Quantifying spillover effects from large farm establishment: The case of Mozambique

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Quantifying spillover effects from large land-based investment: The case of Mozambique

Abstract: Almost a decade after a spike in land demand following the 2007/08 commodity boom, evidence on impacts of this phenomenon remains limited and mostly case study based. We show that information on location and start data of large farms, combined with existing smallholder farm surveys, allows to complement this with a difference in difference approach to systematically assess spillovers from large farm establishment. Illustrative application to Mozambique suggests positive short-term effects from newly established large farms on adoption of agricultural practices and input use by small farms less than 50 km from newly established large operations. Robustness checks for crop farms only also suggest job creation in the proximity of newly established crop, but not livestock farms. Yet, large farm establishment decreased perceived well-being within a 25 km band and, in the time horizon considered here, did not lead to better access to output markets, cultivation of larger areas or, once other factors are controlled for, higher yields. This allows us to reject the notion of negative spillovers from large farm establishment but casts doubt on the wisdom of large unconditional subsidies to attract investors. In addition to drawing policy conclusions for Mozambique, we highlight the methodology's wider applicability and scope for expansion.

JEL Classification: O13, Q12, Q15

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1. Introduction

The 2007/08 food price spike, together with the recognition that a number of countries had large amounts of seemingly unoccupied or unclaimed land triggered an enormous increase in private sector demand for agricultural land (Deininger and Byerlee 2011) and implicitly water (Rulli *et al*. 2013) to satisfy demand for food, fuel, and fiber. Though often denounced as 'land grab' (Hall 2011; Pearce 2012), this phenomenon, which was most acutely felt in Africa (Anseeuw *et al*. 2012), also gave rise to hopes for private capital to complement public investment to make up for decades of underinvestment in agriculture. This, it was argued, could provide a stepping stone towards more rapid rural development and poverty reduction for countries with ample land that remain heavily dependent on agriculture (Collier and Dercon 2014).

A key argument in this debate relates to spillover effects associated with such investment. Supporters note that, via discovery of agro-ecological suitability and provision of demonstration effects to provide local people with new technology and access to credit, input, and labor markets, 'pioneer investors' can generate positive spillovers. In fact, beyond a desire to reduce transaction costs and informational asymmetries, the view that public subsides may be justified as long as they do not exceed the net present value of the stream of spillover benefits generated (Collier and Venables 2012), provides a rationale for agricultural investment promotion agencies all over the world. Critics retort that, especially if subsidies are in the form of cheap land, they may be regressive or attract speculators rather than pioneers who may monopolize factor markets or encroach on land or water resources to which they have no right and which provided a source of livelihood for local populations, causing negative spillovers ((Borras and Franco 2012).

While empirical evidence on the sign and magnitude of spillover effects from large farm establishment in different contexts will thus be of great policy relevance, systematic studies of this topic remain scant. This paper aims to contribute to closing this gap in three ways, namely by (i) presenting a methodology that allows to address this question in ways that build on existing data and generate incentives for their improvement; (ii) applying this methodology to (far from ideal) data from Mozambique to quantify such spillover effects and their spatial reach; and (iii) draw out implications for future data collection and research efforts to increase the precision and policy relevance of such results.

We assume large farms may benefit neighboring small producers by providing employment; access to markets for inputs and output as well as possibly credit; or knowledge of improved techniques that will affect yields. Conversely, large farm can also have negative effects, e.g. by displacing small producers, unauthorized encroachment on land they used earlier; or by large farms acting in monopsonistic ways. We assume spatial proximity to be the main channel for spillover transmission, e.g. via learning about new technology or functioning of local factor markets. While nature and size of such effects will depend on a host of factors including the type of large farm operation (ranching or crop production) and type of crops grown; length of interaction, contractual arrangements, and large farm operators' attributes (e.g. CSR-type activities), we estimate mean effects of large farm establishment on neighboring smallholders using a difference in difference strategy (DID) that focuses on changes over time in the number of or area cultivated by large farms in a certain distance from small farms.

To do so, we use data from the 2012 and 2014 rounds of Mozambique's *Inquérito Agrícola Integrado* (IAI), a survey that includes data from all of the country's large farms plus a sample of small & medium producers (referred to as 'small' producers throughout). Specifically, we use GPS coordinates for 419 large farms established after 2012 to construct, for every small farm in the sample, a measure of whether at least one new large farm was established and total large farm area cultivated (with specific crops) in concentric circles with 0-25 km, 25-50 km, and 50-100 km around it. We assume that any large farm will improve functioning of factor markets (fertilizer, pesticide, or seed use) and adoption of cultural practices, but that specific technology transfers and improvements in yield will materialize only if large and small farms grow the same crop. This allows us to estimate regressions for these two cases separately although, as long as information on parameters of interest from either administrative or survey data is available, heterogeneity of spillovers along other dimensions can be explored in a similar fashion.

We find positive short-term effect from newly established large farms on adoption of agricultural practices and input use by small farms less than 50 km from newly established large operations. Robustness checks for crop farms only also suggest job creation in the proximity of newly established crop, but not livestock farms. Yet, large farm establishment decreased perceived well-being within a 25 km band and, in the time horizon considered here, did not lead to better access to output markets, cultivation of larger areas or, once other factors are controlled for, higher yields. This allows us to reject the notion of negative spillovers from large farm establishment but casts doubt on the wisdom of large unconditional subsidies to attract investors.

Although we obtain interesting results, data limitations, in particular the fact that we only ascertain short-term effects, imply that our main contribution is methodological. Further study of impacts over the longer term and heterogeneity of effects within and beyond Mozambique can help to understand relevant factors and provide robust policy guidance. Combining administrative or survey data on large farms with routinely available smallholder surveys offer low-cost opportunities to move in this direction and assess longer-term effects and the way they vary with modalities of land acquisition, the nature of the investment, investor attributes, or contractual obligations, which are likely to be of high policy interest.

The paper is structured as follows: Section two describes Mozambique's agricultural sector, the challenge of supporting smallholder productivity growth for broad-based poverty reduction, and the potential role of spillovers from large land-based investment. Section three presents data to compare large and small farms' performance and trace small farms' evolution over time. Section four discusses the identification strategy, and provides data on small farms' proximity to newly established large farms to justify it, and discusses results for short-term general or crop-specific spillovers from large farm formation on neighboring smallholders. Section five concludes with implications for policy and future research.

2. The literature on large agricultural investment

To highlight the potential relevance of spillovers emanating from large land-based investment, we review the literature in general and specifically for Mozambique, focusing on endowments, the importance of agriculture for poverty reduction, potential for and challenges of increasing productivity, and investors' possible role in such productivity growth. While, in principle, investment in large production units or higher up in the agricultural value chain can have very positive effects on neighboring small farmers, systematic evidence of the size of such effects remains scant, limiting the scope for evidence-based policy making.

2.1 The role of spillovers literature on impacts from large agricultural investment

After decades of stagnant or declining commodity prices with agriculture considered a "sunset industry", increases in the level and volatility of commodity prices led to a strong rise in global demand for land that, albeit at a lower level, continued even with lower commodity prices, especially in Africa where some countries are considered to have very high levels of unutilized land.[1] For relatively land abundant countries that continue to depend primarily on agriculture, this offers opportunities to attract much-needed capital and in doing so accelerate socio-economic development of hitherto neglected areas and populations.

Yet partly because the size of such demand took many governments by surprise, initial impacts rarely lived up to these hopes, in line with historically high failure rates of agricultural investment (Tyler and Dixie 2013). Institutional fragmentation and lack of capacity to provide information, check investors' plans, assist affected communities in negotiation, and document or monitor compliance with contractual terms implied that many projects were viewed as "land grab" (Pearce 2012) and failed to increase productivity or generate local benefits (Deininger and Byerlee 2011). Weak governance (Arezki *et al*. 2015) often made it difficult for governments to spot pioneers with staying power and ingenuity to deal with the complexity, narrow margins, variable returns, and susceptibility to exogenous shocks of agricultural production. Many land deals thus involved a significant element of speculation by urban elites (Sitko and Jayne 2014) and potential for corruption (Bujko *et al*. 2015). Whether measures to attract such investment in agricultural supply chains (OECD 2014) will be desirable, and if yes, what nature they should take, largely depend on size and nature of spillover effects on neighboring smallholders. Yet, despite their essential role in the debate, few studies have explored these and the way in which they are affected by the nature of investments (e.g. labor intensity of crops grown; type of outgrower arrangements if any), the local economy's nature and level of development, and the type of regulatory oversight exercised by public institutions.

[1] The land available for expansion in Africa, most of it is concentrated in few countries (Deininger and Byerlee 2012), with poor access to infrastructure and low levels of profitability (Jayne *et al*. 2014), and often also very weak governance (Arezki *et al*. 2013; 2015).

At a conceptual level, large farms can benefit neighboring smallholders via a number of channels that include access to improved techniques, factor and output markets, and technology (Benfica *et al.* 2002). If transport or other transaction costs are high, smallholders may be rationed out of input and output markets (Key *et al.* 2000) as quantities involved may be too small to defray these costs even without credit constraints. To the extent that they use these inputs, large farms can provide them to neighboring smallholders, potentially on implicit credit (Benson *et al.* 2012). Large farms tend to employ casual workers on an irregular basis, possibly allowing them to learn simple techniques such as crop rotation to reduce pest pressure and manage nutrients, intercropping to enhance soil nutrient and moisture content, and line sowing to make weed control easier are easily transmitted from large to small farms. Case studies point to positive impacts of agro-processing on labor demand (Maertens *et al.* 2011; Minten *et al.* 2007) or of outgrower schemes for smallholder food productions (Negash and Swinnen 2013). Ethiopian flower farms have also been shown to have positive employment effects (Mano and Suzuki 2013).

Impacts from mechanized production of bulk commodities are likely to differ from this in two ways. First, if land to labor ratios are much higher, positive labor market effects will be less and negative land-related impacts, in particular displacement, more likely. Second, without perishability, aggregation of smallholder output has to confront with side-selling and quality of its own (Hueth *et al.* 2007; Saenger *et al.* 2013). As all of these factors tend to lower benefits and increase risks, it is not surprising to find that in cases involving direct agricultural production of bulk commodities, studies often find ambiguous or negative effects (German *et al.* 2013 ; Schoneveld 2014). Reasons may include failure to adhere to legally required processes of local consultation (Nolte and Voget-Kleschin 2014) and possibly displacement (Hall 2011) and lack of transparency due to limited disclosure or failure to monitor implementation of contracts (Cotula 2014).

It is thus not too surprising to find that, beyond study of effects from specific agro-processing investments, efforts to quantify effects of investment in agricultural production remain limited. Adewumi et al. (2013) is one of the few studies describing impacts of large farm establishment on neighboring smallholder producers in a case study setting in Nigeria. In Zambia, one study finds that smallholders in districts with foreign investment are not worse off in terms of productivity, fertilizer use, and wage income than in those without it and there is convergence in productivity levels between districts with and without foreign investment over 2000-2010 (Sipangule and Lay 2015). Another one highlights that agricultural investment is associated with moderately positive effects in the 1994 to 2007 period, especially for land-scarce households (Ahlerup and Tengstam 2015). In Ethiopia, for a long panel spanning the 2004-13 period, positive impacts from large land transfer remain modest and often crop-specific (Ali *et al.* 2016).

Although it has rarely been used in the agricultural context, assessment of spillovers using proximity as a transmission channel has been widespread in other contexts. Henderson (2003), Moretti (2004), and Currie *et al*. (2015) are key references using this framework to assess externalities at the firm level. It is also used to assess economic and social impacts of mine openings and closings (Chuhan-Pole *et al.* 2015), including on female empowerment (Kotsadam and Tolonen 2015). Before discussing how we apply it to assess short-term, spillover impacts from large farm investment in Mozambique's agriculture, we briefly describe the structure and historical evolution of this sector.

2.2 Agriculture and large land-based investment in Mozambique

Mozambique is endowed with some 35 mn. ha of land suitable for agriculture that has fertile soils, ample rainfall and enormous potential for irrigation. Domestic and neighboring countries' markets offer scope for import substitution and the country's long coastline along the Indian Ocean with major port also provide international market access. But these favorable endowments notwithstanding, low agricultural productivity is one of the key reason for rural poverty to remain pervasive (Arndt *et al.* 2012). Although 80% of Mozambique's population is in agriculture, the sector contributes to only 20% of GDP and poverty may actually be worsening (Cunguara and Hanlon 2012). With only some 6 mn. ha of land cultivated, the country uses only a fraction of its large land endowment (Arndt *et al.* 2010; Deininger and Byerlee 2011). A need to increase smallholder productivity, together with the availability of large amounts of uncultivated land would seem to provide a favorable framework to benefit from increased land demand by investors.

To allow effective ways of developing the country's land resources, a comprehensive land law was passed in 1997, following a long consultative process. The law declares that all land belongs to the state and prohibits sales but recognizes existing use rights. As community-investor partnerships that might internalize some of the spillover effects associated with land-based investment will be possible only if land rights are well defined, the law establishes a participatory process of 'community land delimitation' to formalize rights to community land, agree on its boundaries, and clarify decision-making structures (Norfolk and Tanner 2007). Yet, while there have been some successful delimitation cases, implementation remained slow, partly due to a fear that, once local rights have been recognized, the government may no longer be able to transfer 'unused' land to investors. This limited the scope for such partnerships (deWit and Norfolk 2015). A second way for investors to access land is through a lease (DUAT) awarded by the government based on submission of an investment plan. In theory, submission of an investment plan will trigger receipt of a provisional DUAT that will, after a period of two years, either be converted into a definitive one or cancelled. In practice, it appears that most of the documents held by investors are still provisional. A key policy issue related to this is that, as sales are not allowed, land acquired by failed investments cannot just be transferred to others but requires elaborate state intervention to cancel and reassign the lease. Together with weak and incomplete land records, this makes it difficult to unambiguously ascertain or extinguish pre-existing claims, an issue that has consistently been raised as a challenge for investors (OECD 2013; UNCTAD 2012). It implies that, despite the country's land abundance, the amount of land for which ownership or absence of competing claims can be easily established may be quite limited.

One reason for the relative neglect of agriculture is the country's rich mineral resource endowment that led the government to pursue a development strategy focused on 'mega-projects' (Cunguara 2012). Yet, hopes that these projects, with strong government support, would generate jobs and local linkages were often disappointed. Large investments to rehabilitate the sugar industry (Buur *et al*. 2012) and establish irrigation for rice (Kajisa and Payongayong 2011) notwithstanding, Mozambique's level of agricultural public investment is low even by African standards.[2] It has also been argued that the impact of such spending may have been compromised by a preference for high-visibility projects with short gestation periods compared to alternatives with higher payoff (Mogues and Do Rosario 2015).

To more effectively reduce rural poverty and promote a more inclusive pattern of development, the government's latest strategic plan for agricultural development (PEDSA) puts priority on smallholder-driven agricultural growth. It includes efforts to improve technology, reduce small farmers' capital constraints, and increase the extremely low levels of modern input use some of which show potentially interesting results (Carter *et al*. 2014). Support to smallholders at a micro-level is to be complemented by development of 6 growth corridors to provide infrastructure and public services.[3] Ideally these corridors would provide a springboard for 'pioneer' investors to create market links, fine-tune technology packages, and develop local infrastructure in ways that help increase small farmers' productivity and the area cultivated by them along the lines of Collier and Venables (2012). To provide incentives, the country offers attractive conditions for agricultural investment including low corporate income taxes (with effective rates as low as 2% to increase to 5% over the next decade) and cheap land (with 50-year leases at USD 1/ha and year). A center for promotion of agriculture (CEPAGRI) complements the national (CPI) and several regional investment promotion agencies to attract, nurture, and coordinate investment.

While large land allocations are not a new phenomenon in Mozambique, given the country's violent history that often included repeated and multiple displacements (Myers 1994), the size and long-term impact of the challenges are illustrated by the fact that, following the 2007/08 food price spike, the

[2] Mozambique's spending on R&D in agriculture is less than 0.25% of agricultural GDP, about one third of the 0.69% achieved in Africa overall and one sixth of the l.5% target agreed upon by African countries (World Bank 2011).

[3] The growth corridors are Maputo and Limpopo (with focus on rice, horticulture, cattle and poultry), Pemba-Lichinga (focus on wheat, beans, maize, soja, cotton, potato, tobacco, and poultry), Nacala (cassava, maize, cotton, fruit, poultry, and groundnut), Zambezia (rice, maize, potato, cattle, goats, cotton, and poultry), and Beira (maize, wheat, horticulture, poultry, soya, rice and cattle).

investment agency received expressions of interest for some 12 mn. ha., mostly for bio-fuels (Arndt *et al.* 2010). Evidence of capacity constraints in specific cases (Borras *et al.* 2011) and a desire to avoid serious mistakes led to the imposition of a moratorium and an effort to better map available resources in 2009 (Hanlon 2011). Beyond concerns regarding environmental impacts from such ventures (Vang Rasmussen *et al.* 2012), socio-economic effects will depend on whether labor-intensive outgrower or capital-intensive plantation models are adopted; if food crops will be displaced; and the extent to which technology spillovers to other crops materialize (Arndt *et al.* 2011).

3. Data and descriptive evidence

Data from both large and small farms provide evidence on (i) the smallholder sector's stagnation in terms of access to extension, use of modern practices and purchased inputs as well as yields; (ii) vast differences in yield and intensity of input use between large and small farms and by region that could create potential for spillovers; and (iii) differences in spatial proximity between small and newly established large farms that can serve as a basis for econometric identification of such effects.

3.1 Data and basic characteristics of the smallholder sector

To explore the interaction between large farm establishment and smallholder productivity, we use various years of the *Inquérito Agrícola Integrado* (IAI), a nation-wide survey of all of the country's large farms together with a rather large sample of small and medium ones that is regularly carried out by the Ministry of Agriculture (Megill 2011).[4] The sample for each survey is drawn from a master list that uses information from population and agricultural census (Keita and Gennari 2014). While this design limits the scope of using panel estimation techniques, the 2012 and 2014 small and medium scale surveys were carried out in the same enumeration areas (EA) allowing us to use EA fixed effects. While earlier

[4] Small holdings are defined as cultivating less than 25 ha overall, with less than 10 ha of annual crops and less than 5 ha irrigated land as well as less than 10 cattle, 50 small ruminants or pigs, and less than 200 poultry. Large holdings are defined as cultivating a total of more than 100 ha or more than 50 ha of annual and permanent crops or having at least 100 cattle, 500 small ruminants and pigs or 2000 poultry. Any farm that is neither large nor small will be categorized as medium.

attempts at using GPS to record interviewed farms' location ran into difficulties that prevented consistent implementation at national scale, we have coordinates for large farms that entered the sample in 2014 as well as smallholders in the 2012 and 2014 rounds. To account for climatic conditions, we combine this with public NOAA data on rainfall generate mean precipitation for all 146 districts in the sample.[5]

Use of 2012 survey weights allows us to compute the number of farm households and distribution of cultivated area and certain crops by farm size. Table 1 shows that less than 6 mn. of the country's estimated 35 mn. ha of agriculturally suitable land is used for crop cultivation. Of these, 5.5 mn ha or 90.7% of total area is in the smallholder sector which comprises 3.9 mn. or 99.8% of all farms. As virtually all of smallholders' area is under crops rather than pasture, the smallholder sector accounts for 95.6% of cropped area. By comparison, 8,123 farms (with 2.4% of cropped area) are in the 10-50 ha group and less than 400 above 50 ha. Smallholders cultivate 92% of total cropped area with annual and 1.1% with perennial crops, leaving 5.8% partially fallow. With about 10%, the share of perennials is highest in the 200-1,000 ha size group, declining to 5.4% for the largest farms. Cropping patterns differ by farm size: Smallholders cultivate maize (32%), cassava and pulses (16% each), rice, peanuts (8% each), sorghum (6%) or vegetables and cotton (4% each) although sorghum and rice are highly concentrated in certain regions. Farms in the 50-200 ha range focus on rice, vegetables, and cotton and, though grown by only few of them, sugarcane accounts for 84% of area cropped by farms greater than 500 ha.[6]

Descriptive data for the 2002 to 2014 period suggest Mozambique's small scale sector was rather stagnant over time (table 2). Mean area cultivated per farm decreased markedly, from 2.4 to 1.7 ha. The share of perennials dropped from 8% to 1%. The share of farmers receiving extension advice decreased from 15% to 10% although extension increased income (Cunguara and Moder 2011). Use of animal or mechanical traction, improved seed, and fertilizer remained stable at low levels (some 20%, 10%, and 5%, respectively), indicating ample potential for positive spillovers from large farms as described in the

[5] Regional breakdowns for the variables in tables 1 and 2 are available from the authors upon request.

[6] Unfortunately, a failure to record quantities of purchased inputs applied by large farms makes it impossible to compute profits.

literature (Benson *et al.* 2012). Use of pesticide and manure decreased. There is also a decline in the share of farmers practicing crop rotation (from 35% in 2005 when the question was introduced to 24% in 2014), inter-cropping (88% to 81%), and market integration with the share of farmers selling crops decreasing from 59% in 2002 to 49% in 2014. Modest declines in the share of those with off-farm jobs (17%) or practicing line sowing (45%) also reveal a lack of dynamism in rural areas. With the exception of sugarcane which benefited from post-war rehabilitation and infrastructure construction programs, mean national yields fluctuated considerably over time without showing a clear upward trend.

Mean monthly rainfall in the 1990 to 2000 period was 97.7 mm in the wet season (October to March) and 8.7 mm in the dry season (April to September) with standard deviations of 32.8 mm and 6.4 mm, respectively. For each season, we use the mean deviations from the 1990-2000 mean to indicate if rainfall was below normal or a drought was experienced, defined as the z score of the deviation being below -1. The bottom panel of table 2 illustrates more than 25% of districts experienced below average rainfall in the wet seasons of 2002, 2005, and 2012 but that in most of these the normalized deviation was less than -1, a value that was not reached by 23% of districts in the 2008 dry season.

3.2 Comparing productivity and modern input use between large and small farms

Beyond spatial proximity, a high potential for catch-up as evidenced by large gaps between large and small farms will be conducive to spillovers. Although failure to record quantities of purchased inputs by large farms makes it impossible to compute profits for them, 2014 data in table 3 show clear differences between large and small farms in terms of cultivation practices, access to water and improved inputs, and adoption of measures to conserve soil fertility such as use of organic manure, fertilizer, and yields.

Maize, the main staple, is grown by 55% of large (with mean areas of 18, 14, and 7 ha in the North, Center, and South, respectively) and 83% of small and medium producers (76%, 92%, and 86% in Center, South, and North, respectively). Average yields are among the lowest in Africa without significant difference between large and small producers, despite vast differences between them in the share of area irrigated (19% for large vs. 1% for small and medium farmers), improved seed use (40% vs. 9%), and application of fertilizer (29% vs. 2%), pesticide (21% vs. 1%), and manure (17% vs. 1%).

Cassava is grown by 53% of small & medium producers on an average area of 0.4 ha per farm, compared to 12% of large ones with an average of 1.9 ha. In line with the crop's limited input requirements, smallholders obtain much higher yields than large farms (2.9 vs. 0.8 t/ha with yields above 3 t/ha in the South and Center). Neither large nor small farms use significant levels of modern inputs. The same is true for sorghum, a crop that is grown by 24% of smallholders (about one third each in the North and the Center) but only 7% of large farms, about 16% of which use improved seeds.

Although domestic rice consumption is growing rapidly,[7] the crop is grown by few (5% of large and 13% of small) farmers. Average large farm yields are, with 0.8 vs. 0.5 t/ha, about 60% above those for small farms, partly due to higher use of irrigation (86% vs. 3%), improved seed (73% vs. 5%), fertilizer (73% vs. 3%) and pesticides (68% vs. 1%). Sugarcane is the main large farm crop with (monetary) yields about three times those by smallholders but large differences among large farms (19.3 vs. 22.0 MT/ha in Center vs. South) mirrored by those of smallholders (6.8 vs. 6.7 and 8.8 MT/ha in North, Center, and South).

4. Econometric approach and evidence

To assess short-term effects from large farm establishment on neighboring smallholders, we assume spatial proximity to be the main channel for transmission of effects and use a difference in difference strategy (DID) that focuses on changes over time in number of or area cultivated by newly established large farms in different distance bands from small ones. We show that there is indeed variation in the distance between small and large farms. Specifically, we use GPS coordinates for 419 large farms established after 2012 to construct, for every small farm in the sample, a measure of whether at least one new large farm was established and total large farm area cultivated (with specific crops) in concentric circles with 0-25 km, 25-50 km, and 50-100 km around it. Assuming that any large farm will improve

[7] Rice consumption more than doubled from 2000 to 2010 to 550,000t of which 63% is imported and demand is expected to increase at 7% per year over the next decade or so.

functioning of factor markets (fertilizer, pesticide, or seed use) and adoption of cultural practices, but that specific technology transfers and improvements in yield will materialize only if large and small farms grow the same crop (Ali *et al.* 2016), we then estimate regressions with all large farms and those growing the same crop as independent variables. Of course, it will not be difficult to explore heterogeneity of spillover effects in other dimensions as long as information on relevant parameters is available from either administrative or survey data.

4.1 Estimation strategy

The IAI includes GPS coordinates for 419 large farms that were either newly established or changed owner after 2012 and all smallholders in 2012 and 2014 (see figure 1 for location of large and small farms). This allows us to compute the distance between any small farm and the next large farm newly established during this period as well as the number of newly established large farms in a concentric circle with inner and outer radius of 0-25, 25-50, and 50-100 km from any small farm. Supposing that the spillover effects diminish as the distance increase, we use a difference-in-difference approach whereby differences between pre- and post- establishment periods for households in the same EA are compared between households located close to large farms- and thus affected by the large farms- and those located far away from large farms-and thus unaffected. Combining this with data on smallholders' performance in each year (i.e. before and after large farms were established), we run OLS equations of the form

$$Y_{ijt} = \alpha + \beta L_{ijtd} + \gamma X_{ijt} + R_{jt} + \delta_t + \delta_j + \epsilon_{ijt} \quad (1)$$

where δ_t is a time trend; and δ_j is an EA fixed effect. Y_{ijt} is the outcome variable of interest for small farm *i* in EA *j* in year *t*; L_{ijtd} is a vector of indicator variables that equal 1 if at least one large farm was established after 2012 in a concentric ring of radius *d* around small farm *i* where we limit the distance to be considered to a maximum of 250 km and compute values of L_{ijtd} for cases with inner and outer radius *d* of 0 to 25, 25 to 50 and 50 to 100 km.; X_{ijt} is a vector of control variables including farm size, household composition (number of children, adults and old people), head's gender and age, and highest education in the household and, for regressions of crop yields, also indicator variables for hiring of temporary or permanent workers, use of animal traction, practicing crop rotation, inter-cropping, or line sowing, and crop-specific use of improved seeds, fertilizer, pesticides as well as irrigation; and R_{jt} is a vector containing the average monthly deviations of rainfall from its 1990 to 2000 mean in the wet and dry season, respectively, as well as the square of this deviation to capture weather shocks.

Outcome variables to be used include indicator variables for agronomic practices (rotation, intercropping, and line sowing), indicator variables for input uses (traction, improved seeds, fertilizer, and pesticides), indicator variables for output and labor market participation, and indicator variables for perceived well-being, i.e. if households perceive their economic situation to be better or worse than 3 years ago. We also use indicator variables for access to extension as well as credit, and the natural logarithm of cultivated areas as well as yields of maize, cassava, sorghum, peanuts, rice and sugarcane. In each case, the parameter of main interest is β, i.e. the estimated effect of a new farm having been established within a concentric circle (or ring) with inner and outer radius d from small farm i on different outcome variables, i.e. adoption of practices, input use, output and labor market participation.

To complement the zero-one indicator of large farm establishment at the extensive margin with a measure the intensity of treatment, we also run regressions where L_{ijtd} is replaced by A_{ijtd}, a vector containing the log of total area cultivated by newly established large farms in the concentric ring of radius d around the small farm of interest (e.g. $A_{ijt(25\text{-}50)}$ denotes area cultivated by new large farms in the 25-50 km range from small farm i). Use of logs implies that relevant elements of the coefficient vector β can be interpreted as elasticity.

Table 4 provides descriptive statistics on newly established large farms by distance to small farms. We note that 41% of small farmers had at least one new large farm (with total cultivated areas of 258 ha) established in a 25 km radius, a figure that was, with 82%, 50%, and 11%, respectively, highest in the South, followed by the Center and the North. Nationally, 55% and 74% of small farmers had at least one new large farm (with areas of 467 ha and 966 ha) emerge within a 25-50 or 50-100 km range, respectively. Spillovers that result in yield changes after controlling for practices and purchased input use are likely driven by crop-specific technology, i.e. require not just establishment of any large farm in the vicinity but one that actually grows the same crop. Table A1 in the appendix reports descriptive statistics on newly established large farms growing the same crop in a certain neighborhood.

4.2 Estimated spillovers in terms of technology, market participation, and yields

Estimated impacts of new farm establishment/expansion on adoption of cultural practices and modern input use as displayed in table 5, where the top panel reports results for large farm establishment and the bottom panel those for increases in large farm area, point towards significant limited effects on adoption of agronomic practices and input use in relatively close proximity to new large farms. Large farm establishment within 25 km is estimated to have led to an increase in the incidence of crop rotation and intercropping by 7.3 and 6.1 percentage points respectively compared to the base category of a large farm having opened within a 100-250 km radius. For animal traction, the estimated effect is, with 4.9 points, significant and slightly larger, similar to what is observed for line sowing (4.9 points) and intercropping (6.2 points) compared to only insignificant effects for use of crop rotation at a distance of 25-50 km.

With the exception of an estimated effect of 5.4 for intercropping, we do not find evidence of an impact of new large farms established at a distance of 50-100 km compared to 100-250 km. Opening of large farms within 25 km is also estimated to have led to a 3.3, 1.7 or 2.7 point increase in the incidence of improved seed, fertilizer and pesticide use, an effect that carries over to the 25-50 km radius for fertilizer (for which area of new large farms is also significant with elasticities of 0.004 and 0.003 for 0-25 and 25-50 km. By comparison, opening of farms beyond 50 km is not found to have any effect. For animal traction, intercropping and crop rotation, estimated coefficients on the net increase in new farm area are also significant, estimated magnitudes are much smaller, with a doubling of large farm area estimated to lead to a 1.2 point increase in the incidence of intercropping.

While this points towards modestly positive impacts of large farm establishment on factor market operation and agronomic practices, table 6 suggests that, over the time horizon considered here, establishment of large farms did not improve neighboring small farmers' access to off-farm jobs or markets for output or other factors. Although establishment of large farms has a significant positive impact on use of animal traction, we find no significant effect on total area cultivated, possibly because we are looking at short-term effects only. The relevance of factors that are unrelated to productivity is reinforced by the fact that having seen a new large farm established in the immediate vicinity (< 25 km) is estimated to have resulted in a significant increase by 4.2 points in the likelihood of small farmers' feeling to be worse off than 3 years ago, consistent with highly significant positive point estimates on the likelihood to perceive the current situation worse than 3 years ago in the equation with area of new large farm establishment as independent variable.

Mozambique's large farm sector comprises a significant share of large livestock ranches that may give rise to spillovers that could be quite different from those generated from crop farms. It is important to ensure that our results are not driven by large livestock ranches. To do so, we estimate (1) with L_{ijtd} and A_{ijtd}, denoting the count or area of farms that cultivate at least 50 ha. Results, in appendix tables A2 and A3 are almost identical to what was obtained earlier, thus allaying concerns in this respect. In fact, coefficients on employment point towards a significant effect of new crop farm establishment on job creation for small farmers in a 0-25 km radius from large farms, consistent with the notion that establishment of large crop farms but not ranches generates additional local employment, at least in the short term.

Assuming that transfers of technology that result in increased yields large farms are more likely to have spillover effects on smallholders growing the same crops, we replace the relevant indicators (L_{ijtd} and A_{ijtd}) in equation (1) with equivalent measures for new large farms growing at least 1 ha of the same crop as the small farm in question. Results, in panel A and B of table 7, suggest that, once other inputs are controlled for there is no significant effect of large farm establishment on smallholder yields. This is plausible as, in all crops except rice and sugarcane, negligible or even negative yield differences between large and small farms point towards limited scope for spillovers in this respect and the time elapsed since large farm formation is relatively short.

5. Conclusion and policy implications

We use a DID strategy that relies on physical proximity between large and small farms to explore the impact of large farm establishment on neighboring small farms. For the case of Mozambique, we find evidence of positive short-term spillovers from large farm establishment on neighboring small farmers in terms of adoption of new practices, access to inputs, and, for large crop farms, labor demand. Most spillover effects are quite localized, i.e. establishment of large farms seems to have no impact on smallholders if it is farther than 50 km. Also, we find no positive spillover effects on output market participation, and, if other inputs are controlled for, yields and significant negative impacts of large farm establishment on neighboring smallholders' subjective well-being within a 25 km radius. While this implies that, even in the short term, large land-based investment in Mozambique provides local benefits, the size of these benefits is too small to overcome long-standing under-investment in the country's agricultural sector and that, for reasons that should be explored further, local perceptions of such investment are often less positive. To interpret results, one needs to recognize that their validity hinges on completeness of the data on new farm formation; that long-term effects may be different from short term ones observed here; and that we are only able to estimate average effects while policy makers may be interested in heterogeneity across different dimensions.

Heterogeneity would be of particular interest with respect to endowments such as (i) infrastructure access and soil quality; (ii) modalities of negotiation and contracting such as transparency and outreach in the conduct of legally prescribed community consultations, and arrangements for profit sharing or monitoring; and (iii) the nature of investment such as a focus on crops or livestock, corporate structure; country of origin; clarity of business plans; capital stock, CSR activities envisaged; technical efficiency; and participation in certification schemes or commodity roundtables. While simple improvements in survey design (e.g. asking for the year of establishment or the type of interactions with smallholders) together with quality control are one way to provide greater clarity in this respect, administrative data could provide the same information at much lower cost and in a way that could enhance the capacity of responsible institutions. Building on such data, the methodology applied here could help inform policy on issues such as qualification criteria for investors (e.g. levels of assets or reputation), minimum standards for business plans or documentation of local consultations, and level, destination, and time profile of lease payments well beyond Mozambique. Efforts to ensuring regular availability of such information would offer opportunities to not only improve key institutions' capacity but also gain highly policy relevant insights. This could feed into an evidence-driven analytical agenda that would, by increasing transparency and the scope for accountability and proper management, benefit investors, local communities, and public institutions.

Table 1: Basic characteristics of Mozambique's farms in 2012 by farm size group

	Farm size group					
	0.1-10	**10.1-50**	**50.1-200**	**200.1-1000**	**1000.1-5000**	**above 5000**
Distribution of farms & area						
No. of farms	3,893,083	8,123	176	91	66	19
Share of farms (%)	99.7828	0.2082	0.0045	0.0023	0.0017	0.0005
Total area in farms	5,543,515	137,680	16,976	48,291	134,661	231,255
Share of farm area (%)	90.6932	2.2525	0.2777	0.7901	2.2031	3.7834
Total area cultivated	5,543,450	136,816	13,105	15,363	37,279	53,800
Share of cultivated area (%)	95.5798	2.3590	0.2260	0.2649	0.6428	0.9276
Distribution of cultivated area (proportion)						
Partial fallow	0.058	0.134	0.613	0.474	0.665	0.399
Perennials	0.011	0.027	0.071	0.099	0.049	0.054
Annuals	0.920	0.785	0.316	0.427	0.286	0.547
Maize	0.317	0.324	0.257	0.091	0.062	0.001
Cassava	0.158	0.079	0.014	0.003	0.001	0.000
Sorghum	0.061	0.058	0.020	0.000	0.000	0.000
Peanuts	0.076	0.093	0.014	0.002	0.001	0.000
Rice	0.075	0.004	0.140	0.109	0.002	0.018
Sugarcane	0.006	0.001	0.088	0.152	0.401	0.838
Millet	0.011	0.010	0.006	0.000	0.000	0.000
Pulse	0.163	0.184	0.045	0.040	0.020	0.001
Sweet potato	0.017	0.059	0.037	0.032	0.020	0.002
Cotton	0.039	0.072	0.117	0.085	0.000	0.000
Tobacco	0.007	0.001	0.025	0.011	0.000	0.000
Other cash crops	0.022	0.021	0.084	0.243	0.486	0.137
Vegetables	0.041	0.096	0.152	0.221	0.008	0.004

Source: Own computation from 2012 large, medium, and small IAI survey.

Table 2: Evolution of the small farm sector

	Year				
	2002	**2005**	**2008**	**2012**	**2014**
Characteristics of small and medium farms					
Total area cultivated (ha)	2.40	2.49	2.23	1.77	1.71
… of which with annuals	0.88	0.91	0.92	0.92	0.92
… of which with perennials	0.08	0.03	0.02	0.01	0.01
… of which in partial fallow	0.04	0.06	0.05	0.05	0.06
Received extension advice (yes/no)	0.15	0.18	0.09	0.07	0.11
Used tractor (yes/no)	0.04	0.04	0.03		0.04
Used animal traction (yes/no)	0.20	0.21	0.20	0.18	0.21
Used improved seed (yes/no)		0.09	0.12	0.10	0.11
Used fertilizer (yes/no)	0.05	0.05	0.04	0.03	0.05
Used pesticide (yes/no)	0.07	0.07	0.03	0.04	0.04
Used manure (yes/no)	0.09	0.05	0.03	0.03	0.03
Practiced crop rotation (yes/no)		0.35	0.26	0.28	0.24
Practiced inter-cropping (yes/no)		0.88	0.83	0.79	0.81
Practiced line sowing (yes/no)		0.49	0.45	0.45	0.45
Sold crops (yes/no)	0.59	0.53	0.53	0.50	0.49
Any off-farm employment (yes/no)		0.19	0.17	0.12	0.17
Received credit (yes/no)		0.04	0.03	0.02	0.02
Better off than 3 years ago (yes/no)		0.20	0.29	0.34	0.45
Worse off than 3 years ago (yes/no)		0.49	0.35	0.31	0.21
Yields of small and medium farms					
Maize (kg/ha)	973	781	717	949	1,024
Cassava (kg/ha)	2,961	4,098	2,554	3,566	2,921
Sorghum (kg/ha)	725	511	473	720	714
Peanuts (kg/ha)	414	324	287	422	470
Rice (kg/ha)	558	463	382	492	494
Sugarcane (MT/ha)		6,391	5,400	5,715	6,996
Rainfall					
Wet season (October previous -March current year)					
Monthly rainfall (mm)	98.46	89.29	114.25	104.33	125.62
Monthly rainfall in 1990-2000 (mm)	95.65	94.38	96.17	95.78	96.68
Deviation (mm)	2.81	-5.09	18.07	8.55	28.94
Share of negative deviations	0.45	0.62	0.21	0.42	0.03
Share of z score < -1	0.00	0.01	0.00	0.01	0.00
Dry season (April -September current year)					
Monthly rainfall (mm)	14.02	7.18	4.15	10.34	13.75
Monthly rainfall in 1990-2000 (mm)	7.57	7.77	8.21	8.62	8.71
Deviation (mm)	6.44	-0.59	-4.06	1.73	5.04
Share of negative deviations	0.17	0.59	0.90	0.34	0.30
Share of z score < -1	0.01	0.09	0.23	0.13	0.08
No. of obs.	4,840	6,000	5,783	6,430	5,772

Source: Small farmer data from various IAI survey rounds. Rainfall data from NOAA.
Note: Output of sugarcane is in 2014 MT using the World Bank's consumer price index as a deflator (http://data.worldbank.org/indicator/FP.CPI.TOTL.ZG/countries/MZ?display=default).

Table 3: Inputs and outputs for main crops in 2014

	Total		North		Center		South	
	Large	**Small**	**Large**	**Small**	**Large**	**Small**	**Large**	**Small**
Maize								
Crop cultivated (yes/no)	0.55	0.83	0.65	0.76	0.64	0.92	0.51	0.86
Area (ha)	9.57	0.65	18.00	0.47	13.72	0.87	7.42	0.68
Yield (kg/ha)	1,034	1,025	970	981	1,387	1,095	902	1,015
Share of area irrigated	0.19	0.01	0.09	0.00	0.06	0.01	0.25	0.01
Used improved seed (yes/no)	0.40	0.09	0.36	0.04	0.65	0.14	0.30	0.09
Used fertilizer (yes/no)	0.29	0.02	0.36	0.00	0.43	0.06	0.23	0.01
Used pesticide (yes/no)	0.21	0.01	0.27	0.00	0.27	0.01	0.18	0.02
Used manure (yes/no)	0.17	0.01	0.00	0.00	0.30	0.02	0.13	0.02
Cassava								
Crop cultivated (yes/no)	0.12	0.53	0.29	0.66	0.02	0.21	0.14	0.63
Area (ha)	1.90	0.37	3.40	0.43	1.63	0.22	1.73	0.34
Yield (kg/ha)	821	2,922	651	2,742	671	3,539	852	3,040
Share of area irrigated	0.07	0.00	0.00	0.00	0.00	0.00	0.09	0.00
Used improved seed (yes/no)	0.08		0.00		0.00		0.10	
Used fertilizer (yes/no)	0.06	0.00	0.00	0.00	0.00	0.00	0.07	0.00
Used pesticide (yes/no)	0.08	0.00	0.00	0.00	0.00	0.00	0.10	0.01
Used manure (yes/no)	0.10	0.01	0.00	0.00	0.50	0.02	0.10	0.02
Sorghum								
Crop cultivated (yes/no)	0.07	0.24	0.00	0.32	0.22	0.34	0.03	0.02
Area (ha)	3.20	0.30		0.24	3.79	0.39	2.03	0.26
Yield (kg/ha)	434	714		643	512	841	262	476
Share of area irrigated	0.00	0.00		0.00	0.00	0.00	0.00	0.00
Used improved seed (yes/no)	0.16	0.02		0.01	0.24	0.02	0.00	0.00
Used fertilizer (yes/no)	0.00	0.00		0.00	0.00	0.00	0.00	0.00
Used pesticide (yes/no)	0.00	0.00		0.00	0.00	0.00	0.00	0.00
Used manure (yes/no)	0.03	0.00		0.00	0.05	0.01	0.00	0.03
Peanuts								
Crop cultivated (yes/no)	0.20	0.44	0.18	0.44	0.12	0.30	0.22	0.56
Area (ha)	1.78	0.28	0.67	0.25	2.16	0.24	1.77	0.34
Yield (kg/ha)	381	467	690	532	171	420	404	402
Share of area irrigated	0.02	0.00	0.33	0.00	0.00	0.00	0.01	0.00
Used improved seed (yes/no)	0.10	0.05	0.00	0.02	0.27	0.08	0.07	0.08
Used fertilizer (yes/no)	0.02	0.01	0.33	0.00	0.00	0.03	0.01	0.00
Used pesticide (yes/no)	0.01	0.01	0.33	0.00	0.00	0.01	0.00	0.01
Used manure (yes/no)	0.02	0.01	0.00	0.00	0.00	0.02	0.03	0.01
Rice								
Crop cultivated (yes/no)	0.05	0.13	0.18	0.21	0.00	0.11	0.06	0.03
Area (ha)	31.30	0.54	134.00	0.49		0.65	15.08	0.61
Yield (kg/ha)	789	494	622	423		588	819	983
Share of area irrigated	0.86	0.03	0.00	0.00		0.00	1.00	0.49
Used improved seed (yes/no)	0.73	0.05	0.67	0.03		0.05	0.74	0.33
Used fertilizer (yes/no)	0.73	0.03	0.33	0.00		0.01	0.79	0.33
Used pesticide (yes/no)	0.68	0.01	0.33	0.00		0.01	0.74	0.18
Used manure (yes/no)	0.00	0.01	0.00	0.00		0.01	0.00	0.06
Sugarcane								
Crop cultivated (yes/no)	0.05	0.03	0.00	0.03	0.04	0.03	0.05	0.02
Area (ha)	260.06	0.24		0.26	1079.17	0.21	71.04	0.22
Yield (MT/ha)	21,569	6,996		6,827	19,260	6,716	21,954	8,796
Share of area irrigated	0.75	0.01		0.00	0.67	0.00	0.77	0.03
Used improved seed (yes/no)	0.63				0.25		0.73	
Used fertilizer (yes/no)	0.79	0.02		0.01	0.50	0.00	0.87	0.06
Used pesticide (yes/no)	0.68	0.01		0.00	0.50	0.00	0.73	0.06
Used manure (yes/no)	0.21	0.01		0.00	0.00	0.00	0.27	0.06
No. of obs.	419	5,772	17	2,602	94	1,530	308	1,640

Note: The North comprises Cabo Delgado, Nampula, Niassa, and Zambezia; the Center Manica, Sofala, and Tete; and the South Gaza, Inhambane and Maputo.

Table 4: Smallholders' distance to large farms established between 2012 and 14, overall and by region

	Total	By region		
		North	Center	South
Had new large farm <=25 km (yes/no)	0.41	0.11	0.50	0.82
… if yes, number of large farms	6.31	1.44	4.03	8.62
… if yes, cultivated area of large farms (ha)	258.20	283.37	364.67	192.27
Had new large farm 25-50 km (yes/no)	0.55	0.23	0.69	0.93
… if yes, number of large farms	11.06	1.65	5.13	18.89
… if yes, cultivated area of large farms (ha)	466.51	585.75	377.97	480.13
Had new large farm 50-100 km (yes/no)	0.74	0.51	0.89	0.98
… if yes, number of large farms	22.99	2.23	9.67	51.44
… if yes, cultivated area of large farms (ha)	965.66	581.48	1136.53	1137.14
No. of obs.	5,772	2,602	1,530	1,640

Note: North includes Cabo Delgado, Nampula, Niassa, and Zambezia; Center includes Manica, Sofala, and Tete; South includes Gaza, Inhambane, and Maputo.

Table 5: Estimated impact of proximity to newly formed large farms on modern input use by small farmers

	Agronomic practices				Modern input use			Access to
	Rotation	**Intercrop**	**Line sow**	**Traction**	**Imp. seed**	**Fertilizer**	**Pesticide**	**Extension**
				Panel A				
Any new lg. farm <= 25 km	0.073***	0.061**	-0.001	0.026	0.033*	0.017*	0.027**	0.013
	(0.027)	(0.024)	(0.029)	(0.017)	(0.018)	(0.009)	(0.011)	(0.016)
Any new lg. farm 25-50 km	0.009	0.062**	0.049*	0.049***	0.019	0.024***	0.012	0.005
	(0.030)	(0.025)	(0.029)	(0.014)	(0.016)	(0.009)	(0.014)	(0.016)
Any new lg. farm 50-100 km	0.031	0.054**	-0.013	0.006	-0.013	-0.005	-0.001	0.005
	(0.032)	(0.026)	(0.031)	(0.013)	(0.014)	(0.009)	(0.014)	(0.017)
Observations	12,202	12,202	12,202	12,202	12,202	12,202	12,202	12,202
R-squared	0.168	0.194	0.295	0.575	0.166	0.307	0.251	0.128
				Panel B				
New lg. farm area <= 25 km	0.012**	0.012***	-0.002	0.005	0.003	0.004**	0.003*	0.000
	(0.005)	(0.004)	(0.005)	(0.003)	(0.004)	(0.002)	(0.002)	(0.003)
New lg. farm area 25-50 km	0.006	0.011***	0.007	0.007***	0.006**	0.003**	0.003	0.002
	(0.005)	(0.004)	(0.005)	(0.002)	(0.003)	(0.001)	(0.002)	(0.003)
New lg. farm area 50-100 km	0.003	0.008*	0.003	0.004**	0.001	0.001	0.003	0.003
	(0.005)	(0.004)	(0.004)	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)
Observations	12,202	12,202	12,202	12,202	12,202	12,202	12,202	12,202
R-squared	0.168	0.193	0.295	0.575	0.166	0.308	0.251	0.129

Note: Other control variables that are included throughout but not reported are farm size, household composition (no. of children, adults and old people), headship, head's age, highest education in the household, a time dummy, and rainfall shocks. EA fixed effects are included throughout and standard errors are clustered by EA. *** p<0.01, ** p<0.05, * p<0.1.

Table 6: Estimated impact of proximity to newly formed large farms on smallholders' other outcomes

	Area cult.	Sold crops	Rec. credit	Employ't	Sit. now vs 3a ago better	Sit. now vs 3a ago worse
				Panel A		
Any new lg. farm <= 25 km	-0.013	0.006	-0.001	0.020	-0.019	0.042**
	(0.106)	(0.025)	(0.008)	(0.019)	(0.026)	(0.021)
Any new lg. farm 25-50 km	0.082	0.036	0.005	0.029	0.021	-0.009
	(0.096)	(0.027)	(0.008)	(0.020)	(0.027)	(0.022)
Any new lg. farm 50-100 km	0.041	-0.039	-0.004	-0.054**	-0.015	0.034
	(0.097)	(0.027)	(0.010)	(0.021)	(0.027)	(0.022)
Observations	12,202	12,202	12,202	12,202	12,202	12,202
R-squared	0.217	0.275	0.128	0.144	0.174	0.153
				Panel B		
New lg. farm area <= 25 km	0.003	0.003	0.000	0.003	-0.006	0.008**
	(0.020)	(0.005)	(0.001)	(0.004)	(0.005)	(0.004)
New lg. farm area 25-50 km	0.015	0.003	0.001	0.005	0.002	0.004
	(0.017)	(0.004)	(0.002)	(0.003)	(0.004)	(0.004)
New lg. farm area 50-100 km	0.014	-0.005	-0.002	-0.002	0.001	0.002
	(0.017)	(0.004)	(0.001)	(0.003)	(0.004)	(0.003)
Observations	12,202	12,202	12,202	12,202	12,202	12,202
R-squared	0.217	0.275	0.128	0.144	0.174	0.154

Note: Other control variables that are included throughout but not reported are farm size, household composition (no. of children, adults and old people), headship, head's age, highest education in the household, a time dummy, and rainfall shocks. EA fixed effects are included throughout and standard errors are clustered by EA. *** p<0.01, ** p<0.05, * p<0.1.

Table 7: Estimated impact of proximity to newly established large farms on small famers' yields in main crops

	Maize	Cassava	Sorghum	Peanuts	Rice	Sugarcane
			Panel A			
Any new same-crop large farm <= 25 km	0.014	0.066	0.349	-0.055	0.275	
	(0.072)	(0.144)	(0.415)	(0.125)	(0.289)	
Any new same-crop large farm 25-50 km	0.014	-0.055	-0.203	-0.122	0.371	
	(0.069)	(0.133)	(0.479)	(0.108)	(0.270)	
Any new same-crop large farm 50-100 km	0.081	0.144	0.256	-0.170	-0.258	2.926
	(0.064)	(0.134)	(0.335)	(0.112)	(0.212)	(3.202)
Observations	9,483	6,479	2,767	4,879	1,573	160
R-squared	0.277	0.262	0.282	0.346	0.475	0.915
			Panel B			
New same crop large farm area <= 25 km	-0.009	0.069	0.016	-0.033	-0.015	
	(0.026)	(0.080)	(0.078)	(0.091)	(0.113)	
New same crop large farm area 25-50 km	0.004	0.044	0.009	-0.060	0.089	
	(0.023)	(0.066)	(0.120)	(0.072)	(0.089)	
New same crop large farm area 50-100 km	0.027	-0.003	0.111	-0.063	-0.021	0.362
	(0.016)	(0.054)	(0.092)	(0.050)	(0.042)	(0.396)
Observations	9,483	6,479	2,767	4,879	1,573	160
R-squared	0.277	0.262	0.282	0.345	0.474	0.915

Note: Dependent variable is ln of output (kg/ha) for maize, cassava, sorghum, peanut and rice and ln of output value (MT/ha) for sugarcane. New large farms growing the same crop are included if they cultivate more than 1 ha of the crop in question. Household composition (no. of children, adults and old people), headship, head's age, highest education in the household, a time dummy, and rainfall shocks are controlled for throughout but not reported. Control variables also include ln farm size, quadratic ln farm size, indicator variables for hiring of temporary or permanent workers, use of animal traction, practicing crop rotation, inter-cropping, or line, and crop-specific use of improved seeds, fertilizer, pesticide and irrigation. EA fixed effects are included throughout and standard errors are clustered by EA. *** p<0.01, ** p<0.05, * p<0.1.

Figure 1: Location of large and small farms

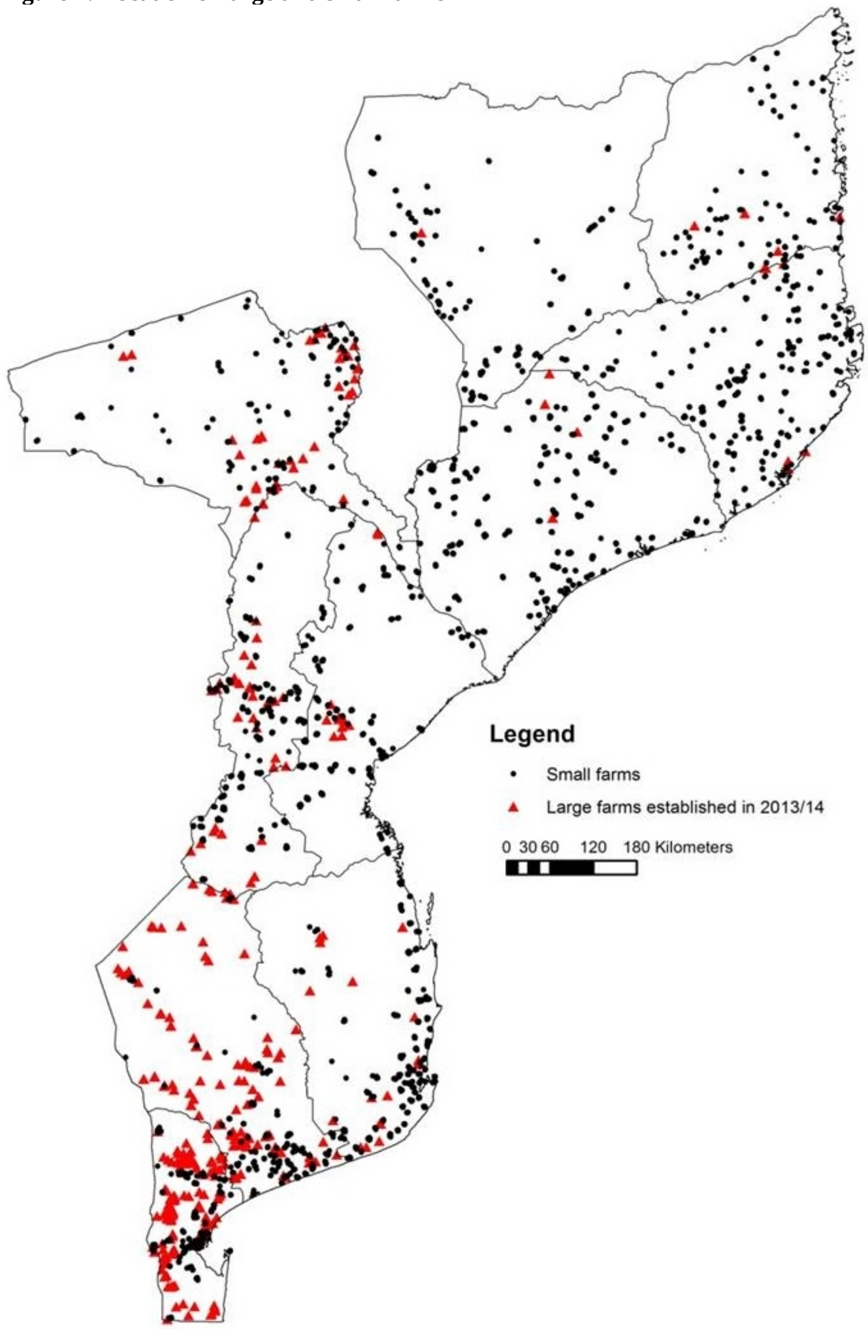

Table A1: Distance matrix to newly established large farms by smallholders by main crops 2014

	Total	North	Center	South
Maize				
Had new large farms <=25 km (yes/no)	0.33	0.09	0.32	0.72
… if yes, number of large farms	3.55	1.38	3.56	3.95
… if yes, maize area (ha)	37.48	25.18	70.09	26.27
Had new large farms 25-50 km (yes/no)	0.47	0.18	0.50	0.89
… if yes, number of large farms	5.92	1.33	4.17	8.28
… if yes, maize area (ha)	51.91	10.98	78.32	50.81
Had new large farms 50-100 km (yes/no)	0.64	0.40	0.72	0.95
… if yes, number of large farms	11.27	1.82	5.77	21.51
… if yes, maize area (ha)	104.32	42.33	92.36	154.48
Cassava				
Had new large farms <=25 km (yes/no)	0.13	0.04	0.04	0.37
… if yes, number of large farms	1.38	1.27	1.00	1.44
… if yes, cassava area (ha)	4.24	6.85	3.00	3.95
Had new large farms 25-50 km (yes/no)	0.26	0.09	0.03	0.75
… if yes, number of large farms	1.91	1.52	1.00	2.01
… if yes, cassava area (ha)	5.15	5.58	3.02	5.14
Had new large farms 50-100 km (yes/no)	0.34	0.15	0.06	0.91
… if yes, number of large farms	3.51	1.78	1.01	4.11
… if yes, cassava area (ha)	9.31	6.77	2.99	10.35
Sorghum				
Had new large farms <=25km (yes/no)	0.03	0.00	0.09	0.03
… if yes, number of large farms	3.10		3.88	1.00
… if yes, sorghum area (ha)	14.63		19.18	2.29
Had new large farms 25-50 km (yes/no)	0.03	0.00	0.12	0.01
… if yes, number of large farms	4.06		4.15	3.00
… if yes, sorghum area (ha)	17.97		18.45	12.00
Had new large farms 50-100 km (yes/no)	0.08	0.00	0.25	0.05
… if yes, number of large farms	3.58		3.90	2.26
… if yes, sorghum area (ha)	14.02		16.03	5.46
Peanuts				
Had new large farms <=25 km (yes/no)	0.15	0.00	0.07	0.46
… if yes, number of large farms	1.75	1.00	1.01	1.87
… if yes, peanuts area (ha)	4.33	1.00	5.62	4.20
Had new large farms 25-50 km (yes/no)	0.25	0.03	0.10	0.74
… if yes, number of large farms	2.31	1.00	1.46	2.48
… if yes, peanuts area (ha)	4.71	1.00	6.53	4.69
Had new large farms 50-100 km (yes/no)	0.30	0.06	0.14	0.84
… if yes, number of large farms	5.08	1.01	1.57	6.07
… if yes, peanuts area (ha)	10.84	1.04	5.87	12.68
Rice				
Had new large farms <=25 km (yes/no)	0.05	0.01	0.00	0.15
… if yes, number of large farms	3.94	1.68		4.11
… if yes, rice area (ha)	46.01	1.68		49.37
Had new large farms 25-50 km (yes/no)	0.12	0.06	0.00	0.33
… if yes, number of large farms	5.05	1.42		6.03
… if yes, rice area (ha)	117.31	196.79		95.72
Had new large farms 50-100 km (yes/no)	0.23	0.13	0.00	0.59
… if yes, number of large farms	7.45	1.41		9.49
… if yes, rice area (ha)	160.33	206.36		144.80
Sugarcane				
Had new large farms <=25 km (yes/no)	0.07	0.00	0.08	0.17
… if yes, number of large farms	2.54		1.62	2.92
… if yes, sugarcane area (ha)	527.66		1360.96	174.76
Had new large farms 25-50 km (yes/no)	0.11	0.00	0.10	0.28
… if yes, number of large farms	3.50		1.54	4.18
… if yes, sugarcane area (ha)	477.49		1087.10	267.19
Had new large farms 50-100 km (yes/no)	0.24	0.00	0.26	0.59
… if yes, number of large farms	4.79		1.89	5.99
… if yes, sugarcane area (ha)	974.03		2353.49	400.32

Table A2: Robustness check for impact of proximity to newly formed crop farms on modern input use by small farmers

	Agronomic practices				Modern input use			Access to
	Rotation	**Intercrop**	**Line sow**	**Traction**	**Imp. seed**	**Fertilizer**	**Pesticide**	**Extension**
				Panel A				
Any new lg. farm <= 25 km	0.064**	0.067***	0.011	0.056***	0.021	0.023**	0.018*	0.009
	(0.026)	(0.024)	(0.029)	(0.018)	(0.018)	(0.010)	(0.010)	(0.016)
Any new lg. farm 25-50 km	0.030	0.042*	0.030	0.029*	0.039**	0.021**	0.031***	0.006
	(0.026)	(0.023)	(0.027)	(0.016)	(0.015)	(0.008)	(0.011)	(0.015)
Any new lg. farm 50-100 km	0.011	0.070***	0.011	0.016	-0.006	-0.002	0.001	0.011
	(0.028)	(0.024)	(0.028)	(0.013)	(0.014)	(0.008)	(0.013)	(0.015)
Observations	12,202	12,202	12,202	12,202	12,202	12,202	12,202	12,202
R-squared	0.168	0.193	0.295	0.575	0.167	0.308	0.252	0.128
				Panel B				
New lg. farm area <= 25 km	0.009**	0.010**	-0.003	0.007*	0.006	0.005**	0.002	0.001
	(0.005)	(0.005)	(0.005)	(0.004)	(0.004)	(0.002)	(0.002)	(0.003)
New lg. farm area 25-50 km	0.007	0.009**	0.004	0.006**	0.008***	0.004***	0.006***	0.002
	(0.005)	(0.004)	(0.005)	(0.002)	(0.002)	(0.001)	(0.002)	(0.003)
New lg. farm area 50-100 km	0.003	0.005	0.003	0.005**	0.002	0.000	0.002	0.002
	(0.004)	(0.004)	(0.004)	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)
Observations	12,202	12,202	12,202	12,202	12,202	12,202	12,202	12,202
R-squared	0.167	0.190	0.295	0.575	0.168	0.308	0.252	0.128

Note: As noted in the text, regressions are identical to those reported in table 5 except for the fact that 'large farms' are only those who cultivate at least 50 ha of crops to avoid results being driven by large livestock farms. Other control variables that are included throughout but not reported are farm size, household composition (no. of children, adults and old people), headship, head's age, highest education in the household, a time dummy, and rainfall shocks. EA fixed effects are included throughout and standard errors are clustered by EA. *** p<0.01, ** p<0.05, * p<0.1.

Table A3: Robustness check for impact of proximity to newly formed crop farms on smallholders' other outcomes

	Area cult.	Sold crops	Rec. credit	Employ't	Sit. now vs 3a ago	
					better	Worse
				Panel A		
Any new lg. farm <= 25 km	0.048	0.032	-0.004	0.040**	-0.005	0.026
	(0.121)	(0.025)	(0.007)	(0.019)	(0.026)	(0.024)
Any new lg. farm 25-50 km	0.087	-0.009	0.008	0.021	0.028	0.006
	(0.095)	(0.024)	(0.007)	(0.018)	(0.025)	(0.023)
Any new lg. farm 50-100 km	-0.013	-0.017	-0.006	-0.038**	-0.015	0.031
	(0.090)	(0.025)	(0.009)	(0.019)	(0.025)	(0.022)
Observations	12,202	12,202	12,202	12,202	12,202	12,202
R-squared	0.217	0.275	0.128	0.144	0.174	0.153
				Panel B		
New lg. farm area <= 25 km	0.003	0.000	0.001	0.005	-0.003	0.006*
	(0.024)	(0.004)	(0.001)	(0.004)	(0.005)	(0.004)
New lg. farm area 25-50 km	0.011	0.001	0.002	0.005	0.002	0.004
	(0.021)	(0.004)	(0.001)	(0.003)	(0.004)	(0.004)
New lg. farm area 50-100 km	0.013	-0.006	-0.002	-0.001	-0.000	0.002
	(0.018)	(0.004)	(0.001)	(0.003)	(0.004)	(0.003)
Observations	12,202	12,202	12,202	12,202	12,202	12,202
R-squared	0.217	0.275	0.129	0.144	0.174	0.153

Note: As noted in the text, regressions are identical to those reported in table 6 except for the fact that 'large farms' are only those who cultivate at least 50 ha of crops to avoid results being driven by large livestock farms. Other control variables that are included throughout but not reported are farm size, household composition (no. of children, adults and old people), headship, head's age, highest education in the household, a time dummy, and rainfall shocks. EA fixed effects are included throughout and standard errors are clustered by EA. *** p<0.01, ** p<0.05, * p<0.1.

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