PRODUCTIVITY EFFECTS OF LAND REFORM:

A Study of Disaggregated Farm Data in West Bengal, India [1]

Pranab Bardhan[2] and Dilip Mookherjee[3]

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Abstract

We study the impact of reforms in land property rights on farm productivity in the Indian state of West Bengal spanning 1982–95. Our analysis is distinguished from earlier studies by use of a disaggregated farm panel, controls for farm extension programs administered by local governments, and for endogeneity of program implementation. We find statistically significant effects of tenancy registration on productivity in tenant farms, but larger general equilibrium spillover effects on non-tenant farms. The productivity effects of tenancy reform were overshadowed by farm input services and infrastructure spending by local governments.

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[2]Department of Economics, University of California, Berkeley

[3]Department of Economics, Boston University

1 Introduction

Land reforms represent policies with significant promise to increase farm productivity as well as reduce rural poverty in developing countries. These reforms include land redistribution, titling programs and regulation of tenancy contracts. A large theoretical literature going back to Adam Smith, Alfred Marshall and John Stuart Mill has focused on the potentially productivity enhancing impact of such reforms, a theme echoed in more recent literature as well.[4] The potentially beneficial incentive effects of these reforms stem from reduction in sharecropping distortions, agency costs of hired labor, and improved access to credit. On theoretical grounds however, the productivity effects are ambiguous as there are a number of possible opposing effects as well, such as loss of scale economies, investment capacity or incentives of owners, and reduced ability of owners to control their tenants.[5] In addition, land reforms could have general equilibrium implications for local prices of key factor inputs, the distribution of land across size classes and ownership forms, and the nature of local governance that affect infrastructure and farm extension programs. Such general equilibrium or governance impacts are less well understood or emphasized in existing literature.

Empirical evidence on the productivity effects of land reforms has been provided in recent years by Besley and Burgess (2000) and Banerjee, Gertler and Ghatak (2002) in the context of Indian agriculture. They employ official government data at relatively high levels of aggregation. Besley-Burgess examine the effects of land reform legislations on growth and poverty reduction in a panel of different Indian states. Banerjee *et al* study the effect of implementation of a given tenancy reform (*Operation Barga*) within the state of West Bengal on rice yields in a panel of different districts, and interpret the effects in terms of reduction of sharecropping distortions. Operation Barga registered sharecropping contracts, protecting sharecroppers from eviction, and legislated minimum shares accruing

[4]For a short history of the classical debates on this question, see Johnson (1950). For a survey of the more recent theoretical literature on sharecropping see Singh (1989) and Bardhan and Udry (1999). Also see Binswanger *et al* (1993) for a survey of the literature on land reform in developing countries.

[5]See Banerjee, Gertler and Ghatak (2002) for analysis of some of these contrasting effects of tenancy regulations.

to the tenant.[6]

Compared to Besley and Burgess, the Banerjee *et al* paper pertains to a substantially lower level of aggregation (districts rather than states) and uses a more reliable measure of sharecropping reform (the proportion of tenants registered, rather than the number of legislative amendments). Yet, the level of aggregation is still too high for the results to be interpretable as the effects on sharecropping distortions alone. A more direct test would require use of data at the level of individual farms, distinguishing between effects on tenant and owner-cultivated farms, and between partial and general equilibrium effects. That is the purpose of this paper.

We use a disaggregated farm panel in West Bengal, which has implemented a range of reforms in land property rights and local governance since the late 1970s. This state experienced a spurt in the rate of growth of agricultural production starting in the 1980s, associated with large increases in the adoption of high yielding varieties (HYV) rice. We are also interested in understanding the main causes of this growth; in particular the role of the land reforms, as distinguished from farm extension programs, changes in market prices, or autonomous processes of diffusion of HYV rice. Our analysis is distinguished from previous studies by its use of more reliable farm production data, the level of disaggregation, controls for other farm extension programs administered by local governments, and for potential endogeneity of program implementation.

Our principal results are the following. Tenancy reforms had a statistically significant, positive impact on farm productivity. However, we cannot precisely distinguish differences in impact between tenant and owner-cultivated farms. There were large spillovers to non-tenant farms, indicating the existence of a significant general equilibrium impact of the tenancy reform. Hence the productivity impact of the reforms cannot be understood in terms of reduction of sharecropping distortions in tenant farms alone. We explore a number of possible channels of productivity spillovers from tenant to owner-cultivated farms. The evidence is not consistent with various channels such as effects on the cost of credit, seeds, land markets, improved targeting of extension programs by local governments, or diffusion of

[6]Further details of the program are provided in Section 2 below.

high-yielding rice varieties. It is possible, however, that they operated via local groundwater markets: increased demand for water by tenants may have stimulated increased investment in tubewells and thereby lowered the equilibrium price of groundwater. We are exploring this channel in our currently ongoing research.

A second set of results concern the relative contribution to farm productivity growth of land titling programs, the tenancy regulation program, and various farm extension programs administered by local governments. We find no statistically significant effects of the land titling program. The contribution of the tenancy regulation program is small, of the order of 5%, in contrast to the estimate of 20% provided by Banerjee *et al* (2002). At the same time the role of farm extension programs was much larger, ranging between 75% growth over 1982–95 resulting from irrigation, and over 100% growth for supply of seeds, fertilizers and credit.[7] In particular the supply of agricultural minikits (containing HYV seeds and fertilizers) had large effects on adoption of high-yielding rice varieties, whereas the tenancy program had no significant effect on these adoption rates.[8]

Section 2 describes the context of West Bengal agriculture, the various land reform and extension programs, and the nature of our data. Section 3 provides the main empirical estimates of the programs on farm productivity. Section 4 explores possible channels of impact, including direct tests for sharecropping distortion in tenant farms, and various channels for spillovers to non-tenant farms. Section 5 concludes.

[7]These pertain to the effect of growth in these factors alone, which over-predict the actual growth observed. There are many other controls in our regression, including common year effects and price changes, which presumably caused actual productivity growth to be lower than is predicted by these input supply programs alone.

[8]Specifically, the bulk of the productivity impact of the tenancy reform consisted of increased yields of traditional rice varieties, and similar increases in areas cropped under both traditional and new rice varieties.

2 Background and Data Description

2.1 Land Reform Programs

Following Independence in 1947, land reforms were an important priority for newly elected governments at both the central and state levels in India. These included abolition of intermediary landlords (*zamindars*), redistribution of lands above mandated ceilings, and regulation of tenancy. Responsibility for agricultural policy is vested in state governments under the Indian Constitution. Respective states proceeded to enact suitable legislation in the early 1950s, with encouragement and assistance from the central government.

Like many other states, West Bengal faced a large number of problems with regard to implementation of land reform laws until the late 1960s, owing to loopholes in legislation, poor land records and lack of political will (associated with the control of the state government by the Congress party, whose rural base rested on the support of landlords). From 1966 until 1971 a number of coalition governments were formed, in some of which Left parties (including the Communist Party of India (Marxist), or CPM) played part. The late 1960s also witnessed an armed peasant uprising in the state associated with extreme Left-wing parties utilizing guerrilla tactics, which seriously threatened law and order in the state. Partly for these reasons, elected governments in the 1970s were more resolved to implement land reforms, by closing legal loopholes, and reinforcing administrative efforts. A new Land Reforms Act was passed in 1971, redefining land ceilings that formed the basis of land redistribution programs. In 1977 a Left-front coalition headed by the CPM won an absolute majority in the state government. From the very beginning implementation of land reforms was a top priority for this government, along with delegation of delivery of development and welfare programs to a newly created three-tier system of directly elected local governments. This Left coalition has subsequently remained in power at the state level until the present day, thus enabling these reforms in land reform implementation and local governance to be continued over successive decades.

There were two principal land reform programs. The first represents appropriation of lands (a process known as *vesting*) above the legislated ceilings from large landowners, and

subsequent distribution of this land to the landless in the form of titles to small land plots (called *pattas*). Most of the vesting had been carried out prior to 1978.[9] According to the Left Front government's own admission, it had been unable to markedly increase the extent of land vested over the amount available in 1978; hence its main initiative has been the distribution of vested land in the form of land titles. Hence we shall focus on the distribution of land titles to the poor. For the state as a whole, P.S. Appu (1996, Appendix IV.3) estimates the extent of land distributed until 1992 at 6.72% of its operated area, against a national average of 1.34%.[10]

The other land reform program involved registration of tenancy contracts. In 1977 the newly elected Left Front government amended the 1971 Land Reforms Act, making sharecropping hereditary, rendered eviction by landlords a punishable offense, and shifted the onus of proof concerning identity of the actual tiller on the landlord. Subsequently they initiated a mass mobilization drive with the assistance of farmer unions (*Kisan Sabha*) and newly empowered local governments to identify sharecropping tenants and induce them to register their contracts with the local Land Records office. Registration was also accompanied by a floor on the share accruing to tenants, amounting to 75% (replaced by 50% if the landlord pays cost of all non-labor inputs). Over a million tenants were registered by 1981, up from 242,000 in 1978 (Lieten (1992, Table 5.1)), increasing to almost one and a half million by 1990. Lieten (1992, p. 161) estimates on the basis of different assumptions concerning the actual number of sharecroppers in the state, that upwards of 80% of all sharecroppers were registered in the state by the early 1990s, while Banerjee *et al* (2002, p.242) estimate this proportion to be around 65%.

These land reforms were complemented with creation of a three tier system of *panchayats* or elected local governments (Gram Panchayats (GPs)), who were delegated responsibility for delivery of various input supply services and local infrastructure. The principal responsibilities entrusted to the *panchayats* included implementation of land reforms, of

[9]We were able to get data on the time pattern of vesting in 34 of our sample villages, where we found 70% had been vested prior to 1978.

[10]Only one other state (Jammu and Kashmir) achieved a higher percentage, with the vast majority of states distributing less than 1.5% of operated area.

the two principal poverty alleviation schemes (the Integrated Rural Development Program which gave subsidized credit to the poor, and employment programs such as Food for Work (FFW), National Rural Employment Program (NREP), Rural Labour Employment Guarantee Program (RLEGP) in the 1980s which were merged into the *Jawahar Rozgar Yojana (JRY)* from 1989 onwards), distribution of subsidized agricultural inputs (in the form of minikits containing seeds, fertilizers and pesticides), local infrastructure projects (including roads and irrigation), and miscellaneous welfare schemes (old-age assistance, disaster relief, housing programs for the poor etc.). The bulk of the funds (78% in our sample) for these programs were devolved to the local governments under various schemes sponsored by the central and state government. The funds percolated down from the central government to GPs through the state government, its district-wide allocations, and then down through the upper tiers of the panchayats at the block and district levels. Upper tiers of the panchayats thus affected allocation across different GPs, while the main role of the GP was to select beneficiaries of these schemes within their jurisdiction.

2.2 Data

Our study is based on data from cost of cultivation surveys carried out by the Department of Agriculture of the state government. These surveys were carried out for the purpose of estimating agricultural costs of principal crops in the state. These are aggregated at the state level and eventually sent to the Commission for Agricultural Costs and Prices at the central government in New Delhi, which uses this information to set foodgrain prices on a cost-plus basis.

A number of reasons make the data from these surveys especially reliable. First, the surveys are not used by the government to estimate agricultural production levels in the state. So they are not subject to reporting biases that have been argued to afflict published statistics of the state government used by most previous studies (including Besley-Burgess (2000) and Banerjee *et al* (2002)).[11] Second, the surveys selected a stratified random sample

[11]Considerable doubt has been raised about the reliability of agricultural output data of the West Bengal state government, by Boyce (1987) and Datta Ray (1994). They describe how the West Bengal state

of farms in West Bengal, first randomly selecting blocks within each district, then selecting pairs of neighboring villages randomly within blocks, and finally selecting a random sample of 8 farms in each village, stratifying by landholdings.[12] Every five years the samples were redrawn and freshly chosen. Third, each selected farm was visited on a bi-weekly basis for five successive years. Trained investigators measured principal outputs and inputs of farms on a weekly basis, and every year filed an assessment of costs on various items, following prescribed norms by the agriculture department. Prices of main inputs and outputs were also collected at the farm-year level.

Detailed farm records could be located for three successive five year panels, spanning 1981–96. Within each five year panel, complete data is available for all farms in each village for an average of four years. We thus create an unbalanced panel covering 89 villages located in all but two districts (Kolkata and Darjeeling, neither of which has any significant agricultural activity).[13]

The farm data is complemented by village data collected from a variety of sources. We carried out household surveys in these villages, and collected data relating to composition and activities of local governments, spanning the period 1978-2004. These enable us to assess changes in the distribution of land, literacy, caste and occupations in the village; composition of elected GPs; details of infrastructure programs and yearly budgets of these GPs. We visited local land reform offices to obtain data on yearly land reform implementation (land titles distributed and tenants registered, including names of beneficiaries and cultivation areas involved). Visits to local lead banks and block development offices

government has often shifted between agricultural statistics collected from sample surveys and crop cutting surveys initiated by Mahalanobis in the 1940s, and those based on subjective 'eye estimates' from the state Directorate of Agriculture. These concerns are aggravated by the frequent use of published statistics by the West Bengal state government to claim credit for their policies in generating a high rate of agricultural growth during the 1980s and the first half of the 1990s.

[12]However we use a sub-sample of the original sample, based on the village-years for which complete farm records could be located in local offices of the state agriculture department. We do not know whether this may have caused any bias.

[13]Darjeeling occupies a hilly terrain at the foothills of the Himalayas. It has a number of tea estates and plantations, but grows no principal foodgrains, cash crops (apart from tea) or vegetables.

generated yearly data on distribution of IRDP credit and agricultural minikits in each village. GP records yielded yearly allocation of spending and scale of various infrastructure projects. We also collected data on rainfall from local recording centers of the state Meteorological department, leading economic indicators at the district or regional level from published statistics of the state government, and outcomes of elections to the state and national legislatures in each constituency spanning the sample areas.

Summary statistics concerning the villages in our sample are provided in Table 1. The sample includes 89 villages in 57 GPs. Each GP consists of ten to twenty elected members of a council governing administration of the jurisdiction of the GP, which usually consists of eight to fifteen villages or *mouzas*. On average each district comprises 20 blocks and 200 GPs. Table 1 shows the principal demographic and asset distribution changes in the sample villages between 1978 and 1998, based on an indirect household survey administered in each village in 1998.[14] The distribution of cultivable non-*patta* land (i.e., excluding land distributed through the land reforms) shows increasing landlessness, as well as a redistribution of land from large to small landowning households, resulting from splitting of large landholdings (via market sales of land and household sub-division).

Table 2 indicates the extent of land reform implemented in our sample by 1998. Approximately 5.4% of cultivable land was distributed to 15% of the population in the form of registered land titles. Approximately 6% of cultivable land involved leased lands on which tenants (*bargadars*) were recorded. However, 2% had already been registered by 1978, so the incremental area covered by the program since 1978 was 4%. The proportion of households registered by 1998 was 4.4%. Aggregating the two programs, therefore, about 11.5% of operational land area was affected, and 20% of all households benefited.

Table 3 depicts trends in agricultural inputs provided by the GPs in our sample vil-

[14]This involved selection of voter lists for 1978 and 1998, and interviews with four or five different senior citizens in each village to identify land and demographic status of each household for those two years respectively. The details of this survey are described further in Bardhan and Mookherjee (BM, hereafter) (2004b). In particular the land distribution obtained thereby when aggregated to the district level matches quite closely the distributions reported in the state Agricultural Census as well as National Sample Survey (NSS) decadal surveys of operational holdings in West Bengal.

lages between 1982–95.[15] The 1980s witnessed larger supplies of IRDP credit and minikits compared with the 1990s. One out of every nine households received minikits in the 1980s, containing seeds, fertilizers and pesticides. The bulk of employment funds were spent by GPs on building and maintenance of local roads; these employment programs created 2-4 mandays of employment per household every year. There was also expansion of areas irrigated by state canals. Greater expansions were witnessed in medium and small irrigation projects, many of which were managed by panchayat officials. Spending on irrigation by the panchayats was highest during the early part of the period, fell sharply throughout the 1980s, and stabilized thereafter. A similar trend was observed for GP spending on local roads, except that there was an upturn towards the end of the period.

The last two rows of Table 3 provide (for the sake of comparison) the land reforms implemented at these corresponding years: these peaked in the first half of the 1980s and tailed away thereafter. Clearly, these became insignificant relative to input and infrastructure provision from the mid-1980s onwards.

Table 4 shows average allocation of cropped area across different crops in our farm sample, and their respective yields (measured by value added per acre). Rice accounted for two-thirds of cropped area, with HYV rice accounting for 28% on average across the entire period. HYV rice yields were two and a half times those of traditional rice varieties. Only potatoes generate a higher return (measured by value added per acre) than HYV rice; however the short potato season (which lasts 70-90 days) limits the acreage devoted to this crop. Other cash crops such as jute and tobacco generate high returns, followed by pulses, vegetables and oilseeds, with wheat generating the lowest returns.

Table 5 shows changes over time in cropping patterns, yields and incomes: these are weighted averages across farms in the sample for the beginning and end of each separate panel (1982–85, 1986–90 and 1991–96).[16] Cropped area per farm grew at a modest rate

[15] These averages use operational land area in different villages as weights, the reason the numbers reported here differ from the unweighted averages reported in BM (2004a, 2006).

[16] Cropped area per farm and hired labor employed are not weighted. The three panels contained 56, 155 and 131 farms respectively. We do not report averages for the first year 1981 of the first panel, owing to many missing observations for that year.

(about 10%) for each five year period in the 1980s, but did not grow in the 1990s. HYV rice adoption rates grew dramatically, from 1 to 8% in the first panel, 16 to 32% in the second panel, and 46 to 53% in the third. Value added per acre in rice grew analogously, by almost 50%, 80% and 30% in the three panels. Farm incomes grew at similar rates, indicating the importance of rice in the growth process. The wage rate of hired workers remained stationary throughout the 1980s, but grew about 20% in the first half of the 1990s. Employment rates increased during the 1980s, but fell by about 15% during the early 1990s. Hence incomes of agricultural workers, the poorest section of the rural population, grew at a modest rate.

Table 6 shows the fraction of farms which leased in land, and associated areas leased in, for different years in the sample, averaged across all the farms in the sample for any given year. This is based on the cost of cultivation survey: we infer if a farm is leasing in land for production of a specific crop in any given year if some rent is paid to a landlord.[17] In the first panel lasting until 1985, there seems to be a downward trend in the extent of tenancy, with the percent land area leased falling from 13% to 7%. In later panels (1986–90, 1991–95) no trends are visible, averaging between 1–2% during 1986–90 and around 6% during 1991–95. The proportion of farms leasing in land seems rather low, ranging between 1–2%.

In comparison Table 2 calculated on the basis of the village land records and the indirect household survey shows that 3–4% of households in the sample villages were registered in the program. So there is possibly some under-representation of tenants in the sample.

Further information concerning the nature of tenancy contracts is not available in the cost of cultivation surveys. For the state of West Bengal as a whole, the Operational Holdings survey of the National Sample Survey (NSS) for the year 1991-92 indicates that 14% of all operational holdings (and 10.4% of the area) was leased in. Of these 3.7% were fixed rent tenants, while 8.8% were sharecroppers. Of the total area leased in, about 48% was on sharecropped contracts, and 19% on fixed rent contracts. Hence on the basis of the NSS estimates the extent of sharecropping tenancy in the state seems rather low, of the

[17]Indeed, we do not know what part of the land devoted to that crop was leased in. So we assume that all of it was. This implies that the tenancy area estimate is biased upward.

order of 5% of operational area. It seems unlikely on this basis that the tenancy registration program could explain a rise in farm yields of the order of 20% estimated by Banerjee *et al* (2002), or a rise in the adoption rate of HYV rice to over 30% of total cropped area by the mid-90s.

The NSS 1991-92 survey also indicates two thirds of all tenancy leases exceeded two years in duration, and 48% exceeded five years in duration. Short term leases of a year or less accounted for 22%. Details concerning tenant crop shares are not available from any source, apart from the survey carried out by Banerjee *et al* (2002) for a sample of 20 villages, who report that the proportion of tenants with crop shares exceeding 75% rose from approximately 5% to approximately 20% with the reforms, and those exceeding 50% rose from 17% to 39%. There is a significant peak at a crop share of exactly 50%, which fell from approximately 80% to approximately 60%. Hence the program appears to have raised crop shares for approximately 20% of the tenants. This reduces the incidence of the program even further. In summary, the extent of area covered by the tenancy registration program appears quite limited, and there is some under-representation of the incidence of tenancy in our sample compared to the entire state.

3 Estimating Effects of Programs on Farm Yields

3.1 Effect of Land Reforms: Theoretical Hypotheses

The effect of land reforms on farm productivity have been the topic of a large literature in development economics. The classic arguments concern Marshallian inefficiencies arising from sharecropping, where the share paid to the landlord acts as a tax on the tenant's effort. Sharecropper registration can raise farmer incentives by capping this implicit tax rate. Other incentive effects arise from removing the right of landlords to evict tenants: the direction of these are ambiguous, owing to conflicts between different effects.[18] Eviction threats can be used by landlords as an incentive device, the removal of which could dull tenant

[18]Regulation of eviction rights may be needed in the absence of the ability of landlords to commit to leases of long duration.

incentives. On the other hand, security of tenure may promote longer time horizons for the tenant and thereby increase investment incentives. These issues are discussed in Bardhan (1984), Dutta, Ray and Sengupta (1989) and Banerjee, Gertler and Ghatak (2002).[19] In addition, registered sharecroppers were eligible to apply for production loans from formal credit channels, which could reduce their credit costs (owing to significant differences in interest rates between formal and informal credit sources).[20]

The incentive effects of redistributing land ownership have also been discussed in previous literature (Bardhan (1973), Berry and Cline (1979), Eswaran and Kotwal (1986), Binswanger *et al* (1993), Mookherjee (1997)). In general, the effect depends on the extent of economies or diseconomies of scale. Given the advantages of family labor cultivation over hired labor, and the relative lack of important sources of scale economies (such as mechanization) in rice cultivation, one might expect small farms to be more productive than large farms. While such a pattern has frequently been empirically observed, it is possible that they reflect differences in unobserved soil characteristics between small and large farms. If more productive lands are more prone to fragmentation, small farms may be expected to have more fertile soils, in which case observed yield differences between small and large farms overstate the effect of land redistribution programs.

As explained previously the land titling program mainly concerned distribution of titles to land that had previously been appropriated from those holding surplus land above legislated land ceilings. Distribution of already-vested lands would enable them to be actively cultivated instead of lying fallow, in which case one would expect a rise in production yields. Of course these yield improvements would be negligible if the transferred lands were of inferior quality or of very small size. The average size of land parcels distributed

[19]The theoretical literature (see, e.g., Mookherjee (1997)) also clarifies that the reforms can raise farm productivity but typically do not constitute a Pareto improvement. Landlords and those with more land than the ceiling allows are typically rendered worse off, while tenants and recipients of land titles are better off. This also explains why sharecropping as an institution persists, despite the existence of associated distortions. Voluntary sales of land to tenants or landless households would therefore not occur in a *laissez faire* economy.

[20]We have learnt this from interviews with government and bank officials, as well as sharecroppers. We do not, however, have data on access and costs of credit.

was approximately half an acre, compared with an average size of 1.5 acres for plots registered under Operation Barga, the tenancy registration program. Moreover, while the latter were cultivable by their very nature, approximately half of all titles distributed consisted of non-cultivable land. We have also been told by bank officials and farmers that we interviewed that farmers were not eligible for bank loans on the basis of the titles received in the land reform program, mainly owing to the uneconomically small size and poor quality of the land parcels concerned. Therefore the productivity impact of the land titling program could be expected to be less significant than the effects of tenancy registration, and we focus principally on the latter.

3.2 Impact of Operation Barga on Farm Value Added Per Acre

Column 1 in Table 7 presents an OLS panel regression of farm value added per acre on a dummy for farms leasing in land, and on the percent of land registered in the village until the previous year, apart from farm, year dummies and controls for farm acreage. [21] Note that the tenancy dummy of obtained from the farm cost of cultivation data, while the tenancy registration rate is obtained from the land records office pertaining to the village as a whole. The reason we do the latter is that we do not know if the tenant farmer in question had registered in any given year. Hence we use the registration rate in the village as a proxy for the likelihood that a randomly chosen tenant farmer has been registered. Even if a particular tenant did not register, the option to register would be expected to raise the bargaining power and hence the share accruing to the tenant. Hence the registration rate in the village is also a reasonable indicator of this outside option effect.

To control for possible endogeneity of the leasing decision, the second column replaces the current lease dummy by the fraction of years in the sample (that the farmer appears) that it leased in land. By construction this is a farm-related variable that does not change

[21] We know from some of the literature on agency problems with respect to hired labor in conjunction with credit market imperfections may cause farms to rely on family labor as far as possible (Eswaran and Kotwal (1986)). Given family size, increases in cropped area cause increasing reliance on hired labor, which therefore tends to increase agency problems and lowers farm profits. We therefore need to include controls for cropped area in the regression to capture this effect.

across years, and represents differences in the average extent of leasing across farms. The interaction of this variable with the extent of tenancy registration in the village represents variations in the effect of the program across tenant and non-tenant farms.

These two columns in Table 7 show that the effect of leasing and its interaction with tenancy registration rates in the village have the signs that would be expected from the Marshall-Mill theory of sharecropping distortions, but these effects are statistically insignificant.

The next set of columns in Table 7 include possible spillover effects of the tenancy registration program on non-tenant farms, as well as controls for the land titling program and other extension programs implemented by local governments. We add the tenancy registration rate as a regressor, besides its interaction with leasing. Note that we use the percent area registered as estimated from the local land records, rather than the proportion of tenants registered (the measure used by Banerjee *et al*). The proportion of area registered obviously represents more closely to the incidence of the program in the village, compared with the proportion of tenants registered. The latter proportion averages around 50% in the sample, and 65% for all West Bengal in 1993, in contrast to less that 5% operational area that was covered by the program.

Note also that the registration rate pertains to the village as a whole: this regressor by itself (i.e., controlling for its interaction with the lease dummy or fraction) represents a common effect of the program on the profitability of *all* farms in the village in future years, via general equilibrium, governance or learning spillovers.

The regressions in columns 3,4 of Table 7 also add as controls the distribution of land titles to poor households, and various farm input supply and infrastructure programs administered by GPs: specifically, cumulative lagged values of: (a) proportion of cultivable land distributed in the form of *pattas*; (b) minikits distributed in the village per household, (c) IRDP credit subsidy delivered per household, (c) log of the cumulative GP expenditures (in constant 1980 prices) per household on local irrigation and road projects, and (d) cumulative mandays of employment generated by GP programs per household. Additional controls include annual rainfall at the nearest weather station, the log of the rice price

received by the farmer, canals and roads provided by the state government in the district, apart from farm and year effects. The regression specification is thus:

$$V_{fvt} = \beta_1 L_{fvt} + \beta_2 L_{fvt} * B_{v,t-1} + \beta_3 A_{fvt} + \beta_4 A_{fvt}^2 + \beta_5 B_{v,t-1} + \beta_6 P_{v,t-1} + \beta_7 E_{v,t-1} + \gamma_f + \delta_t + \epsilon_{fvt}$$

where L_{fvt} denotes the dummy for whether farm f in village v in year t leased in land, $B_{v,t-1}$ denotes cumulative proportion of agricultural land registered under Operation Barga in village until year $t-1$, A_{fvt} is the gross cropped area in the farm in year t, $P_{v,t-1}$ is the cumulative proportion of cultivable land in the village distributed in the form of land titles, $E_{v,t-1}$ is the cumulative per capita delivery of extension services to the village until year $t-1$. The coefficients $\beta_5, \beta_6, \beta_7$ represent spillover effects of village development programs delivered by GPs on future profits of all farms in the village, in contrast to β_2 which is the direct effect on farms leasing in land owing to a reduction in sharecropping distortions.

We see now that inclusion of the village controls representing different government interventions results in a higher coefficient on the interaction of leasing with Operation Barga implementation.[22] However, in no version is this coefficient statistically significant, even at 10% significance level.

More surprising is the strong significance of the spillover effects of the tenancy registration program, the delivery of kits, credit and local irrigation. These represent common effects of these interventions on profitability of all farms in the village, most of which we know (from Table 6) were not leasing any land at all. The estimated spillover effect of tenancy registration on non-tenant farms is larger than the point estimate of the direct impact on the tenant farms.

[22]This reflects a negative partial correlation between Barga implementation and delivery of minikits, the program which we shall see was the largest significant source of farm productivity growth. A regression of % land registered on all the other programs, controlling for village and year effects, shows a statistically significant (at 1%) and negative effect of cumulative minikits delivered per household. In other words, Operation Barga tended to be implemented more vigorously in villages with relatively slow growth in minikit delivery. Hence controlling for the latter results in an increase in the estimated effect of Operation Barga.

3.3 Controls for Endogeneity of Program Implementation

We next examine robustness of the estimates in Table 7 to possible endogeneity of program implementation. Banerjee *et al* (2002) argue that implementation of tenancy registration was largely exogenous, driven by myriad bureaucratic factors external to the villages concerned. Nevertheless to the extent that registration was ultimately demand-driven (being based on a voluntary decision of tenants to register their contracts, and efforts of local governments to implement the program), there is always a danger of possible reverse causality, both at the farm and village level. Specifically, farms or villages that seek to attain higher rates of productivity increase may be more inclined to register themselves or their tenants.

Our previous work on the political economy of the land reforms (BM (2004a,b)) indicates the extent of political competition between the Left Front (LF) and its principal rival during the study period, the Indian National Congress (INC), played a role in explaining temporal village-specific variations in implementation rates. In particular, increased competition resulted in higher implementation rates: there was an inverted-U pattern between implementation and the proportion of GP seats secured by the LF, in a village panel regression of implementation rates. The proportion of seats won by the LF in any given GP election was related, in turn, to a number of factors affecting relative standing of the two parties with voters in the concerned district. These include variables arguably exogenous with respect to time-varying village-specific farm productivity: the presence of the INC in the Lower House (Lok Sabha) of the National Parliament in New Delhi, the annual inflation rate of the CPI in the region in question, and the rate of new manufacturing factory employment in the district, in addition to (and interacted with) local incumbency (fraction of seats won by the LF in the previous GP election).[23]

Accordingly we use as instruments for program implementation the above district, regional and national level determinants of relative competitive strengths of the LF and INC, their squares, and interactions of these with lagged LF share in the GP. The underlying identification assumption is that year-to-year fluctuations in these were uncorrelated with

[23] An Arellano-Bond specification for dynamics of LF share of GP seats is not rejected, implying lagged shares are a valid instrument for current shares after controlling for village fixed effects.

farm productivity in each village, after accounting for their effect on various programs affecting productivity of local farms. The validity of this assumption depends on the comprehensiveness of the set of programs that we include as controls.

One cannot be completely sure of course that all relevant direct channels of influence have been controlled for. But our IV estimates should remove a large source of local time-varying sources of unobserved village-level factors affecting farm productivity growth, predicting them instead on the basis of political and economic factors on a substantially wider geographic area (interacted with local incumbency patterns). The direction of bias associated with potential endogeneity of implementation rates at the local level can be inferred by comparing OLS and IV estimates.

Other extension programs are instrumented by the scale of the corresponding program at the level of the state, interacted with the same variables affecting political competition. The idea here is that temporal fluctuations in the scale of these programs in the state as a whole resulted from financial, administrative and political factors at the level of the state government. These percolated down to villages and farms within those villages through a hierarchical system, with relative allocations across different villages determined partly by the same variables representing political competition at the district or regional levels.

We use this method to control for endogeneity of the three principal programs: IRDP credit, minikits, and sponsored program grants devolved to GPs out of which local irrigation projects are funded. The scale of the program at the state level is estimated by the average supply of the program across all sample villages in any given year.

The detailed set of instruments is therefore the following: lagged cumulatives of (a) percent Congress seats in Parliament in the previous General Election, interacted with lagged Left share of GP seats; (b) local inflation rate of cost of living, interacted with lagged Left share of GP seats; (c) lagged Left share of GP seats; (d) squares of the above variables; (e) interactions of the previous variables with IRDP credit, minikits, and sponsored program funds, averaged across all GPs in that year. F-statistics and partial-R sq. for first stage regressions are reported at the bottom of the Table, all of which are significant.

Column 1 of Table 8 shows the IV estimates of the regression previously reported in

column 3 of Table 7. The IV estimate of the spillover effect of the tenancy registration program, and of the minikits distributed, is approximately twice the size of the OLS estimate. Both are statistically significant at the 1% level. The IRDP credit disbursement effect also gains in significance, and now the employment mandays generated by local infrastructure programs also becomes significant at the 5% level.

The fact that the IV estimates are substantially larger than the OLS estimates possibly reflects the tendency for land reform and farm extension programs to be more vigorously implemented in villages where other sources of farm productivity growth were lower, i.e., they were implemented more vigorously in lagging regions. This may have owed to the efforts of the concerned local governments to speed up development of the lagging regions, and the greater desire of farms in these regions to catch up with those in other regions. Even if one may doubt whether the exclusion restrictions are exactly valid for the set of instruments we use, the fact that the OLS results are strengthened in the IV regressions indicates that it is unlikely that the were driven by endogeneity of program implementation.

The estimated differential impact of tenancy registration on yields of tenant farms *vis-a-vis* owner-cultivated farms is however unchanged; it continues to remain insignificant statistically. Hence controlling for endogeneity of program implementation appears to raise the spillover effect of tenancy registration, without enabling us to precisely measure the direct incentive effects of the reforms. To doubly verify our interpretation of the spillover effects, columns 2 and 3 of Table 8 re-run the same regression in OLS and IV for the sample consisting of pure owner-cultivated farms, and find the same results.

Next, Table 9 reports corresponding OLS and IV regressions at a higher level of aggregation: average yields in the village (computed using the village sample of farms and weighting their respective yields by their relative cropped areas). This allows us to study heterogeneity of treatment impacts on (and changes in composition within the village across) farms of differing sizes. It controls for one set of possible general equilibrium impacts: changes in the distribution of cropped area in the village between marginal farms (with operational holding below 2.5 acres), medium (between 2.5 and 5 acres) and big farms, and the proportion of these respective areas operated by tenant farms. Interactions of the latter with the extent

of tenancy registration in the village are reported in the first three rows, thus allowing the direct incentive effect of the reform to depend on farm size.

We see that the OLS estimate of the direct effect of the reform is significant (at the 10% level) for medium sized farms, and is substantially larger than the previous estimates of the average (direct) effect on all tenant farms. For medium sized farms the direct effect is also substantially larger than the spillover effect. This suggests substantial heterogeneity across different size categories in the direct productivity effects of Operation Barga on tenant farms. However, the IV estimate of the direct effect is statistically insignificant, though of similar magnitude as the OLS estimate. Hence the direct effects of the tenancy reform continue to be imprecisely estimated.

At the same time, the spillover effects continue to be large and significant, though somewhat smaller in magnitude than the farm-level estimate. Presumably induced effects of the programs on the distribution across farms within the village cause some reduction in the productivity effect, but they are not large enough to nullify the increase in intra-farm productivity.

To assess the relative quantitative significance of the direct and spillover effects, as well as of the land reforms relative to farm input services, Table 10A calculates the predicted impact of different programs on farm yields. We calculate the percent change in value added per acre between 1982 and 1995 in a hypothetical village in which the proportion of land registered under Operation Barga was equal to the weighted average for the entire sample (with weights proportional to operational areas of cultivation). We compare this with the change predicted by a hypothetical change in cumulative supply of kits, credit and GP expenditures on irrigation, equal to the weighted average of the observed changes in the sample villages (with weights again taken proportional to operational areas). We calculate the impact of tenancy registration to be of the order of 5% for yields on non-tenant farms. This estimate would be higher for tenant farms, depending on which estimate of the direct productivity impact on tenant farms we take. Tables 7 and 8 indicates the direct impact is smaller than the general spillover effect, while Table 9 indicates it may be two to three times larger for medium-sized farms. This indicates a range of 8 to 20% increase in yields

for tenant farms.

The predicted impact of Operation Barga are dwarfed by those of minikits (over 500%), IRDP credit (over 100%), and matched by local irrigation (6%). The similarity of corresponding regression coefficients suggests that the social rate of return to tenancy registration was comparable to those of other input services. The differences in measured impacts principally reflect differences in the scales of these respective programs.

Table 10B presents more detailed estimates of the predicted impacts of different programs implemented, using actual changes in program implementation in each village for the duration of each farm sample separately. For each five year time block in which any given village appears in the sample, the change predicted in farm yields in those villages by the actual changes observed in different programs is first calculated, using operational land areas of different farms (averaged across different years) to weight different farms. This is subsequently averaged across different villages in the same time block, using their relative operational areas as weights. The broad results remain unchanged from Table 10A. The impact of the tenancy program remains small, that of credit and kits remains roughly the same, and that of GP irrigation expenditures becomes larger. Most of the strikingly large impacts are predicted for the first five years 1981–85, with subsequent impacts tailing off subsequently.

4 Understanding Channels of Impact

In this section we try to understand possible channels of impact of the various programs. To assess the nature of the direct incentive effects of the tenancy reform, we first review evidence concerning the significance of sharecropping distortions by comparing input applications between leased and non-leased plots. Thereafter we seek evidence concerning the nature of the spillover effects of the tenancy reform on non-tenant farms. We explore the plausibility of various channels, ranging from prices of credit, seeds and water; under-reporting of tenancy; induced changes in land distribution or rental markets; improved targeting of extension programs by local governments; and social learning in the process of diffusion of

HYV rice varieties.

4.1 Sharecropping Distortions

The principal finding above is that the direct incentive effects of the tenancy reform were weaker and less precisely measured, compared with the spillover effects. One can seek evidence in alternate ways of the importance of sharecropping distortions, by comparing inputs applied in tenant and non-tenant farms, using the methodology of Shaban (1987) and Braido (2006) to compare factor allocations across sharecropped plots and owned plots in ICRISAT data from South and Central India. Table 11 compares the ratio of input expenditures to the value of output between leased and non-leased plots in HYV and non-HYV rice cultivation respectively. The regressions include farmer and year dummies: hence they compare inputs applied by the same farmer between leased and non-leased plots in the cultivation of the same crop. Since the dependent variable divides input expenditures by the value of output, this controls for heterogeneity between leased and non-leased plots (assuming a Cobb-Douglas specification of the production function, as explained in further detail by Braido (2006)).

The first column of Table 11 shows that farmers significantly under-applied (by about 20%) inputs to leased plots compared with owned plots in HYV rice cultivation. However the third column shows no significant difference in non-HYV rice cultivation. The second and fourth columns interact the leased dummy with the extent of land registered in the village. In the case of HYV rice, the extent of under-application fell by 12% (as a result of 100% registration), but this is statistically insignificant. Since the area registered was substantially smaller than 100%, the evidence shows little direct impact on incentives of farmers to apply inputs on leased plots. In the case of non-HYV rice, tenancy registration has a negative, insignificant effect on the application of inputs in leased plots. Hence we have some direct evidence of the existence of sharecropping distortions but this is limited to HYV rice, and even there we obtain very limited evidence that it was reduced significantly by the tenancy registration program.

4.2 GE Effects: Credit or Seed Prices

One possible channel of general equilibrium impact on the village economy might operate via induced changes in the demand and hence prices of key factors such as credit, seeds or fertilizers. For instance, if registration of tenancy status rendered sharecroppers eligible for credit from banks at interest rates substantially below informal interest rates, informal interest rates within the village for crop loans may have declined. This could generate a spillover to owner-cultivated farms in the same village. Unfortunately the farm data does not include information about actual interest rates paid by farmers, so we cannot directly check for pecuniary externalities through the informal interest rate.

One would expect smaller, poorer farmers to rely more on informal credit, in which case the increases in productivity ought to have been larger for small farms. Table 12 examines differential effects on productivity and incomes of small (less than 5 acre) and marginal (less than 2.5 acre) farms. These are insignificant, both quantitatively and statistically. Therefore there is no evidence of a larger impact on smaller farms. This suggests that impacts on credit market imperfections are unlikely to constitute the source of the measured spillovers.

An alternative indicator of lowered costs of informal credit are the prices of seeds paid by farmers, since informal credit is frequently bundled with purchase of seeds at inflated prices (either directly from lender-traders, or from traders in a triadic relationship with lenders and farmers). The farm data includes reliable data on seed prices actually paid for HYV and non-HYV rice for a reasonably large sub-sample (i.e., containing more than 50%) of farms growing these crops. In regressions of rice seed prices on programs implemented (not reported here), we found no evidence any of the three programs on seed prices.

4.3 Effects on Local Governance and Targeting of Farm Services

The tenancy reforms may have reduced the extent of capture of local government by landed elites, thus serving to target farm services better to small and marginal farms.[24] If smaller

[24]This hypothesis has been advanced in the literature on fiscal decentralization (see, e.g., Bardhan and Mookherjee (2000)), and is frequently invoked by representatives of the Left Front government in West Bengal. However, we have no direct evidence concerning the effects of land reform on targeting, owing to

farms are more productive than large farms[25], this may conceivably raise productivity in the former group, as well as on the average farm.

However, there is no evidence consistent with this hypothesis. Table 12 showed that the impact on small or marginal farms did not significantly exceed that on larger farms. Moreover, in Tables 7 and 8 when we added controls for the proportion of various farm services delivered to small and marginal farms, it turned out to have insignificant impact, and did not alter any of the results reported in those tables.

4.4 Undisclosed Tenancy

The measured spillovers could conceivably reflect undisclosed tenancy: in the presence of sharecropper regulations some landlords may lease land to tenants only if the latter did not disclose the leasing relationship.[26] We have noted in Section 2 that our sample seems to under-represent the extent of tenancy, by comparing with the land records or NSS data for the state as a whole. It is conceivable therefore that some farms claiming to be owner-cultivated were actually tenant farms. The presence of the registration program is likely to raise the bargaining power of these tenants, so some of the measured spillover effects may reflect the positive incentive effects of this.

However, we remain skeptical of this possible explanation. Given the political climate within which these land reforms were implemented, i.e., with LF-led local governments hostile to the interests of large landowners, the tendency or such under-reporting should be more pronounced for small farmers leasing in land from big landowners. We would thus expect a larger measured impact on small and marginal farms. But Table 12 showed that the spillover effects did not differ significantly across farms of varying size.

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the difficulty of statistically identifying this effect in a convincing manner.

[25] Indeed, we do find in our sample that farm value added per acre is declining significantly in farm cropped area

[26] We thank Maitreesh Ghatak for this observation.

4.5 Induced Changes in Land Distribution

An alternative general equilibrium impact of tenancy reforms could be on the distribution of land, via land markets or household fragmentation. However, these would operate by affecting the distribution of cultivated land across farms of varying size and ownership type, and thus cannot explain changes in the productivity *within* farms that have been documented in the previous section to form the bulk of the overall effect. Such effects could arise only if the programs affected the extent to which individual farms tended to lease in land, or by affecting the size of a representative farm (and of course, provided leasing or size had significant productivity effects).

Table 6 indicated no pronounced trends in the extent of leasing. Exploring this issue more carefully, we regressed the proportion of farmers leasing, or area leased within the village, on the various programs implemented, after controlling for farm, year dummies and other controls used in Tables 7 and 8. None of the programs displayed any significant effects.

The regressions in Tables 7 and 8 indicate a significant negative relationship between cropped area and farm productivity, after controlling for farm and year dummies, and all the other controls in those regressions.[27] Is it conceivable that the tenancy program raised farm productivity by inducing a shrinkage in cropped area of the representative farm? Note first that this cannot explain the results of Tables 7,8 because those regressions included farm size among the controls.

Moreover, there is evidence that the tenancy registration program induced an expansion of cropped area. Table 13 presents IV regressions of gross cropped area in the farm as a whole, as well as to HYV rice, non-HYV rice and potatoes, on the various programs implemented, controlling for farm and year dummies. The tenancy program induced a significant net expansion of cropped area, represented principally with increased cropping of both traditional and HYV rice varieties. There is no significant impact of any of the farm extension programs on aggregate cropped area. Hence there is no evidence that the

[27]Farm cropped area and its square formed part of the controls in those regressions, whose coefficients were not reported there. A doubling of cropped area was associated with a 10% reduction of farm value added per acre, which was statistically significant at the 1% level in all the regressions in Tables 7,8.

programs raised farm productivity on account of shrinking farm size or cropped area.

4.6 Adoption and Diffusion of HYV Rice

Table 13 also provides useful information about the impact of the programs on adoption of HYV rice. The tenancy program was associated with a uniform expansion of areas allocated to both traditional and HYV rice, at the expense of area allocated to potatoes. Hence the evidence does not show a significant impact of Operation Barga on HYV rice adoption *vis-a-vis* traditional varieties, after controlling for farm and year dummies. It is therefore unlikely that social learning in the process of diffusion of HYV rice constituted an important source of spillover.

On the other hand, the minikits distributed induced a significant expansion of HYV rice area, as well as area allocated to potatoes, and an insignificant effect on non-HYV rice area. Therefore the minikit distribution program seems to have increased incentives to adopt HYV rice and high-value cash crops such as potatoes (refer Table 4) *vis-a-vis* traditional rice varieties. The estimated impact of minikit supply on area allocated to HYV rice was also ten times larger than the effect of tenancy registration.[28] This probably accounts for the larger productivity impact of the minikits than the tenancy reform.

4.7 Irrigation

Finally, tenancy reform may have affected access to groundwater irrigation. It is well known that the period covered here displayed a substantial increase in irrigation. This was partly on account of the high water needs of the summer *boro* rice crop, which is mostly a HYV crop. Table 14 shows that farm area irrigated by shallow tubewells[29] rose from 7.6%

[28]With 10% land registered, the area allocated to HYV rice increased by approximately .07 acres. The increase in minikits supplied was of the order of 1 minikit per household, implying an increase in HYV rice area by approximately 0.7 acres.

[29]The shallower ones among these consist of wells with a depth of 30–50 feet, costing Rs. 11-12,000 each. The deeper ones, referred to as submersible or min-deep tubewells have an average depth of 180 feet and cost Rs. 50,000 each. These are operated with either diesel pumpsets or electricity.

in 1981 to over 31% in 1995, while from government canals rose from 5.2 to 5.8%, deep tubewells[30] rose from 2.8 to 4.5%, and ponds or river lift schemes (usually constructed by local governments) rose from 7.5 to 14.8%.[31]

Shallow tubewells represent a form of (mostly) private investment in irrigation. The investment required in a shallow tubewell is typically beyond the capacity of small and marginal farmers, who purchase water from larger farmers that can afford to invest in them. Detailed case studies in Moitra and Das (2004) of a number of villages indicate that in the early 1980s the government provided subsidies and loans to farmers in order to invest in shallow tubewells. Later in the 1980s as the water depth fell, investments switched to the deeper submersible wells or dugwells which were more expensive, and in which most of the investments were private and unsubsidized. The significant expansion in these tubewells (combined with their role in expanding *boro* rice cultivation) have raised questions among various commentators about whether the expansion in farm productivity in West Bengal owes more to private investment than government land reforms and extension programs (e.g., Harriss (1993), Moitra and Das (2004)).

It is possible, however, that part of the expansion in private irrigation investments may have been stimulated by the tenancy reform. The tenancy reform may have increased the incentive of tenants to apply water in their farms, and thus shifted the demand function for groundwater outwards. This in turn could have stimulated investments in tubewells by water sellers. The process may have been reinforced by increased access to credit for registered tenants in the early 1980s, for which there are several anecdotal accounts. Since investments in tubewells are lumpy and involve significant fixed costs, the net effect may

[30]These have a depth of between 200-500 feet, and cost approximately Rs 200,000. These are usually provided by the government.

[31]These numbers are calculated for the sample villages on the basis of a 2004 direct household survey of their landholding histories that we have conducted. For each village a random sample of approximately 20 households per village, stratified by landholding, was selected. The reported areas irrigated average across all the households in the sample. These numbers correspond closely with those reported by the West Bengal Census of Minor Irrigation for 1993-94, which reports a 340% rise in shallow tubewells, 161% in dugwells and 45% in deep tubewells in the state between 1987 and 1994. See also Moitra and Das (2004) for a detailed account of groundwater investments in West Bengal.

have been to lower the marginal cost, and hence price, of groundwater.[32]

In ongoing work with Neha Kumar, we are currently trying to find evidence of such linkages of tenancy reform and tubewell investments. Our preliminary findings do indeed find evidence that tenancy reforms and minikit distribution programs had a significant effect on lowering the cost of irrigation. We expect to report these findings in a subsequent paper.

5 Concluding Comments

To summarize, we have found significant effects of Operation Barga on rice yields and farm value added per acre, somewhat smaller in magnitude compared with Banerjee *et al*, using data from an independent source at a disaggregated farm level, with controls for endogeneity of program implementation and other concurrent farm extension programs. The quantitative magnitude of these effects were small compared to those of agricultural kits, credit and local irrigation facilities delivered by local governments. The effectiveness and significance of the latter in particular is striking, indicating the importance of public supplies of agricultural support services in sustaining productivity growth in developing countries. The importance of their role may arise from a combination of factors: credit constraints that restrict the ability of most farmers to purchase these inputs on the market, pecuniary externalities or spillovers in learning associated with inputs that are complementary to adoption of high-yielding rice varieties, and the public good character of local road and irrigation programs.

We found evidence that the program raised yields on tenant farms relative to non-tenant farms, which indicate their role in reducing sharecropping distortions. But this evidence was statistically less reliable, owing perhaps to the low incidence of leasing. The point

[32]This is analogous to the effect of expanding market size in stimulating investments in R&D, as modelled by Dasgupta and Stiglitz (1980) for instance. Suppose there is a Cournot oligopoly of water sellers, who first select a level of investment in fixed costs, where higher investments lower the marginal costs of supply. At a second stage, they compete in selling water and earn a margin above marginal costs in equilibrium. A rightward shift in the demand curve for water will stimulate greater investment, and lower the marginal cost and price of water at the second stage.

estimates imply that the impact of the program on growth of farm yields was quantitatively much smaller than the impact of farm input supply programs. This owed to the small scale of the program, related in turn to the low incidence of leasing.

On the other hand, our results support Banerjee *et al* with regard to the benign impact of tenancy reform on farm productivity, though we offer a different and more detailed account of the channels of these impacts. Our quantitative estimate of the effect is somewhat smaller than theirs, for two reasons. One, they were predicting yields at a much higher level of aggregation, therefore included effects of the reforms on composition of farms between different size categories and tenurial status. Second, they did not control for many other programs administered by local governments that were correlated with implementation of Operation Barga. Nevertheless, the measured impact is still statistically significant and robust to alternative data sources, specifications, controls and treatment of possible endogeneity concerns. The low impact of the program relative to other infrastructural and extension services provided by local governments owed partly to the low incidence of tenancy in West Bengal villages.

Our interpretation of the effects of the tenancy reform also differs considerably from earlier literature, which have focused on Marshall-Mill incentive effects alone. We were surprised by the large spillover effects of the reforms to non-tenant farms, reflecting general equilibrium or other spillover effects. Identification of the precise channel of such spillovers is a challenging task: we did not find evidence consistent with a variety of possible channels in the paper. Our ongoing work suggests that induced effects on private investments in groundwater irrigation formed one channel by which these reforms caused productivity improvements to spread to non-tenant farms.

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TABLE 1: VILLAGE CHARACTERISTICS IN SAMPLE VILLAGES, 1978 AND 1998

	1978	1998
Number of households	228	398
Operational land-household ratio (acre/hh)	1.54	0.87
% households landless	47.3	52.3
% households marginal (0–2.5 acres)	35.2	39.1
% households small (2.5–5 acres)	11.2	6.4
% households medium (5–12.5 acres)	4.7	2.0
% households big (12.5– acres)	1.6	0.3
% land small	56.7	73.9
% land medium	23.9	18.5
% land big	19.5	7.6
% poor households low caste	38.3	39.8
% upto small households illiterate	44.1	31.9
% big households illiterate	4.4	3.2
% households in nonagricultural occupation	41.1	51.4
Population-Bank ratio	41.6	23.1

'Poor' household is either landless or marginal landowner

'Upto small' household is either landless, marginal or small landowner

All land information pertains to distribution of cultivable non-*patta* land owned

Source: indirect household survey;
Population-bank ratio from West Bengal Economic Review, various years

TABLE 2: LAND REFORMS		
	1978 Average	1998 Average
% land area appropriated	16.4*	15.3
% land area, titles distributed	1.4	5.4
% households receiving titles	4.9	14.9
% land area, tenancy registration	2.4	6.1
% households registered	3.1	4.4
% tenants registered	43.4	51.2
Average across sample villages, weighted by operational land areas		
Source: Block Land Records Offices for land reforms implemented		
Indirect household survey, for distribution of operational land and tenancy)		
*Only available for 34 villages		

TABLE 3: TRENDS IN PUBLIC SUPPLIES OF AGRI. INPUTS				
	1982	1985	1990	1995
Minikits per household	0.11	0.11	0.08	0.06
IRDP[a] Credit per household	36	29	25	18
Loc. Govt. Irrigation Expenditure[b]	5233	4265	1485	2627
Loc. Govt. Road Expenditure[c]	6470[d]	4501	2501	4572
Loc. Govt. Employment Mandays per household	3.9	3.0	2.2	1.9
Area Irrigated by State Canals (hectares)	72793	72168	79774	84672
State Road Length (Km)	1271	1282	1309	1320
Cumulative % land area, titles distributed	4.5	5.8	6.2	6.3
Cumulative % land area with tenancy registration	1.9	4.2	4.9	5.1
Rows 1–5: Average yearly flow in sample villages, wtd. by land areas				
Rows 6–7: stocks at district level, West Bengal government data				
a: IRDP Credit Subsidy, 1980 prices;				
b,c: Expenditure out of Employment Program Funds, 1980 prices; d: for year 1983				
Source: Block Agricultural Dev. Offices, Lead Banks, Gram Panchayat budgets, West Bengal Economic Review				

TABLE 4: CROPPING PATTERNS AND RETURNS		
	Percent of Total Total Cropped Area Area Devoted	Value Added per acre (1980 prices)
Rice (HYV)	27.5	4137
Rice (non-HYV)	40.0	1925
Potato	3.2	6831
Jute	11.9	3497
Wheat	4.6	1347
Pulses and Vegetables	5.1	2172
Oilseeds	5.9	1808
Tobacco	1.4	3266
Simple Average across sample villages		
Source: Cost of Cultivation Surveys		

TABLE 5: TRENDS IN FARM PRODUCTIVITY, INCOMES, WAGES						
	1982	1985	1986	1990	1991	1995
Cropped Area (acres)*	.99	1.07	.97	1.06	.98	.98
% Rice Area HYV	1.24	7.63	16.54	32.92	45.87	52.70
Rice Value Added per acre	1055	1565	1624	2983	4135	5546
Value Added per acre	703	854	913	1272	1293	1454
Value Added per farm	7613	10915	11223	19070	20553	27349
Hired Labor Wage Rate	.57	.54	.83	.76	.81	.99
Hired Labor Annual Hrs/Acre	180	188	242	279	319	265
Averaged across farms, weighted by cropped areas, excepting *						
All rupee figures deflated by cost of living index, 1974=100						
Source: Cost of Cultivation Surveys						

TABLE 6: TENANCY TRENDS		
YEAR	% FARMS LEASING	% AREA LEASED
1982	2.13	12.98
1983	3.24	10.34
1984	4.41	13.11
1985	3.38	6.94
1986	0.44	1.2
1987	0.44	1.14
1988	1.02	2.26
1989	0.73	0.89
1990	0.43	2.07
1991	1.17	6.54
1992	2.5	10.33
1993	2.35	3.86
1994	2.41	6.31
1995	1.98	4.27

TABLE 7: EFFECT OF INTERVENTIONS ON FARM PRODUCTIVITY (OLS ESTIMATES)

	(1)	(2)	(3)	(4)
Tenant Dummy	-0.049	-	-.053	-
	(.065)		(.056)	
Tenant Dummy*% Land Registered	0.125	-	0.253	-
	(.186)		(.157)	
% Years Tenant*%Land Registered	-	22.635	-	26.641
		(19.272)		(19.547)
% Land Registered	-	-	0.423***	0.423***
			(.128)	(.128)
% Land Titled	-	-	0.187	0.187
			(.121)	(.120)
Minikits per household	-	-	0.494***	0.496***
			(.167)	(.167)
IRDP Credit per household	-	-	0.001**	0.001**
			(.000)	(.000)
Empl. Mandays per household	-	-	0.048	0.048
			(.031)	(.031)
Log Local Govt. Irrigation Exp.	-	-	0.040**	0.040**
			(.012)	(.012)
Log Local Govt. Road Exp.	-	-	-0.015	-0.015
			(.010)	(.010)
Controls	A	A	A,B	A,B
Farm, Year Dummies	Y	Y	Y	Y
Number obs., farms, w-R sq.	2438,631,.08	2438,631,.08	2085,539,.20	2085,539,.20

Dependent variable: Log Farm Value Added per acre

A Controls: Farm acreage and square

B Controls: Rice price, annual rainfall (village); state canals, roads (district level)
All interventions cumulated at village level until previous year

Robust standard errors in parentheses, clustered at village level

***,**,* denote significant at 1,5,10% respectively

TABLE 8: EFFECT OF INTERVENTIONS ON FARM PRODUCTIVITY (IV ESTIMATES)

	Full Sample	Owner-Cultivators Only	Owner-Cultivators Only
	IV	OLS	IV
Tenant Dummy	-0.034	-	-
	(.058)		
Tenant Dummy*% Land Registered	0.224	-	-
	(.182)		
% Land Registered	0.901***	0.432***	0.885***
	(.238)	(.131)	(.257)
% Land Titled	0.104	0.178	0.225
	(.163)	(.148)	(.503)
Minikits per household	0.890***	0.505***	0.878***
	(.239)	(.173)	(.295)
IRDP Credit per household	0.001***	0.001**	0.001***
	(.000)	(.000)	(.000)
Empl. Mandays per household	0.111**	-	-
	(.05)		
Log Local Govt. Irrigation Exp.	0.036*	0.039***	0.034*
	(.019)	(.012)	(.018)
Log Local Govt. Road Exp.	-0.026**	-0.016	-0.025*
	(.010)	(.010)	(.010)
Controls	A,B	A,B	A,B
Farm, Year Dummies	Y	Y	Y
Number obs., farms	2075,534	1993,520	1981,516

Instrumented: %Land Registered, %Land Titles, Minikits and IRDP per hh
First stage F values 2080.4, 26.16, 60.63, 23.71;
p-values 0.00,0.00,0.00,0.00; partial R-sq. .95,.48,.62,.36 respectively

Dependent variable: Log Farm Value Added per acre

A Controls: Farm acreage and square

B Controls: Rice price, annual rainfall (village); state canals, roads (district level)
All interventions cumulated at village level until previous year

Robust standard errors in parentheses, clustered at village level

***,**,* denote significant at 1,5,10% respectively

TABLE 9: EFFECT OF INTERVENTIONS ON VILLAGE PRODUCTIVITY		
	OLS	IV
%Marginal Farms Leasing*% Land Registered	-0.605	1.801
	(5.341)	(5.227)
%Medium Farms Leasing*% Land Registered	1.922*	1.829
	(1.066)	(1.526)
%Large Farms Leasing*% Land Registered	-7.286	-5.674
	(10.230)	(10.850)
% Land Registered	0.385***	0.683***
	(.135)	(.226)
% Land Titled	0.069	0.018
	(.111)	(.169)
Minikits per household	0.397**	0.636***
	(.173)	(.273)
IRDP Credit per household	0.000	0.001
	(.000)	(.000)
Empl. Mandays per household	0.043***	0.093***
	(.026)	(.047)
Log Local Govt. Irrigation Exp.	0.039***	0.035**
	(.013)	(.017)
Log Local Govt. Road Exp.	-0.012	-0.020
	(.012)	(.012)
Controls	B,C	B,C
Farm, Year Dummies	Y	Y
Number obs., villages	261,67	261,67

Marginal Farm: <2.5 acres; Medium Farm: between 2.5 and 5 acres; rest Large Farms

Instrumented in Col. 2: %Land Registered, %Land Titles, Minikits and IRDP per hh

Dependent variable: area wtd. average of log farm value added per acre in each village-year

B Controls: Rice price, annual rainfall (village); state canals, roads (district level)

C Controls: % village area distribution between size classes, and % of each size class leasing in

All interventions cumulated at village level until previous year

Robust standard errors in parentheses, clustered at village level

***,**,* denote significant at 1,5,10% respectively

TABLE 10A: IMPLIED EFFECTS ON FARM PRODUCTIVITY FOR AVERAGE VILLAGE

	WTD MEAN 1982	WTD MEAN 1995	IV COEFF	PRED. IMPACT VA/ACRE
% Land Registered	.019	.051	.714	+5%
Minikits/HH	.11	1.26	.694	+528%
IRDP Credit/HH	36	359	.0012	+144%
Loc. Govt. Irrig. Exp.	4.04	4.74	0.037	+6%

Predicted change of value added per acre implied by estimated coefficients resulting in a hypothetical village from change in concerned program equal to weighted average of observed changes in the entire sample between 1982-95

TABLE 10B: AVERAGE PREDICTED EFFECT (% CHANGE) IN FARM PRODUCTIVITY, DIFFERENT PERIODS

	1981-85	1986-90	1991-1995
% Land Registered	.18	.81	.89
Minikits/HH	428.34	79.64	8.58
IRDP Credit/HH	82.56	17.72	9.91
Loc. Govt. Irrig. Exp.	74.21	3.86	1.39

Average of predicted percent change of value added per acre in sample villages implied by estimated coefficients and actual changes observed in those villages;
Operational land areas used as weights

TABLE 11: COMPARING INPUT ALLOCATIONS IN RICE CULTIVATION BETWEEN LEASED AND OWNED PLOTS				
	HYV Rice		non-HYV Rice	
Leased Dummy	-.21***	-.22	-.06	-.08
	(.08)	(.14)	(.08)	(.17)
Leased Dummy*% Land Registered		.12		-2.52
		(.10)		(3.16)
No. obs., farms	1828,576	1590,496	2234,660	1911,572
Within-R sq.	.031	.037	.06	.08
OLS Regressions; Dependent Variable: Log of Input Expenditures/Value of Output				
All regressions include farm and year dummies				
Robust standard errors in parentheses, clustered at village level				
***,**,* denote significant at 1,5,10% respectively				

TABLE 12: LAND REFORM AND PUBLICLY SUPPLIED INPUTS: DIFFERENTIAL EFFECTS ON SMALL, MARGINAL FARMS

	Log Farm Value Added Per Acre (IV)	Log Farm Value Added Per Acre (IV)
% Land Registered	0.694**	0.681***
	(.263)	(.251)
% Land Registered*Small Farm	0.029	
	(.026)	
% Land Registered*Marginal Farm		-0.021
		0.019)
% Land Titled	0.592	0.542
	(0.631)	(0.437)
% Land Titled*Small Farm	-0.097	
	(0.379)	
% Land Titled*Marginal Farm		-0.085
		(0.189)
Minikits/HH	0.562**	0.608**
	(0.250)	(0.251)
Minikits/HH*Small Farm	0.036	
	(0.028)	
Minikits/HH*Marginal Farm		-0.003
		(0.026)
IRDP Credit/HH	0.001***	0.001**
	(0.00)	(0.001)
IRDP Credit/HH*Small Farm	-0.00	
	(0.00)	
IRDP Credit/HH*Marginal Farm		0.00
		(0.00)

TABLE 12 continued		
	Log Farm Value Added Per Acre (IV)	Log Farm Value Added Per Acre (IV)
(Log) Loc. Govt. Irrigation Exp.	0.029*	0.029**
	(0.014)	(0.015)
LG Irrig Exp*Small Farm	-0.011	
	(0.008)	
LG Irrig Exp*Marginal Farm		-0.016*
		(0.009)
(Log) LG Road Exp.	-0.023	0.019*
	(0.014)	(0.011)
LG Road Exp*Small Farm	0.000	
	(0.011)	
LG Road Exp*Marginal Farm		-0.003
		(0.008)
LG Empl. Mandays/HH	0.208**	0.125**
	(0.081)	(0.052)
Mandays/HH* Small Farm	-0.108	
	(0.081)	
Mandays/HH*Marginal Farm		-0.002
		(0.044)
No. Obs., farms, Within-R sq.	2091,542, .16	2091,542, .17
Small: $<$ 5 acres; Marginal:$<$ 2.5 acres		
Controls: farm,year dummies; A,B (Table 8)		
IV regression, details as in Table 8		
Robust standard errors in parentheses, clustered at village level		
***,**,* denote significant at 1,5,10% respectively		

TABLE 13: IMPACT OF INTERVENTIONS ON CROPPING PATTERNS				
	TOTAL AREA IV	HYV RICE AREA IV	LOCAL RICE AREA IV	POTATO AREA IV
% Land Registered	1.245**	0.738*	0.765**	-0.226**
	(0.523)	(0.382)	(0.366)	(0.110)
% Land Titled	0.225	0.465	-0.622	0.045
	(0.678)	(0.466)	(0.695)	(.196)
Minikits/HH	0.830	0.748**	.125	.264*
	(0.522)	(0.349)	(.455)	(.155)
IRDP Credit/HH	6.2e-4	1.7e-4	1.2e-4	-1.9e-4
	(6.7e-4)	(5.8e-4)	(7.5e-4)	(1.8e-4)
Log Rice Price (real)[b]	0.257	0.175*	-0.056	-0.057
	(0.332)	(0.162)	(.104)	(.046)
Number obs., farms	2071, 539	2099,542	2099, 542	2099, 542
Within-R sq.	.05	.04	.03	.07
b: Deflated using regional CPI for Agricultural Workers				
Other controls in previous tables included				
Robust standard errors in parentheses, clustered at village level				
***,**,* denote significant at 1,5,10% respectively				

TABLE 14: IRRIGATION EXPANSION, BY SOURCE					
Year	Canals	Deep Tubewells	River lift/pond	Shallow Tubewell	Others
1981	5.20	2.81	7.5	7.62	0.45
1982	5.20	2.81	7.45	8.79	0.46
1983	5.21	2.92	7.54	9.03	0.46
1984	5.22	3.08	8.17	10.97	0.46
1985	5.22	3.22	8.67	13.18	0.46
1986	5.27	3.30	9.08	14.09	0.48
1987	5.28	3.42	9.32	14.81	0.48
1988	5.35	3.55	9.43	15.56	0.54
1989	5.4	3.66	9.97	17.01	0.54
1990	5.41	4.05	11.9	19.43	0.55
1991	5.42	4.10	12.09	20.85	0.55
1992	5.45	4.3	12.43	23.22	0.55
1993	5.45	4.35	12.52	24.27	0.56
1994	5.47	4.41	13.44	29.29	0.68
1995	5.82	4.51	14.85	31.39	0.68
Average fraction of cultivable area in sample villages irrigated, by source					
Source: Household Land Survey Data					