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Article

Cereal Commodity Trade Quantity Measurement Cost and Reliability: Evidence from Local Agricultural Marketplace of Ethiopia

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Abstract: The issue of measurement reliability is certainly undervalued in the local agricultural marketplace organization. Besides, there was nothing identified concerning the extent of cereal commodity trade measurement cost. Hence, this paper aimed to estimate the magnitude of cereals trade quantity measurement cost caused by instrument error and unreliability; mainly by targeting the local marketplace in Ethiopia. The survey was conducted in six different districts' marketplaces (n=602) of Oromia region by employing administered structured questionnaires and site mass measurement calibration. The gathered data were analyzed using independent samples t-test, one sample t-test, and analysis of variance. According to the findings, the actual value measurement means of the quantity of most local units of the farmers were greater than small traders. The independent t-test result indicated that the average values of the quantity of the majority of units of measurement between farmers and small traders were varied significantly. Estimated measuring instruments' error and unreliability associated average measurement cost of one-day market transaction over total cereals marketed amount were higher comparatively for a sack, bowl, and glass units. This study demonstrates that homogeneity in measurement, policy, and institutions that aid cereals trade would have an indispensable role to reduce measurement costs and ensure equitable exchange.

Keywords: Local agricultural marketplace; cereal commodity trade; quantity measurement costs; measurement reliability; Ethiopia.

1. Introduction

The quantity measurement system reliability has a paramount contribution for economic transaction certainly for reducing the costly transfer of wealth and ensuring equitable exchange. In Ethiopia, the district level agricultural marketplace is a notable center for trading numerous products. Most of the people are currently relying on the local marketplace sales location for their agricultural output trade [1]. However, the majority of economic agents are exchanging the cereal commodity in local marketplace vastly by employing multiple, non-uniform and incoherent units of measurement. The local units of quantity measurement are ranging from volumetric (glass, various can and cup, jug, and bowl to weight measures (sack) and mechanical weight balance. In addition, the diverse measuring instrument of the same kind, method of measuring and ways of using instruments are vastly used to conduct cereals trade [2]. Moreover, cereal quantity measurement behavior of trading parties demonstrates the existence of unreliability that created the cost of transaction, measurement, social capital and two-hand palm cereal gift in Ethiopia local marketplace [2]. In general, the heterogeneity of the measurement system creates considerable measurement costs, exchange inequitability, and market disintegration [3, 4, 5, 6, 7, 8].

Nevertheless, the extent of measurement costs happening due to diverse local units, the method of measuring and ways of using measurement instruments in local agricultural marketplaces are not yet investigated. The quantity measurement reliability of cereal transaction between marketplace exchange parties over periodic market days, repeated measurement, and amongst districts are not known as well. Further, we have a little conception about who is gaining and who is losing in the process of quantity measurement of cereal commodity trade. Overall, it is challenging to come to an agreement about the impact of complex and conventional measurement system upon the local economy of a given nation.

The scholars suggest standardized measures and the extension of Ronald Coase's arguments of the nature of the firm to the nature of the market to minimize the positive transaction costs [9, 10, 11, 12, 13, 14]. First, since the introduction of French metric measures in 1790 and Britain imperial measures in 1824, the emphasis of many countries was moved to metrological standardization [15]. But the diffusion of metric and imperial units of measurement to developing countries was failed for a long period of time [16]. Ethiopia government has been implementing metric units of measurement since 1963. However, the diverse kind of local measures are still widely in use in the rural parts of the country. Besides, there is untested deduction whether standardized measures alone are managing the entire measurement problems and costs. In another assertion, the positive effect of metric and imperial units on the local economy compared to traditional measures has been unidentified.

Second, the extension of Coase's arguments of the nature of the firm to the nature of the market as an organization has an implication for rural trading parties to economize positive transaction cost. In this regard, the work of Coase is contributing that the economic transaction coordinated through the institution firm can better save marketing costs than the same transaction organized through the invisible hand of the market institution [13]. Herein, we can understand that a particular institution like a firm institution that plays a role in lessening transaction costs is essential for the marketplace trading system. However, over 80 years, the contribution of Coase's essay that is the costs of using the price mechanism has still not acquired vital academic consideration to solve the real economic growth obstacles such as local marketplace measurement problems.

A panacea to the aforesaid disputes, the study aimed at estimating the extent of cereals quantity measurement costs caused by instruments' error and unreliability mainly by targeting the farmer and small trader participants of local agricultural marketplace. In the present study, the quantity measurement reliability from consistency, conformity, and uniformity dimensions was also investigated. Hence, the people level of feeling mindset about measurement concerns will be lifted hopefully to minding phase in regard to care and diminish measurement cost. Totally, the study frontiers economic knowledge by consolidating the measurement concepts and further validating it as a part of the new institutional economics theory.

2. Literature and conceptual framework

In the literature of transaction costs economics, the sources of measurement problems are viewed from two controversial angles. According to [8], the causes of the measurement problems at the transactional level are emanating from the measurement error. The premise behind this view is that the measurement cost is occurred due to measuring instrument bias or random errors. Hence, managing of measurement issues have been claimed from the management of error, or instrument bias predominantly by targeting a given specific measurement unit. On the other hand, measurement reliability or sameness argue that error approach is a narrower and simplistic method to address the entire sources of measurement problems [17, 18]. Thus, the originator of the sameness approach, Velker, suggest the reliability dimensions (consistency, conformity and uniformity) in his method for addressing the holistic problems of measurement and filling the gap of error method. Herein, we can understand that the measurement costs are happening both in the case of instrument bias and/or unreliability of measurement system.

3. Methods and materials

3.1. The study site

The aggregate cereal production of the Oromia region alone comprises about 44.5 percent of a nation in 2015 [19]. The East and West Shoa zones were chosen among six well-known cereal commodity producer zones of the region [20] (Figure 1). Three study areas were taken from each zone. The selected areas are known in producing cereals. Based on the data obtained from the zonal administration, the total post-harvest cereals production of East and West Shoa Zone in 2015 was 7,965,315 and 15,652,419 quintals (1 quintal is equivalent to 100 kilograms), respectively [21]. Of which, 57.49 and 21.28 percent were produced in Adea, Gimbichu and Lume (East Shoa) and Dendi, Bako-Tibe, and Adea Berga (West Shoa) districts, respectively.

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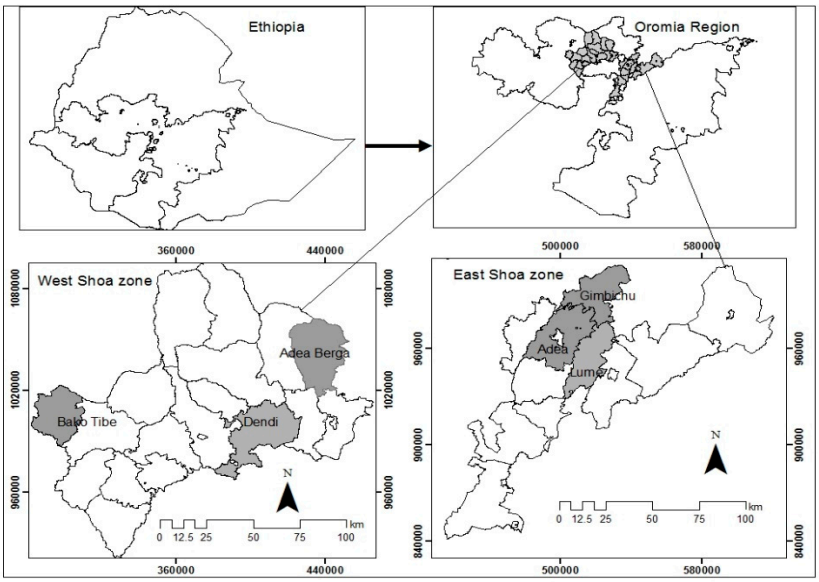

Figure 1. Map of the study area.

3.2. Sampling methods

The study areas were selected using purposive and random sampling methods. The inclusion criteria were the relative volume of cereals production [19] and proximity to the capital city of the country. Furthermore, cereal commodity consumption expenditures of the household [22] and the cereal trade center factor were considered. To this end, six district marketplaces such as Bako-tibe, Dendi, Adea-Berga, Adea, Gimbichu, and Lume were selected for the purpose of the study. The sample of the farmer was determined by using a supposition of 5 percent level of precision; 95 percent level of confidence; 50 percent degree of variability; and the total size of the population [23]. Accordingly, the total sample size (n=400) was distributed into six districts' marketplace depending on their respective number of the farmer households. As a result, the sample size for Dendi, Bako-tibe, Adea-Berga, Adea, Gimbichu, and Lume marketplaces were 91, 67, 65, 67, 56, and 54, respectively. In addition, the small traders buying cereals from the same marketplace or another in order to re-sell them to various parties were included. The small trader population was, therefore, any small trading agent who are selling cereals in each chosen marketplace from July 10 to September 2, 2018. The small trading agent who was buying from the nominated marketplace and selling to non-selected districts were not considered. Hence, 202 (n=202) small traders from Dendi (43), Bako-Tibe (33), Adea-Berga (31), Adea (33), Gimbichu (31), and Lume (31) were addressed, respectively.

3.3. Data type and methods of collection

In this study, both primary and secondary data were employed. The primary data was collected by using the survey method through administered structured questionnaires from July 10 to September 2, 2018. The survey was mainly focused on socio-economic characteristics of farmers and small traders, type and variety of cereal traded, the total supply of cereal marketed, and marketplace conversion convention between measuring instruments and kilogram unit. Besides, measuring instruments used for transaction, cereals amount of measuring units (kilogram), exchange price of

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cereals quantity of each unit were emphasized. To measure and record the actual value of the amount of quantity of each instrument, site calibration for the mass measurement in accordance with international system mass unit standard was performed in collaboration with National Metrology Institute of Ethiopia (Table S5, Material S1). Moreover, the secondary data was obtained from journals, books, working papers, and official reports. The district level agricultural marketplace observation was farther conducted to supplement the survey.

3.4. Methods of data analysis

The data were analyzed by using the 23rd version of the Statistical Package for Social Sciences (SPSS) (IBM corporation, New York, NY USA), particularly through descriptive statistics such as percentage, independent and one samples t-test, and analysis of variance. The OriginPro 9.1 (OriginLab Corporation, Guangzhou, China) data analysis and graphing software were also employed to illustrate market conversion convention between measuring instruments and kilogram unit and actual values distribution of the quantity of measuring units.

3.5. Measurement cost estimation

The study applied two methods to estimate cereals trade measurement costs magnitude of the farmers and small traders in each marketplace. At the district level, agricultural market organization structure of cereal commodity trade is hierarchical. There are two to three marketplaces (MP) in each district. Each marketplace has two to three measurement unit-based market divisions (MD) (Figure 2).

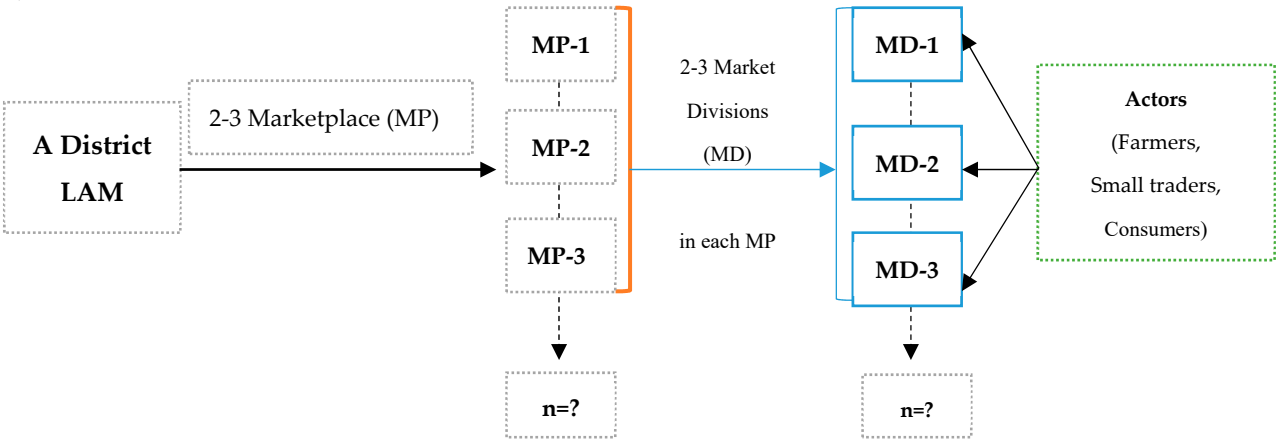

Figure 2: Local Agricultural Market (LAM) structure of cereal commodity trade
Source: Own construction based on observation

In this structure, each marketplace instrument bias and unreliability of cereal quantity measurement were evaluated for both farmers and small traders. The difference between the actual (real) and ideal (true) value of the amount of individual instrument was assessed to estimate error related measurement cost size. In this undertaking, the actual measurement value average of local units was computed and served as the ideal value. Because most of the local units used for commodity trade did not have its own scientific standard. The market conversion convention between measuring instruments and kilogram unit was not used. Because, based on the pilot study, the difference between units of measurement and kilogram unit and their actual value were

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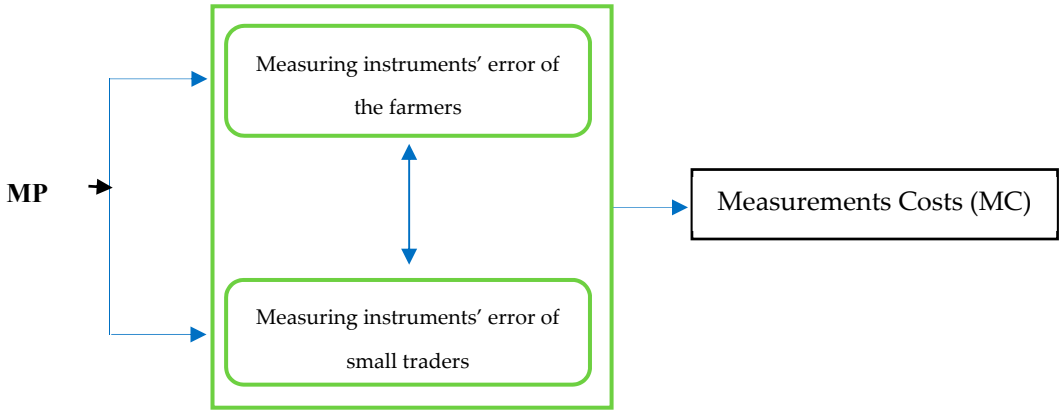
substantial. Thereby, the difference between the actual value of the quantity of measuring units and their average was considered as instruments' error. However, the study applied the range conversion convention between the sack and kilogram as an ideal value; specifically to compute commodity amount of sack unit actual value mean using one samples t-test. For instance, most markets agreed that teff quantity of a sack unit is equivalent to 74-80kg, which is range kilogram amount. Such a range amount convention is comparatively similar with actual value compared to fixed conversion volume between other local instrument and kilogram unit. Besides, the market conversion convention of each instrument was considered as a baseline to estimate the measurement cost over trading parties' total cereals supply. According to the pilot study, there was no common convention of local units to a metric unit. This study, thus, used the conversion agreement of local units agreed by the majority of respondents. In general, the actual measurement average computation method was regarded as an ideal value of local units to estimate error related measurement cost using the study 1 framework.



Study 1: Local units' bias based measurement costs of farmers and small traders

Besides, measuring instruments' unreliability cost were measured from consistency, conformity, and uniformity dimension aspects. Measurement consistency deal whether the measurements remained consistent over time, whether measurement made in a given day is consistent with measurements made a day ago, a week ago, a month ago, or a year ago [17]. For local marketplace context, markets are conducted once or twice or more in a week. Every week, the nature of one day market is very hot, in which farmers relatively supply more products and highly populated market day than that of slack market day. Hence, evaluating measurement unit consistency between a hot and slack market day of the same marketplace is essential.

On the other hand, the measurement is precise, if measurements over repeated observation closely resembled an acceptable or pre-specified value [17]. In the rural marketplace, unlike measurement protocols are existing concerning ways of using instruments and methods of measuring. In few marketplace, people handle the bottom and top edge of the volumetric instrument with their two fingers to measure. People are not necessarily heaping mass over the mouth of volumetric instruments in this context. Elsewhere, people handle the center or upper of measures using two hands after heaping mass on the top mouth of instruments. Further, common applied measuring ways are heaping of the cereal over the mouth of measures. However, the quantity of heaped cereals over the mouth of instruments might not be the same in amount. In this case, the

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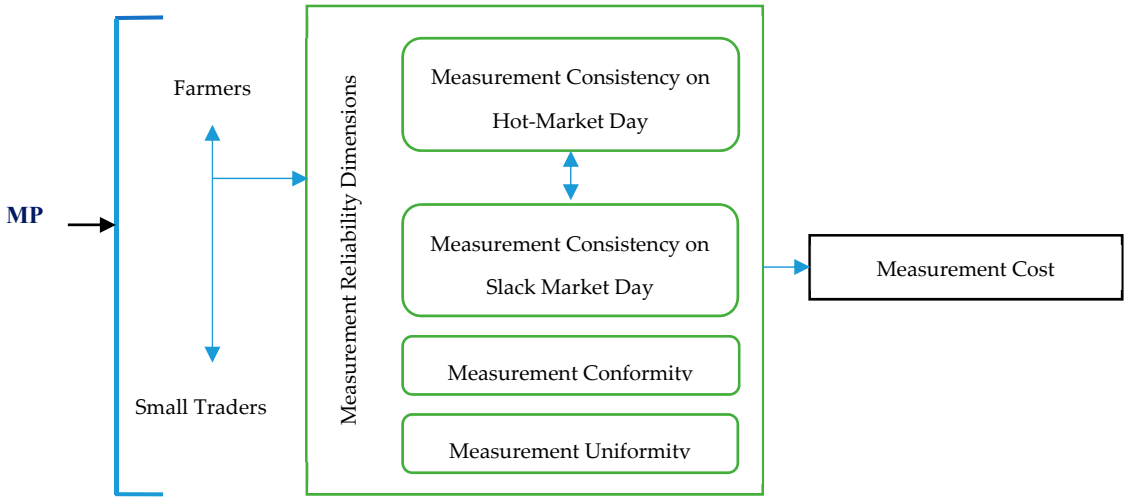
source of variation is not due to instrument error, but due to confusion, or disagreement, regarding the measurements of quantity. Away from these realities, no one can be certain whether over repeated measurement clustered to some average value. Here, the extent to which measurement conform to some pre-specified value was evaluated in the marketplace by testing over repeated measurement of each farmer and small trader.

Moreover, two to three market divisions are structured within a marketplace based on measuring instruments being used for trade. In a division, for instance, a teff cereal measured by can by one party may not be equivalent with other when it is measured and converted into the kilogram. In another assertion, when merchant use multiple measuring instruments or local norms are unclear, the question of unreliability arise. Here, nothing is known in all hierarchy of marketplace whether measurements are uniform in between farmers and small traders (buyers). Based on these facts, it is very essential to look at measurement uniformity among the actors. The detail study framework applied for the measurement reliability of districts' marketplace is depicted in study 2 framework.



Study 2: The farmer and small trader local units' unreliability based measurement costs.

4. Results and discussion

This section comprises the demographic characteristics of trading parties, type, and variety of traded items, and marketplace conversion convention and quantity of local units' actual values distribution. In addition, mean comparison of the actual value of cereals amount of units of measurement was subsequently presented. In the last part of the section, the measuring instruments' error and unreliability associated costs magnitude of both farmers and small traders was computed and discussed.

4.1. Demographic characteristics of respondents

The study found that there was more female farmer percentage in Dendi, Bako Tibe and Adea Berga (Table 1a). In contrast, the male farmers were high in percentage in Gimbichu, Adea and Lume (Table 1b). As indicated in Table 1(b), most small traders in all local marketplaces were female. Besides, the age and education of most farmers and small traders participants fall between the range

of 20-40, and 0-4 schooling years, respectively (Table 1 a and b). Further, most farmers and small traders were married (Table 1 a and b).

Table 1. Demographic characteristics of farmers and small traders.

Items		Study area					
		Dendi Count (%)	Bako Tibe Count (%)	Adea Berga Count (%)	Gimbichu Count (%)	Adea Count (%)	Lume Count (%)
				(a)			
Gender	Male	43(47.25%)	28(41.79%)	28(43.08%)	43(76.79%)	38(56.72%)	29(53.70%)
	Female	48(52.75%)	39(58.21%)	37(56.92%)	13(23.21%)	29(43.28%)	25(46.30%)
Age	≤20	11(12.09%)	9(13.43%)	12(18.46%)	8(14.29%)	0(0%)	2(3.70%)
	20-40	63(69.23)	44(65.67%)	38(58.46%)	30(53.57%)	51(76.12%)	34(62.96%)
	>40	17(18.68%)	14(20.90%)	15(23.08%)	18(32.14%)	16(23.88%)	18(33.34%)
Marital	Single	28(30.77%)	21(31.34%)	16(24.62%)	12(21.43%)	4(5.97%)	14(25.93%)
status	Married	63(69.23%)	46(68.66%)	49(75.38%)	44(78.57%)	63(94.03%)	40(74.07%)
Education	0-4	70(76.92%)	47(70.15%)	51(78.46%)	44(78.57%)	64(95.52%)	43(79.63%)
	5-8	12(13.18%)	14(20.90%)	12(18.46%)	7(12.50%)	2(2.98%)	9(16.67%)
	≥9	9(9.90%)	6(8.95%)	2(3.08%)	5(8.93%)	1(1.50%)	2(3.70%)
Total		91(100%)	67(100%)	65(100%)	56(100%)	67(100%)	54(100%)
				(b)			
Gender	Male	2(4.65%)	3(9.09%)	5(16.13%)	12(38.71%)	6(18.18%)	4(12.90%)
	Female	41(95.35%)	30(90.91%)	26(83.87%)	19(61.29%)	27(81.82%)	27(87.10%)
Age	≤20	0(0%)	0(0%)	2(6.45%)	1(3.23%)	1(3.03%)	2(6.45%)
	20-40	27(62.79%)	28(84.85%)	23(74.19%)	22(70.97%)	23(69.70%)	18(58.06%)
	>40	16(37.21%)	5(15.15%)	6(19.35%)	8(25.81%)	9(27.27%)	11(35.48%)
Marital	Single	0(0%)	3(9.09%)	5(16.13%)	4(12.90%)	5(15.15%)	6(19.35%)
status	Married	42(97.67%)	30(90.91%)	26(83.87%)	27(87.10%)	28(84.85%)	25(80.65%)
	Divorced	1(2.33%)	0(%)	0(%)	0(0%)	0(%)	0(0%)
Education	0-4	30(69.77%)	21(63.64%)	28(90.32%)	30(96.77%)	31(93.94%)	28(90.32%)
	5-8	9(20.93%)	8(24.24%)	2(6.45%)	1(3.23%)	2(6.06%)	3(9.68%)
	≥9	4(9.30%)	4(12.12%)	1(3.23%)	0(%)	0(0%)	0(0%)
Total		43(100%)	33(100%)	31(100%)	31(100%)	33(100%)	31(100%)

Source: Field survey, 2018.

4.2. Type and variety of cereal commodity traded

The study employed sack unit for counting the type and variety of cereal commodity supplied. Because the sack is a tool commonly used for transport agricultural commodity from actors' home to the marketplace. The study found that the majority of farmers and small traders traded one type of cereals on one market day (Table 2). In the other way, the farmer and small trader who were selling more than one type of cereal were very few. Most farmers were trading teff and wheat cereals throughout all districts (Table 2). On the other hand, the small traders were supplying and trading teff, wheat, maize, and sorghum dominantly (Table 2). Moreover, most varieties of cereals offered by farmers and small traders were a white variety (Table 2).

265 **Table 2.** Type and variety of cereal commodity traded within the local marketplace.

Study area	Marketplace actors	Sample size (n)	Type of cereals traded	Variety of cereals				Total
				White	Red	Mixed	Black	
Dendi	Farmers	91	Teff	24	6	5	-	35
			Wheat	36	2	0	-	38
			Barley	19	0	0	-	19
	Small traders	43	Teff	4	4	1	0	6
			Wheat	6	1	0	0	7
			Barley	6	0	1	1	8
			Maize	14	0	0	0	14
			Sorghum	8	4	0	0	12
Bako Tibe	Farmers	67	Teff	36	4	2	-	42
			Wheat	8	0	0	-	8
			Barley	3	0	0	-	3
			Maize	11	0	0	-	11
			Sorghum	3	0	0	-	3
	Small traders	33	Teff	14	1	-	0	15
			Wheat	6	0	-	0	6
			Barley	4	0	-	2	6
			Maize	2	0	-	0	2
			Sorghum	5	1	-	0	6
Adea Berga	farmers	65	Teff	15	5	2	0	22
			Wheat	21	0	0	0	21
			Barley	14	0	0	1	15
			Maize	3	0	0	1	4
			Sorghum	3	1	0	0	4
	Small traders	31	Teff	12	5	2	-	19
			Maize	7	0	0	-	7
			Sorghum	3	3	1	-	7
Gimbichu	Farmers	56	Teff	12	11	-	-	23
			Wheat	32	7	-	-	39
			Sorghum	0	1	-	-	1
	Small traders	31	Teff	5	6	-	-	11
			Wheat	7	0	-	-	7
			Barley	5	0	-	-	5
			Maize	8	0	-	-	8
			Sorghum	2	0	-	-	2
Adea	Farmers	67	Teff	29	13	3	-	45
			Wheat	26	2	0	-	28
			Barley	5	0	0	-	5
	Small traders	33	Teff	10	4	4	-	18
			Wheat	12	0	0	-	12

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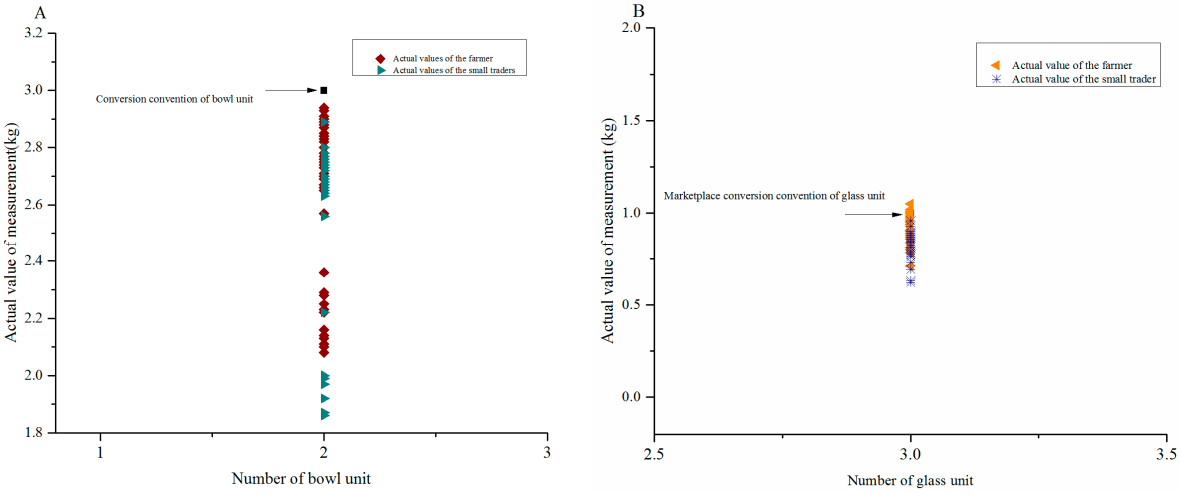
			Barley	4	0	0	-	4
Lume	Farmers	54	Teff	28	1	7	-	36
			Wheat	23	0	0	-	23
			Barley	11	0	0	-	11
	Small traders	31	Teff	11	1	-	-	12
			Wheat	13	0	-	-	13
			Barley	3	0	-	-	3
			Maize	5	0	-	-	5
			Sorghum	1	2	-	-	3

Source: Field survey, 2018.

4.3. Marketplace conversion convention and the distribution of actual values of the measurement

Figures A-G illustrated that the actual value of the quantity of units of measurement (in kilogram (kg)) based on marketplace conversion agreement between each local measures and kilogram unit. The quantity of local units' values was measured and recorded by considering estimated uncertainty of measurement showed in the table S4. The finding indicated that all actual values of cereal quantity of two bowl unit were scattered far below the conversion convention point for both farmers and small traders (Figure A). In Bako Tibe, most of the values of the quantity of three glasses were scattered below conversion point (Figure B). In contrast, the quantity of three can (Merti) unit was greater than conversion volume in Adea Berga district (Figure C). In Figure D, cereal amount of a sack unit was ranging from 40 to 86 kg in Gimbichu, Adea and Lume districts. Most of the actual values of cereal amount of three can unit were dispersed above the point of the convention for both farmers and small traders in Gimbichu and Adea marketplace (Figure E and F). In Lume district, most of the cereals amount of jug unit values for farmers were scattered above the point of agreement. In contrast, most of the values of jug unit for small traders were dotted below the point of a convention (Figure G).



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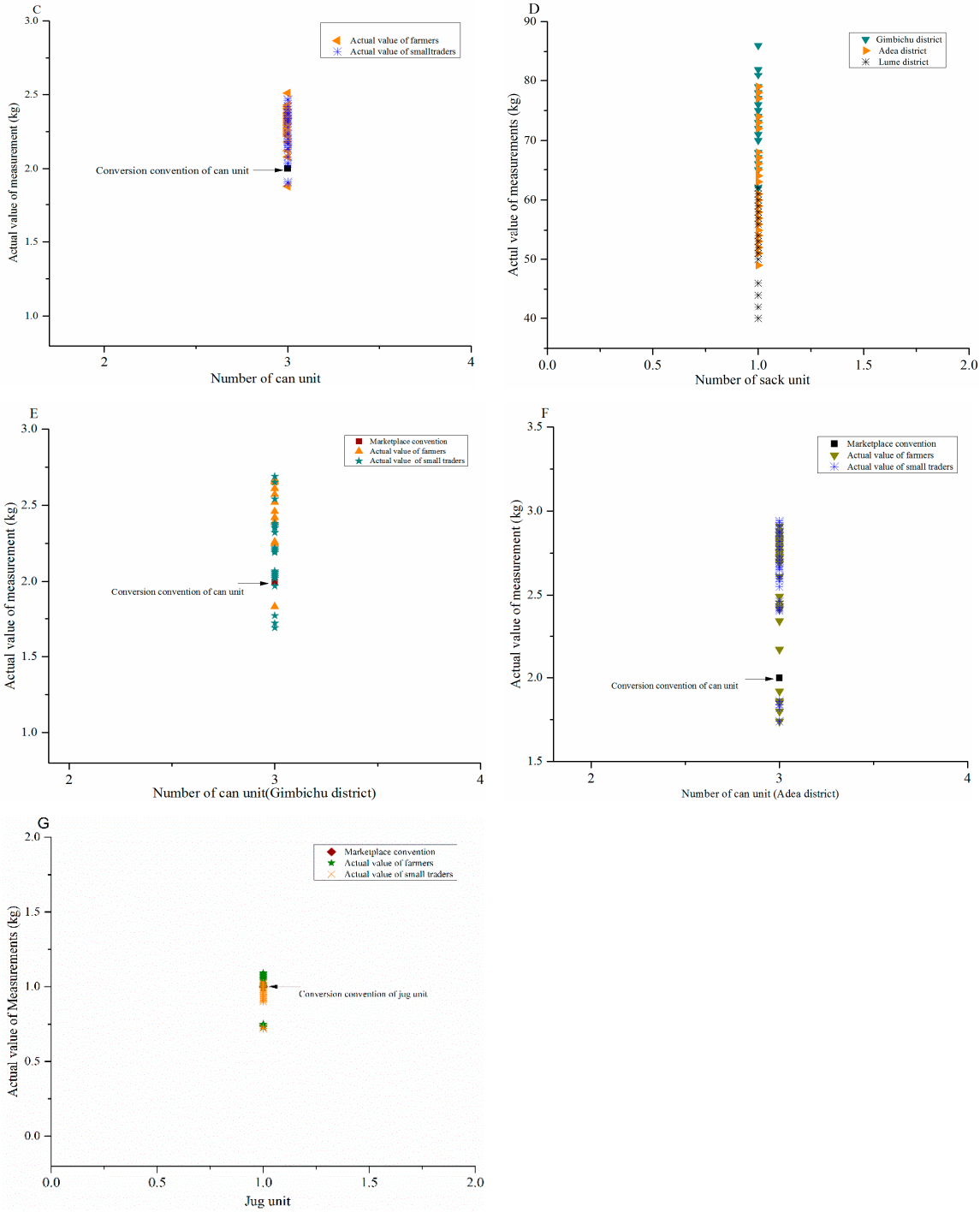

In general, the result revealed that the conversion agreement between measuring instruments and kilogram unit was basically fundamental for trading parties from two essential aspects. Marketplace converting agreement serves the market to adjust the price of the quantity of measuring units with metric units' price that issued and set at the national level. Because the commodity price information provided by the government and agencies in Ethiopia depend on the kilogram unit measurement system. Additionally, reckoning convention helps traders to adjust the price of cereals amount of a particular unit to other sales location measuring instruments while they are trading from one marketplace to other market location. In fact, such basic function of trading requires the

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reliability of local measurement system. However, when the cereals amount of local units converted to kilogram unit using site calibration, as depicted in Figure A-G, the actual values of measurement were highly scattered. These implied that commodity amount was costly transferred from one economic agent to the other. Hence, homogenous measurement unit and the system would have huge potential to alleviate the non-uniformity of values of the measurement.

4.4. Comparison of actual values mean of cereals quantity of local units

Independent samples t-test was employed to compare the actual values summation mean of each cereal quantity of local units (Table 3). The number of values of measurement was taken based on the marketplace conversion convention of each unit. Cereal quantity of two bowl unit, for instance, has been taken as a benchmark in Dendi marketplace for converting the quantity of bowl to kilogram unit, which is equivalent to three kilograms. Hence, two actual values were regarded for the bowl unit to compute t-test. The comparison was also done by considering similar cereal marketed both by farmers and small traders. The results showed that the farmers and small traders actual average value of teff, and wheat quantity of glass; can (White Oats); and jug unit were significantly different in Bako-Tibe, Gimbichu, and Lume districts, respectively (Table 3). In addition, the average value of barley quantity of bowl and jug unit in Dendi and Lume; sorghum quantity of glass and can (White Oats) in Bako Tibe and Gimbichu were statistically varied, respectively.

Table 3. Actual values mean of cereals quantity of local units comparison between farmer and small trader.

Study area	Kind of cereals traded	Marketplace participants	Local unit	Actual Values summation mean	SD	T-value	df	Sig. (2-tailed)
Dendi	Teff	Farmers	bowl	2.76	0.216	0.390	42.00	0.699
		Small traders	"	2.73	0.051			
	Wheat	Farmers	"	2.75	0.150	0.622	43	0.537
		Small traders	"	2.72	0.071			
	Barley	Farmers	"	2.33	0.272	4.471	10.52	0.000***
		Small traders	"	1.98	0.113			
Bako Tibe	Teff	Farmers	glass	0.95	0.617	9.103	51.59	0.000***
		Small traders	"	0.84	0.028			
	Wheat	Farmers	"	0.89	0.015	6.496	6.80	0.000***
		Small traders	"	0.81	0.031			
	Barley	Farmers	"	0.76	0.047	1.213	8	0.260
		Small traders	"	0.71	0.066			
	Maize	Farmers	"	0.90	0.059	3.109	11	0.010**
		Small traders	"	0.77	0.000			
	Sorghum	Farmers	"	0.96	0.021	2.457	7	0.044*
		Small traders	"	0.87	0.066			
Adea Berga	Teff	Farmers	can	2.37	0.040	2.005	25.57	0.056
		Small traders	"	2.33	0.083			
	Maize	Farmers	"	2.14	0.178	-0.240	3.041	0.826
		Small traders	"	2.16	0.019			
	Sorghum	Farmers	"	2.14	0.074	-1.298	9	0.226

		Small traders	"	2.05	0.124			
Gimbichu	Teff	Farmers	can	2.58	0.123	2.795	16	0.013*
		Small traders	"	2.41	0.132			
	Wheat	Farmers	"	2.44	0.119	2.728	13	0.017*
		Small traders	"	2.25	0.147			
	Sorghum	Farmers	"	2.07	0.007	33.941	2	0.001**
		Small traders	"	1.83	0.007			
Adea	Teff	Farmers	can	2.78	0.178	-0.223	32	0.825
		Small traders	"	2.79	0.099			
	Wheat	Farmers	"	2.50	0.096	-1.183	20	0.251
		Small traders	"	2.56	0.113			
	Barley	Farmers	"	1.87	0.067	1.338	7.00	0.223
		Small traders	"	1.82	0.053			
Lume	Teff	Farmers	jug	1.06	0.016	8.148	20	0.000***
		Small traders	"	1.01	0.016			
	Wheat	Farmers	"	1.00	0.012	3.199	17	0.005**
		Small traders	"	0.97	0.023			
	Barley	Farmers	"	0.74	0.010	2.739	6	0.034*
		Small traders	"	0.72	0.010			

*, **, and *** denoted that the mean difference is significant at 1, 5, and 0 percent, respectively.

Source: Field survey, 2018.

In contrast, average value of teff and wheat amount by bowl unit in Dendi; teff, wheat, and barely quantity by can (Bebelac) unit in Adea; teff, maize and sorghum by can (Merti) unit in Adea Berga; and maize quantity by glass in Bako Tibe were not significantly different (Table 3). On another hand, the small trader actual value means of cereals quantity of local units were less than the farmers except for maize quantity by the glass in Bako Tibe; and teff and wheat quantity by the can in Adea (Table 3). These varied values of the quantities of units between farmers and small traders implied that there was either a difference in measuring unit of the same kind, method of measuring, ways of using instruments or diverse mechanism exist among parties to cheat each other as can be stated by [2]. This implied that there was measurement cost occurred due to unreliable measurement system of the marketplace. In another assertion, imprecision of measuring units led trading parties to gain or lose a certain amount of cereals while measurement was performed. To the context, such cereal marketing measurement costs can be saved by aiding trade in terms of institutions and policies.

4.5. Comparison of actual values of cereals quantity of sack unit

In the three districts (Gimbichu, Adea, and Lume) the farmers were using sack unit to trade cereals. Big traders were buying up commodity on the sack and resell them to others neighboring cities using kilogram unit. There were no small traders that are using sack for transacting cereals. Hence, the study conducted one sample t-test to compare cereals amount of sack value mean of farmers in each district. To run this test, the conversion convention value of the quantity of sack for each cereal was taken as population value.

The conversion convention value of the amount of a sack is varied particularly depending on the method of measuring, ways of using sack instrument and types of the sack. In Gimbichu, farmers were ranging a sack value from 74-80kg, and 69-77kg for teff and wheat quantity, respectively. Whereas, teff and wheat quantity of a sack in Adea was about 65kg and 60-64kg, respectively. On another hand, teff, wheat and barley quantity of a sack in Lume are falling in the range of 58-62kg, 50-54kg, and 40-44kg, respectively. Hence, the study takes the average of those ranges as population value (test value) of each cereal to compare the actual values mean with test value (Table 4).

Table 4. Comparison of values means of cereals quantity of the sack unit.

District	Kind of Cereal	Test Value	Mean	Std. Deviation	T-value	df	Sig. (2-tailed)	Mean difference (kg)
Gimbichu	Teff	77kg	72.06	7.11	-2.78	15	0.014**	-4.94
	Wheat	74kg	74.19	4.53	0.24	30	0.814	0.19
Adea	Teff	65kg	62.83	8.06	-1.45	28	0.158	-2.17
	Wheat	62kg	59.44	5.06	-2.15	17	0.047**	-2.56
Lume	Teff	60kg	57.62	2.70	-4.51	25	0.000*	-2.38
	Wheat	52kg	52.65	2.18	1.23	16	0.238	0.65
	Barley	42kg	43.00	2.10	1.17	5	0.296	1.00

*, and **denoted that the mean difference is significant at 1 and 5 percent, respectively.

Source: Field survey, 2018.

The results revealed that the mean significance difference for teff quantity of a sack unit in Gimbichu and Lume; and wheat quantity of a sack in Adea were significant (Table 4). On another hand, the mean of the quantity of wheat per sack in Gimbichu and Lume; teff per sack in Adea; and barley per sack in Lume were not significantly different (Table 4). Yet, the finding clearly showed that the measurement cost happened for the sack unit (Table 4). Here, one can understand that sack based quantity measurement and trade is likely the economy of estimation. In this context, the study suggests either to adopt the standardization of the international measurement unit or develop national idiosyncratic standard measures to reduce such cereals quantity lost amount.

Local markets have varied market conversion convention for cereal quantity of a sack as estimated to kilogram unit. According to [2], these situations were emanated from different kind of sacks, methods of measuring, and way of using sack measuring instrument. To test whether those conditions have an impact on cereals quantity of a sack value difference, the analysis of variance was conducted. The result was indicated that teff and wheat quantity of sack unit value mean comparison of three districts were significantly varied (Table 5). From these findings, the study inferred that the diverse type of sack unit, method of measuring and ways of using sack instrument were highly influencing quantity variation. Toward these, the policy and institutional intervention are essentially important to govern the farmer behavior related to sack measurement system. Thereby, costly transfer of cereal quantity happened due to varied usage of sack unit will be reduced.

Table 5. The actual value means of cereals quantity of sack instrument comparison.

Kind of cereal		Sum of Squares	df	Mean Square	F	Sig.
Teff	Between Groups	2068.771	2	1034.385	25.492	0.000*
	Within Groups	2759.229	68	40.577		
	Total	4828.000	70			
Wheat	Between Groups	5760.365	2	2880.182	160.980	0.000*
	Within Groups	1127.166	63	17.892		
	Total	6887.530	65			

*denoted that the mean difference is significant at less than 1 percent.

Source: Field survey, 2018.

4.6. *Local measuring instruments' error associated measurement costs magnitude*

Based on the study 1 cost estimation framework, the actual measurement summation average of cereal quantity of each measuring unit was computed separately for farmers and small traders, and taken as ideal value. In the measurement cost computation, the marketplace conversion convention between local measures and kilogram unit was used as a baseline to estimate the measurement cost size over trading parties' total marketed cereals. Besides, the computation assumed that the price of cereal quantity of local units over total supply marketing was identical.

The finding showed that the estimated average measurement cost magnitude over total teff, wheat, and barley traded was ranging from 1.49-4.96kg (23.42-56.39birr) for framers and 0.64-2.67kg (9.91-36.59birr) for small traders in Dendi district (Table 6). Comparatively, the small traders' maize and sorghum quantity lost in birr were lowest (Table 6). The small traders' measurement costs mean of total crop traded in terms of kg and birr were less than that of the farmer (Table S1). However, the mean difference of cereal amount lost between farmers and small traders was not significant except for teff per birr (Table S2). In Bako Tibe, the amount of lost quantity was extended from 8.21 to 42.13 birr for farmers and 22.02 to 53.42 birr for small traders (Table 6). The small traders' quantity lost the amount of each cereal was greater than farmers in Bako-Tibe except for teff and sorghum. However, the average value summation of the quantity of three glasses of farmers was higher than that of the small traders (Table 6). The t-test showed that the mean quantity lost in terms of kg and birr were not significantly different (Table S2).

In Adea Berga, the maximum costs incurred on the total supply of farmers was 17.93 birr (Table 6). On another hand, 3.31 birr for maize and 42.43 birr for teff crop were lost by small traders (Table 6). The measurement cost average of farmers for teff was less than that of the small traders, while the mean amount loss of maize was higher for farmers (Table S1). In contrast, the farmers' average value of teff quantity of three can was higher than that of the small traders (Table 6). Besides, the mean difference for teff and maize quantity lost in terms of kg and birr were significant except for maize quantity lost in birr (Table S2).

Table 6. Local units' error associated measurement costs (in kg and birr).

District	Market place actor	Type of cereal	Marketplace conversion convention	Actual value means (kg)	Gained or lost quantity	Measurement costs mean over market convention conversion of local unit	Measurement costs mean over total supply Kg (birr)

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						Mean kg (birr)	SD Kg(birr)	Mean Kg(birr)	SD Kg(birr)
	Farmers	teff	the quantity of 2 bowls =3kg	2.76	gained	0.23(2.06)	0.29(7.66)	5.87(154.39)	8.10(224.08)
			"	"	lost	0.10 (6.02)	0.06(1.19)	1.49(29.83)	1.06(21.26)
Dendi		wheat	"	2.75	gained	0.15(2.74)	0.21(3.97)	3.24(58.98)	4.72(88.98)
			"	"	lost	0.65(0.95)	0.04(0.56)	1.49(23.42)	1.13(18.51)
		barley	"	2.33	gained	0.17(2.45)	0.75(1.15)	3.86(57.00)	2.83(41.90)
			"	"	lost	0.36(4.05)	0.16(1.83)	4.96(56.39)	2.73(30.64)
	Small	teff	"	2.73	gained	0.04(0.82)	0.04(0.87)	1.29(26.27)	1.55(31.78)
	traders		"	"	lost	0.04(0.74)	0.04(0.79)	1.22(25.75)	1.28(27.30)
		wheat	"	2.72	gained	0.16(2.00)	-(-)	2.13(26.56)	-(-)
			"	"	lost	0.02(0.36)	0.09(0.29)	0.64(9.91)	0.44(6.85)
		barley	"	1.98	gained	0.08(1.33)	0.03(0.61)	1.51(25.09)	0.76(11.63)
			"	"	lost	0.06(0.91)	0.10(1.39)	2.67(36.59)	4.83(65.03)
		maize	"	2.68	gained	0.03(0.24)	0.01(0.11)	0.83(6.91)	0.53(4.44)
			"	"	lost	0.02(0.19)	0.03(0.23)	0.77(6.17)	0.99(7.94)
		sorghu	"	2.67	gained	0.02(0.22)	0.01(0.13)	0.58(6.19)	0.43(4.60)
		m	"	"	lost	0.02(0.25)	0.01(0.09)	0.70(8.28)	0.44(5.34)
Bako Tibe	Farmers	teff	quantity of 3 glasses=1kg	0.95	gained	0.07(1.16)	0.03(0.63)	2.59(45.72)	1.89(33.68)
			"	"	lost	0.44(0.67)	0.03(0.45)	2.69(42.13)	1.94(31.09)
		wheat	"	0.89	gained	0.01(0.14)	0.01(0.12)	0.47(6.57)	0.43(6.00)
			"	"	lost	1.58(0.16)	3.12(0.11)	0.63(8.21)	0.42(5.47)
		barley	"	0.76	gained	0.05(1.22)	-	3.95(89.25)	-
			"	"	lost	0.53(0.35)	0.87(0.36)	1.70(34.26)	2.16(43.06)
		maize	"	0.90	gained	0.07(0.34)	0.32(0.14)	4.33(19.00)	1.78(7.91)
			"	"	lost	0.03(0.15)	0.03(0.14)	2.90(12.66)	1.80(9.67)
		sorghu	"	0.96	gained	0.02(0.21)	-	2.09(22.05)	-
		m	"	"	lost	0.01(0.10)	0(0)	0.83(8.54)	0.17(1.88)
	Small	teff	"	0.84	gained	0.03(0.62)	0.01(0.28)	2.76(52.44)	3.04(57.38)
	traders		"	"	lost	0.02(0.28)	0.01(0.19)	2.20(39.04)	1.72(29.07)
		wheat	"	0.81	gained	0.03(0.47)	0.01(0.16)	1.64(25.66)	0.62(9.92)
			"	"	lost	1.02(0.21)	2.00(0.27)	1.56(22.02)	2.22(31.15)
		barley	"	0.71	gained	0.06(1.25)	0.04(1.01)	6.89(124.52)	5.70(90.76)
			"	"	lost	0.89(0.47)	1.88(0.34)	3.60(42.55)	3.44(40.38)
		maize	"	0.77	gained	0.04(0.49)	0.03(0.33)	3.60(44.35)	2.19(27.71)
			"	"	lost	0.08(0.85)	0.02(0.21)	5.07(53.42)	1.23(11.84)
		sorghu	"	0.87	gained	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.00(0.00)
		m	"	"	lost	-	-	-	-
Adea Berga	Farmers	teff	quantity of 3cans=2kg	2.37	gained	0.02(0.49)	0.03(0.69)	0.67(13.95)	1.15(24.30)

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			"	"	lost	0.05(0.84)	0.01(0.28)	0.74(13.77)	0.33(6.74)
		wheat	"	2.29	gained	0.03(0.45)	0.01(0.23)	0.77(12.14)	0.77(12.37)
			"	"	lost	0.03(0.52)	0.03(0.52)	0.57(8.98)	0.44(7.14)
		barley	"	2.29	gained	0.04(0.76)	0.04(0.70)	0.57(10.21)	0.53(9.89)
			"	"	lost	0.07(1.09)	0.08(1.12)	0.67(10.83)	0.42(6.74)
		maize	"	2.14	gained	0.26(2.08)	-	2.77(22.07)	-
			"	"	lost	0.09(0.62)	0.05(0.37)	1.78(13.00)	1.59(12.02)
		sorghu	"	2.14	gained	0.03(0.36)	0.02(0.14)	1.21(11.80)	1.45(11.55)
		m	"	"	lost	0.11(1.61)	-	1.22(17.93)	-
	Small	teff	"	2.33	gained	0.06(1.25)	0.04(0.86)	1.52(30.54)	1.55(30.90)
	traders		"	"	lost	0.06(1.24)	0.04(0.78)	2.21(42.43)	1.52(31.06)
		maize	"	2.16	gained	0.02(0.12)	0.02(0.11)	0.76(5.69)	0.69(4.94)
			"	"	lost	0.02(0.11)	0.01(0.05)	0.48(3.31)	0.22(1.52)
		sorghu	"	2.05	gained	0.03(0.36)	0.02(0.14)	1.21(11.80)	1.45(11.55)
		m							
			"	"	lost	0.11(1.61)	-	1.22(17.93)	-
Gimbic	Farmers	teff	sack unit	72.06	gained	-	-	5.28(116.43)	3.03(70.16)
hu			"	"	lost	-	-	6.79(134.89)	4.29(86.29)
		wheat	"	74.19	gained	-	-	3.32(49.52)	3.55(49.95)
			"	"	lost	-	-	3.54(56.89)	2.12(34.76)
	Farmers	teff	quantity of 3cans=2kg	2.58	gained	0.18(4.15)	0.02(0.54)	2.58(61.31)	0.85(20.60)
			"	"	lost	0.07(1.29)	0.02(0.44)	0.34(6.17)	0.21(3.87)
		wheat	"	2.44	gained	0.19(2.95)	0.01(0.12)	1.64(26.19)	0.07(1.17)
			"	"	lost	0.06(0.92)	0.05(0.84)	0.33(4.95)	0.34(4.83)
	Small	teff	"	2.41	gained	0.06(1.32)	0.24(0.58)	0.88(19.34)	0.64(14.53)
	traders		"	"	lost	0.26(4.97)	0.28(0.92)	2.40(45.34)	0.45(5.02)
		wheat	"	2.25	gained	0.07(1.20)	0.61(1.09)	1.77(29.36)	2.02(35.47)
			"	"	lost	0.18(2.49)	0.16(2.06)	0.54(7.78)	0.43(6.62)
		barley	"	1.79	gained	0.05(0.75)	0.04(0.55)	1.72(24.39)	1.17(16.20)
			"	"	lost	0.18(2.16)	-	1.37(16.43)	-
		maize	"	2.05	gained	0.02(0.05)	0.01(0.03)	0.63(1.86)	0.37(1.08)
			"	"	lost	0.02(0.05)	0.01(0.02)	0.80(2.35)	0.14(0.42)
			"	"	No g/l	0.00(0.00)	-	0.00(0.00)	-
Adea	Farmers	teff	sack unit	62.83	gained	-	-	6.23(138.97)	3.50(111.56)
			"	"	lost	-	-	6.67(172.48)	5.83(161.30)
		wheat	"	59.44	gained	-	-	3.26(46.88)	2.82(44.32)
			"	"	lost	-	-	5.13(75.27)	2.99(43.22)
	Farmers	teff	quantity of 3cans=2kg	2.78	gained	0.23(1.55)	0.25(1.80)	0.99(6.95)	1.06(7.75)
			"	"	lost	0.07(0.51)	0.05(0.34)	0.37(2.66)	0.23(1.63)
		wheat	"	2.50	gained	0.05(0.27)	0.06(0.28)	0.58(2.88)	0.76(3.63)

			"	"	lost	0.09(0.46)	0.08(0.39)	1.15(5.88)	1.63(8.49)
		barley	"	1.87	gained	0.07(0.30)	0.00(0.00)	0.68(2.91)	0.69(2.94)
			"	"	lost	0.05(0.20)	0.03(0.12)	0.57(2.41)	0.40(1.72)
	Small	teff	"	2.79	gained	0.09(0.61)	0.06(0.36)	1.02(6.85)	0.72(4.72)
	traders		"	"	lost	0.08(0.53)	0.05(0.34)	0.53(3.62)	0.44(3.11)
			"	"	No g/L	0.00(0.00)	-	0.00(0.00)	-
		wheat	"	2.56	gained	0.09(1.42)	0.07(1.03)	0.43(6.39)	0.42(6.18)
			"	"	lost	0.09(1.24)	0.71(0.61)	0.73(10.11)	0.61(8.54)
		barley	"	1.82	gained	0.05(0.69)	0.06(0.78)	0.35(4.68)	1.18(2.47)
			"	"	lost	0.02(0.26)	0.01(0.18)	0.14(1.72)	0.15(1.94)
Lume	Farmers	teff	sack unit	57.62	gained	-	-	2.16(49.94)	1.76(44.67)
			"	"	lost	-	-	2.15(46.59)	1.42(30.18)
		wheat	"	57.62	gained	-	-	1.65(25.97)	0.86(13.78)
			"	"	lost	-	-	1.85(26.79)	1.60(23.06)
		barley	"	43	gained	-	-	1.67(18.50)	1.15(13.25)
			"	"	lost	-	-	1.67(17.00)	1.15(11.25)
	Farmers	teff	quantity of 1jug=1kg	1.06	gained	0.02(0.33)	0.01(0.12)	0.49(9.71)	0.31(6.82)
			"	"	lost	0.02(0.41)	0.01(0.19)	0.36(7.36)	0.28(6.00)
			"	"	No g/l	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.00(0.00)
		wheat	"	1.00	gained	0.00(0.08)	0.01(0.09)	0.23(3.59)	0.24(4.01)
			"	"	lost	0.00(0.07)	0.02(0.24)	0.11(0.19)	1.71(2.92)
		barley	"	0.74	gained	0.01(0.10)	0.00(0.00)	0.24(2.29)	0.14(1.39)
			"	"	lost	0.01(0.09)	0.00(0.00)	0.30(2.69)	0.04(0.28)
			"	"	No g/l	0.00(0.00)	-	0.00(0.00)	-
	Small	teff	"	1.01	gained	0.02(0.44)	0.01(0.16)	0.99(22.18)	0.96(21.47)
	traders		"	"	lost	0.01(0.28)	0.01(0.09)	0.49(10.35)	0.66(13.70)
			"	"	No g/l	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.00(0.00)
		wheat	"	0.97	gained	0.02(0.31)	0.01(0.13)	0.75(12.42)	0.60(10.13)
			"	"	lost	0.03(0.37)	0.02(0.31)	0.69(11.00)	0.42(7.09)
			"	"	No g/l	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.00(0.00)
		barley	"	0.72	gained	0.01(0.11)	-	0.21(2.31)	-
			"	"	lost	0.00(0.00)		0.00(0.00)	0.00(0.00)
		maize	"	0.93	gained	0.01(0.10)	0.01(0.09)	0.94(8.24)	0.69(6.11)
			"	"	lost	0.02(0.15)	0.01(0.11)	1.10(9.23)	0.95(7.93)
		sorghu	"	0.92	gained	0.02(0.15)	0.01(0.07)	0.91(9.06)	0.72(7.29)
		m	"	"	lost	0.03(0.32)	-	2.4(25.26)	-

394 Note: Birr is Ethiopian currency. By the end of January 2019, 1 USA dollar = 28.18 Birr.

395 Source: Field survey, 2018.

396 The average teff and wheat amount lost from the market day total supply by farmers in
397 Gimbichu, Adea and Lume was 6.79kg (134.89birr) and 3.54kg (56.89birr); 6.67kg (172.48birr) and

5.13 kg (75.27birr); and 2.15kg (46.59birr) and 1.85kg (26.79birr), respectively (Table 6). The measurement cost was comparatively higher in Adea district (Table 6). In contrast, the cost resulted from using a can by farmers and small traders over aggregate teff and wheat crops in Gimbichu, Adea and Lume were relatively smaller than that of the sack-related biased measurement cost. The reason was that the sack is the primary unit of measurement in those districts. Trading parties were using different can and jug tools for micro cereals marketing. The maximum average quantity lost from can and jug unit in Gimbichu, Adea, and Lume was 45.34 birr, which was incurred by small traders (Table 6). On the other hand, the sum of small traders' average value of cereal quantity for three can in Gimbichu and Adea and one jug unit in Lume was smaller than that of the farmers except for teff and wheat in Adea district (Table 6). However, the t-test results showed that the measurement cost size means over total supply of teff and wheat for can unit were not statistically varied in Gimbichu, Adea, and Lume except for teff in birr in Gimbichu (Table S2).

The result implied that the measuring unit error associated cost was higher mainly for the sack, bowl and glass units of measurement. These units were used primarily for macro cereal supply trading. Whereas, the remaining local units like can and jug were employed as an alternative or for micro-cereals supply marketing purpose. Hence, can and jug unit associated bias costs were relatively smaller. The number of farmers and small traders who lost cereals quantity was 50.54 percent (Table S3). In addition, the frequency of most farmers to conduct market within a month is two times on average [2]. This figure become higher if it is projected for all transaction days made in a year. Therefore, if a half percent of farmers and small traders of all districts faced the same situation throughout the year, a big economy loss will be incurred. In general, either the development of homogenous idiosyncratic measures or the adoption of the international metric and imperial measurement system is suggested to reduce such huge loss of cereal amount [17]. Besides, rules for governing behavior of markets would have a huge potential for economizing measurement costs and making equitable cereals exchanges [24, 25, 26, 27].

4.7. The magnitude of the cost of local measurement tools unreliability

4.7.1. Measurement consistency

The quantity measurement consistency dimension was evaluated in the marketplace where both hot and slack market day were conducted in a week. However, the hot and slack market day were performed only for sack unit of measurement in Gimbichu district. In the remaining study sites, the hot market alone was conducted in different sales locations of the district. For this reason, the measurement consistency evaluation was limited to participating farmers of one study area. Thereby, the farmers' sample size (n=40) was taken for two market days to evaluate the actual value and price mean comparison. The measurement consistency of teff and wheat amount of the sack unit between a hot and slack market day of Gimbichu district was indicated in table 7. The finding showed that the actual values and transaction price mean difference was insignificant (Table 7). These results inferred that the values and price of the quantity of a sack of two market days in a week were not consistent, though the p-value was greater than 0.05.

439 **Table 7.** Hot and slack market day cereal quantity measurement consistency of sack unit.

Type of cereal	Value and price of a sack unit	Nature of the market day	Mean (Kg)	SD (kg)	T-value	df	Sig. (2-tailed)
Teff	Actual value	Hot market day	72.0625	7.11307	-0.897	51	0.374
		Slack market day	74.0811	7.67890			
	Transaction price	Hot market day	1512.1875	130.16616	-0.920	51	0.362
		Slack market day	1554.0541	160.30283			
Wheat	Actual value	Hot market day	74.1935	4.53446	0.546	42	0.588
		Slack market day	73.3846	4.35007			
	Transaction price	Hot market day	1159.3548	73.16354	0.692	42	0.493
		Slack market day	1139.2308	117.15101			

440 Source: Field survey, 2018.

441 4.7.2. Measurement conformity

442 The same approach considered for estimating measures error related cost was used for assessing
443 non-conformity measurement costs. The average actual measurement value was computed and taken
444 as acceptable or pre-specified value. The assumption was to evaluate the deviation of over repeated
445 actual value of cereal quantity of each local unit from their average value. The non-conformity of over
446 repeated actual values of cereal quantity of measuring units were used the conversion convention as
447 a point of reference to estimate cost for the total supply of market actors. The price of cereal quantity
448 of each local unit was identical throughout the total cereal amount trade transaction. The non-
449 conformity associated costs result was the same with local units' error-related costs specified in table
450 6. On the other hand, in both measurement error (Barzel) and sameness (Velkar) methods, the amount
451 of computed measurement cost was identical. These findings are, therefore, not rejecting the views
452 of Velkar on Barzel's measurement error assumptions. Because there were limitations for applying
453 measurement reliability dimensions. The first restraint was that the average values approach was
454 applied due to the lack of some standard for each local measurement unit. Besides, the quantity
455 measurement consistency was confined only to one study area. Moreover, there was the constraint
456 for determining measurement uniformity among districts due to the heterogeneity nature of local
457 units (see section 4.7.3).

458 4.7.3. Measurement uniformity

459 As clearly indicated in this study, the cereal commodity amount of the majority of local units
460 value means of the farmers was greater than that of small traders (table 3). In addition, the average
461 value of the quantity of local unit between farmers and small traders were significantly different for
462 most cereals. From these findings, one can conclude that there was no measurement uniformity in
463 between marketplace actors local units. The policy intervention is thereby fundamental towards
464 quantity measurement heterogeneity problems.

465

466

5. Conclusions

The study conducted on cereal commodity trade quantity measurement cost and reliability in six districts' agricultural marketplace of Oromia region showed that the measurement system was unreliable. According to this survey, the actual values of the quantities of local measures were dispersed far below or above the conversion point of units of measurement. The farmers' actual values mean of the quantity of most local units were greater than that of the small traders. In addition, the comparison of average values of the quantity of the utmost local units between farmers and small traders were significantly varied. These result also indicated that there was no measurement uniformity between farmers and small traders. Moreover, the study found that the diverse type of sack unit, methods of measuring, and ways of using sack instrument were highly influencing quantity variation. These findings were clearly illustrated that the quantity amount was transferred costly from one trading party to the other parties.

The estimated average costs of measuring instruments' error of total cereal commodity traded on one market day were ranging from 17-172.18 birr for sack unit, 6.17-56.39 birr for bowl unit, and 8.21-53.42 birr for glass unit both for farmers and small traders. Similarly, error based costs for can (Merti), can (White Oats), can (Bebelac), and jug unit was 3.31-42.43 birr, 2.35-45.34 birr, 1.72-10.11 birr, and 0.19-25.26 birr, respectively. Comparatively, the measurement costs were higher for the sack, bowl, and glass units of measurement. The reliability method quantity measurement cost extent was identical to error based costs due to the application of the same estimation approach. However, Velkar's views about Barzel's measurement error assumptions was not rejected.

In general, the study concluded that the cereal commodity trade quantity measurement of farmers and small traders were not reliable. The findings additionally revealed that the measuring units' error and unreliability related estimated average costs magnitude on one market day transaction were higher for most cereals traded except for secondary units of measurement and micro-cereals supply marketing. In another way, the farmers and small traders can lose a huge economy especially if the extent of measurement costs is projected for the total transaction days made within a year. In this manner, the spillover effects of the multiple and non-uniform unit of measurement upon local economy are enormous. Based on these facts, the study suggested the complete standardization for the cereal commodity trade measurement system either by the development of national idiosyncratic measuring unit or adopting an international unit of measurement. Besides, institutions and policy interventions are equivalently essential for governing the measurement behavior of actors of the marketplace. To these ends, this study is vital in the context of sub-Saharan countries and/or at a country level to give conscious bell for minding the economic benefit of measurement. Overall, the results of this study have supreme contribution to improve agricultural market functioning, rural incomes, macroeconomic policy, and national markets integration in developing countries where there are complex, multiple and non-uniform local measures.

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507 **Supplementary materials**

508 **Appendix A**

509 **Table S1.** Local units' bias related measurement costs mean over total traded crops (in kg and birr).

District	Type of cereals	Marketplace actors	Mean	SD	Std. Error Mean
Dendi	Teff (Kg)	farmers	1.497	1.057	0.211
		small traders	0.740	0.787	0.394
	Teff (Birr)	farmers	29.829	21.256	4.251
		small traders	1.220	1.277	0.638
	Wheat (kg)	farmers	1.078	1.524	0.247
		small traders	0.770	0.349	0.156
	Wheat (birr)	farmers	16.583	24.751	4.015
		small traders	11.892	5.401	2.416
	Barley (kg)	farmers	4.962	2.732	1.115
		small traders	3.338	5.299	2.650
	Barley (birr)	farmers	56.387	30.640	12.509
		small traders	45.648	71.295	35.647
Bako-Tibe	Teff (kg)	farmers	2.600	1.969	0.386
		small traders	2.200	1.724	0.652
	Teff (birr)	farmers	40.576	31.484	6.175
		small traders	39.039	29.067	10.986
	Wheat (kg)	farmers	0.840	0.000	0.000
		small traders	3.125	2.242	1.585
	Wheat (birr)	farmers	10.940	0.000	0.000
		small traders	44.050	31.141	22.020
	Barley (kg)	farmers	4.503	3.225	1.613
		small traders	4.503	3.225	1.613
	Barley (birr)	farmers	53.190	37.682	18.841
		small traders	53.190	37.682	18.841
Adea-Berga	Teff (kg)	farmers	0.045	0.014	0.006
		small traders	2.209	1.521	0.538
	Teff (birr)	farmers	13.767	6.740	2.752
		small traders	42.434	31.065	10.983
	Maize (kg)	farmers	1.783	1.595	0.921
		small traders	0.480	0.216	0.108
	Maize (birr)	farmers	13.000	12.019	6.939
		small traders	3.308	1.519	0.760
Gimbichu	Teff (kg)	farmers	0.344	0.215	0.096
		small traders	2.400	0.453	0.320
	Teff (birr)	farmers	6.168	3.867	1.729
		small traders	45.340	5.020	3.550
	Wheat (kg)	farmers	0.332	0.344	0.141
		small traders	0.535	0.431	0.305

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	Wheat (birr)	farmers	4.947	4.835	1.974
		small traders	7.780	6.619	4.680
Adea	Teff (kg)	farmers	0.373	0.232	0.067
		small traders	0.593	0.421	0.149
	Teff (birr)	farmers	2.665	1.628	0.470
		small traders	4.074	2.991	1.057
	Wheat (kg)	farmers	1.148	1.626	0.813
		small traders	0.733	0.608	0.248
	Wheat (birr)	farmers	5.875	8.488	4.244
		small traders	10.113	8.537	3.485
	Barley (kg)	farmers	0.567	0.402	0.232
		small traders	0.135	0.148	0.105
	Barley (birr)	farmers	2.410	1.716	0.991
		small traders	1.720	1.937	1.370
Lume	Teff (kg)	farmers	0.357	0.281	0.162
		small traders	0.493	0.662	0.331
	Teff (birr)	farmers	7.360	6.003	3.466
		small traders	10.355	13.703	6.851
	Wheat (kg)	farmers	0.210	0.071	0.050
		small traders	0.688	0.417	0.209
	Wheat (birr)	farmers	3.330	1.160	0.820
		small traders	11.003	7.086	3.543

510

511 **Table S2.** Independent samples t-test for local units' bias related measurement costs over total supply.

District	Local unit	Kind of cereals	t-value	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Dendi	bowl	teff (Kg)	1.365	27	0.184	0.757	0.555	-0.381	1.896
		teff (birr)	6.655	24.993	0.000*	28.609	4.299	19.755	37.462
		wheat (Kg)	0.446	41	0.658	0.308	0.691	-1.087	1.703
		wheat (birr)	0.418	41	0.678	4.691	11.214	-17.957	27.338
		barley (kg)	0.645	8	0.537	1.624	2.516	-4.179	7.427
		barley (birr)	0.333	8	0.748	10.739	32.229	-63.581	85.059
Bako-Tibe	glass	teff (kg)	0.488	31	0.629	0.400	0.819	-1.271	2.071
		teff (birr)	0.116	31	0.908	1.537	13.214	-25.412	28.486
		wheat (kg)	-1.934	3	0.149	-2.285	1.181	-6.045	1.475
		wheat (birr)	-2.017	3	0.137	-33.110	16.413	-85.343	19.123
		barley (kg)	0.000	6	1.000	0.000	2.281	-5.581	5.581
		barely (birr)	0.000	6	1.000	0.000	2.281	-5.581	5.581
Adea-Berga	Can	Teff (kg)	-4.023	7.002	0.005*	-2.164	0.538	-3.436	-0.892

		Teff (birr)	-2.532	7.863	0.036*	-28.667	11.322	-54.856	-2.478
		Maize (kg)	-2.532	7.863	0.036*	-28.667	11.322	-54.856	-2.478
		Maize (birr)	1.389	2.048	0.297	9.693	6.980	-19.677	39.062
Gimbichu	Can	Teff (kg)	-6.154	1.186	0.076	-2.056	0.334	-5.012	0.900
		Teff (birr)	-11.354	5	0.000*	-39.172	3.450	-48.041	-30.303
		Wheat (kg)	-0.691	6	0.515	-0.203	0.294	-0.923	0.516
		Wheat (birr)	-0.671	6	0.527	-2.833	4.225	-13.173	7.506
Adea	Can	Teff (kg)	-1.504	18	0.150	-0.219	0.146	-0.525	0.087
		Teff (birr)	-1.367	18	0.188	-1.409	1.031	-3.574	0.756
		Wheat (kg)	0.580	8	0.578	0.414	0.714	-1.232	2.060
		Wheat (birr)	-0.771	8	0.463	-4.238	5.499	-16.919	8.442
		Barley (kg)	1.395	3	0.257	0.432	0.309	-0.553	1.416
		Barley (birr)	0.422	3	0.702	0.690	1.637	-4.519	5.899
Lume	Jug	Teff (kg)	-0.328	5	0.756	-0.136	0.414	-1.201	0.929
		Teff (birr)	-0.348	5	0.742	-2.995	8.610	-25.127	19.137
		Wheat (kg)	-1.518	4	0.204	-0.478	0.315	-1.351	0.396
		Wheat (birr)	-1.437	4	0.224	-7.673	5.338	-22.493	7.148

*denoted the mean difference is significant at less than 5 percent.

Appendix B

Table S3. Numbers of farmers and small traders gained and lost cereals quantity due to measurement error.

Study site	Marketplace actors	Type of cereals	No of farmers and small traders who gained quantity	No of farmers and small traders who lost quantity	No of farmers and small traders who neither gained nor lost quantity
Dendi	farmers	teff	10	25	-
		wheat	11	27	-
		barely	13	6	-
	small traders	teff	4	4	-
		wheat	1	6	-
		barely	4	5	-
		maize	6	8	-
		sorghum	6	6	-
Bako-Tibe	framers	teff	16	25	-
		wheat	5	4	-
		barely	1	3	-
		maize	3	8	-
		sorghum	1	2	-
	small traders	teff	8	7	-
		wheat	3	4	-
		barely	3	5	-

		maize	2	-	-
		sorghum	4	2	-
Adea-Berga	farmers	teff	13	6	3
		wheat	9	12	-
		barely	9	6	-
		maize	1	3	-
		sorghum	3	1	-
	Small traders	Teff	10	8	-
		maize	3	4	-
Gimbichu	Farmers (sack unit)	teff	9	7	-
		wheat	16	15	-
	Farmers(can unit)	teff	2	5	-
		wheat	2	6	-
	Small traders (can unit)	teff	9	2	-
		wheat	5	2	-
		barely	4	1	-
		maize	4	3	1
Adea	Farmers(sack unit)	teff	15	14	-
		wheat	11	7	-
	Farmers(can unit)	teff	4	12	-
		wheat	6	4	-
		barely	2	3	-
	small traders (can unit)	teff	8	9	1
		wheat	6	6	-
		barely	2	2	-
Lume	Farmers(sack unit)	teff	13	13	-
		wheat	9	8	-
		barely	3	3	-
	Farmers(can unit)	teff	3	3	4
		wheat	3	3	-
		barely	2	2	1
	small traders (can unit)	teff	5	4	3
		wheat	6	4	3
		barely	1	-	-
		maize	3	2	2
		Total	**302**	**327**	**18**

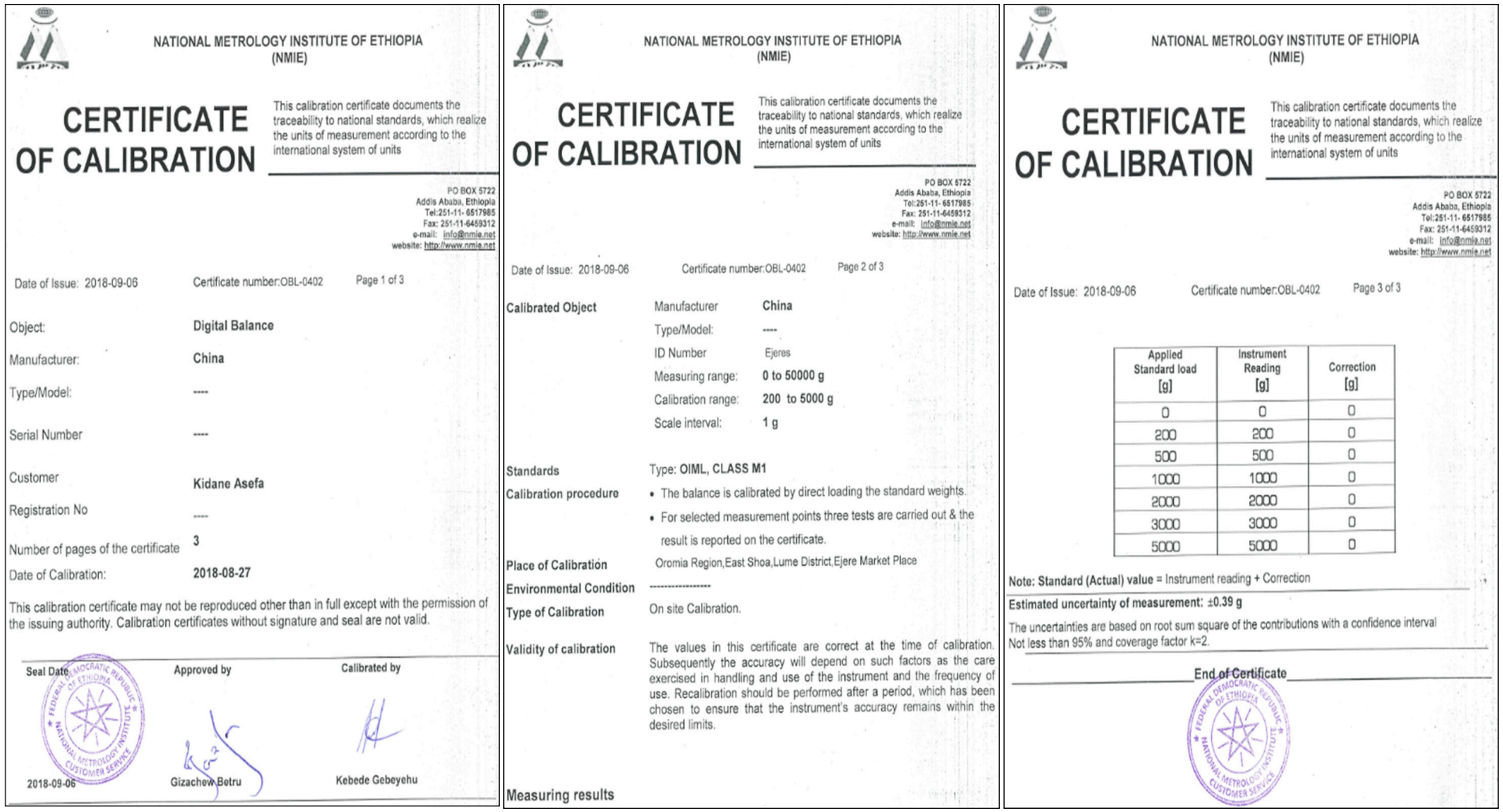
Appendix C

Table S4. Certificate of calibration.

District	Marketplace	Unit of measurement	Certificate number	Object	Calibrated Object (Manufacturer)	Date of calibration	Type of calibration	Measuring range	Calibration range	Estimated uncertainty of measurement [gram]
Dendi	Ginchi	bowl	OBL-0408	Digital balance	China	2018-08-27	Site calibration	0-50000g	200-5000g	±0.39
Bako Tibe	Bako	glass	OBL-0398	Digital balance	"	"	"	0-50000g	200-5000g	±0.39
Adea Berga	Incini	can	OBL-0406	Digital balance	"	"	"	0-50000g	200-5000g	±0.39
Gimbichu	Chafe Donsa	sack	OBL-0399	Mechanical balance	Italy	2018-08-09	"	0-3000kg	5-100kg	±1.03
		can	OBL-0400	Digital balance	China	2018-08-09	"	0-50000g	200-5000g	±0.40
Adea	Godino	sack	OBL-0404	Mechanical balance	Italy	2018-08-11	"	0-3000kg	5-100kg	±1.03
	Robi	sack	OBL-0409	"	Italy	2018-08-14	"	0-3000kg	5-100kg	±1.03
	Godino	can	OBL-0405	Digital balance	China	2018-08-11	"	0-50000g	200-5000g	±0.40
	Robi	can	OBL-0410	"	"	2018-08-14		0-50000kg	200-5000g	±0.40
Lume	Modjo	sack	OBL-0407	Mechanical balance	Italy	2018-08-27	"	0-3000KG	5-100KG	±1.03
	Ejere	sack	OBL-0401	"	"	"	"	0-3000KG	5-100KG	±1.03
	Modjo	jug	OBL-0408	Digital balance	China	2018-08-27	"	0-5000g	200-5000g	±0.39
	Ejere	jug	OBL-0402	"	"	"	"	0-5000g	200-5000g	±0.39

Source: Site calibration measurement collaboration with National metrology institute of Ethiopia (NMIE), 2018.

Material S4: Sample of calibration certificate.



NATIONAL METROLOGY INSTITUTE OF ETHIOPIA
(NMIE)

CERTIFICATE OF CALIBRATION

This calibration certificate documents the traceability to national standards, which realize the units of measurement according to the international system of units

PO BOX 5722
Addis Ababa, Ethiopia
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Fax: 251-11-6459312
e-mail: info@nmie.net
website: http://www.nmie.net

Date of Issue: 2018-09-06 Certificate number:OBL-0402 Page 1 of 3

Object:	Digital Balance
Manufacturer:	China
Type/Model:	----
Serial Number	----
Customer	Kidane Asefa
Registration No	----
Number of pages of the certificate	3
Date of Calibration:	2018-08-27

This calibration certificate may not be reproduced other than in full except with the permission of the issuing authority. Calibration certificates without signature and seal are not valid.

Seal Date	Approved by	Calibrated by
2018-09-06	Gizachew Betru	Kebede Gebeyehu

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Calibrated Object

Manufacturer	China
Type/Model:	----
ID Number	Ejeres
Measuring range:	0 to 50000 g
Calibration range:	200 to 5000 g
Scale interval:	1 g

Standards Type: OIML, CLASS M1

Calibration procedure
- The balance is calibrated by direct loading the standard weights.
- For selected measurement points three tests are carried out & the result is reported on the certificate.

Place of Calibration Oromia Region,East Shoa,Lume District,Ejere Market Place

Environmental Condition ----------

Type of Calibration On site Calibration.

Validity of calibration The values in this certificate are correct at the time of calibration. Subsequently the accuracy will depend on such factors as the care exercised in handling and use of the instrument and the frequency of use. Recalibration should be performed after a period, which has been chosen to ensure that the instrument's accuracy remains within the desired limits.

Measuring results

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This calibration certificate documents the traceability to national standards, which realize the units of measurement according to the international system of units

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Date of Issue: 2018-09-06 Certificate number:OBL-0402 Page 3 of 3

Applied Standard load [g]	Instrument Reading [g]	Correction [g]
0	0	0
200	200	0
500	500	0
1000	1000	0
2000	2000	0
3000	3000	0
5000	5000	0

Note: Standard (Actual) value = Instrument reading + Correction

Estimated uncertainty of measurement: ±0.39 g

The uncertainties are based on root sum square of the contributions with a confidence interval Not less than 95% and coverage factor k=2.

End of Certificate

Author Contributions: Conceptualization, K.A.; Data curation, K.A.; Formal analysis, K.A., B.G., N.H., D.A.; Investigation, K. A.; Methodology, K.A.; Project administration, D. Z.; Supervision, D. Z.; Validation, B.G., N.H., D. Z.,D.A.; Writing – original draft, K.A.; Writing – review & editing, B.G.,D.A., N.H..

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Conflicts of Interest: The authors declare no conflict of interest.

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