

Research Application Summary

The Nexus between agricultural credit and coffee productivity

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Abstract

The Government of Kenya established Commodity Fund in 2006 to provide viable, inexpensive agricultural credit to coffee farmers to boost coffee productivity by facilitating the acquisition of inputs and support of overhead operations. This is against the notion of experts who previously hypothesized that agricultural credit does not have any impact on agricultural productivity since yield is stochastic. Therefore over the years, there has been little – if any – in-depth analysis that has been dedicated to establishing the impact of agricultural credit on coffee productivity to either prove or disapprove this supposition. As a result, this study surveyed 174 smallholder coffee farmers (participants and non-participants in the credit program) in Kiambu County in Kenya between 2017 and 2019 to determine the impact of agricultural credit on coffee productivity. The paper espouses the DEA Malmquist index to estimate the efficiency of coffee productivity for participating (PF) and non-participating (NPF) coffee farmers in the credit program. The empirical results disclose that PF had the highest geometric mean for productivity change (152%), efficiency change (40.5%), technical change (53.2%) and scale efficiency (40.5%). Further, the growth in technical change (TC) and efficiency change (EC) from 2017 to 2019 was higher for PF than NPF. These insights can be used to guide policy directions in terms of agricultural lending and crafting policies aimed at enhancing the efficiency of coffee productivity.

Keywords: Agricultural credit, coffee productivity, DEA Malmquist index, efficiency change, Kenya, productivity change, scale efficiency

Résumé

Le Gouvernement du Kenya a créé le Commodity Fund en 2006 pour fournir un crédit agricole viable et peu coûteux aux caféiculteurs afin de stimuler la productivité du café en facilitant l'acquisition d'intrants et le soutien des frais généraux. Cela va à l'encontre de la notion des experts qui avaient précédemment émis l'hypothèse que le crédit agricole n'avait aucun impact sur la productivité agricole puisque le rendement est stochastique. Par conséquent, au fil des ans, peu d'analyses approfondies, voire aucune, ont été consacrées à l'établissement de l'impact du crédit agricole sur la productivité du café pour prouver ou désapprouver cette supposition. En conséquence, cette étude a interrogé 174 petits producteurs de café (participants et non participants

au programme de crédit) dans le comté de Kiambu au Kenya entre 2017 et 2019 pour déterminer l'impact du crédit agricole sur la productivité du café. Le document épouse l'indice DEA Malmquist pour estimer l'efficacité de la productivité du café pour les caféiculteurs participants et non participants au programme de crédit. Les résultats empiriques révèlent que PF avait la moyenne géographique la plus élevée pour le changement de productivité (152 %), le changement d'efficacité (40,5 %), le changement technique (53,2 %) et l'efficacité d'échelle (40,5 %). De plus, la croissance du changement technique (CT) et du changement d'efficacité (CE) de 2017 à 2019 était plus élevée pour les participants que pour les non participants. Ces informations peuvent être utilisées pour orienter les orientations politiques en termes de prêts agricoles et de politiques d'artisanat visant à améliorer l'efficacité de la productivité du café.

Mots-clés : Crédit agricole, productivité du café, indice DEA Malmquist, changement d'efficacité, Kenya, changement de productivité, efficacité d'échelle

Introduction

Coffee production was introduced in Kenya in 1893 by expatriate farmers who grew the crop in estates up to independence in 1963. After independence, the large coffee estates were subdivided and allocated to smallholder farmers. As a result, the proportion of coffee produced by small farms increased over the years from 50% in 1966 to 60% in 1982 (Maxon, 1992). Today, 80% of Kenyan coffee is produced by smallholder farmers and the rest by estates. These smallholder coffee farmers (SHCFs) are alienated from the credit provided by formal financial institutions (FFIs) due to tough requirements required by financing institutions that have been prompted by informational asymmetries and moral hazard (Stiglitz and Weiss, 1981; FinAccess, 2019). Consequently, SHCFs are forced to use limited inputs (chemical input, fertilizers and uncertified seedlings) due to high production costs of inputs; use of a higher proportion of family labor and labor-intensive methods for coffee husbandry; and overreliance on rainfed agriculture as opposed to using irrigation (ICO, 2019).

With limited options to obtain credit from FFIs, a large number of SHCFs fund coffee production using their meagre savings, credit obtained from well-wishers (family, relatives and friends), shylocks and self-help groups (Kibaara, 2007; Beck and Demirguc-Kunt, 2008; FinAccess, 2019). Unfortunately, these funds acquired from informal means are not normally sufficient to sustain any meaningful long-term agricultural productivity. Needless to say, past initiatives by the GoK for example, formation of Agricultural Finance Corporation (AFC) in 1963 and the requirement that at least 17% of bank loan portfolio should consist of agricultural credit in the '90s failed to spur remarkable improvement of coffee production in Kenya (Seibel, 2002; Condliffe *et al.*, 2008). To address this market failure, the Government of Kenya (GoK) established Commodity Fund (CF) in 2006 to provide viable and inexpensive agricultural credit to coffee farmers to boost coffee productivity by facilitating them to access acquisition of inputs and support overhead operations (Taylor *et al.*, 1986; ICO, 2019).

As of 2014, the GoK had released about 1.54 billion into the CF credit programme targeting coffee farmers. Because it is a revolving fund, CF had disbursed about 3.42 billion by June, 2020. Initially, the credit programme was implemented through financial intermediaries and

farmers' cooperative societies. However, due to the high default rate, CF embraced the direct lending model. To this end, the impact of this credit programme on agricultural productivity has not been established. This is against the notion of experts who have previously hypothesized that agricultural credit does not have any impact on coffee productivity since yields are stochastic in nature. Their school of thought is consistent with previous studies conducted in the developed countries which concludes that farms that got credit did not outperform farms without credit in respect to either competitiveness of balance sheet performance or productivity (Striewe *et al.*, 1996; Brümmer and Loy, 2000). Further, the impact of agricultural credit on coffee productivity in Kenya has not been established to either prove or disapprove this supposition. As a result, this study surveyed smallholder coffee farmers in Kiambu County in Kenya to determine the impact of agricultural credit on coffee productivity.

Agricultural Productivity. The debates on measures to improve agricultural productivity and efficiency have dominated the agricultural arena for a long time due to its significant impact on the reduction of poverty through enhanced food security and better farm returns (Coelli *et al.*, 1998; FAO, 2017). Agricultural productivity is usually measured by technical efficiency (TE). Usually, dismal values of TE are associated with lower output levels and vice versa (Grosskopf, 2002). Further, the concept of TE is consistent with the theory of the firm that postulates that businesses are formed to optimize productivity to maximize profits (Debertin, 2012). However, this might be unachievable if smallholder farmers do not have access to inputs or the right combinations of inputs to get the right output mix given due to credit constraints. Credit empowers farmers to obtain the working capital for the cyclical acquisition of production inputs like agrochemicals, fertilizer, improved cultivars of coffee and hiring of labor. Further, credit facilitates smallholder farmers to acquire and expand farm investments like buildings, agricultural equipment, and land (Ayaz *et al.*, 2011).

Methodology

DEA Malmquist Index. The Malmquist index (MI) was first presented by Caves *et al.* (1982) and since then the Index has gradually evolved into a widely accepted non-parametric technique to estimate productivity. In practice, *MI* is a geometric mean approximation of two indexes that constructs input quantity indices as proportions of distance functions. For instance, a DMU using a set of inputs ($a^t \in \mathcal{R}_+^n$) to produce a positive set of outputs ($b^t \in \mathcal{R}_+^m$), input distance function $D(a^t, b^t)$ is defined on the technology Θ^t as the maximal feasible contraction of a^t that still enables the production of b^t . The distance function gives the optimum quantity that a firm would radially develop its output vector and it is estimated as:

$$D(a^t, b^t) = \max \left\{ \delta \left(\frac{a^t}{\delta} \right), b^t \in \Theta^t \right\} \quad (1)$$

Where

$$D(a^t, b^t) \geq 1 \quad \text{if } (a^t, b^t) \in \Theta^t \quad (2)$$

The technology of production Θ^t comprises entire input-output combinations which are precisely feasible for a given production pathway. With proof that the distance function is the inverse to Farrell's (1957) estimate of technical efficiency, Fare *et al.* (1994) extended the use of *MI* in

DEA models. When estimating *MI* in the DEA framework, Fare *et al.* (1994) emphasized that four distance functions are required to be calculated by four dissimilar linear programming (LP) problems for period t and $t + 1$:

LP Problem I: $D^t(a^t, b^t)$

$$\text{Max}\theta_1 = (D^t(a^t, b^t))^{-1} \quad (1a)$$

Subject to:

$$\theta_1 b_{w,u}^t \leq \sum_{w=1}^W Z_w b_{w,u}^t \quad u = 1, \dots, U \text{ number of outputs} \quad (1b)$$

$$\sum_{w=1}^W Z_w a_{w,u}^t \leq a_{w,v} \quad v = 1, \dots, V \text{ number of inputs} \quad (1c)$$

$$\delta_{w,v} \geq 0 \quad w = 1, \dots, W \text{ number of coffee farms} \quad (1d)$$

LP Problem II: $D^{t+1}(a^{t+1}, b^{t+1})$

$$\text{Max}\theta_1 = (D^{t+1}(a^{t+1}, b^{t+1}))^{-1} \quad (2a)$$

Subject to:

$$\theta_1 b_{w,u}^{t+1} \leq \sum_{w=1}^W Z_w b_{w,u}^{t+1} \quad (2b)$$

$$\sum_{w=1}^W Z_w a_{w,u}^{t+1} \leq a_{w,v} \quad (2c)$$

$$\delta_{w,v} \geq 0 \quad (2d)$$

LP Problem II: $D^t(a^{t+1}, b^{t+1})$

$$\text{Max}\theta_1 = (D^t(a^{t+1}, b^{t+1}))^{-1} \quad (3a)$$

Subject to:

$$\theta_1 b_{w,u}^{t+1} \leq \sum_{w=1}^W Z_w b_{w,u}^{t+1} \quad (3b)$$

$$\sum_{w=1}^W Z_w a_{w,u}^t \leq a_{w,v} \quad (3c)$$

$$\delta_{w,v} \geq 0 \quad (3d)$$

LP Problem IV: $D^{t+1}(a^t, b^t)$

$$\text{Max}\theta_1 = (D^{t+1}(a^t, b^t))^{-1} \quad (4a)$$

Subject to:

$$\Theta_1 b_{w,u}^t \leq \sum_{w=1}^W Z_w b_{w,u}^t \tag{4b}$$

$$\sum_{w=1}^W Z_w a_{w,u}^{t+1} \leq a_{w,v} \tag{4c}$$

$$\delta_{w,v} \geq 0 \tag{4d}$$

The above four-LP problems specified by equations (1a) to (4d) are calculated K times to reach the optimum solution for every DMU. The TE score for the i^{th} DMU at a period t of either PF or NPF is based on both the production amalgamation and technology for period $t+1$. On the other hand, solving for variable returns to scale (VRS) requires that the following constraint equation 5a be imposed on the four problems. Further, estimating either the increasing or decreasing returns entails solving constraint equation 5b. When equation 5b is under CRS, $EF=TE$ and $EF>TE$ denote increasing returns to scale (IRS) and decreasing returns to scale (DRS), respectively.

$$\sum_{w=1}^W \delta_w = 1 \tag{5a}$$

$$\sum_{w=1}^W \delta_w \leq 1 \tag{5b}$$

Similarly, pure technical efficiency (PTE) is denoted by efficiency scores under the VRS constraint. Thus, scale efficiency (SE) scores are determined by dividing VRS to constant returns to scale (CRS) as stated in equation (6a).

$$SE = \frac{TE_{CRS}}{TE_{VRS}} = \frac{TE_{CRS}}{PE} \tag{6a}$$

$$TE_{CRS} = SE \times PE \tag{6b}$$

Under CRS, MI is estimated from the product of efficiency change (EC) and technical change (TC) from period t to $t+1$ respectively as specified in equation (7).

$$[EC] \times [TC] = \left[\frac{D^{t+1}(a^{t+1}, b^{t+1})}{D^t(a^t, b^t)} \right] \times \left[\left(\frac{D^t(a^{t+1}, b^{t+1})}{D^{t+1}(a^{t+1}, b^{t+1})} \right) \left(\frac{D^t(a^t, b^t)}{D^{t+1}(a^t, b^t)} \right) \right]^{\frac{1}{2}} = MI \tag{7}$$

EC is further decomposed into PTE and SE change that is generated from calculation of ratio of two CRS distance functions from period t to $t+1$ as follows:

$$EC = [PTE] \times [SE] = \left[\frac{D_{vrs}^{t+1}(a^{t+1}, b^{t+1})}{D_{vrs}^t(a^t, b^t)} \right] \times \left[\left(\frac{SE^t(a^{t+1}, b^{t+1})}{SE^t(a^t, b^t)} \right) \left(\frac{SE^{t+1}(a^{t+1}, b^{t+1})}{SE^{t+1}(a^t, b^t)} \right) \right]^{\frac{1}{2}} \tag{8}$$

The gap between the observed and the optimum potential production from period t and $t+1$ denotes the EC component whereas TC denotes a shift in technology from period t and $t+1$. Hence, EC mirrors the level to which DMU efficiency enhances or exacerbates, while TC designates the transformation of the efficiency frontiers from period t and $t+1$. $EC=1$ and $EC<1$ in period $t+1$ represent a near-optimum level of production and reduction in efficiency respectively. Similarly, $TC=1$ and $TC<1$ in period $t+1$ show technical progress (TP) due to technology used for productivity

and reduction in TP respectively.

Data sources and collection. The data set consisted of credit details of smallholder farmers maintained at the farmers' cooperative societies (FCS) in Kiambu County (KC) in Kenya. The KC is administratively divided into 12 sub-counties that grow coffee; that is, Thika, Limuru, Kiambu, Lari, Gatundu South, Gatundu North, Juja, Kabete, Ruiru, Githunguri, Kiambaa and Kikuyu. However, six counties were purposively sampled for the study: Thika, Kiambu, Gatundu South, Gatundu North, Ruiru and Githunguri. The data for both participating smallholder farmers who obtained credit and non-participating smallholder farmers who did not obtain credit were collected from the records of FCS at the six sub-counties of Kiambu. A follow-up survey was conducted to ensure the completeness of the data collected. The two data sets were from 2007 to 2019. Only the smallholder farmers of coffee who have land of fewer than eight acres (≈ 3.5 ha) were considered in the study.

Research design. The study used a non-experimental research design whereby data were collected from participating and non-participating farmers in the *CF* credit programme. Data on input and output were collected to determine efficiency. A list of smallholder coffee farmers available in each of the FCS in each sub-county was used to identify both participating and non-participating farmers. The study surveyed 174 smallholder coffee farmers out of 3,250 of the target population. The number of both participating and non-participating farmers was proportionally and randomly selected and were equal in number.

Measurement of study variables. To conduct the DEA analysis, coffee output at the farm level and seven inputs were considered. The gender and level of education were included in the model as control variables. The relevance of variables of each included in the model is hereafter expounded.

B_{itci} is the quantity of harvested coffee in kilograms per acres by coffee farm i in year t with c_i standing for whether smallholder farmer had credit ($i=1$) or not ($i=0$). The input variable a_i for coffee farm i in year t is given as:

Labour cost (a_1): is the total annual cost of labor in Kenya shillings used by *SHCF*, whether *PF* and *NPF*.

The structure of labor (a_2): The proportion of family labor involved in coffee farming.

Fertilizer (a_3): The cumulative number of 50-kilogram bags of fertilizer applied per year on the coffee farm.

Farming area (a_4): is the total acreage of coffee.

Age of the coffee tree (a_5): taken to be equivalent to be from the date of transplanting of the existing coffee bushes to-date

Agrochemicals (a_6): is the total liters of fungicides and pesticides applied on the coffee farm per year.

Approximate age of the farmer (a_7): this variable represents the number of times farmers received advice on sound agronomical practices

Gender (a_8): is a dummy variable of the sex of the household head with 1 if male and 0 if female.

Education (a_9): This is the highest level of formal education of the head of the household. It is coded 1, 2, 3, 4 representing no formal education, primary, secondary and tertiary 4, respectively.

Extension visits (a_{10}): this variable represents the number of times farmers received advice on sound agronomical practices from extension workers. a_{10} is measured as the total number of visits to the coffee producer during the 2017 coffee season.

Coffee variety (a_{11}): is a dummy variable with a value of 1 for the farmer who has improved coffee variety and 0 for a farmer who planted traditional varieties.

Cropping system (a_{12}): is a dummy variable with a value of 1 if the farmer practices a mono-cropping system and 0 for otherwise.

Results and Discussion

Smallholder Coffee Farmer Characteristics. Table 1 provides the summary statistics for *PF*, *NPF* and pooled sample (*PS*). The mean yield for *PF*, *NPF* and *PS* is 2,747.66 kg/ha, 1,115.89 kg/ha and 1,931.77 kg/ha, respectively. The minimum and the maximum yields are 4,884.45 kg/ha and 126.39 kg/ha, respectively. Unlike *PF* who on average use 16% of family labor with the highest being 21%, *NPF* uses on average a higher proportion of family labor at 27% with the highest being 47%. This is congruent to the mean cost of labor of KShs. 208,277.21, KShs. 82,028.17 and KShs. 145,152.68 for *PF*, *NPF* and *PS*, respectively. The lowest and highest cost of labor incurred by the farmer was KShs. 12,161.69 (*NPF*) and KShs. 773,255.99 (*PF*), respectively. The higher structure of labor and the lower cost of labor might be because *NPF* is cutting back costs due to limited finances at their disposal, unlike *PF* who have access to credit and can thus engage hired labor. The fertilizer application rates for *PF*, *NPF* and *PS* were 1,436.80 kg/ha, 872.14 kg/ha and 1,154.46 kg/ha, respectively with the highest and lowest application rates being 11,283.21 kg/ha and 137.33 kg/ha, respectively. The lowest and the highest land under coffee production was 0.74 ha to 8.03 ha, respectively with *PF* and *NPF* having a mean of 5.35 and 4.48 ha, respectively. On the other hand, there was no significant difference in terms of the average age of trees with 33.11 years and 33.36 years for *PF* and *NPF*. The mean agrochemicals applied for *PF*, *NPF* and *PS* was 55,532.24 liters/ha, 18,585.38 liters/ha and 37,058.81 ltrs/ha respectively. The minimum and the maximum agrochemicals applied were 4,884.45 kg/ha and 126.39 kg/ha, respectively.

The demographic characteristics of farmers consisted of six characteristics. The mean approximate age of *PF* and *NPF* was 50 years and 43 years, respectively with the lowest and the highest age being 30 years and 63 years, respectively. The level of education on average for both *PF* and *NPF* was secondary education. The mean number of extension visits for *PF*, *NPF* and *PS* are 4, 2 and 3, respectively with the minimum and the maximum number of visits being 0 and 9, respectively. The gender, variety and cropping system is delineated by dummy variables (1 and 0). For these three variables, 1 represents male, improved variety and mono-cropping while 0 represents female, traditional variety and intercropping for gender, variety and *CS*, respectively.

DEA Malmquist Index. The annual means of MI and its associated components (efficiency change (*EC*), technical change (*TC*), pure efficiency (*PE*) and scale efficiency (*SE*)) for *PF* and *NPF* are captured in Table 2 and Table 3, respectively. Table 2 shows that the geomean for *PC*, *EC*, *TC* and *SE* (scale efficiency) for *PF* (participating farmer) is 152%, 40.5%, 53.2% and 40.5% respectively. For *NPF*, the geomean for *PC* (productivity change), *EC* (efficiency change), *TC* (technical change) and *SE* is shown in Table 3 as 57.7%, 13.3%, 39.3% and 13.3%, respectively. The *PF* recorded a higher *PC* of 95.4% in 2019 due to a greater *TC* of 65.2%. There was also a surge in *EC* and *SE* for *PF* by 61.96% each. On the other hand, *NPF* recorded a slight increase in *PC* from 39.7% in 2018 to 38.8% in 2019 due to a small decrease in *TC* by 0.64%. Besides, the results for *NPF* show that *TC*, *EC*, and *SE* did not contribute significantly to *PC* since all their values were below 50%. Further, *EC* and *SE* increased slightly by 1.96% each. The geomean of *PE* remained constant at 1% for both *PF* and *NPF*.

Table 1. Summary statistics for participating and non participating farmers

Variable	Mean			Minimum		Maximum		Standard Deviation	
	PF	NPF	Pool	PF	NPF	PF	NPF	PF	NPF
Yield	2,747.66	1,115.89	1,473.83	1,303.01	126.39	4,884.45	2,642.68	868.25	639.18
Labor cost	208,277.21	82,028.17	145,152.68	46,826.14	12,161.69	773,255.99	204,261.01	106,190.16	44,470.43
Structure labor	0.16	0.27	0.21	0.13	0.09	0.47	0.21	0.03	0.11
Fertilizer	1,436.80	872.14	1,154.46	233.27	482.60	11,283.21	137.33	1,307.48	2,128.45
Hectares	5.35	4.48	4.91	2.60	0.74	8.03	7.93	1.47	2.35
Age of trees	33.11	33.62	33.36	34.00	18.00	16.00	51.00	10.46	10.05
Agrochemicals	55,532.24	18,585.38	37,058.81	20,752.01	1,559.66	112,368.61	52,205.42	18,428.43	
Inefficiency Estimates									
Age of farmer	50.00	43.38	48.88	35.00	30.00	63.00	58.00	8.03	8.61
Education	1.80	1.83	1.82	0	0	3	3	0.96	0.83
Extension visits	4.02	2.42	3.22	0	0	9	8	2.68	2.31
Gender				0	0	1	1		
Variety				0	0	1	1		
Cropping system				0	0	1	1		

PF= ParticipatingFarmers; NPF= Non Participating Farmers

Table 2. Malmquist Index Summary for participating farmers

Year	Efficiency change	Technical change	Pure efficiency	Scale efficiency	Productivity change
2018	1.104	1.420	1.000	1.104	1.568
2019	1.788	1.652	1.000	1.788	2.954
Geomean	1.405	1.532	1.000	1.405	2.152
Growth 61.96% 16.34% 0.00% 61.96% 88.39%					

Table 3. Malmquist Index Summary for Non Participating Farmers

Year	Efficiency change	Technical change	Pure efficiency	Scale efficiency	Productivity change
2018	1.122	1.397	1	1.122	1.567
2019	1.144	1.388	1	1.144	1.587
Geomean	1.133	1.393	1	1.133	1.577
Growth	1.96%	-0.64%	0.00%	1.96%	1.28%

Discussion

This result indicates that PF (Participating Farmers) had the highest PC, EC, TC, and SE than NPF (Non participating Farmers). The growth in technical change (TC) and efficiency change (EC) from 2017 to 2019 was 61.96% and 16.34%, respectively. For the same period for NPF, the TC increased by 1.96% while the EC decreased by 0.64%. These findings are consistent with previous results (Guirkinger and Boucher, 2008; Fletschner *et al.*, 2010) that demonstrated that there was a positive relationship between agricultural credit and farm productivity. However, other researchers demonstrated that agricultural credit has no significant impact on farm productivity (Carter, 1989; Feder *et al.*, 1990; Bateman and Chang, 2009).

Conclusion and Recommendation

The main objective of this study was to determine the impact of agricultural credit on coffee productivity. The study adopted the DEA Malmquist index to estimate the efficiency of coffee productivity for participating (PF) and non-participating (NPF) coffee farmers in the credit program in Kiambu County in Kenya. Contrary to previous notions emanating from previous research findings, the TGR results empirically demonstrate that agricultural credit has a significant impact on coffee productivity. The MI estimates validate that coffee productivity by PF operated on a loftier (profitable) frontier in comparison to NPF. This implies that access to credit would result in the acquisition of an optimal combination of inputs and lead to improvements in technical efficiency and result in higher output levels. The DMU inefficiency estimates indicate that the credit program interventions aimed at efficiency improvement in NPF should be targeted at enhancing farmers' access to an improved variety and advisory services through extension visits. The higher yield of PF also indicates that the intervention can be useful in mono-cropping. Further, enhancing farmers' access to fertilizers, improved seedlings varieties, hired labor and agrochemicals among other farm inputs might significantly augment coffee production efficiency for NPF. Consequently, access to agricultural credit by coffee farmers is paramount to increase coffee productivity. Thus, deeper comprehension of the interaction between credit and agricultural productivity is very critical in

aiding smallholder coffee farmers allocate resources more efficiently and help policymakers in formulating agricultural credit programs that promote agricultural productivity.

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