

WHAT DOES PUMP SETS ELECTRIFICATION CHANGE? IMPACTS ON CROPPING PATTERNS, PRODUCTIVITY AND INCOMES IN WEST BENGAL

QUE CHANGE L'ELECTRIFICATION DES POMPES ? IMPACTS SUR LES MODE DE CULTURES, LA PRODUCTIVITE ET LES REVENUS AU BENGAL OCCIDENTAL

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ABSTRACT

West Bengal is currently implementing new policies facilitating the access to electrified irrigation for farmers and expects to initiate a second Green Revolution. Based on primary data, this paper aims to estimate the potential impact of these electrification policies. Using a discontinuity design and propensity score methods, we identify that electrification induces a significant change in the cropping patterns and more water intensive crops, especially boro rice, are preferred by farmers. In addition, the cropping intensity is also higher for electric pump owners. However, we cannot identify any significant quantity impact, which means that the yields are not benefitting from an access to electric pumps. On the contrary, there is a significant and positive price effect for boro rice: the farmers irrigating with electrified tubewells have significantly higher value added and consequently higher incomes from their farming activities. Finally, we identify a positive impact of tubewell electrification on the number of irrigations; considered together with the absence of impact on yields, this result questions the sustainability of the electrification policies to manage the groundwater resource.

RÉSUMÉ

Le Bengale occidental met actuellement en œuvre de nouvelles politiques facilitant l'accès à l'irrigation électrifiée pour les agriculteurs et espère lancer une seconde Révolution Verte. Basé sur des données primaires, cette analyse vise à estimer l'impact potentiel de ces politiques d'électrification. En utilisant des méthodes de type *discontinuity design* et *propensity score matching*, nous identifions que l'électrification induit un changement significatif dans les systèmes de culture et des cultures plus intensives en eau, en particulier le riz *boro*, sont préférés par les agriculteurs. En outre, l'intensité des cultures est également plus élevée pour les propriétaires de pompes électriques. Cependant, nous ne pouvons pas identifier un effet de quantité ce qui signifie que les rendements ne bénéficient pas d'un accès à des pompes électriques. Au contraire, il y a un effet de prix significatif pour le riz *boro*: les agriculteurs irrigants avec forages électrifiés ont une valeur ajoutée nettement plus élevée et par conséquent des revenus plus importants de leurs activités agricoles. Enfin, nous identifions un impact positif de l'électrification des pompes sur le nombre d'irrigations; considéré conjointement avec l'absence d'impact sur les rendements, ce résultat questionne la viabilité des politiques d'électrification pour gérer la ressource en eau souterraine.

Keywords: irrigation, electrification, agricultural development, propensity score matching, regression discontinuity design

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1. Introduction

The expansion of electrification in rural areas around the world in 1960s and 1970s was part of the large infrastructure programs financing specific to this period but was also justified by the expectation that access to electricity would foster development to rural areas. Thus, rural electrification is still promoted as a tool for development. Electrification is indeed expected to impact rural household's livelihoods which in turn should be translated into development. But, beyond the correlation which exists between development and electrification, only few studies have carefully took into consideration the selection bias and placement issues in order to establish the causality between rural electrification and development. The existing analyses mainly focus on the welfare impact of the electrification policy keeping aside the productive and especially agricultural impact of the electrification.

Considering this gap in the literature, we here intend to better understand the impact of electricity access for productive purpose and especially agriculture. We are doing so by considering the case of the state of West Bengal in Eastern India which recently changed its policy in regard to obtaining electric connection for groundwater irrigation. This change in the policy results in an upsurge in the number of electric connections. As stated by the literature, the access to groundwater irrigation is expected to revive the agricultural growth of West Bengal (Mukherji, Shah, & Banerjee, 2012). We here investigate the potential impact the electrification policy from a micro-level farmer perspective by considering the impact of electric pump ownership on agricultural cropping choices, cropping intensity, yields, value added and water consumption.

2. Agricultural history of West Bengal and policy changes

In West Bengal, rice yields increased by two times between 1982 and 1995 (Bardhan, Mookherjee, & Kumar, 2012). Several drivers fed this agricultural growth, including the diffusion of High Yielding Varieties (HYV), land reform, institutional reform and improved access to private irrigation. From these drivers, land reform has been largely studied, and the positive effects, especially those of the sharecroppers registration, have been established (Banerjee, Gertler, & Ghatak, 2002). Nevertheless, the role of groundwater irrigation is also not negligible (Mitra & Buisson, 2014). Indeed, from 1987 to 1995 as per the minor irrigation census, 138,000 additional shallow tubewell were dug and used by private farmers both for their own use and for water selling. Nevertheless, after these tremendous progresses, the agricultural growth is somehow struck by a slow-down since the 2000s. Whereas the average annual growth rate of the agriculture sector was 5.4% in the 1980s and 4.56% in the 1990s, it was only 2.2% in the 2000s. Interestingly this slow-down coincides with a slow-down in the production of most of the main crops produced in West Bengal (rice, wheat, pulses, sugar cane, jute), with the exception of oil seeds. This also coincides with a slow-down in the electrification of shallow tube wells and a pike in the diesel prices.

Facing this agricultural stagnation, the Government of West Bengal took in the recent years a number of policies, in particular energy policies, aiming to revive agricultural growth and rural development. The access to groundwater irrigation and especially to electrified irrigation has been facilitated for farmers: whereas a permit was previously required to apply for an electric connection, this requirement has been removed. Now farmers owning pumps of less than five horsepower and tubewells with discharge of less than 30 cubic meters per hour no longer need permits to apply for an electric connection. This amendment is applicable only in blocks considered as safe in regards to their groundwater availability and renewal whereas a permit is still required in the semi-critical blocks. In addition, the farmers who were previously supposed to pay the full cost of the investment required for the electric connection of their tubewells (including poles and wires), can now benefit from a subsidy and should no longer pay the full cost.

These two last changes in the policy already enhance the number of electrified pump sets and should reduce the reliance on costly diesel pump for farmers. Indeed, secondary data provided by the West Bengal State Electricity Department shows a sharp increase in the number of pumpsets electrified and growth rate from 2008 to 2013 are very similar to those registered in the 1980s.

3. Theoretical model: What to expect from tubewells electrification?

From a micro-level perspective, we consider that the electrification of pump sets might have both direct and indirect effects. Direct effects relate to direct beneficiaries, ie the farmers owning the electrified tubewells; whereas indirect effects relate to farmers buying water from these direct beneficiaries. We here focus on the impact for direct beneficiaries.

The direct beneficiaries can either be former water buyers or former diesel pump users. *De facto*, they were often diesel pump users who already owned a tubewell. In that case, electrification is for them a change in technology, they shift from diesel operated to electricity operated pumps, which is expected to reduce the price of pumping and ultimately the price of irrigation. Indeed, the prime cost of a five horse power pump operated for one hour with diesel would be around 41 INR versus 26 INR for the same power operated through electricity in day time and 7 INR in night time. This price effect is expected to impact the profitability of the farm in a context where irrigation is the major input cost. Changes in the input prices structure may also reframe the cost and benefits analysis of different cropping patterns. In particular, water intensive crops should become more profitable and farmers may shift their cropping choices to take advantage of this new structure of prices. In our context of West Bengal, an increase in the areas covered by *boro* paddy may consequently be expected.

In addition and independently from the price effect, direct beneficiaries may also benefit from a quantity effect. Indeed, if the quantity of water they were using was constrained and the crops water-stressed, the electrification may alleviate this constraint.

These two effects are related to the effect of the electrification on the own farm of the beneficiary. But in addition to these effects which are expected to positively impact their income from agriculture, electric pump owners are also water sellers and the electrification may also increase their income from water selling.

4. Data

The below analysis is based on a sample of 1,396 farmers surveyed in six districts from West Bengal in May and June 2013. These farmers belong to 83 villages and the blocks have been purposively selected in administrative units considered as safe and semi-critical in terms of groundwater recharge following a discontinuity design. Thus, 54% of the sample belongs to safe blocks whereas 46% are in semi-critical blocks, but they all face very similar conditions in terms of groundwater access and availability. Within each village, sampled farmers were selected based on a proportional random sampling. This sampling procedure resulted in a balanced sample comprising 28.5% of electric pump owners, 26.5% of diesel pump owners and the rest of non-pump owners and water buyers.

5. Dealing with the selection bias in cross-sectional data

5.1 Discontinuity Design

In order to restrict the endogeneity issue, we use a discontinuity design to select the blocks included in the analysis. The assignment variables used to define safe, semi-critical and critical blocks are the stage of groundwater development (SOD) calculated as percentage of extraction to net renewable recharge, and the significant long term decline of groundwater level before and after monsoon.

Based on these three indicators and following the guidelines of the GEC 1997, blocks are categorized as safe, semi-critical, critical and over-exploited following pre-determined thresholds. Given that the assignment may be considered as quasi-experimental at the threshold level, we use this discontinuity to select the blocks: we select safe blocks which are very near, but less than the cut-off and semi-critical blocks just above the cut-off of the assignment index. Based on this method, we selected 24 blocks, 14 safe and 10 semi-critical, hydrologically these blocks are very similar but the policy implemented differs.

5.2 Propensity score matching

The discontinuity design takes care of the selection bias at the block level, but the same issue is repeated at the farmer level. We consequently use a propensity score matching method to construct a group of counterfactual farmers without electric connection on the basis of similarities of observable characteristics with the treated group of farmers' owning of electric connections.

We here design a model of treatment with three sets of variables: variables measuring the need or the interest for a farmer to become an electric pump owner, variables measuring the social ability for a farmer to undertake successfully the different steps required to obtain an electric connection, this relates to his social capital and third variables on the economic situation of the household. Finally, we include variables to control for the environmental and technical suitability of an electric pump in the village.

The model of treatment above mentioned is used to calculate for each farmer of the sample a propensity score, ie the probability for him to be an electric pump owner based on observable characteristics. The matching between the two groups is based on the nearest-neighbour methodology, where each treated farmer is matched to the five counterfactual units with the closest propensity score providing the bound is inferior to 0.01. The farmers for the treated group for which it is not possible to find matches corresponding to these criteria are excluded from the sample as well as non-matching counterfactual units. On average, 34% of the initial sample size is excluded after matching.

The validity of the propensity score matching methodology for causal inference relies on two necessary assumptions: conditional independence and common support, which are tested and not rejected. Finally, balancing tests are performed and establish the absence of significant differences between treated and non-treated group after the matching.²

6. Results and impacts

The results are presented in the below tables; for each dependant variable, two coefficients are presented corresponding to two methods used for estimating the impact: the Average Treatment Effect (ATE) and a weighted Ordinary Least Square (OLS) regression.

First the electrification of pump sets has a positive and significant impact on the cropping intensity. Indeed, considering the average treatment effect, the crop intensity increased by 10.6 point of percentage. Aside with the increase of the cropping patterns, the cropping choices are also changed when farmers get access to electrification for irrigation. This shift benefits

²The model of treatment and tests are available upon request.

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primary to *boro* crops, with a share of the net cultivated area under *boro* increased by 21.0% for electric pump owners as compared to their non-electrified counterparts.

When measured with our two empirical models, the impact on productivity is not confirmed and the significance is not robust. On the contrary, the impact on the value added is significant and quite high. Farmers who are electric pump owners gain on average 2900 INR more per acre than counterfactual farmers for *boro* rice. These results can be understood as a price effect: the access to irrigation at a lower cost largely reduce the cost of inputs (water is one of these inputs) and increase the profitability of the farm.

We finally consider the impact of being an electric pump owners on the number of irrigations applied to the crop. As expected, a quantity effect is identified here: farmers owning an electric tubewell have easier access to irrigation in terms of timing and cost and increase the frequency of irrigations provided to the crop. This is confirmed by a positive and highly significant coefficient (at less than 1%) for *borobut* also for *amanpaddy*.

		Crop intensity		Share of net cultivated area under aman		Share of the net cultivated area under boro	
		ATE	Weighted OLS	ATE	Weighted OLS	ATE	Weighted OLS
Electric Pump owner		10.673**	19.962***	0.0691***	0.0601***	0.210***	0.273***
		[5.519]	-4.559	[0.0259]	-0.0236	[0.0319]	-0.0283
Common support sample	Non treated	1014		1014		1014	
	Treated	354		354		354	
Sample size			920		920		920

		Output boro - Kg/ac		VA boro - INR/ac		Number of irrigations boro	
		ATE	Weighted OLS	ATE	Weighted OLS	ATE	Weighted OLS
Electric Pump owner		139.769**	97.888	2901.441**	1906.495*	30.686***	36.484***
		[68.0566]	(69.272)	[1160.535]	(1067.701)	[10.370]	(11.356)
Common support sample	Non treated	363		363		363	
	Treated	237		237		237	
Sample size			470		470		470

		Output aman - Kg/ac		VA aman - INR/ac		Number of irrigations aman	
		ATE	Weighted OLS	ATE	Weighted OLS	ATE	Weighted OLS
Electric Pump owner		73.864*	68.669	845.951*	811.774	12.281***	11.7405***
		[42.413]	(44.963)	[494.488]	(512.309)	[4.335]	(3.892)
Common support sample	Non treated	761		761		761	
	Treated	323		323		323	
Sample size			784		784		784

Notes: Figures in brackets are the bootstrapped standard errors (50 replications) and figures in parentheses are the standard errors.

*** stands for 1% of significance, ** for 5% and * for 10%.

7. Conclusion

In this analysis, we use robust quasi-experimental methods (discontinuity design and propensity score matching) to measure the changes induced by getting access (ownership) to an electrify tubewell in West Bengal. Results establish that electrification induces a significant change in the cropping patterns and more water intensive crops are chosen. Yields are not significantly higher for electric pump owners who however benefit from higher incomes and higher value added thanks to the reduction of the input costs. Finally, a positive impact of tubewell electrification on the number of irrigations is identified. Considered with the absence of impact on yields, this last result means that more water is extracted without producing more output. In a context of declining groundwater storage in the region, this questions the sustainability of the electrification policies to manage the groundwater resource. More hydro-economic analyses are required to establish the causality between the electrification of the tubewells and the decline in water tables in some locations; but in the meantime we suggest the implementation of revised pricing rules. Notably, prices can increase with the quantity of electricity consumed and therefore create an economic incentive for limiting extraction beyond a certain level.

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