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Abstract

Why did *some* African smallholders adopt cash crops on a considerable scale, while *most others* were hesitant to do so? This study sets out to explore the importance of factor endowments in shaping the degrees to which cash crops were adopted in colonial tropical Africa. We conduct an in-depth case study of the 'cotton revolution' in colonial Uganda to put the factor endowments perspective to the test. Our empirical findings, based on an annual panel data analysis at the district-level from 1925 till 1960, underscore the importance of Uganda's *equatorial bimodal rainfall distribution* as an enabling factor for Uganda's 'cotton revolution'. We also provide evidence at a unique micro-level, by capitalizing on detailed household surveys from the same period. We demonstrate that previous explanations associating variegated responses of African farmers to cash crops either to the role of colonial coercion, or to a distinction between 'forest/banana' and 'savannah/grain' zones cannot explain the widespread adoption of cotton in Uganda. We argue, instead, that the key to the cotton revolution were Uganda's two rainy seasons, which enabled farmers to grow cotton while simultaneously pursuing food security. Our study highlights the importance of food security and labour seasonality as important determinants of agricultural commercialization in colonial tropical Africa

JEL classification: N17, N57, Q17, C23, N97

Keywords: Agricultural Commercialization, Resource Endowments, African Economic History, Rainfall distribution, Cotton

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I. Introduction

Commercialization of smallholder agriculture has long been an important stepping stone for rural households in developing countries towards greater market participation and income enhancement, and remains so today.[1] The adoption and expansion of cash crops for export was also a key determinant of economic development and agrarian change in tropical Africa during the colonial era, (c. 1880-1960).[2] Some African farmers voluntarily and proactively initiated new farming strategies to participate in the cultivation of cash crops when improved market access (e.g. railroads) enabled them to do so. In particular, farmers in the West African forest and to a lesser extent elsewhere, proactively exploited a combination of market access and favourable ecological conditions to expand and benefit from the production of cocoa, coffee and palm oil.[3] However, in many other cases, African smallholders vehemently opposed cash crops,[4] or suffered from precariousness and food insecurity as a result of forced adoption of inedible crops such as tobacco or cotton.[5]

Why did *some* African smallholders adopt cash crops on a considerable scale, while *most others* were hesitant to do so? In an influential paper, John Tosh (1980) has argued that these different responses can be traced to a considerable extent by the distinction between 'forest' and 'savanna' areas, in which farmers *faced different resource endowments*. Forest areas have fertile soils and well-distributed rainfall patterns, and are suitable for crops that yield high caloric and financial returns, such as yam, banana, coffee and cocoa. However, such conditions, Tosh pointed out, are the 'exception' to the 'rule' of African 'savanna' conditions, which were characterized by brief and erratic rainy seasons, and relied on labour intensive grain cultivation.[6] In the savanna areas, labour was abundant during the dry season, but was fully utilized during the brief agricultural season in securing sufficient food. Consequently, insufficient resources remained available to simultaneously branch out into cash crop production.

Tosh did not advocate *monocausality*, and acknowledges upfront that the limiting nature of labour seasonality is conditional upon the absence of mitigating factors, such as reliable markets

[1] Anderman et al. 'Synergies and tradeoffs between cash crop production and food security; Collier and Dercon 'African agriculture in 50 years'; Maxwell and Fernando 'Cash crops in developing countries'; Pingali and Rosegrant 'Agricultural commercialization and diversification'; Von Braun and Kennedy *Agricultural commercialization, economic development, and nutrition*

[2] Austen *African economic history*; Austin 'Explaining and evaluating the cash crop revolution'; Frankema, Williamson and Woltjer 'An economic rationale for the African scramble'; Tosh 'The cash crop revolution in tropical Africa; Papaioannou and De Haas 'Weather shocks and agricultural commercialization in colonial tropical Africa'

[3] Austin *Labour, land and capital in Ghana*; Austin 'Vent for surplus or productivity breakthrough?'; Berry *Cocoa, custom and socio-economic change*; Hill *The migrant cocoa-farmers*; Hopkins *An economic history of West Africa* Richards et al. *Subsistence to commercial farming*

[4] Isaacman, *'Cotton is the mother of poverty'*; Isaacman and Roberts *Cotton, colonialism and social history*; Likaka *Rural society and cotton in colonial Zaire*; Maat and Hazareesingh *Local subversions of colonial cultures*; Roberts *Two worlds of cotton*

[5] Bryceson *Food insecurity and the social division of labour*; Mandala *Work and control in a peasant economy*; Vaughan 'Food production and family labour'; Watts *Silent violence*

[6] Tosh 'Cash-crop revolution'; Tosh 'Lango agriculture during the early colonial period; Austin 'Resources, techniques and strategies south of the Sahara'; Papaioannou and Frankema 'Rainfall patterns and human settlement in tropical Africa and Asia

for credit and food (enabling households to smooth consumption), and access to capital-intensive farming technologies (increasing food yields and enhancing labour productivity).[7] Yet Tosh made a simple but powerful point that in Africa's labour scarce savanna conditions, the adoption of cash crops was a tricky balancing act that could be detrimental to food security.[8]

While Tosh's explanation for the 'cash crop revolution' is widely cited and reproduced, few scholars have ventured to explicitly confront, evaluate and test the impact of its key components, -- *seasonal labour scarcity* and *food security* – on African agricultural commercialization.[9] In this paper, we put Tosh's argument to the test, by zooming in on a case study of the 'cotton revolution' in colonial Uganda. We proceed as follows. In Section II, we point out that the adoption of cotton among Uganda's smallholders was substantial, and exceptional in a comparative perspective. We refute two common explanations in the literature, namely (i) that the success of cotton in Uganda should be attributed to the benign characteristics of the perennial banana, and (ii) that cotton adoption was the outcome of particularly effective colonial coercion. Instead, we point out that previous literature has overlooked the environmental uniqueness of Uganda, namely its equatorial *bimodal rainfall patterns*, which enabled farmers to combine food crop and cash crop cultivation. In Section III, we provide an in-depth discussion on the link between rainfall patterns, food security and cotton. In Section IV, we proceed to test some of these links econometrically, using a newly constructed panel dataset of annual cotton acreages for 10 districts in Uganda over a 36 year period (1925-60). In Section V, we move even closer to the farm, presenting micro-data from 563 individual households, surveyed during the latter half of the colonial era in 7 villages in southern Uganda. We exploit variation between households in these villages to investigate the complementarity between cash crops and food crops. Section VI concludes.

Our key findings are as follows. Firstly, we establish that *bimodal rainfall distribution* was a crucial factor in the process of cotton adoption among Uganda's banana *and* grain farmers. Farmers were able to smooth labour demands over two separate growing seasons, cultivate food crops during the first and most reliable rainy season while relegating cotton to the second rainy season. Furthermore they were able to annually calibrate the allocation of resources to cotton depending on the success of the preceding food crop harvest. Food security remained at the heart of farming strategies. Secondly, our micro-level analysis reveals complementarity between food crops and cash crops on the household level. When we zoom in on specific crops, we find that cash crops were positively correlated with the cultivation of starchy staples, such as bananas, roots and tubers. These crops are relatively undemanding and more weather-resistant, thus serving well as 'famine reserve crops'. Such complementarity between food crops and cash crops on the household level is consistent with a 'food-security-first' strategy.

Overall, we conclude that the strongest explanation for Uganda's exceptional cotton revolution was its equatorial bimodal rainfall pattern, which provided it with a decisive advantage over

[7] Austin 'Resources, techniques and strategies'; Binswanger & McIntyre 'Behavioral and material determinants of production relations'; De Janvry, Fafchamps & Sadoulet 'Peasant household behavior with missing markets'
[8] Cf. De Janvry, Fafchamps & Sadoulet 'Peasant household behavior' Fafchamps 'Cash crop production, food price volatility, and rural market integration'
[9] The exception is Austin 'Vent for surplus or productivity breakthrough?' for the cocoa revolution in early colonial Ghana.

other areas with a similar institutional setup and level of technology, but only one rainy season. While amending Tosh' distinction between 'forest' and 'savanna' and revising the interpretation of Uganda's 'cotton revolution, we reaffirm the importance of labour seasonality – and resource endowments more broadly – for understanding the uneven participation of farmers in the 'cash crop revolution' of colonial tropical Africa.

II. Making sense of Uganda's cotton revolution

Uganda is a particularly intriguing case of agricultural commercialization in colonial tropical Africa. Firstly, there is the simple fact that *cotton* became Uganda's prime cash crop. Cotton, being a labour intensive, non-edible and poorly remunerating annual crop, is often held to have been a particularly disruptive cash crop.[10] While the European metropoles were keen to see cotton exported from the overseas empire, smallholders did not regard cotton as appealing, since it required substantial labour inputs and yielded low rewards. As a rule, cotton in colonial Africa either entirely failed or was sustained under compulsive regimes. According to Isaacman and Robers, "cotton was not only the premier colonial crop in colonial Africa, it was the premier forced crop."[11] Africans resisted colonial cotton schemes "by planting in poor soils, by neglecting tasks at crucial points in the cotton cycle, by permitting unwanted hybridization, and by refusing to sell their harvest to the export sector."[12] They were also victimized, and, "the extent to which cotton impoverished rural Africans [is indicated by] the widespread malnutrition and hunger throughout colonial Africa. Cotton and food insecurity went hand in hand."[13]

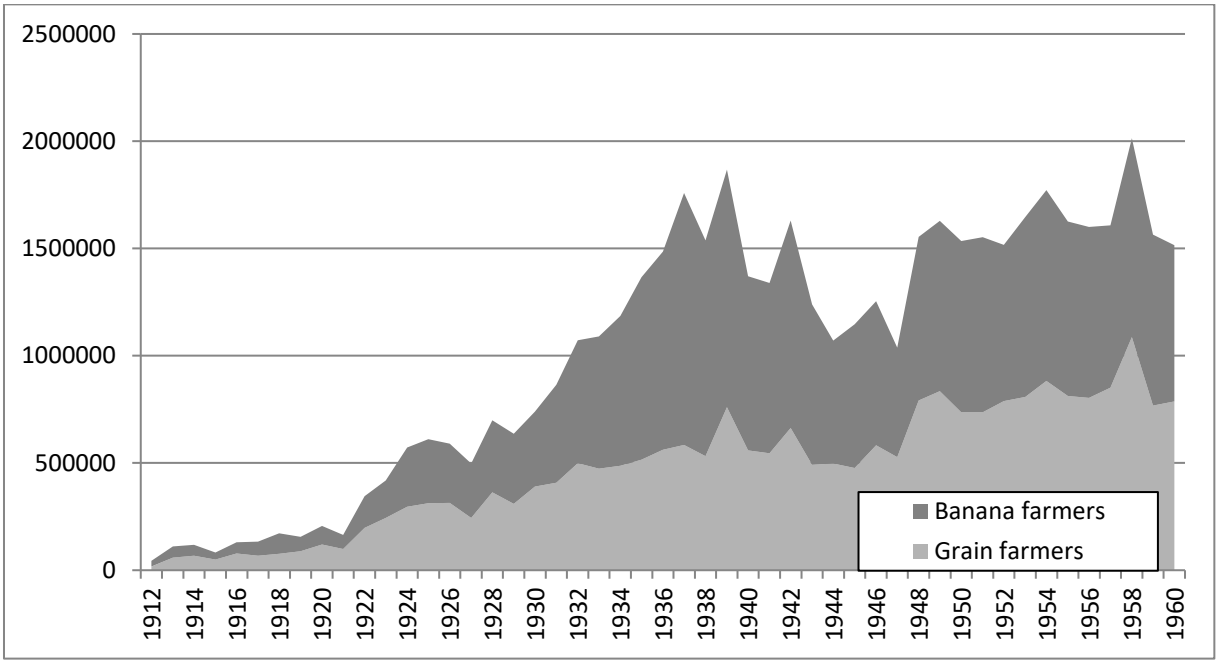
Uganda, clearly, was an exception. Ugandan smallholders adopted cotton on a massive scale, leading to one of the most successful 'cash crop revolutions' in colonial tropical Africa, and ranking Uganda among the top-10 cotton exporters worldwide in per capita terms.[14] Why did Ugandan smallholders invest in the cultivation of cotton relatively more than their counterparts elsewhere in colonial sub-Saharan Africa? Tosh, as well as other scholars grappling with this question from a resource endowment perspective, have conceptualized the Ugandan case as an 'exception that proves the rule', emphasizing its substantially benign ecological conditions in the southern part of the country, and especially its highly productive perennial banana plantations, which could be maintained with relatively undemanding and seasonally well-

[10] Austen, *African economic history*, p. 140; Isaacman 'Peasants and rural social protest'; Isaacman and Roberts *Cotton, colonialism and social history*
[11] Isaacman and Roberts 'Cotton, colonialism and social history', p. 29
[12] Isaacman and Roberts 'Cotton, colonialism and social history', p. 34
[13] Isaacman and Roberts 'Cotton, colonialism and social history', p. 37
[14] Based on four benchmark years. In both 1927-28 and 1938-39, Uganda was the 11th cotton producer worldwide, and had the 4th highest per capita output. In 1951-52, Uganda was still the 11th cotton producer worldwide, and 3rd in per capita terms. In 1960, Uganda was the 18th cotton producer worldwide, and 9th in per capita terms. Despite its great involvement in cotton cultivation, Uganda remained on the margins of the world cotton market, which was dominated by the United States. In 1951-52, for example, the U.S.A. produced 42.6 per cent of all cotton grown worldwide, the U.S.S.R. (the second largest producer) produced 10.7 per cent, and Uganda only 0.9 per cent. 1927-28 based on a map in Porter, p. 45 'Note on cotton and climate'. Data for 1938-39 and 1951-52 from Atkinson 'Cotton: this season and the next', p. 195. Data for 1960 from FAOSTAT Statistics Database.

distributed labour inputs, provided almost exclusively by women.[15] In these conditions, men – similar to their counterparts in the West African forest – were 'underemployed' and could respond quickly and spontaneously to the cash-earning opportunities provided by the construction of the railway in 1901, which connected landlocked Uganda to the world market.[16]

However, there is a key problem with this version of the 'resource endowments' argument. A large share of Uganda's cotton-growing smallholders did not cultivate bananas, but relied on grain-based crop rotations, involving the continuous and laborious cycles of field preparation, sowing, weeding and harvesting which are typical of African savanna conditions.[17] Still, despite the labour intensive characteristics of grain farming, cotton was adopted quickly and on a large scale by farmers in Uganda's savanna.[18] In fact, as can be seen from Figure 1, farmers in the banana and grain regions contributed more or less equally to Uganda's cotton acreage. As indicated by Figure 2, there was also no clear discernible difference in *per capita* involvement of farmers in cotton cultivation between the 'banana' and 'grain' region either. Thus, the benign characteristics of the banana can hardly account for the success of cotton in Uganda.[19]

Figure 1. *Cotton cultivation (acres) in colonial Uganda (1912-1960)*



Sources: Cotton acreages from Uganda *Bluebooks*; Uganda *Report of the Department of Agriculture.*

Figure 2: *Average annual cotton cultivation in Uganda's colonial districts (1925-1960)*

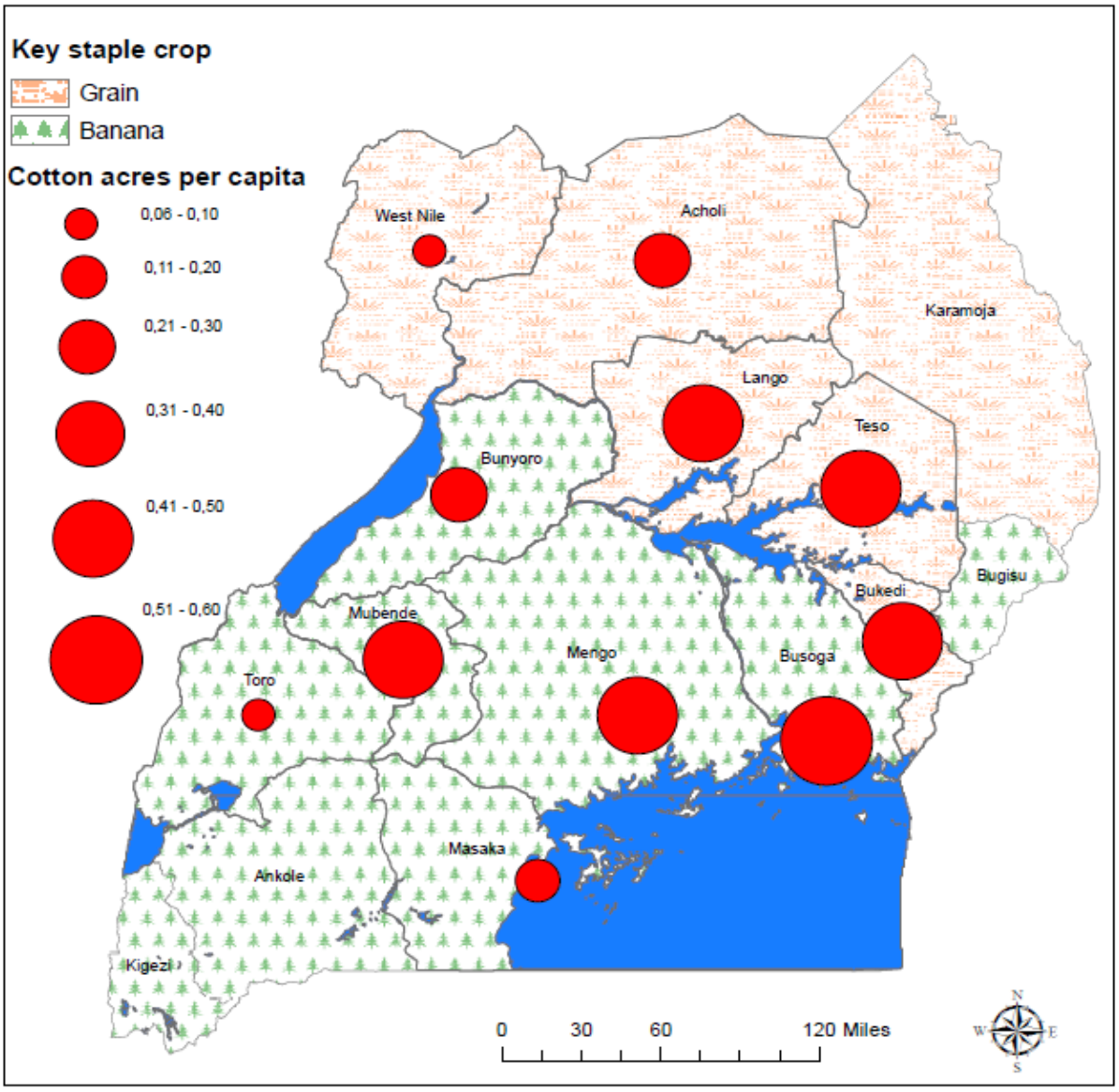
[15] McMaster *A subsistence crop geography*, p. 44; Tosh 'The cash-crop revolution in tropical Africa', p. 92; Austin 'Resources, techniques, and strategies', p. 597 and p. 601; Austin 'Explaining and evaluating the cash crop revolution'; Elliot 'Agriculture and economic development in Africa', p. 136-37

[16] Tosh 'The cash-crop revolution in tropical Africa', p. 92

[17] McMaster *A subsistence crop geography*; Parsons *Systems of agriculture : Introduction and Teso*; Parsons *Systems of agriculture : Northern*, Vail *Agricultural innovation in Teso District*.

[18] Vail *Agricultural innovation in Teso District*

[19] The link between bananas and ecology was already questioned by Wrigley who points out that transition from banana to millet was "more abrupt than was warranted by the natural conditions," suggesting that "the distinction is in part a cultural, that is to say an historical, and not solely an ecological one." Wrigley *Crops and wealth,* p. 6



***Notes*:** Created by the authors using ArcGIS. ***Sources*:** See main text.

Was the cotton revolution in Uganda, perhaps, a case of exceptionally effective colonial coercion? Certainly, colonial coercion played a much more important role in Uganda's early colonial economy than Tosh' rendering of the 'cash crop revolution' – a spontaneous response of previously idle men, acting "without much prompting from the government" – suggests.[20] The initial adoption of cotton in Uganda did not occur in pristine pre-colonial economic conditions in which abundant land and labour lay idle, waiting for a railroad to be built. Instead, the cotton revolution took place after decades of tumultuous colonial intrusion, civil conflict and disease epidemics. Moreover, the introduction of cotton followed upon the introduction of a new landownership system and a colonial head tax, both in 1900. On top of this, men of working age were subjected to a range of new and extended labour obligations, which, by 1908,

[20] Tosh 'Cash-crop revolution', p. 92

added up to 5 or 6 months per year. Expatriate planters had attempted to gain a foothold and pushed for coercion in order to obtain cheap labour, albeit with limited success.[21]

Cotton adoption was an African *response* to colonial policies in two ways. First, it was a way of avoiding some off-farm labour obligations, such as tax labour or forced labour for the colonial government.[22] Men were kept occupied by a significant amount of involuntary labour outside the household,[23] while *women* extended their agricultural work and took up most of the labour inputs in self-employed cotton cultivation.[24] Second, cotton cultivation itself was not without considerable government interference and compulsion either. In 1908, for example, Uganda's governor claimed that the implementation of colonial rules concerning the cultivation of cotton were "of a drastic nature" and could only be successful because "the bare orders of the chiefs were expected to suffice to ensure effective obedience to the rules framed under the ordinance."[25] In 1912, a Ugandan official proudly noted that the government had propagated the cultivation of cotton as " the duty of every good citizen" and boasted that "the increase is almost entirely due to Government influence."[26] Outbreaks of widespread food insecurity in 1908-09 and 1918-19 testifies the disruptive and dramatic nature of economic change in the early colonial period.[27] One historian, directly attributes population decline and repeated food shortages in early colonial Busoga – notably, a *banana* growing area - to its high per capita cultivation of cotton: "although peasants could not eat cotton, [...] cotton could devour peasants."[28]

Still, it would be incorrect to attribute the cotton revolution in colonial Uganda purely or even primarily to coercive policy. The colonial government itself came to realize that the extractive nature of chief-peasant relations under early colonial rule, as well as the extensive labour demands outside the household, worked as a *disincentive* to cotton cultivation, and understood that smallholders would grow *more* cash crops if they were given the freedom and time to do so. In 1922, forced labour for the colonial government was abolished; in 1924, the Government issues a circular 'deprecating the excessive zeal shown by chiefs in fining or imprisoning natives for failing to show sufficient activity in planting;'[29] in 1927, the extractive powers of chiefs were strongly reduced and land tenure arrangements were made more secure; in 1930, labour demands for the native government were made commutable. These measures contributed considerably to the striking acceleration of Uganda's cotton acreage production, as they resulted in greater amounts of male labour being available for cotton cultivation (Figure 1).[30]

[21] Wrigley *Crops and wealth*
[22] Hanson *Landed obligation*, p. 169
[23] Which included cotton cultivation for chiefs and landlords and head loading cotton to ginneries. Ehrlich *The marketing of cotton in Uganda*, p. 91
[24] Hanson, *Landed obligation*, p. 178.
[25] Quoted in Nayenga 'Commercial cotton growing in Busoga District, p. 181
[26] Quoted in Robins *Cotton and race across the Atlantic*, p. 120
[27] Ehrlich 'The economy of Buganda', p. 17
[28] Jorgensen *Uganda: A modern history*, p. 60)
[29] Ehrlich *The marketing of cotton in Uganda*, p. 217
[30] Thus, instead of taking up cash crops immediately – as argued by Tosh – men belatedly became more involved in the cultivation of cash crops. Ester Boserup and others have argued that men turned to cash crops because they sought control over cash income, and because colonial states focused their extension efforts on men. However, some observers in Buganda interpreted the shift towards men quite differently, noting that women themselves

The colonial treasury benefited considerably from this development by ratcheting up the poll tax and by instituting a cotton export tax.[31] Still, several studies from the heydays of Uganda's cotton economy remark on the benefits of the cotton cultivation to growers. Christopher Wrigley (1959), an early economic historian of Uganda, for example notes that, although coercion did not disappear altogether, "from the middle 1920s onwards the cruder sanctions fell into disuse and the activities of the peasants began to reflect, much more straightforwardly than hitherto, their own economic needs and desires."[32] Cyril Ehrlich (1958), another early economic historian of Uganda, similarly emphasizes that

> The first few years of cotton production probably depended primarily on the administration's hold over the chiefs and the chief's power over the people. But there can be little doubt that the eventual success of the crop and the growth of the economy depended essentially on the peasant's desire for cash beyond the immediate demands of taxation.[33]

Ehrlich also points out that "the parts of Uganda which are evidently the richest are those which have felt the impact of cotton," while McMaster (1962) maintains that "the extension of cash crops has brought great and undoubted benefits to Uganda," and Young (1971) describes cotton as the "lumbering oxen that draws Uganda's chariot of development."[34] Recently, De Haas has shown that, from the 1920s onwards, ordinary cotton cultivators were certainly not spectacularly wealthy, but saw their incomes *exceed* subsistence level, and become *better off* than wage labourers, as the colonial taxes took up only a *portion* of their cotton income.[35]

The relatively benign characteristics of Uganda's cash crop economy, in particular from the 1920s onwards, are also exemplified by the large influx of migrants into Buganda from Uganda's non-cash crop growing areas (those furthest removed from transportation facilities), and from the neighbouring territories of Kenya, Tanganyika and, in particular, Ruanda-Urundi. Migrants participated actively in the cash crop economy as sharecroppers, labourers for local farmers, seasonal tenants and permanent tenants.[36] It is notable that food shortages still occurred in Uganda, for example in 1927-28, but that their repercussions were much more limited than earlier episodes of shortage, partly because of several structural measures to improve food security (improved infrastructure, household and communal granaries, cultivation of cassava and sweet potato as famine reserve crops) and partly because of a coordinated government response to lift located food shortages.[37] Cotton continued to be widely grown into the 1960s,

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increasingly *resisted* the expectation of their husbands to grow cotton. No matter how these mechanisms weighed into the shifting gendered distribution for labour, the involvement of men in agricultural effectively increased household labour capacity, thus facilitating the expansion of cash crop cultivation. Boserup *Woman's role in economic development*, p. 19, Hanson *Landed obligation*, p. 178-9

[31] For example, in Teso district, a major cotton growing region, the poll tax rose from 5 shilling in 1919 to 15 shilling in 1921, 21 shilling in 1929 and 28 shilling in 1931. Vail *Agricultural innovation*, p. 146

[32] Wrigley *Crops and wealth in Uganda*, p. 49)

[33] Ehrlich *The marketing of cotton in Uganda*, p.88

[34] Ehrlich *The marketing of cotton in Uganda*, p. 112, McMaster *A subsistence crop geography*, p. 93, Young 'Agricultural policy in Uganda'

[35] Although this portion was high during the 1930s. De Haas 'Measuring rural welfare'

[36] Richards *Economic development and tribal change*

[37] Uganda *Annual report of the department of agriculture* for the years 1927 and 1928. Also, McMaster *A subsistence crop geography*, Vail *Agricultural innovation in Teso District*

after independence, by both banana and grain farmers. In some parts of the banana region, smallholders also began to experiment with more lucrative cash crops, Robusta coffee in particular, which provided higher returns to labour. Towards the end of the colonial era, coffee cultivation was still mostly confined to Buganda, but because of its greater value still had supplanted cotton as Uganda's prime export crop.[38]

When summing up the evidence, we must conclude that neither a distinction between 'banana' and 'grain' areas, nor the presence of particularly effective colonial coercion can explain the exceptional responsiveness of Uganda's smallholders to cotton. The key question, then, remains: how did Ugandan smallholders, unlike their counterparts elsewhere, make cotton work, even after the relaxation of the coercive measures that accompanied its introduction? To solve Uganda's 'cotton puzzle', we suggest a *modified* resource endowments perspective, in which we move away from a distinction between 'savanna and forest' or 'grain and banana', and instead focus on Uganda's *bimodal rainfall pattern*.[39]

III. Did bimodal rainfall enable Ugandan farmers to adopt cotton?

In this section, we outline our basic argument that Ugandan farmers were no different from their counterparts elsewhere in colonial Africa to prioritize food security over cash crop cultivation, but that bimodal rainfall facilitated their exceptional adoption of cotton, for two reasons: (i) they could relegate cotton to the second rainy season to smooth agricultural labour demands, and (ii) they had two opportunities per year to secure their food supply and had the option to reduce the allocation of resources to cotton in the second rainy season in case of a bad food crop harvest in the first rainy season.

Let us begin by providing a basic analysis of the distribution of rainfall across Uganda. For this purpose, we obtained monthly rainfall observations from meteorological stations throughout Uganda, reported annually in the colonial *Blue Books* (until 1945) and subsequently published by the *Meteorological Department*.[40] We choose one meteorological station per district, selecting the station for which most monthly observations are available. The average monthly rainfall for 13 districts are presented in Figure 3 below. Some scholars have argued that generous rainfall as well as its bimodal distribution, are exclusive advantages of the banana regions. However, as Figure 3 clearly shows, rainfall actually tended to be more generous in the grain regions. Although the two rainfall peaks were further apart in the banana region, rainfall was distinctly bimodal throughout Uganda.[41]

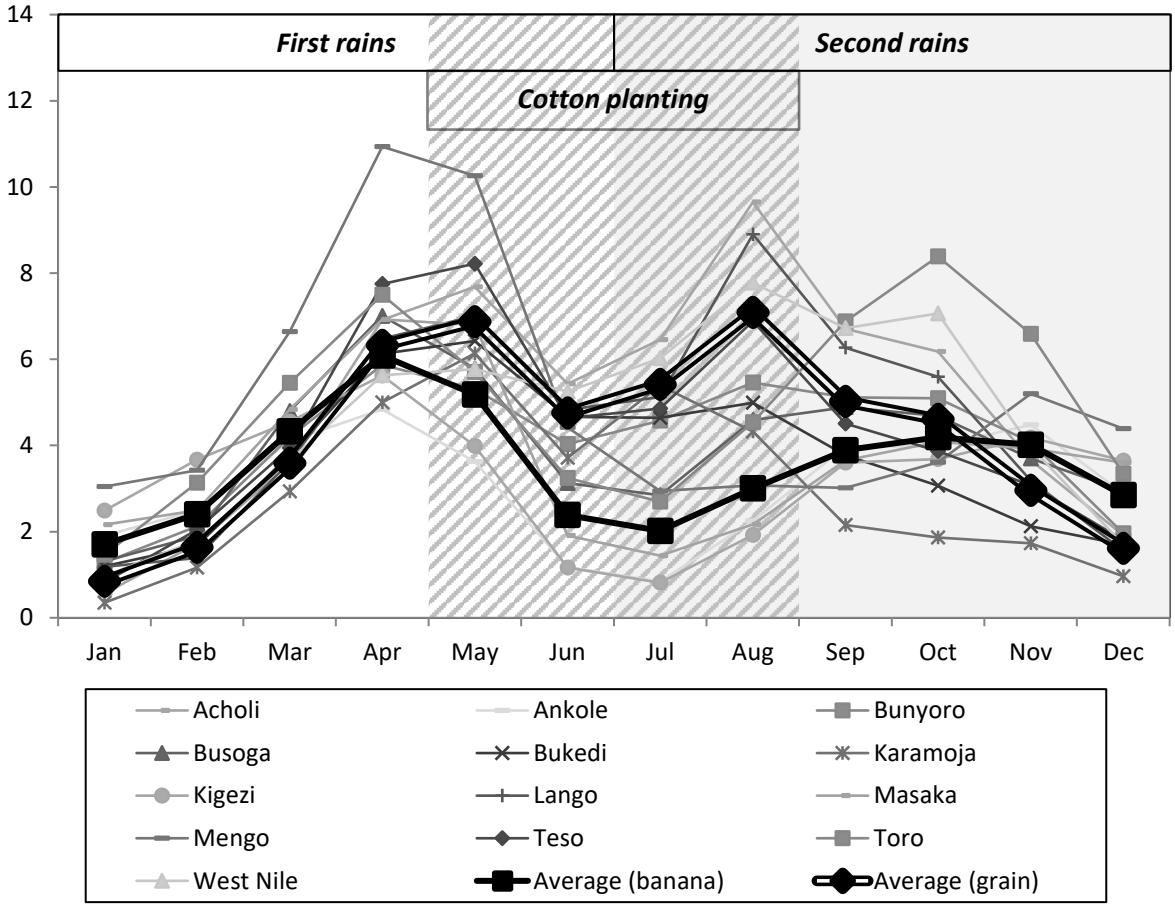
[38] De Haas 'Measuring rural welfare'; Wrigley *Crops and wealth in Uganda*. According to Hogendorn, 'over the years since the First World War, cotton has slowly been overtaken in Uganda by other more profitable cash crops, especially cotton.' This, however, misrepresents the situation outside Buganda (cf. Figure 1 and 2), and even in Buganda coffee overtook cotton after the *Second* World War. Hogendonr 'Economic initiative', p. 315

[39] Including the forest zones of West Africa and much of central Africa

[40] Uganda *Blue Books*, Meteorological Department *Monthly and annual rainfall in Uganda*

[41] Elliot 'Agriculture and economic development in Africa', p. 136-37; Hogendorn 'Economic initiative', p. 312; Isaacman and Roberts 'Cotton, colonialism and social history', p. 23, Reid *A history of modern Uganda*, p. 9

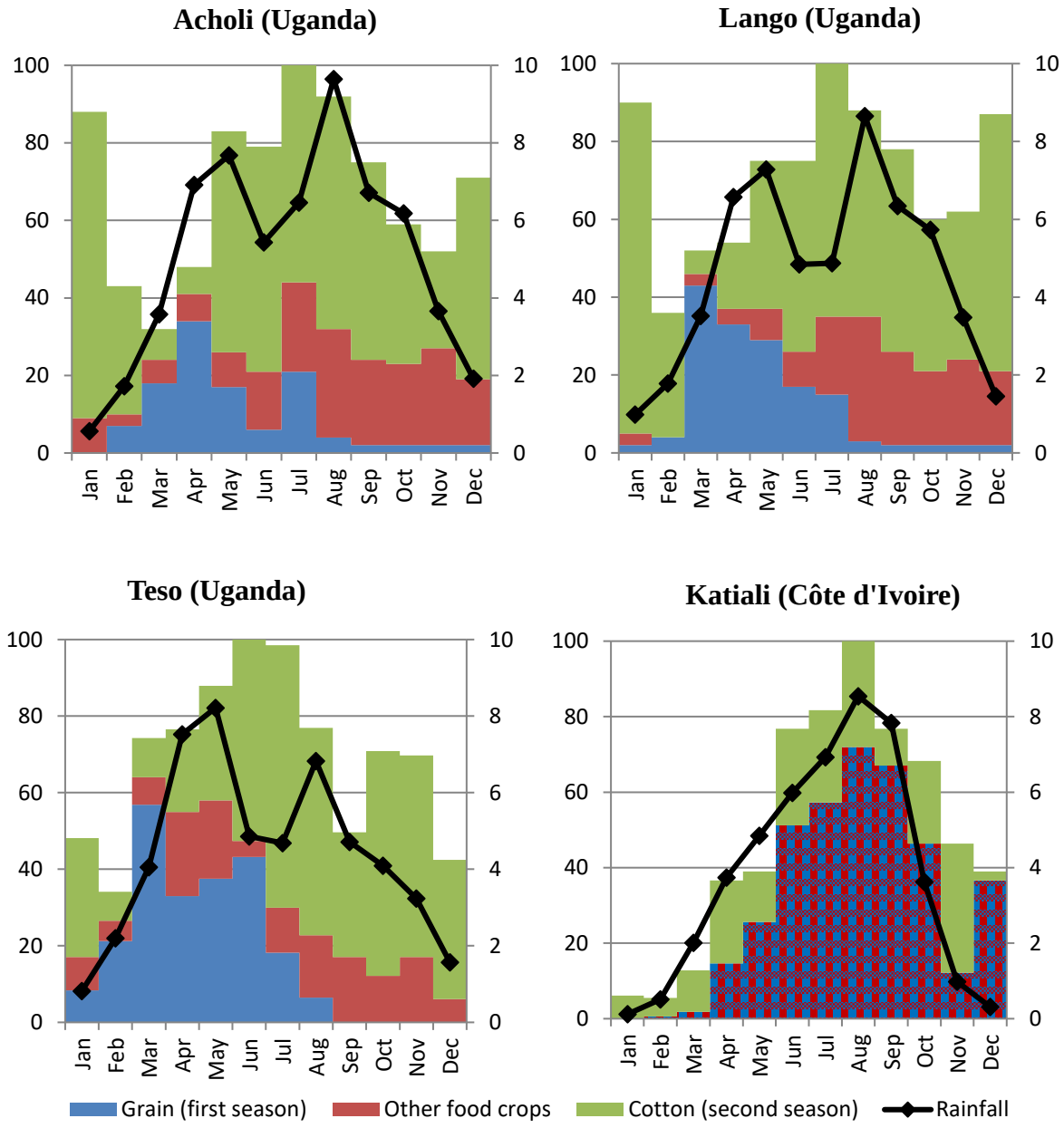
Figure 3. *Average monthly rainfall (inches) in 13 districts of Uganda, 1925-1960*



Sources: See text

Next we assess how bimodal rainfall helped farmers to enhance their *agricultural production capacity*. The relationship between rainfall distribution and labour seasonality is clearly illustrated in Figure 4, which shows the distribution of labour inputs by grain farmers in several cotton growing districts in Uganda and one region in northern Côte d'Ivoire. The unimodal rainfall patterns in Côte d'Ivoire are quite representative for much of the African savanna north and south of the equator. As can be seen, the seasonal distribution of labour in the *unimodal* Ivoirian context is much more skewed. For the Ivorian farmer, cotton and food labour demands both peak at the same time (July), while these same demands were more spread out for the Ugandan farmer, who was able to focus on food crops in the first rainy season, and relegate cotton to the second rainy season.

Figure 4. *Intra-annual distribution of labour inputs (left axis) and rainfall (inches, right axis) of cotton farmers in the savanna. Bimodal (Uganda) versus unimodal (Côte d'Ivoire)*



Notes: Labour inputs include all aspects of cultivation, from preparing the field, sowing, weeding, harvesting and sorting. Monthly labour inputs are expressed as share of the month with the greatest labour input (e.g. July in Lango).

Sources: Acholi and Lango from Cleave *African farmers: labour use*, p. 87, Teso from Vail *Agricultural innovation in Teso District*, p. 104,. Katiali from Bassett *Peasant cotton revolution*, p. 126.

If we assume that the month with the greatest labour input in Figure 4 signifies *the potential maximum household labour capacity*, this would imply that, because of a more favourable seasonal distribution, farmers in the three Ugandan cases were able to use 69 and 71 per cent of their annual labour capacity in agriculture, while farmers in Côte d'Ivoire, could only effectively exploit 49 per cent of their labour capacity to produce crops. This gap of just over

20 percent may well account for the difference between cotton adoption and rejection. Indeed, according to Bassett,

> [Ivorian] colonial officials observed as early as 1912 that it would be difficult to expand cotton cultivation [...] without improving labor productivity. Otherwise, there simply was not enough time in the agricultural calendar if farmers gave priority to food security.[42]

Cotton was not cultivated on a substantial scale in Côte d'Ivoire until the 1960s and after major investments in agricultural technology, inputs and high yielding crop varieties.[43]

Labour demands were thus comparatively smoothly distributed in the Ugandan savanna. Still, the adoption of cotton did require considerable recalibration of the farming calendar. Even when cash crops were relegated to the second rainy season, grain farmers faced some serious labour bottlenecks during the months *between* the two season, when food crops had to be weeded and harvested, and cotton sown – either in newly opened fields, or following the first season food crops.[44] Dealing with this labour bottleneck, farmers again prioritized their food crops, and postponed the planting of cotton, even if late planting meant that cotton yields would be lower. One agricultural economist, for example, noted that for grain farmers (in Uganda's Lango district),

> the complementarity [between millet and cotton] appears to have been achieved through considerable reorganization by the farmers to avoid conflicts in labor use. These adjustments include a spread in the planting season for cotton and delay in planting after the optimum date for high yields.[45]

In one particular area (Teso district), farmers also used ox-ploughs to ease the labour requirements of land preparation for cotton during the labour constrained months (May to July), thus enabling the development of a more labour extensive farming strategy.[46] Even though ploughs had been unknown in the region before the arrival of cotton, they were universally adopted within a timeframe of merely twenty year.[47] The reconfiguration of farming patterns, and the adoption of the plough suggest that farmers were willing and able to adopt a new cash crop, but not at the cost of their food security and that they continued to prioritize the latter over extension of their cash crop income, a risk aversive (and probably prudent) strategy in a context of thin markets and unpredictable climate.[48]

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[42] Bassett *Peasant cotton revolution*, p. 126

[43] Bassett *Peasant cotton revolution*, pp. 107-45, Lele et al. *Cotton in Africa*. The data used for Figure 4 dates from *after* this intensification of farming practices and the cotton take-off We revisit the comparison between the Ugandan and West African savanna in the conclusion.

[44] Tothill *Agriculture in Uganda*, p. 43

[45] Cleave *African farmers: labour use*, p. 87-88. Also Tosh 'Lango agriculture during the early colonial period'.

[46] Vail *Agricultural innovation*. Even though yield figures need to be approached with considerable caution, it is interesting to note that yields in Teso district were the lowest in Uganda ((260 lbs/acre, compared to 370 lbs/acre in the nieghbouring Lango district, and 600 lbs/acre in Mengo district). Low yields suggest that farmers used to plough to *extensify* farming practices and save labour during the critical period between the two rainy seasons. Yield estimates from Uganda *Annual Report of the Department of Agricuture*, 1938, p. 8).

[47] Vail *Agricultural innovation in Teso District*

[48] Janvry, Fafchamps, Sadoulet 'Peasant household behavior'; Fafchamps 'Vulnerability, risk management, and agricultural development'

Secondly, let us look at how bimodal rainfall helped farmers to mitigate the *consequences of harvest failure* and resultant food insecurity. Before the adoption of cotton, farmers across Uganda devoted both rainy seasons to the cultivation of food crops. Cultivation practices were calibrated in such a way that even in years of disappointing harvests sufficient amounts of food were harvested. In good years, this 'natural' surplus of grains or bananas was converted into beer. Sometimes, a 'planned' surplus of food crops was produced and traded for manufactured goods, such as iron hoes, or to pay tax and tribute.[49] In order to adopt a non-edible cash crop, farmers had to forego (part) of their food surpluses. As Tosh has argued for the *Langi*, Ugandan grain farmers, in particular, were hesitant to do so, unless they were sufficiently reassured that serious harvest failures and resultant food shortages could be replenished from communal granaries and food relief provided by the colonial state.[50]

Even after the adoption of cotton, food self-sufficiency continued to be a key priority among Uganda's cotton farmers. As noted before, food security informed smallholders' reluctance to cultivate cotton in the most pronounced and predictable first rainy season and their choice, to the frustration of colonial administrators, to relegate it to the second rainy season instead.[51] Smallholders also dynamically calibrated their commitment to cotton to fluctuating weather conditions and food crop yields. Evidence from the *Annual Reports of the Department of Agriculture* suggests that when farmers faced a disappointing harvest in the first rainy season, they prioritized compensation of the food shortages incurred over cotton planting. They employed several strategies. If weather conditions during the first growing season were unfavourable, farmers prioritized late planting or re-sowing of food crops over timely cotton planting.[52] Sometimes the subsequent late cotton endangered timely planting of food crops the next spring season, in which case farmers uprooted and thus sacrificed cotton to maintain the optimal food crop cycle.[53] Farmers also compensated for their losses by cultivating more food crops during the second growing season, which adversely affected the cotton acreage.[54]

[49] Cohen 'Food production and food exchange'; Hanson *Landed obligation*; Tosh 'Lango agriculture'; Tosh 'The northern interlacustrine region'; Vail *Agricultural innovation*

[50] Tosh 'Lango agriculture'. The fact that the *Langi* were comparatively late to accept cotton, compared for example to their neighbours the *Iteso*, may have related to their general hostility towards colonial rule. Tosh 'Small scale resistance in Lango'; Vail *Agricultural innovation*

[51] McMaster *A subsistence crop geography*; Tothill *Agriculture in Uganda*; Vail *Agricultural innovation in Teso District*

[52] In 1921, "the spring rains were badly distributed and caused failure of early food crops. This in turn necessitated resowing of food crops and consequent delay in preparation for cotton." Uganda *Report of Agriculture, 1921,* p. 38. In 1945,"the early rains [...] were delayed, as a result of which the spring food crops were planted later than usual with the further result of delay in planting the cotton crop." Uganda *Report of Agriculture ,1944/45,* p. 1 In 1952, "planting of the [...] cotton crop was delayed on account of unfavourable weather earlier in the season and [...] there was also some reduction in the total acreage." Uganda *Report of Agriculture, 1952,* p. 34

[53] In 1953, for example, mention is made of farmers who prematurely uprooted their late-planted cotton fields to make space for their spring food crops. Uganda *Report of Agriculture, 1953,* p. 38

[54] Spring 1953 saw a "confused and abnormal pattern of rainfall" and "it was fortunate that good rains were received during the last quarter of the year as these enabled shortages in the spring food crops to be remedied." Uganda *Report of Agriculture, 1953,* p. 1

IV. Cotton and harvest failure: a panel analysis

The remainder of this section is devoted to a panel analysis, designed to empirically test if, as suggested by anecdotal evidence from the *Annual Reports*, farmers flexibly adapted their commitment to cotton cultivation in the second rainy season to food crop harvest outcomes in the first rainy season. If our analysis show that farmers indeed followed such a strategy, then considerable empirical proof emerges, suggesting that food security was at the heart of smallholder's considerations, and that the two chances Ugandan farmers had during the year to achieve this aim gave them a significant advantage over their counterparts operating in areas with unimodal rainfall patterns. Further, we use our analysis to engage with the hypothesis that cotton planting in Uganda's grain regions responded more strongly to food crop harvest failures than cotton planting in the banana regions.

Data description

Cotton acreage. In the absence of detailed information about actual seasonal labour inputs, the acreage of cotton planted is the best indicator of farmers' annual decision about allocation of (labour) resources to cash crop cultivation. Acreage statistics are not 'confounded' with weather conditions during the growing season, which would affect fluctuations irrespective of labour inputs, as would be the case with crop harvest statistics.[55] Moreover, at the moment of planting (typically in May, June, July or August), weather conditions during the *subsequent* growing season are not yet known. This means that the investment in cotton planting is not informed by the weather forecast, but by past trends, such as the development of cotton prices or the extent to which the previous harvest replenished the household's granary.

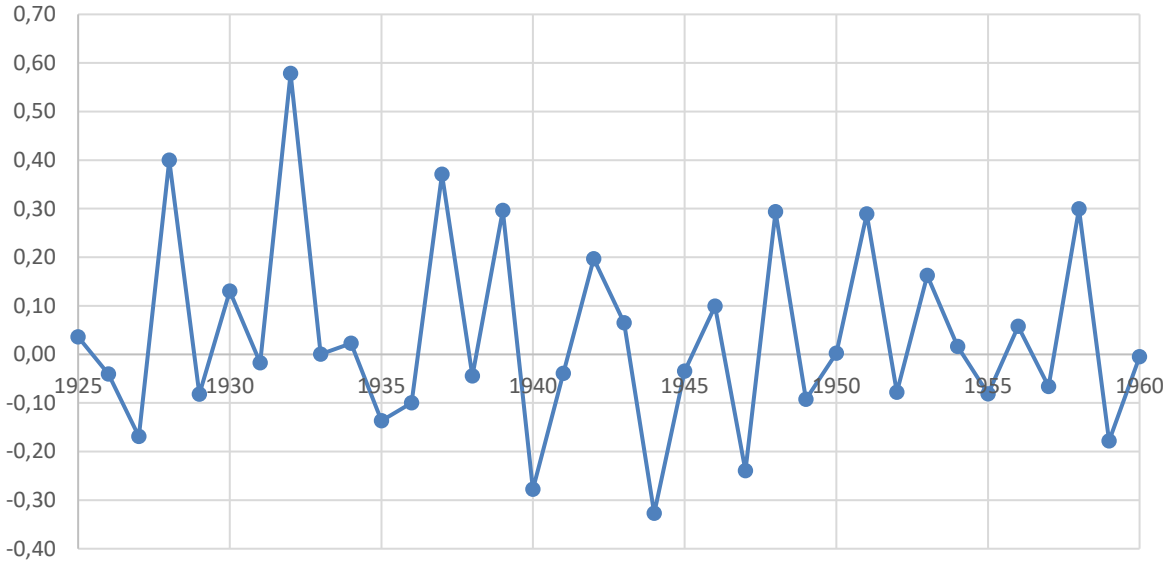
Since cotton played such a crucial role in Uganda's colonial economy, the administration devised a system to monitor the development of the annual cotton acreage. Native administrators were required to count the number of cotton 'fields' or 'gardens' in their area and a standardized conversion, based on the typical field size, was used to turn fields into 'acres'. The figures were then accumulated at the district level and presented annually in the colonial *Blue Books* (until 1945), and the *Report of the Department of Agriculture.*[56] This system was not without its flaws and provides only a rough approximation of the true cultivated acreage. A key problem was that chiefs were known to inflate cotton acreages to impress their superiors. Moreover the conversion rates and measuring practices were altered a couple of times.[57] Still, the acreage statistics at least emerged from a *systematic* data collection effort, rather than guestimates driven by the whims (or indifference) of colonial administrators. We confine our analysis to the years 1925 to 1960 because (i) we have complete data for all districts, except for the war years 1940-43 (for which we interpolate based on province-level statistics),

[55] As harvest outcomes are composed of acreage and yield, the latter of which is affected by weather conditions during the growing season.
[56] A revision for the years 1945-1958 was published in Uganda *Revised crop acreage estimates*
[57] Uganda *Annual Report of the Department of Agriculture*, 1930, pp. 8 & 13; 1934, pp. 6 & 24; 1938, p. 8; Uganda *Revised crop acreage estimates*

and (ii) because coercion had been scaled down by these years, so that we can plausibly link cultivation decisions to choices made by smallholders themselves (Section III).

For our analysis, we divide the cotton acreage per district by the estimated population, derived from the population censuses of 1921, 1931, 1948 and 1959 (with interpolated values).[58] We then take the first difference of the cotton acreage per capita.[59] Inspection of the data shows that each district has distinct individual trends, and that estimates fluctuated annually without any clearly discernible 'suspicious' patterns. This increases our confidence that the data is free of any non-random biases, and that the recorded fluctuations that we exploit in this analysis indeed reflect real increases and decreases of the planted acreage. An example from Busoga district of the first differences of cotton acreages (1925-1960) is provided in Figure 5 below.

Figure 5. *First difference of cotton acreage per capita, Busoga district (1925-60)*



Sources: Authors' calculation. See main text

Rainfall deviation as a proxy for harvest failure. The colonial state did not have the resources required to measure actual food crops yields, but we know from an extensive body of previous research that both *negative rainfall shocks* (droughts) and *positive rainfall shocks* (excess precipitation) have strongly adverse effects on harvest outcomes in a tropical context.[60] We therefore take rainfall deviation during the first rains as a proxy for harvest outcomes. We have no rainfall observations for one small cotton-growing district (Mubende), which we drop from the analysis.

Annual rainfall is a widely used indicator of agricultural conditions in a tropical context. However, since we are dealing with two rainy seasons, and farmers cultivated most of their subsistence requirements during the first rains, we take rainfall for the months *January to June*

[58] Uganda *Census Returns 1911*; Uganda *Census Returns 1921*; Uganda. *Census Returns 1931*; Uganda *Uganda Census 1959*; East African Statistical Department *African population of Uganda (1948)*

[59] $\frac{Acres\ t - Acres\ (t-1)}{Acres\ (t-1)}$

[60] For evidence, discussion of mechanisms and further references Papaioannou 'Climate shocks and conflict'; Papaioannou 'Hunger makes a thief of any man' and Papaioannou & De Haas 'Weather shocks and agricultural commercialization'

as a proxy for food crop yields. As some cotton was planted during May and June (Section III, Figure 3), we alternatively run the analysis using rainfall during the months *January* to *April*, which provides an even cleaner proxy of growing conditions pertaining purely to the first food crop season. Since we hypothesize that farmers pursued a 'food first' strategy, we expect abnormal rainfall (deviation) in the first six months of the year to have a negative effect on cotton planting (acreage) during the second rainy season. We standardize rainfall deviation using z-scores.[61]

Cotton price. The price of cotton is a key observable time-variant factor that we also expect to affect farmers' cotton planting decisions. If farmers faced an upward price trend in year *t-1*, they may expect this trend to continue, hence having an incentive to plant more cotton in year *t*.[62] In 1921, for example, the *Department of Agriculture* noted that "the very high prices obtained for cotton in the previous season gave a great impetus to the native in increasing his area under this crop, so that output for the 1921 season easily exceeded any previous year's production."[63] Still, the effect is not entirely unambiguous. Farmers may not expect a positive trend to persist or they may choose to invest the cotton gains reaped the previous year off the farm. Such different responses to price incentives, however, are not the central concern of our analysis, and we use the price of cotton merely as a control variable. We use annual prices lint cotton in Liverpool, deflated by using an estimate of consumer prices for Uganda.[64]

Coffee income. In some districts, mainly from the 1930s onwards, farmers began to switch from cotton to coffee. Coffee was more lucrative than cotton and yielded higher returns to labour.[65] We may therefore expect that a higher income from coffee in year *t* has a negative effect on cotton planting in year *t+1*. To measure coffee income in year *t*, we use coffee acreage in year *t-5* (since it takes approximately 5 years for Robusta coffee to yield properly), and multiply it with the coffee price in year *t.*[66]

Region dummy. As discussed in Sections II and III of this paper, Uganda was characterized by two rather distinct farming systems. To account for this difference, and to test for any heterogeneous patterns between them, we create a dummy for districts in the grain region. The summary statistics for each of the above variables along with some additional specifications of rainfall deviation are presented in Table 1 below.

[61] : $(x_{i,t} - \bar{x}_i) / \sigma_i$, where $\bar{x}i$ is the long-term mean (1925-60) of each district, $x_{i,t}$ is the annual observation in time t for district i, and σ_i is the standard deviation of each panel, that is for every i

[62] For example the Agricultural Report of 1921 noted that "the very high prices obtained for cotton in the previous season gave a great impetus to the native in increasing his area under this crop, so that output for the 1921 season easily exceeded any previous year's production." Uganda *Report of Agriculture 1921*, p. 6. In the opposite direct, the Report of 1942/43 remarked on "widespread reluctance amongst growers to plant a normal acreage, owing to the low prices paid for seed cotton during the previous year." Uganda *Report of Agriculture*, 1942/43, p. 3

[63] Uganda *Annual Report of the Department of Agriculture*, p. 6

[64] Cotton prices are from Uganda *Annual Report of the Department of Agriculture*. For the deflator, we use the price series provided by Frankema & van Waijenburg, based on barebones subsistence baskets and CPI's for the later years. Dataset appended to Frankema & van Waijenburg 'Structural impediments to African growth?'

[65] De Haas 'Measuring rural welfare'

[66] The price and acreage data are from the same sources as the cotton data.

Table 1. *Summary Statistics, District by Year*

Variable	Obs.	Mean	Std. Dev.	Min	Max
Cotton Acres, first difference	350	0.05	0.26	-0.64	1.17
Rainfall deviation (January-June)	458	0.81	0.59	0.00	3.14
Rainfall deviation (July-December)	459	0.79	0.61	0.00	3.77
Rainfall deviation (January-April)	468	0.79	0.59	0.00	3.16
Rainfall deviation (January-December)	468	0.80	0.60	0.00	3.45
Excessive rainfall shock (January-June)	458	0.17	0.38	0.00	1.00
Drought shock (January-June)	458	0.21	0.40	0.00	1.00
World market price (deflated)	468	0.00	1.00	-1.59	2.55
Coffee Income	468	2.08	6.99	0.00	44.57
Region dummy (grain)	468	0.46	0.49	0.00	1.00

Notes: Authors' calculations. See main text.

Results

To investigate the effect of the food crop harvest on cotton planting, we run the following specification:

$$CottonAcresDiff_{i,t} = \beta_0 + \beta_1 AbsoluteRainfallDeviation_{i,t} + \delta WorldMarketPrice_{i,t} + v_i + \mu_t + (District\ dummy \times Time\ Trend)_{i,t} + \varepsilon_{i,t}. \quad (3)$$

i = 1,2,3,....,10 and t = 1,2,3...,36.

where $CottonAcresDiff_{i,t}$ denotes the first difference of total acreages of cotton planted per capita in district *i* and year *t*. $AbsoluteRainfallDeviation_{i,t}$ denotes the absolute rainfall deviation in January to June of each district *i* from the historical long-term mean of the same district. v_i and μ_t are district and year fixed effects, respectively. We use these controls to account for possible omitted heterogeneity at the level of districts and time periods. These terms are crucial in controlling for factors that may affect the levels of cotton acreages across all districts in the same year, such as the Great Depression and/or World War II. Lastly, $(District\ dummy \times Time\ trend)_{i,t}$ denotes the unobservable district characteristics (v_i) when interacted with a linear time trend (t). In practice, we control for district-specific characteristics to capture district-specific changes of cotton cultivation activity over time.

The coefficient of interest, β_1, is the estimated effect of a one-standard-deviation-change (either positive or negative) in rainfall on the first difference of the cotton acreage. A negative sign, $\beta_1 < 0$, indicates that, on average, extreme rainfall deviations (in the first six months) are associated with a *decrease* in cotton production, as households decide to cultivate more food crops to compensate for the deficient harvest in the first rainy season. In all estimations we cluster standard errors at the district level (no. of clusters = 10) to avoid any autocorrelation concerns of rainfall deviations and the possibility of measurement errors, which are more likely to be correlated within districts across time.

The results are presented in Table 2. A one standard deviation change of rainfall in the first 6 months is associated with a decrease in the production of cotton by 7 percent (column 1). The results remain largely unchanged when we include the world cotton price as a control variable (column 2), and when we add district-specific effects (column 3). Throughout these specifications, the world market price of cotton yields a positive sign, suggesting that rising cotton prices during the previous harvest motivated households to plant more cotton. We perform several falsification tests where we include the rainfall deviation during the second rainy season, from July to December (column 4) and the total *annual* rainfall deviation (column 5), which do not reflect food security at the time of planting, and should therefore not have a significant effect on cotton planting. It is reassuring that these coefficients are not statistically significant, validating further our analysis. Lastly, in column 6, we evaluate the sensitivity of our estimates to the use of an alternative temporal cut-off point, by including the rainfall deviation from January to April, thus excluding the months of May and June in which some smallholders already began to plant cotton. The result with this alternative rainfall indicator is very similar to our baseline result.

The temporal dimension of the regression coefficient of column (1) in Table 2 is presented graphically in Figure 6. The strong negative correlation between weather deviation in the first six months and subsequent cotton planting is quite stable over time, suggesting that our results are not driven by a specific sub-set of years within our timeframe. The fact that the effect persists until the end of our period also shows that farmers' cotton planting decisions were influenced by preceding weather fluctuations all the way up to the end of the colonial period, implying that food security considerations continued to matter for cotton planting. Apparently, markets for food crops did not develop to a sufficient extent to convince farmers that it would be safe to (partially) abandon subsistence farming. Such persistent concern for subsistence production and food security helps to explain why Ugandan households never progressed beyond a stage of *partial commercialization*.[67]

Next, we proceed by investigating whether our baseline effect is stronger in grain areas, compared to banana areas. We also include the estimate of annual coffee production, which we expect to correlate negatively with cotton (i.e. we expect a substitution effect). The results are reported in Table 3. Contrary to our expectations, the grain interaction in Columns (1) and (2) yields a *positive* coefficient, suggesting that the adverse impact of weather shocks on cotton planting was less pronounced in grain regions. However, since the coefficient is not statistically significant, we cannot draw any reliable conclusions from it. As expected, the coffee income variable in column (2) is statistically significant and yields a strong negative correlation with cotton acres. Our baseline effect survives the inclusion of controls. Next, we check the robustness of our baseline findings as well as the symmetricity of the effect. Columns (3) and (4) show that inclusion of rainfall during the previous first season (*t-1)* does not yield a significant effect on the cotton acreage, nor does the inclusion of the lead variable (*t+1*), which serves as a falsification test. Column (5) shows that both droughts and excessive rainfall had a

[67] De Haas 'Measuring rural welfare', p. 3

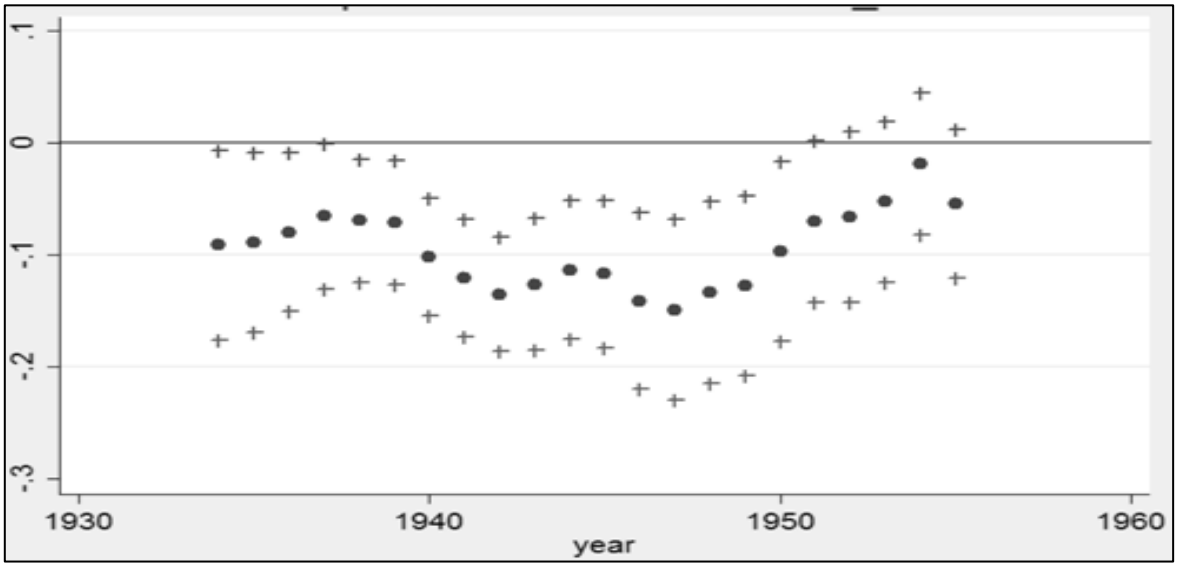
statistically significant adverse effect on subsequent cotton growing, with the effect of excessive rainfall somewhat stronger than the effect of drought shocks.

Table 2. *Rainfall shocks, Price Volatility & Cotton Acres*

	Dependent variable: Cotton Acres					
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	OLS	OLS	OLS	OLS
Rainfall deviation (Jan-Jun)	-0.0702***	-0.0701***	-0.0706***			
	(0.017)	(0.017)	(0.018)			
World Cotton Price		0.0641**	0.0852**			0.0588**
		(0.020)	(0.036)			(0.021)
Rainfall deviation (Jul-Dec)				-0.0040		
				(0.133)		
Rainfall deviation (Jan-Dec)					-0.0171	
					(0.142)	
Rainfall deviation (Jan-Apr)						-0.0806**
						(0.029)
District & Year FE	Y	Y	Y	Y	Y	Y
District-specific effects	N	N	Y	Y	Y	Y
No. observations	341	341	341	341	341	341
No. districts	10	10	10	10	10	10

Notes: *Significant at 10%, **5%, ***1%. Sample period: 1925–1960. OLS-FE. Reported in parentheses are standard errors clustered at the district level. The dependent variable is the first difference of annual cotton acres. District-specific effects indicate the interaction of each district dummy with a time trend.

Figure 6. *Rolling coefficient of the main effect (10 year time window)*



Notes: The y-axis represents the effect (coefficient) of standardized rainfall deviation (Jan-Jun) on the cotton acreage (in percentage points), with 95% confidence intervals for each individual ten year panel.

Table 3. *Robustness, Symmetricity and Grains*

	Dependent variable: Cotton Acres				
	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) OLS
Rainfall deviation (Jan-Jun)	-0.0987**	-0.0943**	-0.0832***	-0.0680***	
	(0.033)	(0.032)	(0.031)	(0.023)	
World Cotton Price	0.0836**	0.0786**	0.0651**	0.0619**	
	(0.035)	(0.027)	(0.029)	(0.030)	
Grain Interaction	0.0494	0.0455			
	(0.040)	(0.038)			
Coffee Income		-0.0020***			
		(0.001)			
Rainfall deviation (Jan-Jun) *t -1*			0.0184		
			(0.024)		
Rainfall deviation (Jan-Jun) *t +1*				0.0009	
				(0.018)	
Excessive Rainfall Shock (Jan-Jun)					-0.0889**
					(0.029)
Drought Shock (Jan-Jun)					-0.0516**
					(0.024)
District & Year FE	Y	Y	Y	Y	Y
District-specific effects	Y	Y	Y	Y	Y
No. observations	341	341	341	341	341
No. districts	10	10	10	10	10

Notes: *Significant at 10%, **5%, ***1%. Sample period: 1925–1960. OLS-FE. Reported in parentheses are standard errors clustered at the district level. The dependent variable is the first difference of annual cotton acres. District-specific effects indicate the interaction of each district dummy with a time trend.

V. Household-level determinants of cash crop cultivation

In this section, we probe one layer deeper into Uganda's rural economy, and examine the complementarity between food crops and cash crops on the household level. Our investigation focuses on a set of village surveys from southern Uganda (the banana region), which were conducted from the late 1930s onwards, when the cash crop economy was firmly established.

Firstly, we explore to what extent there was *substitution* (or *complementarity*) between food crops and cash crops at the level of individual households. On the basis of Section III and IV, which showed that farmers pursued a 'food first' strategy, we do not expect that cash crops supplanted food crops to any large extent.[68] Since first rain food crops tended to be planted in the second season cotton plots of the previous year, an extension of the cotton acreage may even have had "a direct [positive] influence on the available food supplies."[69]

Secondly, we explore the relationship between cash crops and the *portfolio* of food crops. It is often argued in the wider literature on agricultural commercialization that farmers extend their cultivation possibilities by switching from *labour intensive* food crops such as grains and oil crops, to *high yielding* and *less demanding* staples, such as roots, tubers and bananas.[70] An advantage of cassava and sweet potato is that they are resistant to weather fluctuations, and a as result, can be harvested throughout the year and can be kept underground for a prolonged period of time, which makes them suitable as 'famine reserve crops'. The downside of roots, tubers and banana is that they tend to be less nutritious, particularly in terms of protein content.[71] Since Ugandan farmers operating in bimodal rainfall conditions had more opportunities to secure a sufficient food supply, we do not expect a strong substitution between cash crops on the one hand and grains and oil crops on the other. We do expect that cash crop farmers cultivated more roots and tubers to hedge against harvest failure (cf. discussion in Section III).

Data description

Crop cultivation. The village surveys provide acreages for each particular crop. To simplify the analysis, we group all acreage statistics under five headings: 1) bananas, 2) roots and tubers, 3) cereals, 4) protein crops, 5) cotton, and 6) coffee. Acreages are not an ideal unit of comparison, since labour inputs, yields and returns in terms of value or calories per acre differ per crop. To overcome such a limitation, we first estimate production (in kilograms) by picking the most dominant crop in each category, and multiply typical yields per acre for this crop with the stated acreage in the category. Next, we express the value of food crops in terms of the dominant crop's caloric value in each category, and of *cash crops* with their farm gate price (taking the average price for 1935-40).[72] Table 3 summarizes the procedure and the basic assumptions.

[68] cf. Fafchamps 'Cash crop production, food price volatility, and rural market integration'
[69] Uganda *Annual Report of the Department of Agriculture*, p. 8
[70] Clark & Haswell *The economics of subsistence agriculture*, p. 100; Cleave *African farmers: labour use*, p. 141 and p. 213; McMaster *A subsistence crop geography*, p. 71; Tosh 'The cash-crop revolution in tropical Africa', p. 93
[71] De Haas 'Measuring rural welfare', Tosh 'The cash-crop revolution'
[72] One limitation of this approach is that we have to assume that yields are equal across households (or that variation is randomly distributed). However, it is possible that households with cash crops had lower yields, for example because their attention was taken up by cash crops (Allan *The African husbandman*, p. 161). It is also possible that

Table 3. *Crops cultivated and standardized characteristics for the dominant crop*

Category	Sub-category	Crops	KG/acre	Calories/KG	Cent/KG
Food crops	Bananas	Bananas*	2786	677	n/a
	Roots and Tubers	Cassava* Sweet potatoes Irish potatoes	3402	1493	n/a
	Grains	Millet* Sorghum Maize	490	3417	n/a
	Protein crops	Beans* Peas Groundnuts Sesame seed	363	3338	n/a
Cash crops	Cotton	Cotton* Tobacco	181	n/a	23.59
	Coffee	Coffee*	363	n/a	18.08

Notes: Yields are typical yields in a year of normal growing conditions. Since cassava and sweet potato can be kept underground for multiple years, yields are *potential* yields when harvested.
Sources: Prices and yields for bananas, millet and beans from De Haas *Measuring rural welfare*. Yields for cassava retrieved from sources used by De Haas *Measuring rural welfare.*

Consumption needs of the households. Households differ considerably in size. The value of crops cultivated by a household obviously depends on the number of dependent consumers. We therefore express the value of crops per *consumer*, rather than per *household*. We use a basic estimate of adult male equivalents (*AME*), a commonly used deflator of purchasing power accounting for varying consumer needs. We count adult men as 1.0 consumer, adult women as 0.7 consumer, and children as 0.5 consumer.

Livestock. Livestock was an important source of wealth, and we may expect households with greater access to cash income to accumulate more livestock. In turn, access to livestock (i.e. manure and traction power) may contribute to cash crop production. We express livestock as *tropical livestock units* (TLU), counting chicken as 0.01 TLU, sheep and goats as 0.1 TLU and cows as 0.7 TLU. We calculate the economic returns to livestock using Kampala prices for beef.[73]

Off-farm income. It is likely that the introduction of labour intensive cash crops had repercussions for the broader livelihood portfolios of African rural households, limiting their involvement in crafts production, household industry and other non-agricultural activities. This is particularly likely because of Uganda's *bimodal* rainfall distribution, which, as shown in the previous section, resulted in a smoother distribution of agricultural labour requirements, but

farm size and yields correlated, for example because smaller farmers used fewer inputs and left their plots fallow in fewer years. Wilson and Watson 'Two surveys of Kasilang Erony'. These caveats must be kept in mind.
[73] See De Haas 'Measuring rural welfare'

also meant that there was no pronounced agricultural 'off-season' in which households could pursue non-agricultural activities.[74] Unfortunately, we do not have consistent household level estimates of off-farm income. However, we do have information for 310 households about whether off-farm income was a notable source of income or not, enabling us to create a dummy variable. All variables are described in the summary statistics (Table 4) below.

Region. We distinguish two sub-areas in Uganda's banana growing regions: three villages in Buganda (208 households) where substantial amounts of cash crops were cultivated, and four villages in western Uganda (356 households) with fewer cash crops, but more involvement in migratory wage labour.

Table 4. *Summary Statistics, Household Dataset*

Variable	Obs.	Mean	Std. Dev.	Min	Max
Panel (a): Acres per AME					
Ln(Cash Crops)	564	2.43	0.36	0.00	1.95
Ln(Food Crops)	564	0.65	0.34	0.00	1.81
Ln(Banana)	564	0.29	0.34	0.00	1.66
Ln(Roots & Tubers)	564	0.13	0.12	0.00	0.83
Ln(Cereals)	564	0.17	0.21	0.00	1.11
Ln(Protein Crops)	564	0.17	0.22	0.00	1.38
Panel (b): Values per AME					
Ln(Cash Crops)	564	1.71	1.60	0.00	5.58
Ln(Livestock)	564	1.06	0.99	0.00	4.38
Panel (c): Calories per AME					
Ln(Food Crops)	564	13.95	2.56	0.00	16.30
Ln(Banana)	564	9.52	6.07	0.00	15.87
Ln(Roots & Tubers)	564	11.23	4.95	0.00	15.70
Ln(Cereals)	564	8.84	5.90	0.00	15.04
Ln(Protein Crops)	564	9.49	4.55	0.00	14.68
Panel (d): Dummies					
Buganda (region)	564	0.36	0.48	0.00	1.00
Ankole (region)	564	0.07	0.26	0.00	1.00
Kigezi (region)	564	0.37	0.48	0.00	1.00
Bunyoro (region)	564	0.18	0.38	0.00	1.00
Off-Farm Income	310	0.25	0.43	0.00	1.00

Notes: Authors' calculations. See main text.

[74] On dry season activities in a West African context of unimodal rainfall, see Austin 'Resources, techniques, and strategies', Austin 'Labour intensity and manufacturing'

Results

To investigate the associations of cash crops with overall food crops and several sub-categories of food crops, we estimate the following specification using a simple ordinary least square (OLS) regression:

$$Ln(Cash\ Value\ per\ AME)_i = \beta_0 + \beta_1 X'_i + \delta Z'_i + \varepsilon_i \quad (1)$$

where $Ln(Cash\ Value\ per\ AME)_i$ denotes the natural logarithm of cash crop value. X'_i denotes the various indicators of food crops expressed in their caloric value. These include the natural logarithm of bananas, roots and tubers, cereals, protein crops, and all food crops combined. Z'_i denotes the controls. ε_{it} is the error term.

Table 5. *Associations between cash crops, food crops and off-farm income at household level*

	Ln(Cash Value per AME)					
	(1)	(2)	(3)	(4)	(5)	(6)
Ln(Food calories)	0.0778***	0.0672***	0.1581***			
	(0.015)	(0.016)	(0.032)			
Ln(Banana calories)				0.0490***	0.0484***	0.0585***
				(0.008)	(0.010)	(0.015)
Ln(Roots & Tubers calories)				0.0396***	0.0477***	0.0406***
				(0.011)	(0.013)	(0.012)
Ln(Cereal calories)				0.0191	0.0184	0.0526***
				(0.012)	(0.012)	(0.013)
Ln(Protein crops calories)				0.0101	-0.0082	0.0011
				(0.013)	(0.013)	(0.019)
Ln(Livestock per AME)		0.1128**			0.0994**	
		(0.051)			(0.050)	
Off-farm Income			-0.4875***			-0.4607***
			(0.160)			(0.156)
Clustered St. Errors	Household	Household	Household	Household	Household	Household
Controls	Y	Y	Y	Y	Y	Y
No. observations	563	563	310	563	563	310
R^2	0.545	0.549	0.446	0.562	0.565	0.479

Notes: *Significant at 10%, **5%, ***1%. The dependent variable is the logarithm of cash value per AME. Reported in parentheses are standard errors clustered at the household. Controls include region dummies and family types.

Columns (1) to (3) yield a robust and statistically significant positive coefficient between cash crops and food crop caloric values, confirming a *complementary* relationship between food crops and cash crops on the household level. In other words, households with more cash crops also produced more food crops. Although we do not claim any causality here, this finding is in line with our overall argument that food security was an important precondition for farmers to engage in cash crop production. This complementarity effect holds even when we exclude the top 1%, 5% and 25% of households (results not reported), which reassures that the relationship is not driven by outliers (i.e. the poorest or richest households). Moreover, the results are consistent with the idea that households who were more successful in achieving food security also cultivated greater amounts of cash crops, profiting from synergies between food and cash crops.[75] Livestock, which we enter as a control variable, shows the expected sign, as it was associated with more cash crops. Column (3) provides evidence for the expected trade-off between off-farm income and cash crop cultivation.

The results in columns (4) to (6) suggest that households cultivating more cash crops, also cultivated more roots, tubers and bananas. Protein crops remain insignificant throughout all specifications, while the coefficient for cereals show a positive sign only for the sub-sample including information about off-farm income.[76] The positive correlation between cash crops and bananas, roots and tubers suggests that cash crop farmers used these crops to hedge against harvest failures. The absence of a negative correlation between cash crops and grains and oil crops suggests that cash crop farmers, having two rainy seasons at their disposal, were able to sustain the cultivation of their favoured and most nutritious food crops.

In Table A-1 in the Appendix, we check the robustness of our baseline effect. We run specification (1) again, this time using crop acreages instead of caloric values of food crops and monetary values of food crops, thus shedding many of the assumptions on which Table 5 relies. The results remain largely unchanged.

VI. Conclusion

In this study, we have set out to explore the importance of factor endowments in shaping the degrees to which cash crops were adopted in colonial tropical Africa. Our empirical findings, based on a panel data analysis on annual district-level cotton acreage from 1925 to 1960, underscore the importance of Uganda's equatorial *bimodal rainfall distribution* as an enabling factor for Uganda's 'cotton revolution'. To reach our conclusions, we have zoomed in on smallholder cultivation of cotton in colonial Uganda, and amended and tested Tosh' 'labour seasonality' explanation of the Africans' variegated responses to cash crops in the colonial era. The exceptional uptake of cotton among Uganda's smallholders is often attributed to the cultivation of bananas, which, alongside conditions in other 'forest regions,' is posited as an 'exception that proves the rule' of labour constraints in the African savanna. We have

[75] Maxwell and Fernando 'Cash crops in developing countries' Kennedy and Von Braun *Agricultural commercialization, economic development and nutrition*; Pingali and Rosegrant *Agricultural commercialization and diversification*

[76] This result may be explained by the fact that households with off-farm income also shifted to less labour-intensive food crops to compensate for their absence from the farm during parts of the year (McMaster, 1962).

demonstrated, instead, that cotton cultivation in Uganda was not confined to the banana areas, but diffused widely in grain areas as well. We attribute this diffusion to Uganda's rainfall pattern as the 'exceptional' condition in Uganda.

The occurrence of two rainy seasons annually enabled farmers to smooth intra-annual labour demands by pursuing food crop and cash crop cultivation at different part of the year and provided farmers with two chances annually to secure their food supply. Farmers secured their food supply during the first rainy season, while relegating cotton to the second rainy season. Their seasonal commitment to food and cash crops was flexible. In case the food crop harvest in the first season was insufficient, farmers partially substituted cotton cultivation in the second rainy season for additional food crops, to compensate for the incurred shortage. This strategy was prevalent both in the grain and banana regions. At the household level, we find *complementary* between food and cash crops, suggesting that the least food secure farmers mostly stayed away from cash crops, while the more food secure farmers successfully pursued a dual strategy of food security and cash crop production. In particular, we find that cash crop cultivation was positively associated with the production of 'famine reserve' food crops such as roots and tubers.

While this study has focused on showing how Ugandan farmers *successfully* integrated cotton into their farming practices, it also contributes to a better understanding of the *limits* of cash crop adoption in colonial Africa, in two ways. Firstly, we argue that the key to the exceptional uptake of cotton among Uganda's smallholders, was neither intense coercion nor access to bananas, but simply the bimodal rainfall distribution, which enabled them to spread agricultural production over two rainy seasons annually, thus facing less stringent seasonal labour constraints and a lower risk of food insecurity than their counterparts elsewhere. Since bimodal rainfall is confined to equatorial latitudes and did not extend to most other savanna regions, our findings imply that the majority of African farmers did not have the same option to adopt cotton without effectuating any major changes in agricultural practices or giving up food production. Secondly, our temporal analysis has shown that food security concerns affected cotton cultivation decisions of farmers all the way until the end of the colonial period. This implies that farmers operated at the maximum of their agricultural production capacity, which apparently did not extent beyond the initial process of recalibration and cotton adoption during the first decades of colonial rule. Thus, our results are consistent with a type of economic development that involved an initial "productivity breakthrough," followed by extensive growth.[77]

This brings us to some final, broader thoughts and potential directions for future research. Although we argue that labour seasonality is a powerful explanation for disparate responses of African farmers to agricultural commercialization in the colonial era, we do not argue that the colonial 'cash crop revolution' can be understood and explained solely by looking at labour seasonality, or even resource endowments more broadly. In this paper, we have treated thin markets for credit and food, and limited adoption of agricultural technologies as exogenously given. In reality, of course, access to physical and institutional infrastructures, marketing

[77] cf. Austen *African economic history*, p. 138; Austin 'Vent for surplus or productivity breakthrough?; De Haas 'Measuring rural welfare'; Green 'From extensive to involutionary growth'

conditions for food and cash crops, and technology was mediated by colonial governments, who often operated on a shoestring and were unwilling to invest to any large extent in the agricultural development of their colonies. The limited extension of Uganda's agricultural production capacity after the adoption of cotton, and the continued focus on food production, then, should also be seen in the light of underdeveloped food markets and limited agricultural innovation. Moreover, there are other African regions with bimodal rainfall, particularly in central Africa, where cotton was much less well received by smallholders. A Belgian colonial officer in the Congo, for example, noted that "we have failed to make the crop as popular here as in Uganda. The remuneration is inadequate and the blacks are growing the crop only under the pressure of the administration."[78]

In conclusion, we propose that, in a colonial context, bimodality was a *close-to-necessary* condition for a 'cash crop revolution' to occur, while it is very well conceivable that, had institutions been better, the outcomes might have been very different. Had markets functioned better, African farmers might have shown a greater willingness to move away from risk-averse 'food first' cultivation strategies. Had high-yielding crop varieties and labour-saving technologies been introduced, labour demands per unit of food or cash crop would have been reduced, and more African farmers may have been enabled to branch out into cash crops. The development record of northern Côte d'Ivoire provides a case in point. Here, in savanna conditions with unimodal rainfall, farmers had rejected French attempts to introduce export cotton for half a century. However, after the end of formal colonial rule, concerted efforts were made by the government and private investors to increase both food crop and cotton yields, and farmers were provided with access to credit, implements and agricultural technology, which resulted in a belated but impressive 'peasant cotton revolution'.[79]

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[78] cited in Likaka *Rural society and cotton*, p. 89
[79] Bassett *Peasant cotton revolution*; Lele et al. *Cotton in Africa*

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Appendix

Table A-1. *Substitution effect between Cash Crop and Food Crop Acres.*

	Ln(Cash Crop Acres per AME)					
	(1)	(2)	(3)	(4)	(5)	(6)
Ln(Food Acres)	0.1728***	0.1568***	0.294***			
	(0.036)	(0.037)	(0.057)			
Ln(Banana Acres)				0.1367**	0.1321**	0.1837***
				(0.063)	(0.062)	(0.066)
Ln(Roots & Tubers Acres)				0.5200***	0.5001***	0.1431*
				(0.144)	(0.140)	(0.151)
Ln(Cereal Acres)				0.0368	0.0272	0.4278***
				(0.055)	(0.055)	(0.142)
Ln(Protein crops Acres)				0.0077	-0.0065	0.2848
				(0.053)	(0.056)	(0.164)
Ln(Livestock TLU per AME)		0.0231**			0.0210*	
		(0.011)			(0.010)	
Off-farm Income			-0.0479**			-0.0413*
			(0.021)			(0.145)
Clustered St. Errors	Household	Household	Household	Household	Household	Household
Controls	Y	Y	Y	Y	Y	Y
No. observations	563	563	310	563	563	310
R^2	0.475	0.478	0.401	0.493	0.496	0.412

Notes: *Significant at 10%, **5%, ***1%. The dependent variable is the natural logarithm of cash crop value per AME. Reported in parentheses are standard errors clustered at the household. Controls include region dummies and family types.

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