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What happened to the workshop of West Africa? Resilience and decline of handicraft textiles in colonial northern Nigeria, 1911–52

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Abstract

The Sokoto Caliphate of northern Nigeria was the workshop of West Africa in the pre-colonial nineteenth century, producing famous blue-black cloth that reached many markets south of the Sahara as well as across it. Under British colonial rule this large handicraft textile industry was faced with the winds of foreign competition. We rely on a newly digitized set of colonial district reports to measure the impact of trade on northern Nigerian textile manufacturing and find that (contrary to British expectations) areas closer to railway stations were less likely to experience industrial decline. We argue that the resilience of local textiles relied on the low opportunity cost of dry-season labour. Analysing a piece of tax microdata, we show that a low opportunity cost of labour outside of the rainy season was associated with a higher likelihood of engaging in textile by-employment. Seasonal changes in relative factor prices were a trap as well as a refuge. Part-time employment limited specialization and technological innovation, and can help to explain why northern Nigerian textiles eventually declined. Thus, beyond our particular case study, these results contribute to our understanding of the role of seasonality in determining the structure and pace of development of tropical economies.

KEYWORDS
colonialism, deindustrialization, handicraft textiles, railways, West Africa, tropical seasonality

> 'As well-being increases the consumption of Manchester goods will doubtless increase, but it does not altogether follow that the output of the native looms will decrease. It is curious that the Kano weavers themselves think that the railway will enlarge their market. (…) The robes worn by the better-class natives are of a consistency and weight which would astonish us here.'
>
> E. D. Morel, Nigeria: its peoples and its problems, pp. 239–40

The Kano weavers were right. Contrary to most predictions and to the hopes of at least some British officials, northern Nigerian handlooms continued to produce high-quality cloth that proved remarkably resilient in the face of competition from European imports. Today, the prospects of industrialization in tropical sub-Saharan Africa – this time facing Chinese competition – remain central to the subcontinent's chances to converge to the living standards of richer countries. African industrial output per capita is currently the lowest worldwide, and manufacturing employment remains marginal in the labour force.[1] What happened to the substantial handicraft manufacturing that developed in the pre-colonial nineteenth century? How did international trade under colonial rule affect local spinners, weavers, and dyers? Did economic globalization deal a decisive blow to African manufacturing, one which it still has not recovered from?

In this paper we take the deindustrialization debate to the West African savanna. Northern Nigeria, a distinct administrative entity under British rule, after independence has remained a very large and economically diverse region: with around 53 per cent of the Nigerian population, it is over three times as large as any other West African country. The pre-colonial Sokoto Caliphate (1804–1903), which extended over most of it, was the core economy of the Central Sudan in the nineteenth century, and its walled cities, especially Kano, were the largest commercial and manufacturing centres of pre-colonial West Africa. The Caliphate's peasant farms and slave plantations, the latter of a scale comparable to Brazil's or the US South's, produced grains, cotton, and indigo for a large domestic market.[2] The cotton textile handicraft industry achieved substantial scale economies in spinning, weaving, and dyeing, its signature blue-black cloth traded widely south of the Sahara as well as across it to North Africa. How did market integration under British rule change the fortunes of local manufacturing?

We use a newly digitized set of colonial sources to measure the impact of trade on the decline of textile manufacturing in northern Nigeria. By tracing the changes in male textile employment between *c*. 1911 and 1952 across 38 districts (comprising over 2 million people by the end of colonial rule), we show that industrial decline was more pronounced in areas further away from railway stations, controlling for location, population, and agricultural yields. Furthermore, through

[1] In this article, when we say 'Africa', we mean 'sub-Saharan Africa.' For an overview of manufacturing in Africa during and since the colonial period, see Austin, Frankema, and Jerven, 'Patterns'.

[2] For a detailed comparison between the Caliphate's plantations and those of the New World and East Africa, see Salau, *Plantation slavery*, pp. 130–55.

a study of novel land tax microdata from a district in north-western Nigeria in 1934, we offer a reason for the resilience of northern Nigerian textiles: the low opportunity cost of dry-season labour. Exploiting the fact that some farmers in the dataset had access to floodplain land that could be cultivated in the dry season (unlike most of northern Nigeria's arable land), we show that a low opportunity cost of labour outside of the rainy season was associated with a higher likelihood of engaging in textile by-employment, even in the difficult years of the Great Depression. Our argument, and our results, contribute to a renewed scholarly emphasis on the role of seasonality in determining the structure and pace of development of tropical economies.[3]

After this introduction, section I reviews the deindustrialization debate from the perspective of northern Nigeria's pre-colonial economic history. Section II introduces a new district-level dataset to reconstruct changes in male employment in handicraft textiles in the early colonial period. Section III examines the relationship between market integration (measured by proximity to railway stations) and industrial decline, and finds that areas which benefited from trade infrastructure and were connected to the expanding agricultural export economy sustained a demand for high-quality cloth which British manufactures could not satisfy. Section IV focuses on the mechanisms behind the resilience of local textiles. Through the analysis of pieces of tax microdata, it shows that the low opportunity cost of dry-season agricultural employment sustained the competitiveness of northern Nigerian cloth, which was almost always made by part-time weavers and dyers. The seasonal changes in labour costs were, however, a double-edged sword, as they also became an obstacle to specialization. The conclusion considers the implications of the story of northern Nigerian looms for the broader debates on comparative industrial development (past, present, and future), especially in the arid tropics.

I | THE DEINDUSTRIALIZATION DEBATE: A SAVANNA PERSPECTIVE

The standard account of the impact of European colonialism and globalization on textile production in the developing world is the 'deindustrialization of the periphery' thesis.[4] Applied most often to Asia, the Middle East, and Latin America, the deindustrialization thesis argues that the first globalization, especially in the late nineteenth century, caused the widespread, rapid, and definitive decline of formerly prosperous manufacturing industries (crucially textiles) in the global periphery. Following their comparative advantage, and also as a result of foreign investment and intervention, third world economies became highly specialized exporters of primary commodities – foodstuffs or raw materials – while local handicrafts lost their textile market to cheaper machine-made imports. This basic story has not only been accepted by neoclassical economic historians such as Williamson but also formed the basis of radical critiques of European imperialism. Whether this was the result of colonial (or neo-colonial) plots, and whether it should be seen as a desirable pattern of economic development for the periphery or, instead, as a pernicious form of 'underdevelopment' were subjects of a major scholarly debate spearheaded by dependency theory in the 1960s and 1970s.[5] While *dependentista* arguments have fallen out of fashion, the idea that the deindustrialization of the poor periphery was key to the international

[3] Roy, 'Arid tropics'; de Haas, 'Failure of cotton imperialism'. See also Sokoloff and Dollar, 'Agricultural seasonality'.

[4] See, for perhaps the most influential exposition, Williamson, *Trade and poverty*.

[5] For an overview of the debate by one of its main protagonists, see Frank, 'Dependence'. The classic dependency-theory interpretation of African economic history is Rodney, *How europe underdeveloped Africa*; see especially his discussion of

division of labour forged in the nineteenth century, and thereby contributed to the Great Divergence, remains standard in global economic history.[6] The development economics literature has produced almost no examinations of African industrial decline. Revealingly, there is no chapter on Africa in Jeffrey Williamson's *Trade and poverty* – perhaps because it is generally assumed that below the Sahara there was little manufacturing to lose in the first place.

The 'deindustrialization thesis' has come under increasing fire by new empirical research. Working across a range of historical settings, economic historians have shown that handicraft textile manufacturing in the periphery was much more resilient to competition from European imports than had traditionally been assumed, notably in large economies in south and southeast Asia.[7] Economic and social historians of Africa have provided detailed case studies from across the continent.[8] One important conclusion from this recent literature is that the impact of colonial rule and international trade on local textile production varied widely across colonies, and indeed within them.

The scale and scope of northern Nigerian handicraft manufacturing in the pre-colonial nineteenth century was unmatched in the continent. As a German explorer noted in the 1850s, there was 'something grand' about this textile industry, which reached across the Sahara with its cottons and went on to import unfinished Manchester cloth for dyeing in the 1890s, as demonstrated by the pioneering work of Shea and Marion Johnson.[9] Iliffe argued that the jihad (1804) which started the Caliphate in northern Nigeria gave political expression to a natural economic entity, and thereby stoked economic growth in the region.[10] Aside from a shared legal framework, the Caliphate also provided the region with a 'federal' fiscal system, under which variation in tax rates from emirate to emirate encouraged regional specialization centred around what Lovejoy called northern Nigeria's 'textile belt'.[11] The legal framework of the Caliphate was itself instrumental to the development of this textile belt, not least because it regulated the work of the around 1.25–2.5 million slaves in the region, whom Lovejoy estimated accounted for no less than 25 per cent of the population.[12] Slave labour was central to this handicraft textile industry, both because raw materials (cotton and indigo) were grown in slave plantations and because enslaved people also worked seasonally as cloth spinners and dyers.[13] Importantly, the institutional setting of slavery in the Caliphate (which subsisted into the early colonial period) allowed slaves to work for their

textiles, which mirrors Williamson's emphasis on the opening to trade, though it does not see this as a result of specialization according to comparative advantage. For a nuanced historical assessment of Rodney's argument, see Araujo, 'Did Rodney get it wrong'. For a contemporary economic analysis of Africa's past which offered an alternative to dependency theory, see Hopkins' classic *An economic history of West Africa*.

[6] See, for example, Allen, *Global economic history*, pp. 1–8.

[7] Recent studies on Indonesia, east Africa, and India are, respectively, van Nederveen Meerkerk, 'Challenging the deindustrialization thesis', Frederick, 'Global and local forces', and Roy, *The crafts*.

[8] Historical studies on the resilience of West African textile production in the face of European competition are Roberts, *Two worlds*; Byfield, *The bluest hands*; Kriger, *Cloth*, pp. 45–7. On the diversity of paths in East Africa, see Frederick, *Twilight*; Clarence-Smith, 'Textile industry'.

[9] Barth, *Travels*; Shea, 'Economies of scale'; Shea, 'Sokoto Caliphate'; Johnson, 'Calico caravans'.

[10] Iliffe, *Africans*, p. 176. For a more recent overview of the jihad led by Dan Fodio, see Lovejoy, *Jihād*, pp. 148–211.

[11] Lovejoy, 'Plantations', p. 367. Tijani Garba's unpublished doctoral thesis ('Taxation') continues to be the best secondary source to understand taxation under the Caliphate.

[12] Lovejoy, 'Economic impact', p. 106.

[13] Salau, *Plantation slavery*, p. 127; Candotti, 'Hausa textile industry', pp. 196, 202; Lovejoy and Hogendorn, *Slow death*, p. 221.

own account and earn wages (and even sell their cloth at markets during certain times), paying masters a fee known as *murgu*.[14] The legal system surrounding slavery was thus flexible enough to accommodate the dry-season employment of rural slaves in the textile sector.

Marisa Candotti has shown that this handicraft industry remained dynamic during the 'protectorate': the early years of colonial rule following the British conquest of the Caliphate in 1903.[15] Indeed, the sector accommodated even the slow but momentous transition from slavery to free labour. Because in the pre-colonial nineteenth century textile handicraft work had been an occupation for both slaves and free artisans, there was no obstacle for former slaves to remain seasonal spinners or dyers.[16] The competitive nature of textile manufacturing in this textile belt led to concerted but failed attempts to stamp it out to provide a more welcoming market for Manchester. Early in the life of the British protectorate, the system of caravan tolls was changed to give a fiscal preference to British imported cloth, which was struggling to compete with the local variety. Tolls were abolished on imports but maintained at 15 per cent for Nigerian-made cloth, with the predictable effect that British cloth began to win market share. This discriminatory policy was soon abolished in favour of a policy of free trade, to the benefit of Nigerian producers.[17] Nigeria in particular was seen as a promising supplier of raw cotton because of its favourable climate and long history of cotton cultivation, and the British Cotton Growing Association devoted considerable energy and resources to pushing farmers towards cotton cultivation, and diverting their output from the local market to the export market, albeit with decidedly mixed success, as local cotton demand remained buoyant and the Association found it difficult to undercut locals.[18] Modern, capital-intensive textile manufacturing arrived in Nigeria only after the Second World War, when colonial authorities began to believe, in the face of growing anticolonial sentiment in Africa and elsewhere, that continuing colonial rule would depend on economic development and industrialization.[19]

The key message from the specialist historiography, then, is that, by the time the colonial railway reached Kano in 1912, northern Nigeria had a large and dynamic textile manufacturing sector, which had been protected by natural barriers to trade as well as by pre-colonial policy. There was, in short, scope for deindustrialization when the winds of global competition started to blow. The arrival of the railway is particularly meaningful because railways are often depicted as the main vehicle (literally and metaphorically) of deindustrialization in the global periphery. One of the emblematic technologies of the First Globalization, railway development dramatically reduced transport costs and promoted global market integration. For many backward economies (even more than for advanced ones), this meant both a substantial upward shift in their production function and a reorientation of their economies.[20] Within countries, the density of railway networks and their impact was different across regions, often leading to the reallocation of labour and capital between places, industries, and firms.[21] In the absence

[14] Lovejoy and Hogendorn, *Slow death*, pp. 203–7.

[15] Candotti, 'Cotton growing'.

[16] Candotti, 'Hausa textile industry'. The qualitative literature has documented cases of former slaves becoming free dyers; see Lovejoy and Hogendorn, *Slow death*, p. 221.

[17] Johnson, 'Cotton imperialism', p. 184.

[18] See in particular, Onyeiwu, 'Deceived'.

[19] Onyeiwu, 'Modern textile industry'; Maiwada and Renne, 'Kaduna textile industry'.

[20] Bogart et al., 'Growth contribution'; Herranz-Loncán, 'Transport technology'; Coatsworth, 'Indispensable railroads'; Summerhill, 'Big social savings'.

[21] See, for example, Donaldson, 'Railroads'; Jedwab and Moradi, 'Permanent effects'; Tang, 'Railroad expansion'.

of railways, high transport costs meant that regional differentiation in handicraft textiles was stark, as shown by Frederick's comparison of the Benadir coast and the inlands of Ufipa in East Africa.[22] The literature has not sufficiently considered, however, whether railways – which should in principle lead to regional convergence – could instead encourage deindustrialization in one part of a country while promoting industrial resilience in another. We argue that colonial rail in Nigeria had two opposing effects on local industry. The Kano railway opened up Nigeria to the mass-produced cloth of Manchester but also cut domestic transportation costs, enabling producers to more easily sell to Nigerian consumers. For Nigerian textile producers, the challenges of the former effect could, to an extent and for a time, be offset by the opportunities of the latter.

II | RECONSTRUCTING LOCAL MANUFACTURING

Foreign competition in the domestic market is the main channel for the deindustrialization of the periphery in Williamson's *Trade and poverty*. Cheaper, mass-produced imported cloth entering formerly protected (either by geography or tariffs) markets and the increasing global demand for raw materials and foodstuffs were, in Williamson's account, the two key forces behind industrial decline in the largest economies of Asia, the Middle East, and Latin America in the nineteenth century. The transportation revolution, in this perspective, was crucial to realize market integration and set the stage for Ricardian trade forces to operate on a global scale.

And yet Kano weavers remained convinced that the opening of the Lagos–Kano railway and the increasing imports of Manchester cloth would enlarge the market for their higher-quality, thicker cloth.[23] The Kano weavers, as well as insightful foreign observers, knew that the Ricardian assumption of homogeneity of tradeable goods does not always hold in segmented markets with superior goods, such as nineteenth- and early-twentieth-century cloth. As Elise van Nederveen Meerkerk argued for the case of Java, differences in cloth quality and local consumer preferences meant that the Ricardian forces of globalization ran into local limitations.[24] Similarly, Katharine Frederick argued that the sharp decline of handicraft textile production in Malawi and Tanzania in the late pre-colonial and colonial periods depended crucially on local conditions which made the deindustrializing impact of globalization forces much more potent than in West Africa.[25]

To test the impact of trade and competition on northern Nigerian textile manufacturing at a local level, we transcribed the returns of 79 surviving district assessment and reassessment reports from the early colonial period. These were written by British district officers who toured the countryside and met with local village heads, and were then submitted to the colonial 'Resident' (administrator) of each province. The reports contain district-level (and sometimes village-level) data on employment, among other variables. Their geographical coverage is patchy, as is their chronological distribution, ranging from 1910 to 1930, making it impossible to construct time series, but allowing for a snapshot of economic activity at the district level in the early colonial period. These primary sources are held at the National Archives, Kaduna, and at the Kano History Bureau, and have been recently digitized by a team of researchers led by Mohammed

[22] Frederick, *Twilight*, pp. 142–4.

[23] Morel, *Nigeria*, pp. 239–40. As Kobayashi, *Indian cotton textiles* has shown, this consumer preference for high-quality cloth was found in northern Nigeria and across West Africa more generally during the pre-colonial nineteenth century.

[24] van Nederveen Meerkerk, 'Challenging the de-industrialization thesis', p. 1222.

[25] Frederick, 'Global and local forces'.

Salau.[26] These reports have been studied before, especially during the 1970s and 1980s, by scholars who used them chiefly to illustrate their arguments with concrete examples at the local level.[27] While care must be employed in using what are undoubtedly imperfect African colonial statistical sources,[28] we believe that the textile occupational data contained within the assessment reports is likely of a reasonable accuracy, since textile income formed part of the tax base and, under 'indirect rule', local officials had an incentive not to undercount revenue, since it was shared with local authorities. Northern Nigeria was the most 'indirectly ruled' of all British colonies in Africa. Local administration and even judicial systems remained largely controlled by the emirs, as evidenced by the timid British policy towards slavery.[29] Indeed, the theory of 'indirect rule' itself was coined by Frederick Lugard, northern Nigeria's last governor and later first governor-general of Nigeria as a whole.[30]

We try for the first time to make systematic use of the quantitative data available in these reports to construct evidence of change in male manufacturing employment in the colonial period. We do so by linking the assessments' data with the occupational returns from the 1952 census referring to the same provinces, which we georeferenced using historical maps. The 1952 census did not distinguish between textiles and other manufacturing, but we know from the assessment reports that textile work represented the vast majority of manufacturing work in the colonial period. Given boundary and name changes, we were able to link and map only 38 districts of the total for which we have surviving reports (figure 1). Additionally, we also calculated the distance from each district's centroid to the nearest railway station (there were 20 such stations in colonial northern Nigeria) and to Kano (the main city before and during colonial rule). Distances are not simply straight-line distances ('as the crow flies'). Rather, they reflect the least-cost path of travel calculated considering topographical obstacles to mobility, following Özak's estimates (details in the online appendix).[31] We additionally included potential yield for groundnuts (the main export crop in the period) and millet (the main food crop), taken from the Food and Agriculture Organization of the United Nations (FAO) Global Agro-Ecological Zones (GAEZ)'s baseline estimates for low-input, rainfed agriculture (table 1). Unfortunately, we lack district-level employment data for women.

III | MARKET INTEGRATION AND INDUSTRIAL DECLINE

We argue that the deindustrialization thesis, in its starkest terms, contains a falsifiable proposition. If railway-led market integration was lethal to northern Nigerian manufacturing, as the deindustrialization thesis would suggest, then we would find the rate of decline in crafts' employment to be higher in districts close to railway stations. We would expect handicraft producers in districts which remained 'naturally' protected by distance to be more resilient. To offer a measure

[26] The project was funded by the British Library as part of the Endangered Archives programme (grants EAP 087 and EAP535; see https://eap.bl.uk/project/EAP087 and https://eap.bl.uk/project/EAP535).

[27] See Hill, *Rural Hausa*, pp. 236–7, 62; Watts, *Silent violence*, pp. 588–600; Shea, 'Dyed cloth', pp. 59–78.

[28] See, e.g., Westland, 'How accurate are the prices'.

[29] Lovejoy and Hogendorn, *Slow death*, pp. 101–8.

[30] Crowder, 'Indirect rule'.

[31] Özak, 'Distance'. The results of our analysis remain substantially the same if we use simple straight-line distances instead.

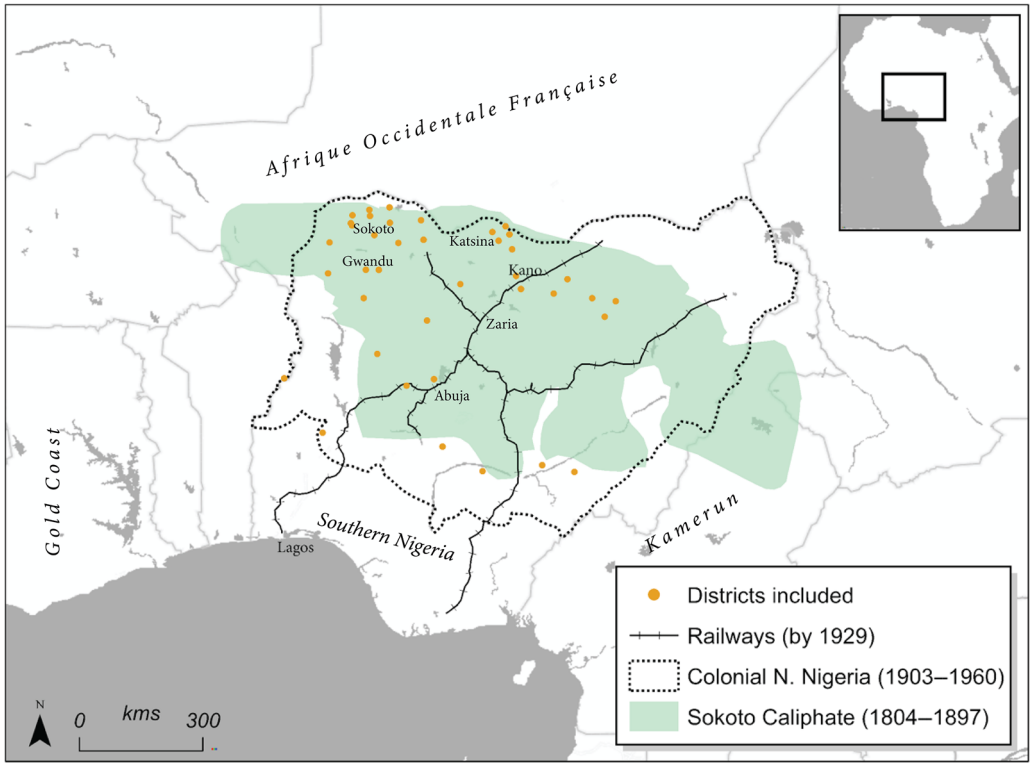

FIGURE 1 Centroid location of 38 districts under study. *Note*: Locations georeferenced by the authors on the basis of historical maps. *Sources*: Survey Department, Lagos: 'Forest Reserve Map of Nigeria', 1952; Northern Nigerian Survey: 'Northern Nigeria: Native Authority Areas', 1962; Geographical Section General Staff: 'Nigeria and part of Tchad' (n° 2871), War Office, 1943. Extent of Sokoto Caliphate taken from Ajayi and Crowder, *History*. [Colour figure can be viewed at wileyonlinelibrary.com]

TABLE 1 Descriptive statistics for the 38 districts under study, 1910s to 1952.

	Mean	Standard deviation	Min	Max
Industrial decline (yearly %)	1.2	2.9	−5.8	6.2
Distance to railway station (km)	123.3	63.5	6.6	249.4
Population growth (yearly %)	1.9	1.8	−2.2	6.6
Groundnut potential yield (tons/ha)	0.32	0.12	0.16	0.73
Millet potential yield (tons/ha)	0.42	0.13	0.15	0.70
Latitude (degrees north)	11.7	1.7	8.0	14.0
Longitude (degrees east)	6.7	2.0	3.0	11.0
Distance to Kano (km)	326.6	161.1	15.9	655.6
Elevation (metres above sea level)	326.8	113.9	106.7	542.6

Note: Industrial decline is measured as the compound yearly rate of decrease in total male employment in crafts, so a negative 'decline' value means growth in male craft employment.

Sources: District Assessment Reports (National Archives Kaduna and Kano History Bureau), Census of Northern Nigeria 1952, FAO-GAEZ database, ESRI world elevation services, and figure 1.

TABLE 2 Explaining industrial decline (cumulative yearly decrease in male craft employment, in %) across northern Nigerian districts.

	Dependent variable: industrial decline
Distance to the nearest railway station (km)	0.019**
	(0.007)
Population growth (yearly %)	−0.889***
	(0.232)
Groundnut potential yield (tons/ha)	2.125
	(4.085)
Geographical controls	YES
Observations	38
R^2	0.42
Adjusted R^2	0.31
F-statistic	3.8***

Note: Observations are northern Nigerian districts. Results were obtained by estimating Equation (1) using the decline in male craft employment between the 1910s and 1952 as the dependent variable. Geographical includes elevation, latitude, and longitude. *Sources*: Table 1.

of the effects of trade openness (as a result of modern transport) on manufacturing employment, we estimate an ordinary least squares (OLS) model in the following form:

$$y_i = Constant + \beta_1 RailStation_i + \beta_2 GroundnutYield + \beta_3 PopGrowth + \gamma X_i + \varepsilon_i \quad (1)$$

On the left side of Equation (1), the dependent variable y_i measures the cumulative rate of decline in the male workforce in crafts between the early colonial period (the actual year varies by district) and 1952. Larger values indicate more decline.[32] On the right side, the main independent variables of interest are $RailStation_i$, which measures the linear distance (in kilometres) between district *i* and the nearest railway station; $GroundnutYield_i$, which measures the potential groundnut yield (in tons per hectare) in district *i* for low-input, rainfed agriculture (historical baseline trend); and $PopGrowth_i$, the cumulative rate of growth of total population in the district in the same period considered for the dependent variable. *X* is a vector of geographical control variables, and ε is an error term. Controls include elevation as well as latitude and longitude, to account for hidden spatial patterns; latitude in particular serves as a proxy for ecosystems, which changed from the southern border between the savanna and the forest belt to the shores of the Sahel.

Table 2 and figure 2 present the results of the model in Equation (1). These suggest that local handicraft producers could benefit from market integration more than the deindustrialization thesis acknowledges. The United Africa Company delivered Manchester textiles and other man-

[32] We are confident that what was considered 'crafts' in these sources is to a very large extent analogous to handicraft manufacturing, of which textiles were by far the largest sector. While a full list of occupations was not included in 1952, previous colonial censuses (1921 and the 1931 'intensive census') did provide enough detail. The only occupation that could be considered a 'service industry' and was included under crafts were butchers (as they were effectively maker–sellers), who represented only 6% and 8% of total male craft employment in those years, whereas textile workers accounted for 60% of male craft employment.

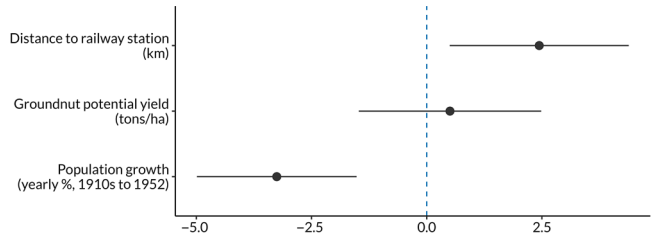

FIGURE 2 Explaining regional differences in industrial decline in northern Nigeria, *c*. 1911–52 (all districts with complete data, $N = 38$, $R^2 = 0.42$). *Note*: Results obtained by estimating Equation (1) using the cumulative yearly decline in male crafts employment as the dependent variable. Whiskers indicate the 95% confidence intervals. Geographical controls included: elevation, latitude, and longitude; distance to Kano was dropped due to collinearity with latitude and longitude. To facilitate interpretation, the coefficients are rescaled by twice their standard deviation in the dataset (on this method, see Gelman, 'Scaling'). Sources: Table 1.
[Colour figure can be viewed at wileyonlinelibrary.com]

ufactures at each railway station, so the foreign competition in the domestic market should have had a larger effect on industrial decline the closer a district was to a station. And yet we find the opposite. Rates of decrease in manufacturing's share of male employment were larger the further away a district was from a railway station. Consider two hypothetical districts observed in 1932: identical, except that district A is 130 km (approximately two standard deviations) further from a railway station than district B. Assigning such that both districts are at the mean of all other variables, by 1952 male employment in crafts in district A would be 50 per cent lower than in district B. A valid concern regarding the interpretation of these results is that they might be the net effect of compositional change within manufacturing employment. Perhaps looms did go quiet(er) near railways, while other industrial activities, such as smithing, prospered. However, the evidence on the persistently large scale of total handicraft cotton production in northern Nigeria (estimated by contemporaries as producing about 50 million square yards per year across the mid- to late-colonial period) leads us to believe that the resilience of craft employment was not achieved in spite of textile work, but through it.[33]

There are other limitations to this empirical exercise. The sample size is unavoidably small, and we cannot rule out the possibility that districts which saw less deindustrialization enjoyed higher population growth due to the fact that their economies were more buoyant. It might also be expected that population growth was significantly higher in places closer to the colonial railway, though this was not in fact that case. Though there is a positive correlation between the two variables, it is not strong (a correlation coefficient of 0.19) and is statistically insignificant ($t = 1.3896$).

Our finding that industrial decline was much less severe (or even non-existent) in districts closer to railway stations is supported by occupational data at the level of provinces. In the core regions of textile production in the centre-north of Nigeria, the absolute number of people working in textile production did not decrease during British rule, and there was, at least until 1931, an effective reallocation of female labour into manufacturing, both in absolute and relative terms.[34] Pre-existing patterns of regional specialization persisted, and indeed were deepened. Resilience predominated in the 'textile belt', and industrial decline dominated elsewhere.

[33] On estimates of handicraft cotton production in northern Nigeria, see de Haas, 'How well'.

[34] Travieso and Austin, 'Occupational structures'.

To use Clingingsmith and Williamson's terms, there was a regional divide between areas of 'weak deindustrialization' (or, we prefer to say, handicraft resilience), where manufacturing's share of employment fell, but no jobs were lost, and areas which went through 'strong deindustrialization' (an absolute fall in industrial employment).[35]

The quantitative literature has studied the economic impact of African colonial railways before, though mostly through a focus on social savings[36] and on agricultural output and urbanization.[37] The impacts of railways on market integration has been examined in other contexts, but not yet for colonial Africa. The two most important justifications for the considerable capital cost of railways from the point of view of colonial governments were the ability to move soldiers into the interior and the ease of evacuating cash crops such as groundnuts. But railways also carried other freight, and expanded the market for local producers of cotton cloth. Given the high cost of transport by other means, proximity to a railway station would have conferred a very strong competitive advantage on producers.

IV | REASONS FOR RESILIENCE

How were local producers able to weather the storm of competition from Manchester? The most immediate mechanism linking proximity to a railway station with industrial resilience were consumer preferences and market segmentation. Access to railways boosted rural incomes (as a result of the expansion of export agriculture),[38] and thereby demand for sophisticated textiles – a segment of the market in which local producers could and did outcompete factory-made imports. As Roy has argued for the case of Indian handicraft textiles, while machines in the early twentieth century could technically produce complex patterns on cloth, local hand-weavers could more effectively cater to consumer taste.[39]

Furthermore, markets near a railway station could supply a range of foreign commodities, which could lead to economies of agglomeration. More people (and from further away) would come to the local weekly market, resulting in the concentration of demand for high-end goods, including locally made cloth. As the Kano weavers had foreseen, and as Roy argues happened also in contemporary India, initially the railways were a force of globalization that helped rather than hindered local handicraft textiles.[40] We do not have district-level data on the demand for British textiles across different segments of the textile market, but the information we do have suggests that northern Nigerian consumers largely disregarded British printed cloth, but bought large quantities of cheap, plain foreign textiles. While northern Nigeria received 40 per cent of all plain 'shirtings and bafts' sold by the United Africa Company in West Africa in 1948–9, its around 20 million inhabitants accounted for only 5 per cent of print cloth imports into West Africa.[41]

[35] Clingingsmith and Williamson, 'Deindustrialization'.

[36] Herranz-Loncan and Fourie, 'For the public benefit'.

[37] Jedwab and Moradi, 'Permanent effects'; Jedwab, Kerby, and Moradi, 'Path dependence and development'.

[38] Hogendorn, *Nigerian groundnut exports*, pp. 105–7.

[39] Roy, *The crafts*, pp. 12–14.

[40] Ibid., pp. 50–4; Frankema and Jerven, 'Writing history backwards'.

[41] The United Africa Company Limited, Statistical & Economic Review, no.6 (Sep. 1950): Merchandise Trading in British West Africa, p. 20.

TABLE 3 Part-time work in textiles and other crafts, Maska District, 1923.

Occupation	Percentage of part-time workers ('also engaged in farming')
Dyers	96%
Weavers	98%
Smiths	98%
Barbers	69%
Butchers	98%

Source: Authors' calculations on the basis of Maska District Katsina Emirate Re-Assessment Report (1923), National Archives Kaduna, BL EAP 535/4/3/5, Appendix III.

While quality and consumer taste greatly mattered, we argue that the main reason for both the absolute resilience and the relative decline of handicraft textiles lies in the complementarities of artisanal manufacturing with agriculture in the seasonal savanna climate. As Frederick and van Nederveen Meerkerk have argued in a comparative study, seasonality is crucial to understanding the prospects for local textile production in times of globalization.[42] During the agricultural season, labour was scarce and land (relatively) abundant. Once the harvest was in, however, factor ratios reversed. The quality of African manufactured output, which was much remarked upon by contemporaries, is intimately linked to seasonal factor ratios. As Austin has argued, production techniques, such as the choice to use narrow looms, even when the technological possibility of broad loom weaving was available,[43] can be explained in large part by these seasonal swings. Given labour's cheapness, using it intensively to create high quality products was a more efficient use of other scarce inputs (such as cotton, indigo and capital).

The assessment reports indicate that much of the textile production of northern Nigeria was part-time work. Tax data from the Kano Province district of Maska in 1923, for example, suggests that across the 18 villages in the area only 4 per cent of dyers worked full time at this occupation, and only 2 per cent of weavers (table 3).[44] The rest all combined their textile production with farming. These composite livelihood strategies were not unique to handicraft textiles, as they also shaped work in other crafts. That much production came from the hands of part-time weavers and dyers is well established in the scholarly literature on northern Nigerian textiles, and Marion Johnson suggested that this helped to explain how handicraft producers had managed to compete with imports.[45] Of course, in Kano itself and probably in other large centres, there were full-time textile workers, who earned considerable incomes and were probably responsible for a significant, though hard to quantify, share of overall production. The assessor of Kano Town reported in 1921 that incomes from any craft in Kano were twice as high as the same craft practised in rural areas (in his view, because of the premium that the Kano brand could command in the market), which helps to explain why full-time, professional weavers could afford to devote themselves to the craft throughout the year.

How can we test the seasonal complementarity between agriculture and handicraft textile production in this savanna economy? A rare piece of microdata – 'micro' both in the sense that it

[42] Frederick and Van Nederveen Meerkerk, 'Local advantage'.

[43] Austin, 'Resources'.

[44] BL, EAP 535/2/4/3/5.

[45] Johnson, 'Technology'.

is at the level of the individual, and that the sample size overall is small – allows us to examine the relationship between textile by-employment and agricultural cultivation. The data come from a tax assessment report from 1934 of the smallish Kalgo district in Gwandu Division, in northwestern Nigeria, close to the border with Niger and Benin.[46] The assessment apparatus was gradually implemented to allow the administration to levy a tax on all economic output, an approach inspired by but not copied directly from the system of permanent settlement instituted in British India.[47] Assessment reports were typically based on the measurement of farms and of output, usually by selecting a sample of farms and extrapolating from those results. In addition, assessment officers counted the number of 'industrialists', meaning usually those who worked in the dry season at some other occupation such as weaving, dyeing, matmaking, and similar handicraft occupations. Often, the assessment reports would give a sketch of the average income of each class of industrialist.

Kalgo district was atypical of the northern provinces of Nigeria due to the large amount of well-watered floodplain known as *fadama* (Hausa for 'marsh', implying rich soil), thanks to its enviable position straddling the Sokoto River. Farmers who had access to *fadama* would grow rice on it during the rainy season. After it had been harvested, they would then plant crops of onions or other high-value vegetables and fruits. Rice was traditionally the main cash crop being exported southwards from this part of northern Nigeria, as well as being a local food staple in the floodplains of the Sokoto–Rima basin.[48] Continuous cultivation of the *fadama* areas (low-lying lands subject to seasonal flooding) was crucial to the region's economy since at least the nineteenth century, when European travellers marvelled at the techniques of irrigation in place.[49] *Fadama* land was cultivated with rice in the rainy months (July–September) and then with irrigated crops (such as sweet potatoes, cotton, indigo, tobacco, onions, and cassava) in the dry season. A 1980 study of Birnin Tudu, also in the Sokoto–Rima basin, found that rice was grown only in *fadama* land, and 79 per cent of plots in which rice was grown during the rainy season engaged in dry-season cropping.[50] We therefore use the yearly output of rice by a household farm as a proxy of effective access to *fadama* land allowing farmers to sow crops in the dry season. Dry-season cultivation was significantly more labour intensive than wet-season cropping, as it relied on daily watering from October to April. Swindell estimated that the average man-hours of work required were three times greater.[51] We therefore expect that dry-season cultivation would be incompatible with textile employment, which was also labour intensive.

The survey gives individual-level data on crop production and industrial by-employment for around 200 farmers from seven areas. The dataset is composed of 212 taxpayers, and lists how much each harvested of corn, cassava, rice, sweet potato, groundnuts, indigo, and cotton (though not all crops were listed for each village, presumably because they were not grown in any of the farms of that village's sample). In the sample of individuals documented, yearly industrial income accounted for £154, which represented 22 per cent of aggregate income (around £628). Table 4 offers descriptive statistics for the local microdata. Overall, in Kalgo district, around 10 percent

[46] BL, EAP 535/2/6/61.

[47] Newbury, 'Accounting for power'; Pierce, 'Looking for the legal', p. 180.

[48] Swindell, Iliya, and Mamman, 'Making a profit', p. 386; Swindell, 'Population and agriculture', p. 86.

[49] Swindell, 'Population and agriculture', pp. 89, 99–100.

[50] Adams, 'Traditional agriculture', pp. 34, 37.

[51] Swindell, 'Population and agriculture', p. 101.

TABLE 4 Summary statistics: individual-level agricultural output from villages surveys in Kalgo district, Gwandu region, 1934.

	N	Mean	Standard deviation	Min	Max
Millet (30 lb bundles)	212	56.170	27.207	5	210
Groundnuts (40 lb bundles)	212	0.132	0.945	0	10
Cassava (50 lb bundles)	212	10.179	13.659	0	80
Cotton (20 lb bundles)	212	0.184	0.814	0	7
Indigo (40 lb bundles)	212	2.358	11.524	0	100
Tobacco (10 lb bundles)	212	0.108	0.861	0	10
Rice (55 lb bundles)	212	8.797	12.873	0	50
Sweet potato (50 lb bundles)	212	0.108	0.856	0	10
Textile by employment (dummy)	212	0.297	0.458	0	1

Sources: Individual assessment reports, Kalgo district, Gwandu division, 1934. National Archives Kaduna. EAP535/2/6/61.

of output was in some way 'industrial', or at any rate non-agricultural. The individual income specimens suggest that weaving occupied workers from 7 to 10 months per year.

The data was collected during the worst of the Great Depression, when agricultural prices and incomes in northern Nigeria were in sharp decline at the same time as the colonial state attempted to increase the fiscal burden on northern Nigerian taxpayers. The slump seems to have been felt in Kalgo, with the arrival of the railway in nearby Birnin Kebbi in 1929 exposing the district to global market forces. The 1934 Kalgo re-assessment argued that there had been a remarkable falling away of industrial profits in the district: 'incomes from these sources [industrial occupations] do not compare with what was usual some five years ago'. Elsewhere in the report, the reporting officer writes that 'most industries, especially in out-villages, render only a fraction of the returns customary a few years ago'.

We have two simple claims to test. First, no matter how large a farmer's earnings from millet were during the rainy season, this kind of agriculture should not have made the farmer any less likely to engage in textile by-employment during the dry season (the 'no crowding out' hypothesis). Second, the possibility of dry-season agriculture should have made a given farmer less likely to engage in textile employment during the dry season, on the assumption that agricultural productivity was high enough to divert labour towards farming if the technology existed to overcome the lack of rain (the 'competition for labour' hypothesis).

This point generalizes that any dry-season work that was more remunerative than handicraft textiles will have acted as a driver of deindustrialization. As the colonial economy developed, opportunities for dry-season work increased, particularly in the services sector, and through seasonal migration (which had long been a part of the northern Nigerian economy). Deindustrialization was an interplay between the (revenue) productivity of textile handicrafts on the one hand and the opportunity cost of that activity on the other. Access to *fadama* increased the latter, but so too would other dry-season employment. New economic opportunities for rainy-season work, however, would not have crowded out textile handicrafts. This, for example, is true of the groundnut boom, which, by raising farmers' incomes, may have enlarged the demand side of the textile market rather than diverting labour away from the supply side. For this reason, we believe that our results – though limited, of course, in space and time – provide evidence for broader forces shaping deindustrialization and resilience.

TABLE 5 Marginal effects of yearly crop production on an individual's likelihood of textile by-employment ($N = 212$ households in villages of Kalgo district, Gwandu region, 1934).

	MODEL 1	MODEL 2
Millet output (30 lb bundles)	0.001	−0.0001
	(0.002)	(0.001)
Rice output (55 lb bundles)	−0.017***	−0.009**
	(0.005)	(0.004)
Groundnut output (40 lb bundles)	−0.009	−0.041
	(0.008)	(0.042)
Other crop output (value in pence)	−0.031	−0.069
	(0.190)	(0.252)
Village dummies	NO	YES
Observations	212	212
RMSE	0.42	0.39

Notes: Observations are individual farmers. Robust standard errors in parentheses.
***, **, and * denote significance at the 1%, 5%, and 10% levels.
Sources: Table 3.

In practice, we estimate the likelihood of a farmer having a textile by-employment as a function of four key variables: the farmer's millet yield, his rice yield, his groundnut yield, and the yields for his complementary crops. The millet yield is a proxy for the farmer's ordinary rainy-season cultivation possibilities, while the (rainy-season) rice yield reflects access to *fadama* land on which secondary crops can be grown in the dry season. If our claims are correct, then the coefficient on the first variable should not be significant (or, if it is, it ought to be positive and not negative), while the coefficient on the second should be negative and significant.

To test these claims, we estimate two models. In the first, we simply pool all observations and estimate the likelihood of textile by-employment with a probit estimator. In the second, we add village-level dummies to account for unobservable local characteristics which could have explained a larger or smaller likelihood of handicraft employment. To ease interpretation, table 5 reports the marginal effects, which measure the change in the probability of textile by-employment for the average observation as a result of a unit-change in each explanatory variable. Heteroskedasticity in the data is controlled by estimating White standard errors, which are reported in parentheses. Figure 3 further facilitates interpretation by rescaling the marginal effects of predictors by twice the standard deviation of these variables in the dataset.

When we estimate the likelihood of dry-season employment, we find no evidence of a positive correlation between the likelihood of dry-season employment and the size of the millet crop. This finding is consistent, we stress, with our argument that rainy-season agriculture did not pose a threat to northern Nigeria's industrial base. We do find strong evidence of a negative relationship between dry-season employment and the cultivation of rice, which we argue is connected with the ability to cultivate *fadama* land – producing rice in the wet season and other crops in the dry. This effect remains significant when we add dummy variables for the individual villages, suggesting that even within villages, *fadama* owners were less likely to have dry-season work in textiles. Importantly, this also shows that *fadama* land is not simply standing in for hidden spatial effects or unobservable village characteristics. Both the 'no-crowding out' and the 'competition for labour' claims find support, therefore, in the microdata from Gwandu. This provides evidence in

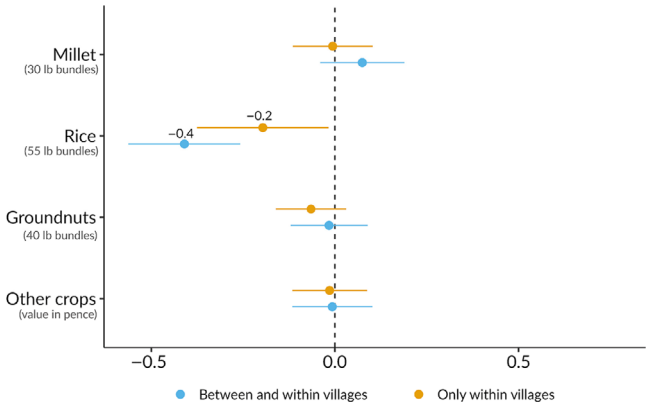

FIGURE 3 Marginal effects of yearly crop production (in bundles) on the likelihood of individual textile by employment, with (orange) and without (blue) village-level dummies. *Notes*: Whiskers show 95% confidence intervals, calculated with robust standard errors. Effects for continuous variables are rescaled by twice the standard deviation of the variable in the dataset (as per Gelman, Scaling). Sources: Table 2.
[Colour figure can be viewed at wileyonlinelibrary.com]

favour of the idea that the reason for resilience was the low opportunity cost of labour in the dry season. 'Technologies', such as *fadama* ownership, that raised that opportunity cost would have fundamentally undermined handicraft textiles in a way that foreign imports appear not to do.

The bulk of rural northern Nigeria did not have access to the kind of dry-season agricultural opportunities that existed in some of the Kalgo district. Our results suggest that, if they had, textile manufacturing might have suffered a more precipitous decline (or indeed never gotten off the ground). Instead, the low opportunity cost of labour outside of the agricultural season made spinning, weaving, and dyeing economically feasible. One limitation of this kind of analysis is that we cannot account explicitly for dry-season migration. This was a phenomenon with a long history in northern Nigeria and the Sahel in general, described evocatively by the Hausa term *cin rani*, or 'eating the dry season'.[52] The opportunity cost of labour in the dry season was not circumscribed by local productive opportunities. Farmers could migrate seasonally to towns or cities to find work. We also know that seasonal migration increased in the early-colonial period, in a context of rising cash-crop exports and emancipation from slavery.[53] It is possible, though we would argue unlikely, that our results could be overturned if those who cultivated rice on *fadama* land in the rainy season migrated to towns in the dry season to work in textile handicrafts. While we think this is unlikely since it would mean leaving valuable land uncultivated. If such migration existed, then it would still conform with the findings of section III – that is, that textile manufacturing was more resilient in the kinds of places connected to the railway, which tended to be more urban, than it was in more marginal, distant areas of northern Nigeria such as Kalgo district.

The deindustrialization thesis finds no support in the northern Nigerian savanna. But neither can we say that there was much potential for the industry to form the basis of a modern textile manufacturing sector. While weavers and spinners proved resilient to globalization, local textile manufacturing did not lead – and almost certainly could not have led – the way to

[52] See, e.g., Rain, *Eaters*; Swindell, 'Farmers, traders and labourers'.

[53] de Haas and Travieso, 'Cash-crop migration systems'.

self-sustained growth and structural change. The adoption of large cement-lined dye-pits is an indication that technological change was possible in the pre-colonial Caliphate, and later the use of tinned indigo and imported yarn shows that even under colonial rule the industry was flexible enough to adopt substitutes that were cheaper or more reliable. The development of a kind of putting out system among dyers in some parts of Kano emirate, directed by cloth merchants, also suggests that there was entrepreneurial capacity among the Kano elite, who could have imported modern spindles or looms. Yet, it took until after the Second World War for modern equipment such as power-looms to be imported in any number into northern Nigeria. By then the widespread practice of wife seclusion had created a theoretically large workforce for labour-intensive textile work, but seclusion physically prevented the establishment of factories to exploit it.[54] The factories that were established relied mainly on male labour, and in any case enjoyed mixed success, as did British colonial attempts to modernize traditional weaving.[55]

Why were northern Nigerian handlooms not a starting point for industrialization? The factor ratio reversals were both a refuge and a trap. On the one hand, the low opportunity cost of labour and hence low reservation wage in the dry season partially shielded handicraft manufacturers from full competition with more technologically advanced countries. On the other hand, it made labour specialization and, perhaps more crucially, domestic technological progress less likely, since capital investments would have to recoup their costs while operating (measured over 12 months) well below their theoretical capacity. As others have argued elsewhere, seasonality has implications for the optimal structure of industry also in temperate regions. For example, the dominance of centralized factories in the nineteenth century United States may have been a consequence of its 'balanced' seasonal calendar, in contrast to the more sharply seasonal pattern of industrial production in England, where cottage industry survived much longer and more extensively.[56] As Postel-Vinay found for nineteenth-century France, less capital-intensive firms found it easier to release labour to agriculture during peak harvesting seasons.[57] But the impacts of seasonality are much starker in the arid tropics, even if much of the literature on macro-development in tropical areas of the world to date has suffered from a lack of emphasis paid to the agricultural and broader economic consequences of the seasonality of precipitation.[58] Rainfall patterns had complicated effects on the 'proto-industrial' potential of northern Nigerian handlooms. The low opportunity cost of labour in periods of low rainfall allowed the industry to survive, while the high opportunity cost of labour during the rainy season acted as a brake on industrial development. As Yarri Kamara has argued recently, Nigerian textiles suffered from a problem of the 'missing middle'.[59] In Nigeria there did not develop, as there did in India, a 'weaver capitalist' class that could adopt foreign technology and adapt it to the conditions of local Nigerian production. Northern

[54] The precise temporal evolution of the incidence of *kulle*, or wife-seclusion, in Hausaland is still not fully documented, though it certainly increased dramatically in the twentieth century. (Porter, 'Note on slavery'; Fisher, 'Slavery and seclusion'; Cooper, 'Reflections on slavery'.) A widely – though not universally – accepted thesis is that agricultural work was considered something that only enslaved women practised, and that emancipation and growing incomes from cash cropping allowed the practice of *kulle* to expand. There is much evidence that secluded women's involvement in handicraft production. See, e.g., Callaway, 'Ambiguous consequences', p. 441; Hill, 'Hidden trade'.

[55] Kilby, *Industrialization*, p. 312.

[56] Sokoloff and Dollar, 'Agricultural seasonality'.

[57] Postel-Vinay, 'Traditional labour markets'.

[58] Roy, 'Arid tropics'.

[59] Kamara, 'Nigerian agbada fabric'.

Nigerian producers were capable of innovating to meet changing market demand, as can be seen in the growth of the production of *adire* cloth in the 1940s and 1950s to meet the new fashion for it.[60] But technology remained largely stagnant.

V | CONCLUSION

In his study of pre-colonial African manufacturing, Thornton argued that the competition with European imports was not merely one between advanced and underdeveloped producers but rather between hand-made products produced by highly skilled craft workers and mass-produced, factory-made European goods.[61] While European manufacturing technology and infrastructure became increasingly efficient in the late-nineteenth and early-twentieth centuries, our study shows that it did not completely displace local production. We have tried to systematically test the 'deindustrialization of the periphery' thesis in a savanna context by exploiting cross-sectional regional variation in industrial employment across northern Nigeria, Africa's largest pre-colonial manufacturer. The analysis of the district-level data, complemented with individual-level micro-data from village surveys, revealed that the workshop of West Africa was not swiftly blown away in a storm of British competition during the colonial period. Northern Nigerian handicraft producers continued to import yarn and thread, to employ hundreds of thousands of workers, and to produce quality cloth, outcompeting British imports at the high-end of the market.

Our paper contributes to a growing literature on the possibilities of industrial growth in the arid tropics.[62] During the colonial period in northern Nigeria, transport infrastructure and the forces of globalization, epitomized by the arrival of the railway to Kano, interacted in specific ways with the tropical seasonality of rainfall – and thus of agriculture and handicraft manufacturing. As a general rule, and contrary to colonial blueprints, we find that proximity to a colonial railway station did not cause deindustrialization; rather, it was strongly associated with handicraft resilience. Moreover, our analysis suggests that railways could have different implications for the structure of employment depending on whether rural producers had access to agricultural land allowing for continuous cultivation also in the dry season, such as *fadama*. Railways enlarged the market for both high-quality local cloth and for cash crops. While the agricultural export economy grew the fastest, the effect on sectoral employment depended on how the local geography interacted with the rainfall seasonality. Where opportunities for cash-cropping extended to the dry season we would expect less craft by-employment to begin with and less handicraft resilience. Where, as in large parts of northern Nigeria, there was less opportunity of dry-season cash-cropping and thus a lower opportunity cost of manufacturing labour, the arrival of the railway could encourage handicraft resilience and cash-cropping, rather than promoting strong deindustrialization.

Integration with the international economy under colonial 'indirect rule' strengthened northern Nigeria's comparative advantage in extensive agriculture, and so the agricultural export economy grew faster than other sectors, including domestic manufacturing. But the looms did not go quiet after the railway reached Kano. In fact, districts which were more closely integrated with the international economy saw a smaller relative decline in manufacturing's share of employment. While, in the late-twentieth and early-twenty-first century, Nigerian manufacturers struggled

[60] Renne, 'Reinterpreting'.

[61] Thornton, 'Precolonial African industry', p. 14.

[62] Roy, 'Arid tropics'.

with Chinese competition, history shows that they were once able to hold important segments of their large domestic market and, as population continues to grow and labour costs fall, may succeed in doing so again in the future.

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DATA AVAILABILITY STATEMENT

The data that supports the findings of this study are available in the supplementary material of this article.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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