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The Impact of Credit Policy on Rice Production in Myanmar

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Abstract

Rural finance has long been an important tool for poverty reduction and rural development by donors and governments, but the impacts have been controversial. Measuring impact is challenging due to identification problems caused by selection bias and governments' targeted interventions, while randomised trial data are scarce and limited to contexts where little to no rural finance exists. Using an author-collected dataset, we provide insights on a large-scale long-lasting subsidised rice credit programme in Myanmar, one of the poorest and, until recently, most economically isolated countries in Asia. Identification relies on a fuzzy regression discontinuity design, exploiting an arbitrary element to the credit provision rule which is based on rice landholding size. Although we find little evidence that rice yield or output is increased, we do see that the programme has some positive effects on total household income, suggesting a positive spillover effect on other farm income activities.

Keywords: *Credit*; *Myanmar*; *regression discontinuity*; *rice production*; *rural finance*.

JEL classifications: *Q14, D14, G21, I38, O16, P34*.

1. Introduction

Over the last six decades, Myanmar has relied on government subsidised credit for household farms as a key financing policy to improve agricultural productivity. The ultimate goal of this policy, as in many developing countries, is to reduce poverty and develop rural areas. At the global level, the last six decades

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can be divided broadly into two distinct episodes of growth and transformation in rural finance. The first episode, from the 1950s to the mid-1980s, witnessed large-scale credit programmes, subsidised by governments and donors, being channelled to the agricultural sector with an aim to increase rural incomes.[2] Contrary to expectations, most of these programmes performed badly with high default rates (Adams *et al.*, 1984), repressed financial markets (McKinnon, 1973), and outcomes that benefited the rich more than the poor (Gonzalez-Vega, 1984). The second episode began in the early 1990s characterised by group lending, a so-called 'critical innovation'. Funding comes mainly from non-governmental organisations (NGOs) providing loans to poor people lacking any financial security (Armendáriz and Morduch, 2010). Early successful experience has brought about an exponential growth of microcredit clients (Morduch, 1999). By 2006, a Nobel Peace Prize was awarded to the pioneers in group lending. However, this momentum came to a halt due to the microfinance crisis in India in 2010. In fact, this microfinance crisis, which is the largest to date, has raised serious concerns about the general impact and sustainability of microfinance (Mader, 2013).

Measuring the impact of credit programmes is challenging due to a self-selection bias. This challenge is further complicated by the targeting nature of financial institutions' and governments' policies. From a methodological point of view, the preferred approach to address these identification problems is to use a randomised control trial (RCT). Thus far, most of the handful of published field experiments consistently show that credit yields a modestly positive, but not transformative effect on household income and expenditure (Banerjee *et al.*, 2015).

An alternative approach to measuring the impact of credit programmes is to use policies which can be viewed as quasi- (or natural) experiments. For example, in 2001, the government of Thailand launched so-called 'Thai Million Baht Village Fund' microfinance programme. The programme provided a one-off million Thai Baht or about US$ 24,000 to create a bank in each of 77,000 rural villages. Since the funding for each village is fixed, regardless of the village characteristics, its injection has been used as a natural experiment by Kaboski and Townsend (2012) to analyse its impact on beneficiary households and villages. Their study suggests a boost in households' consumption and income but a slow-down in asset growth as a result of the injection.

Despite their advantages in measuring an impact, RCTs are resource-intensive and politically infeasible while natural experiments are not readily available. Moreover, experiments tend to measure the impact of credit on *marginal* (i.e. new), not *infra*-marginal (i.e. existing) borrowers (Banerjee *et al.*, 2015). The underlying reason is that RCTs are typically implemented in contexts where little or no rural finance exists to avoid possible confounding factors, thus revealing the impact only on marginal borrowers. While this knowledge is highly policy relevant and methodologically clean, it is also important to learn about the impact on *infra*-marginal borrowers to justify existing lending programmes. Finally, credit lending modalities are diverse, and their impact can be highly contextual, calling for more rigorous evidence from various settings.

[2]For example, the injection of credit into the rural sector in Brazil increased from US$ 2 billion in 1970 to US$ 20.5 billion in 1979 (Kaboski and Townsend, 2011); the annual World Bank lending for agricultural credit project was over US$ 1 billion in the 1980s (Conning and Udry, 2007).

In this light, we make two contributions to the literature. First, we use a fuzzy regression discontinuity (FRD) approach to measure the impact of a large-scale long-lasting subsidised credit programme for rice production in Myanmar on a range of possible outcomes including rice output, yield and income, among others. Identification relies on an arbitrary element in the credit provision rule, which sets a threshold of 10 acres as the maximum for farmers to borrow a fixed amount per acre of rice landholding. As this credit programme has been implemented for decades, our estimates reflect the impact on infra-marginal borrowers.[3] The second contribution is our unique case study of Myanmar. Using author-collected data, we shed light on a country which has come out of its self-imposed isolation from the world only recently and seriously lacks reliable micro data and statistics for farm households. In Myanmar's apparently underdeveloped financial sector, however, the government subsidised credit programme has much higher repayment rates compared to similar programmes in other countries. One of the underlying reasons is arguably the group lending being implemented as early as 1965/1966, well ahead of the global renovation in microfinance in the 1990s.

2. Brief History of Institutional Rural Credit in Myanmar

Until recently, Myanmar had been isolated from the world for decades due to its inward-looking self-reliant policy in the form of the 'Burmese Way of Socialism'. As a result, it remains an agricultural economy in which the agricultural sector represents between 35% to 40% of gross domestic product (GDP), up to 70% of the labour force and generates between 25% to 30% of total export earnings (De Luna-Martinez and Anantavrasilpa, 2014). Rice dominates the agricultural sector, being the main staple of the national diet, a primary source of income for households and bringing important export revenues for the country. In this context, stimulating rice production has been a key priority for the Myanmar government (MoAI *et al.*, 2015), defining its rural finance policies. This section discusses the history of rural institutional finance since the independence in 1948 until recently.

2.1. From the independence to the first reform in 1987/1988

Despite the emphasis on providing sufficient institutionalised agricultural credit to support the agricultural sector, the government had met only 12–15% of the need for rural credit by 1953 (Steinberg, 1981). Since loans, which were provided at 6.5% interest rate per year, were not secured and supervised, their repayment was poor, leading to outstanding farm debt being more than half of farm income (Steinberg, 1981).

The State Agricultural Bank (SAB) was established in 1953 as Myanmar's fundamental institution for rural finance. Yet for the first five years, credit was channeled to farmers via trained field workers and through cooperatives. Eventually, a network of village banks was gradually developed, from 1,290 banks in 1958 to 11,207 banks in

[3]The use of a FRD design to assess the effects of micro credit is not new. For example, Aktaruzzaman and Farooq (2016) use data from 69 villages in Bangladesh to estimate the impact of credit on household expenditure. Also relying on a discontinuity around land size, they found a positive impact of credit on spending at the village level, but mixed effects on the household level. Due to different contexts, data and the lack of external validity regarding FRD, these findings are not directly comparable to ours.

1978, with a presence in almost every village in the country (Steinberg, 1981). From 1953 to 1960, agricultural loans provided by the SAB satisfied just under a quarter of total demand. Interest rates charged to farmers were 12% per year in late 1950s (Win, 1991) while reported repayment rates vary by source, ranging from 70–80% to 92% (World Bank, 1974; Win, 1991).

From 1964 onward, the SAB introduced measures to increase loan repayments. In particular, it reduced the total amount of new loans and provided these only to farmers who had repaid their previous loans (World Bank, 1974). Besides, it imposed a penalty charge of 1% per month above the regular interest charge to borrowers with overdue loans. Finally, from 1965 to 1971, members of village banks were held collectively responsible for repayment of loans. These measures initially improved loan repayments, up to 96% in 1969, but then deteriorated again in the early 1970s (World Bank, 1974, p. 36). During this period the SAB charged an interest rate of 9%, of which village banks kept 6% for their operation and bore the burden of unpaid debts. In 1970, the SAB merged (as the Agricultural Finance Division) with the People's Bank, to form the Union of Burma Bank (UBB), the only bank in Myanmar under a mono-bank system.

Although the high repayment rates in the late 1960s were commendable given that the loans were unsecured, there were some issues with government credit provision. First, loans that became delinquent were usually not followed up and repaid in later years, which resulted in a growing number of farmers ineligible to receive new loans (World Bank, 1974). Second, a severe shortage of institutional credit led to a predominant role of illegal private credit. With interest rates ranging from 40% to 400% per year, private credit was estimated to be three times as much as institutional credit (Steinberg, 1981). Finally, farmers used up to 35% of crop production credit for their subsistence expenses before harvest, a further amount spent on hired labour, and only a small share of credit spared for seed, fertilisers and other productive inputs (World Bank, 1974).

Between 1973 and 1977, the lending operations of village banks reduced substantially due to the implementation of an advance purchase system by the cooperative societies. Under this system, farmers could receive an advance of up to 70% of the government procurement quotas in cash and kind (Steinberg, 1981). In June 1974, the government initiated another advance purchase system but only in rice surplus areas in Lower Burma, while other areas continued to be serviced by village banks (Steinberg, 1981). In these rice surplus areas, farmers could get a further advance from the government, contingent upon their landholding area, but were required to sell their corresponding produce to the state at the state price. Although the official interest was zero under this system, the effective interest could be substantial due to the wedge between the state price and the market price, resulting in farmers' reluctance to participate. Private lending, though illegal, was estimated to account for about 40% of total rural credit provided at interest rates of up to 10% per month (Steinberg, 1981).

In 1976, the Agricultural Finance Division was separated from the UBB to become the Myanmar Agricultural Bank (MAB). The separation followed the 1975 Bank Law, under which the mono-bank system was dismantled; the UBB became the central bank, and three specialised banks emerged under its supervision. In addition to the MAB, these included the Myanmar Economic Bank (MEB) and the Myanmar Foreign Trade Bank. The MAB was in charge of providing seasonal, medium-term, and long-term agricultural loans.

From 1978 to the early 1980s, the MAB had increased its disbursement substantially to support the launch of the Whole Township Rice Production Programme (WTRPP) in 1978. This WTRPP introduced modern high yielding varieties (HYV) of rice to enhance production possibilities. As a result, the MAB's lending increased due to both the expansion of area devoted to HYV and the rise in lending rates to satisfy a much higher need for fertiliser of HYV to generate high yields. Farmers received loans via village banks at the interest rate of 12% and were required to save 1% of the loan. Village banks enjoyed a margin of 4% interest rate, a 10% commission on the loan principal recovered plus 2% of all interest recovered (Win, 1991). These incentives, as well as increased supervision, contributed to smooth disbursement and recovery rates over 90% for seasonal loans. At the same time, the MAB's lending portfolio skewed heavily in favour of rice production, covering 85–88% of all crop loans and approximately 80% of the credit requirement for rice (Win, 1991).

But as the economy deteriorated in the mid-1980s, farmers again faced severe credit constraints. With inflation around 20–30% per annum, money printing to finance budget deficits, the demonetisation of currency notes in 1985 and 1987 and the removal of subsidies on agricultural inputs such as fertiliser in 1987, agricultural inputs became less affordable for farmers. As a result, fertiliser usage dropped to levels as low as before the launch of the WTRPP, reducing the effectiveness of the WTRPP in expanding the use of HYV.

2.2. *From the first reform in 1987/1988 to present*

A market-oriented policy was adopted in 1988, followed by the promulgation of new bank laws to open the financial sector to private and foreign investors. This policy change also saw a restructuring of the MAB. First, the nation-wide network of about 11,200 village banks was replaced with a system of branch banks between 1998 and 2000 (Fujita *et al.*, 2009). This branch network has 220 banks as of 2013, accounting for 23% of all bank branches in Myanmar (De Luna-Martinez and Anantavrasilpa, 2014). Second, the MAB was transferred to the Ministry of Agriculture and Irrigation (MoAI) from the Ministry of Finance and Revenue and subsequently renamed as the Myanmar Agricultural Development Bank (MADB) in 1996. However, the reforms in the financial sector that were initially planned in 1988 were implemented only partially due to the Asian financial crisis in 1997 and the banking crisis in early 2003.

Since 2011, the MADB's subsidised credit policy has been increasingly out-of-date in the context of vigorous economic reforms. In particular, as the economy is growing faster, the consumer price index (CPI) is increasing. This situation makes the interest margin enjoyed by the MADB shrink as it maintained a fixed interest policy of 8.5% per annum. By 2013, the MADB had become dependent on government subsidies, causing a fiscal burden of about 0.2% of GDP (De Luna-Martinez and Anantavrasilpa, 2014). This dependency and fiscal burden has forced the MADB to narrow its lending portfolio to a limited number of crops, despite its mission of providing banking services to support the development of agriculture, livestock, and rural socio-economic enterprises.

Currently the MADB offers two types of loans, namely seasonal crop production loans (SCPL) and term loans (TL). However, its lending activity is dominated by SCPL which in 2012 accounted for 98% of the total loans (De Luna-Martinez and Anantavrasilpa, 2014). SCPL loans have been provided for the production of eight main crops, namely paddy (which becomes rice after the removal of husks by threshing), groundnut, pulses, sesame, cotton, jute, maize and mustard since 1998 (Win, 2013). SCPL for the monsoon season accounts for 85% of all MADB loans (De Luna-Martinez and Anantavrasilpa, 2014). Although 88% of monsoon SCPL loans are for paddy, they still cover only 25–50% of paddy farmers' production costs (Haggblade *et al*., 2013; De Luna-Martinez and Anantavrasilpa, 2014). Meanwhile, the marginalised TL loans are to finance sugarcane plantation, tea processing and solar salt production.

Since 2010, the disbursement of seasonal loans by the MADB has apparently increased sharply, with the nominal value of the credit volume disbursed for 2012–2013 being 46 times that in 2000–2001 (Win, 2013). However, in real value, the loans borrowers received were smaller than those a decade ago, since CPI increased by 640% from 2000 to 2013 (IMF, 2018). Furthermore, coupled with this high inflation was the expansion of sown area by 66% (from 8.7 to 14.4 million acres) and the increase of almost 40% (from 1.16 to 1.59 million) in the number of borrowers (Win, 2013).

As the demand for MADB loans is higher than the supply given the interest subsidy, the MADB has also rationed the loans in addition to focussing only on key crops. In particular, for each season, it lends K 100,000 (approximately USD 100) per acre for paddy production and K 20,000 (approximately USD 20) per acre for other crops. And the maximum loan size is based on the agricultural landholding area for which the farmer has a land titling right, and is capped at 10 acres per farm household.

To maintain high repayment rates while not requiring any collateral from farmers, the MADB has some other lending rules. First, farmers-borrowers need to have their loan applications approved by a loan screening committee set up in each village. The committee comprises the head of village and representatives from the Land Record Department, the Department of Agriculture, the Industrial Crop Department, and the farmers, thereby reducing information asymmetry problems (De Luna-Martinez and Anantavrasilpa, 2014). Second, farmers borrowers are required to form lending groups of 5–10 members, accepting liability for both their individual and other group members' loans (World Bank, 1974; Fujita *et al*., 2009). The MADB only provides loans to farmers in townships with full repayment history. Finally, in addition to having a good credit history, farmers need land titling rights to be eligible for MADB loans. These rights were required for annual registration and renewal until 2012. Under the Farmland Law 2012, farmers have more freedom to sell, transfer, mortgage or rent their land use rights to others and the duration of the right to farm is unlimited as long as certain conditions are met.

To this end, the MADB has maintained high repayment rates unlike its counterparts in many developing countries. Its non-performing loans represented only 0.02% of the total lending in 2012–2013 (Win, 2013). Furthermore, group lending was implemented as early as in 1965/1966, well ahead of the global renovation in microfinance in the 1990s, and has been fully implemented since 1998. However, the downside of this achievement is that more than 3.5 million farmers, most of whom are poor, are not served by the MADB due to the widespread lack of land titles (De Luna-Martinez and Anantavrasilpa, 2014).

The dominant role of MADB started to decline since the adoption of the Microfinance Law in 2011 which opened the rural credit sector to other stakeholders. Based on limited data, an estimate by Duflos *et al*. (2013) suggests that the outstanding loans of MADB represented only 36% of the total outstanding loans by all microfinance providers in 2011–2012, but its clients accounted for more than half of total clients served by these institutions. The latter is due to the MADB having the largest bank network covering the whole country.

3. Study Areas, Data Collection, Crop Credit Market and Variables

3.1. Study areas and data collection

Our empirical analysis draws on a farm household survey conducted in 2014. The sample of farm households was selected using a stratified multistage sampling procedure. The survey was canvassed in Myanmar's three main rice producing regions, Ayeyarwady, Bago and Sagaing, which account for roughly 26%, 17% and 12%, respectively, of the total rice output in Myanmar in 2012–2013 (MoAI, 2013). In each region, the district with the highest rice output was selected as strata in our sampling frame. Two townships from each district were then randomly sampled, and five villages from each township. In the final stage of sampling, farm households were randomly drawn using a circular systematic sampling method with probabilities of being selected proportional to the village's number of farm households. We interviewed 634 farm households in total, of which 215 were in Ayeyarwady, 212 in Bago and 207 in Sagaing. Out of 634 interviewed households, 628 were eligible for MABD credit and used in this paper (see online Appendix S1 for a detailed description of our survey).

The regions vary greatly in soil type, irrigation and remoteness, which is subsequently reflected in household rice production, crop diversity and income sources. For example, the soil in the two Ayeyarwady townships is gley or gley swampy, while Bago features meadow and alluvial meadow. In contrast, the soil in the Sagaing townships varies from meadow and alluvial meadow to red-brown forest soil. The Ayeyarwady and Bago regions are located in the Delta Region where monsoon paddy is usually rain-fed, whereas Sagaing is located in the Central Dry Zone and rice production typically relies on irrigation. Finally, Ayeyarwady and Bago are located near Yangon, the largest city and former capital of Myanmar, while Sagaing is more remote, bordering India in the north of Myanmar.

3.2. Crop credit market

Table 1 provides detailed information on crop credit received by farms in the sample. On average, the outstanding loans in our sample run for about six months, which suggests that these are likely to be seasonal crop production loans. Loans for rice production dominate in all regions, and especially in Ayeyarwady where they account for 100% of all crop credit. The MADB plays a dominant role in loan supply, providing 81% of loans in Sagaing, 58% in Bago and 64% in Ayeyarwady, mostly for rice production. Farmers reported having to satisfy all MADB loan requirements: having land-use-right certificates, having a savings account at MADB, and being part of a lending group in addition to being approved by a village loan screening committee. They were charged an interest rate of 0.71% per month (or 8.5% per annum) and could borrow for up to 10 acres only. All but one (due to illness) repaid both principal and interest when loans reached maturity. The second primary source of credit is from relatives, accounting for 4–5%, 17–18% and 12% in Sagaing, Bago and Ayeyarwady, respectively, of total household total credit. Interest rates per month are much higher than those set by the MADB, at about 4% in Sagaing, 5% in Bago and almost 8% in

Table 1
Crop credit market

Region	Item	Non rice crops					Rice				
		Relatives	Brokers	MADB	NGO	Others	Relatives	Brokers	MADB	NGO	Others
Sagaing	Interest rate (%/month)	2.5		0.71			4.3	0.8	0.71	1.5	1.5
		(3.5)		(0.0)			(3.0)	(2.0)	(0.0)	(.)	(1.3)
	Duration (months)	6.0		6.4			6.2	5.8	6.4	6.0	5.3
		(1.4)		(0.5)			(1.3)	(1.2)	(0.5)	(.)	(2.0)
	Amount (USD)	550		198			527	417	586	100	241
		(212)		(369)			(424)	(306)	(276)	(.)	(406)
	% of credit amount	5		95			4	1	91	1	4
		(19)		(19)			(12)	(7)	(18)	(.)	(12)
	N	2		28			15	6	164	1	21
Bago		5.4	6.0	0.71		4.9	5.2	5.5	0.71	2.8	2.3
		(2.2)	(0.0)	(0.0)		(1.7)	(2.1)	(4.0)	(0.0)	(1.1)	(1.9)
	Duration (months)	6.1	7.0	6.1		6.8	6.3	7.2	6.4	5.8	5.8
		(1.6)	(0.0)	(0.6)		(2.5)	(1.8)	(2.9)	(0.5)	(0.6)	(1.8)
	Amount (USD)	794	925	194		1,475	1,055	1,150	967	447	652
		(649)	(435)	(175)		(1,284)	(1,036)	(859)	(594)	(1,020)	(1,062)
	% of credit amount	17	8	68		8	18	6	70	1	6
		(35)	(24)	(42)		(25)	(24)	(17)	(26)	(4)	(15)
	N	8	4	40		4	91	22	220	11	48
Ayeyarwady	Interest rate (%/month)						7.75	5.91	0.71	1.85	4.81
							(14.0)	(1.7)	(0.0)	(1.1)	(14.4)
	Duration (months)						5.6	7.9	6.0	5.3	4.5
							(1.2)	(2.6)	(0.8)	(0.7)	(2.9)
	Amount (USD)						639	1,068	724	253	1,110
							(714)	(907)	(327)	(104)	(1333)
	% of credit amount						12	2	76	3	7
							(20)	(10)	(23)	(7)	(18)
	N						94	11	345	39	47

Note: Standard deviations are in parentheses.

Ayeyarwady. NGOs and other credit institutions such as pawn shops play a negligible role in credit supply for crop cultivation in the three study regions.[4]

3.3. Variables

The primary outcome variables for our analysis are related to rice production. Rice output is the total output of rice in kilogrammes for each farm over the full year 2013. Total income converted into USD (at January 2014 price) is based on revenues from rice, other crops, livestock, fishery, horticulture and non-farm household business activities per year, all of which are recorded separately.[5] Farm spending on factor inputs per acre, such as fertiliser, family labour and hired labour, and other material inputs are also measured in USD. The key exploratory variable of interest is total MADB credit for summer paddy and monsoon paddy. For land size, we have information on the farm area with land use certificates, as well as the total planted land (both owned and rented, measured in acres) used in annual paddy production.

In addition to these key variables, we use a number of independent variables as controls in the regression analysis, as they may affect rice production. The demographic characteristics of a household are captured by the number of household members and the dependency ratio (the number of non-working family members over the family size). The number of family members available to work determines both farm production and other sources of income. Proxies for the skill level of the farmers are the number of years of farming experience and the education level of the household head. Education is categorised into three different levels: at most primary school, secondary school, and high school or higher education. We also include the age and gender of the household head. The respondent farmers were asked to self-assess the water availability from irrigation or natural sources, such as creeks, rivers, dams and reservoirs, and private channels (rating as 1 = poor, 2 = average, 3 = good or 4 = very good). Availability of agricultural extension services is defined as a farm household receiving services for farming activities, be it from the government, private agencies or NGOs. The distance from a village to a township is considered to be an important factor in applying for agricultural credit. Due to a lack of good roads and transportation, travel time and transportation costs can pose substantial obstacles to credit and diminish production efficiency (Tracey-White, 2005). Li *et al.* (2011) show that households located close to township bank branches are more likely to apply for loans compared to those further away. In our sample, we see that households located more than 96 km from a township's branch bank do not apply for agricultural loans.

Table 2 shows the summary of descriptive statistics for the sample of farm households. The average farm in the sample cultivates 13.7 acres and produces about 15,800 kg rice, generating about 3,200 USD in income/revenues (Table 2, column (2)). Rice output is strongly correlated with land size, as expected. Farm rice income is

[4]Our data show a slightly different picture of the credit market compared to LIFT (2012) regarding the source of credit and interest rates. In particular, LIFT (2012) find that the key source of credit for households is families, friends and brokers and the interest rates are 10–20% per month. This difference comes from different samples, with LIFT (2012) covering all households who live in a broader geographical area, while our sample includes only rice farm households from three regions.

[5]The prevalent exchange rate at the time of the survey was 1,000 Kyat = 1 USD. Please see the online Appendix S1 for further details on survey time and collected information.

Table 2
Summary statistics

Variables	Full sample Mean	Full sample Std. dev.	≤10 acres Mean	≥10 acres Mean	Sagaing Mean	Bago Mean	Ayeyar-wady Mean	H_0: $\bar{X}_{\leq 10} = \bar{X}_{>10}$ *P*-value
Rice output (kg)	15,807	(16,960)	8,084	30,333	5,854	19,034	22,361	0.000
Rice yield (kg/acre)	1,086	(420)	1,053	1,148	800	1,290	1,163	0.007
Rice income (USD)	3,295	(3,651)	1,665	6,362	1,879	3,444	4,537	0.000
Rice income per acre (USD)	224	(104)	221	230	242	216	216	0.308
Total income (USD)	4,453	(4,598)	2,578	7,979	3,051	5,429	4,857	0.000
Total income per capita (USD)	907	(970)	551	1,576	611	1,065	1,040	0.000
Fertiliser per planted acre (USD)	18.1	(23.5)	17.9	18.4	26.3	3.7	24.4	0.031
Rice inputs excl. fertiliser per planted acre (USD)	2.4	(5.7)	2.9	1.7	4.5	0.84	1.7	0.035
Hired labour per planted acre (USD)	31.7	(26.3)	26.4	41.7	25.0	35.3	34.7	0.000
Family labour per planted acre (USD)	16.8	(22.5)	20.8	9.4	24.8	14.7	11.1	0.000
Credit per acre (USD)	76.8	(39.7)	86.6	58.3	80.3	77.5	72.7	0.000
Rice land area with land use certificate (acre)	11.6	(11.3)	5.9	22.4	6.7	13.7	14.3	0.000
Rice planted area (owned or rented, acre)	13.7	(13.0)	7.2	25.9	6.7	14.6	19.7	0.000
Household head								
Age	51	(12)	51	52	52	52	49	0.246
Gender (1 = male)	0.96	(0.21)	0.96	0.95	0.97	0.98	0.91	0.910
At most primary education (1 = yes)	0.61	(0.49)	0.64	0.56	0.63	0.51	0.69	0.067

Table 2
(*Continued*)

Variables	Full sample Mean	Full sample Std. dev.	≤10 acres Mean	≥10 acres Mean	Sagaing Mean	Bago Mean	Ayeyar-wady Mean	H_0: $\bar{X}_{\leq 10} = \bar{X}_{>10}$ *P*-value
Secondary education (1 = yes)	0.25	(0.44)	0.25	0.27	0.23	0.32	0.22	0.507
High school/higher education (1 = yes)	0.13	(0.34)	0.11	0.17	0.14	0.17	0.09	0.075
Farming experience (years)	28	(13)	28	29	29	30	25	0.125
Number of house hold members	5.4	(1.9)	5.2	5.7	5.4	5.4	5.3	0.001
Dependency ratio	0.45	(0.23)	0.43	0.48	0.40	0.42	0.52	0.014
Irrigation deemed good/very good (1 = yes)	0.82	(0.38)	0.78	0.90	0.55	0.94	0.97	0.000
Agricultural extension services (1 = yes)	0.58	(0.49)	0.58	0.58	0.58	0.51	0.64	0.905
Distance to market (km)	17.0	(19.7)	18.6	14.0	28.2	6.5	16.6	0.006
Sagaing (Dry Zone) (1 = yes)	0.33	(0.47)	0.43	0.15				0.000
Bago (Delta Region) (1 = yes)	0.33	(0.47)	0.28	0.44				0.000
Ayeyarwady (Delta Region) (1 = yes)	0.34	(0.47)	0.30	0.41				0.005
N	628		410	218	207	210	211	

about 220 USD per acre, on average, for which, the largest cost component is hired labour (representing 14% of rice income), followed by fertiliser and family labour (8% each). Meanwhile, other inputs including seeds and machines cost only 1% of the rice income on average. This cost structure reflects the current situation of rice production in Myanmar as described by IBRD (2016): labour intensive and lack of investment in mechanisation and high-quality seeds. This situation explains in part the lower rice yield experienced by the country compared with other South East Asian countries such as Vietnam, Indonesia and China.

Also in Table 2, we find little evidence of economy-of-scale in rice production when comparing farms on the two sides of the 10-acre cut-off of the MADB credit policy (columns (4)–(5)). In particular, larger farms have slightly higher rice yield than smaller ones, but the difference in rice income per acre between the two farm types is negligible and not statistically significant at conventional levels (*P*-value = 0.308). The feature that distinguishes them is probably the extent of hired labour. Larger farms use almost twice as much hired labour per acre in comparison with smaller farms. This result is plausible since larger farms have bigger land areas to work with and they are also richer, with income triple that of smaller farms.

Marked differences across the three regions are evident in Table 2, columns (6)–(8). The Delta Region comprising of Ayeyarwady and Bago enjoys conditions that are more favourable for rice farming, such as higher annual rainfall and fertile soils. Here, especially in Ayeyarwady, most farms plant two seasons of rice per year. The low coverage of irrigated areas, being barely 20% of the total area of Myanmar (MoAI, 2013), means most farmers outside the Delta Region can have only one rice crop. Thus average planted land is much larger in Ayeyarwady (19.7 acres) and Bago (14.6 acres) than in Sagaing (6.7 acres). Almost all farms in the Delta Region report to have good or very good irrigation, compared to just over half the respondents in Sagaing.

These differences thus explain the regional variation in outcome variables. Favourable conditions for rice cultivation allows farms in the Delta Region to have not only more output but also higher rice yield. Rice production per farm in the Delta Region is, on average, more than three times larger than in Sagaing while rice yield is about 45–50% higher.

Nonetheless, higher output and yield do not necessarily mean higher rice income/revenues. Although rice income is roughly twice as high in the Delta Region, rice income per acre is higher in Sagaing. The reasons might be twofold. First, the abundant supply of rice in the Delta Region, which accounts for half of the total rice production in Myanmar, may have a downward pressure on rice price. Second, the quality of rice varieties differs, so do their prices. Although HYV generates a higher yield, they are less valued in the market compared with some traditional varieties. Across Myanmar, only 40% of rice production uses modern HYV (MoAI, 2013). Part of the slow but on-going expansion of HYV is due to the low coverage of irrigated areas. Meanwhile, the use of low-yielding traditional seeds with organic inputs and a more extended maturation period remains widespread, probably because they can cope better with the weather and soil conditions (MoAI *et al.*, 2015). Some of indigenous varieties such as Paw San rice which is largely found planted in Sagaing and Ayeyarwady have a high market value and internationally recognised quality (Myint and Napasintuwong, 2016).

Differences in natural and socio-economic conditions also induce regional heterogeneity in input use across regions. The Delta Region is more prone to flooding, and therefore, farmers here are less likely use chemical inputs (MoAI, 2013). As seen in

Table 2, the use of fertiliser is lower in the Delta Region, especially in Bago. Furthermore, the use of hired labour is more common in the Delta Region because farmers here have larger farms and the region is home to many landless people with low levels of income (MoAI, 2013). Finally, farmers in Sagaing, on average, have more credit per acre than their counterparts in the Delta Region since they have smaller farms while the MADB caps its lending at 10 acres.

The lack of sufficient availability of irrigated water in the Dry Zone reduces the incentive for farmers to cultivate rice and turn instead to other crops. Among them, pulses, sugarcane and peanuts are popular because they require less water but enjoy increased export demand. These differences are reflected in the share of rice income in the total income which is much higher in the Delta Region. Within the Delta Region, we also see variation in farming practices. While rice production and income are by far higher in Ayeyarwady, total income is higher in Bago, as farms in Bago have a larger income share from other sources. Bago farmers are also relatively better educated and located much closer to markets.

4. Empirical Strategy

4.1. *Identification*

Our main objective is to identify the causal effect of the MADB credit scheme on a range of various rice-related outcomes such as rice output, yield, and income, as well as the total income of farm households. The primary threat of endogeneity comes from potentially confounding characteristics that affect both rice production and the amount of credit received. First, the targeting design favours relatively more able farmers that tend to have good credit histories. Second, the scheme involves an element of self-selection by which risk averse, lower educated, or less motivated or confident farmers are less likely to take up credit. Both these effects can lead to a positive bias, and hence an overestimate of the effects of providing MADB credit on rice yields and income.

To address this problem, our identification strategy exploits the targeting design of the MADB programme. This programme introduces a discontinuity in eligibility around a threshold of 10-acre rice land area with use right certificates. Farms just below and just above this threshold are not equally eligible for a loan. Obviously, small and large farms are not a proper comparison, as land size is a key factor for production and income. Yet, there is no reason to expect that farms close enough to the threshold on both sides are different in any characteristics other than the MADB eligibility. Note that this threshold is not a clear cut off for being eligible for a loan. Rather, it is the point at which the maximum amount of credit is reached. Farms having fewer than 10 acres of rice land with use right certificates are eligible to borrow USD 100 per acre per cropping season, and the maximum amount that can be borrowed increases linearly with the land size. For farms larger than 10 acres the total amount is capped at USD 1,000 per season for the first 10 acres, which means the average credit per acre decreases with land size. This setup, therefore, implies a *fuzzy* regression discontinuity design (RDD): farms on either side of the threshold receive credit, but at the threshold, there is a discontinuity in the eligible amount of credit per acre.

With this setup, following Lee and Lemieux (2010) we formulate our model as below:

$$\begin{cases} Y_i = \beta_0 + \beta T_i + \beta_l f(L_i) + \beta_x X_i + v_i & \text{where } i = 1, \cdots\cdots, N \\ T_i = \pi_0 + \pi_1 D_i + \pi_l f(L_i) + \pi_x X_i + \epsilon_i & \\ D_i = 1 \text{ for } L_i > 10 \text{ acre}; \quad D_i = 0 & \text{otherwise,} \end{cases} \tag{1}$$

where Y is the outcome of interest, T is the continuous treatment variable or the MADB credit per acre, L is the assignment variable or the land size with use right certificates, X is a vector of predetermined and observable characteristics of the farm household i that might impact the outcome and/or the assignment variable L, and D is the binary treatment indicator.

To estimate the treatment effect of T on Y in the presence of fuzzy RDD, we adopt an instrumental variable (IV) approach as suggested by Hahn *et al.* (2001) and has been widely used by recent literature.[6] The instrument is the treatment indicator D. Since the 10-acre threshold is an arbitrary decision, we expect that conditional on actual land size, D does not affect the outcome variable other than through the MADB scheme, satisfying the exclusion restriction. If the exclusion restriction holds, then we can interpret β as the causal effect of providing credit of USD 1 per acre where β is the ratio of the reduced-form effects of D on Y and D on T, conditional on X and $f(L)$ as shown by Hahn *et al.* (2001).

While β has all the usual properties of an IV estimator, it reflects only a Local Average Treatment Effect (LATE) of the MADB scheme for farmers around the threshold. We thus need to be cautious generalising the estimated treatment effects to smaller and larger farmers, as this requires strong external validity assumptions that we cannot corroborate. For example, smaller and larger farmers are not expected to face the same degree of credit rationing, which would imply heterogeneous marginal effects of credit on productivity. Nonetheless, this threshold is the land size of the 60th centile farm household in our sample and located between the farm sizes of the mean (11.6 acre) and median (8 acre) households. This suggests that our LATE estimates are relevant at least for the 'average farm' in the distribution of rice landholding.

4.2. *Checking the estimation method*

We subject our empirical strategy to various inspections and tests on its appropriateness and validity. We first use graphs to examine the discontinuity of treatment and outcome variables at the threshold. We then confirm our visual examination using reduced form estimates which are the effects of the treatment binary indicator D on the treatment and outcome variables. This indicator variable is a valid instrument, satisfying the exclusion restriction if the treatment is assigned randomly. That is, farmers do not have *precise* control over their landholding (Lee and Lemieux, 2010), and therefore those on two sides of the threshold are not systematically different from each other in their characteristics. Following Lee and Lemieux (2010), we test this assumption using balancing tests on observable variables X.

Our tests and estimates are obtained using data in symmetric intervals $c \pm h$ around the threshold c where c = 10 acre and h is a bandwidth suitable for comparing the 'treatment' and 'control' groups. A relatively small interval around the threshold will reduce estimation precision due to having too few observations. Taking a wide interval may resolve this issue but also introduce bias from farms that are far from the

[6]For example, Ponce and Bedi (2010), Urquiola and Verhoogen (2009), Jacob and Lefgren (2004) and Angrist and Lavy (1999).

threshold and unsuitable comparisons for the farms below the threshold. To address this trade-off and to avoid arbitrariness in the choice of bandwidth values, for each outcome variable, we select a bandwidth that is asymptotically optimal based on squared error loss as proposed by Imbens and Kalyanaraman (2012). We call them IK bandwidths hereafter. Since our sample is quite small while the IV estimator has only large sample properties, we also use the largest possible interval [0, 20] in our analysis.

4.2.1 Visual inspection of discontinuity

Figure 1 presents non-parametric kernel regressions of both treatment T and outcome Y variables against the assignment variable L. All sub-figures are drawn using an optimally data-driven approach proposed by Calonico *et al.* (2015). That is, the number of bins is selected based on a mimicking variance evenly-spaced method using spacings estimators.

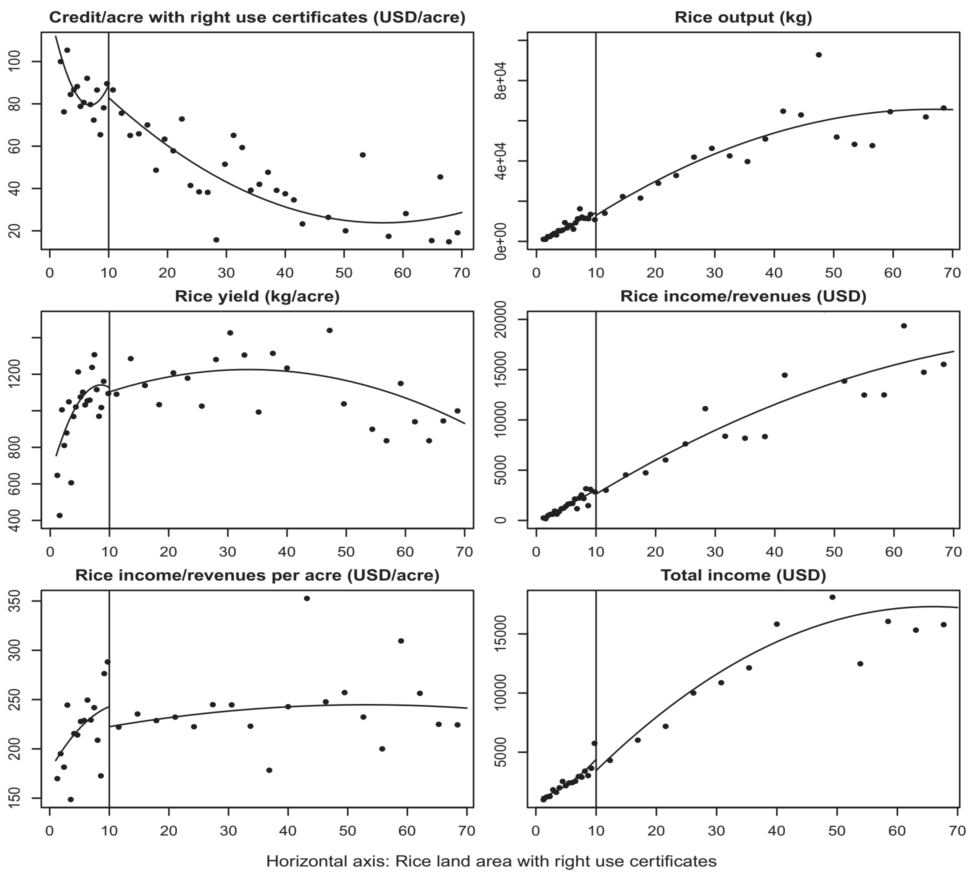

Figure 1. Discontinuities in credit per acre and various outcome variables
***Notes*:** This graph is optimally data-driven drawn using `rdplot` package in R by Calonico *et al.* (2017). `kernel=uniform` and the bin selection is based on the mimicking variance evenly-spaced method using spacings estimators as suggested by Calonico *et al.* (2015).

The discontinuity is clearly observed in the treatment variable in the top-left panel of Figure 1. As can be seen, for farms smaller than 10 acres the average amount of credit per acre hovers around USD 100. The sub-figure also suggests that some farms received more than the maximum eligible amount, especially among the very small farms. This apparent suggestion does not necessarily point to manipulation of targeting. Rather, most being in Sagaing (the Dry Zone), were eligible for MADB credit for two seasons of rice; however, when crop time came, they were not able to cultivate rice in one or both seasons due to lack of water availability. Above 10 acres, we see an apparent decrease of MADB credit per acre, from about USD 80 at the threshold to below USD 20 per acre at 70 acres land size.

For outcome variables, we observe similar but much less pronounced patterns around the threshold. The non-parametric kernel regressions in the right column of Figure 1 show that rice output, rice income and total income are largely linear in land size, but we do see a small discontinuity around 10 acres, especially for the total income. Regarding rice yield, the left middle panel suggests clear economies of scale for small farms as land productivity increases up to around 35 acres when rice yield stabilises at 1,100–1,200 kg/acre. Similarly, rice income per planted acre in the bottom left panel exhibits an increasing trend for small farmers as rice land area increases, but relatively flat for large farms. As in other sub-figures, we see a discontinuity at 10 acres in these two panels.

4.2.2. Reduced form estimates

To confirm our visual inspection, we estimate the reduced-form impacts of the treatment binary indicator D on credit per acre and various outcome variables. For each variable, the impact is estimated for both IK and 10-acre bandwidths, controlling for various functional forms of rice landholding, namely linear, quadratic and cubic forms.

Table 3 presents our results. Overall, estimates using IK bandwidths are much more stable, not only in the level of statistical significance but also in magnitude of the impact. On the contrary, estimates using the 10-acre bandwidth are quite sensitive to the degree of polynomial, presumably due to the noises and differences in farms that are far from the cut-off.

For credit per acre, the impact is by and large statistically significant, confirming its discontinuity at the cut-off seen in the top-left panel of Figure 1. Farms larger than 10 acres receive USD 18–24 MADB credit per acre less than below the threshold, depending on the choice of bandwidth and land functional form. As these reduced form regressions are also the first stage regressions of the IV estimator which is also known as a two-stage least squares estimator, their overall F-statistics reflect the strength of the instrument. To this end, the instrument is weak because most overall F-statistics are smaller than 10, the rule-of-thumb benchmark by Stock and Yogo (2005). The only exception is the reduced form regression for the 10-acre bandwidth with a cubic land function which just makes it for this benchmark (Table 3, column (5)).

For rice output and rice income (total and per acre), we find no statistically significant difference between farms on either side of the threshold. Although their coefficients are in line with the discontinuities observed in Figure 1, the estimates lack precision. We do find some statistical significance in rice yield and total income for both bandwidths. However, the estimates are quite sensitive to the land functional form, especially for rice yield.

In summary, our reduced form estimates confirm the visual discontinuity in Figure 1. The difference between farms on two sides of the threshold is pronounced in the treatment variable but much less so in the outcome variables.

4.2.3. Validity of RDD approach

To test the validity of our RDD approach, Lee and Lemieux (2010) suggest that 'as in a randomised experiment, the distribution of observed baseline covariates should not change discontinuously at the threshold'. That means farmers on two sides of the threshold should be similar in all characteristics X so that the treatment is deemed to be assigned randomly, making the comparison between the control and treatment groups an apple-to-apple one. In RDD literature, this lack of difference in X between the two groups is referred to as X having continuity in the assignment variable at the threshold to contrast it with the corresponding discontinuity of outcome and treatment variables. Likewise, in the IV literature, if the 10-acre cap in lending by the MADB is random in the sense that farmers have no *precise* control over how much land they own[7] to maximise their gain from this lending scheme, we then expect no difference between the two groups. In this case, the binary treatment indicator variable D is exogenous and relevant (for having some correlation with credit per acre, the treatment variable), thus being a valid instrument.

With this in mind, we implement a so-called balancing test. In particular, we run regressions of farm characteristics X on the treatment indicator variable D (=1 if landholding size >10 acre). All regressions control for different degrees of a polynomial of landholding including linear, quadratic and cubic. We do not control for higher than a third order of land polynomial since it does not make much economic sense.

Results of the balancing tests are presented in online Appendix Table S1 for the largest 10-acre bandwidth and various IK bandwidths optimally chosen for outcome variables. To ease presentation, the results for rice income and rice output are not presented since they are similar to those for total income and rice yield, respectively. This similarity is expected since their data are almost identical. Each coefficient estimate in online Appendix Table S1 represents the difference in a farm characteristics variable X between the small and large farmer groups on two sides of the threshold, controlling for landholding. If the groups are similar in X, then the coefficients are statistically insignificant.

We find almost no statistical difference in farm household observable characteristics, regardless of the bandwidth or degree of polynomial. We do find some difference in irrigation and regional indicators which is driven by regional heterogeneity, and not controlled by households. Overall, online Appendix Table S1 suggests that the factors that matter for the outcome are continuous in the assignment indicator, D, thereby lending credence to our fuzzy RD approach. It also indicates the need to look at the causal impacts for not only all regions but also each region separately.

[7]That is, they can choose to have land below the 10-acre cut-off if they prefer, but they cannot manipulate this to have exact 10-acre landholding.

Table 3

Reduced form regressions of treatment and outcome variables against the binary treatment indicator

Bandwidth	IK bandwidth			10-acre bandwidth		
Order of polynomial	Cubic	Quadratic	Linear	Cubic	Quadratic	Linear
Credit/acre	−24.48+	−17.54+	−17.99*	−20.18**	−8.72+	−7.32
	(12.27)	(9.33)	(6.55)	(5.19)	(4.86)	(6.68)
Overall *F*-statistic	3.826	4.256	6.126	10.19	5.654	8.013
Rice output	−2,917	−2,707	−1,157	−727	349	−458
	(2,681)	(2,609)	(2,074)	(1,742)	(1,656)	(1,315)
Overall *F*-statistic	2.115	2.359	2.073	26.66	36.55	45.43
N	156	156	156	533	533	533
Credit/acre	−19.10+	−15.63+	−19.37**	−20.18**	−8.72+	−7.32
	(11.08)	(8.62)	(6.30)	(5.19)	(4.86)	(6.68)
Overall *F*-statistic	3.170	4.322	6.534	10.19	5.654	8.013
Rice yield	−301+	−230	−143	−100	−110	−170*
	(159)	(149)	(121)	(100)	(79)	(77)
Overall *F*-statistic	1.276	1.090	1.478	1.797	2.391	2.607
N	168	168	168	533	533	533
Credit/acre	−17.94**	−13.77**	−15.81**	−20.18**	−8.72+	−7.32
	(6.35)	(4.60)	(4.12)	(5.19)	(4.86)	(6.68)
Overall *F*-statistic	6.048	5.871	8.847	10.19	5.654	8.013
Rice income	−201	−276	−132	−171	14.9	−80.6
	(382)	(346)	(261)	(318)	(309)	(239)
Overall *F*-statistic	22.65	31.21	47.35	26.65	37.47	52.56
N	419	419	419	533	533	533
Credit/acre	−16.38*	−11.81*	−16.29**	−20.18**	−8.72+	−7.32
	(6.61)	(5.45)	(4.98)	(5.19)	(4.86)	(6.68)
Overall *F*-statistic	8.660	6.959	9.425	10.19	5.654	8.013
Rice income per acre	−20.8	−20.5	−22.8	−19.7	−22.6	−27.5
	(39.2)	(35.9)	(25.8)	(26.0)	(21.9)	(19.7)

Table 3
(*Continued*)

Bandwidth	IK bandwidth			10-acre bandwidth		
Order of polynomial	Cubic	Quadratic	Linear	Cubic	Quadratic	Linear
Overall *F*-statistic	0.356	0.492	0.440	0.634	0.815	1.042
N	269	269	269	533	533	533
Credit/acre	−18.45**	−13.67**	−15.39**	−20.18**	−8.72+	−7.32
	(6.29)	(4.63)	(4.28)	(5.19)	(4.86)	(6.68)
Overall *F*-statistic	6.348	5.579	8.310	10.19	5.654	8.013
Total income	−913*	−721+	−482	−668+	−176	−277
	(414)	(376)	(288)	(343)	(287)	(247)
F	11.40	15.64	17.64	18.95	20.41	28.71
N	420	420	420	533	533	533

Notes: Reduced form regressions control for different orders of a polynomial of landholding. Landholding refers to farm land area with certified land use rights. Standard errors in brackets adjusted for stratification at regional level and clustering at village level. Statistical significance: +10%, *5%, ** 1%.

5. Results

Table 4 shows fuzzy RD estimates using data in the IK bandwidths, and the IV estimator specified in equation (1).[8] All regressions control for a polynomial of landholding with use right certificates. Again, we consider landholding in linear, quadratic and cubic functional forms. For each land polynomial order, we further control for farm characteristics and regional indicators. Since irrigation is highly correlated with regional indicators, it is excluded from our list of control variables to avoid high multicollinearity, especially in the context of our small samples.

Estimates of the MADB credit impact on each outcome variable are highly robust across different model specifications. For each land polynomial order, extending the farm-attribute vector X has little bearing on the estimates, especially for rice income and total income. The exception is the estimates of the impact on rice output which are slightly sensitive to controlling regional indicators. It might well be that the widespread use of local seeds and the trade-off between yield and output price make the impact of the MADB credit on rice output region-specific.

Among models with different land functional forms, estimates are similar between those with the second and the third orders. Although all coefficient estimates are consistent as long as the instrument variable is valid, the ones using the third order seem to have the strongest instrument based on F-statistic values of the first stage regression. Again, the model for rice output is an exception in which the instrument variable is the strongest when land is linear.

We find statistically significant effects of MADB credit on total income and rice income per acre but no statistically significant effects on any other outcomes (with and without controls). In particular, the MADB scheme has a strikingly robust impact on total income, albeit a bit weak when land is linear (P-values range from 0.14 to 0.19). Controlling for either a second or third order of a land polynomial, 1 USD MADB credit per acre per season is estimated to increase total annual farm income by 44–54 USD, regardless of whether farm characteristics or regional indicators are controlled. On the other hand, the MADB credit has a statistically significant impact on rice income per acre in only one out of nine regressions, making it appear more like chance than a consistent effect. For other outcomes, the IV estimates are not statistically significant, irrespective of the choice of specification or landholding polynomials.

When we disaggregate the results by region (Table 5), we see that all effects on total income seem to stem from Bago. Again, this is robust to including additional controls and the choice of a land polynomial. The estimated effects on total income in Bago are of similar magnitude as for all regions, but statistically significant mostly at the 10% level, presumably due to the smaller sample size. For Delta Region, we find positive effects of MADB credit on both rice income per acre and total income. In particular, the estimates suggest that an additional 1 USD of seasonal credit per acre is associated with an increase of USD 2.1–2.5 in rice income per acre and of USD 58–61 in total annual income. These estimates, however, are robust to additional controls but not to the choice of landholding polynomial.

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[8]The estimates for the 10-acre bandwidth are similar with more precision but at the same time, more sensitive to the order of a land polynomial. They are available upon request.

Table 4

Instrumental variable regressions with control variables for IK bandwidths: all regions

Order of polynomial[a]		Linear			Quadratic			Cubic		
Outcome variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	N
Rice output	64.18	64.39	39.30	154.19	130.28	111.64	119.13	113.77	16.85	156
	(115.97)	(107.99)	(108.15)	(154.30)	(140.29)	(214.05)	(109.17)	(104.06)	(147.67)	
1st stage *F*-statistic	6.126	6.126	6.126	4.256	4.256	4.256	3.826	3.826	3.826	
Rice yield	7.37	7.00	4.15	14.70	12.50	12.68	15.74	14.27	22.41	168
	(6.35)	(5.49)	(5.31)	(11.00)	(8.86)	(12.92)	(11.36)	(9.31)	(21.01)	
1st stage *F*-statistic	3.170	3.170	3.170	4.322	4.322	4.322	6.534	6.534	6.534	
Rice income	8.34	10.86	12.98	20.06	21.25	26.74	11.18	14.62	18.16	419
	(16.62)	(14.95)	(16.29)	(24.27)	(20.98)	(24.98)	(20.27)	(16.56)	(18.68)	
1st stage *F*-statistic	6.048	6.048	6.048	5.871	5.871	5.871	8.847	8.847	8.847	
Rice income/acre	1.53	1.66	2.86+	1.52	1.59	3.80	1.06	1.10	2.28	269
	(1.64)	(1.31)	(1.65)	(2.49)	(1.92)	(2.98)	(1.89)	(1.49)	(2.26)	
1st stage *F*-statistic	8.660	8.660	8.660	6.959	6.959	6.959	9.425	9.425	9.425	
Total income	31.33	27.37	30.66	52.76+	45.57+	53.76+	49.47*	44.18*	52.23*	420
	(20.49)	(18.28)	(22.68)	(27.33)	(23.50)	(29.13)	(22.94)	(17.99)	(21.35)	
1st stage *F*-statistic	6.348	6.348	6.348	5.579	5.579	5.579	8.310	8.310	8.310	
Control variables										
Farm characteristics[b]	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	
Regional characteristics[c]	No	No	Yes	No	No	Yes	No	No	Yes	

Notes: [a]All regressions control for a polynomial of landholding with certified land use rights; [b]Farmcharacteristics: Household head's age, gender, farming experience, education level, household size, dependence ratio, availability of extension services. [c]Regional characteristics: Distance to the market and regional dummy variables for Sagaing (Dry Zone), Bago (Delta Region) and Ayeyarwady (Delta Region). Standard errors are given in brackets adjusted for stratification at regional level and clustering at village level. Statistical significance: +10%, *5%, **1%.

In general, we find no convincing evidence of MADB credit impacts on yields. One explanation could be that credit was used mostly to meet the shortage of cash before the harvest, rather than to invest in productive means. We do not have data on what exactly farmers used their credit for, but we do have information on their spending on factor inputs for rice production. As seen in Table 2 and discussed earlier, labour and fertiliser account for the bulk of the production costs. However, the IV estimates show no evidence that the MADB loans had any effect on these inputs (results available upon request). Similarly, we find no evidence that farmers used credit to invest in seeds (beyond the use of their harvest) or mechanisation. This result is plausible in the sense that farmers' spending on inputs other than labour and fertiliser accounts for only 1% of their rice income (Table 2). Altogether, these results suggest that the MADB credit was not used to transform production technologies or improve rice yields. This is in line with the existing literature that finds as much as 44% of households reporting food (for consumption) purchases as the primary use of credit, against only 18% households reporting the purchase of agricultural inputs (LIFT, 2012).

Another explanation for the lack of impact on rice yield is the possible focus of rice farmers on producing high-quality rice. Although we do not have data on what variety farmers planted, Ayeyarwaddy and Sagaing are the two largest regions in Myanmar producing Paw San rice – one of the world's highest quality rice. Paw San rice is priced about 33–36% higher than other rice but its adoption remains quite limited due to requiring more labour while having a lower yield than other varieties (Myint and Napasintuwong, 2016). Nonetheless, it is likely that rice income per acre rather than yield is more relevant for farmers. There is some evidence of the MADB credit impact on rice earnings per acre. For the Delta Region (Table 5), this impact is robust to additional controls but sensitive to the choice of a landholding polynomial. For all regions (Table 4), however, the result appears more like chance rather than a robust effect.

On the other hand, we do see a positive effect of credit on total farm income, possibly reflecting the fungibility of money. Farmers plant rice because they are not allowed to make an alternative crop choice when it comes to rice land, at least not in the short term, since their crop choices are bounded by their land use certificates which require them to plant rice in at least one season. They, therefore, optimise their total farm income, not rice income or output specifically. They could have used the option of cheap credit for rice production to fund other activities that generate more profit. This is consistent with the fact that the impact of credit is most pronounced in Bago, which can be attributed to the level of income diversification and favourable location. Farms in Bago not only have relatively high incomes from rice, but they also have the highest income from other crops due to fertile land and having only one cropping season for rice as a result of the lack of water in the dry season. They also have the highest income from horticulture and non-farm services compared to their counterparts in the other two regions, possibly due to location effects. Indeed, farms in Bago are located nearer to markets (on average 6.5 km compared with 28 km in Sagaing and 16.5 in Ayeyarwady) which facilitates income activities other than rice production, thus offering more productive options for cheap credit. Finally, this region is one of the three most developed areas in Myanmar and is close to the largest economic hub of Yangon, hence enjoys high demand and good prices for its agricultural products.

6. Conclusion

Subsidised rural credit has long been an important tool for poverty reduction and rural development by donors and governments but its impact remains controversial. Measuring the impact of subsidised rural credit is challenging for multiple reasons. First, since money is fungible and interest rates have an economy-wide

Table 5
Instrumental variable regressions with control variables for IK bandwidths: by region

Polynomial order[a]	Linear		Quadratic		Cubic		
Outcome variables	(1)	(2)	(3)	(4)	(5)	(6)	*N*
Sagaing							
Rice output	79.0	192	50.8	194	−26.3	−37.8	40
	(118)	(159)	(134)	(278)	(95.3)	(554)	
Rice yield	10.6	32.4	9.60	34.3	2.78	14.4	43
	(12.9)	(31.0)	(13.4)	(29.7)	(10.4)	(21.2)	
Rice income	−498	701	291	189	41.8	61.0	139
	(12,699)	(12,463)	(1,459)	(591)	(79.4)	(91.4)	
Rice income/acre	35.8	63.3	9.05	20.0	3.08	4.83	76
	(351)	(570)	(27.9)	(74.1)	(4.89)	(6.79)	
Total income	−327	−794	415	152	81.6	61.9	140
	(2,952)	(20,748)	(2,345)	(540)	(119)	(77.9)	
Ayeyarwady							
Rice output	−641	−593	−24.1	−71.7	−6,373	−446	53
	(2,370)	(1,314)	(947)	(359)	(166,456)	(1,254)	
Rice yield	−18.8	−17.5	−0.41	−4.13	−37.7	−103.8	58
	(32.7)	(19.5)	(45.5)	(38.1)	(259)	(1,322)	
Rice income	0.72	−0.62	−5.48	−6.60	−15.0	−25.3	135
	(28.2)	(29.9)	(50.7)	(59.6)	(213)	(314)	
Rice income/acre	2.45	1.67	5.98	3.39	6.59	1.63	89
	(3.43)	(2.46)	(9.92)	(4.22)	(29.82)	(5.07)	
Toral income	−8.05	−10.52	−30.1	−36.1	−98.3	−119.9	135
	(26.6)	(26.9)	(53.3)	(69.0)	(519)	(814)	
Bago							
Rice output	123	99.8	209	168	191	215	63
	(76.3)	(69.0)	(213)	(203)	(157)	(163)	
Rice yield	5.78	4.29	15.74	11.2	34.6	25.6	67
	(4.31)	(4.96)	(16.5)	(12.0)	(41.0)	(22.8)	
Rice income	0.78	0.34	6.62	3.55	10.6	10.6	145
	(9.29)	(9.40)	(11.9)	(12.4)	(9.23)	(9.91)	
Rice income/acre	1.10	0.98	1.81	1.23	1.78	1.31	104
	(1.12)	(0.95)	(1.13)	(1.21)	(1.27)	(1.41)	
Total income	35.7	39.5+	57.0+	54.4+	72.4*	72.8+	145
	(21.8)	(21.0)	(30.2)	(26.0)	(27.8)	(32.8)	
Delta							
Rice output	−92.7	−82.5	14.6	3.87	19.3	44.7	116
	(121.1)	(121.3)	(237.4)	(210)	(187)	(171)	
Rice yield	2.46	1.55	20.0	12.4	38.0	28.5	125
	(4.50)	(4.83)	(23.1)	(13.0)	(44.1)	(25.1)	

Table 5
(*Continued*)

Polynomial order[a] Outcome variables	Linear (1)	(2)	Quadratic (3)	(4)	Cubic (5)	(6)	*N*
Rice income	−4.28	−1.92	−0.42	0.81	0.37	4.04	280
	(13.0)	(12.9)	(14.8)	(15.0)	(14.9)	(15.5)	
Rice income/acre	1.30	1.26	2.48*	2.13*	2.12	1.94	193
	(1.12)	(0.91)	(1.18)	(0.91)	(1.40)	(1.16)	
Total income	20.1	20.2	37.6	37.1	58.1+	60.7+	280
	(17.2)	(16.8)	(24.9)	(23.6)	(30.2)	(30.2)	
Farm characteristics[b]	No	Yes	No	Yes	No	Yes	

Notes: [a]Different polynomial orders of acres landholding with certified land use rights; [b]Farm-characteristics: Household head's age, gender, farming experience, education level, household size, dependence ratio, availability of extension services. Standard errors are given in brackets adjusted for stratification at regional level and clustering at village level. Statistical significance: +10%, *5%, **1%.

impact, there are difficulties measuring the direct bearing on borrowers (Von Pischke and Adams, 1980; Adams, 1988). Second, even in a partial equilibrium framework where the impact on borrowers is possibly the only concern, observable data on the outcome of credit programmes contain many confounding factors such as selection bias and the targeting nature of the programmes. As a result, despite a significant number of studies having been devoted to evaluating credit projects, not many are deemed as rigorous. Meanwhile, the rigorous studies rely on data which are either from rare natural experiments or from highly resource-intensive RCT. Even in these cases, the evidence is highly contextual and limited to the impact of marginal borrowers, not infra-marginal borrowers, hence giving little justification for existing programmes.

This paper aims to contribute rigorous evidence to the existing literature. In particular, we evaluate the impact of a long-lasting large-scale subsidised rice credit programme in Myanmar, a poor and, until recently, isolated country. Taking advantage of an arbitrary eligibility rule for credit provision, we apply a fuzzy RD approach to overcome endogeneity caused by potentially confounding characteristics that affect both rice production and the amount of credit received. We find little evidence that the programme's target of increasing rice yield and output is achieved. Nonetheless, we do see an impact of the programme on total household income, suggesting its positive spillover effects on other farm income activities.

Due to the use of the fuzzy RD approach, our evidence reflects only the local average treatment effect of the programme for farmers around the threshold of eligibility. Nonetheless, while we are cautious about generalising the treatment effects for all farms in the sample, we would like to emphasise that the effect is found for households in the middle of the distribution, and is robust to the inclusion of various control variables and a different order of landholding polynomial. Finally, since the IV estimator of the fuzzy RD approach has large sample properties, a significant improvement in this work would be to increase the sample size to enhance its precision.

Supporting Information

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

Appendix S1. The Myanmar Rice Farm Survey (MRFS) 2014.

Table S1. Balancing tests of household characteristics.

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