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Farmer incentives and value chain governance: Critical elements to sustainable growth in Rwanda's coffee sector

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ABSTRACT

Limited producer participation and voice in the governance structures of the coffee value chain in Rwanda, a common occurrence in many agricultural export sectors in the developing world, have resulted in low farm gate prices, restricted competition and few incentives for producers to invest human and capital resources in improved coffee production. A twenty year downward spiral of low productivity and stagnant production has ensued. Survey data from 1024 coffee producing households together with key informant interviews and focus group discussions are used to examine how patterns of investment in coffee affect farmers' productivity and profitability. Findings show that artificially low farm gate cherry prices have driven down coffee production levels and at the same time have enabled a rapid expansion coffee processing capacity. A typology of producers based on capacity to invest and incentives to invest in coffee is constructed to help explain why smallholders are the most productive and largeholder farmers are the least productive when cherry prices are low. Smallholders are 'pushed' to produce out of necessity (poverty avoidance) while largeholders are 'pulled' to produce uniquely by the lure of higher profit margins, which they achieve only when higher producer prices prevail. Policy recommendations are advanced for greater inclusion of producers in the price negotiation process and for adopting a floor price formula that includes the real cost of production as established by this research.

1. Introduction

Understanding farmer investment incentives is essential to promoting sustainable agricultural practices and improving livelihoods throughout the developing world (Tilman et al., 2002), and perhaps nowhere does this observation ring truer than in Rwanda's coffee sector today. Coffee production has been a pillar of rural livelihoods in Rwanda for generations and now serves as a source of cash income for over 355,000 farm households across the country (NAEB, 2016b). Since 2002, the coffee value chain has witnessed a remarkable transformation in quality (from ordinary to fully-washed specialty coffee) and is today well established in specialty coffee markets around the globe (Murekezi et al., 2012). With the construction of over 250 coffee washing stations, the processing segments of the sector have prospered in the transition to specialty grade coffee. Dry mills and export companies, both domestic and international, have similarly emerged during this period (Elder et al., 2012). While the value-added from this transformation has benefited Rwanda in its efforts to compete in high value specialty coffee markets, the country's coffee producers have shared the least in the new prosperity, a condition which Ponte (2002) identifies as a common outcome of farmers having little or no influence on the value chain relative to international trading companies and other more powerful sector actors.

In neglecting to bring in producers as full partners in Rwanda's 'specialty coffee renaissance' and in failing to provide appropriate production incentives, Rwanda's coffee sector leaders have propelled a downward cycle of low farmer investments in their coffee plantations, low productivity, and stagnant coffee production, a constellation of forces that has endured for over 20 years. This multifaceted progression, rooted in non-inclusive governance structures coupled with deficient production incentives to farmers (low farm gate prices) constitutes the principal focus of this research. Our approach to this is problem is enhanced through the construction of a typology and an analysis of the dynamics of how households with different attributes and varying levels of productive capacity are differentially affected by the absence of economic incentives.

Research has amply demonstrated that good governance structures within a value chain are essential to its long-term sustainability. To be

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sure, the movement of product from one stage of the value chain to the next can be a competitive process. At the same time, there is a need for the actors in these stages to hold a common vision, share basic principles, and to co-ordinate efforts to be successful. In the realm of specialty coffee, the need for producers, processors and exporters to all adopt and support practices for producing high quality and fully traceable coffee are among the most important guiding principles to long-term sustainability. But such co-ordination is never assured and the Rwanda coffee value chain provides a glaring example of what happens when co-ordination with coffee producers is missing.

Competing incentives among actors are often the reason why governments choose not to implement policies that are functionally optimal for aggregate growth (World Bank, 2017). In poorly governed sectors there may be certain influential actors that are in a position to leverage their superior bargaining power to maintain policies that enhance their private benefits, even obstructing government initiatives designed to maximize the profitability and success of the sector as a whole. Authors of the World Bank Development Report (2017) highlight transparency, participatory structures and a shared long-term vision among stakeholders as some of the more important elements of good governance necessary for success against such misaligned incentives.

At the country level, there is a rich literature on the connection between participatory governance and successful economic outcomes in Africa and other regions of the world. Radelet (2010), for example, underscores the importance of equal voice and accountability as the crucial aspects of good governance that are linked to economic growth. He has established an index of 'voice and accountability' which, across 54 African countries, measures highest for countries that achieve a positive development trajectory. Radelet also concludes that incentives for agriculture are one of the five key policies for economic success. Similarly, Bassett (2010) in a review and analysis of the cotton industry in West Africa finds that price-setting through non-participatory methods has affected how producers perceive the institutions that are there to serve them, and concludes that lack of participation and transparency in price-setting has caused demonstrably poor outcomes, including suspicion amongst producers and corruption amongst the agency leaders.

Hirschman's Exit, Voice and Loyalty (1970) provides an especially suitable and persuasive framework for capturing the overarching decision-making structure that farmers face both individually and collectively in a sector where they are excluded from the benefits of the new transformation into specialty coffee. The exit-voice-loyalty model posits that members (farmers in this case) have a choice, and that is to either fight for a stronger 'voice' through direct action such as protests and lobbying, or to 'exit' the enterprise. By exit Hirschman observes that physical departure is not necessary; members can also exit simply by choosing to not participate, by dropping out and giving up loyalty to the organization—in the Rwanda coffee farmers' case this means abandoning their loyalty to the coffee cooperative and other members of the coffee sector. Consistent with the voice-exit-loyalty model, we posit that Rwanda's observed decline in production and the farmer investment in their coffee fields can be largely attributed to producers' inability to voice their dissatisfaction or to effect positive change in their circumstances, choosing to 'exit' instead.

More specific to success in the coffee sector, and consistent with the Hirschman framework, Coe (2006) concludes from a cross-sectional study of many Arabica coffee producing countries that the influence of farmer groups in the policy arena is closely tied to positive economic outcomes. In particular, the study finds that in markets where the commodity can be differentiated (such as in the specialty coffee value chain) farmer participation in the regulatory authority, typically the coffee board or its equivalent, can have direct implications in terms of higher prices for producers.

Our research provides a closer look at Coe's country-level hypothesis that coffee sector success is contingent upon farmer participation in the regulatory authority. We maintain that a lack of coffee farmer participation and 'voice' in the annual coffee floor price negotiations and other policy decisions in Rwanda, such as the newly adopted zoning policy, has indeed led to sustained, artificially low farm gate coffee prices. This development is shown to be a major disincentive for farmer investments in their coffee plantations, resulting in a sustained environment of low inputs use, poor farmer profitability, declining production and long-term stagnation in the coffee sector—effectively Hirschman's 'exit'. Through this research we have a rare opportunity to see, up close, how the absence of farmer participation and disregard for producer incentives can harm sector growth. This failure, while ostensibly in the short-term business interests (profit margins) of other actors in the value chain, notably the processors and export companies most actively involved in the price-setting negotiations and in promoting the newly adopted coffee zoning policy, is shown to be harmful to their business interests, and to the entire sector, when viewed over the longer term.

The present research also contributes to our understanding of how the lack of financial incentives to producers plays out across different types of farm households. Too often in the literature coffee farmers are considered as a homogeneous group (Coe, 2006). The present research confronts this misconception head on, observing stark differences in the incentive structures of smallholder and largeholder coffee producers. In short, smallholder investment decisions are pushed to invest in their coffee by sheer economic necessity; largeholder investment, by contrast, is incentivized largely by higher coffee prices.

The lack of price incentives to farmers overall has resulted in a gradual decline and, more recently, stagnation in coffee production over the past 20 years—a source of concern for virtually all stakeholders in the coffee value chain. Indeed, Rwanda's National Agricultural Export Development Board (NAEB) in its strategy statement identifies insufficient production of coffee cherry as the primary constraint to growth in the sector (NAEB, 2016a). The trends are seemingly enigmatic in that coffee productivity in Rwanda is among the lowest in the world, yet international buyers consistently rate its coffees among the very best in the world, easily on par with coffees produced elsewhere in the East Africa region. Other countries in the region, notably Ethiopia and Uganda, have experienced steady growth in their coffee sectors over the past two decades, while Rwanda has not.

Rwanda's official strategic policy objectives are consistently in line with the expressed need to raise the productivity and quality of coffee, as well as to accelerate the shift from 'ordinary' or 'semi-washed' coffee to higher-value 'specialty' coffee (NAEB, 2016a). A critical part of the solution lies in Rwandan coffee producers' capacity and incentives to invest in their coffee. Capacity, in terms of land, labor, cash/capital and knowledge (technical and entrepreneurial), are constrained for many of the country's producers. At the same time, it is well established that adequate farmer capacity will not result in the desired improvements in productivity or quality unless coupled with proper incentives to produce (Odhiambo et al., 2004; Trademark East Africa, 2013; Ndayitwayeko et al., 2014; Bravo-Monroy et al., 2016; Gelaw et al., 2016; Snider et al., 2017). The absence of a policy framework and process that will include producers and motivate them to allocate household resources to coffee is a serious obstacle to reaching Rwanda's goals of establishing a more productive, vibrant and sustainable coffee sector.

Coffee farmers in Rwanda are not alone in their quest for strong financial incentives. For example, Jones and Gibbon (2011) examine how the lack of such incentives similarly affects cocoa producers in Uganda, finding that farmers will often choose to side sell, or invest their labor and resources on other income generating activities, when farm gate prices are not stable or in the absence of proper institutional support. Other research has observed that farmer investments in food crop production have been found to increase when food prices rise (Nose and Yamauchi, 2016).

The present study builds on and contributes to this broader research

literature, drawing on recent evidence from Rwanda to analyze patterns of farmer investment in coffee to understand the drivers of such investments—what factors enable producers to allocate land, labor and capital to coffee production, on the one hand, and what barriers may be present that restrict their investments in the coffee sector, on the other. We start with a review of how coffee production in Rwanda compares with other countries in the region. Historical trends in coffee production and producer prices in Rwanda and other East African coffee-producing countries are then examined based on data from the International Coffee Organization, followed by an analysis of producer data from Rwanda's four main coffee-growing districts. Patterns of investment in coffee are analyzed, including how such investments affect farmers' productivity and gross margins. Factors are identified that make some producer groups more productive and profitable than others, and a typology is constructed based on farmers' capacities and incentives to invest in their coffee. Coffee producer views on the primary barriers and advantages to coffee production are presented along with an analysis of how different types of farm households use the revenues they receive from coffee production. This study concludes by proposing a set of policy actions that will improve producer incentives to invest in their coffee plantations and help the sector to reestablish its footing and direction on a path toward sustainable growth.

1.1. Trends in coffee production and producer prices in Rwanda and other coffee-growing countries in the region

Coffee has long been known as a commodity product with a large footprint in poor, often mountainous countries in the tropics, and as a leading source of economic growth for many of them. In East Africa, Rwanda is one of six major coffee-producing countries, with Ethiopia, Kenya, Tanzania, Uganda, and Burundi being the others. Of these six, Ethiopia is well established as the 'behemoth' producer, followed by Uganda, both of which produce over 20 times the volume of Rwanda (ICO, 2017), which has been producing in the range of 16,000–21,000 MTs in recent years (NAEB, 2016a). All six of these countries are categorized by the World Bank as agriculture-based countries (World Bank, 2008), meaning that agriculture has contributed over 20% of the country's growth. While coffee is a significant contributor to farm incomes in all six countries, in four of them, namely Rwanda, Burundi, Ethiopia and Uganda, coffee is a leading export crop, (FAO, 2004).

As a highly valued export market, coffee has radically evolved in recent decades, posing new challenges and attractive opportunities to aspiring smallholder producers. On a global scale, the demand for premium quality coffees continues to grow. In the United States, one of the world's largest coffee markets, the Specialty Coffee Association reports data showing that the number of daily specialty coffee drinkers has grown from 14% in 2009 to 41% in 2017 (Ward, 2017). This is encouraging news for Rwanda and other countries where high quality Arabica varieties are produced. The price premium received for high quality Arabica coffees is often tied to new marketing channels that can disrupt longstanding market structures and vested interests. The new 'direct trade' relationships between producer groups and specialty coffee buyers create demands for quality that are difficult to achieve in systems built on an undifferentiated commodity coffee product. Another important dynamic in global coffee markets is the gradual 'decoupling' of specialty coffee prices from the more volatile 'NY C' price for commodity grade coffees (Clay and Bizoza, 2018). This has occurred because specialty coffee tends to have a much higher and more stable upside retail price, often $15/lb or more, so that margins remain comfortable even when global prices decline, and secondly because specialty coffee is often sold through direct and longer-term contracts established between producer groups and buyers. Ordinary coffee sold on the C market, by contrast, is typically sold at auction which is known to vary daily, as are most commodity auctions.

The growth of specialty coffee markets means that high-elevation Arabica producers like Rwanda have comparative advantages over neighbors like Uganda and Tanzania which produce mostly at lower elevations and have reputations challenged by a history of exporting large volumes of lower grade, Robusta variety coffees. However, Kenya, Ethiopia and Burundi also are largely 'Arabica only' and smallholder producing countries, so Rwanda still has strong competitors in the region.

It is important to note that Rwanda is well aware that it's comparative advantage lies in high quality specialty coffee markets, and this has been made explicit in the NAEB coffee strategy (NAEB, 2016a). The country is capable of producing exemplary coffees due to its high elevation, agro-ecology and tradition of producing prized Bourbon variety Arabicas. Moreover, due to its mountainous topography and very small coffee plantations (all smallholder) cannot seriously mechanize production; so competing on volumes and price in the lower quality commodity markets is not a sustainable option in the long run. The entire value chain is aware of these facts and actors at all levels are aggressively moving to expand access to specialty coffee markets. Those Rwandan companies that have converted to high end specialty coffee and have paid farmers well for high quality coffee cherry are among the most successful coffee companies in the country.

One important distinction between Rwanda and its neighbors is its negative growth in production over the past five years, and virtual stagnation over the past 20 years, as will be shown in greater detail later in this section. Both of these measures put Rwanda at the bottom of the list of the six East African countries. Why is Rwanda struggling so much more than others in the region to achieve positive growth in this important agricultural sector? Unlike Rwanda, Ethiopia has a large domestic market for consumption of coffee (approximately 50% of Ethiopian production is consumed domestically), which partially explains its stronger growth in coffee. Kenya's advantage in having two harvest seasons (main harvest and a fly crop) each year, instead of only one, seems to have helped in recent years to revive its production trend. It should also be noted that Rwanda and Burundi are the only countries in the region that do not have a significant segment of very large coffee estates. The largest of the 'large farms' in Rwanda and Burundi would be considered mid-sized in countries like Kenya and Uganda. The small farms in Rwanda and Burundi are a logical result of the extremely high population density in these two countries, 483 and 409 people per square km, respectively, compared to densities of 62 and 206 in the neighboring countries. They also have poverty rates that top those in the other four countries (World Bank, 2017).

These historical and agro-ecological differences across coffee producing countries in East Africa have naturally been accompanied by different policy and market environments. Kenya, Ethiopia and Tanzania all have well-organized, national auctions for price discovery, whereas Burundi, Uganda and Rwanda do not. In fact, Rwanda and Burundi are the only two East African countries where a national cherry floor price (the minimum price the farmers must be paid for their cherry) is set by the government. A minimum farm gate price is often thought to protect farmers' interests, similar to a minimum wage. However, the floor price can also be a market distortion that dampens competition and creates disincentives if not well managed. In the context of Rwanda, the cherry floor price is much more than a minimum price; it has become a monopsony price that processors pay for most of the cherry they buy, the result of a regulatory process that effectively eliminates competition for cherry and needed incentives driving quality and productivity improvements. Competition is further diminished by Rwanda's newly adopted zoning policy (Gerard et al., 2017), which geographically restricts where and to whom producers can sell their cherry, and by the requirement that farmers must deliver their cherry to the CWS within six hours of harvest to preserve its quality, which all but eliminates the possibility of selling to more distant washing stations. No other crop in Rwanda is subject to the same formal market restrictions and this poses a significant disadvantage to the coffee grower. Research has shown that under conditions of low

cherry floor prices, producers' share of the export price is very close to their cost of production, meaning they have little no profit margin, while the country's exporters receive comfortable margins of 30 percent and higher (Church, 2018). Without a strong voice in the governance of the sector, especially floor price negotiations, farmers find themselves at the mercy of the more advantaged processors and exporters farther up the value chain.

Overall coffee production in Rwanda is markedly lower today than it was 25 years ago, stabilizing over the past 7–8 years in the range of 280,000 bags (16,800 MT). It is notable that other selected countries in the East Africa region have increased their production during this same timeframe. Ethiopia, for one, has more than doubled its output (based on International Coffee Organization data) and now stands as a model of growth for the entire region (Petit, 2007).[1] In Rwanda, the question remains: How to build farmer capacity and put in place the incentives that can ensure necessary farmer investment in their coffee plantations? An important step has been the gradual transition that the Rwanda coffee sector has made since 2002 toward fully-washed specialty coffee. Today fully-washed specialty coffee constitutes 45–50 per cent of all exported coffee from Rwanda, up from just one per cent in 2002 and 21 per cent in 2007 (NAEB, 2016b). Thus, while the volume of coffee has stagnated over the past 15 years, the quality of green coffee, and the export prices derived from that quality, have risen dramatically and have placed Rwanda on the map internationally as a highly desirable coffee origin (Ndambe, 2015). This transformation has enabled substantial growth in coffee processing. There are currently more than 250 coffee washing stations distributed across Rwanda's major coffee growing regions, numerous dry mills, new entrants to the ranks of exporters, including major multi-national corporations, and in more recent times a remarkable growth in Rwanda's local coffee roasting and retail businesses, spawning an exciting new domestic coffee culture, albeit primarily an urban phenomenon to date. This rapid and ongoing post-harvest processing growth in the coffee value chain underscores the attractiveness of the coffee processing and export business in Rwanda. The inconsistency is that it has occurred over a period when the production of coffee has declined to half of what it was just 20 years ago. The reason for this inconsistency can be found in recent research (Church, 2018) showing that coffee is indeed a very good business with high profit margins for nearly all processors and exporters when their raw material (coffee cherry) can be purchased at rock bottom costs, well below the average price payed in the East Africa region.

While these positive, quality-based developments have added considerable value to Rwanda's coffee, the obvious question is why so little of that value-added has made its way to coffee producers. Farmer compensation in Rwanda has remained largely stagnant and well below that of their counterparts in much of East Africa for the past 20 years. Fig. 1 reveals that producer prices in Rwanda have lagged behind the rest of East Africa by an average of 24 per cent during the period and that overall differential has shown little to no improvement in recent years despite Rwanda's heralded transition to higher quality, fully-washed coffee.

The implication from these observations is that virtually all of the value-added attached to higher quality coffee has accrued to those in the post-harvest stages of the value chain—comprised mainly of washing stations, dry mills and export companies. At one level, it may seem logical that those segments of the value chain responsible for transforming coffee from cherry to green coffee, a detailed and highly specialized process, should be the recipients of the value that transformation adds to the final product. From another perspective, however, the producers must be recognized as partners in the quality-enhancement process, particularly to the extent that their efforts in the field through a range of painstaking best practices (weeding, pruning, mulching, etc.) result in higher quality cherry, with higher density and fewer defects, harvested at precisely the right time (fully mature and red) and delivered to the CWS within a six-hour window to avoid spoilage. Without these critical and costly on-farm steps, Rwanda's fully washed coffees will cup below the 80 point 'specialty' threshold and be classified for sale as 'ordinary coffee,' at best.

Thus, it is maintained here that compensating farmers for their efforts to produce a quality coffee that will fetch top prices on international specialty coffee markets is a critical step, perhaps the most critical step of all, in the long-term success of Rwanda's fully-washed, specialty coffee value chain. No degree of best processing practices can turn low quality cherry into high quality green coffee. Demand-side incentives begin with the farmer; Rwanda's coffee renaissance is yet to embrace that concept. Direct producer participation in the coffee policy and regulatory authority has been shown across Arabica coffee exporting countries globally to be essential to market outcomes, most notably in raising the producers' share of coffee revenue (Coe, 2006). However in Rwanda, coffee cherry prices are set by the coffee board (NAEB) through a formula that uses vastly underestimated farmer cost of production figures and a process that gives inordinate voice to the large and influential coffee processors. The figure historically used for farmers cost of production is 80 RWF[2]/Kg of cherry, while more recent and painstakingly detailed figures show the actual cost to be 177 RWF/Kg (Clay et al., 2016). The price-setting process is one that draws on data from the New York Board of Trade (NYBOT) 'C' current and futures price, Rwanda franc (RWF) to US dollar exchange rates, farmer cost of production, and estimates of processing costs, inputs costs and other empirically derived factors. While there is an initial formula that incorporates these factors, the process is highly subjective in other ways and involves an important degree of negotiation among the stakeholders present. Stakeholders include representatives of the Rwanda government (notably NAEB), farmer cooperatives, wet and dry mill owners/operators, and green coffee exporters. Based on participant observation as well as key informants party to the process, the 'heavy weights' in the negotiations and policy decisions are the processors and exporters (in some cases representatives of multinational corporations). Their dominance comes at the expense of the coffee farmer cooperatives and related organizations such as RWASHOSCCO whose access to data, political capital, business acumen, language proficiency and persuasive powers are inevitably no match in such high level cherry price negotiations and policy setting. One key informant to the study who is often present during the cherry price negotiations confided that the processors and exporters were "so strong that other stakeholders cannot win." The larger multinationals are also reported to leverage their size and influence with threats of "pulling out of Rwanda" altogether if prices and policies are not set to their liking.

Data reported by the International Coffee Organization (ICO) also show Rwanda's average productivity from 2011/12 to 2013/14 at 385 kg/Ha for Arabica green coffee, or approximately 43% below the East Africa average of 604 kg/Ha. The differential in productivity is not so much a function of agro-ecological differences, such as elevation, soils and rainfall, as Rwanda does not differ greatly from its highland African neighbors on these factors. Significant agronomic differences may lie partly in the coffee varieties grown in Rwanda (mainly Bourbon) compared to other countries such as Kenya, where higher-yielding varieties have been adopted at a higher rate (Gatarayiha, 2014). But more, based on dozens of interviews with coffee sector stakeholders, the primary reason for Rwanda's continued low productivity is widely believed to be due to low farmer implementation of best production practices, especially in the use of fertilizers, manure and other inputs, as well as in how coffee trees are maintained in the field through pruning, mulching, stumping, and other labor intensive

[1] International Coffee Organization (ICO) data base, supplemented by data in most recent years from the Rwanda's National Agricultural Exports Development Board (NAEB).

[2] Exchange rate: 1.00 US Dollar = 846 Rwanda Francs (RWF).

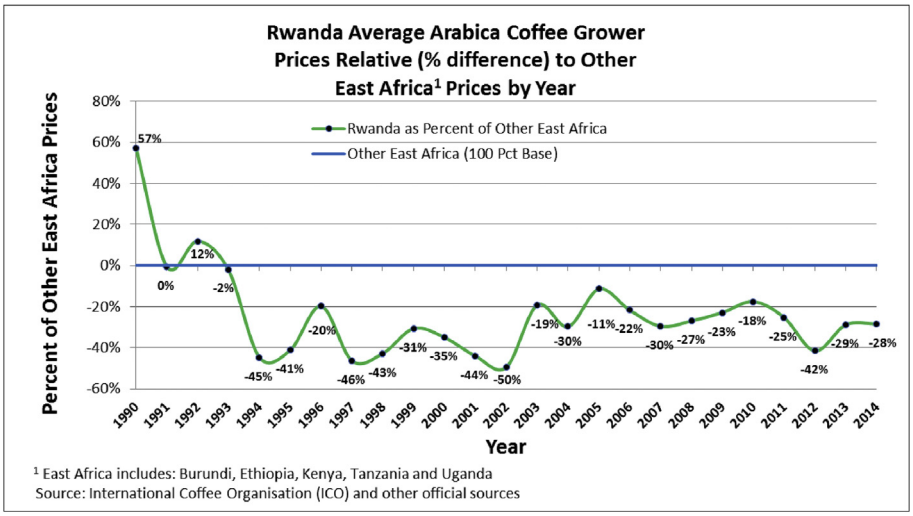

Fig. 1. Rwanda's farm gate prices lag those elsewhere in East Africa.

practices. Implementing best practices is costly, requiring farmers to increase their labor (household and wage labor) and their cash, investments they are not willing to make without the promise of a reasonable return.

These trends beg the questions of whether and how Rwanda's artificially low coffee producer prices and low productivity are related. We hypothesize that they are closely linked, with low producer prices in Rwanda being an important determinant of the country's low productivity and declining/stagnant production over time. Farmers will choose to invest in coffee (and other crops) when they have both the capacity to invest and the incentive to invest. The main incentive to invest one's land, labor and capital in coffee is the expected financial return (cherry prices), discounted for the level of risk (of a poor harvest) that they must assume as a condition to that investment (ICO, 2017). Like most crops, coffee yields are directly affected by variations in weather, pests, diseases and other natural threats, and the risk of one or more of those threats resulting in a poor harvest is substantial. Correlational support for the price-investment hypothesis lies in the finding that historical prices in Rwanda have been closely linked to overall production levels (Clay et al., 2016), and the finding that in recent years coffee producers in Rwanda have been shown to invest in productivity-enhancing practices at a higher rate when coffee prices rise (Clay et al., 2018).

In the following sections we examine data on farmer investments in coffee and how those investments are linked to both farmer capacity and potential returns. We are concerned with how farmer investments affect their productivity as well as their gross margins (profits) and how, in turn, these outcomes are conditioned by their capacity to invest in coffee.

2. Research methods

2.1. Study area and data collection

This study uses a mixed methods approach and draws upon a combination of quantitative and qualitative data collection methodologies (Creswell and Clark, 2017). A survey of coffee growers is the primary source of quantitative information reported; it is supplemented by a program of Focus Group Discussions (FGDs) with coffee sector stakeholders. The survey was conducted early in 2016 on a sample of 1024 households randomly selected from listings of 16 coffee washing stations (CWS) geographically dispersed across four major coffee-growing districts (Rutsiro, Huye, Kirehe, and Gakenke), representing Rwanda's four agricultural provinces (Fig. 2):

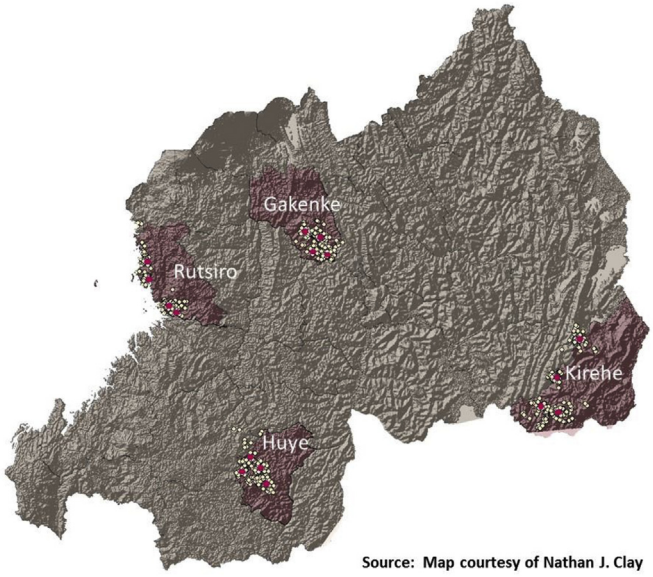

Fig. 2. Map of sampled districts, washing stations and households.

The guiding objective of the CWS selection was to maximize geographic dispersion of the four CWSs in each district and also to ensure that the four in each district would include two that are co-operatively owned and operated and two that are privately owned and operated. From the farmer listings at each of the 16 CWSs, 64 farmers were randomly sampled for study, totaling 1024 (16 CWS x 64 HH) coffee producing households in all.

The survey instruments were developed at the farm household and field levels. Sections of the questionnaire covered a diversity of topics including: coffee growing practices, cost of production, coffee field size, number of trees, slope, location (GPS), cherry production, cherry sales, landholding, equipment and assets, household income, perceptions of barriers to investment in coffee and basic household demographics. The questionnaires were then translated to Kinyarwanda and the survey was fielded over ten consecutive weeks in late 2015/early 2016.

To supplement the quantitative survey data, an extensive series of 35 key informant interviews was conducted with public and private sector leaders in the coffee industry, as well as 20 focus group discussions with the major coffee stakeholder groups in Rwanda, including coffee farmers (male and female separately), washing station managers, coffee exporters, and others. Participants were selected from a listing of

Table 1
Summary descriptive parameters of selected determinants/covariates.
Source: AGLC Radelet, 2010 Baseline Coffee Producer Survey.

	N	Mean	Median	S.D.	Percent		Min	Max
Gender of head (1 = male, 2 = female)	1024	1.18	1	0.39	18.5%	female	1	2
Age of head (years)	1024	51	51	14.18	–		22	94
Education of head (% primary complete)	1024	2.24	2	1.13	39.1%	primary compete	1	10
Member of coop (0 = no, 1 = yes)	1024	0.55	1	0.50	55.4%	members of coop	0	1
Cooperative ownership of CWS (1 = no, 2 = yes)	1024	1.50	1.5	0.50	50.0%	CWS owned by coop	1	2
ICO, 2017 (not including coffee)	1023	318,726	180,000	452,385	–		0	4,350,000
ICO, 2017 from coffee	1021	200,286	125,000	256,166	–		0	2,945,000
Share of total income from coffee	1022	44.5	42.0	27.5			0	1
Nbr of productive coffee trees	1022	706	400	945	–		0	9320
Total cherry production 2015 (KG)	1022	1025	601	1448	–		0	15,500
Total land owned (sq meters)	1024	11,986	9449	10,673	–		0	80,000
Received premium (0 = no, 1 = yes)	1016	0.27	0	0.44	26.9%	received premium	0	1
Price per kg of cherry 2015	1005	198	200.00	32.5	–		100	300
Applied fertilizers (0 = no, 1 = yes)	1024	0.71	1	0.45	71.0%	applied fertilizer	0	1
Applied pesticides (0 = no, 1 = yes)	1024	0.69	1	0.46	68.8%	applied pesticides	0	1
Applied manure (0 = no, 1 = yes)	1024	0.59	1	0.49	59.4%	applied manure	0	1
Elevation of HH (m)	1024	1712	1721	165	–		1310	2179

key stakeholders available to the researchers, and were specifically chosen to represent a range of views pertinent to the topics being explored. A semi-structured interview approach was used, with general questions provided to stimulate discussion around specific topics (Patton, 1990). The interviews lasted approximately 1–2 h each. Data from all of these sources have been integrated into a multi-component database and are drawn upon in our analysis of farmer incentives and capacity to invest in coffee production in Rwanda.

2.2. Data analysis

We use a two-staged analysis to answer our main research questions. In the first stage we analyze the farm household survey data using descriptive statistics and correlations among key variables of interest to set the stage for later multivariate analysis and typology development. In the second stage, analysis of variance (ANOVA) is conducted to examine the independent effects of factors and covariates (identified in stage 1) on coffee productivity and gross margins. Both stages incorporate insights from the qualitative dataset to aid in the interpretation of findings and to formalize the farmer typology which is developed based on these results.

Farm elevation was measured using GPS software and is incorporated into the analysis as a general indicator of agroecology. Elevation is known to correlate highly with temperature, rainfall and relative humidity, all variables that affect coffee quality and sales prices (Scott, 2015). Survey data analyzed also include several variables based on farmer perceptions and opinions. These variables include perceived barriers to production and contingency valuation of prices at which farmers say they would be incentivized to allocate more cash, labor and land to coffee production.

3. Results and discussion

In the sections that follow we present a series of analyses to help understand the determinants of farmer investments in their coffee plantations. We draw on several groups of variables in these analyses including socio-demographic variables (e.g., age and gender of head of household), economic variables (e.g., household income, cherry prices and premiums, land/tree ownership, and gross margins from coffee), and agronomic variables (such as production practices and elevation). Table 1 presents a summary of the descriptive parameters on some of these key determinants.

It is important to note that the sample includes coffee growers in the four sampled districts that produce cherry for the fully-washed coffee channel in Rwanda. Similar to the broader farm population, 18.5 per cent of sampled households are headed by women. We note that these women are disproportionately older and widowed. The average age of heads of households is 51 years and 39.1 per cent of them have completed primary school or higher. Cooperative membership stands at 55.1 per cent, and 50.0 per cent of households take their cherry to a cooperatively owned washing station, a reflection of the sampling frame that equally represented (50%–50%) washing stations that were co-operatively and privately operated.

Median non-coffee income is 180,000 RWF,[3] while median income from coffee is 125,000 RWF, meaning that coffee is a major part of total income of these farm households—44.5 per cent on average. The mean coffee plantation is just over 700 trees (median 400 trees) and the mean cherry production from those trees is 1025 Kg (median 601 Kg). Farm size (owned land) is approximately 1.0 ha (mean 1.2 ha, median 0.94 ha), measurably larger than the average farm size in Rwanda of 0.6 ha (NISR, 2016).[4] Cash premiums are received by just over a quarter of coffee producers typically being paid by buyers for higher quality coffee. The median cherry price received by sampled farmers in 2015 was 200 RWF/Kg and ranged in price from 100 to 300 RWF/Kg, a variation linked mainly to cherry quality and type of buyer. We note that most households sell directly to the CWS or cooperative (91.7 per cent of cherry sold) and they received a median of 200 RWF/Kg for their cherry. The remaining 8.3 per cent of cherry was sold to private traders and the median price received by those households was 180 RWF/Kg, or approximately 10 per cent less.

About two-thirds of farmers in the fully-washed channels in the four districts use recommended inputs with 71.0 per cent applying fertilizers, 68.8 per cent applying pesticides (both mainly from CEPAR/NAEB distributions), and 59.4 per cent apply animal manure to their coffee. Sampled farm households are located in the elevation range between 1300 and 2200 m above sea level, with a mean elevation of just over 1700 m, an elevation range that is recognized by coffee buyers for producing exceptionally high quality coffees.

3.1. Farmer investments in labor, inputs and equipment

Our analysis finds wide variation in how farmers invest in their coffee plantations, both in the types of investments they make and the amounts they invest. The major types of investments farmers make in the production of coffee include household labor, hired labor, purchased inputs and purchased equipment. Overall, they total 231 RWF

[3] 1 USD = 784 RWF.
[4] Average farm size in hectares: 0.45 (West), 0.54 (North), 0.83 (East), 0.5 (South).

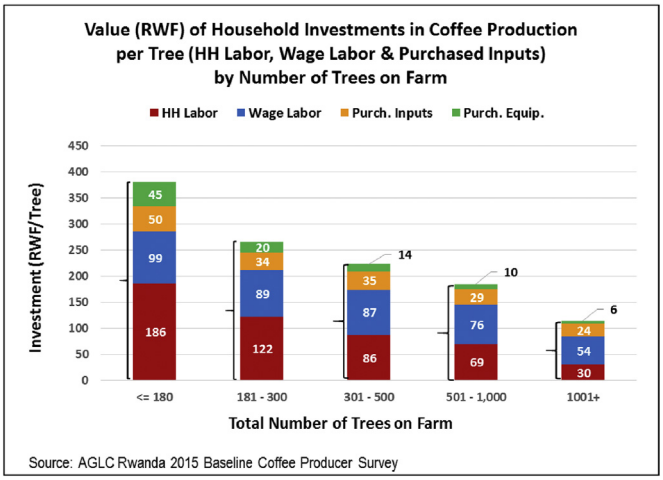

Fig. 3. Smallholder producers invest more per tree than do largeholder producers.

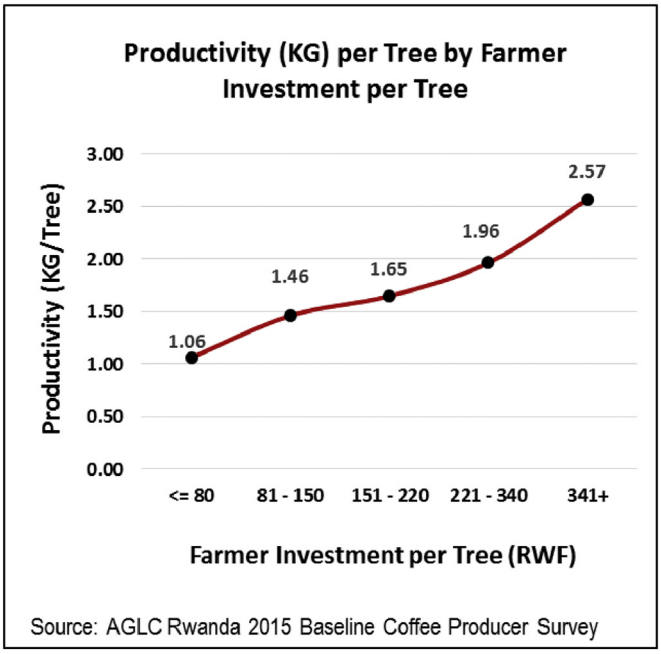

Fig. 4. More farmer investment results in higher productivity per tree.

per tree in 2015. Breaking out this figure proportionally we find that by far the largest investment made by farmers comes in the form of labor at 78.2 per cent of all investments (42.0 per cent as household labor and 36.2 per cent as hired wage labor). This is followed by purchased inputs (fertilizer and pesticides) at 14.8 per cent, and equipment/tools (pruning shears, sacks, etc.) at 8.1 per cent of total farmer investments per coffee tree.

The number of trees in the coffee plantation makes a substantial difference in the amounts that farmers invest per tree. As shown in Fig. 3, farmers with large scale plantations invest markedly less per tree (114 RWF/tree) than those with small plantations (379 RWF/tree), more than a three-fold difference. Part of this difference may be attributed to the economies of scale enjoyed by those with larger plantations. This may be particularly true for capital costs such as equipment, the costs of which can be defrayed across a larger number of coffee trees. But other investments such as household and wage labor for weeding, pruning and harvesting are not likely to see more than modest economies of scale as they are investments that are made tree by tree and are entirely manual tasks with no mechanization or other labor-saving technologies used. Similarly, purchased inputs are thought to bring only small cost savings to larger scale operations, potentially associated with purchasing inputs in larger quantities. However, because few farmers at any scale make such purchases (only 6.0 per cent) and almost all in small quantities (< 100 Kg), we conclude that the advantages of scale in coffee production in Rwanda are minimal.

If not scale, what is it that accounts for the three-fold smallholder to largeholder differential in farmer investments in coffee? And why is it that by far the greatest differential of all is found in the levels of household labor they put into coffee production? The answers to these questions lie in the vast differences among these households in their capacity and incentives to invest, factors examined closely in the sections that follow.

3.2. Do greater investments result in higher productivity?

Overall, productivity in Rwanda is low compared to other coffee producing countries, as discussed earlier. Data from our survey confirm this fact, finding that even among farmers fully or partially engaged in the fully-washed coffee channel, mean productivity measures 1.75 kg/tree and 10.9 Kg/day (of labor).[5] Expanding to include all producers in the country, many not affiliated with coffee washing stations, the estimated productivity is even lower at 1.22 kg/tree (based on data from NAEB National Coffee Census).[6]

To test the question of whether farmer investments (labor, inputs, equipment) result in higher productivity per tree we first ran a simple correlation between the two variables and found, as expected, a positive and highly significant correlation ($r = 0.37$). Viewing that relationship across categories of farmer investment (Fig. 4) we similarly observe a close and ostensibly linear association in which the lowest levels of farmer investment (< 80 RWF/tree) result in the lowest productivity at 1.06 Kg of cherry per tree and, conversely, the highest investments at over 340 RWF/tree produced 2.57 kg/tree. Clearly there is a per-tree payoff to farmers who choose to more closely follow the extension recommendations encouraged by public and private sector agronomists. It is important to note, however, that when observed on a per unit of labor basis (marginal value of labor) the reverse holds true, where greater investment leads to lower productivity per unit of labor ($r = -0.45$). Further analysis shows that farmers who make these higher, recommended levels of investment in their coffee are those with the fewest trees.

Breaking out productivity levels by plantation size (number of productive trees), one finds that farmers with smaller plantations are more productive per tree than are those with larger plantations. This pattern holds even after controlling for many of the factors/covariates known to affect productivity, including: total household non-coffee income, land owned, age of head, education of head, active adults in household and farm elevation (metres above sea level). The analysis of variance (ANOVA) model reported in Fig. 5 (left side) shows that the highest level of productivity, estimated at 2.17 kg/tree, is found among farms with fewer than 180 trees; productivity declines markedly as the size of the plantation grows and hits its lowest point, estimated at 1.08 kg/tree, among those with more than 1000 trees. We note that previous research has found a similar inverse relationship between farm size and productivity in Rwanda (Clay et al., 2002, 2014; Ali and

[5] Coffee yields are typically reported as Kg/tree or Kg/ha. We use Kg/tree in this analysis as it is most common for tree crop yields and because farmers in Rwanda know well how many trees they have, as inputs are distributed to them based on their numbers of trees. By contrast Rwandan farmer estimates of the land area they have in coffee is known to be a less accurate measure.

[6] Estimated from NAEB 2015 Coffee Census figures: 93, 376, 065 Kg cherry/76, 287, 097 productive trees (> 3yrs) = 1.22 kg/tree.

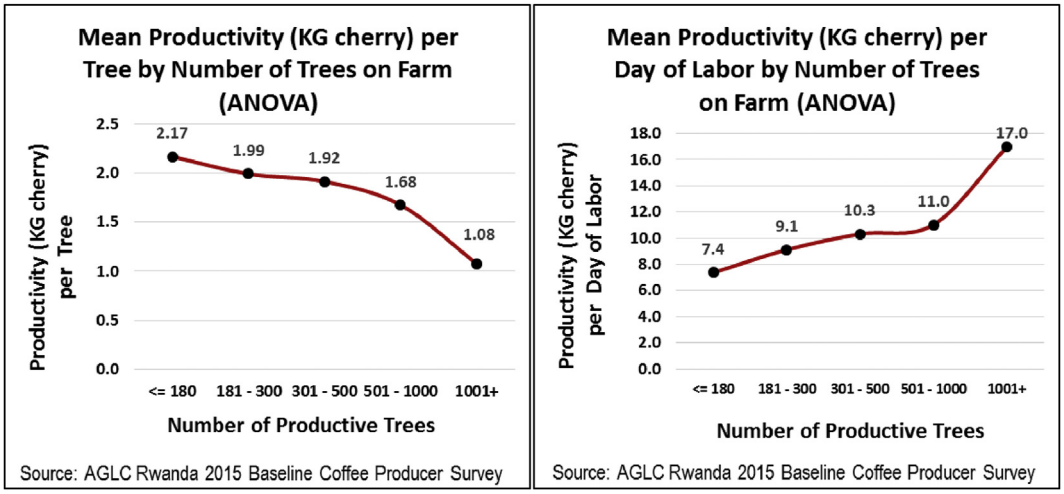

Fig. 5. Comparison of productivity (per tree and per day of labor) by plantation size.

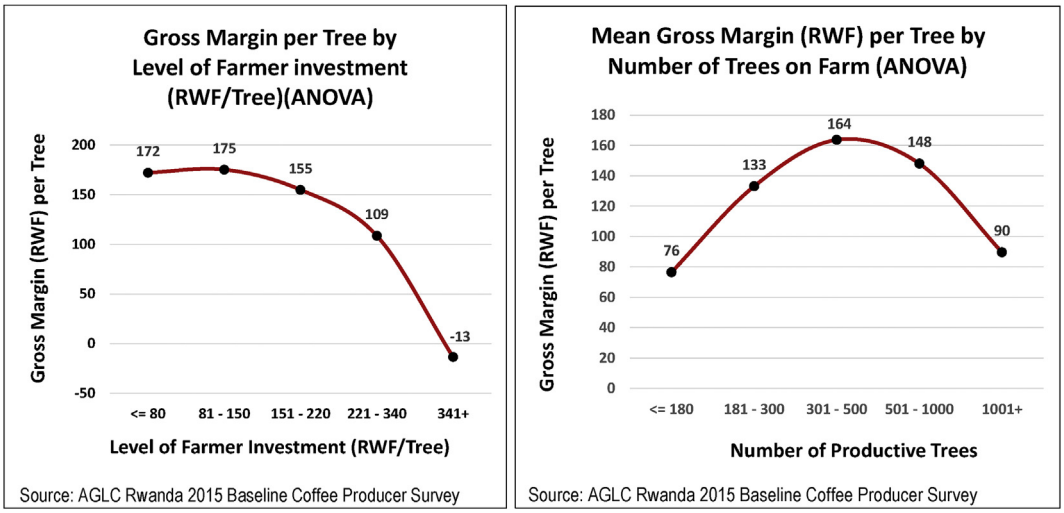

Fig. 6. Gross margins per tree of Rwanda's coffee farmers across levels of farmer investment and plantation size.

Deininger, 2014; Ansoms et al., 2009) and elsewhere in the developing world (Foster and Rosenzweig, 2017; Odhiambo, 1998).

By contrast, we note the reverse effect (Fig. 5, right side) vis-à-vis productivity per day of labor invested in coffee production (including household and wage labor). Smaller farms put far more labor into their production practices but produce only 7.4 kg of cherry per day, compared to a 17.0 kg/day return for the farmers with the largest plantations. Thus, while the smallholders invest more (mostly more labor) and produce substantially more per tree as a result, there is a clear diminishing return to that labor investment. This result mirrors findings in other recent studies of labor and productivity on Rwanda's small farms (Ali and Deininger, 2014). Indeed, the labor productivity registered for smallholder coffee farmers is so low that many of these smallholder coffee farmers in fact make less per day working in their own coffee fields than they can working as day-laborers on their neighbors' farms, which on average pays around 700 RWF per day.

3.3. Do these investments and productivity rates translate into higher returns to farmers?

While there is a clear drop in productivity associated with lower investments and more trees on the farm, it is equally important to examine how returns to farmers (gross margins) vary across these groups. Gross margins, or profits, are measured at the farm level as total revenues from cherry sales, less the cost of production (GM = cherry revenues - cost). On average, farmers in the sample made a profit of 91,699 RWF (median 33,198 RWF) from their coffee sales. That total farm figure translates to 121 RWF (median 87 RWF) per productive tree. Dissecting the range of values in these distributions shows that just over 30 per cent of farms in the study have negative gross margins, meaning that their costs outweighed their revenues. What this shows, in practical terms, is that these households with negative profits provided their own labor (the major production cost) at an effective rate somewhere below the prevailing agricultural wage rate (700 RWF/day) paid in the four coffee-growing districts surveyed.

Breaking out gross margins by levels of farmer investment reveals that the least remunerative farms are those where farmers invest the most (Figure 6, left side), after controlling for factors and covariates in the ANOVA model.[7] This can be seen in the upper quintile of

[7] Factors include gender and level of investment; covariates include number of productive coffee trees, total household non-coffee income, land owned, age of head, education of head, active adults in household, and farm elevation (m).

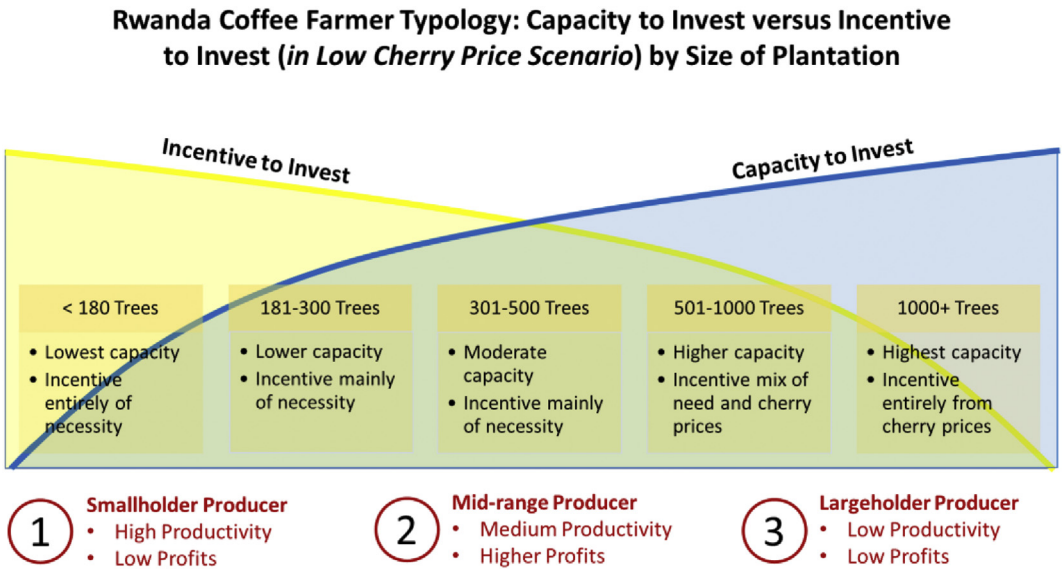

Fig. 7. In a low cherry price scenario, largeholder producers invest at a lower levels because they have other income options and are mainly incentivized by cherry prices; by contrast, smallholder producers do not have other options and thus invest at higher levels out of necessity (to avoid sliding into poverty).

Table 2
Indicators of HH capacity to invest in coffee by number of trees on the farm.
Source: AGLC Radelet, 2010 Baseline Coffee Producer Survey.

Number of Trees	Active adults in HH	Total land owned	Livestock owned (TLU)	Non-coffee ICO, 2017	% Inc from ag labor	Hired labor (FRW)	% HHH member of Coop	N
< = 180	2.6	7477	0.84	208,913	12.7%	12,941	33.0%	194
181–300	2.7	8685	1.00	227,887	8.5%	21,100	54.0%	200
301–500	3.0	11,426	1.09	295,439	4.6%	34,466	51.7%	234
501 - 1000	3.1	12,661	1.32	357,747	2.8%	54,529	62.2%	209
1001 +	3.6	20,141	1.62	516,390	1.1%	102,909	77.0%	187
Total	3.0	11,986	1.17	318,726	5.9%	44,314	55.4%	1024
Sig.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	

Number of trees	**% HHH female**	**% HHH no educ**	**% HHH sec + educ**	**% HHH single (never mar)**	**% HHH widow/ widower**	**% HHH aged < = 30**	**% HHH aged 71 +**	**N**
< = 180	24.2%	31.4%	1.5%	7.2%	21.6%	7.2%	12.9%	194
181–300	24.0%	31.0%	1.5%	2.0%	22.0%	6.5%	11.5%	200
301–500	17.5%	26.5%	2.6%	2.1%	14.1%	6.4%	6.4%	234
501 - 1000	11.0%	28.2%	2.9%	1.9%	10.0%	3.8%	7.7%	209
1001 +	16.0%	25.7%	6.4%	2.1%	12.8%	4.8%	4.3%	187
Total	18.5%	28.5%	2.9%	3.0%	16.0%	5.8%	8.5%	1024
Sig.	0.002	0.619	0.028	0.006	0.002	0.577	0.012	

investments (341 + RWF/tree), the only group with a negative gross margin, at −13 RWF/tree. Despite the fact that these farms are the most productive (per tree) as shown earlier, they are also the least profitable of all. Conversely, those in the low investment categories are the least productive, yet the most profitable.

It is similarly revealing how gross margins vary by number of productive trees on the farm. We find that households with few trees, while far more productive than those with more trees, are indeed the least profitable farms, returning an estimated 76 RWF per tree (Figure 6, right side). Yet those at the other end of the scale, farms with 1000 + trees, are almost as unprofitable at 90 RWF/tree. There is a strong curvilinear relationship between number of trees on the farm and returns per tree. Those in the middle, notably those in the 301–500 range, make the most of all per tree at an estimated 164 RWF per tree, roughly double the profits of households at the two extremes, all else equal.

3.4. Solving the farmer investment, productivity, profits puzzle

What accounts for the ostensibly contradictory patterns of productivity and investment? What causes smallholders to be the most highly invested and productive farms yet the least profitable of all? At the other end of the scale, why are the largest coffee farms so poorly invested and unproductive compared to others? And finally, what are the factors that make farmers in the middle range among the most invested, productive and profitable farmers in the entire country? The answers to these puzzling questions will help us to understand why Rwanda's productivity remains so low and why production has stagnated for so many years.

We maintain that the answer lies in the differences in the capacities and incentives to invest held by farmers at opposite ends of the farm size spectrum. As noted earlier, high performance in agriculture requires that producers have both the capacity and the incentive to invest. Farmers must hold the resources and abilities to invest in their coffee trees and they must also be motivated to do so. One without the other will not have a positive result.

Results from the study enable us to characterize three types of coffee producing households based on their differences in capacities, incentives, productivity and profits. We refer to them as smallholders, largeholders and those in the middle range. Figure 7 helps to visually capture how these producer types compare and perform in their levels of productive capacity on the one hand and their incentives to invest on the other. Below, we describe and discuss the unique characteristics of each.

Smallholder coffee farmers. Starting with the smallholder farmers, those with relatively few coffee trees (mean trees = 106), we find that their capacity to invest in their coffee trees tends to be severely limited. Table 2 presents a profile of producers by number of trees on the farm. The data show that households with few trees have significantly less household labor, less land, and fewer livestock. Their non-coffee incomes are lower and substantially more likely to be based on agricultural labor on the farms of others. They are less likely to hire laborers to help with their coffee. Only a third of farmers with 180 trees or fewer are members of a coffee cooperative, an institution known to be beneficial to farmers in Rwanda as a promoter of good agricultural practices and source of premium payments for quality coffee (Ortega et al., 2016). These findings are consistent with findings from Overfield (1998) in which he studies how smallholder coffee producers in Papua New Guinea allocated their resources when facing low bargaining power. Having more trees on the farm translates into higher cooperative membership; there are costs associated with initial buy-in and annual fees for cooperative members and those with larger plantations are in a better position to meet these costs. Table 2 also shows that households with few trees are also significantly more likely to be female, widowed, with lower levels of formal education, and in the 71 + age group. Household heads with 180 trees or less are disproportionally over 70 years of age or under 30.

While these smallholder coffee farmers have exceptionally low productive capacity and few advantages, they are nonetheless more productive than those with larger coffee plantations. Their higher productivity comes in spite of their low capacity. What they do have is significantly greater motivation to produce—a motivation borne of *necessity*. With little land, few trees, little labor or sources of outside income, these households have to squeeze out every bit of value they can from their meager resources. They invest their own labor because that is all they have to invest. Their coffee production is highly labor intensive and many, as we have found, draw less income working in their own coffee fields than they can working on their neighbors' farms. And this is the reason that their per-tree profits are extremely low. They are caught in a squeeze; unable to uproot trees and start over they simply make the best of what they have. In the words of one Rutsiro farmer: “If you don't work, you don't get anything. You have to get your hands out of your pockets.” We also know that for many of these low-resource farmers, coffee is their main source of cash income. It is a source of income that they cannot do without. As another Rutsiro farmer confided, “We used the coffee money to buy food. It only helped only for 1½ - 2 months this year because the cherry price was so low.” Their main constraint is low capacity, not motivation.

Largeholder coffee farmers. At the other extreme, the largeholder coffee farmers with over 1000 trees, is a group that has an average of 2200 trees and holds all of the advantages that, as just described, the smallholder coffee farmer does not. They are privileged to have more land, more labor, more livestock, and more cash income from non-farm sources (Table 2). They are more highly educated, neither very old nor very young, they are married, and they are far more likely to be cooperative members. In short, they have the highest productive capacity of any farmer group in our sample.

While this group of largeholder coffee farmers has superior capacity, they also have far and away the lowest productivity of all (1.08 kg/tree). What these households lack is the incentive to be more productive. Because they have other options—more land, other sources of income—and often these options are more remunerative than coffee, many choose to disinvest in coffee, either temporarily or permanently. The smallholder is ‘pushed’ (out of necessity) to invest and to produce more; the largeholder, by contrast, must be ‘pulled’ into investment in coffee. There must be an attraction, and that attraction comes mainly in the form of higher and more stable cherry prices.

Largeholder coffee farmers have a strong business orientation and they have the capacity to produce significant quantities of coffee if they choose, but at current, artificially low cherry prices most largeholders take an ‘austerity approach,’ investing only enough to keep their coffee plantations minimally maintained and minimally productive. Most of the labor they use to maintain and harvest their coffee comes as external wage labor. As one farmer commented, they “see the cash go through their hands” at the end of the day and they know they are losing money at current coffee prices. So they hold back on their investments. The same goes for inputs such as fertilizers and manure. They have the cash available but many do not see coffee as a profitable investment with prices held so low. At current prices coffee is a losing proposition. As an example, a Rutsiro coffee farmer with 7500 trees, reduced from 10,000 trees in 2012, says that “with the prices in 2016 remaining the same as last year (around 170 RWF/Kg cherry) I will probably again reduce the number of coffee trees I have.” With the price at 170 RWF he can't cover the cost of labor. He plans to replace the coffee with banana trees. He says he needs at least 250 RWF/Kg cherry to cover the labor cost and make some profit.

Mid-range coffee farmers. Coffee producers in the middle range, those with as few as 181 and as many as 1000 trees, share attributes with both their smallholder and largeholder counterparts. They have greater productive capacity than those at the very low end, with mid-sized land holdings and coffee plantations (Table 2) averaging 557 productive trees on 0.20 ha. They are of mixed ages with moderate levels of household labor and non-farm income. In nearly all ways they are farmers with enough capacity to free themselves from the day-to-day survival mentality and level of poverty seen in the true smallholder group ($\leq$180 trees). But the mid-level producers are by no means resource rich. They must still invest their own land, labor and cash to the fullest degree to maintain a livelihood that keeps them a step ahead of poverty. They do not enjoy the freedoms of the largeholder group ($>$ 1000 trees) to simply shift focus to other crops and areas of their farms or non-farm enterprises. They do not have the option to ignore or even abandon their trees as the largeholder group can when cherry prices drop below a profitable level. What makes producers of the middle range so unique is that they have some productive capacity to invest in coffee (like the largeholder), but they also are highly motivated to maximize their returns from what modest resources they do have (like the smallholder). This combination of capacities and incentives to invest places them above all others in terms of their per-tree profit margins. As depicted above (Figure 6), this group generates a positive cash flow of 133–164 RWF/tree, substantially outperforming those at the upper and lower extremes.

This typology of coffee producers helps us to understand the characteristics, motivations and strategies of three important groups of producers in Rwanda. The reason those with larger plantations have low gross margins per tree is because they optimize their investments in coffee and when prices are low they invest very little—less than a third of what the smallest quintile of farmers invest. They can do this because they have other, more remunerative options. They have higher capacity in terms of education, off-farm income, larger holdings, more livestock, etc. When prices are too low they have the luxury of using that superior capacity in other ways than coffee production. In short, the larger plantation groups can afford to take a low investment approach to their coffee. They do only what is necessary in terms of weeding, mulching and pruning—whatever is optimal for their purposes. Some very large producers indicate that they are satisfied in totally abandoning their trees when prices are low, and that can be the optimal approach in their circumstances.

By contrast, at the low end of the spectrum, smallholder coffee

producers are more productive (per tree) than medium and largeholder farmers, yet their margins are often negative. They lack capacity (land, labor, cash, training) to shift into other crops or activities but at the same time they are highly motivated to extract as much value as they can from their small plantations simply out of economic necessity. For them it is a food security issue. Maximizing their returns, even at diminishing rates, is the only option to keep these households from sliding into poverty. Their main investment is their own household labor. Despite higher productivity, their high labor investment makes coffee unprofitable for most.

Though farmers of different sizes and types each apply their own strategies for success, and some have better results than others in terms of productivity and gross margins, this is not to say that they are all of equal weight or importance to the future of Rwanda's coffee sector. Certainly all households are worthy of attention and support from other stakeholders in the value chain; a sustainable approach must also be an equitable approach. Yet, not all groups have an equal impact on the success of the sector. The fact is that the largeholder producers have a disproportionate effect on sector performance simply by virtue of the number of coffee trees they farm. While farms of 1000 + trees account for just 18.4 per cent of all coffee farmers in our sample, they farm 56.4 per cent of all the trees. By contrast, the smallholders comprise an equivalent share of coffee households (18.9 per cent) yet they farm only 2.8 per cent of the trees—a 20-fold difference. The sheer number of trees farmed by the largeholder group assures that the direction of the coffee sector will, in large measure, be determined by the management decisions they make.

3.5. Incentivizing farmers to invest in their coffee plantations

The challenge of raising farmer investment in coffee production is not new in Rwanda (Mujawamariya et al., 2013; Clay et al., 2002). For many years the vicious cycle of low incentives, low investment and low production has brought decades of sub-par producer prices and stagnant coffee exports. So when asked why they do not invest more in their coffee trees, it is not surprising to learn that the majority of farmers cite low cherry prices (71 per cent) and unstable cherry prices (46 per cent) as the main barriers to their investment. Many also point to a lack of inputs distribution (35 per cent) and high cost of inputs (19 per cent) as barriers, reinforcing the finding that farmers have grown accustomed to receiving subsidized fertilizer and pesticide distributions (though in insufficient amounts) and rarely consider outright cash expenditures for inputs.

It is also instructive to find that the high labor requirements in coffee production are identified by 28 per cent of coffee farmers as an obstacle to their investment in coffee. Not only is coffee a labor-intensive crop, when following best agricultural practices for pruning, mulching, weeding, etc., but we know that over a third of all coffee producers (35.6 per cent) hire most of the labor they put into these tasks. This is particularly true of those with larger plantations, for whom household labor is rarely sufficient to meet their needs even at low investment levels. Interviews and focus group discussions with some largeholder coffee producers drew explicit comments about the high cost of labor (especially since 2012 when they say higher wage rates were imposed) and their preference for minimizing cash expenditures until higher cherry prices warrant the greater outlays for labor.

In spite of these barriers, 99 per cent of surveyed farmers reported that coffee is advantageous to them because it is a source of cash. While many crops, even traditional subsistence crops such as sweet potatoes, are also an important source of cash, few can provide cash in larger sums the way coffee does. It is, after all, the country's top cash crop and by and large is not consumed domestically. When asked about how they spend their coffee revenues, farmers often identify larger single costs such as health services, school fees or livestock. But this pattern of expenditures is by no means universal, especially when broken out by overall income levels. Low income households, for example, often use their coffee revenues for basic expenses such as food and clothing, reinforcing our earlier observations about investment incentives for smallholders being about meeting the household's most basic necessities. Wealthier producers, by contrast, tend to use their coffee revenues on larger, one-time items such as school fees, other assets and to a lesser degree on small business investments and savings.

Returning to the reported advantages to coffee production, only 16 per cent of producers claim to grow coffee because they find it profitable. This response, together with the finding that low and unstable prices are seen as a deterrent to farmer investment in coffee, are further explored through a set of contingent valuation questions in which producers were asked whether cherry prices were high enough for them to invest more of their cash, labor and land in coffee, and if not, at what price they would make these investments. The results from these conditional questions are reported in Table 3.

Two important conclusions can be underscored. The first is that only one in six farmers agrees that cherry prices (200 RWF/Kg in 2015) are high enough for them to allocate more cash for inputs, labor or land to the production of coffee. The second important finding is that there is considerable consensus that the level at which they would again be interested in investing their resources in coffee production, versus other crops or opportunities, is 300 RWF per Kg of cherry. This is the median price at which farmers indicate coffee would be an attractive investment for them. Some farmers indicated even higher cherry prices and thus the mean value ranges from 345 to 373 RWF.

At the current 2016 cherry floor price of 150 RWF, it seems almost

Table 3
Household opinions on cherry prices and their motivation to invest more cash, labor and land in their coffee plantations.
Source: AGLC Radelet, 2010 Baseline Coffee Producer Survey.

Investment type	Yes/No	Are cherry prices high enough to invest more … ?		If no, how high would cherry prices have to go (FRW) to invest more … ?	
		N	%	Mean RWF	Median RWF
Prices are high enough to purchase more inputs?	No	839	81.9→	345	300
	Yes	185	18.1		
	Total	1024	100.0		
Prices are high enough to allocate more labor to coffee?	No	864	84.4→	349	300
	Yes	160	15.6		
	Total	1024	100.0		
Price high enough to allocate more land to coffee?	No	884	86.3→	373	300
	Yes	140	13.7		
	Total	1024	100.0		

Table 4
ANOVA: Estimated productivity (KG/Tree) by premium received, adjusted for gender and covariates[a].
Source: AGLC Radelet, 2010 Baseline Coffee Producer Survey.

Productivity measure	Premium Received	N	Predicted Mean Productivity (KG/Tree)			Sig.
			Unadjusted	Adjusted for Factors (Gender of HHH)	Adjusted for Factors and Covariates*	
Productivity (KG cherry) per tree	No	722	1.64	1.63	1.63	0.000
	Yes	269	2.09	2.10	2.11	

[a] Covariates: Nbr of trees on farm, Total HH non-coffee income, Total land owned, Age of HHH, Educ. of HHH, Active adults in HH, Elevation.

certain that stakeholder aspirations for breaking the cycle of low productivity and stagnant revenues will again not be realized. The incentives are simply not there for the vast majority of the country's coffee producers, particularly among the largeholder producers for whom the cherry price is the primary incentive to invest in coffee. At the same time, recent research has shown that profit margins of coffee processors and exporters typically run in the range of 30 percent or more, depending on the quality of coffee, with higher quality coffee generating even higher gross margins (Church, 2018).

3.6. Premium payments: an added incentive for higher coffee production

Another piece of the incentive puzzle is the payment of premiums, an additional amount that often comes as a 'second payment' at the end of the season after coffee is cupped and sold. The premiums are paid mainly by the coffee buyers, often as a reward for higher quality in the coffee produced. Normally premiums are distributed through the CWS or farmer cooperative and their amounts are proportional to the volume of cherry individual farmers deliver to the washing station. In 2015 only 29 per cent of sampled coffee farmers received premiums for their coffee and of these, two-thirds were members of a coffee producer cooperative; one-third were nonmembers. Not surprisingly, one of the most important advantages of cooperative membership as cited by farmers (48 per cent) is the fact that they often provide premiums to members. The premiums are believed to be an important incentive for improving coffee quality and for strengthening farmer allegiance to the cooperative or CWS.

Premiums also provide a measurable incentive for farmers to improve productivity. Table 4 presents the results of an analysis of variance model that assesses the impact of premiums on farmer productivity (Kg/tree), controlling for gender and a set of covariates known to influence or otherwise distort the effects of premium distributions, as noted. We find that farms that received premiums have an estimated productivity of 2.07 kg/tree compared to 1.64 kg/tree for those not receiving a bonus. This translates into a 26 per cent improvement in productivity as a consequence of the premium payment.

This finding is especially germane to our understanding of farmer incentives. It demonstrates how sensitive farmers are to relatively small changes in remuneration. The average premium received by farmers in 2015 was 16.4 RWF/Kg. This amounts to a modest 8.3 per cent bonus payment to the 200 RWF median price they received over the course of the harvest season. Yet the impact this payment has on their productivity, a 26 per cent bump, is significant. This finding is fully consistent with the 'poor but efficient' hypothesis (Schultz, 1964), which holds that farmers respond positively to price incentives by efficiently allocating their resources to improve production.

What makes the premiums especially effective as a motivator is that they are not just a one-off payment. They are often paid with some regularity, normally at year's end. When farmers know ahead that their performance will be rewarded with a premium, they do what they can to avail themselves of that advantage. We posit that the stability or recurrence of such bonus payments is critical to their impact.

4. Conclusions

This research addresses a glaring problem that has plagued Rwanda's coffee value chain for two decades: how governance structures that exclude producers can result in policy that disincentives coffee farmers, leading to a downward cycle of declining farmer investment, low productivity and low profitability. We find that as Rwanda's coffee value chain has evolved toward high value, high quality specialty markets, governance structures in the coffee sector have not changed accordingly. As observed in Coe's macro-level analysis of coffee producing countries throughout the world, farmer participation in the regulatory authorities is essential for the realization of positive producer outcomes. The Rwanda case presented in this study provides a worthy test of this hypothesis and reports findings that are decidedly consistent with it. The diminished voice and position of producers in annual farm gate price negotiations and other policy decisions has resulted in chronically low prices and little incentive for farmers, particularly largeholders, to produce more or better quality coffee. Declining production has ensued. Based on in-depth key informant interviews, focus group discussions, and producer survey results we conclude that the coffee sector policy process in Rwanda is flawed. It is flawed both in the formula used for setting prices, one that undervalues the true cost of production to farmers, and in the process itself, one that diminishes the voice of the producer groups in favor of the those higher up the value chain who gain measurable advantage thanks to their greater political capital, business acumen, negotiating skills, and language proficiency. Their influence over the process has been directly observed and reported by informants at all levels of the value chain. They are seen as the force that drives farm gate floor prices to unsustainably low levels and the recent zoning policy that has restricted competition (and potential higher farm gate prices) in certain regions of the country. Farmers have reported dissatisfaction with their plight and strongly believe that processors, most notably the coffee washing station owners, are the primary beneficiaries of those high level policy decisions (Gerard et al., 2017).

Another noteworthy contribution of this research lies in its analysis of how different farm household capacities and incentive structures influence farmer investment strategies. Data presented in this analysis provide a unique perspective on how smaller, low resource producers differ from their higher capacity largeholder counterparts in their incentives to invest in their coffee plantations. We find that smallholders lack capacity but are highly motivated to extract as much value as they can from their small plantations simply out of economic necessity. They live on the edge and the prospects of going hungry and sliding into poverty are very real. Their core investment is their own household labor. Despite higher productivity, diminishing returns to their high labor investment makes coffee unprofitable for most. Largeholder coffee producers, by contrast, have the lowest productivity of all farmer groups. They have high capacity but do not use that capacity for coffee production. They are responsive mainly to coffee cherry prices and when prices are low, they have been found to effectively abandon their coffee plantations or even uproot trees in favor of other crops and activities. As the vast majority of coffee trees are located on largeholder farms, a continuing regime of artificially suppressed cherry prices in Rwanda has led to an overall decline and stagnation of coffee production over the past two decades.

This research makes an important observation about farmer behavior that should transcend the coffee sector and the case of Rwanda. We posit that when producer prices are held artificially low, such differences in the incentives of smallholders and largeholders can be observed among coffee and other cash crop producers across Africa and can help to explain why smallholders are often more productive, per hectare or per tree, than are largeholders with far greater productive capacity. Their incentive structures are entirely different, with smallholders being pushed to produce out of necessity (poverty avoidance) and largeholders being pulled to produce only by the lure of higher profit margins, which they only achieve when higher producer prices prevail. Future research is needed to test this hypothesis and should do so in both high and low producer price environments. We hypothesize that where the producer voice is loudest and where producer prices are comparatively high, the incentive structure will favor the commercially oriented and high capacity largeholder.

Drawing upon the findings and analyses presented in this study we have identified a set of policy changes and programmatic interventions that the government of Rwanda and other leaders of the coffee sector should consider to help create needed incentives for producers to invest their labor, cash and eventually more land in their coffee plantations. These investments will, in turn, result in higher productivity and higher incomes all along the value chain—both necessary conditions for the

longer term sustainability of the coffee sector. These recommendations are also relevant to other countries and cash crop value chains other than coffee, such as tea and cocoa, which are often highly structured and with producer prices that are governed by commodity boards and other regulatory authorities rather than by free market forces.

First, the Rwanda coffee board (NAEB) must accelerate conversations about how cherry floor prices are established, with special attention to how they will give a more prominent voice to coffee producers, particularly larger coffee producers who, even at very low levels of productivity, account for nearly half of Rwanda's coffee production. While greater voice generally implies some level of immediate participation in the policy process, we note that beyond the direct participation of coffee producers in the policy arena, effective policy will also depend on a broader recognition among all stakeholders that coffee producers have been unfairly marginalized for the past two decades and must be accepted as a valued resource and a vital force for sustainable growth in the coffee sector. This recommendation can be further generalized to other countries and value chains and is bolstered by international research which finds that including producers in the coffee regulatory authority (e.g., in coffee floor price negotiations and related policy decisions) is critical to helping producers to secure a fair share of coffee sector revenues (Coe, 2006). Coe puts this conclusion bluntly: "Although the mission statements of such coffee authorities frequently articulate goals such as to 'maximize financial returns to all coffee producers,' one can hardly expect an exporter-dominated authority, for example, to adhere to such ideals at their own expense." This is precisely the challenge facing all coffee stakeholders in Rwanda, as well as Burundi, Uganda and other countries where farm gate prices are set by government authorities.

In addition to moving toward a more inclusive process, regulatory agencies must incorporate the real cost of production (CoP) into the formula used to guide floor price negotiations. In the case of Rwanda, our research estimates farmer CoP at 177 RWF/Kg of cherry. The longstanding CoP figure of 80 RWF/Kg cherry adopted by the government of Rwanda is badly antiquated and based on hypothetical costs to a farmer with 2500 trees rather than the actual median of 400 trees in Rwanda. The coffee board should also consider conducting a recurring survey, possibly on a 3-year cycle, to ensure that accurate cost of production figures will be available and used in establishing floor prices for the sector. This applied research program will also enable the government to track and inform policy on how CoP changes over time and whether producers are becoming more efficient in their use of resources, adopting better practices, purchasing more inputs, improving productivity, profiting from coffee, among other relevant research questions.

A third recommendation emanating from this research concerns premium payments to farmers, which are found to have an important positive effect on productivity as those receiving premiums enjoy yields 26 per cent higher, all else equal, than those who do not. Although premiums have a significant motivational impact, incentivizing farmers to produce more coffee, currently only 1 in 4 coffee producers receives a premium. Premiums paid by buyers will likely lead to higher quality cherry from farmers, but the principal challenge lies in how to jumpstart the virtuous circle of high quality coffee cherry, generating higher prices from green coffee buyers, which in turn enable more premiums to be paid to farmers. There are numerous policy options that warrant consideration for how to initiate and incentivize delivery of high quality, mature, ripe cherry. Involving farmer groups in formulating policy on premium payments is a good governance practice that should be adopted as a common sense first step.

These observations extend well beyond the case of Rwanda and apply to other countries and value chains that require close coordination among stakeholder groups at different stages of production and processing. Good governance through inclusiveness, transparency and attention to equitable outcomes is a necessary condition for success, particularly where regulatory structures such as setting farm gate prices and geographic zoning for traceability overshadow market forces in incentivizing needed investment for improved sector performance.

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