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Value Addition and Processing by Farmers in Developing Countries: Evidence From the Coffee Sector in Ethiopia

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[rough draft]

Abstract

Washed coffee is being sold in international markets with a premium of more than 20%. However, only about 30% of Ethiopia's coffee export is washed and the small-scale coffee farmers, processors, exporters, and the country are missing out on sizable opportunity of commanding higher rewards. Relying on unique datasets and using a double hurdle technique, we examined factors affecting the decision and amount of selling coffee in red berries -the primary input for washing coffee- instead of the dried type. Results show that lack of access to wet mills, lack of enough red berry buyers, and bad quality coffee harvest reduce the likelihood of coffee sales in red berries form and hence a subsequent lower level of washed coffee. On the other hand, government's action of deciding designated selling dates, membership to a cooperative, and access to advances and loans increase the likelihood of selling coffee in red berries form.

Keywords: Value addition**,** Coffee, Ethiopia

1. Introduction

The recent globalization and expanding international markets offer considerable opportunities for smallholder producers in developing countries to operate in these markets. On the other hand, global market is also shifting towards 'buyer-driven' value chains with buyers recently embedding complex quality information into widely accepted standards. In order to benefit from the expanding opportunities, hence, producers must adhere to these stringent quality and safety standards and regulations in these markets (Dolan and Humphrey, 2000; Ponte, 2004; Daviron and Ponte, 2005; Swinnen, 2007). This is also true for smallholding farmers and other stakeholders in coffee exporting developing countries that are faced with different challenges including controlling and producing in cost effective ways in order to guarantee the quality and value added of their product (Trienekens, 2011; Donnet et al., 2008). Value addition through improved processing might lead to higher incomes and prices for coffee producers. For coffee, value can be added in such ways as washing, specialty production, environmental sustainability, produce's origin and characteristics.

Coffee quality depends importantly on the type of processing, i.e. 'wet' or 'dry'. In 'wet processing', commonly known as 'washing', fresh red berries are de-pulped, fermented and washed using wet-mill machines (Alemu et.al., 2009; Minten et.al., 2014). For coffee to be processed in 'wet', coffee farmers need to supply their coffees in fresh red-berries of certain level of ripeness. They should deliver the red-berries to washing stations within 10-12 hours of harvesting. This is in contrast to dry processing, where berries are dried, often in the house of the farmer, and hulled using hullers. Wet processing is generally regarded as producing a higher quality coffee and commands a significant premium over unwashed coffee at the export level-20% higher (Minten et.al., 2014). However, even when there are seemingly significant price premiums for washed coffee, only about 30% of Ethiopia's coffee export is washed and both the country and small-scale coffee farmers are missing out on the opportunity of commanding higher rewards. It is however not well understood what the constraints are to achieving higher rates of washed coffee in the country as it might be linked to a lack of investments in wet mills or to a lack of demand by farmers due to limited alternative saving instruments, lack of labour rewards for the farmers, quality issues or fear of theft that push farmers to harvest too early to allow for wet processing. This study hence, addresses one of the most important challenges in the sector-i.e. constraints of value addition and value addition strategies. We analyze the patterns and determinants of selling coffee in red berries - the prerequisite for processing coffee in wet- and factors affecting the volume of red berries sales.

The paper is structured as follows: the next section presents background on Ethiopian coffee, section three describes data used and the methodology employed, section four discusses qualitative and quantitative results while the last section concludes.

2. Background of Coffee in Ethiopia

Ethiopia, widely known for its diverse and unique Arabica flavors, is origin and Africa's biggest coffee producer and exporter (USDA, 2012; Petit, 2007). Coffee in Ethiopia is generally produced in the West, South and South Western part of the country[1]. According to the classification of the Ethiopian Coffee Liquoring Unit (CLU)[2], the major coffee quality indicators are type of processing i.e., whether it is 'wet' or 'dry' and source of origin i.e., the specific production area in the country which is mainly dictated by soil type and agro-climatic conditions (Werako et.al., 2009; LMC, 2003). As for the source of origin, 'Jima', 'Nekemte', 'Sidama', 'Yirgachefe', and 'Harar' -the names pertaining to the areas they are produced- are the best qualities and also account for more than 85 percent of total production and supply (Dahlberg, 2011; CSA, 2013).

Coffee is the primary cash crop and integral to both the national GDP and the livelihoods of millions of people in Ethiopia where policy makers in Ethiopia regard the sector as crucial in terms of its potential to raise smallholders' income, government revenue, and foreign currency (GTP 2010; Petit, 2007). It has accounted on average for about 5% of GDP and about 10% of total agricultural production for the past three to four decades (USDA, 2012).

Despite a recent decline in its share in total export, coffee still remains by far the most important export item in Ethiopia (Minten et al., 2014, NBE, 2013). Over 20 million people, nearly a quarter of the total population, directly or indirectly rely on income from the sector for their livelihood (Alemu et.al, 2009; USDA, 2012).

Smallholder households with small and fragmented land size (usually less than half a hectare) account for 95 percent of all coffee produced in Ethiopia while state owned farms and private investors account for 4.4 percent and 0.6 percent, respectively (Worako et.al., 2009).

Despite its importance both at the macro and micro household level, the sector's performance has remained unsatisfactory and smallholder producers face a number of challenges in the form of low productivity and quality, lack of access to markets, little opportunities for value addition, lack of capital and access to credit to invest in machineries and to pay for transport to sell outputs. Consequently, any policy change and shocks in production or prices have a direct impact on the earnings of these farming households, other stakeholders and on the national economy.

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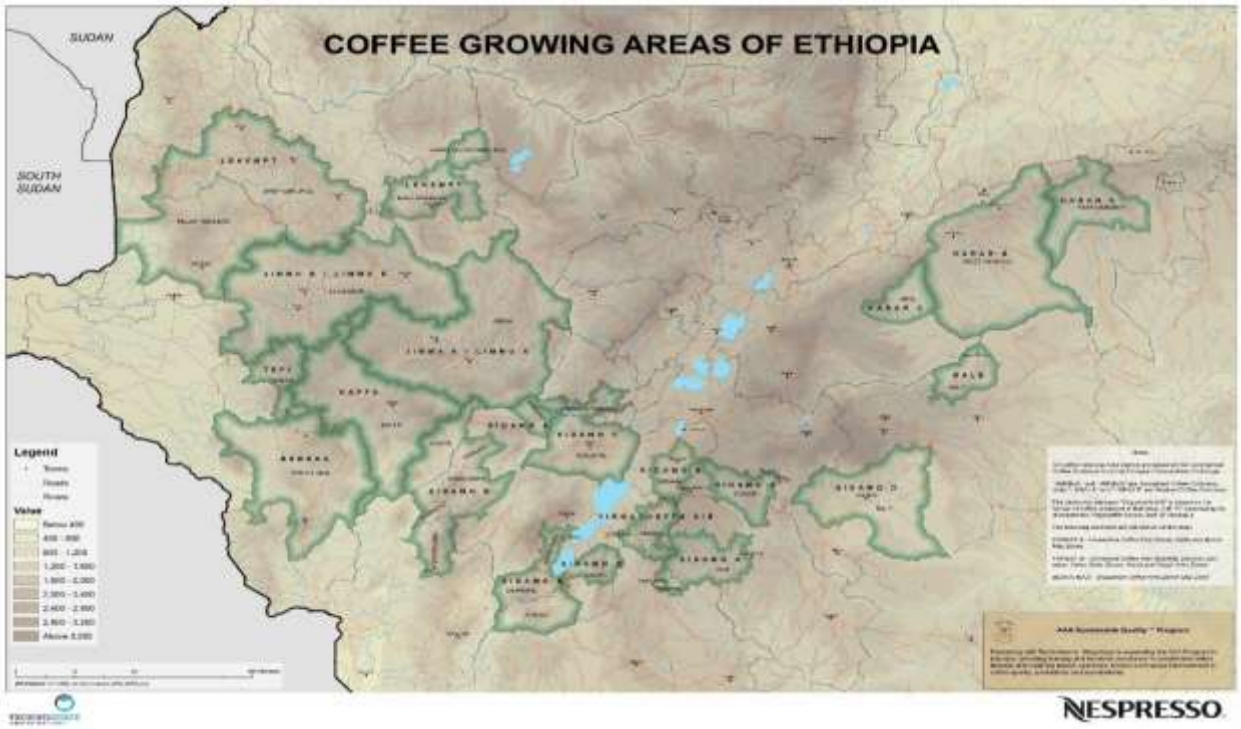
[1] Ethiopian coffee is cultivated through four different systems: Forest, Semi-forest, Garden, and state-owned or private commercial. The Forest coffee is a wild coffee in deep forest and accounts for about 10 percent of total coffee production ; the semi-forest coffee- which is grown in forest as well with certain degree of human interference - accounts for about 30 percent. The Garden coffee – which accounts for over 50 percent of total production, is planted by smallholder farmers and usually intercropped with cereals, fruits, and vegetables (Petit, 2007 ; Minten et.al., 2014).

[2] The CLU is a unit that grades the quality of each coffee and ensures that the coffees meet the required standards. The grading invloves detailed physical and cup inspections.



Source: TechnoServe Ethiopia (2014)

Figure 1: Coffee production areas in Ethiopia

2.1.Wet processing and red berries sales in Ethiopia

For coffee to be processed in wet and have proper fragrance, and smoothness, coffee berries should be picked when they fully ripe -i.e., when the berries are high with aromatic oil and lower organic acid content (Musebe et al., 2011; Kufa 2012). Once they turn bright red, they should be picked within 2-3 days –implying that cherry picking is a rather laborious task and hence costly. Coffee farmers (or rural assemblers) need to take the fresh harvested red berries into washing stations within 10-12 hours of picking or otherwise, the berries may no longer be suitable for washing. This would imply that coffee farmers in relatively remote areas may be forced to sell their coffees in dry berries even if they want to sell in red form.

Value addition through improved processing might lead to higher incomes and prices for coffee producers, processors and traders. Figure 2 (a)-(c) below present non-parametric estimates of premiums between wet-processed and dry-processed coffee at export, wholesale, and producer level. Figure 2 (a) shows that washed coffee earns significantly higher premium as compared to the unwashed type at the export level which is consistent with findings of Minten et.al (2014) that showed up to 25% higher premium for washed coffee at same level. Similarly, figure 2 (b) indicates that washed coffee gets higher premium at a wholesale level -i.e., at the Ethiopian Commodity Exchange (ECX) level. Comparison of prices, expressed in birr/kg, received by the

farmers for red berries[3] and dried coffee also displays that the red berries get higher premium, also indicating larger return of washing coffee at the producer level (Figure 2 (c)).

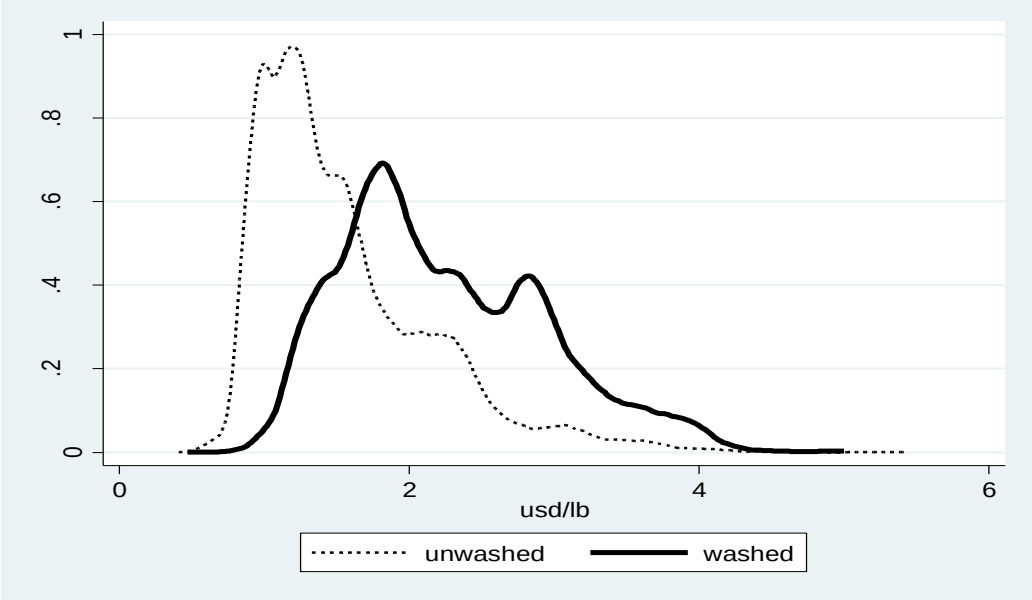


Figure 2 (a): Density of washed versus unwashed coffee at the export level (2007-2014)

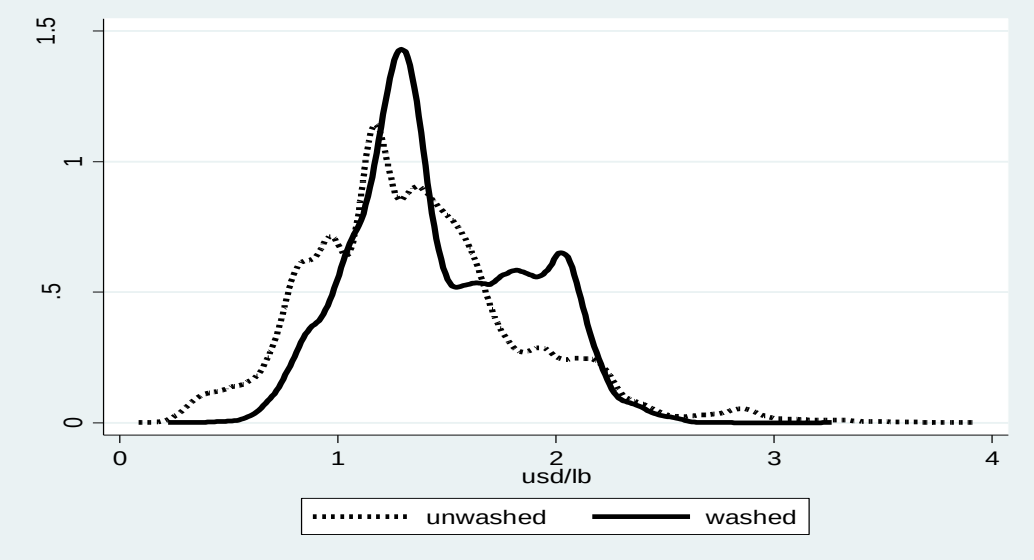
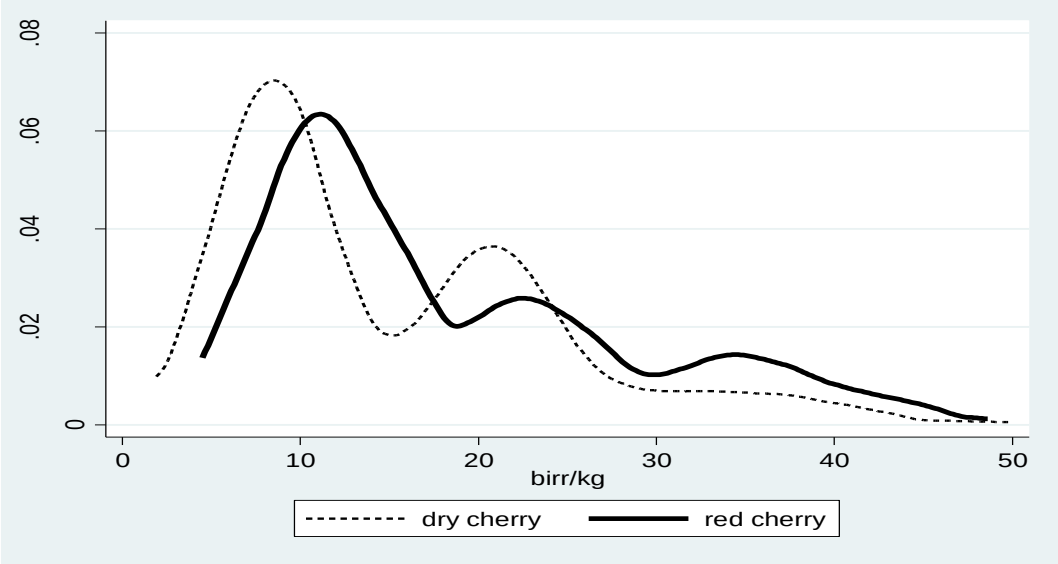


Figure 2 (b) : Density of washed versus unwashed coffee at the ECX level (2008-2014)

[3] For resonable comparison, we converted red berries into comparable dried version form. On average, about 3 kgs of red berries when they lose moisture and dry are equivalent to a kilogram of dried version. Generally, 2-3 kgs of dried coffee and 5-6 kgs of red berries can be converted into 1 kg of clean exportable bean, though the conversion could vary depending on source of origin (Sualeh and Dawid, 2013).



Source: Based on data from Ministry of Trade, ECX, and ESSP 2012

Figure 2 (c) : Density of prices of dry versus red cherries at the producer level (2006-2012)

To put this non-parametric results in context, figure 3 presents the full and utilized capacity of red berry sales, wet-mill machines, and dry-processing (hulling) machines. The two panels of the figure indicate considerable underutilization in all of the three capacities. At the household level, despite having access to wet mills in their close proximity, a number of coffee producing households are reluctant to use them. Only about 19% of their total harvested coffee is sold as red berries even though more than 43% of coffee farmers stated to have access to red-berry markets (panel a). Similarly, looking at panel b of same figure, there seems to be considerable underutilization at the processors level where just under 9% of the wet mills and under 22% of the hulling machines are utilized during the survey period.

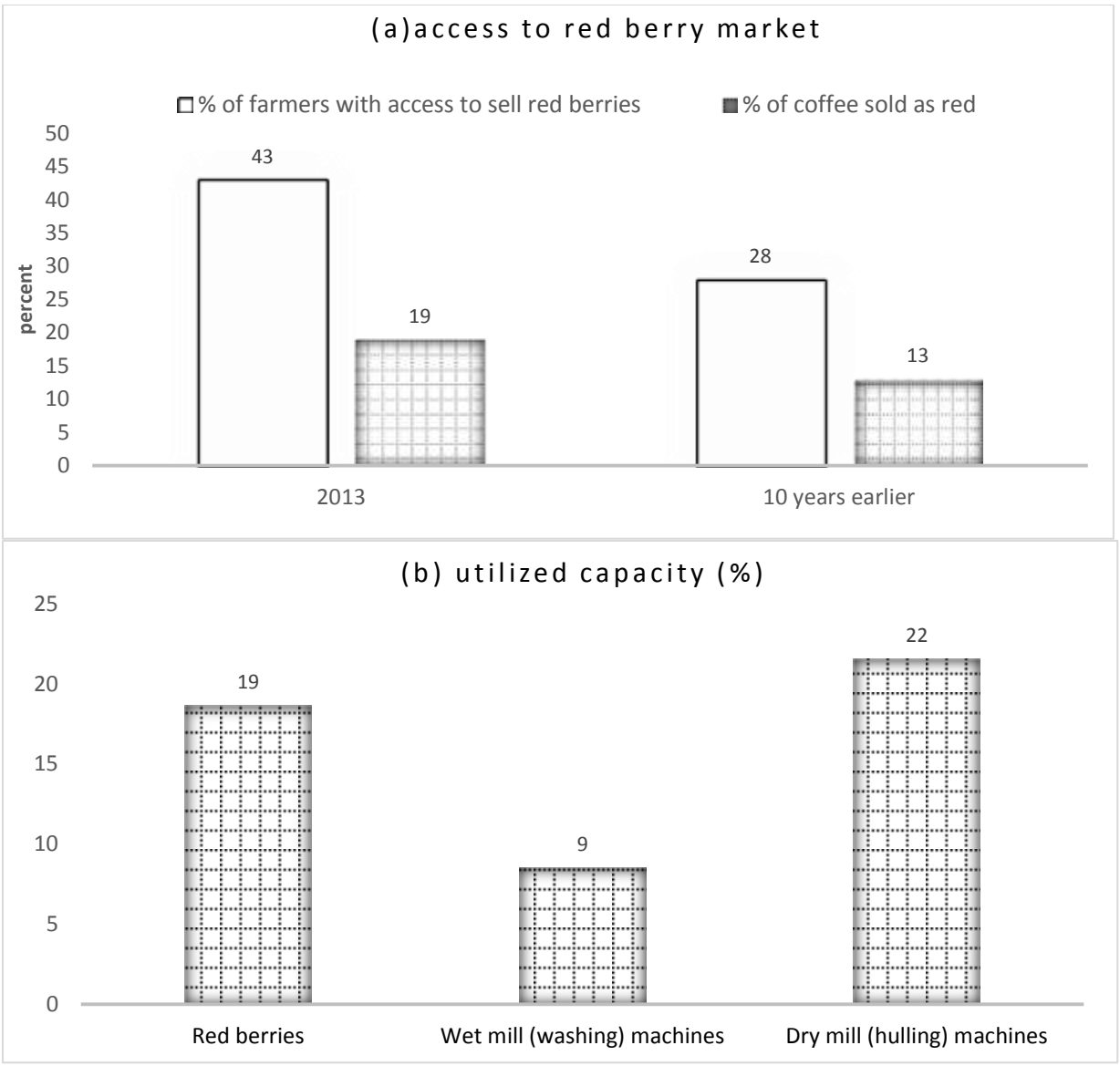
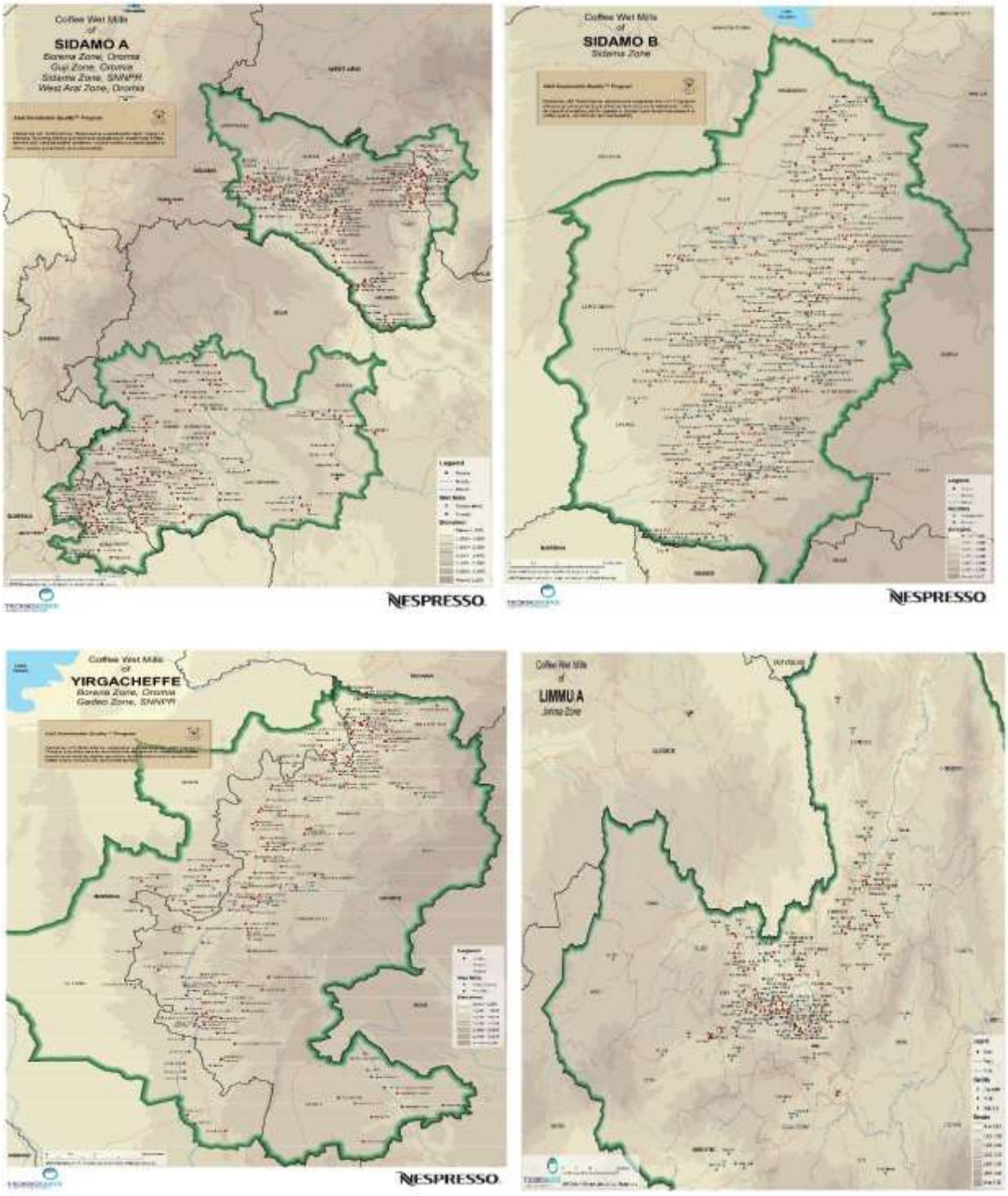


Figure 3: Access and capacity utilization of Ethiopian coffee

In spite of these seemingly significant price premiums for red berries, for washed coffee, and also the considerable under capacity, only about 30% of Ethiopia's coffee export is washed (Minten et.tal., 2014; NBE, 2013) and the small-scale coffee farmers, processors, exporters, and the country are missing out on the opportunity of commanding higher rewards. These phenomenon would lead to such questions as what would be the perceived benefits and constraints to the sales of red berries by farmers and subsequent washing by processors.



Source: TechnoServe Ethiopia (2014)

Figure 4: Distribution of wet mill machines for major coffee types in Ethiopia (2012)

3. Data and methodology

3.1. Data

This study uses both primary and secondary data sources. After undertaking a large number of in-depth interviews with key players in the sector including producers, pulpers, transporters, traders, and cooperatives, we conducted a unique primary survey in February 2013. The survey covered 1,600 coffee farming households in the largest coffee producing zones of the country. To assure most relevant parties are included, we followed a distinctive sampling method where the zones were stratified based on the coffee variety produced, as defined in the classification for export markets by the Ethiopian Coffee Liquoring Unit -i.e.,Sidama, Jima, Nekemte, Harar, and Yirgachefe. Within each strata, woredas[4] were ranked from the highest to the lowest producers and divided in two: the less productive woredas and the more productive woredas (each cultivating 50% of the area). Two woredas were randomly selected from each group. A list of all the kebeles of the selected woredas was then obtained. Two kebeles were randomly chosen from each category, the top and the bottom 50% producing kebeles. Finally, a list of all households in those selected kebeles was made. They were ranked from small to large coffee producers (based on areas cultivated in the year before the survey). We divided the farmers in two groups, the less productive and the more productive ones (each cultivating 50% of the area). A total of 20 farmers were then selected: 10 from the less productive and 10 from the highly productive ones. A total of 16 kebeles times 20 farmers, i.e. 320 farmers were interviewed per stratum. Detailed questions were asked on production processes including input, labor, and land use, harvesting, volume, sales, and other marketing aspects.

In addition to the household survey, a unique community level survey was also conducted at the keble[5] level in a similar method where detailed questions were asked with carefully selected focus groups. We also acquired unique export, wholesale, and producer level datasets. Table 1 below describes most of the variables used in the study. The descriptive (mean) values are presented by the five coffee types.

Majority of coffee growing household heads are males (94%), married (93%), with average age of about 45 years, and with overall average of 4th grade education level. Most of these coffee farmers identify themselves as Oromo (74%), and Sidama (14%) while 55% and 29% respectively categorize themselves as Protestant and Islam religion followers. The farming households are of about 6.4 household size. Twenty six percent of the farmers are members of a coffee cooperative. More than half of these farmers (53%) own mobile phones. About 35% of marketable coffee is sold in the form of red berries even though there is considerable heterogeneity across the different coffee types. About 60% of marketable coffee in Sidama is sold in red berries form. This is considerable given just about 38%, 18%, 1%, and 15% of

[4] The next administrative unit below zones

[5] The lowest administrative unit in the country

marketable coffee is sold in the same form in Yirgachefe, Jima, Nekemte, and Harar areas respectively. Given Harar coffee is not processed as washed, the 15% share of red berry sales is probably be due simply to buyers buying the red form in the intention of drying it themselves for later dried marketing or processing.

Table 1: descriptive (average) of household characteristics and some of the variables by major coffee type

Variables	Unit	Sidama	Yirgachefe	Jimma	Nekemte	Harar	Overall
Coffee sold as fresh red cherries	share	58.95	38.17	17.66	0.94	15.33	34.49
Gender	% male	96.8	92.7	92.3	93.1	95.0	93.9
Age	year	46.0	46.3	45.8	46.5	40.7	45.2
Education	number	4.1	4.3	3.2	4.3	1.8	3.6
Martial Status	% married	95.5	94.2	90.8	91.1	94.1	93.0
Household Size	number	7.1	7.2	6.1	5.4	6.7	6.4
Ratio of dependants	share	58.7	60.1	51.1	48.6	61.8	55.4
Ethinicity							
Amhara	share	1.5	2.6	9.2	0.3	1.9	2.9
Oromo	share	24.6	37.2	98.4	99.8	100.0	73.8
Sidama	share	73.5	1.1	0.0	0.0	0.0	13.7
Others	share	1.9	61.7	1.6	0.2	0.0	12.6
Religion							
Orthodox	share	5.7	13.8	25.3	15.5	3.7	13.1
Protestant	share	84.7	77.0	15.8	81.9	0.0	55.1
Islam	share	3.6	3.1	58.3	1.4	95.0	28.9
Others	share	6.1	6.1	0.6	1.2	1.2	2.9
Coffee cooperative member	share	53.0	39.8	14.6	15.2	9.7	25.8
Model farmer	share	48.2	45.6	36.6	35.7	26.8	38.5
Received advance	% yes	2.7	6.5	4.5	3.9	2.2	4.0
Received loan	% yes	26.1	25.4	27.3	41.4	29.8	30.9
Source of information							
No information	share	0.6	8.2	6.5	6.1	1.9	4.8
Farmer/trader	share	83.3	82.0	72.3	76.8	84.4	79.5
Radio/TV	share	15.4	5.6	18.9	14.6	11.6	13.3
Mobile phone	share	0.7	4.2	2.2	2.4	2.2	2.4
Mobile phone	% own	53.7	55.4	62.0	48.3	46.9	52.9
Travel time to:							
Nearest wet-mill	minutes	90.8	50.8	132.3	108.4	.	92.8
Nearest huller	minutes	138.2	94.6	150.9	115.6	98.4	119.7
All weather road	minutes	98.6	56.9	50.3	65.5	67.2	67.4
Woreda administration office	minutes	140.7	120.9	135.4	125.7	109.3	126.4
Nearest cooperative	minutes	67.9	81.7	86.6	63.6	72.9	74.5
Asset							
Livestock	birr	13 592.1	11 434.3	17 761.6	11 302.4	13 635.9	13 335.2
Non-livestock	birr	3 885.2	7 684.2	5 871.0	3 083.3	1 356.9	4 324.1

3.2.Methodology: Double Hurdle Model

We are interested in modeling factors that determine coffee sales in red berries form. Substantial proportion of coffee producers, for a number of possible reasons, are observed with zero sales of coffee in red-berries form. Given the high percentage of zeros, the particular interpretation given to zero observations can have a crucial bearing on the estimation approach adopted. Such a relationship can potentially be estimated with a limited dependent variables in the form of a

Tobit model (Tobin, 1958) or the Generalized Tobit model proposed by Heckman (1979). Nevertheless, both models rely on some restrictive underlying assumptions[6].

Following Croppenstedt et.al. (2003); Rude et.al. (2014), this study employs the Double Hurdle (DH) Model. Using this technique, we study factors determining the decision and amount of coffee sales in red berries form. Given our primary interest to estimate factors determining red berry sales (including lack of market access to sell coffee in red berries form), we first estimate the probability of having access to red berry sales and then estimate the amount[7]. The probabilities are estimated based on observable household characteristics and other controls and by splitting the sample into adopters (red berry sellers) and non-adopters (dried berry sellers). The DH technique enables us model the separate decision of participation and amount. This represents two separate but related decisions coffee producers make before they realize a positive level of red berries sales: participation decision and the amount decision. The technique relies on two crucial assumptions: (a) the level of independence between the residuals in the two decisions and (b) dominance-i.e., whether the participation decision dominates the quantity decision.

The technique constitutes three components: (i) percentage of observed red berries sales (ii) the participation equation, and (iii) the quantity equation. Following Jones, 1989; and Croppenstedt et.al., 2003, the three components can be represented as:

Observed red berry sales: Y=d . y** (1)

First hurdle –i.e., participation equation:

$$w=\alpha' z+u \qquad u \sim N(0,1) \tag{2}$$

$$d = \begin{cases} 1 & if\ w > 0 \\ 0 & otherwise \end{cases}$$

Second hurdle -i.e., quantity of red berries sales (percentage equation):

$$y^*=\beta' x+v, \qquad v \sim N(0,\sigma^2)$$

$$y^{**} = \begin{cases} y^* & if\ y^* > 0 \\ 0 & otherwise \end{cases} \tag{3}$$

Where z and x represent controls that affect the participation and quantity decisions and u and v are additive disturbance terms which are randomly distributed with a bivariate normal

[6] For detailed discussions of these models and the differences with double-hurlde model, please refer to (Wooldridge, 2002)

[7] We, however, have information on why coffee farmers with access do not sell their coffees in red berries form which are discussed in the result discussion section.

distribution. A positive level of red berry coffee sale y is observed only if the individual (or the household) is a potential red berry seller (d=1) and actually sales coffee in red berries form (y∗∗).

Besides, to account for the possible presence of heteroscedasticity, the variance of the error terms are specified as a function of a set of continuous variables:

$$\sigma i = \exp(zi'h) \qquad (4)$$

Where zi is a vector of continuous variables included in x ($zi \in$ x) and h is a conformable vector of coefficients.

Given that we are modeling an actual red berry sales (i.e., instead of potential) it seems that dominance applies and that it is less likely to be a latent positive expected red berry sales. This means that we model the marginal effect of different covariates on actual red berry sales i.e., not potential. Hence, we are interested in E[y|Z, X] instead of E[y**|Z, X] probably justifying the use of double hurdle model than Heckman's selection model.

Denoting zero red berry sales as 0 and positive red berry sales as +, the likelihood function for the full double-hurdle model with heteroscedasticity correction and independent error terms can be written as:

$$L = \prod_0[1 - \Phi(\alpha'z)\,\Phi(\beta'x)/\sigma i]\ \prod_+[\Phi(\alpha'z)\,\frac{1}{\sigma i}\ \phi(\frac{yi-\beta' x}{\sigma i})] \qquad (5)$$

where Φ denotes the standard normal CDF (univariate or multivariate) and ϕ is the univariate standard normal PDF.

Maximization of the maximulihelihood (ML) of (5) gives consistent estimates of the parameters of the latent equations. This model hypothesizes that the participation and consumption decisions are made separately and that there is a feedback effect from the level of sale to the participation decision. Marginal effects can be obtained by differentiating the ML estimates (at relevant sample mean) with respect to the corresponding variable of interest.

4. Results and Discussion

We recall that the non-parametric estimates showed under figure 2 (c) demonstrates that, on average, a red berry price received is larger as compared to a price received for a comparable dried version at producer level. However, given the non-parametric nature of the analysis, it does not necessarily control for other important confounding elements. Hence, employing a matching technique that relies on the likelihoods from a probit regression undertaken (not shown here), we look at the possible impact of selling coffee in red berries form has on price received and also on other selected outcome of interest. As red berry selling farmers may be distributed across the selected areas in a non-random way, comparing red berry sellers (adopters) with non-red berry

sellers (non-adopters) might yield biased results due to unobserved differences between the two groups. Matching on a large set of variables will allow us to control for any differences between groups due to observables. We will use the most appropriate matching technique based on the extent of covariate balance that results from matching and then look at the impact of red berry coffee sales on yield, prices received, and adoption of different coffee production technologies (e.g., improved seeds, stumping, pruning etc).

Table 2 below presents results of such exercises. The upper panel displays simple OLS/Probit regressions for comparison purpose while the lower panel shows results of the different matching exercises including the impact on prices received. Focusing on our primary results of interest-the impact of selling coffee in red form on prices received is found to be positive. It, however, appears that the result does also depend on the conversion rate between red and dried forms of coffee[8]. As discussed earlier, conversion rates from red to dried form vary between 2.5:1 to 3:1 depending on quality and coffee type. Taking the 2.5:1 conversion rate, the effect of selling coffee in red form on prices would be negative. However, when we consider the widely used conversion rate-i.e., 3:1 (Minten et.al., 2014; Petit, 2007), selling in red form would result in higher premium. The table also displays possible effect of selling red berry coffee on other important outcomes.

[8] The overall avreage is about 2.5-3:1 conversion rate between red berries to dried berries (as red berries condiderably lose weight due maily to moisture lose during drying). The conversion rates, however, slightly varies intra coffee types with Sidama, Jima and Harar displaying relatively larger conversion rates.

Table 2: Possible impacts of selling coffee in red berries form on selected outcomes

		Dependent Variables									
Variables	Unit	Yield	Area with improved seeds	Stumped trees	Meltched	Prunning	Composed area	Tilled/hoed coffee area	Weeded coffee area	Price (red 2.5:1 dry)	Price (red 3:1 dry)
		Quintal/ha	Share	share	yes=1	yes=1	Share	yes=1	yes=1	birr/kg	birr/kg
OLS/Probit Regression		Coefficient									
Sell in red form	yes=1	**-0.804**	-0.040	-0.337	**0.681**	-0.006	**3.470**	**0.186**	**0.073**	**-0.431**	**0.396**
Distance to nearest saving instit	km	-0.016	**-0.186**	**0.034**	-0.003	0.001	**0.106**	**-0.008**	**-0.002**	0.005	0.008
Designated red cherries selling d	yes=1	**-1.090**	**-1.746**	0.304	-0.068	**0.587**	**8.051**	**0.465**	**0.098**	**0.520**	**0.552**
Time to nearest wetmill	minutes	**-0.017**	**0.018**	**-0.009**	**0.003**	**0.002**	0.004	**0.002**	**0.001**	-0.001	-0.001
Time nearest huller	minutes	**0.008**	**-0.050**	-0.001	**-0.003**	0.001	**-0.023**	0.001	0.000	-0.002	-0.003
Time to all season road	minutes	**0.007**	**-0.057**	**-0.009**	**-0.004**	**0.002**	**-0.046**	**-0.003**	**-0.001**	**-0.004**	**-0.005**
Time to nearest cooperative	minutes	0.002	-0.004	-0.001	**-0.002**	-0.002	0.004	-0.001	**-0.001**	-0.001	-0.001
Member of coffee cooperative	yes=1	**0.653**	**-3.013**	-0.103	-0.070	**-0.195**	**1.944**	**0.129**	-0.007	**0.335**	**0.625**
Time patient		**-1.250**	**-6.376**	0.253	0.010	**0.199**	1.749	**0.234**	**0.047**	0.184	0.212
Time impatient		0.112	**2.513**	-0.073	**0.388**	-0.114	**2.283**	**-0.135**	-0.010	-0.174	-0.091
Risk behavior included		yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Household characteristics included		yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Asset indicators included		yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Zone dummies included		yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
_cons		**7.553**	11.557	-1.736	**-0.875**	**-1.042**	**29.705**	4.584	**1.085**	**21.087**	**21.234**
Number of observation		1373	1373	1476	1476	1476	1476	1162	1476	1447	1447
Pseudo (R)-squared		0.11	0.11	0.14	0.28	0.13	0.40	0.24	0.31	0.18	0.20
F (,)/ LR chi2( )		4.61	4.61	6.51	555.31	259.97	27.57	357.39	18.88	8.77	9.51
Prob > F/Prob > chi2		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Matching Regression											
ATET-Nearest neighbour	Coef.	**-2.445**	**-5.364**	**0.961**	**0.297**	0.015	**16.518**	**0.047**	**0.047**	**-0.532**	**0.598**
matching	z-value	-4.64	-4.12	4.49	15.27	0.74	15.16	2.84	2.84	-4.26	4.65
	Coef.	0.566	**-1.843**	**-1.494**	**0.348**	**0.160**	**12.889**	**0.086**	**0.086**	**-0.733**	**0.362**
ATET- Kernel matching	z-value	1.39	-1.43	-4.45	17.39	7.45	11.39	5.02	5.02	-5.75	2.82
ATET -Regression adjustment	Coef.	0.288	**-5.990**	-0.341	**0.508**	**0.223**	**18.298**	**0.144**	**0.144**	**-1.313**	**-0.270**
matching	z-value	0.27	-1.86	-0.47	11.45	4.71	12.04	3.27	3.27	-4.17	-0.89
Note: Robust standard errors for all matching exercises											
Bold figures: significant at 5% significance level											

Even though the results from both the non-parametric and parametric estimates indicate a significant premium related to selling coffee in red berries form and washing coffee, the overwhelming majority (about 70%!) of Ethiopian coffee is still sold in dried version. This implies that different stakeholders in the value chain are missing out on the opportunity of commanding higher rewards.

We start our discussion with self-reported major explanations given by coffee farmers themselves as to why they are not selling their coffees in red berries form. This gives a good indication of possible factors behind the low level of red berries sales. As presented in figure 5, the overwhelming majority of coffee farmers (92%) identified using coffee as a saving mechanism (i.e., drying and storing their coffee) as the major reason for not selling their coffees

in fresh red berries form. Harvesting bad quality (e.g, picked from the ground), and late ripening are also mentioned as significant reasons behind low red berry sells as respectively mentioned by 17% and 16% of the farmers. Lack of enough buyers of red berries (7%), early harvesting due to fear of theft (5%), lack of labor for timely red berry harvest (3%), and storing coffee as a means of spreading out income over the year (3%) are also indicated as among the reasons why farmers are not selling their coffees in red form.

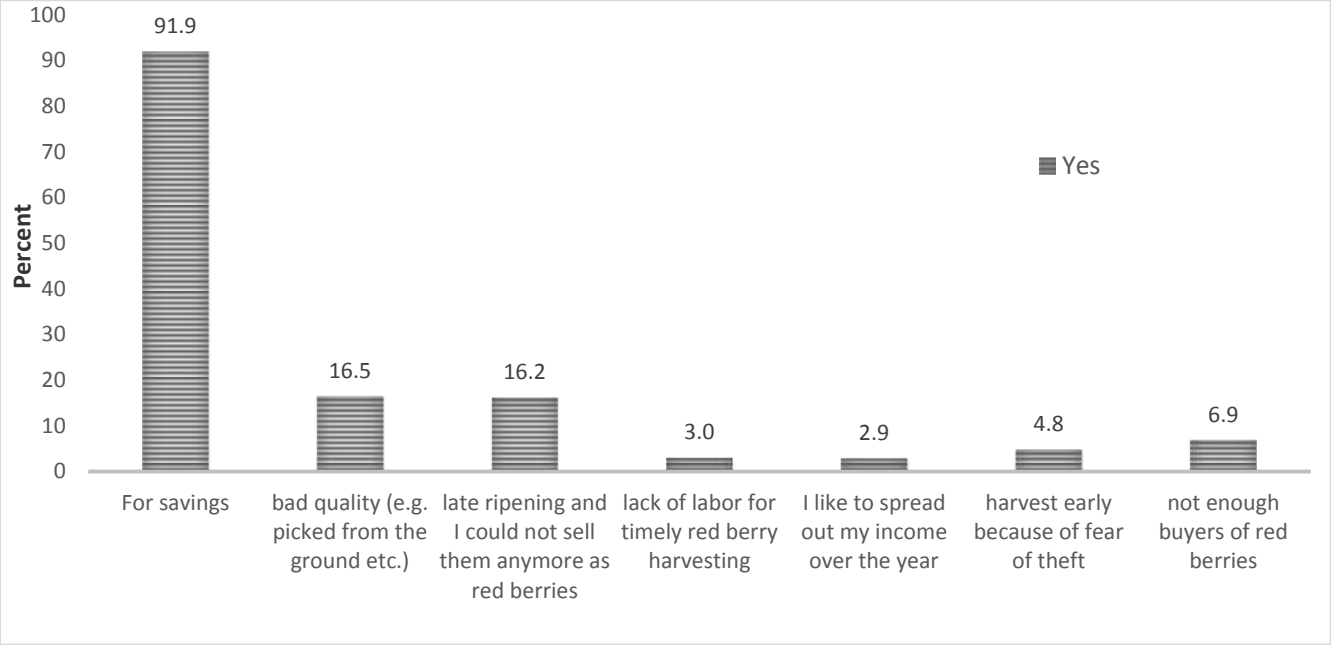


Figure 5: Self-reported reasons for not using wet-mills

Based on the matching results, the self-reported reasons forwarded by the farmers, and our observations from the frequent field visits, we put forward and test five major possible challenges we think are behind the lower rate of red berries sales. We look at each of them in detail and later on empirically test their validity.

Challenge 1 : Presence of washing stations

The first challenge we analyze is access to wet mills. Table 3 below summarizes prevalence of wet-mill across the five coffee types. Overall, only 40% of the coffee farmers access wet mill. The distribution, however, varies quite significantly across the coffee types. Coffee farmers in in Sidama and Yirgachefe areas have good access to washing stations: Sidama (89%) and Yirgachefe (88%). In contrast, just 17% of farmers in Jima and about 5% of the farmers around Nekemte area stated having access to wet mill. Average number of wet-mills per community also confirms the generally low level of access to wet-mills. Despite an improvement over the last decade up from 0.3 wet mills per community, the current overall average of 0.8 wet mills per community is still low given the fact that 66% of the communities are with no access to wet

mills, 9% have access to just one wet mill, 18% have two wet mills while only 3% and 5% of the communities have just three, and more than three wet mills per community respectively.

Table 3: Access to red cherry markets and wet-mill machines

Descriptives	Unit	Sidama	Yirgachefe	Jima	Nekemte	Harar	Overall
HH Survey							
Farmers with access to red cherries market	%	89.4	87.8	16.7	4.7	-	39.7
Community Survey							
Number of wet mills in a community							
Now	mean	1.5	1.5	0.6	0.2	-	0.8
10 years ago	mean	0.7	0.5	0.3	0.1	-	0.3
Share of communities with:							
0 wet-mill	%	31.3	37.5	75.0	87.5	100.0	66.3
1 wet-mill	%	12.5	18.8	6.3	6.3	-	8.8
2 wet-mills	%	50.0	25.0	6.3	6.3	-	17.5
3+ wet-mills	%	6.3	18.8	12.5	-	-	7.5
Importance of cooperatives							
Private mills	%	60.0	76.9	50.0	33.3	.	62.2
Cooperative mills	%	40.0	15.4	50.0	66.7	.	35.1
Share company	%	-	7.7	-	-	.	2.7

The same table also shows the role of cooperatives and private enterprises in providing wet mill services. Nationally, 35% of wet mills are owned by cooperatives, and 62% by private owners. Their relative importance also differs across the coffee types in that cooperatives play larger role in areas predominantly known for processing coffee in dried form.

Further evidence of the role access to wet-mill plays in determining coffee sales in red berries form can be seen from Figure 6. The figure shows relationship between percentage of red berries sales and travel time (in minutes) to nearest washing stations by zone. It indicates that access to wet mills in close proximity could be one of the major factors influencing farmers' decision of selling coffee in red berries form. Generally, farmers that are close to a wet-mill machine tend to sell significantly higher percentage of coffee in red berries form. In the three coffee growing areas with more wet mills (Sidama, Yirgachefe, and Jima), the relationship is clearly downward sloping –the share of red berries sales declines considerably as travel time to the nearest wet mill increases.

This scenario indicates huge potential to increase the share of red berry sales and subsequent washing by increasing farmers' access to wet-mills which in turn could have considerable implication on farming households' income and export value.

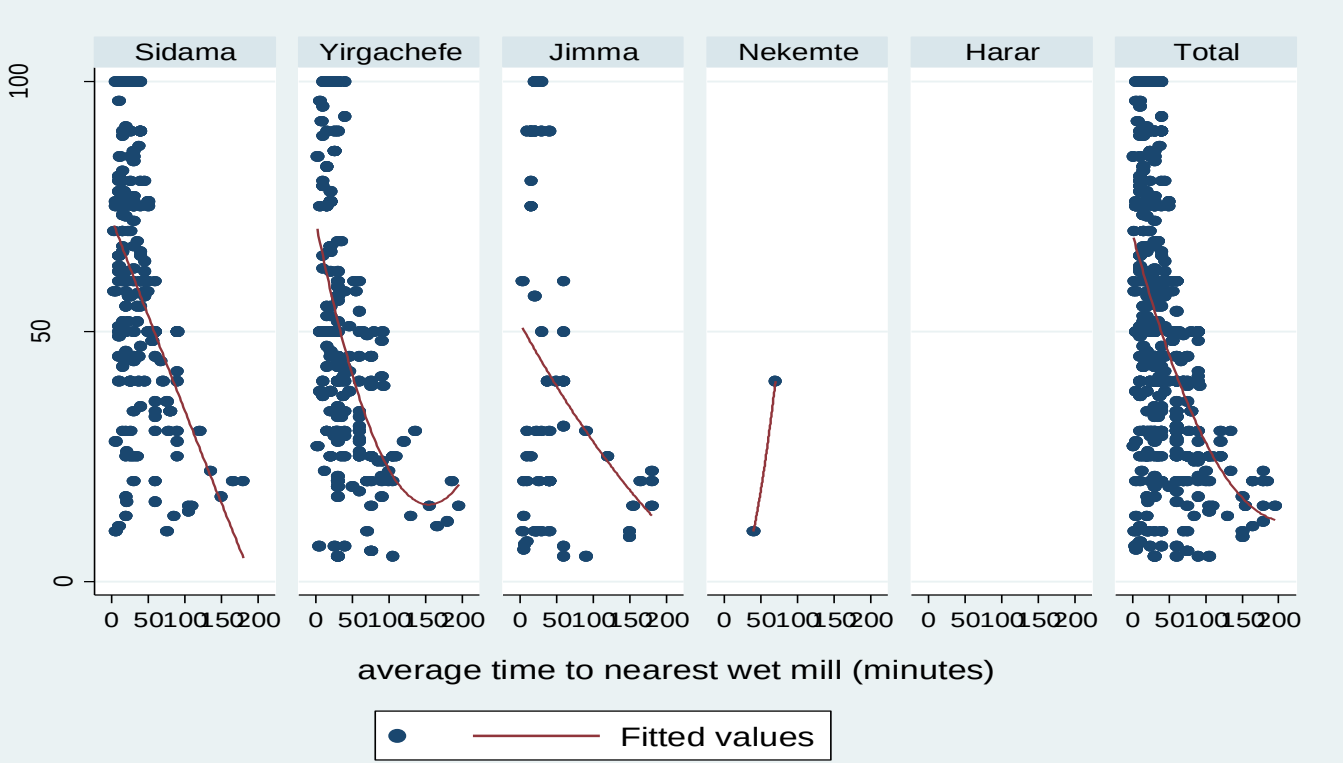


Figure 6 : Share of red berries in total sales by distance and by major coffee types

Challenge 2 : Quality issues and fear of theft

As mentioned earlier, the quality of washed coffee can significantly be increased if during harvesting, coffee berries are picked when they are fully ripe (i.e., right red all over). Any early and under-ripen or late harvest due especially to fear of theft could result in poor coffee processing leading to below standard quality and hence decreases the likelihood of coffee sales in red berries form (Worako et.al., 2009). We study if farmers engage themselves in early (and hence under-ripen) harvesting due to fear of theft and/or fear of the berries being eaten by animals such as apes. Figure 7 summarizes descriptive results. Only 4 percent and 2 percent of the farmers respectively stated that they had to engage in early and under-ripen coffee harvest due to fear of theft or fear of the berries being eaten by animals. Combined effect of early harvesting due to either fear of theft or fear of the berries being eaten by animals is less than 4 percent probably indicating these factors are less important in determining coffee sales in red berries form.

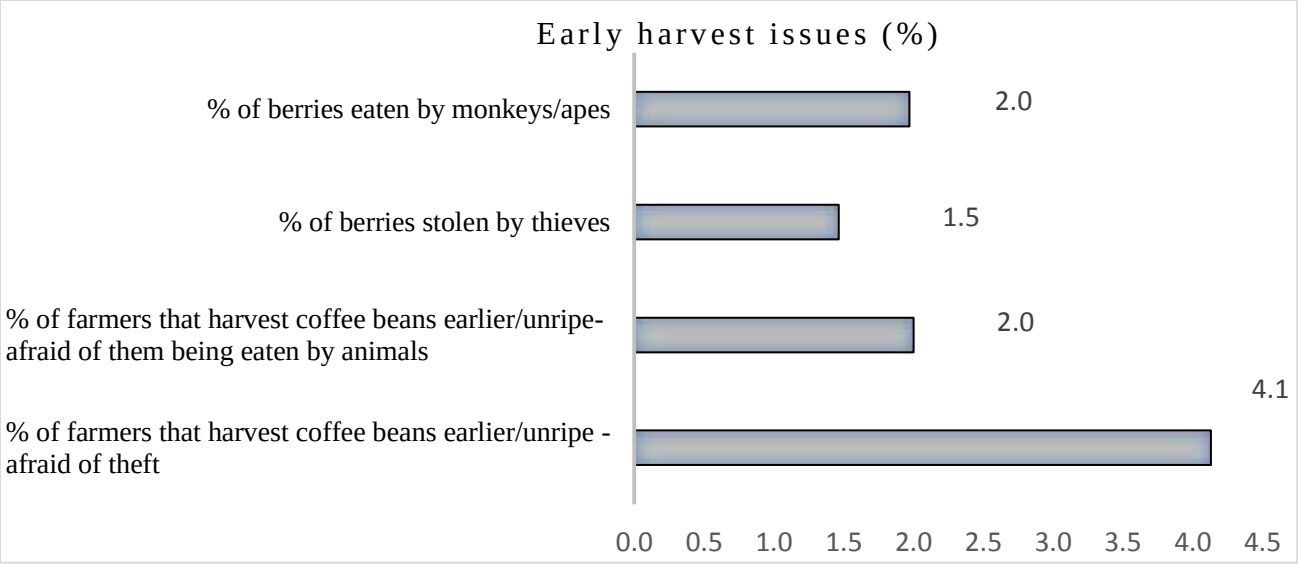


Figure 7: Proportion of early harvest due to fear of theft or fear of the berries being eaten by animals

Challenge 3 : Lack of savings instruments

As a follow up to the point discussed under self-reported reasons that farmers do not sell in red berries because they use the dried form as a saving mechanism, we examine if farmers do so due to lack access to formal saving mechanisms. Table 4 presents information on access to and extent of use of the different saving mechanisms in the respective areas. The vast majority of these coffee farmers (88%) stated to have access to the traditional local saving mechanisms such as 'idir' and 'equb' and only 35% and 14% of the farmers reported to have access to saving & credit associations, and access to formal banks or micro finance institutions respectively. Those coffee farmers without access to the stated saving mechanisms in their respective communities have to travel between 15-19 Kms to access the services.

The same table also shows that 76% of coffee farmers agree to the hypothesis that they prefer to keep their coffee in dried form for later sale and spread out their income over the year.

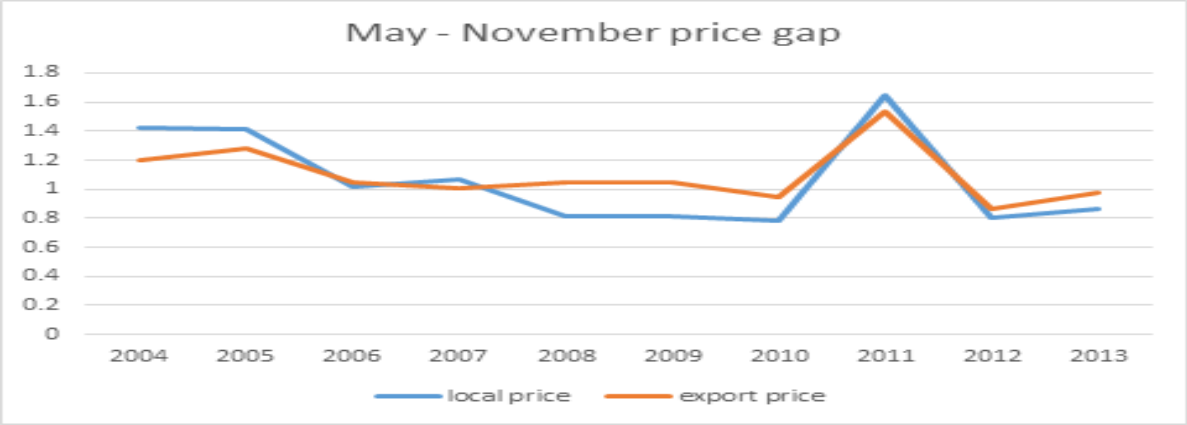
Most of these coffee producing farmers (68%) use the traditional saving mechanism whereas just about 17% and 18% of these farmers use services of savings & credit associations, and bank or microfinance institutions, respectively. This indicates that even when they have access, farmers may be reluctant to use the formal (relatively modern) saving schemes. This phenomenon- that only few coffee farmers use formal saving institution even when they have access to -lead us to question why. Given the relatively better premium of selling coffee in red berries form, why don't farmers with access to saving institutions sell their coffees in red berries and put the money in a bank and possibly earn an additional interest on top of the higher premium. Could it be a

case that farmers are better off keeping their coffee in dry (even in the event of facing storage and handling costs) than selling in red and keeping their money in bank and earn interest rate?

Table 4: Access to and use of saving mechanisms

Savings	Unit	Local Savings	Savings & credit assoc.	Bank/MFI
Is this form of savings available in the kebele	%yes	87.7	34.7	13.6
If available, do you use this saving form	%yes	68.3	17.1	17.6
If not available, how far is the closest one-kms	kms	14.7	16.7	19.2
Farmers' belief on using dried coffee as a means of saving				
Instead of selling in red form, farmers use dried form as a means of saving and to spread out their income over the year	%	Yes, I agree		75.7
		No, I disagree		19.2
		It depends		4.7
		I don't know		0.4

To test this particular hypothesis, we did a simple exercise where we consider the price of red berry received in November (main harvest month) with the money from the sale being kept in a bank earning real interest rate up until May. We compared this with the price of dry coffee in May (main dry selling month). We did this May-November comparison for over the last 10 years. Results of such analysis (figure 8) indicate that it is generally better to sell coffee later on during the year than selling earlier- i.e., coffee farmers that sold in May get slightly larger benefit (about 7% more) as compared to ones that sold in November. The same pattern was seen at the export level as well. This exercise may shade light on the possible reasons why farmers persist on keeping their coffees in dried form and opt for later sale than selling in fresh red berries form even when they access formal saving institutions in close proximity and in the event of seemingly higher per unit price for red.



Source: based on data from CSA (2004-2013)

Figure 8: Calculated May November gap for coffee with export and local prices (2004-2013)

This premise seems to be supported by the farmers as evidenced by producers' beliefs on rewards of selling their coffee in red berries than in dried berries (figure 9). Quite significant portion of the farmers interviewed, 63%, believe that it is more profitable to keep coffee longer and hence sell it in dried form. About 34% of them believe that selling in red berries is more profitable whereas the remaining small proportion think that the return is either the same or varies from year to year.

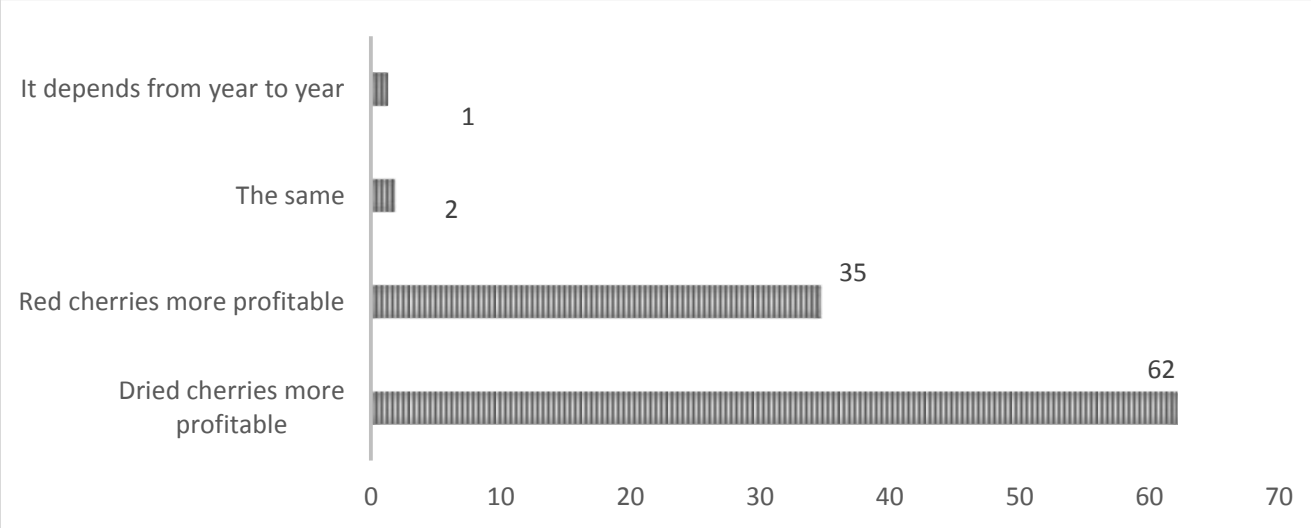


Figure 9: Farmers' beliefs on profitability of red versus dried cherries-all farmers

Challenge 4 : Labor requirements

As in most developing coffee producing countries, coffee harvesting in Ethiopia is conducted by selective picking of the ripe berries- a laborious process that requires as many labor as available. To avoid over ripe and subsequent loss of quality, coffee farmers are required to use all capable members of their family and hired labor for the process. This is especially so if the farmers decide to sell in red berries indicating a large demand and hence a possible competition for labor during the period.

In line with the labor and other costs related to red and dry berry sales, we present in Table 5 comparisons of two of major costs involved: harvesting and marketing. Accordingly, relying on a simple paired t-test, Table 5 presents comparison of quantity sold per transaction, labor requirements as proxied by harvesting costs, and average marketing costs between coffee farmers selling in red berries and those selling in dried form. The average quantity sold per transaction is considerably lower for farmers selling in red berries (53 kg per transaction) as compared to those selling in dried form (236 kgs per transaction). Harvesting costs differ only

slightly between the two groups with the costs marginally larger for farmers selling in red berries as evidenced by the borderline significance t-value. However, average marketing costs –as measured by average transport cost per kilogram of coffee sold- are considerably larger for those farmers selling in red berries implying that marketing costs probably matter more than harvesting costs in influencing coffee farmers' decision of selling their coffees in fresh red berries form. One could also think of storage costs related to keeping the coffees in dried form. Nonetheless, as almost all coffee farmers in Ethiopia use part of their residential area to keep their coffee and do not necessarily incur direct costs related to storage[9], they are likely not to calculate the implicit costs related to storage and as such storage costs may not influence their decision to sell their coffee in dried form.

Table 5: Comparison of costs related to selling coffee in red and dried form

			Red		Dry		T-test difference
Labor requirements	No. of Obs.	Unit	Mean	Std.Err.	Mean	Std.Err.	Mean (difference)
Quantity sold per transaction	478	kgs	53.4	4.2	235.8	13.8	**-182*** **
Harvesting cost (labor)	385	birr	1427.7	87.3	1398.6	87.8	**29***
Average Marketing costs (transport cost)	478	birr/kg	0.186	0.017	0.118	0.010	**0.068*** **
***, **, * significant at 1%, 5%, and 10% significant levels respectively							

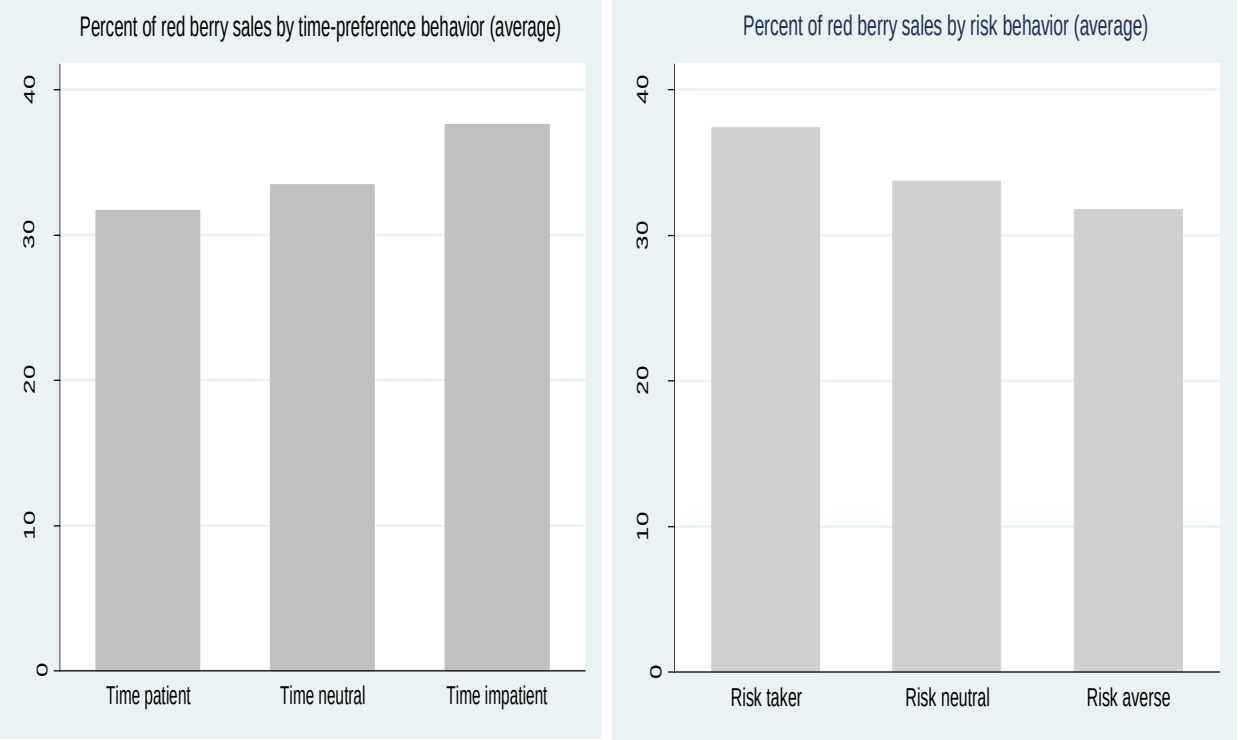
Challenge 5 : Time preference, risk behavior and rewards

The fifth challenge we consider is whether or not the time-preference and risk behavior of coffee farmers influence their decision to sell coffee in red berries form. To test this hypothesis, we had to first categorize the farmers based on their time and risk behaviors. Following widely used methodologies to identify each of time and risk preferences of agents and relying on experimental data we gathered, we categorize farmers based on their respective time and risk preference behaviors.

Figure 10(a) shows, the correlation between percent of red berries sales and the farmers' time preference, calculated following the technique used as in, for example, Curtis (2002), Bradford (2004). It is interesting to see that farmers' time preference seemingly well correlated with level of red berries sales. The impatient farmers do seem to sell higher proportion (38%) of their coffee in red berries, the time indifferent ones sell moderate proportion (about 33%), while the time patient coffee farmers sell lower proportion (about 31%). Similarly, figure 10(b) shows the relationship between percent of red berries sales and risk behavior – calculated following

[9] Nevertheless, they could inccur losses during storage eventhough , in our survey, very few farmers reported to have inccurred losses related to storage

experimental approach as in, for example, Gardner and Steinberg (2005), and Gortera J. and Schilpc. P. (2012). It can be seen from the figure that risk takers do sell considerably larger portion of their coffees in red berries (about 38%), the risk neutral and risk averse ones selling much lower proportion of their coffee in red berries- about 33% and 32% respectively.



(a) (b)

Figure 10. Correlation between percent of coffee sold in red berries and risk behavior of farmers

Results of the Double Hurdle estimations

In the following section, relying on the double-hurdle technique, we further empirically identify the major factors guiding the decision and amount of red berry sales. Table 6 presents five different specifications for each of the decision to sell in red (all under columns A) and the amount of red berry sales (under columns B). Column (6) of same table displays the Average Partial Effect while column (7) shows results of Tobit estimation.

As generally results are robust to the different specifications, here, by presenting estimates of selected variables, our discussion is focused on results of specification (5) -our preferred specification. Accordingly, looking at the results in detail, travel time to nearest saving institution is found to have no influence in both the decision and the quantity of red berry sales.

This is consistent with the result found under qualitative analysis that farmers are reluctant to use the saving institutions even when they have access to due probably to the rather negative real interest rates. Similarly, time to nearest wet mills, does not influence the likelihood of red berry sales. However, more travel time to a wet-mill station considerably reduces the quantity of red berry sales. As expected, the sign of travel time to the nearest wet mill is negative- consistent with the hypothesis that the further away the wet mills the lower the likelihood of selling red berries. Every additional 10 minutes' walk away to the nearest wet-mill lowers the amount of red berry sales by about 0.5 kilograms. In contrast, the further away the hullers from a coffee farmer, the more likelihood that coffee farmers sell in red than in dry. Likewise, the further away a coffee producer from the nearest all weather road and woreda administration office, the lower the chance of selling coffee in fresh red berries form. More travel time to these units reduces the volume of red berry sales as well.

Government's interference in the form of deciding selling dates for red berries has a positive effect on the decision to sell coffee in red berries. This government's policy of designating different selling dates for red and dry also considerably increases amount of red berry sales. However, government's action of dictating selling prices somehow reduces the likelihood of selling in red. It however, does not affect the quantity.

Consistent with the qualitative result under the previous section, early and under ripen harvest of berries due to fear of theft is not found to affect either the decision or the amount of red berries sales. Bad quality coffee harvest reduces the likelihood of selling coffee in red. This is expected as the bad quality coffee would not find a buyer and producers would not have an option except selling in red. The quantity is not affected. Lack of labor during harvest negatively influences the decision to sale coffee in red berries. Given positive sales, it also considerably reduces the volume of red berries sales where coffee farmers that lack labor during harvest season do sell about 14 kilogram less red berries as compared to ones with adequate labor. Predictably, lack of enough red berry coffee buyers would significantly reduce the likelihood of both selling coffee in red berries and quantity of red berries sells. Lack of red berry buyers in close proximity, reduces red berry sales by 36 kilograms –which is considerable given the overall small amount of red berry sales by the small-scale farmers.

We also wanted to test whether the decision and amount of red berry sales are influenced by the money time preference and risk preference of the farmers. Accordingly, results indicate that time preference does not influence the decision to sell coffee in red berries form. However, give positive level of red berry sales, coffee farmers with high discount rate (highly impatient ones) tend to sell significantly larger quantity of coffee in red berries form as compared to time-neutral farmers. The time-patient farmers are not found to be different to the time-neutral ones. Similarly, correlation between risk-behavior and percent of red berry sales indicates that risk taking behavior of farmers considerably influences the decision to sell in red. As one would expect, risk takers (with the risk probably related either to spending it all and running out of

money after they sell in red or the risk of inflation) are significantly more likely to sell in red while risk averse farmers are more likely to sell their coffee in dried form. Similarly, given positive sales, risk takers tend to sell more red berry coffee with about 2.5 kilograms more red berries than risk-neutral farmers.

Membership to a coffee cooperative increases the likelihood of selling in red. It, however, does not influence the quantity. Coffee farmers that have access to a loan (of at least 100 birr=6 USD) are more likely to sell their coffee in red as compared to farmers that don't. The decision of selling fresh red berries probably be influenced by loan repayment. The quantity does not seem to be affected. 'Model' farmers-i.e., farmers identified as more efficient and successful by the community and the government- are no different as compared to ordinary farmers in their decision of selling their coffee in red form. However, once they decide to sell in red, they tend to sell considerably more quantity - 5 kilograms more.

On the other hand, coffee farmers mainly access information through other coffee farmers, radio, TV, and mobile phones. With respect to having no coffee related information (the default), acquiring more information through other farmers, radio, or mobile phones all significantly reduce the probability to sell coffee in red berries. Accessing information through other farmers/trader and radio/TV could also lead to larger volume of red berry sales.

Table 6 : Determinants of the decision and volume of red berry sales-marginal effects of the first and second hurdles and APE[10][11]

Variables	Unit	Decision to sell in red (mfx)					Quantity of red berry sales (mfx)					Partial Effect (Cragg)	Tobit
		1A	2A	3A	4A	5A	1B	2B	3B	4B	5B	6	7
percent of red berries sale	**(share)**												
distance to nearest saving institution	km	-0.006***	-0.002	-0.002	0.006*	-0.006	-0.376***	-0.161**	-0.140**	0.018	0.100*	0.0617*	-0.159
time to nearest wet mill	minutes		-0.000	-0.000	0.001	-0.003		-0.107***	-0.098***	-0.070***	-0.052***	-0.0321***	-0.094***
time to nearest huller	minutes		0.004***	0.004**	0.005***	0.020***		-0.020	-0.032	-0.045	-0.078***	-0.0482***	0.189***
time to all season road			-0.001	-0.001	-0.003***	-0.008***		-0.095***	-0.093***	-0.108***	-0.065***	-0.0398***	-0.066**
timto woreda administration			-0.002**	-0.002**	-0.005***	-0.016***		0.173***	0.176***	0.162***	0.179***	0.110***	-0.029
time cooperative			-0.001*	-0.001*	0.001	0.006***		-0.195***	-0.184***	-0.154***	-0.126***	-0.0776***	-0.070***
Source of market info (default=no info)													
Farmer traders			-0.558*	-0.580*	-0.394	-4.200***		-11.810**	-15.360**	-18.185**	-17.001**	-10.46**	-35.541***
Radio Tv			-0.898***	-0.921**	-0.837**	-4.059***		-19.880**	-23.380**	-30.345**	-25.158**	-15.47***	-41.919***
Mobile phone			-0.323	-0.397	-0.126	-4.032***		-15.625**	-18.763**	-16.117**	-9.452	-5.814	-32.635***
received loan	yes=1		0.353***	0.344**	0.343***	0.567***		1.451	0.991	-0.389	0.823	0.506	6.869***
Time neutral (default)													
time_patient				0.084	0.268***	0.048			0.054	2.290	-1.151	-0.708	2.277
time_impatient				0.006	0.002	-0.174			7.266***	7.365***	5.125***	3.152***	2.614
risk neutral (default)													
risk_taker				0.305**	0.178**	0.819***			6.820***	6.996***	3.769**	2.318**	7.389***
risk_averse				-0.178*	-0.131	-1.103***			4.038	4.554	1.065	0.655	-7.739*
membership coffee cooperative	yes=1				0.611***	1.030***				1.484	0.263	0.162	8.407***
model farmer (defaule=ordinary)					0.040	0.174				0.868	5.414***	3.330***	10.450***
Self-reported reasons for not selling red													
bad quality	yes=1					-2.862***					-1.284	-0.79	-13.513***
lack of labor during harvest	yes=1					-1.178***					-13.766**	-8.467***	-13.247*
fear of theft	yes=1					0.263					-7.757	-4.771	12.013*
no enough buyers of red	yes=1					-2.047***					-35.508**	-21.84***	-37.821***
gov't decides selling date	yes=1					0.472***					6.022***	3.704***	6.015**
gov't sets prices for red	yes=1					-0.783***					1.789	1.1	-3.770
_cons		0.432***	1.176***	1.107***	-0.699***	7.452***	51.799***	71.699***	69.430***	51.339***	46.092***		77.153***
Asset indicators included		no	no	no	yes	yes	no	no	no	yes	yes	yes	yes
Household characteristics included		no	no	no	no	yes	no	no	no	no	yes	yes	yes
Regional dummies included		no	no	no	no	yes	no	no	no	no	yes	yes	yes
sigma _cons		34.681***	28.003***	27.560***	25.438***	18.669***							26.227
Log pseudolikelihood		-8387.807	-6212.126	-6185.51	-5909.478	-2396.7391							-2553.891
No of obs		2297	1592	1592	1592	688							688
*** p<0.01, ** p<0.05, * p<0.1													

[10] We used the 'craggit' stata command which is written by Burke (2009).

[11] Standard errors for the APE were calculated through bootstrapping with 200 replications

5. Conclusions

Washed coffee is being sold in international markets with a premium of more than 20%. However, only 30% of coffee is washed in Ethiopia indicating a huge potential to raise poor coffee farmers' income and also increase the performance of a hugely coffee reliant Ethiopian economy. Relying on unique surveys at different levels of the value chain and using the most appropriate double hurdle technique, we studied factors determining the decision to sale coffee in red berries, the prerequisite for washing coffee, and the quantity of red berry sales.

Results show that lack of access to wet mills (in close proximity), lack of enough red berry buyers, and bad quality coffee reduce the likelihood of red berries sales. On the other hand, government's action of deciding designated selling dates, membership to a cooperative, and getting advances increase the likelihood of selling coffee in red berries form.

Government's interference in the form of deciding selling dates for red berries has a positive effect on both the decision to sell coffee in red berries and also the amount. This government's policy of designating different selling dates for red and dry should be further strengthened in order to realize more red berry sales. However, this should also be accompanied with proper incentive for the producers so that they would willingly participate in the marketing of coffee in fresh red berries form. On the other hand, shortage of labor during harvest and lack of enough red berry buyers both negatively influence the decision and amount of coffee in red berries form.

It is also interesting to find out that time-preference and risk taking behavior of coffee farmers influencing the decision and volume of red berry sales. Results display that given positive level of red berry sales, time impatient coffee farmers do sell larger quantity of coffee in red berries form as compared to time-neutral farmers. On the other hand, risk taking coffee farmers are found to be more probable to sell their coffees in red berries form as compared to the risk neutral and risk averse coffee farmers. Risk loving coffee farmers do also sell considerably larger quantity of red berry coffee as compared to risk-neutral coffee farmers.

We also found out that membership to a coffee cooperatives increases the likelihood of selling in red. Furthermore, coffee farmers that have access to a loan (of at least 100 birr=6 USD) are more likely to sell their coffee in red as compared to farmers that don't.

These results have considerable policy implications. Given the negative correlation between red berry sales and travel time to nearest wet-mills, the government can design ways of improving accessibility of wet-mills. The government can, for example, provide loans to both cooperatives and private processors and also give them proper incentives so that they invest in wet-mills. Such provision of loan by covering wider areas and strengthening purchasing power of cooperatives and private processor, could also address the issue of lack of red berry buyers and also production of high quality coffee. Such action is expected to increase the likelihood of red berry

sales and subsequent washing of coffee. Similarly, given that membership to a coffee cooperative increases the likelihood of selling coffee in red berries form, government can further strengthen the role of cooperatives and also ensure that proper incentive mechanisms are in place to attract more coffee growers into membership

Even though Ethiopia has recently showed tremendous economic growth with significant leap in provision of major infrastructures including the change in the road sector albeit from a low base, the country is yet to even reach the average level of Sub Saharan Africa. In line with this and given the result that travel time to all weather roads influence the decision to sell coffee in red berries form, further effort by the part of the government in provision of these services could also be an obvious policy implication.

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