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Honours Thesis

This Little Village Went to Market:

Roads, trade frictions, and market access in India.

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Declaration

I hereby declare that the content of this thesis is my own work and that, to the best of my knowledge, it contains no material published or written by any other author or authors, except where acknowledged. This thesis has not been submitted for award of any other degree or diploma at the University of New South Wales or any other educational institution.

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Abstract

In this paper, I study the agricultural market outcomes of connecting over 150,000 isolated villages to the wider Indian economy. Utilising India's $40 billion rural roads program, I find that improving connection to previously isolated areas results in an increase in prices received by farmers. I find evidence that this is a result of increased bargaining power, as farmers can now travel farther and interact with more markets. Higher prices generated by connection causes increased agricultural output, compounding the welfare gains of price rises. These changes are robust to shifts in the composition of the workforce. In more rural areas agriculture's share of the workforce increases, while decreasing in less rural areas.

1 Introduction

Globally, large infrastructure barriers have led to unequal development between urban and rural populations, leaving the incidence of poverty to fall most heavily on rural inhabitants. At the turn of the millennium, the World Bank (2006) estimated that over a billion people lived over 2km away from the nearest all-weather road. Governments and supranational bodies have begun large scale programs to increase access to isolated communities, aiming to boost economic opportunities and social services for inhabitants[1]. Although a growing segment of literature has focused on drawing causal impacts on investments in infrastructure, it has often been focused either on historical or urban outcomes. Missing from this conversation are the effects on the economy targeted by investment.

This paper is concerned with understanding how a large-scale rural roads program in India induces changes in the rural economy. Specifically I ask two questions: does improving infrastructure increase interaction between the wider economy and a previously isolated village? How do markets and farmers respond to this increased interaction? Given the higher rates of rural labour in developing economies' agricultural sector, understanding how infrastructure projects affect the agricultural industry is crucial. Particularly given potential diffusion of high wages, following an increase in prices that rural farmers receive.

India's diversity makes it an ideal case study to investigate agriculture benefits across different contexts and climates[2]. Similar to global facets of poverty, India's

[1]The World Bank has made this a priority, partnering with governments in India, Brazil and Vietnam to invest in improving infrastructure for small rural communities

[2]As an indicator of cultural diversity, the 2001 census lists over 120 languages, belonging to

poor generally reside in small rural areas, with over 300 million rural inhabitants lacking access to an all-weather road in 2000 (PMGSY, 2011). The Prime Minister's rural road building program, hereafter PMGSY, targeted small villages that lacked all-weather access to a market centre[3]. Two important definitions for this paper are treatment and market access. I define treatment to be roads either constructed or upgraded under the PMGSY program. Market access is the degree to which a supplier can interact with the wider economy.

In this paper I examine the PMGSY's effect on prices received by farmers, agricultural production and employment within the agricultural industry. I begin by formalising expectations of empirical analysis, designing a simple model to contextualise hypotheses. In order to draw conclusions on the reactions of farmers and markets to increased treatment, I model their interaction with a Nash bargaining problem. This class of models considers how prices are set based on bargaining power, retail prices, trade frictions and farmers' outside option of not selling. The theoretical environment entails a farmer bargaining between markets in order to find the best price. This model makes three basic predictions: first, prices are expected to increase in places where farmers had lower bargaining power prior to treatment. Second, farmers grow the crop that generates the highest return. Third, agricultural labour reduces in areas near cities, following treatment, and increases in more isolated areas.

To test these predictions, I create a novel data set, by combining data from various sources: the PMGSY monitoring site, the Indian Department of Agriculture, the Food and Agriculture Organisation, The Indian Census (1991-2011), Google Maps and The Database of Global Administrative Areas to build a comprehensive panel data set over 10 years. I then implement a differences-in differences strategy, exploiting temporal variation in program roll-out across a sample of districts who received the PMGSY program between 2001-2011. For the difference-in-difference to be a suitable specification, it is required to meet several identifying assumptions. Most important of which is that the order of treatment is not related to outcomes of interest. That is, districts that received a road early in the program did not do so because they had different agricultural outcomes than other districts during pre-treatment. I directly test for this by running the first three years of treatment on data for 1997-2000, finding significant evidence to suggest that these assumptions hold in my data.

5 different linguistic families. India's geography includes snowy mountains, deserts and jungles, containing large mega cities and tiny rural communities.

[3]Market centres were defined as the location that are the "centres of activities for marketing agricultural produce and inputs, servicing of agricultural implements, health, higher education etc." (PMGSY, 2001)

Considering that the theoretical model's prediction are driven by heterogeneity in pre-treatment market access, the overall hypothesised effects of the PMGSY on prices, output, and employment are ambiguous. Indeed, simple difference-in-difference estimates generate no evidence of average treatment effects. To elucidate the heterogeneous treatment effects predicted by the model, I utilise the in depth data set I created to distinguish between crucially different contexts. I do so by introducing various interaction terms, allowing estimates to vary for different areas within the the empirical analysis. The findings are consistent with the predictions the model: farmers receive lower prices in areas of high market access and higher prices in areas of low access. This suggests that improving market access enables greater bargaining power for previously unconnected farmers, likely due to the fact they can now reach more markets. Further results support the suitability of this effect. Increasing the feasibility of travelling between districts, by building roads in nearby districts, leads markets to respond by raising prices, consistent with the belief of new roads cause higher prices due to farmers being able to reach more markets. I also find evidence that farmers respond to increased connection by both increasing output and changing production to generate higher returns. As both price and quantity increase, farmer welfare increases significantly.

I conduct several robustness checks to verify the extent to which my baseline estimates are robust to considering different mechanisms, samples and empirical specifications. Firstly, I determine the extent to which changes to labour mobility confound the theoretical underpinning of my results. There is a lack of evidence for this labour shift mechanism, as estimates continue conforming to model prediction under areas of higher and lower labour mobility. Secondly, an all India highway network was rolled out contemporaneously to the rural roads' construction. Market access effects of the highways, rather than the rural roads, could be the causal link observed. However, excluding districts close to the highway network does not change the estimated effects of treatment, suggesting that my findings are robust to the highway's construction. Thirdly, I investigate implications of government procurement on treatment. Government involvement in the market may reduce the responsiveness of farmers to treatment. Model predictions are still present in results of price and output when excluding high procurement states, indicating results are robust to government procurement. Finally, I change the definitions of each interaction term to determine the reliance of results on particular definition thresholds, finding all mechanisms and findings suggested are consistent across different definitions.

My analysis and first contribution focuses on uncovering and isolating mechanisms behind market and farmer reactions following improvements in market access for rural communities. Studying increases in rural market access in India provides a unique context in which agricultural demand and supply effects are largely separated. Regulation of the first point of sale heavily favours intermediary buyers of agricultural produce, leading to significant expansion on the number of intermediaries within the market (Chand, 2012). These low economies of scale have led to high mark-ups and low responsiveness of intermediary prices to increases in retail prices (Mitra, Mookherjee, Torero, and Visaria, 2018). Therefore, by studying road building in the Indian context I am able to concentrate solely on supply side effects, and thus isolate market-farmer reactions.

My second contribution is providing an analysis of the market access effects of rural road construction. While there does exist bodies of literature studying rural road construction and rural market access, these two areas have yet to be intersected. There exists a growing segment of work attempting to estimate the impact of rural roads on technological adoption, agricultural land values and consumption growth, little attention has been placed on improvements from market access (Ali, 2011; Shrestha, 2017; Dercon, Gilligan, Hoddinott, and Woldehanna, 2009). Of the few authors who have studied the market access implications of rural roads, most have focused on road improvements in Vietnam (Mu and van de Walle, 2011), Sierra Leone (Casaburi, Glennerster, and Suri, 2013) and Peru (Sotelo, 2015), with none focused on the effects of new road creation. As a result estimates of the improvements generated are potentially dampened. In contrast to these authors, I analyse both construction of new roads and improvements of existing roads. This yields a more complete context in which to draw market access implications of infrastructure improvements for rural communities.

My third, and final, contribution is to provide evidence in the debate over previously identified PMGSY mechanisms. Of the papers that have previously investigated PMGSY, there are two key strands to note: one focuses on the labour mobility mechanism of the program, while the other focuses on the consequences of shifting relative prices. Asher and Novosad's (2016) investigation into labour mobility finds evidence that improving rural infrastructure causes a shift away from the agricultural sector. Shamdasani (2016) further explores the possibility of labour mobility mechanisms, applying an agricultural decision-making lens to investigate the PMGSY program. The central finding is that improving market access for rural districts causes a switch from subsistence farming to market-oriented crop production. The mechanism suggested is that increasing the integration of labour markets enables a greater labour pool to be available for cultivators, supporting investments to make the shift towards market-orientated production. However, Aggarwal (2018), through a study of of several developmental outcomes, posits that changes in relative prices, from lower transport costs, is likely to be the most significant explainer of the program's development effects. My analysis considers both of these mechanisms. In doing so, I find evidence that within the context of crop production, price mechanisms are more important in the explanation of results than the labour mobility mechanism.

The remainder of the paper is as follows. Section 2 provides context on the program and pertinent facets of India. Section 3 contains information on the collection and transformation of the data implemented in this analysis. Section 4 contains the theoretical framework in which subsequent estimation and results are grounded. Section 5 outlines the empirical strategy used in Section 6, which presents the results of my findings and are tested for robustness in Section 7. Finally, Section 8 concludes the paper with a discussion of findings and policy implications.

2 Context

2.1 Road Construction

PMGSY is chiefly a development program, connecting isolated villages to the wider Indian economy. Prior to the program, approximately 300 million individuals lived in villages with low levels of geographic mobility[4]. This low mobility was caused by either the absence of roads or of the poor quality of existing roads. If roads did exist, they were often rendered unusable due to poor drainage and potholes, particularly during monsoon season. The program was specific in which villages to target and how the program rolled out. Only villages with populations above 500 (250 in tribal or mountainous areas) without a paved road within 500 meters of the village centre were selected to be treated. The program utilised a least-cost approach to designing road networks to link villages to the closest market centre. As such, PMGSY also treatedvillages that did not meet the program criteria if they happened to be on a target village's least cost path. PMGSY included both the building of new roads to unconnected communities and the upgrading of roads for villages that had a connection that did not meet the all-weather standard[5]. The program was announced in late 2000 and used population figures from the 2001 census to identify target villages.

[4]On average 0.9% of the Indian population migrate each year, a figure more than ten times lower than the US. Of those who migrated between 1991 and 2001, 82% migrated within the same state, and 60% within the same district (Colmer, 2015)

[5]The program defines all weather roads to be roads that have enough drainage capacity to remain operable during all weather conditions. The upgrade provided was surfacing of previously existing unsurfaced roads. New roads were completely new, starting from the earth-work stage PMGSY (2001).

Although federally designed , the roll out of the roads was implemented by individual states. At the outset of the program, states were charged with creating a list of unconnected villages, ranked by their population. This list was then used to determine the timing of construction for each target village. Villages with populations above 1,000 connected first, followed by populations above 500 and finally the sub-500 population group. The program is scheduled to finish by mid-2019, with 82% of the targeted villages connected by December 2017 (Mustaquim, 2017).

Concurrent to the PMGSY roll-out was the construction of the Golden Quadrilateral (GQ), a six-lane highway system that connected the four large economic centres of India: Delhi, Mumbai, Kolkata and Chennai. The construction of the GQ was launched in 2001, and aimed to increase movements goods and people via reducing trade costs between cities (Kaushik, 2015). Although initially estimated to be finished by 2006, delays over land acquisition and supplier disputes extended the project which was completed in 2012 (National Highway Authority of India, 2015). Districts would have a significantly larger boost in market access if they benefited from both PMGSY and the GQ's construction, compared to districts only treated by PMGSY. Ensuring that GQ effects do not influence the impacts estimated for PMGSY is an important consideration when making drawing any inference on the causes of PMGSY benefits due to their contemporaneous roll-out, and is therefore accounted for as a robustness check of my results.

2.2 Legislative Background

India has maintained a significant policy of providing subsidised food grains to households since the colonial era. During the 1960s India began major food subsidy and farmer support programs, including the Public Distribution System (PDS) and Minimum Support Price (MSP) for agricultural commodities. These programs continue to be central facets of India's welfare system (Chand, 2003). The Indian government attempts to influence prices for 23 agricultural crops by announcing a national MSP for each crop at the beginning of each sowing season. This is an attempt to shield producers from speculative price shocks, as when prices fall below the announced MSP the government is charged to increase procurement. In practice, unless the government is procuring significant amounts of each crop the MSP is largely ineffective, as even if the price falls below the MSP the government does not procure significant amounts for 21 of the 23 crops. The two crops primarily purchased by the government are rice and wheat which form central components of the PDS (Kaul, 2018). Most of this procurement is concentrated in the states of

Haryana and Punjab, with intermediaries charged with purchasing the majority and then onselling to the government (Chatterjee and Kapur, 2017)[6].

The wholesale of agricultural commodities is regulated by two key legislative instruments, the Essential Commodities Act (1955) and the state level Agricultural Produce Market Committee (APMC) Acts. The Commodities Act was enacted to remove hoarding from the market, and has since evolved to reduce storage and free movement of produce (Planning Commission, 2015). While the APMC Acts attempted to increase market efficiency and transparency, the modern-day effect is that farmers are forced to sell within the state of harvest, reducing competition between markets. These two institutional facets lead to intermediaries having significant bargaining power relative to farmers, subsequently causing the suppression of prices received by farmers (Chand, 2012). Although there have been legislative and bureaucratic efforts to effect changes to this system, there have ultimately been no significant changes (Chaterjee, 2018)[7] .

2.3 Agricultural Industry

Most of India's population is employed in the agricultural sector, accounting for 54.6% of the population, 17.4% of India's GDP and roughly 10% of export earnings in 2011. India's arable land is the second largest in the world, while the gross irrigated crop area is the largest in the world (USDA, 2011). Wheat, maize and rice accounted for almost 50 percent of the total cropped area of India in 2012, and it is to these three cereals that I have restricted my evaluation[8]. Between July 2012 and July 2013 agricultural households made up 57.8 percent of total estimated rural households in India, 69 percent of which owned less than one hectare (NSSO, 2014). The average agricultural household size was 5.1, 40% of whom were self-employed in agricultural activity and average monthly income per agricultural household was USD 115 (Rukmini, 2015).

Maize is mainly utilised as a non-food crop, with much production being used as cattle feed or as fuel (Joshi, 2005). Therefore, farmers who sell maize are not restricted by the APMC acts, with most maize transactions not occurring within these produce markets. Agricultural production is heavily concentrated on rice and wheat, with most of this production occurring within the northern Indo-

[6]Chaterjee (2018) finds little evidence of bias when estimating agricultural prices without controlling for procurement, with masses of prices below the MSP for each crop in each year

[7]Efforts include the passing of the the 2018 Model Act, and the Report of Task Force On Agricultural Marketing Reforms in 2001

[8]Sorghum was included in previous versions of this paper. It has been removed as certain sets of data were not available for sorghum.

Gangetic regions of India[9]. Water-intensive traditional farming practices, involving the flooding and wet tilling of farmland, are still in use within these regions. A range of government programs has promoted the use of groundwater to irrigate the water-intensive crops of rice and wheat, causing a significant overuse of groundwater irrigation and subsequently a severe drop in the water table (Bhatt, Kukal, Busari, Arora, and Yadav, 2016)[10]. As the groundwater falls, Hira (2009) finds that it causes three significant negative consequences: greater underground pumping costs; growing infrastructure costs for lengthening tube wells and the degradation of water quality from the up-welling of salts from the deeper, more saline, native groundwater. For consistency with my data sources, I use the word paddy, which is pre-processed rice, throughout my analysis of prices. When discussing output I use the term rice, the final product of paddy.

2.4 The National Rural Employment Guarantee Act

The National Rural Employment Guarantee Act (NREGA) guarantees the right to work, entitling all adults to at least 100 days of wages from unskilled labour per year. NREGA targeted individuals that were unemployment and provided them with work less than 5 kilometres away. If the government was unable to find them work within this distance, individuals were entitled to receive unemployment benefits (Ministry of Rural Development, 2005).The Act was initially piloted in 200 rural districts and, following success, was extended to all districts in 2008. The program is significant both in scope and scale, with over US$ 25 billion being spent to pay wages of 12 million people (Mann and Pande, 2012).

3 Data

3.1 Roads

For information concerning the implementation of the road network, data was collected surrounding the roll out of the roads program via the Online Management and Monitoring System. Baseline connectivity status, population, year of completion and whether a village benefited from the scheme are all contained within the set. The benefit is broken down into two categories: villages that received a new road and

[9] As a guide, rice and wheat account for 15% and 10% of total agricultural output in India. Maize, the third most produced cereal, accounts for only 2.4% (Directorate of Economics and Statistics, 2014).

[10] Government policies include: providing free electricity for irrigation purposes, pushing high yield varieties of wheat and rice on non-rice/wheat producers and infrastructure construction to divert water flow for irrigation. (Qazi, 2017)

villages that received an updated road. For the purposes of this paper, I consider any improvement or construction of roads to be PMGSY treatment of a district. I only included villages that received treatment from the start of the program in 2001 to 2011, as I exploit differences in the timings of treatment to generate results. Due to the resolution of other data sources, I aggregate treatment to district levels. To gain a measure of the application of treatment within a I district I create a proportion of treatment variable for each definition of treatment. This is done by summing the number of individuals treated within a district for each year in my sample, dividing by the district's population gives me the proportion of treated individuals within a district for any year.

3.2 Prices & Quantities

District-wise crop-wise intermediary prices are collected and published by the Ministry of Agriculture. Representative villages are selected from each district. The number of villages is dependent on the extent to which the crop is grown but is always no fewer than ten. Following the commencement of the harvest, prices are collected weekly during the peak marketing period at local intermediary markets where farmers make their first point of sale. The published price data is a yearly weighted (by quantity) average from each village in each district. PDF files were provided for each year and each district, I then manually extracted data from each of these PDFs, cleaned and organised into tabular form.

The Ministry of Agriculture also provides information concerning the district-wise, crop-wise, season-wise production of crops. The data is a series of estimates undertaken by the Directorate of Economics and Statistics. The estimates are created by multiplying area records retained by revenue agencies with yield estimates taken from thousands of annual experiments undertaken across India. As the area statistics are generated from the revenue agencies, this data is unlikely to capture subsistence farming as subsistence farmers are unlikely to report produce to the revenue agencies. The quantities are summed across seasons to generate a yearly production total for each crop in each district.

3.3 Agricultural Employment

Indian census data for the years 1991, 2001 and 2011 were collected from the International Crop Research Institute for the Semi Arid Tropics' (ICRISAT) Village Dynamics in South Asia (VDSA) project. This data was collected from the Registrar General and Census Commissioner of India and aggregated up to the district level. From this information I extract data on the number of rural cultivators and agricultural labourers, in each district, in each census year.

3.4 Land Productivity

The data on land productivity comes from the FAO's Global Agro-Ecological Zones (GAEZ) project. GAEZ predicts the potential yield at a given location for several crops. The estimates are calculated for each 5 arc minute grid on Earth[11]. Suitability indexes based on maximum yield are then generated for each crop within each grid from the potential yield estimates, ranging from one, very high, to seven, very marginal. These predictions are generated from an agronomic model using data on the natural inputs of each location, using distinct parameters for each of crop. These parameters are calculated following extensive field and laboratory experiments undertaken by the FAO. I downloaded the raster data for maize from the FAO, imported it into GIS software and extracted each district's median suitability for each of the three crops. Using the same data I generate an alternate measure of of suitability, for robustness checks. This variable is based on the proportion of land within a district for each suitability class. Transforming the raster data into shape files, I calculate the area for the district and the coverage of each index. Combining these two statistics yields information on the district wise proportional distribution of each suitability class.

3.5 Other GIS Data & Surrounding District Treatment

I downloaded digital maps from the Database of Global Administrative Areas, which provides various high-resolution country maps dis-aggregated down to administrative boundaries. From here I was able to map price, output and road data to each district on the map. As there are roughly three times more districts that reported a price than districts that report a quantity, inter-district trading is a significant phenomenon and necessitates the estimation of a surrounding district producer treatment variable. Through GIS software I calculated the treatment in each producer district for each year (t) as a proportion of the state population (s) and then weighted this by the inverse of the average distance from each market district (i) to each producer district (j), for each crop (k).

[11] Arc minute grids in kilometers squared changes across latitudes, over India it is roughly 10km^2

$$ProducerTreatment_{it}^{k} = \sum_{j}^{J} \left\{ \frac{1}{distance_{ij}} \times \frac{treated_{jt}}{statepop_{s}} \right\} \tag{1}$$

where $i \neq j$, state of $i =$ state of j and $j =$ all producers of k

As the APMC law restricts farmers to sell within the state of harvest, only districts within the same state were included. If a district reported both a price and a quantity, the districts treatment was netted out of the producer treatment variable.

In a similar fashion, I am able to determine areas likely affected by the GQ. Information on the placement of the highway network was downloaded from Google Maps, and fit over the district GIS maps. I then calculated the shortest distance between each district and the highway network, determining districts within a 10 kilometre radius to be likely affected by the GQ. I did this as Ghani, Goswami, and Kerr (2015) did not recover significant GQ effects for districts over 10 kilometres away from the highway.

3.6 Summary Statistics

Included within the appendix is a summary of the means and standard deviations of the main variables used in this analysis, split by treatment type. Overall, districts that received an upgrade and districts that received a new road are highly similar. These districts only significantly differ by level of pre-treatment market connection, unexpected as targets of new roads were selected on this factor. Another key takeaway is the amount of districts that received both an upgrade and a new road, likely driving the similarities between the samples.

4 Theoretical Framework

This section outlines a simple theoretical model for analysing the reactions of farmers and markets to road construction. The disparate contexts of India make homogeneous responses to road improvements and construction unlikely. By grounding this paper in a theoretical environment I allow estimation to be flexible. This deepens understanding as divergent contexts and results can be traced back to the model to disentangle underlying mechanisms.

An economy consists of I districts and two agents, farmers F and intermediaries

M. Each farmer f in each district i, is fixed to their specific plot of land, while each intermediary m is identified by the location of their market. A farmer decides between growing crops, K, determined by what is best grown on each parcel of land. This decision is based on what price is offered for each crop at different markets, p_m^k. Intermediaries decide on what price to offer each farmer based on the price it can receive in the retail market, p_r^k, as the intermediary attempts to maximise mark ups, $\mu_m^k = p_r^k / p_m^k$.

4.1 Market Interaction

It is costly to move goods across locations. These costs are captured by iceberg trade costs, $\tau_{im} > 1$, the amount of crops a farmer must transport from the district for one unit of crop to reach the market m, i.e. the amount that is brought to the market is Q_i^{fk}/τ_{im} and the local price is $p_i^k = \frac{p_m^k}{\tau_{im}}$. Farmers within each district bargain collectively with each intermediary m over the price of each crop. The outcome is determined by Nash bargaining, where the outside option is selling within the district for the autarky price ($\underline{p}_i^k$), instead of selling in the market.

If δ is the bargaining weight of the farmer, the Nash bargaining outcome is the solution to:

$$\max_{\lambda} = (\lambda - \underline{p}_i^k Q_i^{fk})^{\delta} (p_r^k Q_i^{fk}/\tau_{im} - \lambda)^{1-\delta} \tag{2}$$

Where λ is farmer income ($p_m^k Q_i^{fk}$). Solving 2 yields[12]

$$p_m^k = \delta p_r^k + (1-\delta)\underline{p}_i^k \tau_{im} \quad \text{and} \quad p_i^k = \frac{\delta p_r^k}{\tau_{im}} + (1-\delta)\underline{p}_i^k$$

4.2 Production Decision

In each district, land and labour (L and N, respectively) are the only factors of production. Land varies in productivity, A_i^{fk}, with only one crop being grown on parcel of land. Total production by each farmer, in each district, for each crop is

$$Q_i^{fk} = A_i^{fk} \left(N_i^{fk}\right)^{\alpha} \left(L_i^{fk}\right)^{1-\alpha} \tag{3}$$

[12] See appendix for worked solution.

where L_i^{fk} is $\{0,1\}$; if the land is not used to grow crop k, quantity of k is zero. The decision to grow a crop is based on the local price, as the farmer attempts to maximise income. To do so, the farmer decides how much labour to employ, with each unit of labour costing w, a labourer's wage. The wage in a local village is determined by wages in an urban centre, u, and the cost of travelling from the village to the urban centre τ_{iu}^{l}.

$$w_i = \frac{w_u}{\tau_{iu}^{l}}$$

Intuitively, this labour travel cost is an increasing function of both distance and infrastructure barriers. Considering both the local price and the cost of labour, the farmer decides to produce the crop that will maximise revenue, $\pi_i^k = p_i^k Q_i^{fk}$. Maximising with respect to labour choice, and solving for production, the farmer produces[12]

$$Q_i^{fk} = \left(A_i^{fk}\right)^{1/(1-\alpha)} \left(\alpha p_i^k / w_i\right)^{\alpha/(1-\alpha)} \tag{4}$$

4.3 Model Predictions

As roads are built, trade frictions are expected to fall. This fall in τ_{im} will increase the local price but will lower the market price (p_m^k), as the farmer's outside option ($\underline{p}_i^k \tau_{im}$) and local price ($p_i^k$) are net of the cost of bringing produce to market, suggesting that even a reduction in price will still generate a larger surplus. Quantity produced by the farmer, Q_i^{fk}, is expected to increase with falls in trade costs, as higher prices received induces farmers to produce more, visible with reference to equation 4.

Improving market connection is expected also to increase the bargaining power of farmers, as farmers can now interact with previously unreachable intermediaries. The assumption is that there is little competition within markets, with competition for farmers' produce existing only between markets. Given the amount of cartelisation between sellers within an Indian wholesale produce market, intermediaries often offer a single price to farmers, suggesting that this assumption is consistent with reality (Chand, 2012). Increasing bargaining power will raise both the local price and market price, as they are pushed towards the higher retail price (p_r^k). Similarly to the direct effect, this indirect effect of increasing bargaining power for farmers will also raise quantity produced, as again the local price has increased, following connection.

However, output is not predicted to go up uniformly across crops. Connection is modelled to change the prices that farmers receive, likely changing the relative prices of commodities. In an attempt to maximise returns, changes in relative prices may induce farmers to alter their crop portfolios. As a result, it is expected that some crop production will reduce following connection, while others will increase. Moreover, improving and constructing roads also reduces the cost of travelling to urban centres, causing an upward pressure on wages within the village. With reference to equation 4, it is evident that increases in wages paid by producers will reduce production. Reductions in the labour travel cost are more pronounced in areas closer to the city. This suggests that most of this upward pressure will come from more urban linked villages, as the workforce gains more job opportunities in the nearby urban sites.

5 Empirical Strategy

5.1 District Level Analysis

Given the data available I am constrained to a district level analysis. For estimation I employ a staggered difference-in-difference approach, comparing the impact of the program only for districts that benefited under this program. By exploiting the spatial and temporal roll out of the program districts that have not yet benefited provide the counterfactuals for treated districts, likely estimating greater causality than utilising a sample including non-benefiting districts. As the order of the roll-out is organised by population size, with larger towns receiving roads before smaller towns, the difference in treatment timings is expected to be unrelated to the dependent variables of interest. To capture treatment effects I use two different specifications. The first specification, equation (5), is a binary specification. It captures treatment with a dummy variable which is equal to one once a road has been built/upgraded within the district. The other specification is an intensity of treatment specification, equation (6). This specification is similar to the first, with a proportion of population of treatment variable included in the specification. This variable increases over time as different villages within a district are treated in different years. Each specification is run four times, once each for the impact of a pooled benefit (build + upgrade), only upgraded roads, only build roads and once where both upgrade and build effects are estimated jointly.

$$\log(y_{it}^{k}) = \alpha + \beta_1 * T + \gamma_t + \phi_i + \varepsilon_{it}^{k} \tag{5}$$

$$\log(y_{it}^k) = \alpha + \beta_1 * T + \beta_2 * (D_{it}/N_d) + \gamma_t + \phi_i + \varepsilon_{it}^k \tag{6}$$

In both equations (5) and (6), y represents price, output or employment. The superscript k is crop, while subscripts i index districts, and t is time periods. The constant term in the equation is denoted by α. The dummy indicator of treatment is T, which equals one once a district has benefited and zero elsewhere. The number of individuals benefited within a district is D, and N is the district population. District and time fixed effects, ϕ and γ, are employed through this analysis along with standard errors, ε, clustered at the district level.

Given the ambiguity in results generated by the theoretical model, the difference in difference models of equations 5 and 6 are unlikely to yield significant insights into the mechanisms behind market-farmer reactions to treatment. Therefore, I explore how treatment responses vary in different contexts, in an attempt to isolate predicted effects in different areas. Throughout the paper I achieve this by including interaction effects on the treatment variables. These interaction terms capture disparate settings within the sample. The first interaction term used is to isolate areas of high and low baseline market access, with districts above the median value of pre-treatment connection defined as connected. Secondly, I separate districts based on their capacity to grow maize. Using the GAEZ data I declare the 30% most productive districts to have an advantage in production. Finally, I attempt to distinguish treatment responses based on whether a district is more or less rural. The definition of rural is based on the density of towns in a district.

5.2 Pre-trends

A crucial assumption of implementing my strategy is that units not yet treated are suitable counterfactuals for the treated units. It is plausible that states targeted villages to receive benefits early on in the roll out if they had differing economic outcomes. To investigate this assumption, I examine whether the order of entry into the PMGSY program is related to my outcomes of interest, before the program begins, via a placebo test. Utilising price data for 1998 - 2000 and output data from 1997 - 2000, I copy the first three years of treatment (2001 - 2003) into the pre-treatment period of 1998 - 2000 and then run specifications identical to equations (5) and (6) for all four definitions of treatment.

The total impact of the road program will be a function of the coefficients on the dummy and proportion treated variables. As such, the estimates reported throughout the paper are the estimates once a district has reached a typical end of program connection level, which is defined as the average proportion of the population that had been treated (by an upgrade road, a new road or both) by 2011. The rural roads building program was announced in 1998, following the introduction of levies on petrol and diesel designed to accumulate funds for construction (Business Line, 2003). This is years before the first before the first village was treated, suggesting that pre-treatment anticipation effects could influence estimates. Regression outputs for all specifications are included in the appendix. Within each of the subsequent tables, odd numbered columns respond to the binary specification while even numbered columns are results from the proportion specification.

Table 5.1 contains the results for the placebo test on agricultural prices. In panels A and B there are significant estimates on the binary specifications, build for wheat and upgrade for paddy. While the estimates for wheat are particularly weak, both of these anticipation effects are insignificant once controlling for the proportion of the population treated, suggesting the lack of pre-treatment effects. The only issue highlighted by this placebo test is on the estimation of wheat price effects following an upgrade treatment. Given the long time between announcement and roll-out, I cannot refute the possibility of anticipation effects influencing my results. With reference to my initial price estimates, this may be the reason why I do not recover results as the pre-treatment effects bias downwards my estimate.

Table 5.1: Marginal Effects, Price Placebo Test

	Log(Price)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Wheat								
Benefit	-0.004	0.006						
	(0.016)	(0.052)						
Upgrade			0.020	0.121**			0.013	0.108**
			(0.021)	(0.051)			(0.022)	(0.053)
Build					-0.026*	-0.026	-0.025*	-0.021
					(0.014)	(0.026)	(0.014)	(0.028)
Observations	552	552	552	552	552	552	552	552
Panel B: Paddy								
Benefit	0.078***	0.004						
	(0.020)	(0.052)						
Upgrade			0.064***	0.08			0.061***	0.053
			(0.019)	(0.131)			(0.020)	(0.128)
Build					-0.018	-0.062	-0.013	-0.053
					(0.022)	(0.039)	(0.022)	(0.037)
Observations	534	534	534	534	534	534	534	534
Panel C: Maize								
Benefit	-0.039	-0.030						
	(0.06)	(0.096)						
Upgrade			-0.039	-0.067			-0.040	-0.069
			(0.069)	(0.351)			(0.073)	(0.364)
Build					-0.003	0.006	-0.007	0.000
					(0.024)	(0.029)	(0.027)	(0.038)
Observations	402	402	402	402	402	402	402	402

Odd columns correspond to binary specification, even columns to intensity specification
Standard errors, clustered at district, in parentheses
Year and district fixed effects included
*** p<0.01, ** p<0.05, * p<0.1

Similarly, there is evidence of parallel pre-treatment trends for early treated districts in terms of output, as shown in table 5.2. As with price, the only worry for pre-treatment effects is on wheat. Despite the sizeable magnitude of this estimate, it is weak in significance, suggesting limited implications for my analysis. Considering the initial production results (table 6.11) where wheat is both estimated and expected to increase, the potential bias introduced would lead to underestimation. Suggesting that, estimates more strongly reflect the theoretical hypothesis.

Table 5.2: Marginal Effects, Output Placebo Test

	Log(Output)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Wheat								
Benefit	0.082*	-0.110						
	(0.045)	(0.127)						
Upgrade			0.046	0.103			0.018	0.082
			(0.046)	(0.130)			(0.054)	(0.130)
Build					-0.083	-0.228*	-0.078	-0.224*
					(0.051)	(0.123)	(0.058)	(0.125)
Observations	1,036	1,036	1,036	1,036	1,036	1,036	1,036	1,036
Panel B: Rice								
Benefit	0.186**	-0.063						
	(0.083)	(0.259)						
Upgrade			-0.091	-0.025			-0.131	-0.083
			(0.074)	(0.178)			(0.102)	(0.194)
Build					-0.062	-0.192	-0.104	-0.240
					(0.084)	(0.211)	(0.107)	(0.233)
Observations	1,024	1,024	1,024	1,024	1,024	1,024	1,024	1,024
Panel C: Maize								
Benefit	0.032	0.062						
	(0.070)	(0.162)						
Upgrade			0.037	-0.168			0.055	-0.161
			(0.079)	(0.209)			(0.084)	(0.207)
Build					0.04	0.100	0.056	0.125
					(0.066)	(0.110)	(0.071)	(0.112)
Observations	1,020	1,020	1,020	1,020	1,020	1,020	1,020	1,020

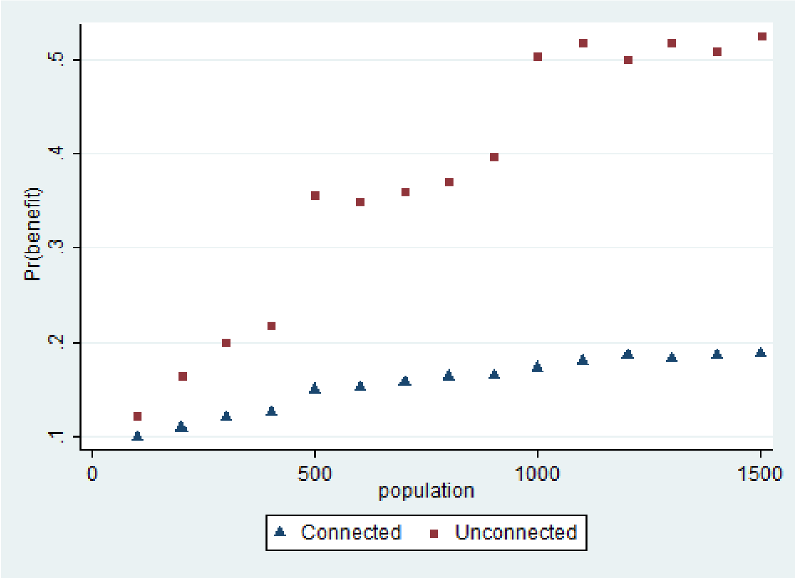
Odd columns correspond to binary specification, even columns to intensity specification
Standard errors, clustered at district, in parentheses
Year and district fixed effects included
*** p<0.01, ** p<0.05, * p<0.1

5.3 Program Compliance

The PMGSY program had strict rules regarding allocation of treatment, both in terms of who could be connected and the order by which villages were connected. To analyse the extent to which these rules were complied with, estimated probabilities of a village being treated before 2011, as a function of the village's population and pre-treatment connectivity, are shown in figure 5.1. As visible from the figure there are discontinuous jumps around the 500 and 1,000 population levels and unconnected villages are more likely to have benefited than connected villages, demonstrating compliance. However, it is also evident that the program rules have not been strictly followed. Districts below the 500 person threshold have benefited and villages with populations between 500 and 1,000 have begun to be connected before all villages above 1,000 people have been connected. This is likely due to villages being targeted as they were between the targeted village and market centre, thereby causing inadvertent treatment of untargeted villages (PMGSY, 2011).

The possibility remains, however, that some villages received treatment based on political favour rather than the programs guidelines. Witsoe (2012) and Bussell (2010) demonstrate the extent of political corruption within India, making treatment outside program guidelines a concern. Aggarwal (2018) previously studied the program and did an in depth analysis on the probability of favourable allocation by state governments. Regressing the probability of benefiting under the program with a range of data concerned with the range of amenities provided to each village by 2001, the finding was that none of these were ultimately significant. Therefore, as favourable treatment under PMGSY is likely to be correlated with previous amenity allocation which is uncorrelated with treatment, there is very little evidence of any villages entering into the program due to political favour. When considering corruption, it is possible that funds were allocated without any construction taking place, thereby introducing attenuation into estimation. This issue is unlikely. The Indian government has gone to significant lengths to make the process as transparent as possible, publishing information on multiple steps throughout the program.

Figure 5.1: Probability Benefited, by Pre-Treatment Connectivity



6 Results

6.1 Price Results

As outlined in the theoretical framework, the expectation on prices from the policy is ambiguous. The construction and improvement of roads is likely to reduce trade frictions, lowering wholesale prices. Improving connection is also expected to increase farmer bargaining power, which would raise wholesale prices. If the reduction in trade frictions is dominant then I expect the coefficient on treatment variables to be negative. If it is positive, the bargaining power effect will outweigh the trade friction effect.

Table 6.1 reports the baseline results for the estimation of the impact of prices. The binary specifications are presented in odd columns, and the intensity specifications in the even. In panels A, B and C, the impacts on upgrading roads is estimated to be negative, despite only being significant for paddy prices, suggesting the friction effect to be dominating and reducing prices by roughly 5%, regardless of the specification implemented. Conversely, the positive estimated effects of new roads, however, provides evidence of the bargaining power effect being stronger when roads are built raising prices by roughly 2-5% following treatment.

Putting these results together, the impact on the program's targeted (previously unconnected) villages is estimated to be positive, as it is these villages that received a new road. This is unsurprising, as the increase in distances feasibly reached is greater when new roads are built as opposed to existing roads being upgraded. As farmers can now travel farther the number of markets of that they can reach has increased, inducing competition between markets for the farmer's crops and thus raising the bargaining power of the farmer. As farmers with a pre-existing road were already able to travel to various markets, this bargaining power mechanism is less of a factor when considering impacts for upgraded roads. As such, as the trade frictions fall the farmer's opportunity cost of transporting to market falls and markets bargain over this new surplus, yielding a lower price.

Table 6.1: Marginal Effects, Price Results

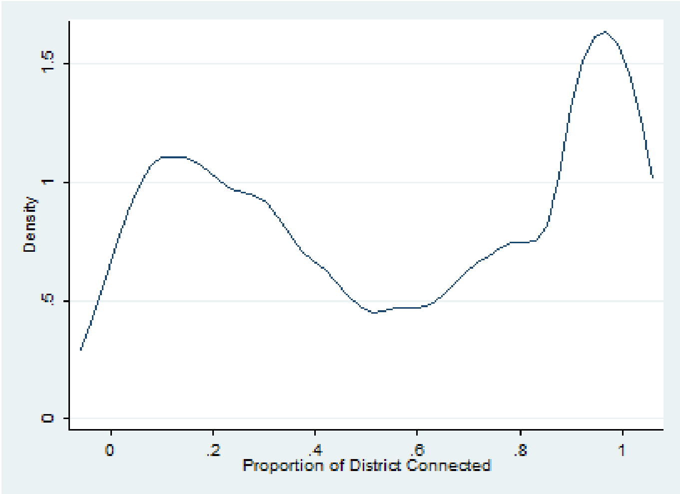
	Log(Price)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Wheat								
Benefit	0.0556**	0.054**						
	(0.018)	(0.024)						
Upgrade			-0.005	-0.013			0.001	-0.006
			(0.015)	(0.015)			(0.015)	(0.016)
Build					0.035	0.044**	0.035**	0.040**
					(0.015)	(0.017)	(0.016)	(0.019)
Observations	1,210	1,210	1,210	1,210	1,210	1,210	1,210	1,210
Panel B: Paddy								
Benefit	-0.052***	0.002						
	(0.018)	(0.021)						
Upgrade			-0.051***	-0.056***			-0.052***	-0.032*
			(0.018)	(0.018)			(0.018)	(0.019)
Build					-0.016	0.017	-0.025	0.006
					(0.015)	(0.015)	0.015	(0.015)
Observations	1,001	1,001	1,001	1,001	1,001	1,001	1,001	1,001
Panel C: Maize								
Benefit	0.085***	0.051						
	(0.028)	(0.042)						
Upgrade			-0.025	-0.060			-0.022	-0.063
			(0.042)	(0.047)			(0.043)	(0.050)
Build					0.022	0.025	0.016	0.007
					(0.021)	(0.026)	(0.021)	(0.026)
Observations	935	935	935	935	935	935	935	935

Odd columns correspond to binary specification, even columns to intensity specification
Standard errors, clustered at district, in parentheses
Year and district fixed effects included
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

6.1.1 Unconnected Districts

I investigate this further by allowing estimation to vary by baseline market access. To do so I split the sample based on pre-treatment market connectivity, a proxy for market access. As visible from figure 6.1, there are two relatively disparate groups within my sample, with clumps of districts around high and low pre-treatment connectivity. I define connected districts to have a proportion above the distribution's median, and unconnected districts a proportion below. Using this proxy for market access, the price effects theorised in section 3 lose their ambiguity. Areas with low baseline market access benefit from the program as they can now interact with a greater number of markets, increasing their bargaining power. Therefore, I expect that unconnected districts should see market prices rise faster than their connected counterparts. Districts with high baseline market access are likely already in contact with a significant number of markets, dampening benefits from improved market access. Thus, connected districts are expected to see prices fall, as the direct trade friction effect dominates the indirect effect.

Figure 6.1: Pre-Treatment Connectivity, Kernel Density



To estimate these potential heterogeneous treatment effects I generate a dummy variable that equals one if a district is unconnected in the period before program roll-out. I then this interact dummy with the treatment variables for both the binary and intensity specifications. As before, each specification is run four times for each definition of treatment and the coefficients are reported in the appendix.

Tables 6.2 - 6.4 contain the estimates for these new specifications. For most part, the results are as expected. Connected districts receive lower prices regardless of the treatment type, while unconnected districts receive higher prices. Interestingly, this effect is common for both the upgrading and building of roads, despite new roads generating larger estimates in paddy estimation. This indicates that the mechanism is not individual villages being connected, but the aggregate increase in market access within the district.

Unconnected districts that report a price for wheat are estimated to have price increase by roughly 5% following reaching the and average level of connection in 2011. This estimate is generally robust between build and upgrade treatment, with the pooled benefit definition of treatment being roughly 10%. For connected districts wheat prices are expected to fall by 3-4%, this is solely driven by upgrades. Potentially, the direct and indirect price effects offset each other when considering build treatments. Districts with low market access see increases in the price of paddy by 10-12% for upgrades across all specifications, whereas new roads induce increases by roughly 40% once a typical level has been reached, again suggesting the bargaining power effect being dominant. Higher baseline market access areas have price trending downwards, with prices falling by 5% and 20-25% for upgrade and build treatments. Further providing evidence that this indirect bargaining price effect is a feature of unconnected districts, as connected districts are likely already in contact with most markets. Estimates for maize prices are much less significant, although there is some indication that new roads in unconnected districts increase prices by 5%. This is unsurprising as maize is generally a fodder crop, maize farmers are able to sell their harvest as an input, reducing the effects of connection to intermediate produce markets.

Table 6.2: Marginal Effects, Price of Wheat & Unconnected

	Log(Price)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.020	-0.004						
	(0.015)	(0.027)						
Uncon. Benefit	0.093***	0.124***						
	(0.028)	(0.031)						
Upgrade			-0.041***	-0.035***			-0.033**	-0.036**
			(0.012)	(0.013)			(0.013)	(0.016)
Uncon. Upgrade			0.085***	0.073***			0.040**	0.076***
			(0.025)	(0.025)			(0.023)	(0.026)
Build					-0.001	0.058	0.001	0.050
					0.021	(0.041)	(0.022)	(0.037)
Uncon. Build					0.050**	-0.033	0.079***	-0.064*
					(0.023)	(0.056)	(0.025)	(0.045)
Observations	1,210	1,210	1,210	1,210	1,210	1,210	1,210	1,210

Odd columns correspond to binary specification, even columns to intensity specification
Standard errors, clustered at district, in parentheses
Year and district fixed effects included
*** p<0.01, ** p<0.05, * p<0.1

Table 6.3: Marginal Effects, Price of Paddy & Unconnected

	Log(Price)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	-0.059***	-0.048*						
	(0.022)	(0.027)						
Uncon. Benefit	0.018	0.064**						
	(0.033)	(0.034)						
Upgrade			-0.076***	-0.072***			-0.077***	-0.056***
			(0.015)	(0.017)			(0.015)	(0.016)
Uncon. Upgrade			0.123***	0.134***			0.123***	0.109***
			(0.036)	(0.034)			(0.035)	(0.035)
Build					-0.049**	-0.299***	-0.028	-0.224***
					(0.020)	(0.067)	(0.020)	(0.072)
Uncon. Build					0.057***	0.497***	0.006	0.340***
					(0.026)	(0.104)	(0.026)	(0.108)
Observations	1,001	1,001	1,001	1,001	1,001	1,001	1,001	1,001

Odd columns correspond to binary specification, even columns to intensity specification
Standard errors, clustered at district, in parentheses
Year and district fixed effects included
*** p<0.01, ** p<0.05, * p<0.1

Table 6.4: Marginal Effects, Price of Maize & Unconnected

	Log(Price)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.070**	0.004						
	(0.030)	(0.049)						
Uncon. Benefit	0.039	0.075						
	(0.060)	(0.069)						
Upgrade			0.010	-0.023			0.017	-0.025
			(0.022)	(0.026)			(0.022)	(0.026)
Uncon. Upgrade			-0.080	-0.106			-0.087	-0.102
			(0.085)	(0.084)			(0.084)	(0.090)
Build					-0.012	0.101	-0.021	0.080
					(0.030)	(0.127)	(0.027)	(0.088)
Uncon. Build					0.057*	-0.127	0.068**	-0.100
					(0.033)	(0.200)	(0.033)	(0.145)
Observations	935	935	935	935	935	935	935	935

Odd columns correspond to binary specification, even columns to intensity specification
Standard errors, clustered at district, in parentheses
Year and district fixed effects included
*** p<0.01, ** p<0.05, * p<0.1

6.1.2 Price Impacts from Surrounding District Treatment

Price data is collected at markets within districts, whereas output data is gathered via government surveys and estimates. There are roughly three times as many producer districts (districts that reported a quantity) then there are market districts (districts that reported a price), indicating the presence of inter-district trading and the need to control for nearby producer treatment when estimating prices.

To do so, I utilise the producer treatment variable and included it in the baseline price specifications as an independent variable. This variable is calculated using equation 1 and controls for construction of new roads in areas producing each crop, weighted by the distance from the district reporting the price. The construction of the new roads increases the feasibility of inter-district trading, and increases the distance farmers can travel into neighbouring districts. Both of these are expected to encourage farmers to either seek out further away markets or induce intermediaries to compete for output by their raising prices. These two effects are consistent with the increased bargaining power mechanism detailed in the Theoretical framework, as such estimates on the producer treatment variable are expected to be positive.

Results of the estimation of nearby producer treatment are displayed in tables 6.5 - 6.7. The estimate is positive for the prices of paddy and wheat, although only significant under paddy. This is consistent with the expectation, improving feasibility of distant inter-district trade leads markets to increase prices. Interestingly, when the nearby district treatment is estimated to be significant. the intra-district effect of new or upgraded roads is either insignificant or negative. This suggests that increases in bargaining power arise due to increased producer access to markets in other districts. This is logical, if roads increased the opportunities of new markets most of them would be of a significant distance from the farmer and therefore likely to be in another district.

Table 6.5: Marginal Effects, Price of Wheat & Surrounding Treatment

	Log(Price)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.055***	0.045**						
	(0.016)	(0.023)						
Upgrade			0.001	-0.005			0.006	0.000
			(0.014)	(0.016)			(0.015)	(0.017)
Build					0.034**	0.031	0.036**	0.031
					(0.014)	(0.019)	(0.015)	(0.020)
Prod. Treatment	0.006	0.006	0.005	0.003	0.005	0.006	0.006	0.005
	(0.004)	(0.004)	(0.004)	(0.005)	(0.004)	(0.006)	(0.004)	(0.006)
Observations	1,210	1,210	1,210	1,210	1,210	1,210	1,210	1,210

Odd columns correspond to binary specification, even columns to intensity specification
Standard errors, clustered at district, in parentheses
Year and district fixed effects included
*** p<0.01, ** p<0.05, * p<0.1

Table 6.6: Marginal Effects, Price of Paddy & Surrounding Treatment

	Log(Price)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	-0.040**	-0.022						
	(0.017)	(0.022)						
Upgrade			-0.029	-0.024			-0.031	-0.025
			(0.019)	(0.022)			(0.020)	(0.022)
Build					-0.015	-0.003	-0.021	-0.007
					(0.014)	(0.017)	(0.015)	(0.017)
Prod. Treatment	0.016***	0.014***	0.013***	0.014***	0.016***	0.011*	0.013***	0.009
	(0.004)	(0.005)	(0.005)	(0.005)	(0.004)	(0.007)	(0.005)	(0.008)
Observations	1,001	1,001	1,001	1,001	1,001	1,001	1,001	1,001

Odd columns correspond to binary specification, even columns to intensity specification
Standard errors, clustered at district, in parentheses
Year and district fixed effects included
*** p<0.01, ** p<0.05, * p<0.1

Table 6.7: Marginal Effects, Price of Maize & Surrounding Treatment

	Log(Price)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.080***	0.038						
	(0.028)	(0.041)						
Upgrade			-0.029	-0.089*			-0.027	-0.087*
			(0.041)	(0.050)			(0.041)	(0.050)
Build					0.020	0.021	0.012	0.010
					(0.021)	(0.026)	(0.022)	(0.028)
Prod. Treatment	-0.003	-0.001	-0.005	-0.018	-0.003	-0.004	-0.004	-0.017
	(0.009)	(0.009)	(0.009)	(0.012)	(0.009)	(0.012)	(0.009)	(0.013)
Observations	935	935	935	935	935	935	935	935

Odd columns correspond to binary specification, even columns to intensity specification
Standard errors, clustered at district, in parentheses
Year and district fixed effects included
*** p<0.01, ** p<0.05, * p<0.1

6.1.3 Price Impacts from Surrounding Unconnected District Treatment

Previous estimates indicate that prices increase more when considering unconnected districts, as they benefit mainly through the increased number of markets that farmers can access. Logically this effect should persist when looking at surrounding district treatment effects. To observe if this is true, I limit the producer treatment variable to only include producer districts that are in the bottom half of the baseline connectivity status distribution, i.e. only include unconnected producer districts as j districts in equation 1, and then calculate treatment and distance to market districts as before. As the average distance between markets and all producer districts and markets and only unconnected districts are relatively similar, I can compare the magnitude of effects between the estimates presented below and the estimates presented under the original specification of producer treatment. I suspect that including only unconnected districts within the producer treatment variable will yield a greater positive coefficient on producer treatment, as the indirect effect should more predominantly be observed than under the previous calculation of producer treatment.

Comparing these results in tables 6.8 - 6.10, to the previous producer treatment variables in tables 6.5 - 6.7, the variable is now significant when estimating most specifications for the price of wheat, while maintaining significance in the estimation of paddy. As the producer treatment estimate becomes significant, once restricted to unconnected producers, for wheat, this suggests that the bargaining power effect is more present in low market access areas. The impact of intra-district new roads on prices becomes positive once the producer treatment variable is limited to unconnected districts, suggesting that intra-district treatment is absorbing the positive effects of surrounding district treatment. However, estimates under paddy price is almost identical for both specifications of surrounding treatment. This is consistent with new roads increasing the market options for all districts, not just low market access areas, thereby inducing markets to bid each others' prices up. Similar to all previous estimates of maize price, there is very little evidence of non-zero impacts of road connection. Again, this is likely to be due to farmer's ability to sell maize as an input, and therefore are not required to sell in these intermediary markets where my data is collected.

Table 6.8: Marginal Effects, Price of Wheat & Surrounding Unconnected Treatment

	Log(Price)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.056***	0.044**						
	(0.016)	(0.022)						
Upgrade			0.002	-0.003			0.007	0.002
			(0.014)	(0.016)			(0.015)	(0.016)
Build					0.033**	0.028	0.035**	0.028
					(0.014)	(0.019)	(0.015)	(0.020)
Uncon. Prod. Treatment	0.008*	0.008**	0.007*	0.006	0.007*	0.009	0.007*	0.008
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.006)	(0.004)	(0.006)
Observations	1,210	1,210	1,210	1,210	1,210	1,210	1,210	1,210

Odd columns correspond to binary specification, even columns to intensity specification
Standard errors, clustered at district, in parentheses
Year and district fixed effects included
*** p<0.01, ** p<0.05, * p<0.1

Table 6.9: Marginal Effects, Price of Paddy & Surrounding Unconnected Treatment

	Log(Price)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	-0.039**	-0.028						
	(0.017)	(0.021)						
Upgrade			-0.027	-0.021			-0.029	-0.023
			(0.019)	(0.022)			(0.019)	(0.022)
Build					-0.017	-0.011	-0.022	-0.014
					(0.014)	(0.015)	(0.015)	(0.015)
Uncon. Prod. Treatment	0.018***	0.017***	0.016***	0.017***	0.019***	0.016***	0.015***	0.014*
	(0.004)	(0.004)	(0.004)	(0.005)	(0.004)	(0.006)	(0.004)	(0.007)
Observations	1,001	1,001	1,001	1,001	1,001	1,001	1,001	1,001

Odd columns correspond to binary specification, even columns to intensity specification
Standard errors, clustered at district, in parentheses
Year and district fixed effects included
*** p<0.01, ** p<0.05, * p<0.1

Table 6.10: Marginal Effects, Price of Maize & Surrounding Unconnected Treatment

	Log(Price)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.080***	0.038						
	(0.028)	(0.041)						
Upgrade			-0.030	-0.089*			-0.028	-0.087*
			(0.041)	(0.051)			(0.041)	(0.052)
Build					0.020	0.021	0.012	0.011
					(0.021)	(0.027)	(0.022)	(0.028)
Uncon. Prod. Treatment	-0.003	-0.001	-0.005	-0.018	-0.004	-0.004	-0.005	-0.018
	(0.010)	(0.010)	(0.010)	(0.012)	(0.010)	(0.012)	(0.010)	(0.013)
Observations	935	935	935	935	935	935	935	935

Odd columns correspond to binary specification, even columns to intensity specification
Standard errors, clustered at district, in parentheses
Year and district fixed effects included
*** p<0.01, ** p<0.05, * p<0.1

6.2 Output results

Holding relative prices and factors of production constant, the theoretical model suggests that PMGSY treatment increase agricultural output unambiguously. As regardless of whether the direct or indirect price effect is dominant, the farmer's surplus from selling to markets increases. This larger surplus induces the farmer to increase production in order to raise revenue. Estimating treatment effects on districts' agricultural production, assuming homogeneous treatment effects, will test to see if the PMGSY program did indeed induce changes to relative prices or factor allocation, thereby creating incentives for changes in production patterns. If the program did not generate substitution between crops, estimates in this baseline output regression should be both significant and positive. Negative or insignificant values would suggest that improving market access leads to the changing of a farmer's crop portfolio.

Results for the program's impact on farm output are contained in table 6.11. While there is evidence that suggests that new roads increased wheat production by over 10%. Estimates for rice and maize production are insignificant or negative, with maize estimated to decrease by 15% and 25% following connection by new and upgraded roads and rice production largely estimated to remain constant following treatment. This is consistent with the PMGSY creating a mechanism for farmers to switch crops towards a more lucrative substitute. Alternatively, reducing travel costs between rural and urban centres is expected to increase wages, thereby increasing the costs of production and potentially forcing farmers to exit the market.

Table 6.11: Output of Wheat, Rice & Maize

	Log(Output)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Wheat								
Benefit	0.067	0.012						
	(0.042)	(0.061)						
Upgrade			0.044	0.107*			0.059	0.085
			(0.044)	(0.056)			(0.045)	(0.052)
Build					0.125**	0.0615	0.137***	0.099**
					(0.041)	(0.048)	(0.043)	(0.050)
Observations	3,654	3,654	3,654	3,654	3,654	3,654	3,654	3,654
Panel B: Rice								
Benefit	0.084	0.256***						
	(0.080)	(0.094)						
Upgrade			0.082	0.029			0.084	0.132
			(0.098)	(0.101)			(0.099)	(0.116)
Build					0.008	0.097	0.024	0.136*
					(0.061)	(0.068)	(0.062)	(0.071)
Observations	4,272	4,272	4,272	4,272	4,272	4,272	4,272	4,272
Panel C: Maize								
Benefit	0.025	-0.324**						
	(0.115)	(0.144)						
Upgrade			-0.102	-0.074			-0.099	-0.242**
			(0.084)	(0.112)			(0.086)	(0.115)
Build					0.044	-0.113	0.028	-0.183*
					(0.081)	(0.097)	(0.085)	(0.104)
Observations	2,426	2,426	2,426	2,426	2,426	2,426	2,426	2,426

Odd columns correspond to binary specification, even columns to intensity specification
Standard errors, clustered at district, in parentheses
Year and district fixed effects included
*** p<0.01, ** p<0.05, * p<0.1

6.2.1 Production in Unconnected Districts

Prices in unconnected districts rise for rice and wheat following PMGSY treatment. It is within these districts, therefore, that I expect rice and wheat production to increase the most. This is a central and direct result of the the model presented in section 4. Higher prices of rice and wheat leads farmers to respond by increasing rice and wheat production, as quantity increases monotonically with price. Re-running the connected/unconnected specification on agricultural production, estimates for rice and wheat output in unconnected districts should be significantly more positive than the estimates for connected districts. Expectations for maize are unclear. Previous connected/unconnected estimation of prices did not yield many significant results. However, as maize is a fodder crop unobserved changes to the livestock market may induce changes in maize's production.

Rice and wheat estimates for this specification, contained in tables 6.12 and 6.13, are as expected. Generally, the changes in unconnected districts' price map directly to changes in its quantity, providing strong evidence for the positive relationship between price and quantity. This is particularly so when observing wheat production. Increases in the quantity of wheat harvested are consistently twice as large as price estimates, with a similar pattern of significance across variables. Treating unconnected districts leads to an increase of wheat production by 15%. This result is present for both upgraded roads and new roads, but becomes insignificant on new roads when controlling for the proportion of population connected by the roads. Rice production is also strongly related to price estimates. Production of rice in unconnected districts is estimated to increase by 15-20% following treatment. This result is robust across binary and intensity specifications as well as upgrade and build treatments. However, estimates di lose significance when jointly estimating build and upgrade effects in the intensity specification, a small deviation from the connected/unconnected price results.

Despite the lack of PMGSY induced changes in the price of maize, under the connected/unconnected output specification PMGSY is estimated to significantly influence maize production in unconnected districts. In table 6.14 upgrading roads in unconnected districts strongly correspond to a reduction in output of 25%. This result is consistent for both specifications and when controlling for the effects of new road construction. Moreover, the intensity specification does report significant increases of 50% for building new roads once the consistently negative effects of upgrading roads is controlled for. Again, given the lack of data on the livestock market, it is hard to contextualise these results with reference to price movements observed. Estimates for connected district production of all three crops are largely all insignificant. Suggesting that the reductions in price estimated previously for these districts have not induced strong enough substitution effects for production to decrease in connected districts.

Table 6.12: Output of Wheat by Connected/Unconnected

	Log(Output)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.004	0.004						
	(0.050)	(0.066)						
Benefit * Uncon.	0.144***	0.180**						
	(0.050)	(0.084)						
Upgrade			-0.007	0.043			0.049	0.019
			(0.040)	(0.049)			(0.039)	(0.044)
Upgrade * Uncon.			0.150***	0.163***			0.078**	0.141***
			(0.041)	(0.041)			(0.038)	(0.042)
Build					0.027	0.031	0.048	0.069
					(0.053)	(0.066)	(0.053)	(0.074)
Build * Uncon.					0.158***	0.045	0.134***	-0.075
					(0.054)	(0.091)	(0.052)	(0.106)
Observations	3,656	3,656	3,656	3,656	3,656	3,656	3,656	3,656

Odd columns correspond to binary specification, even columns to intensity specification
Standard errors, clustered at district, in parentheses
Year and district fixed effects included
*** p<0.01, ** p<0.05, * p<0.1

Table 6.13: Output of Rice by Connected/Unconnected

	Log(Output)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	-0.077	0.055						
	(0.077)	(0.111)						
Benefit * Uncon.	0.264***	0.267**						
	(0.062)	(0.121)						
Upgrade			-0.122**	-0.139**			-0.066	0.017
			(0.052)	(0.061)			(0.054)	(0.072)
Upgrade * Uncon.			0.187***	0.176***			0.089	0.045
			(0.067)	(0.066)			(0.068)	(0.069)
Build					-0.090	0.054	-0.079	0.071
					(0.077)	(0.090)	(0.078)	(0.093)
Build * Uncon.					0.278***	0.178*	0.231***	0.161
					(0.064)	(0.101)	(0.062)	(0.098)
Observations	4,261	4,261	4,261	4,261	4,261	4,261	4,261	4,261

Odd columns correspond to binary specification, even columns to intensity specification
Standard errors, clustered at district, in parentheses
Year and district fixed effects included
*** p<0.01, ** p<0.05, * p<0.1

Table 6.14: Output of Maize by Connected/Unconnected

	Log(Output)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.170	-0.244						
	(0.129)	(0.243)						
Benefit * Uncon.	-0.153	-0.594**						
	(0.105)	(0.268)						
Upgrade			0.050	-0.059			0.061	-0.090
			(0.086)	(0.122)			(0.084)	(0.140)
Upgrade * Uncon.			-0.260***	-0.278***			-0.265***	-0.295***
			(0.101)	(0.093)			(0.100)	(0.095)
Build					0.182*	-0.161	0.121	-0.259
					(0.107)	(0.159)	(0.107)	(0.174)
Build * Uncon.					-0.135	0.341	-0.014	0.537**
					(0.110)	(0.222)	(0.107)	(0.260)
Observations	3,562	3,562	3,562	3,562	3,562	3,562	3,562	3,562

Odd columns correspond to binary specification, even columns to intensity specification
Standard errors, clustered at district, in parentheses
Year and district fixed effects included
*** p<0.01, ** p<0.05, * p<0.1

6.2.2 Production Switching by Productive Advantage

Evidently, price and production estimates for unconnected districts, although similar, do not perfectly match. This suggests that there are some production effects not evidently clear from the price estimates. The PMGSY program likely enables previously unfeasible trade opportunities. Given Shamdasani (2016) found evidence of post-treatment crop diversification, this would most likely result in farmers reducing production of rice and wheat, the staples of Indian agriculture. These new found opportunities likely increase the value of crops that were not previously harvested, as the pre-PMGSY market options did not support their production. Areas that are most likely to have this effect are those that have the outside option of growing non-rice/wheat crops, but lacked a market incentive to shift away from crop staples. To investigate this theory I examine PMGSY's effects on crop production within areas amenable to maize production. These areas are captured in the maize advantage dummy variable which indicates the 30% most maize productive areas in India. As farmers have the non-staple option of growing maize, increasing market opportunities through road connection should see value for maize increase and induce an observable switch from rice and wheat towards maize.

Coefficients on the interaction of maize advantage and treatment support this hypothesis. Building new roads is estimated to reduce wheat and rice production within areas that have an advantage in maize, see table 6.15 and 6.16. Once the proportion of a districts population receiving a new road has reached average end of sample levels, both wheat and rice production falls by 15%. As visible from table 6.17, maize production within these areas, however, increases by 37%, after a typical proportion of the population receives new roads. Suggesting that when districts have an outside option to growing rice and wheat, they alter production patterns. Interestingly, effects for upgrading roads in maize advantage areas are not estimated to be significant. This is consistent with a PMGSY induced increase in market options, as building roads allows farmers to travel further than improving roads, encountering more, previously unavailable, market opportunities. Tables 6.15, 6.16 and 6.17 all suggest that this maize increasing mechanism is isolated to the advantage areas. Maize production is estimated to reduce while rice and wheat are estimated to increase in the non-advantage areas.

Table 6.15: Output of Wheat with Maize Advantage

	Log(Output)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.116**	0.139**						
	(0.047)	(0.063)						
Benefit * Adv.	-0.099*	-0.152**						
	(0.055)	(0.067)						
Upgrade			0.072*	0.117**			0.064	0.094*
			(0.038)	(0.051)			(0.042)	(0.049)
Upgrade * Adv.			-0.061	-0.083*			-0.013	-0.021
			(0.041)	(0.046)			(0.039)	(0.052)
Build					0.196***	0.174***	0.205***	0.202***
					(0.055)	(0.063)	(0.056)	(0.065)
Build * Adv.					-0.150***	-0.180**	-0.140**	-0.165**
					(0.058)	(0.071)	(0.060)	(0.079)
Observations	3,516	3,516	3,516	3,516	3,516	3,516	3,516	3,516

Odd columns correspond to binary specification, even columns to intensity specification
Standard errors, clustered at district, in parentheses
Year and district fixed effects included
*** p<0.01, ** p<0.05, * p<0.1

Table 6.16: Output of Rice with Maize Advantage

	Log(Output)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.02	0.224**						
	(0.075)	(0.101)						
Benefit * Adv.	-0.002	-0.015						
	(0.062)	(0.075)						
Upgrade			0.001	-0.124			-0.011	-0.057
			(0.061)	(0.087)			(0.064)	(0.093)
Upgrade * Adv.			-0.02	0.09			0.005	0.155
			(0.072)	(0.092)			(0.073)	(0.098)
Build					0.046	0.184**	0.046	0.221***
					(0.071)	(0.077)	(0.074)	(0.084)
Build * Adv.					-0.063	-0.114*	-0.065	-0.177***
					(0.06)	(0.063)	(0.058)	(0.065)
Observations	3,516	3,516	3,516	3,516	3,516	3,516	3,516	3,516

Odd columns correspond to binary specification, even columns to intensity specification
Standard errors, clustered at district, in parentheses
Year and district fixed effects included
*** p<0.01, ** p<0.05, * p<0.1

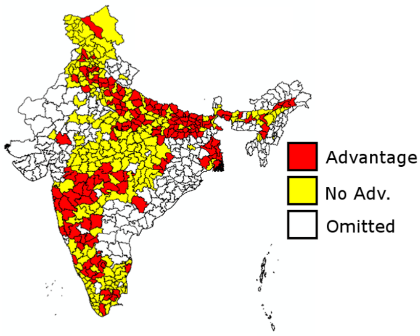
Table 6.17: Output of Maize with Maize Advantage

	Log(Output)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	-0.001	-0.414						
	(0.125)	(0.16)						
Benefit * Adv.	0.157	0.293**						
	(0.109)	(0.132)						
Upgrade			-0.083	-0.259**			-0.026	-0.287**
			0.082	0.126			(0.08)	(0.124)
Upgrade * Adv.			0.108	0.254**			-0.018	0.043
			(0.100)	(0.127)			(0.100)	(0.139)
Build					-0.088	-0.204*	-0.099	-0.284**
					(0.098)	(0.106)	(0.106)	(0.12)
Build * Adv.					0.295***	0.379***	0.305***	0.370**
					(0.112)	(0.134)	(0.113)	(0.146)
Observations	3,516	3,516	3,516	3,516	3,516	3,516	3,516	3,516

Odd columns correspond to binary specification, even columns to intensity specification
Standard errors, clustered at district, in parentheses
Year and district fixed effects included
*** p<0.01, ** p<0.05, * p<0.1

There are several potential reasons as to what these newly feasible market opportunities are which incentives the switching into maize. As I unfortunately do not have the non-produce market data, I am unable to pin down a causal link. The most likely cause of this increase in maize production are PMGSY induced changes to the livestock market. As smooth roads make the transportation of livestock significantly more easy, it is likely that road construction led to an increase in production where maize is an input. Indeed, Aggarwal (2018) finds a 10% increase in dairy consumption for treated districts, lending credence to this maize production mechanism. Another probable causal link is the diffusion of high-yield maize seeds that were introduced during the sample period, making maize an attractive substitute. Suri (2011) finds considerable informational barriers to seed adoption in areas of with poor infrastructure, suggesting that the spread of the new maize seeds is tied to PMGSY treatment. Moreover, as visible from 6.2, most of the advantage areas are in the northern areas of India. These areas have significant water issues and rising water-usage costs. As maize is significantly less water-intensive than both rice and wheat, this water issue compounds the benefits to switching out of wheat and rice to maize via the newly available seeds (Wrigley, Corke, Seetharaman, and Faubion, 2015).

Figure 6.2: Maize Advantage by District



6.3 Labour Composition

Previous work on PMGSY has found that the program led to a large shift of labour out of agriculture (Asher and Novosad, 2016), and the possibility of this labour shift inducing the previous results is a significant concern. This particularly significant as in 2006 the Indian Government began the National Rural Employment Guarantee Act (NREGA) which had a secondary focus of constructing durable public assets. Thus, it is highly probable that labour used in the construction of the PMGSY roads was sourced via the NREGA labour pool, and that wages generated under NREGA influence village outcomes observed. To investigate the labour market effects of NREGA within districts, I use census data from 1991, 2001 and 2011 on the number of rural individuals engaged in agriculture[13]. As Shamdasani (2016) found Asher and Novosad's effect to be localised around villages close to towns, I expect districts with a higher density of towns to see larger shifts out of agriculture while lower town density areas intensify in agriculture as this is the main labour

[13]Rural figures were focused on as they are the types of villages that were principally targeted under PMGSY. For the census to deem a village rural it must have a population below 5,000, 75% of the workforce must work in agriculture and population density must be below 400 square kilometres (Office of the Registrar General & Census Commissioner, 2011). These figures were used as rural inhabitants are the target of the PMGSY program.

opportunity available. This is also consistent with the NREGA guidelines as if villages are further away from urban centres, there are likely fewer unskilled labour opportunities less than 5 kilometres away, reducing the NREGA driven shift out of agriculture. Splitting the sample into rural and non-rural districts, defined as districts below and above the median number of towns per square kilometre, and running the binary and intensity specifications. As the census data was collected, aggregated to district level and disseminated by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), areas that are not in the semi-arid tropics of India are not included in the data set[14]. This restricts my sample from over 350 districts to 205 districts.

In panel A of table 6.18, there is an evidently stark difference in the number of individuals choosing to grow crops. Once rural areas have reached a typical level of connection, the number of cultivators increases by over 20%. This effect is largely focused on rural new roads, as upgrade's estimates become insignificant once accounting for the proportion of people connected with new roads. Non-rural areas experience a decline of roughly 10% of the number of cultivators, consistent with the estimates found by Shamdasani. Again, these effects are largely due to the construction of new roads, as the estimates on upgrade reduce both in magnitude and significance as the impacts of build are controlled for. Panel B contains results for agricultural labour. Results for rural district are comparable with results in Panel A, with most estimates having overlapping confidence intervals, and effects largely being driven by new roads. For non-rural areas the estimates are harder to interpret, upgraded districts is estimated to decrease. This effect becomes stronger when accounting for the proportion of individuals exposed to new roads. This suggests that non-rural cultivators that remained followings PMGSY, intensified their production towards agriculture, as agricultural labour increases while the number of cultivators decrease.

[14]A balance of covariates for this new sample is included within the appendix. The difference between built/upgraded and non-built/upgraded are similar to the full sample, with considerable overlap of treatment occurring in the majority of districts

Table 6.18: Rural Employment in Agricultural Sector

	Log(Employed)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Cultivators								
Benefit	-0.071*	0.043						
	(0.038)	(0.062)						
Benefit * Rural	0.253***	0.200***						
	(0.041)	(0.041)						
Upgrade			-0.115***	-0.080*			-0.056*	0.019
			(0.033)	(0.046)			(0.029)	(0.045)
Upgrade * Rural			0.181***	0.159***			0.063*	0.008
			(0.035)	(0.037)			(0.035)	(0.041)
Build					-0.161***	-0.125***	-0.146***	-0.109***
					(0.037)	(0.035)	(0.040)	(0.042)
Build * Rural					0.254***	0.232***	0.216***	0.213***
					(0.042)	(0.039)	(0.045)	(0.049)
Observations	615	615	615	615	615	615	615	615
Panel B: Agr. Labour								
Benefit	-0.110**	0.267**						
	(0.044)	(0.113)						
Benefit * Rural	0.158**	0.069						
	(0.067)	(0.079)						
Upgrade			-0.125**	-0.252***			-0.065	0.017
			(0.050)	(0.061)			(0.045)	(0.066)
Upgrade * Rural			0.162**	0.216***			0.096*	0.021
			(0.066)	(0.062)			(0.055)	(0.053)
Build					-0.050	0.211***	-0.022	0.218***
					(0.051)	(0.058)	(0.052)	(0.068)
Build * Rural					0.191***	0.145*	0.136**	0.144*
					(0.072)	(0.075)	(0.062)	(0.079)
Observations	615	615	615	615	615	615	615	615

Odd columns correspond to binary specification, even columns to intensity specification
Standard errors, clustered at district, in parentheses
Year and district fixed effects included
*** p<0.01, ** p<0.05, * p<0.1

6.3.1 Employment Changes & Demand Side Price Effects

These changes in the labour market of affected districts may possibly drive the price results seen in previous sections. Throughout this paper I have focused on supply-side mechanisms. If wage changes drive the results seen thus far, it would invalidate most of the previous discussion. The hypothesised mechanism is as follows: if previously unconnected individuals can now earn a higher wage, they will increase demand for each crop, bidding up the price in the retail market. This will then feedback into the intermediary market, with farmers expanding output in response to the higher prices generated by wage induced increases in demand. The Indian context of this program makes this an unlikely mechanism. There are large supply chains with each middleman interacting with only a small proportion of total producers. This leads to a sizeable wedge between the price the farmer receives and the price the consumer pays, dampening the responsiveness of intermediary prices to increases in retail prices (Chand, 2012; Mitra et al., 2018).

I assume individuals leave the agricultural sector in response to higher wage opportunities elsewhere, a safe assumption considering the low wage nature of agriculture (Otsuka, 2013). As non-rural areas saw a greater shift out of agriculture, I restrict price estimation to the districts present in the ICRISAT sample and only include the non-rural districts. These districts were previously estimated to reduce employment in agriculture, and therefore I assume have the largest increase in wages induced by PMGSY. Under this restricted sample the wage mechanism is likely to be most present and should go to invalidate the previous connected/unconnected through more positive estimated treatment effects on price driven by the higher wage prompted demand effects of PMGSY.

Tables 6.19 - 6.21 have very similar results to those shown under the previous estimation in tables 6.2 - 6.4, with connected districts' intermediary price falling and unconnected districts' price rising. This suggests that the direct and indirect effect, of lower trade frictions and increasing bargaining power, on prices is robust to the changes in the composition of a village's workforce and the subsequent change in wage levels within a village.

Table 6.19: Price of Wheat & Unconnected in Non-Rural District

	Log(Price)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	-0.114***	-0.251***						
	(0.022)	(0.051)						
Uncon. Benefit	0.237***	-0.162						
	(0.026)	(0.121)						
Upgrade			-0.096***	-0.173***			-0.099***	-0.190***
			(0.020)	(0.027)			(0.020)	(0.047)
Uncon. Upgrade			0.181***	0.173***			0.190***	0.189***
			(0.033)	(0.027)			(0.034)	(0.052)
Build					0.036	-0.090	0.018	-0.210
					(0.051)	(0.568)	(0.045)	(0.485)
Uncon. Build					-0.044	0.252	-0.054	0.290
					(0.077)	(0.907)	(0.066)	(0.769)
Observations	176	176	176	176	176	176	176	176

Odd columns correspond to binary specification, even columns to intensity specification
Standard errors, clustered at district, in parentheses
Year and district fixed effects included
*** p<0.01, ** p<0.05, * p<0.1

Table 6.20: Price of Paddy & Unconnected in Non-Rural District

	Log(Price)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	-0.030	-0.048						
	(0.030)	(0.083)						
Uncon. Benefit	0.000	-0.082						
	(0.039)	(0.107)						
Upgrade			-0.059**	-0.081**			-0.054**	-0.053
			(0.025)	(0.041)			(0.025)	(0.048)
Uncon. Upgrade			0.073**	0.096***			0.065**	0.057
			(0.028)	(0.027)			(0.029)	(0.040)
Build					-0.047**	-0.614**	-0.040	-0.544**
					(0.023)	(0.252)	(0.027)	(0.265)
Uncon. Build					0.073***	1.019**	0.048*	0.874**
					(0.026)	(0.404)	(0.027)	(0.422)
Observations	363	363	363	363	363	363	363	363

Odd columns correspond to binary specification, even columns to intensity specification
Standard errors, clustered at district, in parentheses
Year and district fixed effects included
*** p<0.01, ** p<0.05, * p<0.1

Table 6.21: Price of Maize & Unconnected in Non-Rural District

	Log(Price)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.090*	0.104						
	(0.050)	(0.087)						
Uncon. Benefit	0.131***	0.128						
	(0.042)	(0.158)						
Upgrade			0.003	-0.011			0.007	0.021
			(0.043)	(0.066)			(0.042)	(0.071)
Uncon. Upgrade			0.092	0.087			0.064	0.062
			(0.080)	(0.067)			(0.065)	(0.083)
Build					0.019	-0.166	0.029	-0.092
					(0.054)	(0.343)	(0.052)	(0.243)
Uncon. Build					0.113**	0.415	0.079	0.288
					(0.055)	(0.552)	(0.060)	(0.392)
Observations	154	154	154	154	154	154	154	154

Odd columns correspond to binary specification, even columns to intensity specification
Standard errors, clustered at district, in parentheses
Year and district fixed effects included
*** p<0.01, ** p<0.05, * p<0.1

6.3.2 Labour Effects & Output

Within this paper I have provided evidence of location specific changes in agricultural production due to PMGSY treatment. Strong enough correlation between these locations and changes in the rural workforce induced by the PMGSY, could account for a significant portion of my previous agricultural production results. This would suggest that farmers are not switching between crops, rather areas that intensify agriculture produce more of everything, while areas that see reductions in the agricultural labour force produce less agricultural output. To test for this I re-run the productive crops estimate under the restricted ICRISAT sample, including only rural areas in estimation. If previous results were driven by the intensification of individuals in the agricultural industry, results in this restricted estimation should be positive for all crops and have greater magnitude than the previous full sample estimates. Results generated under this restricted sample, contained in tables 6.22 - 6.24, are very similar to the previous output advantage results. Although there is some reduction in significance, likely due to the restricted sample, the signs of the coefficients are almost identical to previous estimates. It is therefore unlikely that changes in the composition of the rural workforce are accounting for the majority of the impacts estimated previously.

Table 6.22: Output of Wheat with Maize Advantage, in Rural Area

	Log(Output)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.150*	0.374***						
	(0.082)	(0.127)						
Benefit * Adv.	-0.331***	-0.283***						
	(0.096)	(0.103)						
Upgrade			0.023	-0.011			0.027	0.041
			(0.051)	(0.073)			(0.051)	(0.073)
Upgrade * Adv.			-0.247***	-0.221***			-0.127*	0.006
			(0.079)	(0.083)			(0.074)	(0.081)
Build					0.294***	0.406***	0.262***	0.444***
					(0.090)	(0.099)	(0.096)	(0.115)
Build * Adv.					-0.308***	-0.322*	-0.242**	-0.332*
					(0.097)	(0.174)	(0.098)	(0.181)
Observations	1,119	1,119	1,119	1,119	1,119	1,119	1,119	1,119

Odd columns correspond to binary specification, even columns to intensity specification
Standard errors, clustered at district, in parentheses
Year and district fixed effects included
*** p<0.01, ** p<0.05, * p<0.1

Table 6.23: Output of Rice with Advantage, in Rural Area

	Log(Output)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.249	0.711***						
	(0.185)	(0.211)						
Benefit * Adv.	-0.558***	-0.441**						
	(0.171)	(0.196)						
Upgrade			0.036	0.092			0.024	0.188
			(0.107)	(0.118)			(0.108)	(0.130)
Upgrade * Adv.			-0.342**	-0.345**			-0.288*	-0.127
			(0.159)	(0.169)			(0.159)	(0.173)
Build					0.137	0.335**	0.044	0.373**
					(0.146)	(0.150)	(0.145)	(0.151)
Build * Adv.					-0.331*	-0.247	-0.179	-0.136
					(0.197)	(0.207)	(0.198)	(0.216)
Observations	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095

Odd columns correspond to binary specification, even columns to intensity specification
Standard errors, clustered at district, in parentheses
Year and district fixed effects included
*** p<0.01, ** p<0.05, * p<0.1

Table 6.24: Output of Maize with Maize Advantage, in Rural Area

	Log(Output)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.006	-0.185						
	(0.186)	(0.217)						
Benefit * Adv	0.110	0.330						
	(0.203)	(0.261)						
Upgrade			-0.021	0.056			-0.008	0.043
			(0.098)	(0.125)			(0.101)	(0.126)
Upgrade * Adv.			0.249	0.313			0.112	0.045
			(0.169)	(0.197)			(0.160)	(0.229)
Build					-0.262*	-0.436***	-0.227	-0.380*
					(0.134)	(0.161)	(0.148)	(0.207)
Build * Adv.					0.357*	0.481*	0.300	0.444*
					(0.211)	(0.269)	(0.192)	(0.269)
Observations	994	994	994	994	994	994	994	994

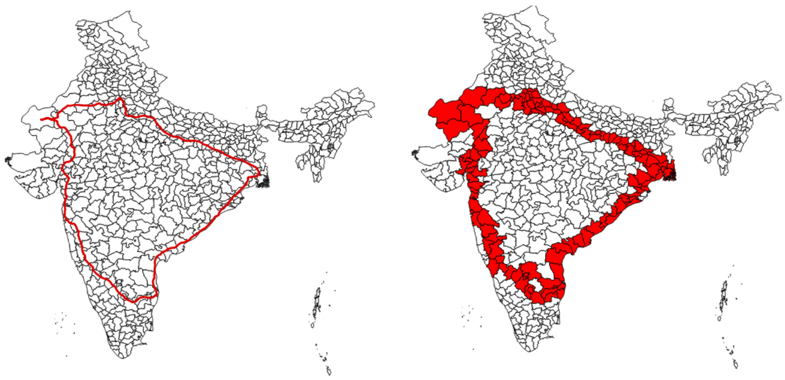
Odd columns correspond to binary specification, even columns to intensity specification
Standard errors, clustered at district, in parentheses
Year and district fixed effects included
*** p<0.01, ** p<0.05, * p<0.1

7 Robustness

7.1 The Golden Quadrilateral Highway Network

Contemporaneous to the roll-out of the PMGSY program was the construction of the Golden Quadrilateral (GQ) highway network. Although PMGSY roads were explicitly restricted from joining to highways of a similar standard as the GQ, the construction of the highway nearby to districts is a potential factor that may distort results (PMGSY, 2001). Unfortunately, I do not have the data concerning the spatial and temporal roll-out of the GQ network, only the final placement of the highways. Thus, I am unaware of both when and where this highway network started effecting districts. To isolate my results from the GQ's influence, I define districts within 10 kilometres to be connected to the GQ, following Ghani et al. (2015), remove these districts from the sample and re-estimate all findings found previously[15].

Figure 7.1: Golden Quadrilateral Network & Nearby Districts



All of my findings are robust to this change in sample. Of the minor changes generated from the removal of the GQ affected districts, as visible from tables 7.1 - 7.7. Previous analysis holds. Pre-treatment unconnected districts are still estimated to raise prices while connected districts lower prices following treatment. Evidence persists that districts with an advantage in maize increase maize's production, while lowering rice and wheat production. Finally, the estimated labour effects of PMGSY, without the GQ linked districts, are in line with the full sample estimates. As estimates still suggest that construction and improvement of rural roads shrink the agricultural workforce in non-rural areas, while growing it in rural areas.

[15]Ghani et al.'s results were robust to both measuring from the centre of the district and the closest edge, here I have used the measurement from the closest edge.

Table 7.1: Price of Wheat & Unconnected, without GQ Districts

	Log(Price)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.015	-0.012						
	(0.014)	(0.029)						
Benefit * Uncon.	0.094***	0.000						
	(0.026)	(0.043)						
Upgrade			-0.033**	-0.030*			-0.029*	-0.035**
			(0.015)	(0.016)			(0.015)	(0.017)
Upgrade * Uncon.			0.116***	0.106***			0.111***	0.108***
			(0.026)	(0.026)			(0.026)	(0.027)
Build					-0.016	-0.083	-0.009	-0.036
					(0.016)	(0.067)	(0.017)	(0.059)
Build * Uncon.					0.057***	0.167*	0.041**	0.059
					(0.018)	(0.098)	(0.018)	(0.083)
Observations	1,089	1,089	1,089	1,089	1,089	1,089	1,089	1,089

Odd columns correspond to binary specification, even columns to intensity specification
Standard errors, clustered at district, in parentheses
Year and district fixed effects included
*** p<0.01, ** p<0.05, * p<0.1

Table 7.2: Price of Paddy & Unconnected, without GQ Districts

	Log(Price)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	-0.052**	-0.037						
	(0.022)	(0.027)						
Benefit * Uncon.	0.028	-0.002						
	(0.026)	(0.042)						
Upgrade			-0.069***	-0.065***			-0.070***	-0.047**
			(0.016)	(0.019)			(0.016)	(0.018)
Upgrade * Uncon.			0.089***	0.096***			0.089***	0.078***
			(0.027)	(0.024)			(0.025)	(0.024)
Build					-0.061***	-0.296***	-0.047**	-0.247***
					(0.021)	(0.064)	(0.022)	(0.067)
Build * Uncon.					0.047**	0.462***	0.009	0.356***
					(0.022)	(0.095)	(0.025)	(0.096)
Observations	880	880	880	880	880	880	880	880

Odd columns correspond to binary specification, even columns to intensity specification
Standard errors, clustered at district, in parentheses
Year and district fixed effects included
*** p<0.01, ** p<0.05, * p<0.1

Table 7.3: Price of Maize & Unconnected, without GQ Districts

	Log(Price)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.069**	0.001						
	(0.032)	(0.050)						
Benefit * Uncon.	0.055	-0.019						
	(0.057)	(0.080)						
Upgrade			0.020	-0.012			0.023	-0.023
			(0.028)	(0.025)			(0.027)	(0.028)
Upgrade * Uncon.			0.021	0.011			0.019	0.018
			(0.052)	(0.052)			(0.052)	(0.055)
Build					0.007	0.085	0.011	0.101
					(0.033)	(0.125)	(0.031)	(0.101)
Build * Uncon.					0.012	-0.119	0.015	-0.140
					(0.047)	(0.205)	(0.043)	(0.167)
Observations	880	880	880	880	880	880	880	880

Odd columns correspond to binary specification, even columns to intensity specification
Standard errors, clustered at district, in parentheses
Year and district fixed effects included
*** p<0.01, ** p<0.05, * p<0.1

Table 7.4: Output of Wheat with Advantage & without GQ Districts

	Log(Output)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.230***	0.242***						
	(0.066)	(0.085)						
Benefit * Adv.	-0.283***	-0.283***						
	(0.063)	(0.076)						
Upgrade			0.139***	0.249***			0.102**	0.195***
			(0.046)	(0.064)			(0.047)	(0.060)
Upgrade * Adv.			-0.176***	-0.184***			-0.058	-0.058
			(0.048)	(0.058)			(0.045)	(0.065)
Build					0.300***	0.250***	0.299***	0.277***
					(0.061)	(0.068)	(0.065)	(0.076)
Build * Adv.					-0.268***	-0.277***	-0.247***	-0.254***
					(0.060)	(0.072)	(0.061)	(0.082)
Observations	3,202	3,202	3,202	3,202	3,202	3,202	3,202	3,202

Odd columns correspond to binary specification, even columns to intensity specification
Standard errors, clustered at district, in parentheses
Year and district fixed effects included
*** p<0.01, ** p<0.05, * p<0.1

Table 7.5: Output of Rice with Advantage, without GQ Districts

	Log(Output)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.152**	0.391***						
	(0.076)	(0.095)						
Benefit * Adv.	-0.233***	-0.247***						
	(0.075)	(0.086)						
Upgrade			-0.016	-0.043			-0.021	0.070
			(0.056)	(0.061)			(0.059)	(0.072)
Upgrade * Adv.			-0.147*	-0.180*			-0.124	-0.150
			(0.085)	(0.101)			(0.085)	(0.105)
Build					0.109	0.219***	0.065	0.189**
					(0.078)	(0.082)	(0.077)	(0.079)
Build * Adv.					-0.121	-0.110	-0.059	-0.039
					(0.074)	(0.073)	(0.068)	(0.070)
Observations	3,508	3,508	3,508	3,508	3,508	3,508	3,508	3,508

Odd columns correspond to binary specification, even columns to intensity specification
Standard errors, clustered at district, in parentheses
Year and district fixed effects included
*** p<0.01, ** p<0.05, * p<0.1

Table 7.6: Output of Maize with Maize Advantage, without GQ Districts

	Log(Output)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.040	-0.375**						
	(0.159)	(0.187)						
Benefit * Adv.	0.140	0.229						
	(0.127)	(0.144)						
Upgrade			-0.075	-0.232			-0.030	-0.294**
			(0.106)	(0.147)			(0.103)	(0.144)
Upgrade * Adv..			0.116	0.217			0.026	0.010
			(0.123)	(0.151)			(0.122)	(0.164)
Build					-0.059	-0.179	-0.055	-0.257*
					(0.115)	(0.121)	(0.124)	(0.135)
Build * Adv.					0.228*	0.293**	0.217*	0.290*
					(0.123)	(0.142)	(0.123)	(0.155)
Observations	2,864	2,864	2,864	2,864	2,864	2,864	2,864	2,864

Odd columns correspond to binary specification, even columns to intensity specification
Standard errors, clustered at district, in parentheses
Year and district fixed effects included
*** p<0.01, ** p<0.05, * p<0.1

Table 7.7: Rural Employment in Agricultural Sector, without GQ Districts

	Log(Employed)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Cultivators								
Benefit	-0.106**	-0.016						
	(0.043)	(0.063)						
Benefit * Rural.	0.290***	0.238***						
	(0.051)	(0.045)						
Upgrade			-0.164***	-0.149***			-0.074**	-0.014
			(0.039)	(0.051)			(0.034)	(0.050)
Upgrade * Rural.			0.206***	0.192***			0.067*	0.013
			(0.041)	(0.041)			(0.041)	(0.048)
Build					-0.184***	-0.139***	-0.166***	-0.144***
					(0.048)	(0.044)	(0.052)	(0.051)
Build * Rural.					0.284***	0.247***	0.241***	0.240***
					(0.052)	(0.046)	(0.057)	(0.057)
Observations	495	495	495	495	495	495	495	495
Panel B: Agr. Labour								
Benefit	-0.189***	0.260**						
	(0.052)	(0.125)						
Benefit * Rural.	0.228***	0.101						
	(0.086)	(0.092)						
Upgrade			-0.219***	-0.325***			-0.153***	-0.017
			(0.068)	(0.076)			(0.059)	(0.084)
Upgrade * Rural.			0.239***	0.277***			0.169**	0.061
			(0.086)	(0.080)			(0.072)	(0.072)
Build					-0.095	0.196***	-0.040	0.218***
					(0.068)	(0.070)	(0.064)	(0.076)
Build * Rural.					0.240***	0.173**	0.136*	0.139
					(0.089)	(0.088)	(0.074)	(0.090)
Observations	495	495	495	495	495	495	495	495

Odd columns correspond to binary specification, even columns to intensity specification
Standard errors, clustered at district, in parentheses
Year and district fixed effects included
*** p<0.01, ** p<0.05, * p<0.1

7.2 Government Procurement of Crops

Potential influence of government procurement on my estimates is a factor worth considering. Farmers within my sample may have one time-invariant intermediary, the Indian Government. If this were true, it would likely dampen the bargaining power effects and crop-switching effects suggested by this paper. Chatterjee and Kapur (2017) suggest variation in procurement is driven by farmer awareness of the program, with highest rates of awareness and procurement within the states of Haryana and Punjab. The Minimum Support Price (MSP) is issued annually for all of India, so MSP induced impacts are controlled for with the time fixed effects. Moreover, the Public Distribution System does not buy maize, reducing the incentive for farmers to switch out of the procured crops of rice and wheat and into maize.

Districts within Punjab and Haryana, therefore, are likely to be most resistant to both the price changes and crop switching effects of PMGSY.

Under this thinking, excluding districts in Punjab and Haryana should increase the magnitude of estimates, as they are no longer offset by high rates of procurement. Oppositely, I find that results of connected/unconnected price effects and the switching into maize to be robust to the exclusion of these two states. Indicating that my results are not influenced by Indian procurment of crops within my sample.

Table 7.8: Price of Wheat & Unconnected, without Procuring States

	Log(Price)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.007	-0.073						
	(0.023)	(0.047)						
Benefit * Uncon.	0.096***	-0.066						
	(0.031)	(0.067)						
Upgrade			-0.042	-0.050*			-0.035	-0.062*
			(0.026)	(0.029)			(0.026)	(0.032)
Upgrade * Uncon.			0.124***	0.114***			0.118***	0.119***
			(0.033)	(0.032)			(0.033)	(0.034)
Build					-0.012	-0.085	0.000	0.009
					(0.020)	(0.072)	(0.020)	(0.081)
Build * Uncon.					0.048**	0.165	0.035*	-0.002
					(0.020)	(0.101)	(0.021)	(0.125)
Observations	979	979	979	979	979	979	979	979

Odd columns correspond to binary specification, even columns to intensity specification
Standard errors, clustered at district, in parentheses
Year and district fixed effects included
*** p<0.01, ** p<0.05, * p<0.1

Table 7.9: Price of Paddy & Unconnected, without Procuring States

	Log(Price)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	-0.077***	-0.200***						
	(0.022)	(0.063)						
Benefit * Uncon.	0.029	-0.210***						
	(0.032)	(0.080)						
Upgrade			-0.113***	-0.135***			-0.115***	-0.117***
			(0.016)	(0.032)			(0.017)	(0.034)
Upgrade * Uncon.			0.127***	0.136***			0.125***	0.117***
			(0.026)	(0.025)			(0.024)	(0.024)
Build					-0.070***	-0.383***	-0.047*	-0.295***
					(0.021)	(0.096)	(0.025)	(0.060)
Build * Uncon.					0.054**	0.601***	0.005	0.415***
					(0.023)	(0.149)	(0.027)	(0.086)
Observations	825	825	825	825	825	825	825	825

Odd columns correspond to binary specification, even columns to intensity specification
Standard errors, clustered at district, in parentheses
Year and district fixed effects included
*** p<0.01, ** p<0.05, * p<0.1

Table 7.10: Price of Maize & Unconnected, without Procuring States

	Log(Price)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.067	-0.000						
	(0.041)	(0.058)						
Benefit * Uncon.	0.034	-0.046						
	(0.063)	(0.082)						
Upgrade			0.024	-0.014			0.027	-0.025
			(0.032)	(0.031)			(0.031)	(0.036)
Upgrade * Uncon.			0.017	0.016			0.016	0.023
			(0.055)	(0.055)			(0.054)	(0.059)
Build					0.009	0.029	0.012	0.067
					(0.031)	(0.101)	(0.029)	(0.080)
Build * Uncon.					0.008	-0.028	0.011	-0.080
					(0.045)	(0.165)	(0.041)	(0.136)
Observations	836	836	836	836	836	836	836	836

Odd columns correspond to binary specification, even columns to intensity specification
Standard errors, clustered at district, in parentheses
Year and district fixed effects included
*** p<0.01, ** p<0.05, * p<0.1

Table 7.11: Output of Wheat with Maize Advantage & without GQ Districts

	Log(Output)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.230***	0.242***						
	(0.066)	(0.085)						
Benefit * Adv.	-0.283***	-0.283***						
	(0.063)	(0.076)						
Upgrade			0.139***	0.249***			0.102**	0.195***
			(0.046)	(0.064)			(0.047)	(0.060)
Upgrade * Adv.			-0.176***	-0.184***			-0.058	-0.058
			(0.048)	(0.058)			(0.045)	(0.065)
Build					0.300***	0.250***	0.299***	0.277***
					(0.061)	(0.068)	(0.065)	(0.076)
Build * Adv.					-0.268***	-0.277***	-0.247***	-0.254***
					(0.060)	(0.072)	(0.061)	(0.082)
Observations	3,202	3,202	3,202	3,202	3,202	3,202	3,202	3,202

Odd columns correspond to binary specification, even columns to intensity specification
Standard errors, clustered at district, in parentheses
Year and district fixed effects included
*** p<0.01, ** p<0.05, * p<0.1

Table 7.12: Output of Rice with Advantage & without Procuring States

	Log(Output)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.097	0.335***						
	(0.075)	(0.093)						
Benefit * Adv.	-0.250***	-0.285***						
	(0.071)	(0.083)						
Upgrade			-0.015	-0.092			-0.015	0.024
			(0.054)	(0.067)			(0.057)	(0.075)
Upgrade * Adv.			-0.180**	-0.264**			-0.155*	-0.247**
			(0.081)	(0.105)			(0.082)	(0.111)
Build					0.182**	0.326***	0.128*	0.246***
					(0.075)	(0.080)	(0.074)	(0.075)
Build * Adv.					-0.122*	-0.116*	-0.045	-0.001
					(0.066)	(0.066)	(0.063)	(0.065)
Observations	3,862	3,862	3,862	3,862	3,862	3,862	3,862	3,862

Odd columns correspond to binary specification, even columns to intensity specification
Standard errors, clustered at district, in parentheses
Year and district fixed effects included
*** p<0.01, ** p<0.05, * p<0.1

Table 7.13: Output of Maize with Maize Advantage & without Procuring States

	Log(Output)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	-0.016	-0.433***						
	(0.133)	(0.167)						
Benefit * Adv.	0.195*	0.324**						
	(0.112)	(0.135)						
Upgrade			-0.111	-0.278**			-0.064	-0.330**
			(0.092)	(0.138)			(0.090)	(0.136)
Upgrade * Adv.			0.124	0.310**			0.020	0.113
			(0.108)	(0.142)			(0.110)	(0.161)
Build					-0.033	-0.180	-0.036	-0.231*
					(0.103)	(0.110)	(0.112)	(0.124)
Build * Adv.					0.249**	0.326**	0.243**	0.295*
					(0.114)	(0.137)	(0.119)	(0.156)
Observations	3,387	3,387	3,387	3,387	3,387	3,387	3,387	3,387

Odd columns correspond to binary specification, even columns to intensity specification
Standard errors, clustered at district, in parentheses
Year and district fixed effects included
*** p<0.01, ** p<0.05, * p<0.1

7.3 Alternate Specifications of Interaction Terms

7.3.1 Unconnected

Previously districts were defined as being unconnected if they were below the median pre-treatment market connection level. To determine the robustness of this definition I increase the threshold of definition, such that now the bottom 75% of the pre-treatment distribution are considered unconnected. This is done to separate the districts before the second spike in connection levels in figure 6.1. Results of this re-specification are contained within tables 7.14 - 7.16. As before, unconnected districts receive higher prices post-treatment, and connected districts receive lower prices, indicating that the previous finding, of the bargaining power effect being stronger in areas with lower market access, is robust. Estimates between the two definitions of unconnected are relatively similar, although there are some changes in significance. Notably, is the decrease in the magnitude and significance of new roads on unconnected districts for maize and paddy, and the increase in significance of the negative estimates for new roads in wheat reporting connected districts. Both of these results are consistent with the increased average level of pre-treatment market connection in both the connected and unconnected groups, induced by the increasing of the pre-treatment market connectivity threshold set.

Table 7.14: Price of Wheat & Unconnected Redefined

	Log(Price)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.013	-0.002						
	(0.015)	(0.027)						
Benefit * Uncon.	0.078***	0.039						
	(0.024)	(0.043)						
Upgrade			-0.017	-0.023			-0.007	-0.015
			(0.016)	(0.017)			(0.017)	(0.020)
Upgrade * Uncon.			0.040*	0.042*			0.033	0.037*
			(0.021)	(0.021)			(0.022)	(0.022)
Build					-0.036**	0.070	-0.028*	0.122
					(0.014)	(0.197)	(0.015)	(0.192)
Build * Uncon.					0.064***	-0.102	0.058***	-0.185
					(0.015)	(0.314)	(0.016)	(0.308)
Observations	1,210	1,210	1,210	1,210	1,210	1,210	1,210	1,210

Odd columns correspond to binary specification, even columns to intensity specification
Standard errors, clustered at district, in parentheses
Year and district fixed effects included
*** p<0.01, ** p<0.05, * p<0.1

Table 7.15: Price of Paddy & Unconnected Redefined

	Log(Price)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	-0.010	-0.002						
	(0.028)	(0.036)						
Benefit * Uncon.	-0.060*	-0.090*						
	(0.034)	(0.052)						
Upgrade			-0.062***	-0.071***			-0.069***	-0.049**
			(0.015)	(0.018)			(0.015)	(0.020)
Upgrade * Uncon.			0.009	0.008			0.013	0.003
			(0.017)	(0.018)			(0.017)	(0.018)
Build					-0.021	-0.234**	-0.016	-0.165*
					(0.016)	(0.098)	(0.027)	(0.100)
Build * Uncon.					-0.020	0.380**	-0.038	0.243
					(0.020)	(0.151)	(0.031)	(0.152)
Observations	1,001	1,001	1,001	1,001	1,001	1,001	1,001	1,001

Odd columns correspond to binary specification, even columns to intensity specification
Standard errors, clustered at district, in parentheses
Year and district fixed effects included
*** p<0.01, ** p<0.05, * p<0.1

Table 7.16: Price of Maize & Unconnected Redefined

	Log(Price)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.070**	-0.001						
	(0.033)	(0.059)						
Benefit * Uncon.	0.026	-0.062						
	(0.054)	(0.095)						
Upgrade			0.039	0.005			0.033	-0.012
			(0.032)	(0.036)			(0.033)	(0.039)
Upgrade * Uncon.			-0.014	-0.009			-0.007	0.002
			(0.039)	(0.037)			(0.040)	(0.039)
Build					0.049	0.237	0.042	0.141
					(0.042)	(0.410)	(0.041)	(0.342)
Build * Uncon.					-0.049	-0.357	-0.033	-0.208
					(0.051)	(0.662)	(0.049)	(0.553)
Observations	935	935	935	935	935	935	935	935

Odd columns correspond to binary specification, even columns to intensity specification
Standard errors, clustered at district, in parentheses
Year and district fixed effects included
*** p<0.01, ** p<0.05, * p<0.1

7.3.2 Maize Advantage

Originally, crop advantage was determined by finding the 30% most fertile districts for growing maize, following aggregation to the district level by taking the median GAEZ index. This aggregation can take a number of forms. While the median describes a typical field in a district, it fails to consider if only a small fertile field in an otherwise infertile district does the majority of the production. As such, to determine the robustness of the previous output-advantage results, I redefine a district that has at least 15% of its area indexed as the most fertile areas, this yields a class of the top 20% most fertile districts for producing maize. Using the newly defined advantage districts, I re-estimate crop production within maize advantage districts, see tables 7.17 - 7.19.

With this new specification of maize advantage, I still find evidence of crop switching towards maize. However, estimated effects of treatment on rice production in advantage areas are insignificant. This could potentially be a result of no longer considering districts as a whole when defining advantage and the now overlap of

Particularly as the estimated effects of PMGSY within this district on maize production is significantly more positive than previous estimates, suggesting that

Table 7.17: Output of Wheat with Maize Advantage Redefined

	Log(Output)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.111***	0.124*						
	(0.043)	(0.068)						
Benefit * Adv.	-0.296***	-0.317***						
	(0.061)	(0.080)						
Upgrade			0.079**	0.116**			0.085**	0.113***
			(0.035)	(0.049)			(0.036)	(0.044)
Upgrade * Adv..			-0.219***	-0.216***			-0.115**	-0.072
			(0.052)	(0.057)			(0.048)	(0.074)
Build					0.181***	0.150***	0.186***	0.183***
					(0.046)	(0.053)	(0.048)	(0.056)
Build * Adv.					-0.272***	-0.287***	-0.221***	-0.261***
					(0.068)	(0.083)	(0.073)	(0.098)
Observations	3,627	3,627	3,627	3,627	3,627	3,627	3,627	3,627

Odd columns correspond to binary specification, even columns to intensity specification
Standard errors, clustered at district, in parentheses
Year and district fixed effects included
*** p<0.01, ** p<0.05, * p<0.1

Table 7.18: Output of Rice with Maize Advantage Redefined

	Log(Output)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.036	0.239***						
	(0.066)	(0.085)						
Benefit * Adv.	-0.039	-0.017						
	(0.072)	(0.080)						
Upgrade			-0.060	-0.090			-0.054	0.020
			(0.044)	(0.056)			(0.046)	(0.062)
Upgrade * Adv..			-0.005	0.018			-0.016	0.013
			(0.074)	(0.091)			(0.075)	(0.090)
Build					0.059	0.165**	0.046	0.172**
					(0.063)	(0.067)	(0.067)	(0.073)
Build * Adv.					0.018	0.027	0.030	0.020
					(0.079)	(0.075)	(0.079)	(0.070)
Observations	4,250	4,250	4,250	4,250	4,250	4,250	4,250	4,250

Odd columns correspond to binary specification, even columns to intensity specification
Standard errors, clustered at district, in parentheses
Year and district fixed effects included
*** p<0.01, ** p<0.05, * p<0.1

Table 7.19: Output of Maize with Maize Advantage Redefined

	Log(Output)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	-0.019	-0.455***						
	(0.109)	(0.153)						
Benefit * Adv.	0.494***	0.703***						
	(0.170)	(0.217)						
Upgrade			-0.143**	-0.266**			-0.123*	-0.380***
			(0.071)	(0.110)			(0.071)	(0.113)
Upgrade * Adv..			0.584***	0.812***			0.427***	0.602***
			(0.144)	(0.173)			(0.116)	(0.179)
Build					-0.042	-0.169*	0.001	-0.194**
					(0.086)	(0.094)	(0.090)	(0.096)
Build * Adv.					0.566***	0.682**	0.339	0.373
					(0.218)	(0.265)	(0.217)	(0.307)
Observations	3,518	3,518	3,518	3,518	3,518	3,518	3,518	3,518

Odd columns correspond to binary specification, even columns to intensity specification
Standard errors, clustered at district, in parentheses
Year and district fixed effects included
*** p<0.01, ** p<0.05, * p<0.1

7.3.3 Rural

Rural districts were previously defined as being in the lower half of the town per square kilometre distribution, i.e. below the median. The town density distribution is skewed towards the right. To test the robustness of the distribution I now redefine the threshold value of town density to be the mean, under this definition 75% of the ICRISAT sample is now considered rural. Given both the small 10 kilometre radius found by Shamdasani (2016) and the imprecision of the definition of rural, it is likely that most results are driven by the extremes of the distribution, i.e. districts with many villages near towns are likely to have a considerably higher town density. The findings presented in table 7.20, demonstrate that the finding of rural areas intensifying in agriculture and non-rural areas moving out of agriculture is robust to this altering of the definition of rural.

Table 7.20: Rural Employment in Agriculture, Rural Redefined

	Log(Employed)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Cultivators								
Benefit	-0.174***	-0.062						
	(0.053)	(0.073)						
Benefit * Rural	0.321***	0.269***						
	(0.057)	(0.057)						
Upgrade			-0.215***	-0.225***			-0.092***	-0.016
			(0.041)	(0.069)			(0.035)	(0.068)
Upgrade * Rural			0.249***	0.263***			0.088**	0.038
			(0.046)	(0.064)			(0.038)	(0.063)
Build					-0.245***	-0.157***	-0.205***	-0.115**
					(0.054)	(0.043)	(0.058)	(0.054)
Build * Rural					0.294***	0.204***	0.238***	0.153***
					(0.055)	(0.043)	(0.058)	(0.057)
Observations	615	615	615	615	615	615	615	615
Panel B: Agr. Labour								
Benefit	-0.203***	0.271**						
	(0.073)	(0.119)						
Benefit * Rural	0.243**	0.052						
	(0.095)	(0.096)						
Upgrade			-0.231***	-0.319***			-0.089	0.136
			(0.084)	(0.098)			(0.061)	(0.090)
Upgrade * Rural			0.246**	0.240**			0.104	-0.132*
			(0.098)	(0.099)			(0.070)	(0.080)
Build					-0.169**	0.110	-0.116**	0.072
					(0.080)	(0.071)	(0.059)	(0.074)
Build * Rural					0.300***	0.237***	0.236***	0.272***
					(0.093)	(0.087)	(0.066)	(0.087)
Observations	615	615	615	615	615	615	615	615

Odd columns correspond to binary specification, even columns to intensity specification
Standard errors, clustered at district, in parentheses
Year and district fixed effects included
*** p<0.01, ** p<0.05, * p<0.1

8 Discussion & Conclusion

A central characteristic of poverty in India is the suppression of farmer prices by intermediaries who have significantly more market power and political clout (Chand, 2012). The main causal implication of the PMGSY suggested by this paper is that connecting rural communities to the wider economy yields higher prices for the rural farmers, thereby reducing the the transfer of welfare from farmers to intermediaries via low prices. Increasing the prices received significantly aides the alleviation of poverty in rural areas, as following an increase in farmer prices there is a diffusion of higher, non-farm related incomes within a community (Aksoy and Isik-Dimelik, 2010). The development implications of this are sizeable. Higher incomes are associated with everything from improved nutrition (Headey, 2013) to the more equitable treatment of women (Razavi, 2012). Further, Aggarwal (2018) suggests that higher, PMGSY generated incomes are a central trigger for the improvements in a swathe of development outcomes within her work, particularly the increased attainment of early childhood education.

The PMGSY program also induces a range of production and employment effects, further boosting development. I have provided evidence that following increases in price, farmers increase crop production. Moreover, PMGSY treatment also improves market opportunities for a farmer, creating value of previously un-grown crops and a subsequent shift in crop selection. These output effects compound welfare benefits, as farmers receive a significant boost in income as both quantity supplied and price received increase. The PMGSY program also has implications for the labour market. In rural areas employment increases in agriculture. Despite a shift out of agriculture in less rural areas, cultivators who remain increase the amount of labour hired on their land. Moreover, previous work by Asher and Novosad (2016) finds that those who leave agriculture do so for higher paying jobs in a non-agricultural sector. Therefore, following treatment rural communities benefit both from higher levels of employment as well as increased output, compounding the welfare benefits induced by price changes.

Results presented within this paper could inform decision makers on a range of policy issues, most evidently on debates and considerations concerning investments into similar large scale infrastructure projects. Furthermore, this paper is also relevant in discussions of any policies likely to alter agricultural bargaining power and market integration, such as market design policies, competition laws, expansions of telecommunication services and agricultural export promotions.

I recognise the limitations in terms of external validity within this analysis. Although the Indian society and geography has aspects similar to numerous low income rural areas, a range of structural and institutional factors reduce the probability of the replication of results in other contexts. Both the effects of the APMC Acts and the concentration of farmers on rice and wheat production likely increase the magnitude and significance of results found within this context. There is room for further study in this area. Creating a connection between a national economy and a small rural community is likely to generate long-run structural changes. Evaluation of these changes on development outcomes should be central in order to determine the full costs and benefits of such road building programs. Moreover, obtaining information concerning the distribution of market locations and measures of farmer bargaining power could be used to fully validate the proposed farmer bargaining power mechanism suggested by this paper. Finally, the spill over effects of the increased prices generated by the rural farmers on the local economy need to be investigated. Given the majority of rural communities are not net producers, if the spill over effect were negligible, welfare outcomes of the PMGSY program would be severely limited.

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A Summary Statistics & Samples Included

Figure A.1: Districts Included

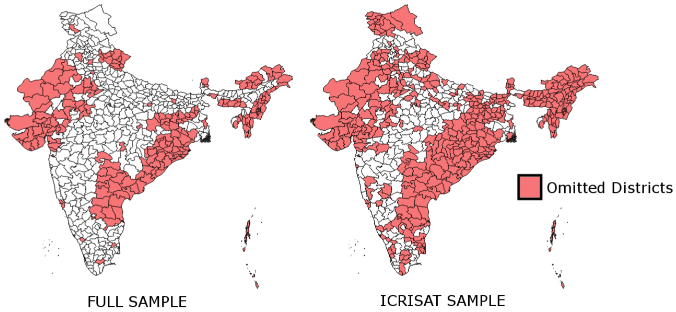

Table A.1: Summary Statistics

	Full Sample		Upgrade		Build	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Market Connectivity, 2000	0.55	0.36	0.63	0.34	0.49	0.34
Build: Proportion Treat	0.16	0.17	0.12	0.14	0.18	0.17
Upgrade: Proportion Treat	0.13	0.11	0.15	0.11	0.11	0.10
District Pop. (1,000s)	1,492	938	1540	869	1526	960
Maize Advantage	0.39	0.49	0.40	0.49	0.39	0.49
Pop. Density (/km^2)	335.22	272.87	342.97	277.91	347.57	286.68
Towns (Pop. >5,000)	267.10	386.44	283.71	388.34	279.28	396.63
Town Density (/km^2)	0.07	0.13	0.07	0.14	0.07	0.14
Observations	382	382	320	320	334	334

Table A.2: Summary Statitistics, ICRISAT Sample

	Full Sample		Upgrade		Build	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Market Connectivity, 2000	0.61	0.33	0.65	0.32	0.55	0.32
Build: Proportion Treat	0.11	0.12	0.10	0.11	0.13	0.12
Upgrade: Proportion Treat	0.13	0.10	0.15	0.10	0.12	0.09
District Pop. (1,000s)	1,774	1,001	1,784	865	1,820	1028
Maize Advantage	0.38	0.49	0.38	0.49	0.37	0.48
Pop. Density (/km^2)	348.57	304.52	352.98	302.86	369.84	322.29
Towns (Pop. >5,000)	338.09	435.41	336.20	420.18	360.81	452.69
Town Density (/km^2)	0.08	0.17	0.09	0.17	0.09	0.18
Observations	205		187		175	

*** p<0.01, ** p<0.05, * p<0.1

B Solution to Model

$$\textbf{Solving} \max_{\lambda} \quad (\lambda - p_{\underline{i}}^k Q_i^{fk})^{\delta}(p_r^k Q_i^{fk}/\tau_{im} - \lambda)^{1-\delta} \quad \text{where } \lambda = p_m^k Q_i^{fk}/\tau_{im}$$

$$\delta(\lambda - p_{\underline{i}}^k Q_i^{fk})^{\delta-1}(p_r^k Q_i^{fk}/\tau_{im} - \lambda)^{1-\delta} + (1-\delta)(\lambda - p_{\underline{i}}^k Q_i^{fk})^{\delta}(p_r^k Q_i^{fk}/\tau_{im} - \lambda)^{\delta} = 0$$
$$\delta(\lambda - p_{\underline{i}}^k Q_i^{fk})^{-1}(p_r^k Q_i^{fk}/\tau_{im} - \lambda) + (1-\delta) = 0$$
$$(\delta - 1)/\delta = \tfrac{p_r^k Q_i^{fk}/\tau_{im} - \lambda}{\lambda - p_{\underline{i}}^k Q_i^{fk}}$$
$$\lambda = \delta(p_r^k Q_i^{fk}/\tau_{im} + (1-\delta) p_{\underline{i}}^k Q_i^{fk}$$
$$\mathrm{p}_m^k = \delta p_r^k + (1-\delta) p_{\underline{i}}^k \tau_{im}$$

$$\textbf{Solving} \ \max \quad p_i^k Q_i^{fk} - w_i N_i^{fk}$$

$$\alpha p_i^k A_i^{fk} (N_i^{fk})^{\alpha-1} = w_i$$
$$\mathrm{N}_i^{fk} = \left(\tfrac{w_i}{\alpha p_i^k A_i^{fk}}\right)^{\frac{1}{\alpha-1}}$$
$$\mathrm{p}_i^k Q_i^{fk} = p_i^k = p_i^k A_i^{fk} (\left(\tfrac{w_i}{\alpha p_i^k A_i^{fk}}\right)^{\frac{\alpha}{\alpha-1}}$$
$$\mathrm{Q} = \mathrm{A}^{\frac{1}{1-\alpha}} \left(\alpha \tfrac{p_i^k}{w_i}\right)^{\frac{\alpha}{1-\alpha}}$$

C Regression Coefficients

Table C.1: Coefficients: Placebo Test, Price Results

	Log(Price)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Wheat								
Benefit	-0.004	-0.004						
	(0.016)	(0.016)						
Pop Benefit		0.036						
		(0.180)						
Upgrade			0.020	-0.005			0.013	-0.010
			(0.021)	(0.027)			(0.022)	(0.028)
Pop Upgrade				0.886**				0.825*
				(0.435)				(0.445)
Build					-0.026*	-0.026*	-0.025*	-0.023
					(0.013)	(0.014)	(0.014)	(0.014)
Pop Build						0.000		0.017
						(0.150)		(0.159)
Observations	552	552	552	552	552	552	552	552
Adj. R-squared	0.699	0.698	0.699	0.701	0.702	0.701	0.701	0.701
Panel B: Paddy								
Benefit	0.078***	0.077***						
	(0.020)	(0.020)						
Pop Benefit		-0.254						
		(0.179)						
Upgrade			0.064***	0.062***			0.061***	0.058**
			(0.019)	(0.024)			(0.020)	(0.024)
Pop Upgrade				0.128				-0.035
				(1.003)				(0.992)
Build					-0.018	-0.014	-0.013	-0.009
					(0.022)	(0.022)	(0.022)	(0.022)
Pop Build						-0.283		-0.262
						(0.202)		(0.190)
Observations	534	534	534	534	534	534	534	534
Adj. R-squared	0.695	0.697	0.691	0.690	0.688	0.689	0.690	0.691
Panel C: Maize								
Benefit	-0.039	-0.040						
	(0.060)	(0.060)						
Pop Benefit		0.034						
		(0.159)						
Upgrade			-0.039	-0.035			-0.040	-0.036
			(0.069)	(0.052)			(0.073)	(0.054)
Pop Upgrade				-0.224				-0.230
				(2.418)				(2.477)
Build					-0.003	-0.004	-0.007	-0.008
					(0.024)	(0.023)	(0.027)	(0.027)
Pop Build						0.059		0.044
						(0.099)		(0.119)
Observations	402	402	402	402	402	402	402	402
Adj. R-squared	0.737	0.736	0.737	0.736	0.736	0.735	0.736	0.734
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered at Dist.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Clustered standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.2: Coefficients: Placebo Test, Output Results

	Log(Price)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Wheat								
Benefit	0.081* (0.045)	0.092** (0.046)						
Pop Benefit		-0.711 (0.466)						
Upgrade			0.046 (0.046)	0.031 (0.061)			0.018 (0.054)	0.008 (0.066)
Pop Upgrade				0.501 (1.132)				0.519 (1.102)
Build					-0.083 (0.051)	-0.064 (0.051)	-0.078 (0.058)	-0.053 (0.058)
Pop Build						-0.975 (0.703)		-1.015 (0.701)
Observations	1,036	1,036	1,036	1,036	1,036	1,036	1,036	1,036
Adj. R-squared	0.966	0.966	0.966	0.966	0.966	0.966	0.966	0.966
Panel B: Rice								
Benefit	0.186** (0.083)	0.198** (0.084)						
Pop Benefit		-0.919 (0.907)						
Upgrade			-0.091 (0.074)	-0.106 (0.083)			-0.131 (0.102)	-0.143 (0.106)
Pop Upgrade				0.565 (1.391)				0.416 (1.358)
Build					-0.062 (0.084)	-0.045 (0.082)	-0.104 (0.107)	-0.083 (0.104)
Pop Build						-0.870 (1.169)		-0.932 (1.275)
Observations	1,024	1,024	1,024	1,024	1,024	1,024	1,024	1,024
Adj. R-squared	0.809	0.809	0.809	0.809	0.809	0.809	0.809	0.809
Panel C: Maize								
Benefit	0.032 (0.070)	0.030 (0.070)						
Pop Benefit		0.114 (0.534)						
Upgrade			0.037 (0.079)	0.082 (0.095)			0.055 (0.084)	0.098 (0.098)
Pop Upgrade				-1.753 (1.727)				-1.815 (1.682)
Build					0.040 (0.066)	0.033 (0.067)	0.056 (0.071)	0.034 (0.071)
Pop Build						0.398 (0.598)		0.539 (0.574)
Observations	1,020	1,020	1,020	1,020	1,020	1,020	1,020	1,020
Adj. R-squared	0.949	0.949	0.949	0.949	0.949	0.949	0.949	0.949
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered at Dist.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Clustered standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.3: Coefficients: Price Results

	Log(Price)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Wheat								
Benefit	0.051***	0.052***						
	(0.017)	(0.017)						
Pop. Benefit		-0.032						
		(0.067)						
Upgrade			-0.003	0.003			0.003	0.008
			(0.014)	(0.014)			(0.015)	(0.015)
Pop. Upgrade				-0.087				-0.090
				(0.066)				(0.076)
Build					0.034**	0.033**	0.035**	0.035**
					(0.015)	(0.015)	(0.015)	(0.015)
Pop. Build						0.025		-0.007
						(0.076)		(0.085)
Observations	1,210	1,210	1,210	1,210	1,210	1,210	1,210	1,210
Adj. R-squared	0.902	0.902	0.901	0.901	0.901	0.901	0.901	0.902
Panel B: Paddy								
Benefit	-0.050***	-0.045***						
	(0.018)	(0.017)						
Pop. Benefit		0.141***						
		(0.043)						
Upgrade			-0.047***	-0.044**			-0.049***	-0.037**
			(0.018)	(0.018)			(0.018)	(0.018)
Pop. Upgrade				-0.068				0.015
				(0.067)				(0.066)
Build					-0.019	-0.020	-0.027*	-0.025*
					(0.014)	(0.014)	(0.015)	(0.015)
Pop. Build						0.191***		0.156***
						(0.045)		(0.047)
Observations	1,001	1,001	1,001	1,001	1,001	1,001	1,001	1,001
Adj. R-squared	0.918	0.919	0.919	0.919	0.918	0.920	0.920	0.921
Panel C: Maize								
Benefit	0.081***	0.078***						
	(0.028)	(0.028)						
Pop. Benefit		-0.142						
		(0.114)						
Upgrade			-0.027	-0.018			-0.025	-0.016
			(0.040)	(0.039)			(0.041)	(0.040)
Pop. Upgrade				-0.278**				-0.335**
				(0.133)				(0.163)
Build					0.020	0.021	0.013	0.017
					(0.021)	(0.021)	(0.021)	(0.020)
Pop. Build						-0.022		-0.105
						(0.096)		(0.118)
Observations	935	935	935	935	935	935	935	935
Adj. R-squared	0.732	0.733	0.731	0.732	0.731	0.731	0.731	0.733
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered at Dist.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Clustered standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.4: Coefficients: Price of Wheat & Unconnected

	Log(Price)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.017	0.041***						
	(0.014)	(0.013)						
Benefit*Uncon.	0.091***	0.058**						
	(0.026)	(0.029)						
Pop. Benefit		-0.183**						
		(0.088)						
Pop. Benefit*Uncon.		0.183***						
		(0.066)						
Upgrade			-0.035**	-0.017			-0.028*	-0.014
			(0.014)	(0.013)			(0.014)	(0.013)
Upgrade*Uncon.			0.076***	0.043			0.070***	0.046*
			(0.025)	(0.028)			(0.025)	(0.027)
Pop. Upgrade				-0.093				-0.138
				(0.068)				(0.085)
Pop.Upgrade*Uncon.				0.331**				0.339**
				(0.129)				(0.136)
Build					0.002	0.006	0.003	0.006
					(0.019)	(0.018)	(0.020)	(0.019)
Build*Uncon.					0.046**	0.039*	0.037*	0.028
					(0.021)	(0.023)	(0.021)	(0.023)
Pop. Build						-0.384		-0.273
						(0.343)		(0.370)
Pop. Build*Uncon.						0.391		0.175
						(0.333)		(0.348)
Observations	1,210	1,210	1,210	1,210	1,210	1,210	1,210	1,210
Adj. R-squared	0.891	0.892	0.891	0.892	0.890	0.890	0.891	0.892
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered at Dist.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Odd columns correspond to binary specification, even columns to intensity specification
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.5: Coefficients: Price of Paddy & Unconnected

	Log(Price)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	-0.051**	-0.032						
	(0.021)	(0.021)						
Benefit*Uncon.	0.003	-0.025						
	(0.033)	(0.033)						
Pop. Benefit		-0.061						
		(0.067)						
Pop. Benefit*Uncon.		0.240***						
		(0.064)						
Upgrade			-0.073***	-0.070***			-0.075***	-0.060***
			(0.015)	(0.015)			(0.015)	(0.014)
Upgrade*Uncon.			0.116***	0.107**			0.115***	0.087*
			(0.039)	(0.045)			(0.038)	(0.044)
Pop. Upgrade				-0.011				0.013
				(0.058)				(0.063)
Pop.Upgrade*Uncon.				0.239				0.220
				(0.305)				(0.300)
Build					-0.045**	-0.027*	-0.030	-0.021
					(0.019)	(0.016)	(0.019)	(0.017)
Build*Uncon.					0.046*	0.006	0.005	-0.015
					(0.025)	(0.024)	(0.025)	(0.024)
Pop. Build						-1.527***		-1.218***
						(0.345)		(0.390)
Pop. Build*Uncon.						1.694***		1.303***
						(0.347)		(0.387)
Observations	1,001	1,001	1,001	1,001	1,001	1,001	1,001	1,001
Adj. R-squared	0.909	0.911	0.913	0.913	0.909	0.911	0.913	0.914
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered at Dist.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Odd columns correspond to binary specification, even columns to intensity specification
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.6: Coefficients: Price of Maize & Unconnected

	Log(Price)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.069**	0.067**						
	(0.031)	(0.029)						
Benefit*Uncon.	0.031	0.032						
	(0.056)	(0.059)						
Pop. Benefit		-0.208						
		(0.134)						
Pop. Benefit*Uncon.		0.063						
		(0.149)						
Upgrade			0.013	0.029			0.018	0.027
			(0.023)	(0.022)			(0.023)	(0.020)
Upgrade*Uncon.			-0.091	-0.105			-0.095	-0.097
			(0.093)	(0.081)			(0.092)	(0.083)
Pop. Upgrade				-0.325**				-0.350**
				(0.126)				(0.143)
Pop.Upgrade*Uncon.				-0.108				-0.116
				(0.321)				(0.343)
Build					-0.007	-0.015	-0.014	-0.018
					(0.030)	(0.030)	(0.027)	(0.025)
Build*Uncon.					0.045	0.060*	0.052	0.065*
					(0.033)	(0.033)	(0.032)	(0.033)
Pop. Build						0.656		0.524
						(0.803)		(0.571)
Pop. Build*Uncon.						-0.693		-0.580
						(0.811)		(0.594)
Observations	935	935	935	935	935	935	935	935
Adj. R-squared	0.700	0.700	0.701	0.702	0.700	0.699	0.701	0.701
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered at Dist.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Odd columns correspond to binary specification, even columns to intensity specification
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.7: Coefficients: Price of Wheat & Surrounding Treatment

	Log(Price)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.055***	0.056***						
	(0.016)	(0.016)						
Pop. Benefit		-0.039						
		(0.069)						
Upgrade			0.001	0.003			0.006	0.009
			(0.014)	(0.014)			(0.015)	(0.015)
Pop. Upgrade				-0.059				-0.061
				(0.071)				(0.074)
Build					0.034**	0.035**	0.036**	0.037**
					(0.014)	(0.015)	(0.015)	(0.016)
Pop. Build						-0.025		-0.033
						(0.098)		(0.099)
Prod. Treatment	0.217	0.225	0.189	0.113	0.189	0.228	0.200	0.173
	(0.148)	(0.148)	(0.149)	(0.164)	(0.146)	(0.201)	(0.144)	(0.202)
Observations	1,210	1,210	1,210	1,210	1,210	1,210	1,210	1,210
Adj. R-squared	0.891	0.891	0.890	0.890	0.890	0.890	0.890	0.890
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered at Dist.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Odd columns correspond to binary specification, even columns to intensity specification
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.8: Coefficients: Price of Paddy & Surrounding Treatment

	Log(Price)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	-0.040**	-0.040**						
	(0.017)	(0.017)						
Pop. Benefit		0.061						
		(0.050)						
Upgrade			-0.029	-0.030			-0.031	-0.032
			(0.019)	(0.019)			(0.020)	(0.020)
Pop. Upgrade				0.037				0.043
				(0.071)				(0.070)
Build					-0.015	-0.017	-0.021	-0.022
					(0.014)	(0.014)	(0.015)	(0.015)
Pop. Build						0.085		0.089
						(0.079)		(0.080)
Prod. Treatment	0.565***	0.493***	0.478***	0.509***	0.588***	0.408*	0.462***	0.313
	(0.141)	(0.162)	(0.166)	(0.182)	(0.141)	(0.241)	(0.166)	(0.281)
Observations	1,001	1,001	1,001	1,001	1,001	1,001	1,001	1,001
Adj. R-squared	0.911	0.911	0.911	0.911	0.911	0.911	0.911	0.911
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered at Dist.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Odd columns correspond to binary specification, even columns to intensity specification
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.9: Coefficients: Price of Maize & Surrounding Treatment

	Log(Price)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.080***	0.078***						
	(0.028)	(0.028)						
Pop. Benefit		-0.140						
		(0.117)						
Upgrade			-0.029	-0.020			-0.027	-0.018
			(0.041)	(0.039)			(0.041)	(0.039)
Pop. Upgrade				-0.485***				-0.484**
				(0.182)				(0.184)
Build					0.020	0.019	0.012	0.011
					(0.021)	(0.022)	(0.022)	(0.021)
Pop. Build						0.008		-0.002
						(0.128)		(0.131)
Prod. Treatment	-0.093	-0.021	-0.162	-0.628	-0.121	-0.133	-0.158	-0.620
	(0.331)	(0.338)	(0.334)	(0.416)	(0.333)	(0.428)	(0.335)	(0.460)
Observations	935	935	935	935	935	935	935	935
Adj. R-squared	0.700	0.701	0.700	0.702	0.699	0.699	0.699	0.701
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered at Dist.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Odd columns correspond to binary specification, even columns to intensity specification
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.10: Coefficients: Price of Wheat & Surrounding Unconnected Treatment

	Log(Price)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.056***	0.057***						
	(0.016)	(0.016)						
Pop. Benefit		-0.044						
		(0.069)						
Upgrade			0.002	0.003			0.007	0.009
			(0.014)	(0.014)			(0.015)	(0.015)
Pop. Upgrade				-0.041				-0.050
				(0.067)				(0.071)
Build					0.033**	0.035**	0.035**	0.037**
					(0.014)	(0.015)	(0.015)	(0.015)
Pop. Build						-0.042		-0.050
						(0.096)		(0.099)
Uncon. Prod. Treatment	0.285*	0.299**	0.258*	0.205	0.249*	0.319	0.260*	0.279
	(0.148)	(0.149)	(0.150)	(0.155)	(0.147)	(0.204)	(0.145)	(0.197)
Observations	1,210	1,210	1,210	1,210	1,210	1,210	1,210	1,210
Adj. R-squared	0.891	0.891	0.890	0.890	0.891	0.891	0.891	0.890
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered at Dist.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Odd columns correspond to binary specification, even columns to intensity specification
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.11: Coefficients: Price of Paddy & Surrounding Unconnected Treatment

	Log(Price)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.014	0.011						
	(0.037)	(0.038)						
Pop. Benefit		-0.299**						
		(0.136)						
Upgrade			0.042*	0.047**			0.030	0.035
			(0.024)	(0.022)			(0.024)	(0.022)
Pop. Upgrade				-0.413**				-0.420***
				(0.154)				(0.154)
Build					-0.067**	-0.068**	-0.057**	-0.059**
					(0.025)	(0.025)	(0.026)	(0.027)
Pop. Build						0.098		0.148
						(0.284)		(0.304)
Uncon. Prod. Treatment	1.200	2.141**	1.270	1.207	1.442*	1.119	1.461*	0.913
	(0.875)	(0.845)	(0.857)	(0.831)	(0.837)	(1.199)	(0.830)	(1.199)
Observations	539	539	539	539	539	539	539	539
Adj. R-squared	0.817	0.819	0.818	0.821	0.819	0.818	0.819	0.822
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered at Dist.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Odd columns correspond to binary specification, even columns to intensity specification
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.12: Coefficients: Price of Maize & Surrounding Unconnected Treatment

	Log(Price)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.080***	0.078***						
	(0.028)	(0.028)						
Pop. Benefit		-0.140						
		(0.116)						
Upgrade			-0.030	-0.020			-0.028	-0.018
			(0.041)	(0.039)			(0.041)	(0.039)
Pop. Upgrade				-0.477**				-0.477**
				(0.183)				(0.186)
Build					0.020	0.020	0.012	0.012
					(0.021)	(0.022)	(0.022)	(0.021)
Pop. Build						0.011		-0.004
						(0.124)		(0.130)
Uncon. Prod. Treatment	-0.106	-0.031	-0.184	-0.649	-0.140	-0.157	-0.181	-0.638
	(0.348)	(0.354)	(0.355)	(0.440)	(0.350)	(0.438)	(0.356)	(0.479)
Observations	935	935	935	935	935	935	935	935
Adj. R-squared	0.700	0.701	0.700	0.702	0.699	0.699	0.699	0.701
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered at Dist.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Odd columns correspond to binary specification, even columns to intensity specification
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.13: Coefficients: Output Results

	Log(Output)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Wheat								
Benefit	0.062	0.061						
	(0.041)	(0.041)						
Pop. Benefit		-0.169						
		(0.202)						
Upgrade			0.041	0.012			0.056	0.013
			(0.044)	(0.042)			(0.045)	(0.040)
Pop. Upgrade				0.652***				0.504**
				(0.235)				(0.215)
Build					0.127***	0.149***	0.139***	0.161***
					(0.041)	(0.045)	(0.043)	(0.046)
Pop. Build						-0.500**		-0.346
						(0.223)		(0.222)
Observations	3,654	3,654	3,654	3,654	3,654	3,654	3,654	3,654
Adj. R-squared	0.955	0.955	0.955	0.955	0.955	0.955	0.955	0.955
Panel B: Rice								
Benefit	0.041	0.050						
	(0.066)	(0.068)						
Pop. Benefit		0.608***						
		(0.178)						
Upgrade			0.055	0.061			0.056	0.101
			(0.096)	(0.097)			(0.097)	(0.103)
Pop. Upgrade				-0.187				0.213
				(0.294)				(0.302)
Build					0.001	-0.024	0.012	-0.004
					(0.061)	(0.060)	(0.061)	(0.059)
Pop. Build						0.624***		0.761***
						(0.166)		(0.215)
Observations	4,272	4,272	4,272	4,272	4,272	4,272	4,272	4,272
Adj. R-squared	0.933	0.933	0.933	0.933	0.933	0.933	0.933	0.933
Panel C: Maize								
Benefit	0.013	-0.007						
	(0.117)	(0.117)						
Pop. Benefit		-1.052***						
		(0.362)						
Upgrade			-0.091	-0.073			-0.089	-0.123
			(0.084)	(0.093)			(0.086)	(0.096)
Pop. Upgrade				-0.482				-1.117
				(0.916)				(0.914)
Build					0.037	0.062	0.021	0.032
					(0.085)	(0.084)	(0.088)	(0.085)
Pop. Build						-0.762**		-1.105***
						(0.357)		(0.370)
Observations	3,570	3,570	3,570	3,570	3,570	3,570	3,570	3,570
Adj. R-squared	0.894	0.895	0.894	0.894	0.894	0.894	0.894	0.895
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered at Dist.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Odd columns correspond to binary specification, even columns to intensity specification

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table C.14: Coefficients: Output of Wheat by Connected/Unconnected

	Log(Oytput)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.004	-0.009						
	(0.050)	(0.044)						
Benefit * Uncon.	0.144***	0.164***						
	(0.050)	(0.048)						
Pop Benefit		0.047						
		(0.196)						
Pop Benefit * Uncon.		-0.109						
		(0.194)						
Upgrade			-0.007	-0.003			0.049	0.002
			(0.040)	(0.037)			(0.039)	(0.033)
Upgrade * Uncon.			0.150***	0.057			0.078**	0.022
			(0.041)	(0.047)			(0.038)	(0.045)
Pop Upgrade				0.321				0.115
				(0.220)				(0.216)
Pop. Upgrade * Uncon.				1.477***				1.662***
				(0.342)				(0.392)
Build					0.027	-0.019	0.048	-0.007
					(0.053)	(0.051)	(0.053)	(0.051)
Build * Uncon.					0.158***	0.242***	0.134**	0.180***
					(0.054)	(0.058)	(0.052)	(0.054)
Pop. Build						0.293		0.455
						(0.312)		(0.374)
Pop. Build * Uncon.						-0.725**		-0.938**
						(0.352)		(0.405)
Observations	3,656	3,656	3,656	3,656	3,656	3,656	3,656	3,656
Adj. R-squared	0.955	0.955	0.955	0.955	0.955	0.955	0.955	0.956
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered at Dist.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Odd columns correspond to binary specification, even columns to intensity specification
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.15: Coefficients: Output of Rice by Connected/Unconnected

	Log(Output)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	-0.077	-0.024						
	(0.077)	(0.075)						
Benefit * Uncon.	0.264***	0.171***						
	(0.062)	(0.056)						
Pop Benefit		0.279						
		(0.285)						
Pop Benefit * Uncon.		0.381						
		(0.250)						
Upgrade			-0.122**	-0.101*			-0.066	-0.013
			(0.052)	(0.054)			(0.054)	(0.058)
Upgrade * Uncon.			0.187***	0.135*			0.089	0.055
			(0.067)	(0.069)			(0.068)	(0.069)
Pop Upgrade				-0.265				0.207
				(0.340)				(0.342)
Pop. Upgrade * Uncon.				0.569				-0.133
				(0.552)				(0.554)
Build					-0.090	-0.073	-0.079	-0.064
					(0.077)	(0.080)	(0.078)	(0.081)
Build * Uncon.					0.278***	0.207***	0.231***	0.192***
					(0.064)	(0.065)	(0.062)	(0.065)
Pop. Build						0.758*		0.809*
						(0.406)		(0.420)
Pop. Build * Uncon.						-0.107		-0.115
						(0.390)		(0.391)
Observations	4,261	4,261	4,261	4,261	4,261	4,261	4,261	4,261
Adj. R-squared	0.941	0.941	0.941	0.941	0.941	0.941	0.941	0.941
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered at Dist.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Odd columns correspond to binary specification, even columns to intensity specification
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.16: Coefficients: Output of Maize by Connected/Unconnected

	Log(Output)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.170	0.143						
	(0.129)	(0.119)						
Benefit * Uncon.	-0.153	-0.125						
	(0.105)	(0.088)						
Pop Benefit		-1.362**						
		(0.690)						
Pop Benefit * Uncon.		0.315						
		(0.558)						
Upgrade			0.050	0.055			0.061	0.066
			(0.086)	(0.095)			(0.084)	(0.091)
Upgrade * Uncon.			-0.260**	-0.129			-0.265***	-0.159
			(0.101)	(0.118)			(0.100)	(0.114)
Pop Upgrade				-0.796				-1.089
				(0.920)				(0.992)
Pop. Upgrade * Uncon.				-2.078**				-1.889*
				(0.982)				(1.063)
Build					0.182*	0.233**	0.121	0.196*
					(0.107)	(0.107)	(0.107)	(0.106)
Build * Uncon.					-0.135	-0.176*	-0.014	-0.064
					(0.110)	(0.104)	(0.107)	(0.107)
Pop. Build						-2.346***		-2.704***
						(0.835)		(0.961)
Pop. Build * Uncon.						1.897**		2.213**
						(0.828)		(0.954)
Observations	3,562	3,562	3,562	3,562	3,562	3,562	3,562	3,562
Adj. R-squared	0.907	0.908	0.907	0.908	0.907	0.907	0.907	0.909
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered at Dist.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Odd columns correspond to binary specification, even columns to intensity specification
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.17: Coefficients: Output of Wheat by Connected/Unconnected

	Log(Oytput)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.004	-0.009						
	(0.050)	(0.044)						
Benefit * Uncon.	0.144***	0.164***						
	(0.050)	(0.048)						
Pop Benefit		0.047						
		(0.196)						
Pop Benefit * Uncon.		-0.109						
		(0.194)						
Upgrade			-0.007	-0.003			0.049	0.002
			(0.040)	(0.037)			(0.039)	(0.033)
Upgrade * Uncon.			0.150***	0.057			0.078**	0.022
			(0.041)	(0.047)			(0.038)	(0.045)
Pop Upgrade				0.321				0.115
				(0.220)				(0.216)
Pop. Upgrade * Uncon.				1.477***				1.662***
				(0.342)				(0.392)
Build					0.027	-0.019	0.048	-0.007
					(0.053)	(0.051)	(0.053)	(0.051)
Build * Uncon.					0.158***	0.242***	0.134**	0.180***
					(0.054)	(0.058)	(0.052)	(0.054)
Pop. Build						0.293		0.455
						(0.312)		(0.374)
Pop. Build * Uncon.						-0.725**		-0.938**
						(0.352)		(0.405)
Observations	3,656	3,656	3,656	3,656	3,656	3,656	3,656	3,656
Adj. R-squared	0.955	0.955	0.955	0.955	0.955	0.955	0.955	0.956
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered at Dist.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Odd columns correspond to binary specification, even columns to intensity specification
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.18: Coefficients: Output of Rice by Connected/Unconnected

	Log(Output)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	-0.077	-0.024						
	(0.077)	(0.075)						
Benefit * Uncon.	0.264***	0.171***						
	(0.062)	(0.056)						
Pop Benefit		0.279						
		(0.285)						
Pop Benefit * Uncon.		0.381						
		(0.250)						
Upgrade			-0.122**	-0.101*			-0.066	-0.013
			(0.052)	(0.054)			(0.054)	(0.058)
Upgrade * Uncon.			0.187***	0.135*			0.089	0.055
			(0.067)	(0.069)			(0.068)	(0.069)
Pop Upgrade				-0.265				0.207
				(0.340)				(0.342)
Pop. Upgrade * Uncon.				0.569				-0.133
				(0.552)				(0.554)
Build					-0.090	-0.073	-0.079	-0.064
					(0.077)	(0.080)	(0.078)	(0.081)
Build * Uncon.					0.278***	0.207***	0.231***	0.192***
					(0.064)	(0.065)	(0.062)	(0.065)
Pop. Build						0.758*		0.809*
						(0.406)		(0.420)
Pop. Build * Uncon.						-0.107		-0.115
						(0.390)		(0.391)
Observations	4,261	4,261	4,261	4,261	4,261	4,261	4,261	4,261
Adj. R-squared	0.941	0.941	0.941	0.941	0.941	0.941	0.941	0.941
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered at Dist.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Odd columns correspond to binary specification, even columns to intensity specification
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.19: Coefficients: Output of Maize by Connected/Unconnected

	Log(Output)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.170	0.143						
	(0.129)	(0.119)						
Benefit * Uncon.	-0.153	-0.125						
	(0.105)	(0.088)						
Pop Benefit		-1.362**						
		(0.690)						
Pop Benefit * Uncon.		0.315						
		(0.558)						
Upgrade			0.050	0.055			0.061	0.066
			(0.086)	(0.095)			(0.084)	(0.091)
Upgrade * Uncon.			-0.260**	-0.129			-0.265***	-0.159
			(0.101)	(0.118)			(0.100)	(0.114)
Pop Upgrade				-0.796				-1.089
				(0.920)				(0.992)
Pop. Upgrade * Uncon.				-2.078**				-1.889*
				(0.982)				(1.063)
Build					0.182*	0.233**	0.121	0.196*
					(0.107)	(0.107)	(0.107)	(0.106)
Build * Uncon.					-0.135	-0.176*	-0.014	-0.064
					(0.110)	(0.104)	(0.107)	(0.107)
Pop. Build						-2.346***		-2.704***
						(0.835)		(0.961)
Pop. Build * Uncon.						1.897**		2.213**
						(0.828)		(0.954)
Observations	3,562	3,562	3,562	3,562	3,562	3,562	3,562	3,562
Adj. R-squared	0.907	0.908	0.907	0.908	0.907	0.907	0.907	0.909
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered at Dist.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Odd columns correspond to binary specification, even columns to intensity specification
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.20: Coefficients: Output of Wheat with Maize Advantage

	Log(Price)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.191***	0.196***						
	(0.050)	(0.051)						
Benefit * Adv.	-0.227***	-0.241***						
	(0.052)	(0.053)						
Pop Benefit		-0.042						
		(0.219)						
Pop Benefit * Adv.		0.075						
		(0.240)						
Upgrade			0.112***	0.115***			0.089**	0.086**
			(0.039)	(0.038)			(0.041)	(0.039)
Upgrade * Adv.			-0.138***	-0.185***			-0.040	-0.093**
			(0.041)	(0.046)			(0.038)	(0.044)
Pop Upgrade				0.241				0.181
				(0.259)				(0.245)
Pop Upgrade * Adv.				0.489*				0.576**
				(0.282)				(0.288)
Build					0.258***	0.275***	0.263***	0.281***
					(0.050)	(0.052)	(0.053)	(0.054)
Build * Adv.					-0.249***	-0.267***	-0.235***	-0.256***
					(0.056)	(0.060)	(0.056)	(0.057)
Pop Build						-0.328		-0.154
						(0.264)		(0.273)
Pop Build * Adv.						0.063		0.026
						(0.390)		(0.399)
Observations	3,685	3,685	3,685	3,685	3,685	3,685	3,685	3,685
Adj. R-squared	0.956	0.956	0.956	0.956	0.956	0.956	0.956	0.956
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered at Dist.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Odd columns correspond to binary specification, even columns to intensity specification
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.21: Coefficients: Output of Rice with Maize Advantage

	Log(Output)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.115*	0.116*						
	(0.068)	(0.067)						
Benefit * Adv.	-0.236***	-0.205***						
	(0.065)	(0.059)						
Pop Benefit		0.775***						
		(0.182)						
Pop Benefit * Adv.		-0.197						
		(0.185)						
Upgrade			0.015	-0.009			0.011	0.035
			(0.048)	(0.050)			(0.050)	(0.053)
Upgrade * Adv.			-0.182**	-0.111			-0.159**	-0.100
			(0.072)	(0.073)			(0.073)	(0.073)
Pop Upgrade				0.050				0.433
				(0.268)				(0.288)
Pop Upgrade * Adv.				-0.705				-0.644
				(0.581)				(0.563)
Build					0.117*	0.086	0.068	0.049
					(0.067)	(0.066)	(0.066)	(0.064)
Build * Adv.					-0.131**	-0.115*	-0.053	-0.039
					(0.064)	(0.066)	(0.060)	(0.062)
Pop Build						0.814***		0.799***
						(0.189)		(0.203)
Pop Build * Adv.						-0.064		0.037
						(0.189)		(0.195)
Observations	4,280	4,280	4,280	4,280	4,280	4,280	4,280	4,280
Adj. R-squared	0.940	0.940	0.939	0.940	0.939	0.940	0.939	0.940
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered at Dist.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Odd columns correspond to binary specification, even columns to intensity specification
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.22: Coefficients: Output of Maize with Maize Advantage

	Log(Output)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	-0.017	0.061						
	(0.124)	(0.112)						
Benefit * Adv.	0.179*	-0.077						
	(0.105)	(0.083)						
Pop Benefit		-1.752***						
		(0.323)						
Pop Benefit * Adv.		1.412***						
		(0.354)						
Upgrade			-0.084	0.080			-0.031	0.066
			(0.085)	(0.090)			(0.082)	(0.086)
Upgrade * Adv.			0.105	-0.125			-0.011	-0.228**
			(0.102)	(0.110)			(0.103)	(0.104)
Pop Upgrade				-2.145**				-2.393***
				(0.882)				(0.897)
Pop Upgrade * Adv.				2.359**				1.678*
				(0.923)				(0.977)
Build					-0.064	0.032	-0.073	0.006
					(0.097)	(0.093)	(0.105)	(0.097)
Build * Adv.					0.272**	0.067	0.280**	0.087
					(0.110)	(0.101)	(0.113)	(0.101)
Pop Build						-1.396***		-1.713***
						(0.295)		(0.344)
Pop Build * Adv.						1.572***		1.472***
						(0.518)		(0.547)
Observations	3,642	3,642	3,642	3,642	3,642	3,642	3,642	3,642
Adj. R-squared	0.909	0.911	0.909	0.910	0.909	0.911	0.909	0.912
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered at Dist.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Odd columns correspond to binary specification, even columns to intensity specification
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.23: Coefficients: Rural Employment in Agriculture

	Log(Employed)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Cultivator								
Benefit	-0.071*	-0.071*						
	(0.038)	(0.041)						
Benefit * Rural	0.253***	0.254***						
	(0.041)	(0.045)						
Pop Benefit		0.402**						
		(0.155)						
Pop Benefit * Rural		-0.169						
		(0.112)						
Upgrade			-0.115***	-0.137***			-0.056*	-0.085***
			(0.033)	(0.034)			(0.029)	(0.031)
Upgrade * Rural			0.181***	0.214***			0.063*	0.130***
			(0.035)	(0.042)			(0.035)	(0.041)
Pop Upgrade				0.400**				0.728***
				(0.175)				(0.194)
Pop Upgrade * Rural				-0.397**				-0.876***
				(0.175)				(0.204)
Build					-0.161***	-0.168***	-0.146***	-0.167***
					(0.037)	(0.044)	(0.040)	(0.045)
Build *Rural					0.254***	0.248***	0.216***	0.249***
					(0.042)	(0.052)	(0.045)	(0.055)
Pop Build						0.252		0.345*
						(0.195)		(0.197)
Pop Build * Rural						-0.072		-0.163
						(0.226)		(0.233)
Observations	615	615	615	615	615	615	615	615
Adj. R-squared	0.944	0.944	0.939	0.939	0.943	0.943	0.943	0.943
Panel B: Agr. Labour								
Benefit	-0.110**	-0.059						
	(0.044)	(0.047)						
Benefit * Rural	0.158**	0.054						
	(0.067)	(0.066)						
Pop Benefit		1.149***						
		(0.390)						
Pop Benefit * Rural		0.045						
		(0.237)						
Upgrade			-0.125**	-0.135**			-0.065	-0.024
			(0.050)	(0.056)			(0.045)	(0.049)
Upgrade * Rural			0.162**	0.249***			0.096*	0.115*
			(0.066)	(0.076)			(0.055)	(0.065)
Pop Upgrade				-0.816**				0.292
				(0.363)				(0.450)
Pop Upgrade * Rural				-0.242				-0.683*
				(0.337)				(0.370)
Build					-0.050	-0.048	-0.022	-0.043
					(0.051)	(0.058)	(0.052)	(0.055)
Build *Rural					0.191***	-0.004	0.136**	0.011
					(0.072)	(0.086)	(0.062)	(0.082)
Pop Build						1.544***		1.551***
						(0.396)		(0.451)
Pop Build * Rural						0.671		0.602
						(0.432)		(0.451)
Observations	615	615	615	615	615	615	615	615
Adj. R-squared	0.932	0.936	0.932	0.934	0.933	0.943	0.933	0.943
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered at Dist.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Clustered standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table C.24: Coefficients: Price of Wheat & Unconnected, in Non-Rural Areas

	Log(Price)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	-0.114***	-0.012						
	(0.022)	(0.041)						
Benefit * Uncon.	0.237***	0.128***						
	(0.026)	(0.041)						
Pop Benefit		-0.841***						
		(0.268)						
Pop Benefit * Uncon.		0.763***						
		(0.214)						
Upgrade			-0.096***	-0.067**			-0.099***	-0.067**
			(0.020)	(0.025)			(0.020)	(0.025)
Upgrade * Uncon.			0.181***	0.154***			0.190***	0.163***
			(0.033)	(0.031)			(0.034)	(0.050)
Pop Upgrade				-0.739***				-0.860***
				(0.207)				(0.265)
Pop Upgrade * Uncon.				0.271				0.371
				(0.213)				(0.218)
Build					0.036	0.076	0.018	0.050
					(0.051)	(0.045)	(0.045)	(0.039)
Build * Uncon.					-0.044	-0.146**	-0.054	-0.128*
					(0.077)	(0.060)	(0.066)	(0.068)
Pop Build						-0.987		-1.552
						(3.481)		(2.956)
Pop Build * Uncon.						1.462		1.534
						(3.317)		(2.841)
Observations	176	176	176	176	176	176	176	176
Adj. R-squared	0.853	0.861	0.857	0.864	0.850	0.856	0.856	0.862
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered at Dist.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Odd columns correspond to binary specification, even columns to intensity specification
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.25: Coefficients: Price of Paddy & Unconnected in Non-Rural Areas

	Log(Price)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	-0.030	-0.010						
	(0.030)	(0.027)						
Benefit * Uncon.	0.000	-0.035						
	(0.039)	(0.039)						
Pop Benefit		-0.137						
		(0.267)						
Pop Benefit * Uncon.		0.336						
		(0.215)						
Upgrade			-0.059**	-0.056**			-0.054**	-0.032
			(0.025)	(0.023)			(0.025)	(0.026)
Upgrade * Uncon.			0.073**	0.032			0.065**	0.006
			(0.028)	(0.059)			(0.029)	(0.062)
Pop Upgrade				-0.179				-0.151
				(0.241)				(0.267)
Pop Upgrade * Uncon.				0.894				0.708
				(0.915)				(1.107)
Build					-0.047**	-0.014	-0.040	-0.014
					(0.023)	(0.023)	(0.027)	(0.024)
Build * Uncon.					0.073***	0.007	0.048*	0.007
					(0.026)	(0.025)	(0.027)	(0.026)
Pop Build						-3.573**		-3.153*
						(1.545)		(1.597)
Pop Build * Uncon.						3.721**		3.188*
						(1.529)		(1.593)
Observations	363	363	363	363	363	363	363	363
Adj. R-squared	0.919	0.921	0.921	0.922	0.920	0.923	0.922	0.922
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered at Dist.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Odd columns correspond to binary specification, even columns to intensity specification
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.26: Coefficients: Price of Maize & Unconnected in Non-Rural District

	Log(Price)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.090*	0.091						
	(0.050)	(0.052)						
Benefit * Uncon.	0.131***	0.113**						
	(0.042)	(0.050)						
Pop Benefit		0.044						
		(0.368)						
Pop Benefit * Uncon.		0.105						
		(0.249)						
Upgrade			0.003	0.002			0.007	0.012
			(0.043)	(0.044)			(0.042)	(0.042)
Upgrade * Uncon.			0.092	0.095			0.064	0.031
			(0.080)	(0.133)			(0.065)	(0.119)
Pop Upgrade				-0.093				0.065
				(0.328)				(0.373)
Pop Upgrade * Uncon.				-0.113				0.434
				(1.010)				(0.716)
Build					0.019	0.028	0.029	0.034
					(0.054)	(0.055)	(0.052)	(0.051)
Build * Uncon.					0.113*	0.082	0.079	0.083
					(0.055)	(0.062)	(0.060)	(0.058)
Pop Build						-1.149		-0.752
						(2.095)		(1.472)
Pop Build * Uncon.						1.222		0.751
						(2.049)		(1.459)
Observations	154	154	154	154	154	154	154	154
Adj. R-squared	0.905	0.904	0.898	0.896	0.899	0.898	0.899	0.896
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered at Dist.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Odd columns correspond to binary specification, even columns to intensity specification
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.27: Coefficients: Output of Wheat with Maize Advantage in Rural Area

	Log(Price)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.150*	0.117						
	(0.082)	(0.081)						
Benefit * Adv.	-0.331***	-0.285***						
	(0.096)	(0.095)						
Pop Benefit		0.904**						
		(0.359)						
Pop Benefit * Adv.		0.005						
		(0.342)						
Upgrade			0.023	0.067			0.027	0.065
			(0.051)	(0.056)			(0.051)	(0.056)
Upgrade * Adv.			-0.247***	-0.342***			-0.127*	-0.165*
			(0.079)	(0.092)			(0.074)	(0.091)
Pop Upgrade				-0.544				-0.169
				(0.520)				(0.503)
Pop Upgrade * Adv.				0.787				1.112**
				(0.505)				(0.549)
Build					0.294***	0.208**	0.262***	0.217**
					(0.090)	(0.080)	(0.096)	(0.084)
Build * Adv.					-0.308***	-0.167*	-0.242**	-0.159*
					(0.097)	(0.090)	(0.098)	(0.088)
Pop Build						1.178***		1.349***
						(0.404)		(0.460)
Pop Build * Adv.						-0.821		-0.910
						(0.999)		(0.990)
Observations	1,119	1,119	1,119	1,119	1,119	1,119	1,119	1,119
Adj. R-squared	0.926	0.927	0.926	0.926	0.927	0.928	0.927	0.928
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered at Dist.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Odd columns correspond to binary specification, even columns to intensity specification
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.28: Coefficients: Output of Rice with Maize Advantage in Rural Area

	Log(Output)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.249	0.147						
	(0.185)	(0.175)						
Benefit * Adv.	-0.558***	-0.478***						
	(0.171)	(0.164)						
Pop Benefit		1.986***						
		(0.625)						
Pop Benefit * Adv.		0.130						
		(0.572)						
Upgrade			0.036	0.027			0.024	0.002
			(0.107)	(0.114)			(0.108)	(0.112)
Upgrade * Adv.			-0.342**	-0.381**			-0.288*	-0.208
			(0.159)	(0.184)			(0.159)	(0.189)
Pop Upgrade				0.454				1.300
				(0.694)				(0.786)
Pop Upgrade * Adv.				0.230				0.528
				(1.050)				(0.912)
Build					0.137	-0.016	0.044	-0.053
					(0.146)	(0.143)	(0.145)	(0.143)
Build * Adv.					-0.331*	-0.165	-0.179	-0.097
					(0.197)	(0.206)	(0.198)	(0.198)
Pop Build						2.086***		2.540***
						(0.711)		(0.803)
Pop Build * Adv.						-0.428		-0.205
						(0.788)		(0.881)
Observations	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095
Adj. R-squared	0.945	0.947	0.945	0.945	0.945	0.946	0.945	0.946
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered at Dist.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Odd columns correspond to binary specification, even columns to intensity specification
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.29: Coefficients: Output of Maize with Maize Advantage in Rural Area

	Log(Output)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.192	0.309*						
	(0.169)	(0.160)						
Benefit * Adv.	0.090	-0.241**						
	(0.131)	(0.121)						
Pop Benefit		-1.564***						
		(0.527)						
Pop Benefit * Adv.		1.862***						
		(0.563)						
Upgrade			-0.120	-0.033			-0.109	-0.017
			(0.098)	(0.103)			(0.101)	(0.098)
Upgrade * Adv.			0.261**	0.048			0.232*	-0.048
			(0.129)	(0.130)			(0.131)	(0.125)
Pop Upgrade				-0.431				-0.521
				(0.864)				(0.866)
Pop Upgrade * Adv.				2.036*				1.315
				(1.178)				(1.224)
Build					-0.093	0.069	-0.027	0.095
					(0.126)	(0.132)	(0.131)	(0.130)
Build * Adv.					0.197	-0.099	0.076	-0.137
					(0.130)	(0.150)	(0.127)	(0.140)
Pop Build						-2.353***		-2.140***
						(0.616)		(0.727)
Pop Build * Adv.						2.382***		2.141***
						(0.701)		(0.769)
Observations	1,618	1,618	1,618	1,618	1,618	1,618	1,618	1,618
Adj. R-squared	0.904	0.906	0.904	0.905	0.904	0.906	0.904	0.906
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered at Dist.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Odd columns correspond to binary specification, even columns to intensity specification
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.30: Coefficients: Price of Wheat & Unconnected, Redefined

	Log(Price)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	-0.191	-0.088						
	(0.150)	(0.138)						
Benefit * Adv.	0.226	-0.176						
	(0.199)	(0.178)						
Pop Benefit		-0.864*						
		(0.492)						
Pop Benefit * Adv.		2.349***						
		(0.719)						
Upgrade			-0.096	-0.025			-0.088	-0.019
			(0.084)	(0.099)			(0.086)	(0.097)
Upgrade * Adv.			0.342**	0.010			0.171	-0.149
			(0.163)	(0.175)			(0.158)	(0.168)
Pop Upgrade				-0.015				-0.060
				(0.978)				(0.923)
Pop Upgrade * Adv.				2.681*				1.913
				(1.395)				(1.540)
Build					-0.391***	-0.281**	-0.352**	-0.264*
					(0.141)	(0.135)	(0.149)	(0.138)
Build * Adv.					0.390*	0.137	0.305	0.096
					(0.211)	(0.237)	(0.197)	(0.207)
Pop Build						-1.576**		-1.157
						(0.628)		(0.762)
Pop Build * Adv.						1.893		1.598
						(1.261)		(1.340)
Observations	1,034	1,034	1,034	1,034	1,034	1,034	1,034	1,034
Adj. R-squared	0.912	0.914	0.912	0.914	0.913	0.914	0.913	0.914
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered at Dist.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Odd columns correspond to binary specification, even columns to intensity specification
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.31: Coefficients: Price of Paddy & Unconnected, Redefined

	Log(Price)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	-0.010	0.009						
	(0.028)	(0.029)						
Benefit * Uncon.	-0.060*	-0.076**						
	(0.034)	(0.035)						
Pop Benefit		-0.041						
		(0.089)						
Pop Benefit * Unco		0.180**						
		(0.075)						
Upgrade			-0.062***	-0.055***			-0.069***	-0.045***
			(0.015)	(0.015)			(0.015)	(0.016)
Upgrade * Uncon.			0.009	0.003			0.013	-0.001
			(0.017)	(0.022)			(0.017)	(0.022)
Pop Upgrade				-0.107				-0.030
				(0.092)				(0.109)
Pop. Upgrade * Uncon.				0.072				0.050
				(0.097)				(0.106)
Build					-0.021	-0.006	-0.016	-0.008
					(0.016)	(0.018)	(0.027)	(0.024)
Build * Uncon.					-0.020	-0.041*	-0.038	-0.047*
					(0.020)	(0.022)	(0.031)	(0.028)
Pop. Build						-1.357**		-0.935*
						(0.552)		(0.549)
Pop. Build * Uncon.						1.545***		1.067*
						(0.549)		(0.543)
Observations	1,001	1,001	1,001	1,001	1,001	1,001	1,001	1,001
Adj. R-squared	0.909	0.910	0.911	0.910	0.909	0.911	0.911	0.912
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered at Dist.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Odd columns correspond to binary specification, even columns to intensity specification
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.32: Coefficients: Price of Maize & Unconnected, Redefined

	Log(Price)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.070**	0.071**						
	(0.033)	(0.032)						
Benefit * Uncon.	0.026	0.026						
	(0.054)	(0.055)						
Pop Benefit		-0.255						
		(0.201)						
Pop Benefit * Unco		0.104						
		(0.184)						
Upgrade			0.039	0.040			0.033	0.033
			(0.032)	(0.026)			(0.033)	(0.026)
Upgrade * Uncon.			-0.014	-0.000			-0.007	0.008
			(0.039)	(0.042)			(0.040)	(0.043)
Pop Upgrade				-0.243				-0.311
				(0.201)				(0.224)
Pop. Upgrade * Uncon.				-0.125				-0.085
				(0.256)				(0.255)
Build					0.049	0.042	0.042	0.034
					(0.042)	(0.038)	(0.041)	(0.035)
Build * Uncon.					-0.049	-0.040	-0.033	-0.017
					(0.051)	(0.044)	(0.049)	(0.042)
Pop. Build						1.157		0.636
						(2.417)		(1.988)
Pop. Build * Uncon.						-1.163		-0.704
						(2.422)		(1.998)
Observations	935	935	935	935	935	935	935	935
Adj. R-squared	0.700	0.700	0.700	0.701	0.699	0.699	0.699	0.700
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered at Dist.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Odd columns correspond to binary specification, even columns to intensity specification
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.33: Coefficients: Output of Wheat by Treatment Level Redefined

	Log(Price)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.076**	0.086**						
	(0.038)	(0.040)						
Benefit * Heavy	0.041	0.775***						
	(0.055)	(0.299)						
Pop Benefit		0.314						
		(0.271)						
Pop Benefit * Heavy		-1.621**						
		(0.659)						
Upgrade			0.076**	0.005			0.099**	0.033
			(0.038)	(0.034)			(0.040)	(0.036)
Upgrade * Heavy			-0.055	-0.060			-0.059	-0.061
			(0.039)	(0.039)			(0.039)	(0.040)
Pop Upgrade				2.192***				2.063***
				(0.424)				(0.396)
Pop Upgrade * Heavy				-1.784***				-1.555***
				(0.330)				(0.317)
Build					0.118**	0.066	0.132***	0.065
					(0.047)	(0.042)	(0.049)	(0.044)
Build * Heavy					0.073	0.218***	0.086	0.205***
					(0.065)	(0.065)	(0.063)	(0.065)
Pop Build						0.628		0.868**
						(0.387)		(0.399)
Pop Build * Heavy						-1.021**		-1.041**
						(0.417)		(0.410)
Observations	3,657	3,657	3,657	3,657	3,657	3,657	3,657	3,657
Adj. R-squared	0.957	0.957	0.957	0.958	0.957	0.957	0.957	0.958
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered at Dist.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Odd columns correspond to binary specification, even columns to intensity specification
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.34: Coefficients: Output of Rice, by Treatment Level Redefined

	Log(Output)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.036	0.041						
	(0.063)	(0.065)						
Benefit * Heavy	0.180***	0.280						
	(0.052)	(0.241)						
Pop Benefit		0.706***						
		(0.270)						
Pop Benefit * Heavy		-0.540						
		(0.508)						
Upgrade			-0.076	-0.071			-0.065	-0.021
			(0.056)	(0.060)			(0.057)	(0.062)
Upgrade * Heavy			0.055	0.060			0.060	0.064
			(0.067)	(0.069)			(0.067)	(0.070)
Pop Upgrade				-0.218				0.354
				(0.557)				(0.573)
Pop Upgrade * Heavy				-0.041				-0.136
				(0.580)				(0.576)
Build					0.024	-0.013	0.020	-0.008
					(0.065)	(0.066)	(0.066)	(0.067)
Build * Heavy					0.148**	0.105*	0.142**	0.103*
					(0.059)	(0.059)	(0.060)	(0.059)
Pop Build						1.646***		1.749***
						(0.454)		(0.477)
Pop Build * Heavy						-1.004**		-1.030**
						(0.407)		(0.413)
Observations	4,246	4,246	4,246	4,246	4,246	4,246	4,246	4,246
Adj. R-squared	0.940	0.941	0.940	0.940	0.940	0.941	0.940	0.941
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered at Dist.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Odd columns correspond to binary specification, even columns to intensity specification
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.35: Coefficients: Output of Maize, by Treatment Level Redefined

	Log(Output)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.029	0.026						
	(0.104)	(0.103)						
Benefit * Heavy	-0.411***	-0.436						
	(0.087)	(0.410)						
Pop Benefit		-0.467						
		(0.498)						
Pop Benefit * Heavy		0.268						
		(0.947)						
Upgrade			-0.129	-0.107			-0.127	-0.134*
			(0.084)	(0.077)			(0.084)	(0.077)
Upgrade * Heavy			0.130	0.135			0.133	0.115
			(0.100)	(0.099)			(0.099)	(0.099)
Pop Upgrade				-0.404				-1.211
				(1.010)				(0.999)
Pop Upgrade * Heavy				-0.634				-0.403
				(0.920)				(0.918)
Build					0.076	0.063	0.075	0.052
					(0.097)	(0.090)	(0.098)	(0.089)
Build * Heavy					-0.027	0.092	-0.031	0.101
					(0.114)	(0.090)	(0.112)	(0.092)
Pop Build						-0.839		-1.449
						(0.957)		(0.958)
Pop Build * Heavy						0.099		0.344
						(0.898)		(0.899)
Observations	3,593	3,593	3,593	3,593	3,593	3,593	3,593	3,593
Adj. R-squared	0.906	0.906	0.905	0.905	0.905	0.905	0.905	0.906 heightDistrict FE
Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered at Dist.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Odd columns correspond to binary specification, even columns to intensity specification
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.36: Coefficients: Output of Wheat with Maize Advantage Redefined

	Log(Price)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.111***	0.108**						
	(0.043)	(0.043)						
Benefit * Adv.	-0.296***	-0.229***						
	(0.061)	(0.062)						
Pop Benefit		0.056						
		(0.217)						
Pop Benefit * Adv..		-0.317						
		(0.329)						
Upgrade			0.079**	0.060*			0.085**	0.061**
			(0.035)	(0.032)			(0.036)	(0.031)
Upgrade * Adv.			-0.219***	-0.213***			-0.115**	-0.112*
			(0.052)	(0.060)			(0.048)	(0.057)
Pop Upgrade				0.395*				0.364*
				(0.222)				(0.208)
Pop Upgrade * Adv.				-0.023				0.256
				(0.335)				(0.412)
Build					0.181***	0.182***	0.186***	0.191***
					(0.046)	(0.048)	(0.048)	(0.050)
Build * Adv.					-0.272***	-0.217***	-0.221***	-0.192***
					(0.068)	(0.073)	(0.073)	(0.073)
Pop Build						-0.192		-0.044
						(0.250)		(0.255)
Pop Build * Adv.						-0.367		-0.361
						(0.473)		(0.485)
Observations	3,627	3,627	3,627	3,627	3,627	3,627	3,627	3,627
Adj. R-squared	0.954	0.954	0.954	0.954	0.954	0.954	0.954	0.954
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered at Dist.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Odd columns correspond to binary specification, even columns to intensity specification
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.37: Coefficients: Output of Rice with Maize Advantage Redefined

	Log(Output)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.036	0.053						
	(0.066)	(0.066)						
Benefit * Adv.	-0.039	-0.088						
	(0.072)	(0.072)						
Pop Benefit		0.657***						
		(0.166)						
Pop Benefit * Adv..		0.257						
		(0.179)						
Upgrade			-0.060	-0.044			-0.054	0.005
			(0.044)	(0.045)			(0.046)	(0.048)
Upgrade * Adv.			-0.005	-0.043			-0.016	-0.043
			(0.074)	(0.082)			(0.075)	(0.086)
Pop Upgrade				-0.317				0.104
				(0.330)				(0.332)
Pop Upgrade * Adv.				0.398				0.368
				(0.613)				(0.583)
Build					0.059	0.034	0.046	0.035
					(0.063)	(0.062)	(0.067)	(0.065)
Build * Adv.					0.018	0.006	0.030	0.004
					(0.079)	(0.085)	(0.079)	(0.080)
Pop Build						0.782***		0.820***
						(0.163)		(0.179)
Pop Build * Adv.						0.109		0.085
						(0.211)		(0.220)
Observations	4,250	4,250	4,250	4,250	4,250	4,250	4,250	4,250
Adj. R-squared	0.938	0.939	0.938	0.938	0.938	0.939	0.938	0.939
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered at Dist.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Odd columns correspond to binary specification, even columns to intensity specification
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.38: Coefficients: Output of Maize with Maize Advantage Redefined

	Log(Output)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	-0.019	-0.008						
	(0.109)	(0.106)						
Benefit * Adv.	0.494***	0.101						
	(0.170)	(0.129)						
Pop Benefit		-1.572***						
		(0.313)						
Pop Benefit * Adv..		2.173***						
		(0.612)						
Upgrade			-0.143**	-0.027			-0.123*	-0.069
			(0.071)	(0.069)			(0.071)	(0.069)
Upgrade * Adv.			0.584***	0.243			0.427***	0.125
			(0.144)	(0.166)			(0.116)	(0.130)
Pop Upgrade				-1.665**				-2.180***
				(0.723)				(0.730)
Pop Upgrade * Adv.				3.695***				3.099**
				(1.133)				(1.248)
Build					-0.042	0.004	0.001	0.036
					(0.086)	(0.086)	(0.090)	(0.085)
Build * Adv.					0.566***	0.342**	0.339	0.111
					(0.218)	(0.170)	(0.217)	(0.183)
Pop Build						-1.025***		-1.371***
						(0.281)		(0.295)
Pop Build * Adv.						1.788*		1.377
						(0.936)		(1.004)
Observations	3,518	3,518	3,518	3,518	3,518	3,518	3,518	3,518
Adj. R-squared	0.909	0.911	0.909	0.910	0.909	0.910	0.909	0.912
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered at Dist.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Odd columns correspond to binary specification, even columns to intensity specification

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table C.39: Coefficients: Rural Employment in Agriculture, Rural Redefined

	Log(Employed)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Cultivator								
Benefit	-0.174***	-0.170***						
	(0.053)	(0.060)						
Benefit * Rural	0.321***	0.315***						
	(0.057)	(0.065)						
Pop Benefit		0.383*						
		(0.207)						
Pop Benefit * Rural		-0.144						
		(0.163)						
Upgrade			-0.215***	-0.195***			-0.092***	-0.092**
			(0.041)	(0.044)			(0.035)	(0.043)
Upgrade * Rural			0.249***	0.224***			0.088**	0.097**
			(0.046)	(0.049)			(0.038)	(0.044)
Pop Upgrade				-0.209				0.532
				(0.454)				(0.511)
Pop. Upgrade * Rural				0.284				-0.427
				(0.440)				(0.504)
Build					-0.245***	-0.281***	-0.205***	-0.247***
					(0.054)	(0.068)	(0.058)	(0.071)
Build * Rural					0.294***	0.322***	0.238***	0.283***
					(0.055)	(0.071)	(0.058)	(0.074)
Pop. Build						0.735**		0.790**
						(0.301)		(0.326)
Pop. Build * Rural						-0.532*		-0.587*
						(0.314)		(0.337)
Observations	615	615	615	615	615	615	615	615
Adj. R-squared	0.945	0.945	0.941	0.941	0.943	0.944	0.944	0.944
Panel B: Agr. Labour								
Benefit	-0.203***	-0.166**						
	(0.073)	(0.077)						
Benefit * Rural	0.243**	0.186*						
	(0.095)	(0.097)						
Pop Benefit		1.541***						
		(0.419)						
Pop Benefit * Rural		-0.423						
		(0.277)						
Upgrade			-0.231***	-0.350***			-0.089	-0.113
			(0.084)	(0.111)			(0.061)	(0.078)
Upgrade * Rural			0.246**	0.435***			0.104	0.179*
			(0.098)	(0.126)			(0.070)	(0.093)
Pop Upgrade				0.221				1.743**
				(0.791)				(0.842)
Pop. Upgrade * Rural				-1.409*				-2.245***
				(0.778)				(0.792)
Build					-0.169**	-0.183*	-0.116*	-0.220***
					(0.080)	(0.097)	(0.059)	(0.081)
Build * Rural					0.300***	0.190*	0.236***	0.243**
					(0.093)	(0.113)	(0.066)	(0.097)
Pop. Build						1.745***		1.737***
						(0.522)		(0.563)
Pop. Build * Rural						0.213		0.131
						(0.535)		(0.562)
Observations	615	615	615	615	615	615	615	615
Adj. R-squared	0.933	0.937	0.933	0.936	0.935	0.944	0.934	0.945
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered at Dist.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Clustered standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.40: Coefficients: Price of Wheat & Unconnected, without Procuring States

	Log(Price)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.007	0.032						
	(0.023)	(0.022)						
Benefit * Uncon.	0.096***	0.061*						
	(0.031)	(0.033)						
Pop Benefit		-0.368**						
		(0.157)						
Pop Benefit * Uncon.		0.350***						
		(0.117)						
Upgrade			-0.042	-0.020			-0.035	-0.018
			(0.026)	(0.024)			(0.026)	(0.025)
Upgrade * Uncon.			0.124***	0.085**			0.118***	0.085**
			(0.033)	(0.034)			(0.033)	(0.035)
Pop Upgrade				-0.214*				-0.307**
				(0.126)				(0.150)
Pop. Upgrade * Uncon.				0.408***				0.471***
				(0.134)				(0.154)
Build					-0.012	-0.008	0.000	0.013
					(0.020)	(0.020)	(0.020)	(0.019)
Build * Uncon.					0.048**	0.043*	0.035*	0.016
					(0.020)	(0.022)	(0.021)	(0.023)
Pop. Build						-0.458		-0.027
						(0.393)		(0.513)
Pop. Build * Uncon.						0.449		-0.066
						(0.368)		(0.487)
Observations	979	979	979	979	979	979	979	979
Adj. R-squared	0.883	0.885	0.886	0.887	0.883	0.883	0.886	0.887
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered at Dist.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Odd columns correspond to binary specification, even columns to intensity specification
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.41: Coefficients: Price of Paddy & Unconnected, without Procuring States

	Log(Price)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	-0.077***	-0.043**						
	(0.022)	(0.021)						
Benefit * Uncon.	0.029	-0.019						
	(0.032)	(0.033)						
Pop Benefit		-0.555***						
		(0.195)						
Pop Benefit * Uncon.		0.667***						
		(0.173)						
Upgrade			-0.113***	-0.100***			-0.115***	-0.093***
			(0.016)	(0.019)			(0.017)	(0.018)
Upgrade * Uncon.			0.127***	0.092***			0.125***	0.081***
			(0.026)	(0.031)			(0.024)	(0.028)
Pop Upgrade				-0.244				-0.167
				(0.258)				(0.281)
Pop. Upgrade * Uncon.				0.613				0.506
				(0.379)				(0.387)
Build					-0.070***	-0.043**	-0.047*	-0.031
					(0.021)	(0.018)	(0.025)	(0.022)
Build * Uncon.					0.054**	0.009	0.005	-0.021
					(0.023)	(0.022)	(0.027)	(0.026)
Pop. Build						-2.021***		-1.572***
						(0.561)		(0.326)
Pop. Build * Uncon.						2.175***		1.604***
						(0.555)		(0.322)
Observations	825	825	825	825	825	825	825	825
Adj. R-squared	0.906	0.909	0.911	0.912	0.905	0.909	0.912	0.913
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered at Dist.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Odd columns correspond to binary specification, even columns to intensity specification
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.42: Coefficients: Price of Maize & Unconnected, without Procuring States

	Log(Price)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.067	0.065*						
	(0.041)	(0.037)						
Benefit * Uncon.	0.034	0.034						
	(0.063)	(0.063)						
Pop Benefit		-0.231						
		(0.146)						
Pop Benefit * Uncon.		0.095						
		(0.150)						
Upgrade			0.024	0.021			0.027	0.018
			(0.032)	(0.025)			(0.031)	(0.025)
Upgrade * Uncon.			0.017	0.040			0.016	0.044
			(0.055)	(0.062)			(0.054)	(0.063)
Pop Upgrade				-0.247*				-0.303*
				(0.131)				(0.164)
Pop. Upgrade * Uncon.				-0.329				-0.289
				(0.450)				(0.457)
Build					0.009	0.006	0.012	0.013
					(0.031)	(0.031)	(0.029)	(0.026)
Build * Uncon.					0.008	0.012	0.011	0.020
					(0.045)	(0.042)	(0.041)	(0.033)
Pop. Build						0.133		0.327
						(0.584)		(0.470)
Pop. Build * Uncon.						-0.148		-0.367
						(0.586)		(0.499)
Observations	836	836	836	836	836	836	836	836
Adj. R-squared	0.691	0.690	0.690	0.692	0.690	0.689	0.689	0.690
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered at Dist.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Odd columns correspond to binary specification, even columns to intensity specification
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.43: Coefficients: Output of Wheat with Maize Advantage & without Procuring States

	Log(Price)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.230***	0.229***						
	(0.066)	(0.066)						
Benefit * Adv.	-0.283***	-0.280***						
	(0.063)	(0.063)						
Pop Benefit		0.044						
		(0.240)						
Pop Benefit * Adv.		-0.011						
		(0.266)						
Upgrade			0.139***	0.092**			0.102**	0.056
			(0.046)	(0.046)			(0.047)	(0.045)
Upgrade * Adv.			-0.176***	-0.172***			-0.058	-0.070
			(0.048)	(0.054)			(0.045)	(0.052)
Pop Upgrade				1.100***				0.967***
				(0.379)				(0.340)
Pop Upgrade * Adv.				-0.080				0.082
				(0.393)				(0.401)
Build					0.300***	0.313***	0.299***	0.306***
					(0.061)	(0.063)	(0.065)	(0.067)
Build * Adv.					-0.268***	-0.288***	-0.247***	-0.269***
					(0.060)	(0.064)	(0.061)	(0.062)
Pop Build						-0.379		-0.174
						(0.272)		(0.279)
Pop Build * Adv.						0.058		0.080
						(0.391)		(0.406)
Observations	3,202	3,202	3,202	3,202	3,202	3,202	3,202	3,202
Adj. R-squared	0.949	0.949	0.949	0.949	0.949	0.949	0.949	0.949
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered at Dist.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Odd columns correspond to binary specification, even columns to intensity specification
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.44: Coefficients: Output of Rice with Advantage & without Procuring States

	Log(Output)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.097	0.099						
	(0.075)	(0.074)						
Benefit * Adv.	-0.250***	-0.208***						
	(0.071)	(0.063)						
Pop Benefit		0.830***						
		(0.194)						
Pop Benefit * Adv.		-0.276						
		(0.196)						
Upgrade			-0.015	-0.051			-0.015	0.011
			(0.054)	(0.056)			(0.057)	(0.059)
Upgrade * Adv.			-0.180**	-0.040			-0.155*	-0.043
			(0.081)	(0.078)			(0.082)	(0.079)
Pop Upgrade				-0.285				0.086
				(0.424)				(0.438)
Pop Upgrade * Adv.				-1.457**				-1.321*
				(0.706)				(0.677)
Build					0.182**	0.153**	0.128*	0.104
					(0.075)	(0.073)	(0.074)	(0.071)
Build * Adv.					-0.122*	-0.096	-0.045	-0.012
					(0.066)	(0.069)	(0.063)	(0.065)
Pop Build						1.032***		0.844***
						(0.206)		(0.207)
Pop Build * Adv.						-0.104		0.056
						(0.198)		(0.206)
Observations	3,862	3,862	3,862	3,862	3,862	3,862	3,862	3,862
Adj. R-squared	0.939	0.939	0.939	0.939	0.939	0.939	0.939	0.940
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered at Dist.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Odd columns correspond to binary specification, even columns to intensity specification
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.45: Coefficients: Output of Maize with Maize Advantage & without Procuring States

	Log(Output)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	-0.016	0.066						
	(0.133)	(0.120)						
Benefit * Adv.	0.195*	-0.067						
	(0.112)	(0.089)						
Pop Benefit		-1.755***						
		(0.334)						
Pop Benefit * Adv.		1.412***						
		(0.365)						
Upgrade			-0.111	0.081			-0.064	0.053
			(0.092)	(0.098)			(0.090)	(0.095)
Upgrade * Adv.			0.124	-0.153			0.020	-0.230**
			(0.108)	(0.116)			(0.110)	(0.111)
Pop Upgrade				-2.511**				-2.675**
				(1.023)				(1.052)
Pop Upgrade * Adv.				3.009***				2.229*
				(1.064)				(1.147)
Build					-0.033	0.059	-0.036	0.046
					(0.103)	(0.097)	(0.112)	(0.103)
Build * Adv.					0.249**	0.046	0.243**	0.047
					(0.114)	(0.103)	(0.119)	(0.106)
Pop Build						-1.424***		-1.650***
						(0.307)		(0.353)
Pop Build * Adv.						1.474***		1.307**
						(0.519)		(0.558)
Observations	3,387	3,387	3,387	3,387	3,387	3,387	3,387	3,387
Adj. R-squared	0.910	0.912	0.910	0.911	0.910	0.911	0.910	0.912
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered at Dist.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Odd columns correspond to binary specification, even columns to intensity specification
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.46: Coefficients: Output of Maize by North without Procuring States

	Log(Output)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.034	0.068						
	(0.118)	(0.113)						
Benefit * North	0.019	-0.130						
	(0.123)	(0.096)						
Pop Benefit		-1.504***						
		(0.371)						
Pop Benefit * North		0.800**						
		(0.380)						
Upgrade			-0.035	-0.034			0.011	-0.042
			(0.078)	(0.081)			(0.074)	(0.078)
Upgrade * North			-0.130	0.035			-0.236**	-0.097
			(0.099)	(0.112)			(0.097)	(0.101)
Pop Upgrade				-0.587				-0.828
				(0.929)				(0.985)
Pop. Upgrade * North				-1.470*				-2.011**
				(0.883)				(0.956)
Build					0.007	0.117	-0.037	0.056
					(0.089)	(0.088)	(0.093)	(0.091)
Build * North					0.176	-0.044	0.279*	0.071
					(0.145)	(0.127)	(0.148)	(0.127)
Pop. Build						-1.564***		-2.085***
						(0.357)		(0.403)
Pop. Build * North						1.774***		1.933***
						(0.508)		(0.533)
Observations	3,565	3,565	3,565	3,565	3,565	3,565	3,565	3,565
Adj. R-squared	0.907	0.909	0.907	0.908	0.907	0.909	0.908	0.910
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered at Dist.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Odd columns correspond to binary specification, even columns to intensity specification
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.47: Coefficients: Price of Wheat & Unconnected, without GQ Districts

	Log(Price)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.017	0.044***						
	(0.016)	(0.014)						
Benefit * Uncon.	0.100***	0.059*						
	(0.028)	(0.030)						
Pop. Benefit		-0.174*						
		(0.093)						
Pop. Benefit * Uncon.		0.208***						
		(0.067)						
Upgrade			-0.041***	-0.024**			-0.036**	-0.023
			(0.013)	(0.012)			(0.014)	(0.014)
Upgrade * Uncon.			0.127***	0.094***			0.121***	0.094***
			(0.025)	(0.028)			(0.025)	(0.029)
Pop. Upgrade				-0.088				-0.111
				(0.071)				(0.087)
Pop. Upgrade * Uncon.				0.292**				0.301**
				(0.120)				(0.132)
Build					-0.020	-0.020	-0.012	-0.012
					(0.018)	(0.016)	(0.019)	(0.017)
Build * Uncon.					0.065***	0.061***	0.044**	0.040*
					(0.019)	(0.021)	(0.020)	(0.021)
Pop. Build						0.350*		0.323*
						(0.209)		(0.170)
Pop. Build * Uncon.						-0.296		-0.380**
						(0.210)		(0.157)
Observations	1,089	1,089	1,089	1,089	1,089	1,089	1,089	1,089
Adj. R-squared	0.897	0.899	0.900	0.901	0.897	0.897	0.900	0.901
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered at Dist.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Odd columns correspond to binary specification, even columns to intensity specification
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.48: Coefficients: Price of Paddy & Unconnected, without GQ Districts

	Log(Price)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	-0.059**	-0.036*						
	(0.022)	(0.021)						
Benefit * Uncon.	0.043*	0.007						
	(0.025)	(0.027)						
Pop. Benefit		0.001						
		(0.069)						
Pop. Benefit * Uncon.		0.201***						
		(0.066)						
Upgrade			-0.072***	-0.066***			-0.073***	-0.051***
			(0.016)	(0.017)			(0.016)	(0.015)
Upgrade * Uncon.			0.097***	0.063**			0.096***	0.048**
			(0.027)	(0.029)			(0.026)	(0.024)
Pop. Upgrade				0.003				0.038
				(0.066)				(0.069)
Pop. Upgrade * Uncon.				0.544*				0.448
				(0.306)				(0.280)
Build					-0.067***	-0.044**	-0.048**	-0.036*
					(0.021)	(0.018)	(0.022)	(0.020)
Build * Uncon.					0.059**	0.010	0.011	-0.014
					(0.023)	(0.021)	(0.025)	(0.025)
Pop. Build						-1.598***		-1.271***
						(0.356)		(0.379)
Pop. Build * Uncon.						1.764***		1.370***
						(0.360)		(0.372)
Observations	880	880	880	880	880	880	880	880
Adj. R-squared	0.906	0.909	0.910	0.910	0.907	0.910	0.910	0.912
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered at Dist.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Odd columns correspond to binary specification, even columns to intensity specification
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.49: Coefficients: Price of Maize & Unconnected, without GQ Districts

	Log(Price)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.068**	0.069**						
	(0.030)	(0.029)						
Benefit * Uncon.	0.068	0.066						
	(0.059)	(0.063)						
Pop. Benefit		-0.259*						
		(0.143)						
Pop. Benefit * Uncon.		0.125						
		(0.140)						
Upgrade			0.017	0.024			0.021	0.021
			(0.026)	(0.023)			(0.025)	(0.022)
Upgrade * Uncon.			0.033	0.041			0.030	0.047
			(0.051)	(0.066)			(0.051)	(0.066)
Pop. Upgrade				-0.289**				-0.324**
				(0.130)				(0.155)
Pop. Upgrade * Uncon.				-0.310				-0.293
				(0.467)				(0.487)
Build					-0.001	-0.005	0.004	-0.001
					(0.033)	(0.034)	(0.032)	(0.030)
Build * Uncon.					0.028	0.033	0.028	0.044
					(0.044)	(0.043)	(0.041)	(0.037)
Pop. Build						0.576		0.700
						(0.729)		(0.596)
Pop. Build * Uncon.						-0.559		-0.739
						(0.724)		(0.610)
Observations	880	880	880	880	880	880	880	880
Adj. R-squared	0.693	0.693	0.692	0.694	0.691	0.690	0.691	0.693
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered at Dist.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Odd columns correspond to binary specification, even columns to intensity specification
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.50: Coefficients: Output of Wheat with Maize Advantage, without GQ Districts

	Log(Price)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.218***	0.235***						
	(0.055)	(0.057)						
Benefit * Adv.	-0.235***	-0.271***						
	(0.061)	(0.060)						
Pop Benefit		-0.258						
		(0.224)						
Pop Benefit * Adv.		0.155						
		(0.252)						
Upgrade			0.108**	0.100**			0.092*	0.078*
			(0.045)	(0.042)			(0.047)	(0.044)
Upgrade * Adv.			-0.135***	-0.162***			-0.041	-0.091*
			(0.046)	(0.050)			(0.044)	(0.050)
Pop Upgrade				0.308				0.116
				(0.283)				(0.260)
Pop Upgrade * Adv.				0.300				0.353
				(0.290)				(0.293)
Build					0.308***	0.350***	0.316***	0.347***
					(0.060)	(0.062)	(0.063)	(0.063)
Build * Adv.					-0.245***	-0.301***	-0.233***	-0.282***
					(0.063)	(0.066)	(0.064)	(0.064)
Pop Build						-0.558**		-0.449*
						(0.264)		(0.268)
Pop Build * Adv.						0.262		0.246
						(0.403)		(0.414)
Observations	2,970	2,970	2,970	2,970	2,970	2,970	2,970	2,970
Adj. R-squared	0.955	0.955	0.955	0.955	0.955	0.956	0.955	0.956
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered at Dist.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Odd columns correspond to binary specification, even columns to intensity specification
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.51: Coefficients: Output of Rice with Maize Advantage, without GQ Districts

	Log(Output)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.152**	0.148*						
	(0.076)	(0.076)						
Benefit * Adv.	-0.233***	-0.196***						
	(0.075)	(0.066)						
Pop Benefit		0.856***						
		(0.202)						
Pop Benefit * Adv.		-0.186						
		(0.193)						
Upgrade			-0.016	-0.037			-0.021	0.012
			(0.056)	(0.057)			(0.059)	(0.060)
Upgrade * Adv.			-0.147*	-0.076			-0.124	-0.057
			(0.085)	(0.083)			(0.085)	(0.082)
Pop Upgrade				-0.044				0.410
				(0.286)				(0.312)
Pop Upgrade * Adv.				-0.673				-0.608
				(0.628)				(0.605)
Build					0.109	0.062	0.065	0.035
					(0.078)	(0.076)	(0.077)	(0.075)
Build * Adv.					-0.121	-0.088	-0.059	-0.032
					(0.074)	(0.076)	(0.068)	(0.071)
Pop Build						0.931***		0.916***
						(0.210)		(0.228)
Pop Build * Adv.						-0.118		-0.039
						(0.201)		(0.208)
Observations	3,508	3,508	3,508	3,508	3,508	3,508	3,508	3,508
Adj. R-squared	0.944	0.945	0.944	0.944	0.944	0.945	0.944	0.945
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered at Dist.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Odd columns correspond to binary specification, even columns to intensity specification
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.52: Coefficients: Output of Maize with Maize Advantage, without GQ Districts

	Log(Output)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Benefit	0.040	0.143						
	(0.159)	(0.139)						
Benefit * Adv.	0.140	-0.133						
	(0.127)	(0.098)						
Pop Benefit		-1.822***						
		(0.361)						
Pop Benefit * Adv.		1.308***						
		(0.357)						
Upgrade			-0.075	0.092			-0.030	0.086
			(0.106)	(0.111)			(0.103)	(0.104)
Upgrade * Adv.			0.116	-0.082			0.026	-0.188
			(0.123)	(0.127)			(0.122)	(0.119)
Pop Upgrade				-2.269**				-2.655**
				(1.078)				(1.105)
Pop Upgrade * Adv.				1.941*				1.286
				(1.081)				(1.143)
Build					-0.059	0.057	-0.055	0.051
					(0.115)	(0.107)	(0.124)	(0.112)
Build * Adv.					0.228*	-0.004	0.217*	0.006
					(0.123)	(0.111)	(0.123)	(0.108)
Pop Build						-1.409***		-1.832***
						(0.318)		(0.374)
Pop Build * Adv.						1.563***		1.497***
						(0.489)		(0.525)
Observations	2,864	2,864	2,864	2,864	2,864	2,864	2,864	2,864
Adj. R-squared	0.910	0.912	0.910	0.911	0.910	0.911	0.910	0.913
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered at Dist.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Odd columns correspond to binary specification, even columns to intensity specification
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1