and maximum prices faced by each household.

The adult equivalent variable is computed for each household by using the approach proposed by Deaton & Zaidi (2002). We used the following formulae: $AE = NA + 0.67 * NYA + 0.33 * NC$, with AE= Adult-Equivalent scale, NA: Number of Adults (>20 years old) in the household, NYA= Number of Young Adult (between 17 and 20 years old) and NC= Number of Children (less than 17 years old).

7.2 Estimated absolute poverty line

The poverty line is calculated in five steps that follows a usual method implemented by the World Bank all over the world. These steps are replicated with each of the three seasonal living standards and the annual real living standards in order to estimate seasonal and chronic poverty measures, respectively. Moreover, these steps in each case are applied alternatively with minimum and maximum prices. A total of 8 poverty lines are therefore estimated.

Defining a reference group of poor households

A reference group was constructed on the basis of the distribution of the real living standard per adult equivalent. It is used to ensure that the consumption patterns employed for defining the poverty line are not overly influenced by those of wealthy households. It corresponds to the lowest half of the distribution. This is consistent with nearly 42 per cent of the population being considered officially as poor (Institut National de la Statistique du Niger and Banque Mondiale, 2013).
We regrouped the seven regions into two strata: South (formed by Dosso, Tahoua and Tillaberi regions) and North (formed by Agadez, Diffa, Maradi and Zinder). This distinction allows for a better control of the geographical variations in household consumption habits. Thus, the reference groups are constituted separately for the North and the South, and their union represents the reference group for the whole country.

Defining the caloric need for household belonging to the reference group

The caloric intake per capita per day, for each household, is computed by converting the recorded food quantity consumed by the household over the year into calories. For this conversion the FAO food composition table for West Africa in 2012 was used (Stadlmayr et al., 2012). Calories requirements for households in this reference group, in each stratum, are specified as 2700 Kcal per day and per adult to account for moderate activity level. The National Institute of Statistics of Niger uses instead an energy requirement of 2400 Kcal/day per individual. However, we want to account for typically relatively higher activity level of agro-pastoralist households who are not fully sedentary.
The 2700 Kcal requirement per day per adult is then multiplied by the average equivalent scale in the reference group and divided by the corresponding average household size. This adjustment allows us to account for nutritional requirement increasing with age and gender of household members.
The mean unit price of the calorie consumed in each stratum for the reference group is then calculated as the ratio of the average value of food consumption in the reference group by its average calorie intake.

Defining the food poverty line

The food poverty line is the minimum income needed for a household to have access to the calories required for an active life. Based on the unitary price of calories consumed by a household in the reference group and his energy requirement, the calculus of the food poverty line is the value of the calorie requirement. The food poverty line is calculated for each of the two strata (North and South).

Defining the absolute poverty line

The absolute poverty line is obtained by extrapolating the food poverty line to the whole range of consumption. This allows for the inclusion of non-food consumption by using a food Engel curve which is consistent with the Quadratic Almost Ideal Demand System. The estimated Engel curve equation is:

$$s_i = a + b \times \ln(x_i) + c \times \ln(x_i)^2 + d \times N_i + \varepsilon_i$$

where s_i is the share of food expenditure in the total expenditure of household i, x_i is its daily real total consumption, N_i are household socio-demographics characteristics, and ε_i is an error term. The coefficients a, b, c, and d are estimated by the Ordinary Least Squares method, as is typical in the World Bank methodology. The estimation results are shown below.

Two different equations have been estimated separately for the North and the South. The absolute poverty line z_j for a stratum j is obtained by replacing s_i by the ratio of the food poverty line by z_j and solving numerically in z_j the following equation of the estimated Engel Curve : $\frac{z_j^f}{z_j} = a_j + b \times \ln(z_j) + c \times \ln(z_j)^2$, where z_j^f is the computed food poverty line in the stratum j for the whole household (i.e. the previous food poverty line computed is multiplied by the average household size of the corresponding reference group in the stratum j). The fixed effects a_j accounts for the different means values of other independent variables in the North and the South. The absolute poverty line in the stratum j, z_j, is obtained by solving the above equation with the bisection method. The value obtained is then divided by the mean adult equivalent scale of the reference group of the stratum j, which makes the poverty line comparable to the specified real living standards.

Table 12 : Estimated Engel curve

	s_i					
Variables	National level (N=671)		North (N=284)		South (N=387)	
	Pmin	Pmax	Pmin	Pmax	Pmin	Pmax
$\ln(x_i)$	.740***	.713***	.753**	.773*	.697***	.654***
	(.201)	(.186)	(.378)	(.398)	(.144)	(.120)
$[\ln(x_i)]^2$	-.046***	-.043***	-.048*	-.048*	-.042***	-.039***
	(.014)	(.013)	(.026)	(.027)	(.009)	(.007)
ln(Adult-Equivalent)	-.055***	-.048***	-.033	-.035	-.068***	-.057***
	(.015)	(.014)	(.026)	(.028)	(.017)	(.016)
Area of living: 1 if in the South and 0 otherwise	.029**	.035**	-	-	-	-
	(.013)	(.014)				
Constant	-1.97***	-1.92***	-2.00	-2.13	-1.82***	-1.68***
	(.695)	(.65)	(1.29)	(1.39)	(.548)	(.465)

Note: Values in parentheses are standard errors. *,** and *** means significant at the 10%, 5% and 1% respectively.