COMPETITION AND MARKET POWER IN DEVELOPING MARKETS: EVIDENCE FROM FERTILIZAER MAKRETS IN INDIA*

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Abstract

Can competition promoting policies substitute direct interventions for increasing modern input use in developing countries? In this paper I study the effect of entry by new competitors into a market for agricultural inputs dominated by a former monopoly, during deregulation. I suggest an empirical measure of market share advantage by the former monopolist, based on the notion of captive consumers, and incorporate it into a model of entry in a market for a homogeneous good. I find that the availability of commercial credit promotes entry and reduces the disproportionate market share held by the former monopolist. I use a price deregulation reform which occurred during the period of analysis to identify the effect of entry on variable profits. Results show that entry increases the intensity of competition, but only with the entry of the fourth competitor.

1 Introduction

The availability and the usage of chemical fertilizers is generally considered a major engine of growth for agricultural productivity. It has therefore received the attention of both national policy makers and international development institutions, and is often a subject of heavy regulation and government interventions in developing countries (a useful survey of fertilizer

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policies in several countries appears in Kelly and Crawford (2007)). The development literature focused on the determinants of modern input adoption among farmers in developing agricultural systems. Learning processes and the effect of neighbor behavior in the use of fertilizers have been analyzed (Duflo et. al (2004), Krishnan and Patnam (2014), Foster and Rosenzweig (2010), Conely and Udry (2010), Croppenstedt et. al (2003)), as have different methods of government support in agro-input markets, and their effect on market outcomes (Barker and Hayami 1976, Gulati and Sharma (1995), Xu et al. (2009) and Chirwa et al. (2011)). However, little attention has been given to the role of firm dynamics and market outcomes in determining fertilizer use. Kelly et al. (2003) discussed the effects of various initiatives to provide inputs and credit directly to farmers. They suggest that these efforts often reduce the ability of market development programs to stimulate commercial interest in input supply. In this paper, I focus on patterns of firm competition and resulting market outcomes in Indian Agricultural, the empirical analysis of which is made possible by the availability of new firm level data of fertilizer sales.

In Asia, agricultural growth has been attributed to massive public investment in agricultural research, and fertilizer distribution and supply systems (Desai (1988)). The fertilizer sector in India has indeed been characterized by intense government intervention and market control, including government monopolies in importing and distribution of fertilizer (up until the 1970's) and price controls and subsidies of fertilizer products. The extent to which these policies may have hampered the formation of efficient private markets in fertilizer wholesale remains unanswered. In this paper I study the market for potassium fertilizer, which went through a process of liberalization, starting from the 1970's when new firms received permission to enter the market of importing and distribution of potassium chloride, previously controlled by a single government monopoly. In 2010, during the period of analysis, the sector went through a second stage of liberalization when prices were deregulated. Responding to an increasing burden of fertilizer subsidies, the central government released the maximum retail price previously set by the government to be decided by the firms. It is evident that the monopolistic history of the sector still affects market outcomes even decades after liberalization, as the former monopoly continues to hold dominant market shares in many districts, even when facing competition by an increasing number of firms. The empirical analysis in this paper is designed to study the patterns of competition between new competitors and the historical incumbent, to determine which market characteristics are linked to increased competition and reduced incumbent market power, and test whether increased entry by new firms, where observed, indeed increases the intensity of competition to the benefit of the farmers.

Government monopolies are a common phenomena, not exclusive to the developing world.

Recent decades have seen a reverse tendency, to liberalize and/or privatize previously government controlled sectors. How a history of a government monopoly affects patterns of competition after liberalization is a matter of great interest in the literature, and potentially holds significant implications for market policies. Seim and Waldfogel (2013) study entry patterns in the presence of government control and in its absence in US liqueur stores, concluding that government regulation reduces entry by 2.5 times. Megginson and Netter (2001) survey empirical studies on privatization. A most relevant issue discussed in this literature is post privatization market concentration. Theory provides that in the long run privatization should encourage further entry (Anderson et al. (1997) show this for a differentiated industry). Why then do we often observe post privatization market concentration? Newbery (1995) discussed this phenomena for the case of UK power market. He explains that the duopoly created in the process of privatization had a disproportionate pricing power after privatization, was due to their share in non-baseload plants. Broadman (2000) discusses structural dominance in privatized Russian industries. Among the explanations provided there were corruption, lack of enforcement of private property rights, the dominance of the government in the distribution channels and local authority licensing. Kim and Yoon (2004) discuss determinants of consumer loyalty in the Korean mobile telephony market. Certain product parameters are found to be more important for consumer loyalty than others. Bronnenberg et al. (2009) relate current market share distribution to the historical order of entry, by evaluating the effect of proximity to the brand's city of origin on its current market share. In a similar sense, I attempt to explain the market share advantage by the historical monopoly in the Indian potash market, and relate this advantage to market characteristics. I find that the availability of commercial (vs. state or cooperative) credit sources is related to increased competition and reduced market power by the former monopoly after liberalization. This also extends existing work on the importance of credit availability for farmer productivity (Karlan et al. 2014, Lamb 2003, Cole et al. 2013, Feder et al. (1990), Guirkinger and Boucher (2008)).

To analyze the sources of market share concentration I suggest an empirical measure of market share advantage ($\tilde{\lambda}$) representing the disproportionate market share held by the historical monopoly. The suggested measure is based on the idea of captive consumers and a residual demand equally divided between all competitors, including the incumbent. This measure is preferred to considering market shares alone as it takes into account the number of firms competing. To study the competitive effect of entry by new competitors, I incorporate market share advantage into a static entry model with a homogeneous product and otherwise symmetric firms (as in Bresnahan and Reiss 1991). I add a quantity equation to understand the effect of entry on consumption (similar to the approach in Abraham et al. 2007). To

deal with the endogeneity of market structures, I use the number of firms ordered probit as a selection rule for the quantity equation. The two equations are jointly estimated using a Maximum Likelihood procedure.

To identify the effect of entry on the intensity of competition I take advantage of the price deregulation reform which took place during the period of analysis. I estimate the model once during the fixed-price period and a second time during the market-prices period. Assuming that fixed costs are the same in both periods, and that entry doesn't change variable profits in the fixed price period, I am able to separate out the entry effect on variable profits in the market-prices period. The empirical analysis links entry and reduced market share advantage by the former monopoly to availability of commercial credit (vs. state or cooperative credit), the Regional Rural Banks program aimed to provide credit in agricultural rural areas is found to be the most effective in promoting competition. Both entry and commercial credit are found to increase consumption of potassium fertilizer. Entry is found to increase competition, but only from the fourth entrant, suggesting that market structures with fewer entrants may still accommodate some forms of cartelization. The remainder of the paper is organized as follows: Section 2 provides a brief industry background of the Indian fertilizer sector, Section 3 presents the suggested empirical measure of market share advantage, Section 4 shows the theoretical model and empirical specification, Section 5 presents the data, Section 6 presents results from regular ordered-probit and OLS estimations, Section 7 presents the selection and full model results and section 8 concludes.

2 Industry Background

Chemical fertilizers were introduced in India together with high yield variety (HYV) seeds in the 1950's, starting a period of substantial growth in agricultural production, later referred to as the Green Revolution of India. This growth in productivity allowed India to reach self-sufficiency in its food supply, although evidence is building that insufficient use of the imported potash and phosphate fertilizers has weakened the positive relationship between fertilizer application and output in recent years. The increasing interest in policies promoting balanced fertilization provides further reason to investigate market outcomes in the markets for the different types of fertilizers.

Due to a lack of local natural reserves, potassium chloride is imported into India from global suppliers (mainly from Canada, Russia, Israel, Germany and Jordan). It is repackaged in India and sold under the brands of local fertilizer companies. The fertilizer sector is highly regulated by government policy, with the goal of providing farmers with fertilizers at affordable prices. Historically, the marketing of potash was handled exclusively by a single

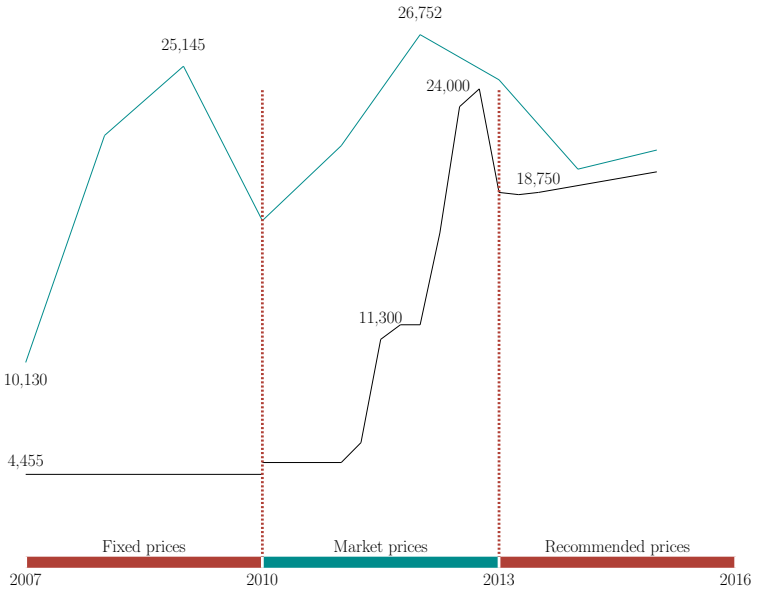
government agency, Indian Potash Supply Agency (IPSA), in which the leading importers of fertilizers acted as shareholders. IPSA was also the only fertilizer company allowed to operate a nation-wide distribution network, while domestic producers (of Nitrogen and mixed fertilizers) were limited to regional markets. In the 1970's IPSA was turned into Indian Potash Limited (IPL). Its ownership structure was reformed to include cooperative and public sector institutions (the largest shareholder today is IFFCO, a large cooperative institution, with 33.99%), and other companies were allowed to enter the potash marketing business.

However the industry was still far from deregulated. In 2007 (the first year in our data) the marketing of potassium and phosphate fertilizers was handled by the private sector (and a few government and cooperative sector companies), but maximum retail prices (effectively fixed prices) were still fixed by the government at the country level, and firms were eligible for subsidies per quantity sold. Only in 2010, in a step called the Nutrient Based Subsidy (NBS) policy, were potassium and phosphate fertilizer prices deregulated and allowed to be set by the companies. In 2013 the government reinstalled some measure of price intervention, by publishing recommended prices with a threat to withhold subsidies from companies presenting higher prices. Kharif[1] 2007 and Kharif 2012 were therefore chosen to represent a period with government controlled prices (the earliest in the data) and a period with competitive prices (the latest prior to the recommended prices), respectively. Throughout the period, supply of nitrogen fertilizer remained entirely regulated, and all prices and margins are still set by the government to date. Figure 1 presents average prices of potassium chloride before and after deregulation, capturing the significant increase in prices in the after period. The graph also presents the international price of potash. After deregulation the local price converged to follow the import price more closely.

Figure 2 presents the changes in market structure in the different Indian districts following the price deregulation. In 2007 when the government maximum retail price policy effectively kept prices low, high levels of competition are observed nearly only in close proximity to international ports. The high costs of transportation in this market explains this pattern from the supply side. After price deregulation, in 2012 we see more districts with a larger number of active firms and significantly fewer districts with less than two firms. The new areas with high numbers of competitors are mostly in the north and center-west of the country, in proximity to production locations of the nitrogen and phosphate fertilizers, and the natural resource deposits that serve as inputs to this industry. Since Potassium is entirely imported from foreign producers, the proximity to the local industry is interpreted as a proxy for a fertilizer distribution network already in place for marketing the other types

[1]Kharif is the main (monsoon) agricultural season in India, running roughly between April and October, which is the first half of the Indian financial year.

Figure 1: Regulation Time-Line and Prices



The blue line on top plots the import price of potassium chloride in Indian rupees per ton (source: comtrade.un.org) , the black line plots the average retail price of potash for Indian farmers (source: department of fertilizers, GOI).

of fertilizers, affecting the fixed cost encountered by new competitors entering the Potash marketing business.

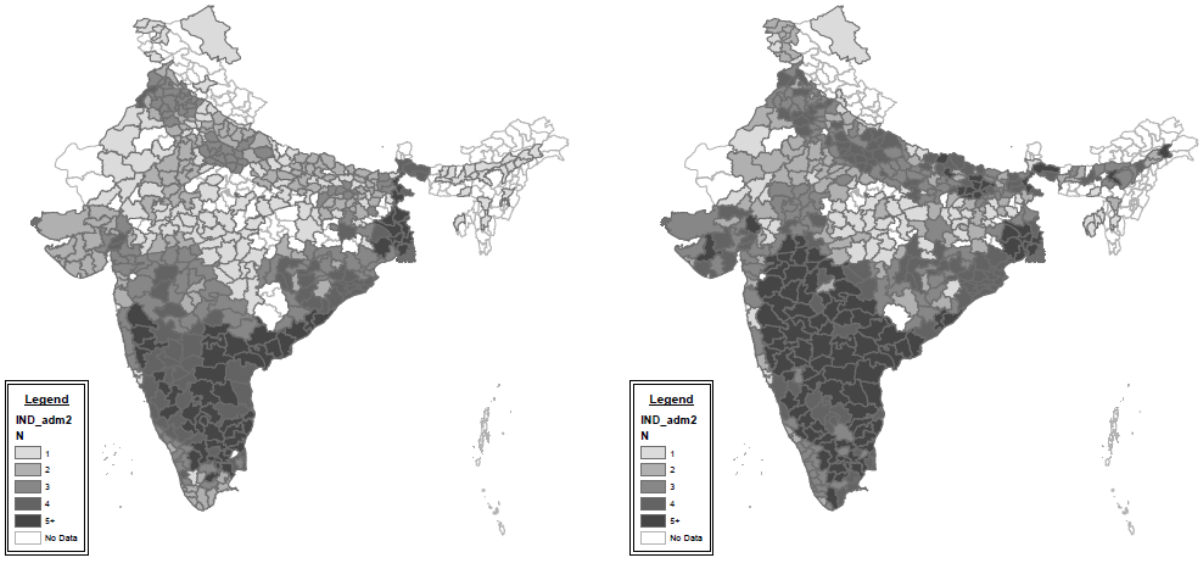
Indian fertilizer companies both produce and sell imported fertilizers[2] through their wholesale dealer networks spread across multiple districts and states. Farmers buy the products from retailers located in the rural areas. To finance agricultural inputs, farmers rely on locally available credit from cooperative banks and credit societies, commercial banks, government programs and the retailers themselves. One of the larger cooperative institutions in India is IFFCO (Indian Farmers Fertilizer Cooperative Ltd.). This characteristic of the market will be an important factor in my explanation of the former monopoly advantage.

The companies that are active in the potassium fertilizer market[3], besides IPL, are a mix of state-government and private enterprises. Most players are also producers of other types of fertilizers, and are multi-market competitors selling potassium in many districts and even multiple states (see tables 1 and 2). In 2012-2013 the number of private companies as apposed to public or cooperative companies increased. IPL holds a dominant market share

[2]Indian companies produce around 60% of the Nitrogen fertilizer (urea) used in India, and about 10% of Phosphate fertilizer.

[3]I focus on Potassium Chloride (also called Muriate of Potash), and do not include any mixed fertilizers which contain combinations of the different NPK nutrients in different levels.

Figure 2: Number of Potash Marketing Firms (Kharif 2007, Kharif 2012)



Source of data: Fertilizer Monitoring System (FMS), by the Department of Fertilizers in the Ministry of Chemicals, Petrochemicals and Fertilizers, GOI.

in a large share of the markets (71% on average in 2007-2008 and 61% in 2012-2013) and is active in almost all of the markets (the number of markets with positive sales where IPL is not active is between 2 and 9 markets in the different periods). When considering the market shares of IPL in 2007-08 versus 2012-13 (see Figure 3), we see that after deregulation there are many fewer markets where IPL holds the entire market, and the whole density is generally shifted to the left. Although some heterogeneity exists between the market shares of the firms competing against IPL, it appears that the heterogeneity in the number of firms competing against IPL and in the market share captured by this "fringe" are of first order interest. For this reason, I will assume for now that all of the firms except IPL are homogeneous, and leave the competition dynamics between the new entrants as a matter for future research.

Table 1: Firms in the Potash Marketing Sector, Kharif 2007-2008

Company	States	Ditricts	Market share (mean)	Type	Produced Products
IPL	25	422	71%	Mixed	-
TCL	8	126	33%	Private	DAP, Urea, Complex
CFCL	6	77	25%	Private	Urea
ZIL	5	69	20%	Private	DAP, Urea, Complex
PPL	6	76	18%	Private	DAP, Complex
RCF	13	153	17%	Public	Urea, Complex
CFL	6	72	12%	Private	DAP, Complex
IFFCO	2	38	11%	Cooperative	DAP, Urea, Complex
MCFL	4	52	10%	Private	DAP, Urea, Complex
GNVFC	5	55	7%	Public	Urea, Complex
FACT	2	18	4%	Private	Complex
GFCL	1	7	4%	Mixed	DAP
DFPCL	1	1	3%	Private	Complex
TFCL	2	7	2%	Private	Phosphate, Complex

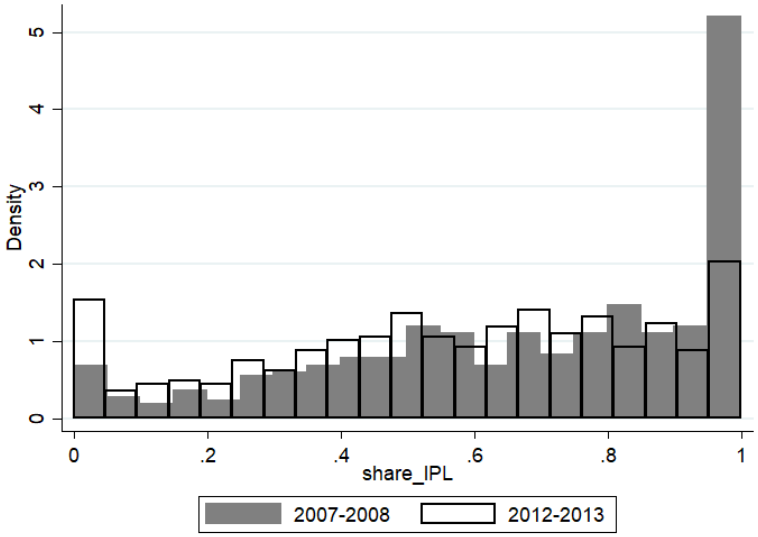
Market shares are calculated among markets with positive sales. Source of production data: Department of Fertilizers, GOI.

Table 2: Firms in the Potash Marketing Sector, Kharif 2012-2013

Company	States	Ditricts	Market share (mean)	Type	Produced Products
IPL	23	444	61%	Mixed	-
TCL	4	33	32%	Private	DAP, Urea, Complex
IGF	3	82	25%	Private	Urea
CFCL	8	137	24%	Private	Urea
SFC	7	108	23%	Private	Urea
ZIL	7	91	20%	Private	DAP, Urea, Complex
PPL	9	134	17%	Private	DAP, Complex
NFCL	6	104	14%	Private	Urea
DFPCL	5	53	14%	Private	Complex
FACT	4	54	13%	Private	Complex
CFL	14	139	13%	Private	DAP, Complex
RCF	9	112	13%	Public	Urea, Complex
MCFL	5	83	13%	Private	DAP, Urea, Complex
GNVFC	4	31	6%	Public	Urea, Complex

Market shares are calculated among markets with positive sales. Source of production data: Department of Fertilizers, GOI.

Figure 3: IPL Market Share (Kharif 2007, Kharif 2012)



3 An empirical measure of market share advantage $\tilde{\lambda}$

How should one measure the market share advantage held by the incumbent? Using the firm's market share provides limited information. A 50% market share might be reasonable in a market with two firms, but would tell a different story in a market with five competing firms. An HHI index provides additional information on the variance between the market shares of the different firms, but it is harder to connect to a theoretical market model. I suggest an empirical measure which is simple to calculate using market shares and the number of firms operating in the market, and can also be related to a model of captive demand.

Think of a demand function for a homogeneous good proportional to market size:

$$Q = d(P, X) \cdot S$$

Q is aggregate demand, d is per-capita demand, P are prices, X are demand shifters and S is the market size. Now assume there is a share of the consumers, λ, which is captive to the historical monopoly. This notion can be motivated by different explanations, such as control of the incumbent over some of the retailing networks, infrastructure, or credit sources offered to the buyers. Next, assume that the rest of the demand is symmetrically divided between the firms operating in the market. The market share of the former monopoly consists of the

captive demand and a symmetric proportion from the residual demand:

$$s^{FM} = \lambda + (1 - \lambda)\frac{1}{N}$$

and the market share of any other firm $j \neq FM$ is a symmetric proportion from the residual demand:

$$s_j = (1 - \lambda)\frac{1}{N}$$

For $N = 1$ the market share of the former monopoly is 1. As the number of firms tends to infinity, the market share of the former monopoly tends to λ, and the market share of all other firms tends to zero. In the equation for the market share of the incumbent, two variables are directly observed: the number of firms and the market share of the former monopoly. It is then simple to derive the empirical counterpart of λ, $\tilde{\lambda}$, which can be calculated from the observed variables:

$$\tilde{\lambda} = \frac{s^{FM} - \frac{1}{N}}{1 - \frac{1}{N}}$$

$\tilde{\lambda}$ can be calculated for any market with at least two firms. It can be negative, if the market share of the former monopoly is smaller than the symmetrical outcome $\frac{1}{N}$. $\tilde{\lambda}$ equals zero if the former monopoly market share is exactly the symmetrical outcome, and takes a positive value if the s^{FM} is larger than $\frac{1}{N}$. When N tends to infinity, the symmetrical outcome tends to zero and any positive market share is interpreted as captive consumers (λ tends to s^{FM}). In our sample of firms, the majority of the markets have a positive $\tilde{\lambda}$, consistent with the captive consumers hypothesis, while around 8-11% of the markets have a negative $\tilde{\lambda}$.

Table 3: Number of Markets with Positive and Negative $\tilde{\lambda}$

	$\tilde{\lambda} > 0$	$\tilde{\lambda} < 0$
2007-2008	525	42
2012-2013	492	64

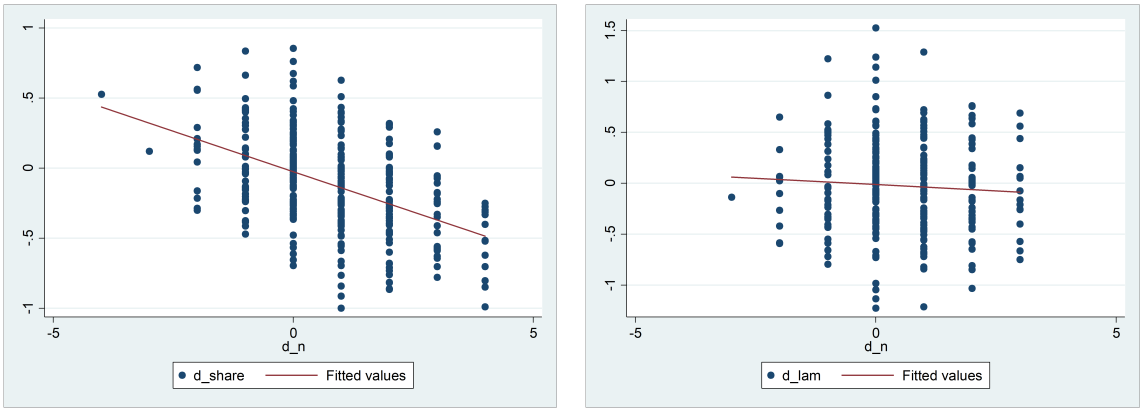
Compare $\tilde{\lambda}$ to the measure used in Jeanjean and Houngbonon (2017). They define the degree of (firm specific) market share asymmetry as:

$$\Delta_i = s_i - \frac{1}{N}$$

which is the numerator of our $\tilde{\lambda}$. This measure has some similar mathematical properties

to our measure: it is negative when $\tilde{\lambda}$ is negative, and is also bounded by the firm's market share from above as we increase N. However, our $\tilde{\lambda}$ is always bounded between 0 and 1, so long as the former monopoly is indeed dominant, whereas Jeanjean and and Hougbonon's measure's upper bound is increasing in the number of firms (from 0.5 for $N = 2$ to 1 as N goes to infinity). As I mean to model λ as a function of various determinants and as it will, in part, determine the number of firms, it is important it not be a priori bounded in this way. Moreover, the two measures carry a different interpretation for intermediate values. Assume $N = 2$ and $s^{FM} = 3/4$; In this case the asymmetry measure takes the value of 0.25 which just means that, empirically, the actual market share missed the symmetrical outcome by 0.25. At the same time $\tilde{\lambda} = 0.5$, which means that assuming a model of captive consumers, we can say that 0.5 of the consumer population is captive to the former monopoly, while the rest of the market is symmetrically divided between the firms.

Figure 4: The change in the IPL market share and in $\tilde{\lambda}$ on the change in N



(a) Δs^{IPL} on ΔN

(b) $\Delta\tilde{\lambda}$ on ΔN

The change in the market share of the former monopoly is plotted against the change in the number of firms, both defined at the district level as the change between Kharif 2007 and Kharif 2012. While the IPL market share on average drops with the number of competitors, its disproportionate market share as caputred by $\tilde{\lambda}$ does not follow the same pattern.

In the empirical application I assume λ is determined exogenously with regard to the market structure and market outcomes. I will allow it to depend on specific market characteristics (e.g. types of available credit). Following from this, λ itself is not expected to systematically change with the number of firms. In contrast, the market share of the former monopoly, $s^{FM} = \lambda + (1 - \lambda)/N$ is expected to decrease with the number of firms. This is because, given some λ, the more firms enter the market, the smaller the share that each firm captures from the part of the market divided symmetrically (and this is illustrated in the example in the previous section). Using the data at hand, I can examine these relationships.

Comparing the same markets between 2007 and 2012, I regressed the change in the number of firms on the change in market share, and then on the change in the empirical counterpart of λ. Figure 4 plots these changes and the fitted regression lines. Indeed, the market share presents a significant negative relationship with the number of firms, while $\tilde{\lambda}$ does not.

4 Model

Assume fixed average variable costs AVC and fixed costs F, then average variable profits are:

$$V = P - AVC(W)$$

Fixed costs are allowed to vary with the number of firms, as in Bresnahan and Reiss (1991). In the fertilizer wholesale sector this can reflect the necessity to invest in constructing a dealer network while first entering a new market. This might be more difficult for later entrants, if local dealers show some level of loyalty to incumbent firms.[4]

$$F_N = F(W, N) \tag{1}$$

In equilibrium, both demand and variable profits depend on equilibrium prices P. Under the market prices regime, prices will be a function of the number of firms in the market (depending on the intensity of competition), demand and cost shifters.

$$P_N = P(X, W, \theta_N) \tag{2}$$

Prices are expected to rise with variables in X, W which increase demand or costs. Under the regulated regime, prices are set by the government, so $P_N = \bar{P}$. I can then write the equilibrium values of total quantity sold, fixed costs and variable profits:

$$d_N = d(P_N, X) \tag{3}$$

$$V_N = P_N - AVC(W) \tag{4}$$

[4]This is very similar to the notion Abraham et. al present for the US hospital market, on the need for a new hospital to build a cadre of referring physicians.

4.1 Entry

A firm will enter a market if entry entails non-negative profits. Following are the profits obtained by the historical monopoly when it is the only firm in the market[5], and by a marginal firm in a market with $N > 1$ firms:

$$\Pi_1 = d_1 \cdot S \cdot V_1 - F_1 \tag{5}$$

$$\Pi_N = \left[\frac{1}{N}(1-\lambda)\right] d_N \cdot S \cdot V_N - F_N \tag{6}$$

The per-firm minimum market size is then:

$$s_1 = S_1 = \frac{F_1}{V_1 \cdot d_1} \tag{7}$$

$$s_n = \frac{S_N}{N} = \frac{F_N}{(1-\lambda) d_N \cdot V_N} \tag{8}$$

λ does not enter the monopoly entry threshold, but it makes subsequent entry thresholds higher, which means that a larger population is necessary to support any market structure except for a monopoly. The entry threshold ratios, representing the rate at which variable profits change with the number of entrants, are:

$$\frac{s_2}{s_1} = \frac{F_2}{F_1} \cdot \frac{V_1 \cdot d_1}{(1-\lambda) V_2 \cdot d_2} \tag{9}$$

$$\frac{s_N}{s_{N-1}} = \frac{F_N}{F_{N-1}} \cdot \frac{V_{N-1} \cdot d_{N-1}}{V_N \cdot d_N} \tag{10}$$

The entry threshold ratio is the product of the change in the fixed costs with subsequent entrants, and the change in per-capita variable profits. Per-capita profits are a combination of the change in per-capita quantities and profit margins. If competition increases with entry $\frac{d_{N-1}}{d_N}$ should be larger than one, and $\frac{V_{N-1}}{V_N}$ should be smaller than one (consistent with lower equilibrium prices). Although threshold ratios are identified, it is not possible to separate out the change in fixed costs in this framework. The contribution of Abraham et al., which I follow in my analysis, is using quantity data to identify the competitive effect on quantity, $\frac{d_{N-1}}{d_N}$. Then, assuming the effect of entry on fixed costs is the same before and after the price deregulation, and that there is no effect on per potential-consumer variable profits when

[5] I assume that any market with 1 firm, the monopolist is the historical monopoly. Empirically, the number of markets that defy this rule is negligible.

prices are fixed, I can separate out the entry effect on variable profits by estimating the model for these two periods.

The empirical analysis will focus on three central outcome variables, as prescribed by the data available and the salient features of the industry: The total quantity sold, the market share of the historical monopoly and the number of active firms. Therefore, the model contains three outcome equations:

$$Q = d(P, X) \cdot S(Y) \tag{11}$$

$$s^{FM} = \frac{q^{IPL}}{Q} = \lambda + \frac{1}{N}(1 - \lambda) \tag{12}$$

$$\Pi_N = \begin{cases} d_N \cdot S \cdot V_N - F_N & \text{, if} \quad N = 1 \\ \\ \frac{1}{N}(1 - \lambda) \cdot d_N \cdot S \cdot V_N - F_N & \text{, if} \quad N > 1 \end{cases}$$

Π_N is a latent variable, unobserved by us. For estimation, I parametrize the functional forms with exponents of linear expressions, as in Abraham et. al 2007. This form provides simple exposition for the full model and a straightforward discussion of identification:[6]

$$S(Y) = \exp(Y\gamma + \varepsilon_S) \tag{13}$$

$$d_N = \exp(X\beta_X + W\beta_W + \beta_N + \varepsilon_d) \tag{14}$$

$$V_N = \exp(X\alpha_X + W\alpha_W - \alpha_N + \varepsilon_V) \tag{15}$$

$$F_N = \exp(W\delta_W - \delta_N + \varepsilon_F) \tag{16}$$

$$\lambda = 1 - \exp(Z\eta_Z + \varepsilon_\lambda) \tag{17}$$

β_N, α_N and δ_N are number of firms dummy variables. They represent the effect of entry on per-capita demand and variable profits (through changes in prices), which are expected to be negative and positive, respectively, and the effect of entry on fixed costs (expected to be positive). Z contains other variables affecting the advantage for the former monopoly, specifically cooperative credit sources, cooperative dealers, and institutional consumers. Then, the

[6] Bresnahan and Reiss (1991) instead employ a linear parametrization.

condition for the N^{th} firm to enter the market (for $N > 1$), $\Pi_N > 0$, becomes:

$$Z\mu_Z + Y\gamma + X\mu_X + W\mu_W + \varepsilon_\Pi > \mu_N \tag{18}$$

where $\mu_Z = \eta_Z$, $\mu_X = \beta_X + \alpha_X$, $\mu_W = \beta_W + \alpha_W - \delta_W$, $\mu_N = \alpha_N - \delta_N + \ln N - \beta_N$, and $\varepsilon_\Pi = \varepsilon_\lambda + \varepsilon_d + \varepsilon_V - \varepsilon_F$. In monopoly markets where the distinction between captive and non-captive buyers is moot, the entry condition for the monopolist is:

$$Y\gamma + X\mu_X + W\mu_W + \varepsilon_\Pi > \mu_1 \tag{19}$$

where $\mu_1 = \alpha_1 - \delta_1 - \beta_1$, and $\varepsilon_\Pi = \varepsilon_\lambda\varepsilon_d + \varepsilon_s + \varepsilon_V - \varepsilon_F$. Assuming standard normal distributions for all the error terms, the combination of the two entry equations yields an ordered probit-like form. The only deviation from the standard ordered probit is that the variables included in Z do not enter in the entry condition for the first entrant. The quantity equation takes the linear form:

$$\ln Q_N = Y\gamma + X\beta_X + W\beta_W + \beta_N + \varepsilon_Q \tag{20}$$

where $\varepsilon_Q = \varepsilon_d + \varepsilon_S$, and the competitors' market share equation:

$$\ln\left(\frac{1}{N}\right) + \ln(1-\lambda) = Z\eta_Z + \varepsilon_\lambda \tag{21}$$

The quantity equation suffers from both endogeneity and selection bias. To deal with this, I use the number of firms equation as a selection rule for the quantity equation.

4.2 Identification

4.2.1 The entry effect on quantity

The quantity equation suffers both from selection bias, since only markets with positive sales are included, and from endogeneity - due to the number-of-firms dummies appearing on its right hand side. The solution to both of these issues is to estimate the two equations together, using the entry ordered probit as a selection equation for the number of firms in the market. For the selection restriction I use the distance from the production locations of nitrogen and phosphate fertilizers and the distance from natural deposits of oil and phosphates, used in the production process of those fertilizers. These distances proxy for an existing fertilizer retail network in the area, affecting the fixed cost encountered when entering the business of marketing Potash. To recall, all potash fertilizer is imported into India and not locally produced.

4.2.2 The combined entry effect on variable profits and fixed costs

We can see that from the number of firms ordered probit, only $(\alpha_N - \beta_N - \delta_N)$,$(\beta_X + \alpha_X)$ and $(\beta_W - \delta_W + \alpha_W)$ are identified. The quantity equation identifies β_X, β_W and β_N, so I can additionally obtain α_X, $(\delta_W + \alpha_W)$ and $(\alpha_N - \delta_N)$. This is the same as in Abraham et al. 2007: by adding the quantity equation I can obtain the effect of entry on quantity (β_N), and conclude whether entry has an effect on competition, since a positive response on the demand side to entry implies a downward shift in prices (assuming the good is homogenous); However, this effect can't be quantified. I can further obtain a measure for the combined effect of entry on variable profits and fixed cost, but cannot separate the two.

4.2.3 The competitive effect of entry

However, taking advantage of the change in the price regime, combined with the information from the quantity equation, I can obtain additional information. I can decompose the entry threshold ratios into the different components. The entry threshold ratio is:

$$\frac{s_N}{s_{N-1}} = \frac{F_N}{F_{N-1}} \cdot \frac{V_{N-1}}{V_N} \cdot \frac{d_{N-1}}{d_N} \tag{22}$$

I can derive the entry effect on per-capita demand, $\frac{d_{N-1}}{d_N}$, from the market structure fixed effects in the quantity equation. I assume that under the fixed price regime, $\frac{V_{N-1}}{V_N} = 1$ (since there is no price effect of entry and average variable costs are assumed to be constant), and that the effect of entry on fixed costs is the same in both regimes. Notice that I allow an effect of entry on the per-capita demand, even though prices are fixed. Although using a homogeneous good framework, here I allow the notion that the product may not be completely homogeneous. As actual markets may be smaller than markets as defined here, perhaps at the village or sub-district level, location of new products within a district (unobserved by us) can change the size of the market and affect buyers' choices. This suggests a Hoteling type product heterogeneity.

Now I can easily derive the entry effect on variable costs under market prices, and the entry effect on fixed costs.

4.3 Distributional Assumptions and Likelihood

The selection model consists of two equation, the quantity equation and the number of firms equation which will be used as the selection rule. For brevity I will use a concise representation, let $\widetilde{x\beta}$ stand for $Z\mu_Z + X\mu_X + W\mu_W$ and $\widetilde{z\delta}$ stand for $X\beta_X + W\beta_W$. Then the quantity equation can be written as:

$$\ln Q_N = \widetilde{z\delta} + Y\gamma + \beta_N + \varepsilon_Q \tag{23}$$

And the number of firms equation which will be used as the selection rule:

$$\widetilde{x\beta} + Y\gamma + \varepsilon_\Pi > \mu_N$$

Quantity is observed only if the number of firms is positive, which causes a sample selection bias, as in Heckman (1979). In addition, the market structure dummy variables in the quantity equation are endogenous. To treat both of these obstacles, I use the number of firms ordered Probit as a selection rule for the number of firms that enter into the quantity equation. Assuming ε_π is standard normal and that ε_Q is normally distributed with mean 0 and variance σ^2, with a correlation coefficient between the two terms ρ:

$$\begin{pmatrix} \varepsilon_\pi \\ \varepsilon_Q \end{pmatrix} \sim N\left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 & \rho\sigma \\ \rho\sigma & \sigma^2 \end{pmatrix} \right) \tag{24}$$

then, the conditional distribution of ε_π given ε_Q is:

$$(\varepsilon_\pi | \varepsilon_Q) \sim N\left(\frac{\rho \cdot \varepsilon_Q}{\sigma}, \quad 1 - \rho^2 \right) \tag{25}$$

The likelihood of observing one district with $N_i > 0$ firms and log-quantity lnQ_i can be written as the conditional probability of observing N_i given lnQ_i times the probability of observing lnQ_i:

$$\begin{gathered} L(N_i, lnQ_i | \widetilde{x_i\beta}, \widetilde{z_i\delta}, Y_i, \gamma, \mu_{N_i}, \mu_{N_i+1}, \sigma, \rho) = \\ L(N_i | lnQ_i, \widetilde{x_i\beta}, \widetilde{z_i\delta}, Y_i, \gamma, \mu_{N_i}, \mu_{N_i+1}, \sigma, \rho) \cdot L(lnQi | \widetilde{z_i\delta}, Y_i, \gamma, \sigma) = \\ = \tfrac{1}{\sigma}\phi(t_i) \cdot \left[\Phi\left(\tfrac{\mu_{N_i+1} - \widetilde{x_i\beta} - Y_i\gamma - \rho t_i}{\sqrt{(1-\rho^2)}} \right) - \Phi\left(\tfrac{\mu_{N_i} - \widetilde{x_i\beta} - Y_i\gamma - \rho t_i}{\sqrt{(1-\rho^2)}} \right) \right] \end{gathered} \tag{26}$$

where $t_i = \left(\frac{lnQ_i - \widetilde{z_i\delta} - Y_i\gamma - \beta_N}{\sigma_Q} \right)$. Taking logs and summing across all of the observations yields the log-likelihood function to be maximized. This derivation of the likelihood function is similar to the one in Chiburis & Lockshin (2007), who also present an estimation procedure for a linear equation with an ordered Probit selection rule. They assume the coefficients in the linear equation are different for each category defined by the ordered Probit. This assumption is not helpful in estimating our model so it is not used here. To incorporate the effect of λ only for markets with at least two firms, markets with less than two firms will have the same likelihood contribution as written above, only with $\widetilde{x_i\beta} = X\beta_X + W\beta_W$.

4.4 Entry thresholds

Following an ordered Probit estimation, I can calculate the Bresnahan and Reiss entry thresholds, i.e. the minimum market size necessary to support each market structure. I will write the condition for at least n firms to profitably enter a market. To deal with the random shock element in the ordered Probit, I will state that: The minimum size of population necessary to support a market structure is such that sets the probability to observe at least n firms to be at least one half.

$$\text{Prob(at least n firms)} = \text{Prob}(\widetilde{x\beta} + Y\gamma + \varepsilon_\pi > \mu_n) \tag{27}$$

$$= \text{Prob}(\varepsilon_\pi > \mu_n - \widetilde{x\beta} - Y\gamma) = 1 - \Phi(\mu_n - \widetilde{x\beta} - Y\gamma) \geq 0.5$$

Let $Y = \ln(s)$, then:

$$\Phi(\mu_n - \widetilde{x\beta} - \gamma \cdot \ln(s)) \leq 0.5 \tag{28}$$

$$\mu_n - \widetilde{x\beta} - \gamma \ln(s) \leq 0.6915$$

$$\ln(s) \geq \frac{\mu_n - \widetilde{x\beta} - 0.6915}{\gamma}$$

$$S_n = \exp\left(\frac{\mu_n - \widetilde{x\beta} - 0.6915}{\gamma}\right)$$

$$s_n = \frac{S_n}{n} = \frac{1}{n}\exp\left(\frac{\mu_n - \widetilde{x\beta} - 0.6915}{\gamma}\right)$$

Notice, that while s_n is a function of the other covariates (x) (and can therefore be calculated only by using their mean values, as in Abraham et al. (2007)), the same is not true for the entry threshold ratios:

$$\frac{s_{n+1}}{s_n} = \frac{n}{n+1}\exp\left(\frac{\mu_{n+1} - \mu_n}{\gamma}\right) \tag{29}$$

This ratio also does not depend on the arbitrary 0.5 threshold on the probability.

5 Data

The main source of data for the empirical analysis presented here is the Indian government Fertilizer Monitoring System (FMS) portal. Since fertilizer importers and producers receive subsidy reimbursements on the basis of actual sales, the government maintains information on the sales of fertilizer products from the sales points at the district level. Our estimation uses total sales in the main agricultural season, $Kharif$ which spans April through October of each year. I use data from two years: 2007-2008 and 2012-2013.[7] A more dynamic approach might be of interest given the available time series data; however as additional information would be necessary to identify sunk costs (by separating actual sales from market presence), I don't take this route in the current paper. Instead I focus on two years, one during the government fixed prices period, and one after the price deregulation.

5.1 The product

I look at sales of Muriate of Potash (MOP), also known as Potassium Chloride or simply Potash. MOP is a straight Potassium fertilizer (meaning it does not include any of the two other fertilizer nutrients, Phosphate and Nitrogen). The whole supply of MOP in India is imported from international producers, and marketed locally under the brands of local fertilizer companies. Some care needs to be taken here, as MOP is also used in the local production of some mixed fertilizers. However the majority of Potash consumed in India is through MOP, 77% in 2010 (Kinekar (2011)), so I chose to ignore the sales of potash through complex fertilizers in this analysis. Another aspect I ignore by focusing on the market for MOP is the complex complementarity-substitution relationships in the input choices of the different types of nutrients.[8]

5.2 Market definition

The market definition relies both on the available data and on the sector characteristics. The unit of analysis will be an Indian district; India had 604 districts in the 2011 census of India. The districts are a complete division of the country's territory, so I do not have isolated markets as in Bresnahan and Reiss (1991), which ensures that there is no competition between markets. However, demand in the fertilizer sector is highly localized, as farmers do not tend to travel outside their village to purchase fertilizers, let alone the district, making

[7] The financial year in India begins in April and ends in March, so the Kharif season of the year 2007-2008 is April 2007 through October 2007.

[8] I address this topic to some degree in Chapter 2, dealing with farmer fertilization practices.

the markets as defined here generally 'self-contained'. A more relevant concern is sub-markets existing within our defined markets, as some districts are very large.[9] However, this is consistent with the idea of sub-populations who might not have access or information with regard to the full set of competing brands. If the 'true' market is the village, then the definition of a market at the district level in effect includes may such smaller markets. Conditions specific to these local markets, such as accessibility to credit and the product set (and credit) offered in the retail outlets, will define local demand for the competing brands. Consequently, a portion of the district may be entirely excluded from purchasing specific brands.

5.3 Credit Constraints and Brand Choice-Sets

The Indian agricultural sector is characterized by a large proportion of small and budget constrained farmers (Karlan et al. 2014, Lamb 2003, Cole et al. 2013). This makes the availability of agricultural credit to farmers a prerequisite for the successful retailing of agricultural inputs. Rural credit sources are particularly important in the marketing of fertilizers as their application is necessary quite early in the production process. Narayanan (2016) related a 1.7% of increase in fertilizer application to a 10% increase in credit flow at the state level. The availability of local credit sources can potentially affect the outcomes in the markets for fertilizers not only by helping farmers finance their input purchases, but also by making funding available to retailers for their trading activities. However, the availability of credit sources can also have an indirect competitive effect, by defining the choice set of stores and brands available to farmers.

The non-institutional sources of credit are an important source of rural credit in India, accounting for around 30% of total credit in the 1990's (after gradually dropping from almost 93% in 1951) (Mohan 2006). These comprise credit from money lenders, usually at a very high interest rate, credit from traders, landlords and commission agents, for which future produce is used as collateral, and credit from family members – usually to meet personal expenditures. Government policy on agricultural credit has been to promote the institutionalization of the credit sources, and improve the availability of banking services to small and remote farmers (Hoda and Prerena 2015). Within the institutionalized banking system, the rural cooperative credit institutions are the oldest and most extensive form of rural credit in India. The cooperative system provides short-term credit through Primary Agricultural Credit Societies at the village level, District and State Cooperative Banks. Long term credit is made available through primary and state level Cooperative Agriculture and

[9] and also include urban populations which are not relevant for our study.

Table 4: Variable names and definitions

Variable	Description	Source
N	The number of firms selling in the district	FMS
lnQ	Ln of the total quantity sold in the district (measured in kg)	"
ln_no_lam	$\ln(1-\tilde{\lambda})$	calculated
Total area (ln)	Ln of total area of agricultural holdings in the district	Agricultural Census, rounds 2005-06, 2010-11
Average plot size	Average size of agricultural holdings	"
rice_irrig	Share of area under irrigated rice	"
rice_nirrig	Share of area under rain-fed rice	"
wheat_irrig	Share of area under irrigated wheat	"
wheat_nirrig	Share of area under rain-fed wheat	"
rice	Share of area under rice	"
wheat	Share of area under wheat	"
institutional	Share of area under institutional holdings	"
Distance from port	Distance from district centroid to nearest port	
Distance from plant	Distance from district centroid to nearest fertilizer plant	
Distance from deposits	Distance from from district centroid to oil and phosphate deposits	
Nationalised banks	Number of branches belonging to nationalized banks	
Regional rural banks	Number of branches belonging to Regional Rural banks	
State bank of India and assoc.	Number of branches belonging to State Bank of India and its associates	
Cooperative banks	Number of villages with a cooperative bank (weighted by village population)	Village Directory in the Census of India, rounds 2005-2006, 2010-2011
Agricultural credit societies (coop.)	Number of villages with an agricultural credit society (weighted by village population)	"
Commercial banks	Number of villages with a commercial bank (weighted by village population)	"
Rail facilities		"
IFFCO retail network		FMS

Rural Development Banks.

Table 5: Commercial Credit - Total Bank Branches in Rural Areas

Bank Group	2007	2012
Nationalized Banks	11,929	14,333
Regional Rural Banks	3,978	6,698
SBI and its associates	3,487	4,902
Old Private Sector Banks	505	689
New Private Sector Banks	99	563
Other Public-Sector Banks	44	82
Local Area Banks	5	5
Small Finance Banks	5	8
Foreign Banks	0	4

Source: https://dbie.rbi.org.in

Table 6: Cooperative Credit - Number of Villages with Available Cooperative Credit

Type	2007	2012
Agricultural Credit Societies	47,625	32,137
Cooperative Banks	10,589	11,308

The village directory of the census rounds 2005-06, 2010-11

The main forms of non-cooperative agricultural credit are scheduled commercial banks, and Regional Rural Banks (RRB's). In order to expand institutional credit to the agricultural sector, the government nationalized 14 commercial banks in 1969, and 6 more in 1980. In 1975 the government established the Regional Rural Banks network, specifically to provide credit in the rural areas. In 1982 NABARD (The National Bank for Agriculture and Rural Development) was established, to promote agricultural credit in the national level and provide financial assistance to rural financial institutions.

Several local surveys have been conducted to uncover the determinants of farmers' store choices and brand purchase decisions of agricultural inputs such as fertilizers and pesticides (Pingali and Kaundiya (2014) provide a survey of these studies). When seeking information on the purchase of inputs it appears that farmers rely heavily on personal past experience, then on fellow farmers, and then on the store selling agri-inputs (Franklin (2011, cited in Pingali and Kaundiya), Tripp and Pal (1998)). These sources affect the farmer's choice of

store and product brand. When choosing the store where farmers will buy their inputs, they take into consideration the availability of quality brands for inputs where quality is an issue. Pingali (2004, cited in Pingali and Kaundiya) found that farmers preferred to shop for pesticides in town outlets even when their village had a shop offering pesticides, since town outlets guarantee quality, credit and product range. Mishra et. al (2000) also found that farmers were willing to travel some distance for quality seeds. However in the case of fertilizers, where sub-standard products don't seem to be a problem, preference was for the closest village outlet. The store decision was also connected to the farmers' credit requirements. Farmers with available credit sources were free to choose the store according to perceived quality, while farmers replying on credit from the retailers were restricted in their choice of stores to those willing to extend credit. The choice of brands for the latter is then restricted to the ones offered by the dealer.

While store choice appears to be governed by quality considerations (given credit is available), brands are selected relying on personal experience rather than considering technical aspects of the product. Tripp and Pal (1998) discovered that brand awareness is different in developed and undeveloped areas. In developed areas, farmers form consideration sets over product brands. In less developed areas, farmers seem to be unaware of the actual brand names, and often referred to the product by the company name or by the location where they believed the product was produced (sometimes giving the same name to two different brands). Pingaly (2002) found that with regard to pesticides the pioneer brand image was important (was considered with better technical efficiency relative to follower brands), especially for prophylactic applications (and less so for curative products).

This anecdotal evidence provides the basis underlying the model used in this chapter. We can believe there is a potentially substantial share of farmers constrained to a narrower choice set of stores and product brands. Is it possible that in areas dominated by cooperative credit, credit constrained farmers would be "captive" consumers of the former monopoly, a major share of which is currently owned by a large agricultural cooperative? The empirical application will test this hypothesis. We might not, however, be able to pin down the mechanism through which source of credit affect market dominance, whether it is through credit to retailers from different sectors, thus making the availability of shops different in different areas, or through credit to buyers linked to purchasing specific brands. To get at this more detailed data on types of credit used by the different actors will be necessary.

6 Single equation results

Before turning to the full model, I present results from single equation estimations. Tables 7-9 presents the number of firms ordered-Probit. This estimation is consistent and can be later compared to the results from the full model. The size of the market, measured as log area of holdings, and the distance from port, measuring variable costs of transportation, are significant and have the correct sign in all specifications. Additional 100 km in the distance from the nearest port predicts a decrease of 0.15-0.2 in the number of competing firms. The share of irrigated area under rice has a strong positive effect on the number of firms, while non-irrigated rice or wheat have a negative or insignificant effect. I present results with and without irrigation status, because of possible endogeneity due to input complementarity. Other demand shifters that turn out significant in 2012 but not in 2007 are rail services and (weakly) share of institutional holdings. The distance from plants works well as a cost shifter in 2007, as it is significantly negative (predicting a 0.1-0.15 decrease in the number of firms every 100 km more in the distance from the nearest plant), but in 2012 it is not significant.

Two variables that have a surprising significant effect are the average size of holdings and the distance for deposits. Average size of holdings is significant and negative in all specifications (I repeated the estimation using the share of large farms and obtained the same result). This is counter intuitive if we expect larger or richer farms to be more likely to use modern and expensive inputs. However this result is consistent with the finding in the agricultural literature that larger farms and holdings are less productive per unit of land than small holdings. One of the explanations that have been suggested is that farmers with larger farms actually use less modern inputs and invest their resources in other more profitable activities of the farm (animal husbandry etc.) (Chand et al. 2011). Our results (here and in the quantity equation) are consistent with this hypothesis.

The distance from deposits is significant and positive in almost all specifications. This might result from the correlation of the deposits locations with specific agro-ecological zones that have an effect on the demand side, as it has a positive and significant sign also in the quantity equation.

Looking at types of available credit, we see that in almost all specifications, cooperative banks and credit societies do not significantly affect the number of firms, while commercial banks have a significant positive effect. Ten additional nationalized bank or RRB branches predict an increase of around 0.1-0.2 in the number of firms. Institutional holdings also have a positive and significant effect on the number of firms, and so does the retail network of IFFCO in 2007.

Table 9 presents the ordered-Probit cutoff points and the calculated per-firm entry thresh-

Table 7: Number of Firms Ordered Probit

	2007	2007	2007	2007	2012	2012	2012	2012
Total area (ln)	0.745***	0.639***	0.693***	0.739***	1.067***	1.108***	0.986***	1.031***
	(0.099)	(0.100)	(0.108)	(0.102)	(0.102)	(0.105)	(0.099)	(0.101)
Average plot size	-0.442***	-0.333***	-0.312**	-0.393***	-0.371***	-0.398***	-0.342***	-0.385***
	(0.104)	(0.112)	(0.123)	(0.114)	(0.126)	(0.125)	(0.119)	(0.119)
Distance from port	-0.247***	-0.253***	-0.279***	-0.281***	-0.151***	-0.134***	-0.169***	-0.142***
	(0.036)	(0.037)	(0.035)	(0.036)	(0.031)	(0.031)	(0.030)	(0.030)
Distance from plant	-0.125**	-0.120*	-0.157**	-0.128**	0.0747	0.0833	0.00226	0.023
	(0.062)	(0.064)	(0.063)	(0.064)	(0.060)	(0.061)	(0.059)	(0.060)
Distance from deposits	0.189***	0.219***	0.097*	0.146***	0.160***	0.101*	0.153***	0.092
	(0.056)	(0.057)	(0.055)	(0.055)	(0.053)	(0.057)	(0.052)	(0.056)
Share under irrigated rice	1.262***	0.888***			1.539***	1.385***		
	(0.255)	(0.268)			(0.290)	(0.300)		
Share under rainfed rice	-0.457*	-0.807***			-1.084***	-1.033***		
	(0.255)	(0.279)			(0.288)	(0.288)		
Share under irrigated wheat	0.566	0.548			0.34	0.197		
	(0.399)	(0.400)			(0.400)	(0.407)		
Share under rainfed wheat	-3.761**	-4.664***			-1.234*	-1.14		
	(1.598)	(1.589)			(0.720)	(0.726)		
Share under rice			0.554***	0.259			0.365*	0.26
			(0.189)	(0.200)			(0.201)	(0.205)
Share under wheat			1.377***	1.289***			1.024***	0.823**
			(0.369)	(0.374)			(0.355)	(0.358)
Obs.	405	404	405	404	378	377	378	377
log likelihood	-501.5	-485.6	-512.1	-505.9	-417.6	-408.5	-445.5	-430.8

Standard errors in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 8: Number of Firms Ordered Probit - cont.

	2007	2007	2007	2007	2012	2012	2012	2012
Institutional credit sources:								
Nationalized banks		0.016***		0.018***		0.009**		0.0132***
		(0.004)		(0.004)		(0.004)		(0.004)
State bank of India and assoc.		0.025*		0.003		-0.041***		-0.044***
		(0.013)		(0.012)		(0.011)		(0.011)
Regional rural banks		0.009**		0.011**		0.014***		0.0182***
		(0.005)		(0.005)		(0.005)		(0.005)
Cooperative banks		-0.001	-0.001	0.0004	0.001	0.002	0.003	0.004*
		(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Agricultural credit societies (coop.)	0.001	-0.0003	0.001	-0.0001	-0.0001	0.000262	-0.0002	0.0003
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Commercial banks			0.008***				0.005**	
			(0.002)				(0.002)	
Rail facilities	-0.003	-0.01*	-0.011**	-0.011**	0.0004	-0.0004	-0.007*	-0.009**
	(0.005)	(0.006)	(0.005)	(0.005)	(0.004)	(0.004)	(0.004)	(0.004)
Institutional plots	2.555**	2.491**	2.943**	2.598**	5.959***	5.862***	5.131***	5.241***
	(1.168)	(1.175)	(1.162)	(1.168)	(1.398)	(1.407)	(1.357)	(1.379)
IFFCO retail network	1.902***	1.803***	1.868***	1.868***	0.556	0.504	0.883***	0.721**
	(0.400)	(0.406)	(0.403)	(0.406)	(0.346)	(0.350)	(0.342)	(0.347)
Obs.	405	404	405	404	378	377	378	377
log likelihood	-501.5	-485.6	-512.1	-505.9	-417.6	-408.5	-445.5	-430.8

Standard errors in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 9: Ordered Probit cutoffs and calculated entry threshold ratios

	2007	2007	2007	2007	2012	2012	2012	2012
Cutoff 1	7.056***	5.882***	6.674***	7.162***	11.43***	11.72***	10.60***	10.96***
	(1.202)	(1.207)	(1.282)	(1.231)	(1.199)	(1.216)	(1.160)	(1.172)
Cutoff 2	8.065***	6.908***	7.628***	8.114***	11.99***	12.31***	11.09***	11.50***
	(1.213)	(1.217)	(1.292)	(1.241)	(1.216)	(1.234)	(1.174)	(1.188)
Cutoff 3	8.922***	7.779***	8.452***	8.924***	12.77***	13.12***	11.80***	12.24***
	(1.216)	(1.219)	(1.293)	(1.244)	(1.230)	(1.250)	(1.186)	(1.201)
Cutoff 4	9.744***	8.660***	9.257***	9.748***	13.74***	14.11***	12.67***	13.14***
	(1.224)	(1.227)	(1.298)	(1.252)	(1.247)	(1.268)	(1.199)	(1.216)
Cutoff 5	10.46***	9.455***	9.958***	10.49***	14.48***	14.88***	13.35***	13.86***
	(1.233)	(1.234)	(1.305)	(1.260)	(1.258)	(1.279)	(1.208)	(1.225)
Obs.	405	404	405	404	378	377	378	377
log likelihood	-501.5	-485.6	-512.1	-505.9	-417.6	-408.5	-445.5	-430.8
s2/s1	1.934	2.492	1.979	1.816	0.847	0.854	0.827	0.84
	(0.028)	(0.039)	(0.030)	(0.026)	(0.010)	(0.010)	(0.009)	(0.010)
s3/s2	2.107	2.606	2.191	1.997	1.388	1.379	1.364	1.364
	(0.019)	(0.026)	(0.022)	(0.018)	(0.010)	(0.010)	(0.010)	(0.010)
s4/s3	2.261	2.977	2.397	2.289	1.851	1.834	1.805	1.809
	(0.016)	(0.021)	(0.018)	(0.016)	(0.010)	(0.010)	(0.010)	(0.010)
s5/s4	2.08	2.778	2.201	2.193	1.612	1.602	1.606	1.607
	(0.013)	(0.018)	(0.015)	(0.014)	(0.008)	(0.008)	(0.008)	(0.008)

Standard errors in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

old ratios. The 2007 relative entry thresholds are larger than one, and as such, are similar to those found in Bresnahan and Reiss (1991). However they do not converge to one soon after the second entrant, or at all. In 2007 the ratios diminish with subsequent entry but stay significantly larger than one even at the seventh entrant. The 2012 thresholds are lower than the 2007 thresholds, showing that markets of the same size became more profitable in the deregulated environment, and were thus able to sustain larger market structures. The first relative entry threshold is lower than one in 2012, but this could possibly result from a small sample of markets with 2 firms in this year (26). The other thresholds are larger than one and also don't converge to one with subsequent entry.

Tables 10-11 presents OLS estimates for the log-quantity equation. The number of observations here is smaller than in the ordered probit, because only markets with positive sales enter. As discussed, this estimation suffers from selection and endogeneity issues which are addressed in the full model. The market size variable and the distance from port again have the right sign and are significant in all specifications. Irrigated wheat and irrigated rice are the only variants that are weakly significant (and positive) in some of the specifications. As before, the average size of holdings has a significant negative sign in most specifications, consistent with the reversed productivity phenomenon. Worth noticing is that the size of the negative coefficient of the log average size of holdings in the quantity equation is very similar to the positive coefficient of the log area. This in practice means that the sold quantity depends only on the number of holding and not on the area (since both variables are entered in logs and average size is the total area divided by the number of holdings).

Table 12 presents the OLS estimation of the market share equation. The number of observations is again smaller than that in the quantity equations since only markets with at least two firms enter here. The dependent variable is the non-captive market share, calculated using the empirical $\tilde{\lambda}$. Here, the available credit sources are the only variables that seem to have an effect. The commercial banks, and specifically Regional Rural banks have a positive and significant effect on the market share non-captive to the former monopoly in both years, predicting an increase of around 1% in the market share non-captive to IPL with every ten RRB branches. While cooperative banks, and agricultural credit societies have a negative effect, when significant.

Table 10: Quantity Sold OLS

	2007 (1)	2007 (2)	2007 (3)	2007 (4)	2012 (5)	2012 (6)	2012 (7)	2012 (8)
Total area (ln)	0.306**	0.331**	0.275*	0.324**	0.455***	0.414***	0.320***	0.289**
	(0.143)	(0.143)	(0.141)	(0.142)	(0.116)	(0.116)	(0.113)	(0.112)
Average plot size	-0.301**	-0.347**	-0.265*	-0.349***	-0.330**	-0.345**	-0.232	-0.225*
	(0.137)	(0.136)	(0.136)	(0.129)	(0.140)	(0.134)	(0.143)	(0.136)
Distance from port	-0.129***	-0.122***	-0.119***	-0.129***	-0.041	-0.0405	-0.038	-0.0411
	(0.044)	(0.044)	(0.043)	(0.043)	(0.033)	(0.033)	(0.032)	(0.032)
Share under irrigated rice	0.356		0.494*		0.627**		0.364	
	(0.289)		(0.279)		(0.283)		(0.269)	
Share under rainfed rice	0.053		0.0001		-0.23		-0.287	
	(0.321)		(0.299)		(0.286)		(0.285)	
Share under irrigated wheat	0.838*		0.806*		-0.138		0.0647	
	(0.434)		(0.434)		(0.429)		(0.422)	
Share under rainfed wheat	-3.571		-3.385		-0.534		-0.549	
	(2.171)		(2.169)		(0.749)		(0.747)	
Share under rice		0.282		0.28		0.225		0.082
		(0.228)		(0.226)		(0.206)		(0.201)
Share under wheat		0.861**		0.9**		0.148		0.242
		(0.408)		(0.405)		(0.368)		(0.362)
Institutional credit sources:								
Nationalized banks	0.012**	0.012**		0.012***	0.003	0.005		
	(0.005)	(0.005)		(0.005)	(0.003)	(0.003)		
State bank of India and assoc.	-0.02	-0.025*		-0.026*	-0.019*	-0.0177*		
	(0.015)	(0.014)		(0.014)	(0.010)	(0.010)		
Regional rural banks	0.0007	0.0006		-0.00002	-0.005	-0.004		
	(0.005)	(0.005)		(0.005)	(0.004)	(0.004)		
Obs.	300	300	301	300	288	288	288	288
R-sq.	0.591	0.593	0.583	0.593	0.599	0.587	0.6	0.59

Standard errors in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 11: Quantity Sold OLS - cont.

	2007 (1)	2007 (2)	2007 (3)	2007 (4)	2012 (5)	2012 (6)	2012 (7)	2012 (8)
Cooperative banks	0.001	0.001	0.003		0.005**	0.005***	0.005***	0.005***
	(0.003)	(0.003)	(0.003)		(0.002)	(0.002)	(0.002)	(0.002)
Agricultural credit societies (coop.)	0.001	0.001*	0.001*	0.001*	-0.0008*	-0.000791*	-0.001***	-0.001***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.0004)	(0.0004)	(0.0004)	(0.0004)
Commercial banks			0.0008	0.0007			0.005**	0.005**
			(0.001)	(0.001)			(0.002)	(0.002)
Rail facilities	-0.001	-0.001	-0.0002	-0.001	0.001	-0.002	-0.006	-0.007**
	(0.006)	(0.006)	(0.006)	(0.006)	(0.004)	(0.004)	(0.004)	(0.004)
Institutional plots	5.528***	5.760***	5.487***	5.809***	1.616	1.318	1.712	1.465
	(1.313)	(1.310)	(1.315)	(1.307)	(1.317)	(1.314)	(1.311)	(1.300)
IFFCO retail network	-0.673	-0.619	-0.65	-0.599	0.317	0.358	0.233	0.297
	(0.440)	(0.441)	(0.441)	(0.438)	(0.332)	(0.333)	(0.327)	(0.326)
N=2	0.755***	0.886***	0.770***	0.876***	0.513**	0.522**	0.497**	0.482*
	(0.213)	(0.205)	(0.213)	(0.205)	(0.249)	(0.249)	(0.247)	(0.246)
N=3	1.833***	1.965***	1.808***	1.953***	0.875***	0.956***	0.885***	0.942***
	(0.221)	(0.214)	(0.222)	(0.214)	(0.251)	(0.250)	(0.248)	(0.247)
N=4	1.960***	2.098***	2.027***	2.072***	1.377***	1.501***	1.420***	1.510***
	(0.265)	(0.257)	(0.263)	(0.258)	(0.266)	(0.262)	(0.261)	(0.258)
N=5+	2.323***	2.508***	2.336***	2.465***	2.237***	2.400***	2.208***	2.329***
	(0.295)	(0.279)	(0.283)	(0.282)	(0.279)	(0.271)	(0.274)	(0.266)
Constant	2.275	1.737	2.576	1.862	0.38	0.75	1.86	2.151
	(1.759)	(1.737)	(1.736)	(1.737)	(1.384)	(1.384)	(1.361)	(1.358)
Obs.	300	300	301	300	288	288	288	288
R-sq.	0.591	0.584	0.583	0.585	0.58	0.571	0.578	0.572

Standard errors in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 12: Non-Captive Market Share $(1 - \tilde{\lambda})$ OLS

	2007 (1)	2007 (2)	2012 (3)	2012 (4)
Average plot size	0.242**	0.159	-0.018	-0.006
	(0.097)	(0.097)	(0.071)	(0.073)
Nationalized banks	0.003		-0.001	
	(0.004)		(0.002)	
State bank of India and assoc.	0.013		-0.001	
	(0.011)		(0.007)	
Regional rural banks	0.015***		0.012***	
	(0.004)		(0.003)	
Cooperative banks	-0.0001	-0.001	-0.0004	-0.002*
	(0.002)	(0.002)	(0.001)	(0.001)
Agricultural credit societies (coop.)	-0.002***	-0.001**	0.001	0.0002
	(0.0005)	(0.0004)	(0.0003)	(0.0003)
Institutional plots	-0.559	-0.538	0.27	-0.158
	(1.223)	(1.280)	(0.885)	(0.889)
IFFCO retail network	0.134	0.238	-0.205	-0.215
	(0.287)	(0.298)	(0.206)	(0.204)
Commercial banks		0.001*		0.004***
		(0.001)		(0.001)
Constant	-0.876***	-0.757***	-0.799***	-0.776***
	(0.115)	(0.113)	(0.087)	(0.084)
Obs.	227	228	262	262
R-sq.	0.145	0.05	0.095	0.065

Standard errors in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

7 Selection and full model results

In this section I present results from the selection model, separately for each of the two years and from the full model. The selection model is a maximum likelihood estimation using the likelihood function in subsection 5.4. The model is estimated separately for 2007-2008 and for 2012-2013, with no restrictions on the parameters. The variables affecting λ are also not restricted to affect only the markets with more than two firms. The starting point for the optimization is an arbitrary point close to 0 (using coefficients from a two stage estimation does not affect the outcome).

Table 13: Selection models for the two years and the full model

	Selection Model 2007	Selection Model 2012	Full Model
$\underline{\beta}$			
Total area (ln)	0.517***	0.947***	0.82***
	(0.106)	(0.110)	(0.061)
Average plot size	-0.152	-0.371***	-0.342***
	(0.107)	(0.118)	(0.071)
Distance from port	-0.304***	-0.129***	-0.213***
	(0.035)	(0.030)	(0.021)
Distance from plant	-0.146**	-0.071	-0.125***
	(0.063)	(0.055)	(0.038)
Distance from deposits	0.1403**	0.045	0.099***
	(0.064)	(0.057)	(0.036)
Share under rice	0.422**	0.376*	0.673***
	(0.193)	(0.196)	(0.130)
Share under wheat	1.594***	0.696**	1.201***
	(0.360)	(0.335)	(0.232)
Institutional credit sources:			
Nationalized banks	0.018***	0.0103***	0.006***
	(0.004)	(0.003)	(0.003)
Regional rural banks	0.0098**	0.016***	0.009***
	(0.004)	(0.005)	(0.003)
Cooperative banks	0.001	0.003	0.004***
	(0.002)	(0.002)	(0.002)
Agricultural credit societies (coop.)	-0.0002	0.0004	0
	(0.001)	(0.001)	(0.000)
State bank of India and assoc.	0.001	-0.052***	-0.022***
	(0.012)	(0.011)	(0.008)

Standard errors in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 14: Selection models for the two years and the full model - Cont.

$\underline{\delta' s}$			
Average plot size	0.707**	0.297	-0.585***
	(0.302)	(0.255)	(0.090)
Share under rice	-0.505***	-0.561***	0.673***
	(0.126)	(0.132)	(0.130)
Share under wheat	0.422**	0.376*	1.128***
	(0.193)	(0.196)	(0.301)
Institutional credit sources:			
Nationalized banks	0.906	0.618	0.01***
	(0.709)	(0.385)	(0.003)
Regional rural banks	0.015**	0.009**	0.003
	(0.007)	(0.004)	(0.004)
Cooperative banks	0.004	0.001	0.004***
	(0.006)	(0.005)	(0.002)
Agricultural credit societies (coop.)	0.001	0.006***	0
	(0.003)	(0.002)	(0.000)
State bank of India and assoc.	0.001	-0.001**	-0.04***
	(0.001)	(0.000)	(0.009)
Distance from port	-0.026*	-0.043***	-0.213***
	(0.014)	(0.012)	(0.021)
$N = 2$	-0.161	-0.103***	0.526***
	(0.103)	(0.040)	(0.164)
$N = 3$	1.612***	0.417	0.849***
	(0.497)	(0.291)	(0.196)
$N = 4$	1.662**	0.5695	0.851***
	(0.669)	(0.361)	(0.246)
$N = 5+$	1.688*	0.896*	0.869***
	(1.012)	(0.487)	(0.324)
σ_Q	1.131***	1.089***	1.217***
	(0.072)	(0.071)	(0.052)
ρ	0.1896	0.463***	0.481***
	(0.072)	(0.071)	(0.067)

Standard errors in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 15: Selection models for the two years and the full model - Cont.

	Selection Model 2007	Selection Model 2012	Full Model
2007 cutoffs			
μ_1	4.543***		8.351***
	(1.209)		(0.762)
μ_2	5.452***		9.361***
	(1.222)		(0.754)
μ_3	6.214***		10.101***
	(1.223)		(0.756)
μ_4	6.976***		10.823***
	(1.225)		(0.761)
μ_5	7.695***		11.48***
	(1.233)		(0.768)
2012 cutoffs			
μ_1		9.663***	7.954***
		(1.240)	(0.742)
μ_2		10.165***	8.527***
		(1.260)	(0.735)
μ_3		10.848***	9.176***
		(1.274)	(0.743)
μ_4		11.703***	10.005***
		(1.288)	(0.752)
μ_5		12.392***	10.69***
		(1.300)	(0.762)
Obs.	404	377	781
Log-Likelihood	-979.62	-845.93	-1876.2

Standard errors in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 16: Entry threshold ratios from full model

	2007	2012
s2/s1	1.712***	1.006***
	(0.021)	(0.017)
s3/s2	1.641***	1.471***
	(0.014)	(0.016)
s4/s3	1.809***	2.064***
	(0.012)	(0.016)
s5/s4	1.782***	1.846***
	(0.012)	(0.013)

Standard errors in parentheses, calculated using the delta method *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Then I show the results from the full model, where I set all parameters to be the same between the two years, except for the cutoffs in the entry equation. In the final model I also set the coefficient of the market size to be the same in the entry and quantity equations, as in the theoretical model. The results are not very different from the preliminary estimations.

7.1 Calculated parameters and competitive effects

Table 17: Combined entry effect on variable profits and fixed costs

	$(\alpha_N - \delta_N)_{2007}$	$(\alpha_N - \delta_N)_{2012}$
$N = 2$	9.194***	8.36***
	(0.856)	(0.840)
$N = 3$	9.851***	8.926***
	(0.876)	(0.865)
$N = 4$	10.288***	9.47***
	(0.908)	(0.901)
$N = 5+$	10.739***	9.949***
	(0.957)	(0.952)

Standard errors in parentheses, calculated using the delta method *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 18: Calculated per-capita demand ratios

d2/d1	d3/d2	d4/d3	d5/d4
1.692***	1.382***	1.002***	1.018***
(0.278)	(0.222)	(0.182)	(0.369)

Standard errors in parentheses, calculated using the delta method *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 19: Calculated fixed cost ratios

F2/F1	F3/F2	F4/F3	F5/F4
2.901	2.271	1.815	1.814

Table 20: Calculated variable profits ratios

V2/V1	V3/V2	V4/V3	V5/V4
1.704	1.117	0.878	0.966

Tables 18-20 present the calculated ratios. The effect of entry on per-capita quantity is positive and generally decreasing. It seems to approach 1 around the fourth entrant in 2007. The effect is larger in 2012 at least for the 4th-5th entrant, which is consistent with the added price effect. The entry effect on variable profits is negative (the ratios are smaller than 1) only beginning with the fourth entrant, and remains negative with the fifth entrant. This suggest very strongly that three firms is not enough to provide competition, that for prices to drop there must be at least a fourth firm in the market. Yet the tendency of estimated fixed costs to increase with the number of firms shows the difficulties that such firms have in entering a market. The effect of entry on fixed costs is substantial, the second entrant faces 4 times higher fixed costs than the first entrant according to our results. The effect diminishes with subsequent entry but remains large even at the 5th entrant.

Overall, the results of my analysis point to several potential policy implications. Firm entry into geographical markets was found to increase the intensity of competition (lowering variable profits of the marginal entrant), thus potentially reducing prices of inputs for farmers. This provides basis to consider the process of market liberalization and deregulation as

an alternative to the direct price-fixing mechanism used by the government for potassium and phosphate fertilizers, at least formally until 2010 and in a softer form after 2013, and is still used for nitrogen fertilizer. The role of interactions between the private, government and cooperative sectors in the credit market in influencing market shares and competition patterns in the product market, is interesting and worth exploring further. In the case of fertilizers, government intervention in encouraging the placing of commercial bank branches in rural areas is found to have some positive effect on the ability of new competitors to enter markets and capture market shares from the historical monopoly. While physical infrastructure development is often an important role for the government in market development, attention should also be directed to the availability of institutional aspects such as competing credit sources in the local markets.

8 Conclusion

The entry model presented here provides a framework to discuss some important features of the Indian Potassium fertilizer market. I added a notion of captive consumers to the Bresnahan and Reiss framework, allowing a market share advantage to a former monopoly. In the empirical application I related this advantage to the structure of the local credit market. Commercial banks and Regional Rural Banks in particular were found to have a negative effect on the population of captive consumers, and subsequently a positive effect on the number of competing firms. Cooperative credit sources were found to have a zero or negative effect. This has important implications on the effects of government policy in the credit market on the outcomes in product markets.

As in Abraham et al. 2007, I used quantity information to add identification to the entry model parameters and rule out a fixed-cost-only driven entry effect. To further separate the effect of entry on variable profits, I took advantage of the change in price regulation between the two periods of analysis, going from a government set fixed price, to market prices. By assuming no entry effect on variable profits in the fixed price period, I was able to derive this effect in the market prices period. A negative effect on variable profits is only found in the fourth and fifth entrant. The fixed cost effect of entry turns out to be very significant. These results give room for deliberation on possible policy routs to increase competition in the deregulated fertilizer markets. Particularly in light of the recent debate on the possibility to introduce deregulation to the cheaper nitrogen fertilizer as well. While so far directly intervening in this market by setting prices and subsidies, it is worth further exploring other routs that will improve the competitive environment in the market.

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